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NONRESIDENT TRAINING COURSE

November 1996



Steelworker, Volume 2

NAVEDTRA 14251

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Although the words "he," "him," and "his" are used sparingly in this course to enhance communication, they are not intended to be gender driven or to affront or discriminate against anyone.

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ERRATA #1 29 May 2001

Specific Instructions and Errata for
Nonresident Training Course

STEELWORKER, VOLUME 2, NAVEDTRA 14251

1. This errata supersedes all previous errata. No attempt has been made to issue corrections for errors in typing, punctuation, etc., that do not affect your ability to answer the question or questions.

2. To receive credit for deleted questions, show this errata to your local course administrator (ESO/scorer). The local course administrator is directed to correct the course and the answer key by indicating the questions deleted.

3. Assignment Booklet, NAVEDTRA 14251.

Delete the following questions, and leave the corresponding spaces blank on the answer sheets:

Questions	Questions
2-44	5-12
3-16	6-31
3-17	7-23
3-18	7-55
4-45	8-51
4-52	8-52
4-55	

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PREFACE

By enrolling in this self-study course, you have demonstrated a desire to improve yourself and the Navy. Remember, however, this self-study course is only one part of the total Navy training program. Practical experience, schools, selected reading, and your desire to succeed are also necessary to successfully round out a fully meaningful training program.

COURSE OVERVIEW: In completing this nonresident training course, you will demonstrate a knowledge of the subject matter by correctly answering questions on the following subjects:

Technical Administration
Layout and Fabrication of Sheet Metal and Fiberglass Duct
Structural Terms/Layout and Fabrication of Structural Steel and Pipe
Fiber Line
Wire Rope
Rigging
Reinforcing Steel
Pre-engineered Structures: Buildings, K-Spans, Towers, and Antennas
Pre-engineered Storage Tanks
Pontoons
Pre-engineered Structures: Short Airfield for Tactical Support
Steelworker Tools and Equipment

THE COURSE: This self-study course is organized into subject matter areas, each containing learning objectives to help you determine what you should learn along with text and illustrations to help you understand the information. The subject matter reflects day-to-day requirements and experiences of personnel in the rating or skill area. It also reflects guidance provided by Enlisted Community Managers (ECMs) and other senior personnel, technical references, instructions, etc., and either the occupational or naval standards, which are listed in the *Manual of Navy Enlisted Manpower Personnel Classifications and Occupational Standards*, NAVPERS 18068.

THE QUESTIONS: The questions that appear in this course are designed to help you understand the material in the text.

VALUE: In completing this course, you will improve your military and professional knowledge. Importantly, it can also help you study for the Navy-wide advancement in rate examination. If you are studying and discover a reference in the text to another publication for further information, look it up.

1996 Edition Prepared by
SWC Michael P. DePumpo

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SAFETY PRECAUTIONS

Safety is a paramount concern for all personnel. Many of the Naval Ship's Technical manuals, manufacturer's technical manuals, and every Planned Maintenance System (PMS) maintenance requirement card (MRC) include safety precautions. Additionally, OPNAVINST 5100.19 (series), *Naval Occupational Safety and Health (NAVOSH) Program Manual for Forces Afloat*, and OPNAVINST 5100.23 (series), *NAVOSH Program Manual,* provide safety and occupational health information. The safety precautions are for your protection and to protect equipment.

During equipment operation and preventive or corrective maintenance, the procedures may call for personal protective equipment (PPE), such as goggles, gloves, safety shoes, hard hats, hearing protection, and respirators. When specified, your use of PPE is mandatory. You must select PPE appropriate for the job since the equipment is manufactured and approved for different levels of protection. If the procedure does not specify the PPE, and you aren't sure, ask your safety officer.

Most machinery, spaces, and tools requiring you to wear hearing protection are posted with hazardous noise signs or labels. Eye hazardous areas requiring you to wear goggles or safety glasses are also posted. In areas where corrosive chemicals are mixed or used, an emergency eyewash station must be installed.

All lubricating agents, oil, cleaning material, and chemicals used in maintenance and repair are hazardous materials. Examples of hazardous materials are gasoline, coal distillates, and asphalt. Gasoline contains a small amount of lead and other toxic compounds. Ingestion of gasoline can cause lead poisoning. Coal distillates, such as benzene or naphthalene in benzol, are suspected carcinogens. Avoid all skin contact and do not inhale the vapors and gases from these distillates. Asphalt contains components suspected of causing cancer. Anyone handling asphalt must be trained to handle it in a safe manner.

Hazardous materials require careful handling, storage, and disposal. PMS documentation provides hazard warnings or refers the maintenance man to the Hazardous Materials User's Guide. Material Safety Data Sheets (MSDS) also provide safety precautions for hazardous materials. All commands are required to have an MSDS for each hazardous material they have in their inventory. You must be familiar with the dangers associated with the hazardous materials you use in your work. Additional information is available from you command's *Hazardous Material Coordinator.* OPNAVINST 4110.2 (series), *Hazardous Material Control and Management,* contains detailed information on the hazardous material program.

Recent legislation and updated Navy directives implemented tighter constraints on environmental pollution and hazardous waste disposal. OPNAVINST 5090.1 (series), *Environmental and Natural Resources Program Manual,* provides detailed information. Your command must comply with federal, state, and local environmental regulations during any type of construction and demolition. Your supervisor will provide training on environmental compliance.

Cautions and warnings of potentially hazardous situations or conditions are highlighted, where needed, in each chapter of this TRAMAN. Remember to be safety conscious at all times.

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SUMMARY OF STEELWORKER TRAINING MANUALS

VOLUME 1

Steelworker, Volume 1, NAVEDTRA 14250, consists of chapters on the following subjects: properties and Uses of Metal; Basic Heat Treatment; Introduction to Welding; Gas Cutting; Gas Welding; Soldering Brazing, Braze Welding and Wearfacing; Shielded Metal-Arc Welding and Wearfacing; and Gas Shielded-Arc Welding.

VOLUME 2

Steelworker, Volume *2*, NAVEDTRA 14251, consists of chapters on the following subjects: Technical Administration; Layout and Fabrication of Sheet Metal and Fiber-Glass Duct; Structural Steel Terms/Layout and Fabrication of Structural Steel and Pipe; Fiber Line; Wire Rope; Rigging; Reinforcing Steel; Pre-engineered Structures: Buildings, K-Spans, Towers, and Antennas; Pre-engineered Storage Tanks; Pontoons; pre-engineered Structures: Short Airfield for Tactical Support; and Steelworker Tools and Equipment.

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CHAPTER 1

TECHNICAL ADMINISTRATION

When you achieve the status of PETTY OFFICER, it becomes your most important advancement in the Navy. Sewing on your first chevron carries many responsibilities with it. Among these responsibilities is the commitment to become an effective supervisor/leader, instructor, and administrator in all military, technical, and safety areas of your rating.

As a petty officer, you will begin to develop your ability to manage the work that is done by your personnel as well as to supervise/lead them.

As you gain experience as a petty officer and increase your technical abilities as a Steelworker, your skill as leader becomes more and more important as you lead/supervise personnel assigned to you. At each rating level, you will be given more responsibility and will be expected to seek the responsibility associated with that particular rating level. The intent of this chapter is to help you understand the importance of leadership, to show you the practical aspects of applying leadership principles coupled with sound administrative practices, and to help you use and prepare the administrative "paperwork" that you will be involved with as a crew leader.

CONSTRUCTION ADMINISTRATION

As your crew leader or supervisor experience grows, you begin to assume greater responsibility for the work of others. As this is occurring, you will also assume greater administrative duties. For this reason, you must understand that proper administration is the backbone of any project. You will have personnel assigned to your project who must be employed effectively and safely. Therefore, you not only have to meet production requirements and conduct training but also must know and apply the procedures required to process "paperwork" correctly,

Administration is the mechanical means that a person or an organization uses to plan, organize, supervise, manage, and document activities. It provides a means of telling you such things as what has been planned, what is required, what has occured, what is completed, what personnel are assigned, and so on. Try keeping all that information in your head for even a small assignment/project. You will begin to understand the variety of methods used to administer the job. Administration ranges from just keeping a notebook in your back pocket to filling out a variety of reports and forms.

As a growing leader in the Navy, you must learn about and become effective in the use of administrative tools as well as the tools of your trade. Once you become comfortable with using these tools, you will then develop the skill of a successful administrator who can lead and direct people in getting the job done right and done well.

PLANNING PERSONNEL WORK ASSIGNMENTS

While planning for a small or large project, you must consider the abilities of your crew. Use PRCP data, which will be discussed later in the chapter. Next, consider any special tools and equipment you will need and arrange to have them at the jobsite when the work is started. Determine who will use these tools, and ensure the crew members assigned know how to use them Properly and safely.

To assure that the project is done properly and on time, you should consider the method of accomplishment as well as the skill level (PRCP level) of your crew. When there is more than one way of constructing a particular project, you must analyze the methods and choose the one best suited to the project conditions and the skill levels of your crew. Listen to suggestions from others. If you can simplify a method and save time and effort, by all means do it.

As the petty officer in charge of a crew, you are responsible for crew member time management as well as your own. You must plan constructive work for your crew. Always remember to PLAN AHEAD! A sure sign of poor planning is that of crew members standing idle each morning while you plan the events for the day. At the close of each day, you should confirm the plans for the next workday. In doing so, you will need answers on the availability y and use of manpower, equipment, and supplies. Keep the following questions in mind:

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1. Manpower. Who is to do what? How is it to be done? When is it to be finished? Since idleness will breed discontent, have you arranged for another job to start as soon as the first one is finished? Is every crew member fully used?

2. Equipment. Are all necessary tools and equipment on hand to do the job? Is safety equipment on hand?

3. Supplies. Are all necessary supplies on hand to start the job? If not, who should take action? What supply delivery schedules must you work around?

Have a definite work schedule and inspection plan. Set up realistic daily goals or quotas. Personally plan to check the work being done at intervals and the progress toward meeting the goals. Spot-check for accuracy, for workmanship, and the need for training.

Organizing

As a crew leader or supervisor, you must be able to ORGANIZE. This means that you must analyze the requirements of a job and structure the sequence of events that will bring about the desired results.

You must develop the ability to look at a job and estimate how many man-hours are required for completion. You will probably be given a completion deadline along with the job requirements. Next (or perhaps even before making your estimate of man-hours), plan the job sequences. Make sure that you know the answers to questions such as the following:

- What is the size of the job?
- Are the materials on hand?
- What tools are available, and what is their condition?
- Is anyone scheduled for leave?
- Will you need to request outside support?

After getting answers to these questions, you should be able to assign your crews and set up tentative schedules. If work shifts are necessary, arrange for the smooth transition from one shift to another with a minimum of work interruption. How well you do is directly related to your ability to organize.

Delegating

In addition to organizing, you must know how to DELEGATE. This is one of the most important characteristics of a good supervisor. Failure to delegate is a common failing of a new supervisor. It is natural to want to carry out the details of a job yourself, particularly when you know that you can do it better than any of your subordinates. Trying to do too much, however, is one of the quickest ways to get bogged down in details and to slow down a large operation. On some projects, you will have crews working in several different places. Obviously, you cannot be in two places at the same time. There will be many occasions when a crew member needs assistance or instruction on some problem that arises. If he or she has to wait until you are available, then valuable time will be lost. Therefore, it is extremely important for you to delegate authority to one or more of your experienced crew members to make decisions in certain matters. However, you must remember that when you delegate authority, you are still responsible for the job. Therefore, it is very important that you select a highly qualified individual when you delegate authority.

Coordinating

A supervisor must be able to COORDINATE. When several jobs are in progress, you need to coordinate completion times so one can follow another without delay. Possessing coordinating skill is also very helpful when working closely with your sister companies or shops. Coordination is not limited to projects only. You would not want to approve a leave chit for a crew member and then remember a school during the same time period. Nor would you want to schedule a crew member for the rifle range only to find the range coaches unavailable at that time.

Production

The primary responsibility of every supervisor is PRODUCTION. You and your crew can attain your best by doing the following:

- Plan, organize, and coordinate the work to get maximum production with minimum effort and confusion.
- Delegate as much authority as possible, but remain responsible for the final product.
- Continuously supervise and control to make sure the work is done properly.
- Be patient ("Seabees are flexible and resourceful").

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Supervising/Leading Work Teams

Before starting the project, you should make sure your crew understands what is expected of them. Give your crew instructions, and urge them to ask questions. Be honest in your answers. If you do not know, say so; then find the correct answers and inform your crew. Establish goals for each workday and encourage your crew members to work together as a team while accomplishing these goals. Goals should be set that will keep your crew busy but also ensure these goals are realistic. Do not overload your crew or undertask them. During an emergency, most crew members will make an all-out effort to meet the deadline. But people are not machines, and when there is no emergency, they cannot be expected to work at an excessively high rate continuously.

While the job is underway, check from time to time to ensure that the work is progressing satisfactorily. Determine if the proper methods, the materials, the tools, and the equipment are being used. If crew members are doing the job incorrectly, stop them, and point out what is being done unsatisfactorily. Then explain the correct procedure and check to see that it is followed.

NOTE: When you check the work of your crew members, do it in such a way that they will feel that the purpose of checking is to teach, guide, or direct, rather than to criticize or find fault.

Make sure your crew members take all applicable safety precautions and wear/use safety apparel/ equipment that is required. Also, watch for hazardous conditions, improper use of tools and equipment, and unsafe work practices that could cause mishaps and possibly result in injury to personnel. Many young personnel ignore danger or think a particular safety practice is unnecessary. This can normally be corrected by proper instruction and training. Safety **awareness is paramount,** and it must be a state of mind and enforced daily until the crew understands its importance. When this occurs, you MUST NOT allow the crew to become complacent in safety matters. Constant training and awareness is the key; therefore, conduct safety lectures daily!

When time permits, rotate crew members on various jobs within the project. Rotation gives them varied experience. It also helps you, as a crew leader, to get the job done when a crew member is out for any length of time.

As a crew leader, you should be able to get others to work together in getting the job accomplished. Maintain an approachable attitude toward your crew so that each crew member will feel free to seek your advice when in doubt about any phase of the work. Emotional balance is especially important; you must not panic before your crew, nor be unsure of yourself in the face of conflict.

Be tactful and courteous in dealing with your crew. Never show partiality to certain members of the crew. Keep your crew members informed on matters that affect them personally or concern their work. Also, seek to maintain a high level of morale because low morale can have a detrimental effect on safety awareness and the quality and quantity of the work your crew performs.

As you advance in rate, more and more of your time will be spent in supervising others. Therefore, learn as much as you can about the subject of supervision. Study books on supervision as well as leadership. Also, watch how other supervisors operate and do not be afraid to ASK QUESTIONS.

TOOL KITS AND REQUISITIONS

Tool kits contain all of the craft hand tools required by one four-member construction crew of a given rating to pursue their trade. The kits kits can be augmented with additional tools to complete a specific job requirement. However, kits must not be reduced in any type of item and must be maintained at 100 percent of the kit allowance.

As a crew leader, you are authorized to draw the tools required by the crew. In so doing, you are responsible for the following:

- Maintaining complete tool kits at all times
- Assigning tools within the crew
- Ensuring proper use and care of assigned tools by the crew
- Preserving tools not in use
- Securing assigned tools

TOOL KIT INVENTORIES

To ensure that the tools are maintained properly, the operations officer and the supply officer establish a formal tool kit inventory and inspection program. You, as a crew leader, must have a tool kit inventory performed at least once a month. Damaged and worn tools must be returned to the central toolroom (CTR)

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for replacement. Tools requiring routine maintenance are turned in to CTR for repair and reissue. Requisitions will be submitted through prescribed channels for replacement items.

PREPARING REQUISITIONS

As a crew leader, you should become familiar with forms that are used to request material or services through the Naval Supply System. Printed forms are available that provide all the necessary information for physical transfer of the material and accounting requirements.

Two forms used for ordering materials are the Single-Line Item Consumption/Management Document (Manual), NAVSUP Form 1250 (fig. 1-1), and the Requisition and Invoice/Shipping Document, DD Form 1149 (fig. 1-2).

As a crew leader, you are not usually required to make up the entire NAVSUP Form 1250; however, you must list the stock number (when available) of the item, the quantity required, and the name or description of each item needed. This form is turned in to the company expediter, who will check it over, complete the rest of the information required, and sign it. Then it is forwarded to the material liaison officer (MLO) or supply department for processing.

You are not likely to use DD Form 1149 often since the items most frequently ordered are bulk fuels and lubricants. This form is limited to a single page and must contain no more than nine line items. It is not necessary to fill in all the blocks on this form when it is used as a requisition.

When ordering material, you need to know about the national stock number (NSN) system. Information on the NSN system and other topics relating to supply is provided in *Military Requirements for Petty Officer Third Class,* NAVEDTRA 10044-A.

TIMEKEEPING

In a battalion deployed overseas, as well as at shore-based activities, your duties can involve the posting of entries on time cards for military personnel. Therefore, you should know the type of information called for on time cards and understand the importance of accuracy in labor reporting. You will find that the labor reporting system primarily used in Naval Mobile Construction Battalions (NMCBs) and the system used at shore-based activities are similar.

A labor accounting system is mandatory to record and measure the number of man-hours that a unit spends on various functions. In this system, labor utilization data is collected daily in sufficient detail and in a way that enables the operations officer to compile the data readily. This helps the operations officer manage manpower resources and prepare reports to higher authority.

A unit must account for all labor used to carry out its assignment, so management can determine the amount of labor used on the project. Labor costs are figured and actual man-hours are compared with

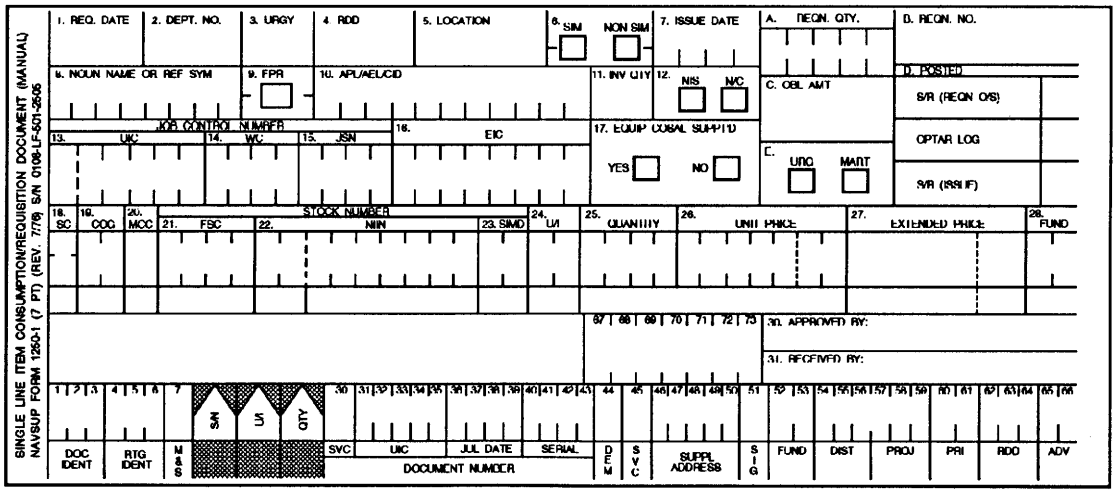
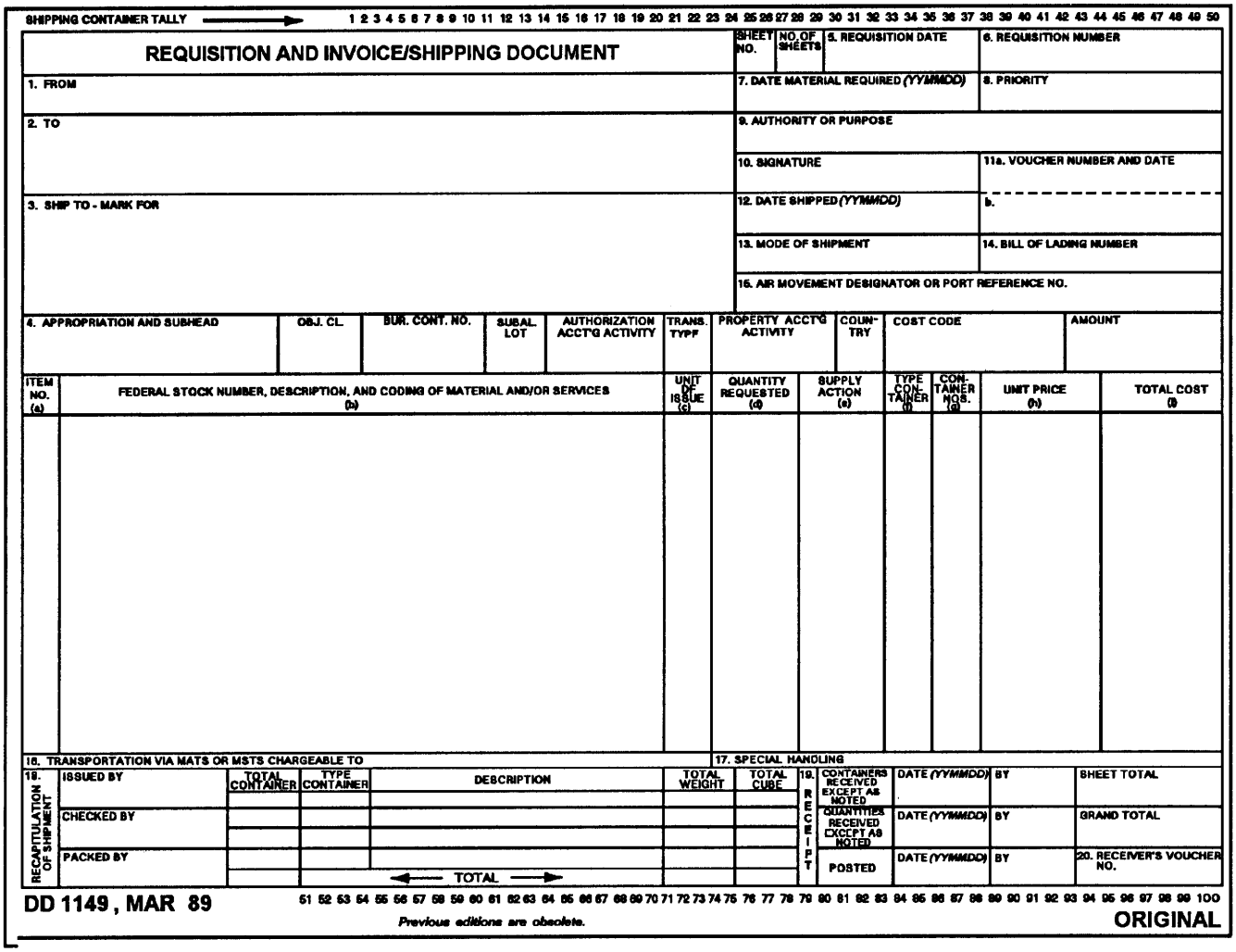


Figure 1-1.—NAVSUP form 1250.

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SHIPPING CONTAINER TALLY → 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

REQUISITION AND INVOICE/SHIPPING DOCUMENT

	SHEET NO. / NO. OF SHEETS	5. REQUISITION DATE	6. REQUISITION NUMBER
1. FROM	7. DATE MATERIAL REQUIRED (YYMMDD)		8. PRIORITY
2. TO	9. AUTHORITY OR PURPOSE		
	10. SIGNATURE		11a. VOUCHER NUMBER AND DATE
3. SHIP TO - MARK FOR	12. DATE SHIPPED (YYMMDD)		b.
	13. MODE OF SHIPMENT		14. BILL OF LADING NUMBER
	15. AIR MOVEMENT DESIGNATOR OR PORT REFERENCE NO.		

4. APPROPRIATION AND SUBHEAD	OBJ. CL.	SUR. CONT. NO.	SUBAL. LOT	AUTHORIZATION ACCT'G ACTIVITY	TRANS. TYPE	PROPERTY ACCT'G ACTIVITY	COUNTRY	COST CODE	AMOUNT

ITEM NO. (a)	FEDERAL STOCK NUMBER, DESCRIPTION, AND CODING OF MATERIAL AND/OR SERVICES (b)	UNIT OF ISSUE (c)	QUANTITY REQUESTED (d)	SUPPLY ACTION (e)	TYPE CONTAINER (f)	CONTAINER NOS. (g)	UNIT PRICE (h)	TOTAL COST (i)

16. TRANSPORTATION VIA MATS OR MSTS CHARGEABLE TO

17. SPECIAL HANDLING

RECAPITULATION OF SHIPMENT

18.	ISSUED BY	TOTAL CONTAINER	TYPE CONTAINER	DESCRIPTION	TOTAL WEIGHT	TOTAL CUBE
	CHECKED BY					
	PACKED BY			← TOTAL →		

RECEIPT

19.				
	CONTAINERS RECEIVED EXCEPT AS NOTED	DATE (YYMMDD)	BY	SHEET TOTAL
	QUANTITIES RECEIVED EXCEPT AS NOTED	DATE (YYMMDD)	BY	GRAND TOTAL
	POSTED	DATE (YYMMDD)	BY	20. RECEIVER'S VOUCHER NO.

DD 1149, MAR 89

51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

Previous editions are obsolete.

ORIGINAL

Figure 1-2.—DD Form 1149.

previous estimates based on jobs of a similar nature. When completed, this information is used by unit managers and higher commands for developing planning standards. Although labor accounting systems can vary slightly from one command to another, the system described here can be considered typical.

CATEGORIES OF LABOR

The type of labor performed must be broken down and reported by category to show how labor has been used. For timekeeping and labor reporting purposes, all labor is classified as either productive or overhead.

Productive Labor

PRODUCTIVE LABOR includes labor that directly or indirectly contributes to the accomplishment of the mission of the unit, including construction operations, military operations, and training. Productive labor is accounted for in three categories: direct labor, indirect labor, and military, which is called "other" on some timekeeping cards.

1. DIRECT LABOR includes labor expended directly on assigned construction tasks either in the field or in the shop that contributes directly to the completion of an end product. Direct labor must be reported separately for each assigned construction task.

2. INDIRECT LABOR comprises labor required to support construction operations but does not produce an end product itself.

3. MILITARY or "Other" includes military functions and training necessary to support the mission.

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Overhead Labor

OVERHEAD LABOR is not considered to be productive labor because it does not contribute directly or indirectly to the completion of an end product. Included is labor that must be performed regardless of the assigned mission.

LABOR CODES

During the planning and scheduling of a construction project, each phase of the project considered as direct labor is given an identifying code. Because there are many types of construction projects involving different operations, codes for direct labor reporting can vary from one activity to another. For example, excavating and setting forms can be assigned code R-15; laying block, code R- 16; and installing bond beams, code R-17. You will use direct labor codes to report each hour spent by each of your crew members during each workday on assigned construction tasks.

Codes are also used to report time spent by crew members in the following categories: indirect labor, military operations and readiness, disaster control operations, training, and overhead labor. The codes shown in figure 1-3 are used at most activities to indicate time spent in these categories.

TIMEKEEPING CARDS

Your report is submitted on a Daily Labor Distribution Report form (timekeeping card), like the one shown in figure 1-4. The form provides a breakdown by man-hours of the activities in the various labor codes for each crew member for each

PRODUCTIVE LABOR. Productive labor includes all labor that directly contributes to the accomplishment of the Naval Mobile Construction Battalion, including construction operations and readiness, disaster recovery operations, and training.

DIRECT LABOR. This category includes all labor expended directly on assigned construction tasks, either in the field or in he shop, and which contributes directly to the completion of the end product

INDIRECT LABOR. This category comprises labor required to support construction operations, but which does not produce n itself. Indirect labor reporting codes are as follows:

X01 Construction Equipment Maintenance, Repair and Records	X04 Project Expediting (Shop Planners)	X06 Project Material Support
X02 Operation and Engineering	X05 Location Moving	X07 Tool and Spare Parts Issue
X03 Project Supervision		X08 Other

MILITARY OPERATIONS AND READINES. This category comprises all manpower expended in actual military operations, unit embarkation, and planning and preparations necessary to insure unit military and mobility readiness. Reporting codes areas follows:

M01 Military Operations	M04 Unit Movement	M06 Contingency	M08 Mobility & Defense Exercise
M02 Military Security	M05 Mobility Preparation	M07 Military Administrative Functions	M09 Other
M03 Embarkation			

DISASTER CONTROL OPERATIONS

D01 Disaster Control Operations	D02 Disaster Control Exercise

TRAINING. This category includes attendance at service schools, factory and industrial training courses, fleet type training, and short courses, military training, and organized training conducted within the battalion. Reporting codes are as follows:

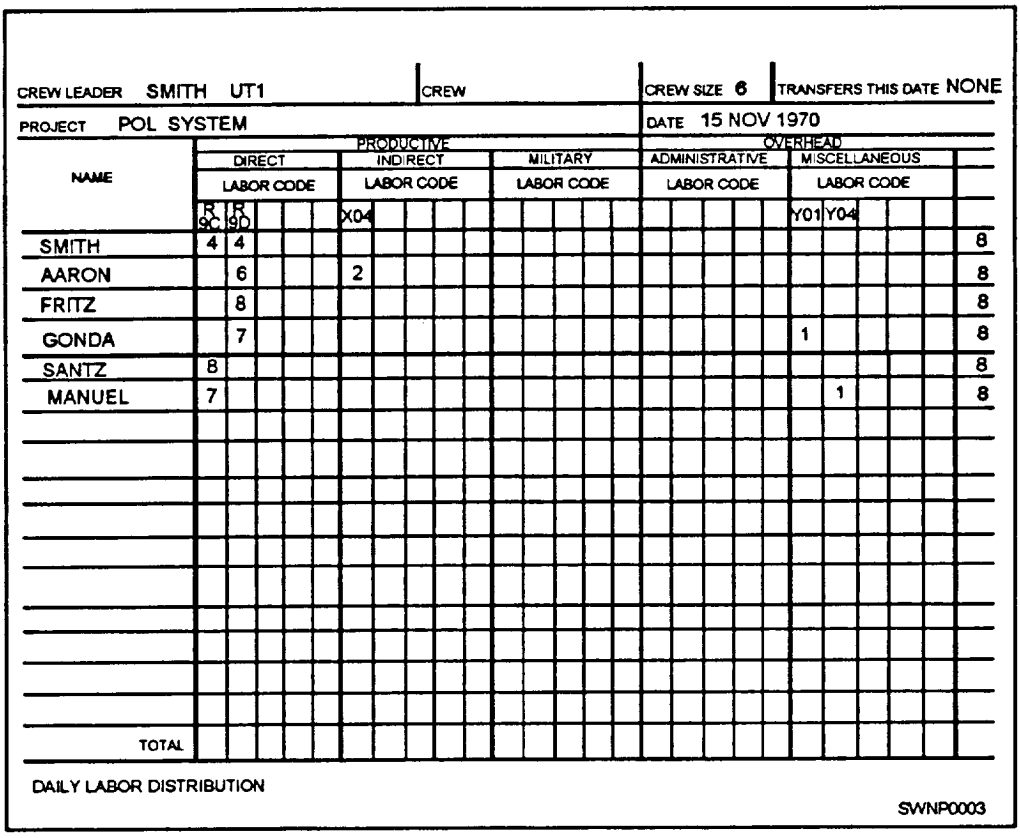
T01 Technical Training	T03 Disaster Control Training	T05 Safety Training
T02 Military Training	T04 Leadership Training	T06 Training Administration

OVERHEAD LABOR. This category includes labor which must be performed regardless of whether a mission is assigned and which does not contribute to the assigned mission. Reporting codes are as follows

Y01 Administrative & Personnel	Y06 Camp Upkeep& Repairs	Y10 personal Affairs
Y02 Medical& Dental Department	Y07 security	Y11 Lost Time
Y03 Navy Exchange and Special Semites	Y08 Leave& Liberty	Y12 TAD not for unit
Y04 Supply& Disbursing	Y09 Sickcall, Dental& Hospitalization	Y13 Other
Y05 commissary		

Figure 1-3.—Labor codes.

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CREW LEADER SMITH UT1 | CREW | CREW SIZE 6 | TRANSFERS THIS DATE NONE

PROJECT POL SYSTEM | DATE 15 NOV 1970

NAME	PRODUCTIVE: DIRECT LABOR CODE					PRODUCTIVE: INDIRECT LABOR CODE					MILITARY LABOR CODE					OVERHEAD: ADMINISTRATIVE LABOR CODE					OVERHEAD: MISCELLANEOUS LABOR CODE					
	R 9C	R 9D				X04															Y01	Y04				
SMITH	4	4																								8
AARON		6				2																				8
FRITZ		8																								8
GONDA		7																			1					8
SANTZ	8																									8
MANUEL	7																					1				8
TOTAL																										

DAILY LABOR DISTRIBUTION

SWNP0003

Figure 1-4.—Typical timekeeping card.

day on any given project. It is reviewed at the company level by the staff and platoon commander and then initialed by the company commander before it is forwarded to the operations department. It is tabulated by the management division of the operations department, along with all of the daily labor distribution reports received from each company and department in the unit. This report is the means by which the operations office analyzes the labor distribution of total manpower resources for each day. It also serves as feeder information for preparation of the monthly operations report and any other source reports required of the unit. This information must be accurate and timely. Each level in the company organization should review the report for an analysis of its own internal construction management and performance.

PERSONNEL READINESS CAPABILITY PROGRAM

The Personnel Readiness Capability Program (PRCP) was developed for use within the Naval Construction Force (NCF). The PRCP is based upon skill inventories of personnel and provides personnel information to all levels of management within the NCF. 'Ibis increases the ability of management to control, to plan, and to make decisions concerning the readiness of each unit. The PRCP is also used to identify the rating skills required and to determine the formal training and individual skills required by the Naval Facilities Engineering Command. Figure 1-5 is an example of a PRCP.

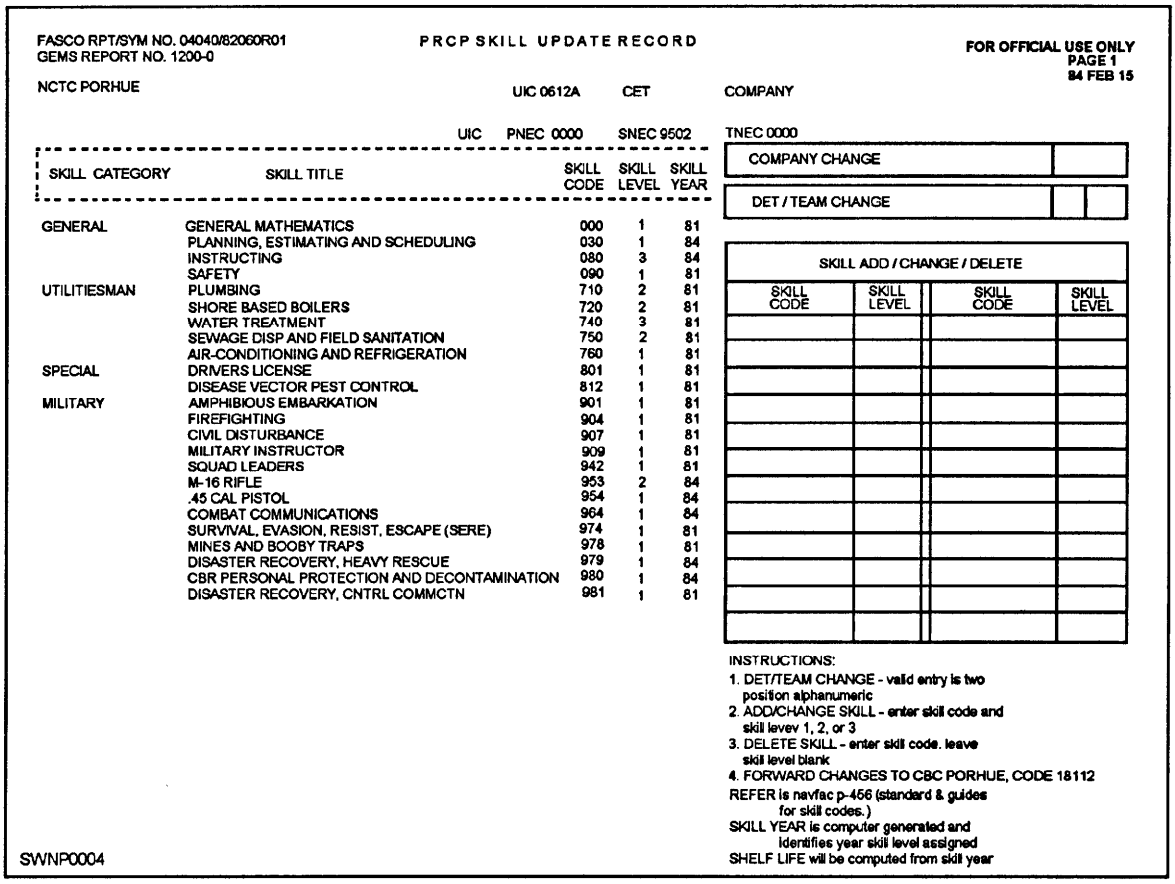
NAVFAC P-458

Guidance for the PRCP has been published in a one volume publication, NAVFAC P-458, to ease its use by staff personnel and PRCP interviewers. The PRCP contains standard skill definitions applicable to the NCF, Standards and Guides, that consist of seven separate manuals (one for each Seabee rating), and is the primary tool of the interviewer in collecting and updating data.

SKILL INVENTORIES

An accurate and current skill inventory is the backbone of PRCP. Without this information, any planning done would be questionable. The PRCP is

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FASCO RPT/SYM NO. 04040/82060R01
GEMS REPORT NO. 1200-0

PRCP SKILL UPDATE RECORD

FOR OFFICIAL USE ONLY
PAGE 1
84 FEB 15

NCTC PORHUE

UIC 0612A CET COMPANY

UIC PNEC 0000 SNEC 9502 TNEC 0000

COMPANY CHANGE

DET / TEAM CHANGE

SKILL CATEGORY	SKILL TITLE	SKILL CODE	SKILL LEVEL	SKILL YEAR
GENERAL	GENERAL MATHEMATICS	000	1	81
	PLANNING, ESTIMATING AND SCHEDULING	030	1	84
	INSTRUCTING	080	3	84
	SAFETY	090	1	81
UTILITIESMAN	PLUMBING	710	2	81
	SHORE BASED BOILERS	720	2	81
	WATER TREATMENT	740	3	81
	SEWAGE DISP AND FIELD SANITATION	750	2	81
	AIR-CONDITIONING AND REFRIGERATION	760	1	81
SPECIAL	DRIVERS LICENSE	801	1	81
	DISEASE VECTOR PEST CONTROL	812	1	81
MILITARY	AMPHIBIOUS EMBARKATION	901	1	81
	FIREFIGHTING	904	1	81
	CIVIL DISTURBANCE	907	1	81
	MILITARY INSTRUCTOR	909	1	81
	SQUAD LEADERS	942	1	81
	M-16 RIFLE	953	2	84
	.45 CAL PISTOL	954	1	84
	COMBAT COMMUNICATIONS	964	1	84
	SURVIVAL, EVASION, RESIST, ESCAPE (SERE)	974	1	81
	MINES AND BOOBY TRAPS	978	1	81
	DISASTER RECOVERY, HEAVY RESCUE	979	1	84
	CBR PERSONAL PROTECTION AND DECONTAMINATION	980	1	84
	DISASTER RECOVERY, CNTRL COMMCTN	981	1	81

SKILL ADD / CHANGE / DELETE

SKILL CODE	SKILL LEVEL	SKILL CODE	SKILL LEVEL

INSTRUCTIONS:
1. DET/TEAM CHANGE - valid entry is two position alphanumeric
2. ADD/CHANGE SKILL - enter skill code and skill levev 1, 2, or 3
3. DELETE SKILL - enter skill code. leave skill level blank
4. FORWARD CHANGES TO CBC PORHUE, CODE 18112

REFER is navfac p-456 (standard & guides for skill codes.)
SKILL YEAR is computer generated and identifies year skill level assigned
SHELF LIFE will be computed from skill year

SWNP0004

Figure 1-5.—PRCP Skills Update Record.

the management tool used to determine the readiness of the unit and identify skill deficiencies in which the troops must be trained. It is used with the requirements established by the Commander, Second Naval Construction Brigade (COMSECONDNCB), and Commander, Third Naval Construction Brigade (COMTHIRDNCB), which are issued in their joint instruction COMSECOND/COMTHIRDNCBINST 1500.1 (series). This instruction identifies and defines the skills required to meet peacetime and contingency operations and specifies the required number of personnel that must be trained in each skill.

NOTE: A "skill" is a specific art or trade. For PRCP purposes, skills are described as either a "manipulative" or "knowledge" skill.

SKILL CATEGORIES

Skills required by the PRCP have been classified into five major categories as follows:

1. **Individual General Skills** (PRCP 040-090). These are essentially nonmanipulative skills (knowledge) related to two or more ratings, such as material liaison office operation (PRCP 040), instructing (PRCP 080), and safety (PRCP 090).

2. **Individual Rating Skills** (PRCP 100-760). These are primarily manipulative skills associated with one of the seven Seabee ratings. Some examples areas follows: pipe welding (PRCP 612), for the Steelworker rating; cable splicing (PRCP 237), for the Construction Electrician rating; and shore-based boiler operation (PRCP 720), for the Utilitiesman rating.

3. **Individual Special Skills** (PRCP 800-830). These are technical skills performed by personnel in several ratings, including personnel that are not Occupational Field 13 (Seabees). Examples are as follows: forklift operation (PRCP 800), ham radio operation (PRCP 804), and typing (PRCP 803).

4. **Military Skills** (PRCP 901-981). Military skills are divided into three subcategories: mobilization, disaster recovery, and Seabee combat readiness.

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Examples are aircraft embarkation (PRCP 902), M-16 rifle use and familiarization, disaster recovery, and heavy rescue (PRCP 979).

5. **Crew Experience Skills** (PRCP 1000A-1010A). These skills are attained by working with others on specific projects. Most of these projects are related to advanced base construction, such as an observation tower (PRCP 1002A), fire fighting (PRCP 1009A), and bunker construction (PRCP 1008A).

A skill inventory has three principal steps. First, each skill is accurately defined and broken down into task elements. Second, a standard procedure for obtaining the information is developed. This procedure helps to ensure that the information, regardless of where it is collected or by whom, meets standards of acceptability. The third step is the actual collection of the skill data and includes the procedures for submitting the data to the data bank.

When you become a crew leader, it will be your responsibility to your crew members to provide them with the opportunity to learn new skills. This can be done through training or by assigning your crew to various types of work whenever possible. You and your crew members can gain a higher skill level by determining the training requirements needed and satisfying them. Then you, as the crew leader, should report these newly acquired skills to the PRCP coordinator, who will add them to your other skills and to the skills of each crew member. It is your responsibility to see that this skill information is kept current and accurate. For additional information on the PRCP program, interview techniques, and procedures, refer to the *NCF/SEABEE 1 and C,* NAVEDTRA 12543.

SAFETY PROGRAM

As a petty officer, you must be familiar with the safety program at your activity. You cannot perform effectively as a petty officer unless you are aware of the importance of the safety program. You should know who (or what group) comprises and establishes the safety policies and procedures you must follow. You should also know who provides guidelines for safety training and supervision. Every NCF/NMCB unit and shore command are required to implement a formal safety organization.

In the Seabees, everyone is responsible for safety. According to the *NCF Safety Manual,* COMSECONDNCB/COMTHIRDNCBINST 5100.1 (series), the battalion safety office administers the battalion safety program and provides technical guidance. Overall guidance comes from the *Navy Occupational Safety and Health Program Manual* (NAVOSH), OPNAVINST 5100.23 (series). If you have any questions concerning safety on the jobsite, the safety office is the place to get your questions answered.

It is not the responsibility of the safety office to prevent you from doing something you know or suspect is unsafe, but they do have the authority to stop any operation where there is impending DANGER of injury to personnel or damage to equipment or property. Safe construction is your responsibility, and ignorance is no excuse. It is your responsibility to construct safely.

SAFETY ORGANIZATION

The safety organization of the NMCB provides for (1) the establishment of safety policy and (2) control and reporting. As shown in figure 1-6, the Battalion Safety Policy Organization is made up of the policy committee, supervisors' committee, equipment, shop, and crew committees. The SAFETY POLICY COMMITTEE is presided over by the executive officer. Its primary purpose is to develop safety rules and policy for the battalion. This committee reports to the commanding officer, who must approve all changes in safety policy.

The SAFETY SUPERVISORS' COMMITTEE is presided over by the battalion's safety chief and includes safety supervisors assigned by company commanders, project officers, or officers in charge of detail. This committee provides a convenient forum for work procedures, safe practices, and safety suggestions. Its recommendations are sent to the policy committee.

The EQUIPMENT, SHOP, AND CREW COMMITTEES are assigned as required. Each

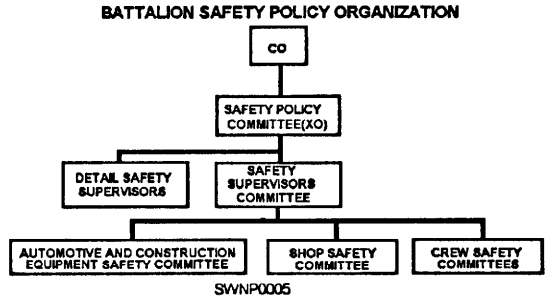


Figure 1-6.—The Safety Organization Chart of the NMCB.

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committee is usually presided over by the company or project safety supervisor. The main objective of the committee is to propose changes in the battalion's safety policy to eliminate unsafe working conditions or prevent unsafe acts. These committees are your contact for recommending changes in safety matters. In particular, the equipment committee reviews all vehicle mishap reports, determines the cause of each mishap, and recommends corrective action. As a crew leader, you can expect to seine as a member of the equipment, shop, or crew safety committee. Each committee forwards reports and recommendations to the Safety Supervisors' Committee.

CONSTRUCTION SITE SAFETY

The work involved in construction and maintenance/repair is inherently dangerous, and many of the functions that must be performed contain elements hazardous to personnel. The type of work performed on construction sites is broad and encompasses are as for which substantial material on safety has been written.

General Safety Concerns

This chapter addresses the major areas of general safety concerns and references other publications that are used by NCF/PHIBCB safety and supervisory personnel.

"Safety is everybody's responsibility." This is a rule that must be adhered to during all phases of construction, maintenance and repair, and battalion operations. Training at all levels and enforcement of safety regulations during all types of work is the ongoing responsibility of each Seabee.

Safety at the construction site has elements of general construction, steel erection, high work, and rigging and weight handling. Specialized and detailed areas of safety include weight-handling operations, construction and use of scaffolding, and welding and cutting. Numerous safety manuals and publications provide detailed procedures and regulations for these types of work.

Safety References

Some of the more useful manuals and handbooks applicable to tasks performed on construction sites and maintenance shops are as follows:

1. *Naval Construction Force Safety Manual.* This manual is applicable to COMSECONDNCB/ COMTHIRDNCB units and also covers many areas useful to PHIBCBs.
2. *General Safety Requirements Manual, Corps* of Engineers, EM 385. This field manual contains guidance primarily concerning construction.
3. *Occupational Safety and Health Standards for the Construction Industry (29 CFR 1926).*

Safety Procedures/Standards

Major safety procedures/standards that are required on a jobsite that apply to both construction sites and construction/repair of pontoon structures are as follows:

1. Hard hats must be worn by all personnel in the area, including visitors.

2. Post the site with a hard hat area sign and warning signs (red for immediate hazards and yellow for potential hazards).

3. The safety manuals, EM 385 and the 29 CFR 1926, are required to be kept on the jobsite.

4. Housekeeping is important. Keep materials well sorted, stacked, and accessible. Remove excess items. Keep discarded items and trash picked up. Watch and remove hipping hazards.

5. Designate and mark vehicle/forklift traffic lanes and areas.

6. Each jobsite must have emergency plans posted, containing the location of the nearest phone, the telephone numbers, and the reporting instructions for the ambulance, the hospital, the physician, the police, and the fire department personnel.

7. If a medical facility is not readily accessible (due to time or distance), two crew members must be both first aid and CPR qualified.

8. For every 25 personnel or less, one first-aid kit must be on site and checked weekly for consumable items.

9. If toilet facilities are not readily available, you must provide portable facilities,

10. Drinking water must be provided from an approved source and labeled for "drinking only." Common use cups are not allowed.

11. Temporary fencing is required as a safety measure to keep unauthorized personnel away from potential hazards if the jobsite is in an area of active use.

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12. Eyewash stations are required on all jobsites.

Fire Extinguishers

An adequate number of fire extinguishers are required to be on site. The number required is determined by the types of extinguisher required to extinguish the various types of materials, such as paint, corrosives, and other flammables, on the jobsite. Also, the size of the jobsite must be considered, and there must be one extinguisher at each welding station. Refer to the EM 385 for further guidance.

- Material Safety Data Sheets are required to be on site for all hazardous material. (MSDS will be discussed in this chapter.)
- All high work is serious business. Work above 5 feet in height must be particularly well planned and personnel safety constantly enforced.

Scaffolds

Accidents occur when high work becomes so routine that safety measures become lax and inspection of scaffolds is not performed. A healthy respect for the hazards must be maintained. References (1) and (3) contain detailed safety information on scaffolds, and additional safety guidance can be found in reference (2). Scaffold safety is also discussed in chapter 6 of this manual. Some of the more general precautions are the following:

- Work above 5 feet must have scaffolding provided.
- People working above 12 feet and not on scaffolding must have a safety belt and lifeline.
- Ground personnel must be kept clear of high work.
- Never use makeshift, expedient scaffolding.
- Inspect scaffold members and equipment daily before work is started. Keep all members in good repair without delay.
- Do not use scaffolds for storage space.
- Use handlines for raising and lowering objects and tools.
- Do not paint scaffolds since painting can conceal defects.

Welding and Cutting

A significant part of construction and maintenance/repair work is welding and cutting. Safety was addressed in volume 1 of this manual and is addressed here as a part of general on-site safety concerns. Safety precautions required for this work are extensive and specialized. The importance be shown by the extent of guidance on welding safety provided in references (1), (2), and (3). One point to bear in mind is that welding safety must be concerned with other personnel on the jobsite as well as the people performing the work. A list of some of the more basic precautions and procedures welders must be aware of or adhere to should include the following:

- Eye injury.
- Burns.
- Toxic vapors.
- Electric shock (when applicable).
- Fire and explosion.
- All welding equipment should be inspected daily. Remove the defective items immediately from service.
- personnel protective equipment and clothing must be considered an integral part of the work and must be inspected and maintained accordingly. No compromises in the protection of welders is allowed.
- Areas should be marked with Danger - Welding and Eye Hazard Area signs.
- Welders working above 5 feet must be protected by railings or safety belts and lifelines.
- When welding any enclosed space or pontoons, ensure that a vent opening is provided and that the space is free of flammable liquids and vapors.
- Do not weld where flammable paint or coating can cause a fire hazard.
- After welding is completed, mark the area of hot metal or provide some means of warning other workers.

SAFETY RESPONSIBILITIES

Figure 1-7 shows the Battalion Safety Control and Reporting Organization. As a crew leader, you will report to the safety supervisor, who directs the safety program of a project. Duties of the safety supervisor

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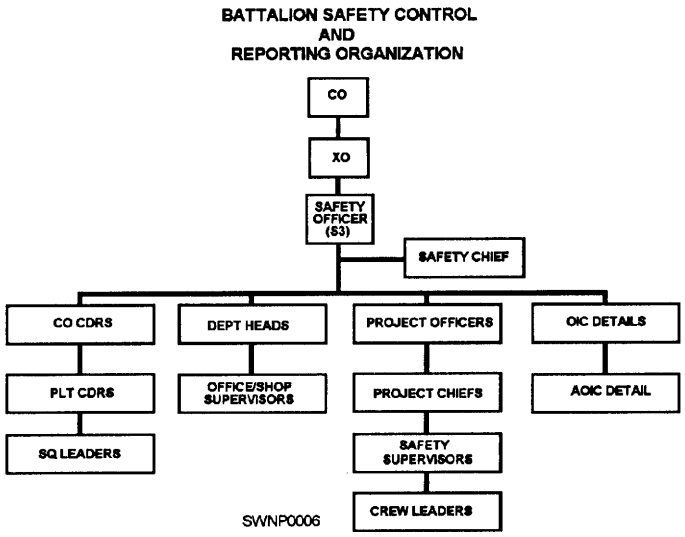


Figure 1-7.—Battalion Safety Control and Reporting Organization.

include indoctrinating new crew members, compiling mishap statistics for the project, reviewing mishap reports submitted to the safety office, and comparing safety performances of all crews.

The crew leader is responsible for carrying out safe working practices under the direction of the safety supervisor or others in position of authority (project chief, project officer, safety chief, and safety officer). You, as the crew leader, must be sure each crew member is thoroughly familiar with these working practices, has a general understanding of pertinent safety regulations, and makes proper use of protective clothing and safety equipment. Furthermore, be ready at all times to correct every unsafe working practice you observe and report it immediately to the safety supervisor or the person in charge. When an unsafe condition exists, the safety supervisor (or whoever is in charge) has the power to stop work on the project until the condition is corrected.

In case of a mishap, you must ensure that anyone injured gets proper medical care as quickly as possible. Investigate each mishap involving crew members to determine its cause. Remove or permanently correct defective tools, materials, and machines as well as environmental conditions that contribute to the cause of a mishap. Afterwards, you are required to submit the required written reports.

SAFETY TRAINING

New methods and procedures for safely maintaining and operating equipment are constantly being developed. Therefore, you must keep abreast of the latest techniques in maintenance and operational safety and then pass them onto your crew members. Keep them informed by holding daily standup safety meetings. As crew leader, you are responsible for conducting each meeting and for passing on information that the safety supervisor has organized and assembled. Information (such as the type of safety equipment to use, where to obtain it, and how to use it) is often the result of safety suggestions received by the Safety Supervisors' Committee. Encourage your crew members to submit their ideas or suggestions to this committee.

At times, you will hold a group discussion to pass the word on specific mishaps that are to be guarded against or have happened on the job. Be sure to give plenty of thought to what you are going to say beforehand. Make the discussion interesting and urge the crew to participate. The final result should be a group conclusion as to how the specific mishap could have been prevented.

Your daily standup safety meetings also give you the chance to discuss matters pertaining to safe operation and any safety items, such as riding in the back of a vehicle, prestart checks, and maintenance of automotive vehicles, assigned to a project. Since these vehicles are used for transporting crew members as well as cargo, it is important to emphasize how the prestart checks are to be made and how the vehicles are to be cared for.

In addition to standup safety meetings, you are also concerned with day-to-day instruction and on-the-job training. Although it is beyond the scope

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of this manual to describe teaching methods, a few words on your approach to safety and safety training at the crew level are appropriate. Getting your crew to work safely, like most other crew leader functions, is basically a matter of leadership. Therefore, do not overlook the power of personal example in leading and teaching your crew members. Soon you will discover that they are quick to detect differences between what you say and what you do. It is unreasonable to expect them to maintain a high standard of safe conduct if you do not. As a crew leader you must be visible at all times and show your sincere concern for the safety of your crew. Although it is not the only technique you can use, leadership by example has proven to be the most effective of those available to you.

HAZARDOUS MATERIAL

Various materials are used in shops and jobsites throughout the NCF, some of which can be hazardous. The key to the NAVOSH program is to inform the workers about these hazards and the measures necessary to control hazardous materials. To track all hazardous materials, the Department of Defense (DoD) has established the Hazardous Material Information System (HMIS), OPNAVINST 5100.23 (series), which is designed to obtain, store, and distribute data on hazardous materials procured for use. This information is readily available through every supply department.

MATERIAL SAFETY DATA SHEET

A Material Safety Data Sheet (MSDS), OSHA Form 174 or an equivalent form (fig. 1-8), shall be completed for each hazardous item procured and shall be submitted to the procuring activity by the contractor/manufacturer/vendor.

Upon drawing any hazardous material, MLO provides the crew leader with an MSDS. The MSDS identifies all hazards associated with exposure to that specific material. It also will identify any personnel protective equipment or other safety precautions required as well as first-aid/medical treatment required for exposure. The crew leader is required by federal law to inform crew members of the risks and all safety precautions associated with any hazardous material present in the shop or on the jobsite. This can be done during each daily safety lecture as the material is drawn and delivered to the jobsite/shop. All hands must be informed before the material can be used; therefore, it is a good practice to have a sign-off sheet on the actual MSDS. Additionally, the MSDS must be posted conspicuously, and all hands are aware of its location-at the jobsite, shop spaces, and any other approved hazardous material storage area.

HAZARDOUS MATERIAL CONTROL PROGRAM

The Hazardous Material Control Program is a Navy-wide program to administer the correct storage, handling, usage, and disposition of hazardous material. Steel workers are tasked with monitoring and complying with this program. Hazardous waste disposal has become a serious concern for the Naval Construction Force today. Cleaners, acids, fluxes, mastics, sealers, and *even* paints are just a few of the hazardous materials that can be present in your shop/jobsite. As a crew leader, you are responsible for the safety and protection of your crew. You are equally responsible for the protection of the environment. There are stiff fines and penalties that apply to NCF work as well as civilian work for not protecting the environment ! You are not expected to be an expert in this area. You should, however, immediately contact the environmental representative or the safety office in case of any environmental problem (spill, permits, planning, and such).

HAZARDOUS WARNING MARKINGS AND LABELS

Specific hazards can be determined at a glance by referring to warning markings and labels that identify hazardous materials. Hazardous warning markings and labels are necessary to show clearly the hazardous nature of the contents of packages or containers at all stages of storage, handling, use, and disposal. When unit packages (marked packages that are part of a larger container) are removed from shipping containers, the continuity of the specific hazard warning must be preserved. This is normally done by applying the appropriate identifying hazardous label to the hazardous material container or package.

The Department of Transportation (DOT) labeling system shown in figure 1-9 is a diamond-shaped symbol segmented into four parts. The upper three parts reflect hazards relative to health, fire, and reactivity. The lower part reflects the specific hazard that is peculiar to the material.

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Material Safety Data Sheet

May be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Standard must be consulted for specific requirements.

U.S. Department of Labor
Occupational Safety and Health Administration
(Non - Mandatory Form)
Form Approved
OMB No. 1218 - 0072

IDENTITY *(As Used on Label and List)*

Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.

Section I

Manufacturer's Name	Emergency Telephone Number
Address *(Number, Street, City, State, and Zip Code)*	Telephone Number for Information
	Date Prepared
	Signature of Preparer *(Optional)*

Section II — Hazardous Ingredients / Identity Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% *(Optional)*

Section III — Physical / Chemical Characteristics

Boiling Point		Specific Gravity ($H_2O = 1$)	
Vapor Pressure (mm Hg)		Melting Point	
Vapor Density (Air = 1)		Evaporation Rate (Butyl Acetate = 1)	

Solubility in Water

Appearance and Odor

Section IV — Fire and Explosion Hazard Data

Flash Point (Method Used)	Flammable Limits	LEL	UEL

Extinguishing Media

Special Fire Fighting Procedures

Unusual Fire and Explosion Hazards

(Reproduce Locally)

OSHA 174, Sept. 1985

SWNP0007

Figure 1-8A.—Material Safety Data Sheet (front).

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Section V — Reactivity Data

Stability	Unstable		Conditions to Avoid
	Stable		

Incompatibility *(Materials to Avoid)*

Hazardous Decomposition or Byproducts

Hazardous Polymerization	May Occur		Conditions to Avoid
	Will Not Occur		

Section VI — Health Hazard Data

Route(s) of Entry: Inhalation? Skin? Ingestion?

Health Hazards (Acute and Chronic)

Carcinoganicity: NTP? IRAC Monographs? OSHA Regulated?

Signs and Symptoms of Exposure

Medical Conditions
Generally Aggravated by Exposure

Emergency and First Aid Procedures

Section VII — Precautions for Safe Handling and Use

Steps to Be Taken In Case Material is Released or Spilled

Waste Disposal Method

Precautions to Be Taken In Handling and Storing

Other Precautions

Section VIII — Control Measures

Respiratory Protection *(Specify Type)*

Ventilation	Local Exhaust	Special
	Mechanical *(General)*	Other

Protective Gloves	Eye Protection

Other Protective Clothing or Equipment

Work/Hygienic Practices

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Figure 1-8B.—Material Safety Data Sheet (back).

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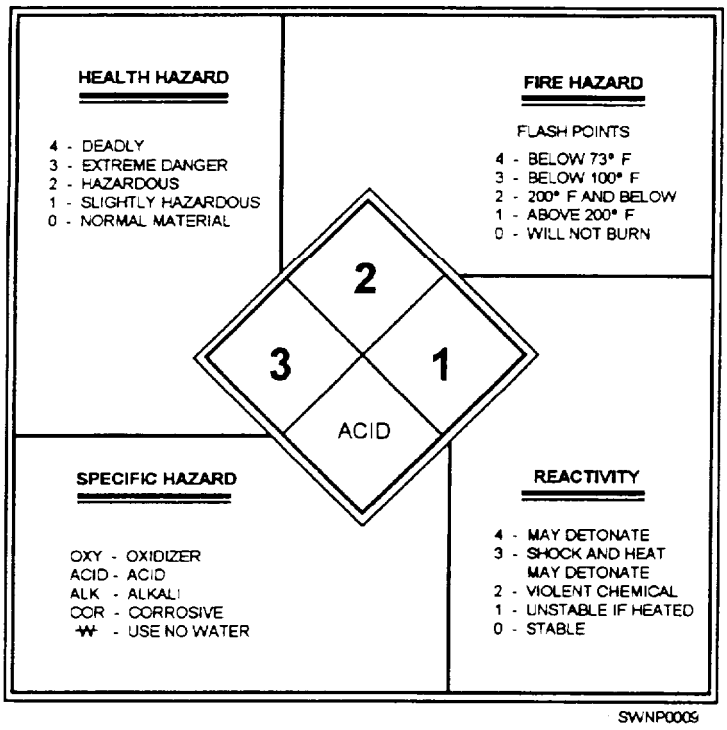


Figure 1-9.—Hazardous Code Chart.

The four specific hazards that the labels are designed to illustrate are as follows:

Health Hazard—the ability of a material to either directly or indirectly cause temporary or permanent injury or incapacitation.

Fire Hazard—the ability of a material to bum when exposed to a heat source.

Reactivity Hazard—the ability of a material to release energy when in contact with water. This term can be defined as the tendency of a material, when in its pure state or as a commercially produced product, to polymerize, decompose, condense, or otherwise become self-reactive and undergo violent chemical changes.

Specific Hazard—this term relates to a special hazard concerning the particular product or chemical that was not covered by other labeled hazard items.

The degree of hazard is expressed in numerical codes as follows:

4 = extremely dangerous material

3 = dangerous hazard

2 = moderate hazard

1 = slight hazard

0 = no hazard

The example shown in figure 1-10 describes the hazards of methyl ethyl ketone. Methyl ethyl ketone is usually found mixed with paints, oils, and greases from solvent cleaning, paint removers, adhesives, and cleaning fluid residues. The numbers on the label identify this chemical compound as follows:

- Health Hazard 2, “Hazardous”
- Fire Hazard 4, “Flash point below 73°F, extremely dangerous material”
- Reactivity 3, “Shock or heat may detonate, dangerous material”
- Specific Hazard, “None”

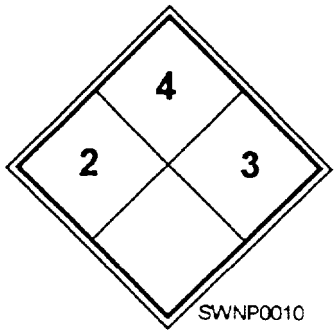


Figure 1-10.—Hazard warning lahel for methyl ethyl ketone.

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Other specific labeling requirements are provided in the NAVSUPINST5100.27 (series). All supervisors should carefully review the contents of this instruction.

HAZARDOUS MATERIAL STORAGE

The safest practice concerning hazardous material is to draw only the amount of material that can be used that day. Storing hazardous materials on the jobsite requires the use of approved storage containers. These containers must be placed a minimum of 50 feet away from any ignition device or source. Plan for the delivery of proper storage equipment before having hazardous materials delivered to the jobsite. Since many hazardous materials require separate storage containers (as an example, corrosives and flammables cannot be stored together), consult your safety office

HAZARDOUS MATERIAL TURN-IN

Any excess material must be disposed of through an authorized hazardous material disposal facility. Proper labeling of hazardous materials is critical. Properly labeled, waste can be disposed of for a relatively low price. Unidentified material must first be analyzed, which is extremely expensive. Anytime you turn-in hazardous material, an MSDS must accompany the material and ensure the MSDS is ledgeable. This will save valuable time and expense and make the job easier for supply.

Avoid mixing unlike types of waste. Do not mix waste paint thinner in a waste oil drum. The Navy sells uncontaminated waste oil for a profit. If only minor amounts of any other substance are present in the waste oil, the Navy must pay high prices for analysis and disposal. The best method for disposal is properly labeling the materials and returning them, unmixed, to the supply department. Each container must be clearly labeled, preferably with the BM line item or other supply tracking documentation. It is always best to check with the battalion MLO staff or safety office for proper disposal procedures.

PLANNING AND ESTIMATING (P&E)

Good construction planning and estimating procedures are essential for any Seabee. This section is intended to give crew leaders helpful information for planning, estimating, and scheduling construction projects. This material is designed to help you understand the concepts and principles and is NOT intended to be a reference or establish procedures. There are Special Construction Battalion Training classes (SCBT) specifically for Steelworker P&E as well as C-1 Advanced P&E school (NEC 5915) for Seabees.

NOTE: There are various techniques for planting, estimating, and scheduling. The procedures described herein are suggested methods that have been proved with use and result in effective planning and estimating.

PLANNING

Planning is the process of determining requirements and devising and developing methods and actions for constructing a project. Good construction planning is a combination of many elements: the activity, material, equipment, and manpower estimates; project layout; project location; material delivery and storage; work schedules; quality control; special tools required; environmental protection; safety; and progress control. All of these elements depend upon each other. They must all be considered in any well-planned project. Proper planning saves time and effort, making the job easier for all concerned.

ESTIMATING

Estimating is the process of determining the amount and type of work to be performed and the quantities of material, equipment, and labor required. Lists of these quantities and types of work are called estimates.

Preliminary Estimates

Preliminary estimates are made from limited information, such as the general description of projects or preliminary plans and specifications having little or no detail. Preliminary estimates are prepared to establish costs for the budget and to program general manpower requirements.

Detailed Estimates

Detailed estimates are precise statements of quantities of material, equipment, and manpower required to construct a given project. Underestimating quantities can cause serious delays in construction and even result in unfinished projects. A detailed estimate must be accurate to the smallest detail to quantify requirements correctly.

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Activity Estimates

An activity estimate is a listing of all the steps required to construct a given project, including specific descriptions as to the limits of each clearly definable quantity of work (activity). Activity quantities provide the basis for preparing the material, equipment, and manpower estimates. They are used to provide the basis for scheduling material deliveries, equipment, and manpower. Because activity estimates are used to prepare other estimates and schedules, errors in these estimates can multiply many times. Be careful in their preparation!

Material Estimates

A material estimate consists of a listing and description of the various materials and the quantities required to construct a given project. Information for preparing material estimates is obtained from the activity estimates, drawings, and specifications. A material estimate is sometimes referred to as a Bill of Material (BM) or a Material Takeoff (MTO) Sheet.

Equipment Estimates

Equipment estimates are listings of the various types of equipment, the amount of time, and the number of pieces of equipment required to construct a given project. Information, such as that obtained from activity estimates, drawings, specifications, and an inspection of the site, provides the basis for preparing the equipment estimates.

Manpower Estimates

The manpower estimate consists of a listing of the number of direct labor man-days required to complete the various activities of a specific project. These estimates will show only the man-days for each activity, or they can be in sufficient detail to list the number of man-days for each rating in each activity—Builder (BU), Construction Electrician (CE), Equipment Operator (EO), Steelworker (SW), and Utilitiesman (UT). Man-day estimates are used in determining the number of personnel and the ratings required on a deployment. They also provide the basis for scheduling manpower in relation to construction progress.

When the *Seabee Planner's and Estimator's Handbook,* NAVFAC P-405, is used, a man-day is a unit of work performed by one person in one 8-hour day or its equivalent. One man-day is equivalent to a 10-hour day when the *Facilities Planning Guide,* NAVFAC P-437, is used.

Battalions set their own schedules, as needed, to complete their assigned tasks. In general, the work schedule of the battalion is based on an average of 55 hours per man per week. The duration of the workday is 10 hours per day, which starts and ends at the jobsite. This includes 9 hours for direct labor and 1 hour for lunch.

Direct labor ("Timekeeping" as previously discussed) includes all labor expended directly on assigned construction tasks, either in the field or in the shop, that contributes directly to the completion of the end product. Direct labor must be reported separately for each assigned construction item. In addition to direct labor, the estimator must also consider overhead labor and indirect labor. Overhead labor is considered productive labor that does not contribute directly or indirectly to the product. It includes all labor that must be performed regardless of the assigned mission. Indirect labor includes labor required to support construction operations but does not, in itself, produce an end product.

SCHEDULING

Scheduling is the process of determining when an action must be taken and when material, equipment, and manpower are required. There are four basic types of schedules: progress, material, equipment, and manpower.

Progress schedules coordinate all the projects of a Seabee deployment or all the activities of a single project. They show the sequence, the starting time, the performance time required, and the time required for completion.

Material schedules show when the material is needed on the job. They can also show the sequence in which materials should be delivered.

Equipment schedules coordinate all the equipment to be used on a project. They also show when it is to be used and the amount of time each piece of equipment is required to perform the work.

Manpower schedules coordinate the manpower requirements of a project and show the number of personnel required for each activity. In addition, the number of personnel of each rating (Steelworker, Builder, Construction Electrician, Equipment Operator, and Utilitiesman) required for each activity for each period of time can be shown. The time unit

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shown in a schedule should be some convenient interval, such as a day, a week, or a month.

NETWORK ANALYSIS

In the late 1950s, a new system of project planning, scheduling, and control came into widespread use in the construction industry. The critical path analysis (CPA), critical path method (CPM), and project evaluation and review technique (PERT) are three examples of about 50 different approaches. The basis for each of these approaches is the analysis of a network of events and activities. The generic title of the various networks is network analysis.

The network analysis approach is now the accepted method of construction planning in many organizations. Network analysis forms the core of project planning and control systems and is accomplished by completing the following steps:

1. **Develop construction activities.** After careful review of the plans and specifications (specs), your first step is to break the job down into discreet activities. Construction activities are generally less than 15 days in duration and require the same resources throughout the entire duration.

2. **Estimate construction activity requirements.** Evaluate the resource requirements for each construction activity. Identify and list all of the materials, tools, equipment (including safety-related items), and manpower requirements on the Construction Activity Summary (CASS) Sheet.

3. **Develop logic network.** List the construction activities logical] y from the first activity to the last, showing relationships or dependencies between activities.

4. **Schedule construction activities.** Determine an estimated start and finish date for each activity based on the sequence and durations of construction activities. Identify the critical path. This will help focus attention of management on those activities that cannot be delayed without delaying the project completion date.

5. **Track resources.** As the crew leader, you must be sure the necessary resources are available on the project site on the day the work is to be performed. For materials on site, this will be as easy as submitting a material request, NAVSUP Form 1250-1, to the material liaison office (MLO) several days in advance. For local purchase requirements, such as a concrete request to MLO, a request can be required 2 to 3 weeks in advance.

6. **Control resources.** As the crew leader, you are also responsible for on-site supervision of all work performed. Productive employment of available resources to accomplish assigned tasking is your greatest challenge.

PROGRESS CONTROL

Progress control is the comparing of actual progress with scheduled progress and the steps necessary to correct deficiencies or to balance activities to meet overall objectives.

CONSTRUCTION DRAWINGS

In planning any project, you must be familiar with construction drawings and specifications. The construction of any structure or facility is described by a set of related drawings that gives the Seabees a complete sequential graphic description of each phase of the construction process. In most cases, a set of drawings shows the location of the project, boundaries, contours, and outstanding physical features of the construction site and its adjoining areas. Succeeding drawings give further graphic and printed instructions for each phase of construction.

TYPES OF CONSTRUCTION DRAWINGS

Drawings are generally categorized according to their intended purposes. Some of the types commonly used in military construction are discussed in this section.

Master Plan Drawings

MASTER PLAN DRAWINGS are commonly used in the architectural, topographical, and construction fields. The y show sufficient features to be used as guides in long-range area development. They usually contain section boundary lines, horizontal and vertical control data, acreage, locations and descriptions of existing and proposed structures, existing and proposed surfaced and unsurfaced roads and sidewalks, streams, right-of-way, existing utilities, north point indicator (arrow), contour lines, and profiles. Master plan and general development drawings on existing and proposed Navy installations are maintained and constantly upgraded by the

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resident officer in charge of construction (ROICC) and by the Public Works Department (PWD).

Shop Drawings

SHOP DRAWINGS are drawings, schedules, diagrams, and other related data to illustrate a material, a product, or a system for some portion of the work prepared by the construction contractor, subcontractor, manufacturer, distributor, or supplier. Product data include brochures, illustrations, performance charts, and other information by which the work will be judged. As an SW, you will be required to draft shop drawings for minor shop and field projects. You can draw shop items, such as doors, cabinets, and small portable structures (prefabricated berthing quarters, and modifications of existing buildings), or perhaps you will be drawing from portions of design drawings, specifications, or from freehand sketches given by the design engineer.

Working Drawings

A WORKING DRAWING (also called project drawing) is any drawing that furnishes the information required by a Steelworker to manufacture a part or a crew to erect a structure. It is prepared from a freehand sketch or a design drawing. Complete information is presented in a set of working drawings, complete enough that the user will require no further information. Project drawings include all the drawings necessary for the different Seabee ratings to complete the project. These are the drawings that show the size, quantity, location, and relationship of the building components.

A complete set of project drawings consists of general drawings, detail drawings, and assembly drawings. General drawings consist of "plans" (views from above) and "elevations" (side or front views) drawn on a relatively small defined scale, such as 1/8 inch = 1 foot. Most of the general drawings are drawn in orthographic projections, although sometimes details can be shown in isometric projections. Detail drawings show a particular item on a larger scale than that of the general drawing in which the item appears, or it can show an item too small to appear at all on a general drawing. Assembly drawings are either an exterior or a sectional view of an object showing the details in the proper relationship to one another. Usually, assembly drawings are drawn to a smaller scale than are detail drawings. This procedure provides a check on the accuracy of the design and detail drawings and often discloses errors.

Red-lined Drawings

RED-LINED DRAWINGS are the official contract drawings that you will mark up during construction to show as-built conditions. Red-lined drawings are marked in color "red" to indicate either a minor design change or a field adjustment.

As-built Drawings

AS-BUILT DRAWINGS are the original contract drawings (or sepia copies) that you will change to show the as-built conditions from the red-lined drawings. Upon the completion of the facilities, the construction contractor or the Naval Military Construction Force (NMCB) is required to provide the ROICC with as-built drawings, indicating construction deviations from the contract drawings. All of the as-built marked-up prints must reflect exact as-built conditions and must show all features of the project as constructed. After the completion of the project, as-built marked-up prints are transmitted by the ROICC to the engineering field division (EFD).

ORDER OF PROJECT DRAWINGS

Project drawings for buildings and structures are arranged in the following order:

1. TITLE SHEET AND INDEX—Contain specific project title and an index of drawings. (Used only for projects containing 60 or more drawings.)
2. SITE or PLOT PLANS-Contain either site or plot plans or both, as well as civil and utility plans. For small projects, this sheet should include an index of the drawings.
3. LANDSCAPE AND IRRIGATION (if applicable).
4. ARCHITECTURAL (including interior design as applicable).
5. STRUCTURAL.
6. MECHANICAL (heating, ventilation, and air conditioning).
7. PLUMBING.
8. ELECTRICAL.
9. FIRE PROTECTION.

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Title Blocks

The title block identifies each sheet in a set of drawings. (See fig. 1-11.) Generally, the title block is located at the bottom right comer of the drawing regardless of the size of the drawing (except for vertical title block). For further information on the layout of title blocks, refer to the *Engineering Aid 3.*

The information provided in the title block is important information that a Steelworker MUST understand. The information includes the following:

- Architect's name
- Architect's seal
- Drawing title
- Date prepared
- Revisions
- Designed by
- Checked by
- Drawing numbers
- Name of local activity
- Code ID number (80091 NAVFAC)
- Letter designation
- Size of drawing
- Scale of drawing
- ABFC drawing number (if applicable)
- Approved by

There are many variations to title blocks. Depending on the preparing activity (NAVFAC, NCR, NMCB, etc.), all title blocks should contain the same information listed above.

Drawing Revisions

A Revision block contains a list of revisions made to a drawing. The Revision block is located in the upper right-hand corner. The Revision block can include a separate "PREPARED BY" column to indicate the organization, such as an architectural engineering firm, that prepared the revision. Like title blocks, revision blocks can vary in format with each command.

Graphic Scales

Graphic scales are located in the lower right-hand comer of each drawing sheet, with the words *Graphic Scales* directly over them. The correct graphic scales must be shown prominent y on each drawing because, as drawings are reduced in size, the reductions are often NOT to scaled proportions. Remember, scaling a drawing should be done as a "last resort."

Drawing Notes

NOTES are brief, clear, and explicit statements regarding material use and finish and construction methods. Notes in a construction drawing are classified as specific and general.

SPECIFIC notes are used either to reflect dimensional information on the drawing or to be explanatory. As a means of saving space, many of the terms used in this type of note are often expressed as abbreviations.

GENERAL notes refer to all of the notes on the drawing not accompanied by a leader and an arrowhead. As used in this book, general notes for a set of drawings covering one particular type of work are placed on the first sheet of the set. They should be



Figure 1-11.—Title block.

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placed a minimum of 3 inches below the space provided for the revision block when the conventional horizontal title block is used. When the vertical title block is used, you can place the general notes on the right side of the drawing. General notes for architectural and structural drawings can include, when applicable, roof, floor, wind, seismic, and other loads, allowable soil pressure or pile-bearing capacity, and allowable unit stresses of all the construction materials used in the design. Notes for civil, mechanical, electrical, sanitary, plumbing, and **similar** drawings of a set can include, when applicable, references for vertical and horizontal control (including soundings) and basic specific design data.

General notes can also refer to all of the notes grouped according to materials of construction in a tabular form, called a SCHEDULE. Schedules for items, like doors, windows, rooms, and footings, are somewhat more detailed. Their formats will be presented later in this chapter.

MAJOR CATEGORIES OF PROJECT DRAWINGS

Generally, working or project drawings can be divided into the following major categories: civil, architectural, structural, mechanical, electrical, and fire protection. In Seabee construction, however, the major categories most commonly used are as follows: CIVIL, ARCHITECTURAL, STRUCNTURAL, MECHANICAL, and ELECTRICAL sets of drawings.

Regardless of the category, working drawings serve the following functions:

- They provide a basis for making material, labor, and equipment estimates before construction begins.
- They give instructions for construction, showing the sizes and locations of the various parts.
- They provide a means of coordination between the different ratings.
- They complement the specifications; one source of information is incomplete without the others.
- Civil working drawings encompass a variety of plans and information to include the following:
- Site preparation and site development
- Fe ricing
- Rigid and flexible pavements for roads and walkways
- Environmental pollution control
- Water supply units (that is, pumps and wells)

Depending on the size of the construction project, the number of sheets in a set of civil drawings can vary from a bare minimum to several sheets of related drawings. Generally, on an average-size project, the first sheet has a location map, soil boring log, legends, and it sometimes has site plans and small civil detail drawings. (Soil boring tests are conducted to determine the water table of the construction site and classify the existing soil.) Civil drawings are often identified with the designating letter C on their title blocks.

SITE PLANS

A SITE PLAN furnishes the essential data for laying out the proposed building lines. It is drawn from notes and sketches based upon a survey. It shows the contours, boundaries, roads, utilities, trees, structures, references, and other significant physical features on or near the construction site. The field crews (Equipment Operators) are able to estimate and prepare the site for conduction and to finish the site (including landscaping) upon completion of construction by showing both existing and finished contours. As an SW, you should be familiar with the methods and the symbols used on maps and topographic drawings.

Site plans are drawn to scale. In most instances, the engineer's scale is used, rather than the architect's scale. For buildings on small lots, the scales normally used are 1 inch = 10 feet.

PROJECT FOLDERS

The intent of this section is to acquaint you with the basic concepts and principles of project management and is NOT intended to be a reference but also to make you familiar with the contents of a project folder.

The project folder, or package, consists of nine individual project files. These files represent the project in paper format-a type of project history from start to finish.

File No. 1-General Information File

File No. 1 is the General Information File and contains the following information:

LEFT SIDE—The left side of the General Information File basically contains information

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authorizing the project. The file should have the following items:

- Project scope sheet.
- Tasking letter (fig. 1-12).
- Project planning checklist.
- Project package sign-off sheet.

RIGHT SIDE—The right side of the General Information File contains basic information relating to coordinating the project. The file should have the following items:

- Project organization.
- Deployment calendar.
- Preconstruction conference notes.
- Predeployment visit summary.

File No. 2—Correspondence File

File No. 2 is the Correspondence File and consists of the following items:

LEFT SIDE—The left side contains outgoing messages and correspondence.

RIGHT SIDE-The right side of the file contains incoming messages and correspondence.

Date: _____

MEMORANDUM

From: Operations Officer
To:

Subj: PROJECT _____

1. _____ Company is tasked as the prime contractor for the subject project. Project planning and estimating should be accomplished by the crew leader and/or project crew, in accordance with current battalion procedures. Plans, specs, and master activity description (if applicable) are available from S3QC.

2. The CBPAC manday estimate for NMCB-74's tasking is _____

3. Project scope:

4. The folowing dates are established as milestones to be met for your project planning:

ITEM	DUE DATES
Familiarization with project	
Establish Detail Activities	
Complete Front of cas Sheets	
Prepare MTO	
Finalize Mini Computer Input	
Prepare Level II	
Safety Plan	
Quality Control Plan	
Final Package Review	

5. Sub-contractor (s) for the subject project is/are _____

6. Regress will be monitored by S3 at short informal meetings. Contact S3 or S3A, if you have any questions.

copy to:

Figure 1-12.—Project tasking letter.

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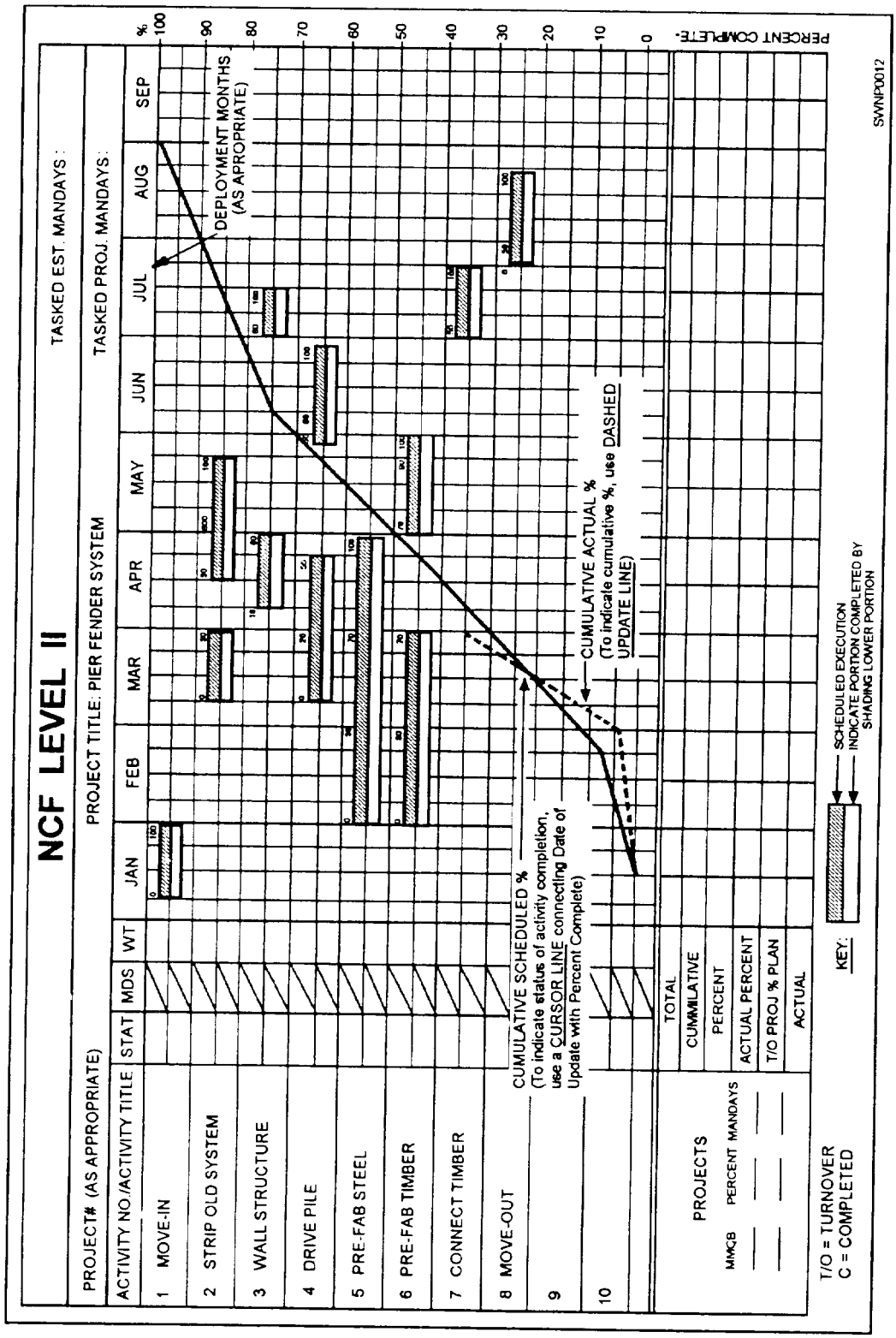


Figure 1-13.—Level II.

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File No. 3—Activity File

File No. 3, the Activity File, contains the following information:

LEFT SIDE—The left side contains the Construction Activity Summary Sheets of completed activities.

RIGHT SIDE-The right side of the file contains the following form sheets:

- Master Activity Sheets.
- Level II. A general schedule for each project prepared for the operations officer by the company. It contains a general schedule for each project and contains all of the major work elements and a schedule for each prime contractor or project manager based upon major work (fig. 1-13).
- Level II Precedence Diagram.
- Master Activity Summary Sheets (fig. 1-14).
- Construction Activity Summary Sheets (fig. 1-15).

File No. 4—Network File

File No. 4 is the Network File. It contains the following information:

LEFT SIDE—The left side contains the following documents:

- Computer printouts.
- Level III is a detailed schedule fore each project, developed by the company selected as prime contractor and assisted by the companies selected as subcontractor. The Level III not only serves as stool in which the prime contractor and subcontractor manage their projects but it also provides important data, enabling the operations officer to redistribute or reschedule assignments and to arrange for extra personnel, equipment, or special training required for the task. Level III shows such details as crew sizes, material delivery dates, and periods where special tools/equipment will be required on the project.
- Level III Precedence Diagram.

RIGHT SIDE—The right side of the Network File contains the following items:

- Resource leveled plan for manpower and equipment.
- Equipment requirement summary.

File No. 5—Material File

File No. 5 is the Material File. It contains the following information:

LEFT SIDE—The left side contains the work sheets that you, as a project planner, must assemble. THe list includes the following items:

- List of long lead items (fig. 1-16).
- 45-day material list.
- Material transfer list.
- Add-on/reorder justification forms.
- Bill of Material/Material Takeoff Comparison Work Sheet (fig. 1-17).
- Material Takeoff Work Sheet (fig. 1-18).

RIGHT SIDE—The right side of the Material File contains the Bill of Material (including all add-on/reorder BMs) supplied by the Naval Construction Regiment.

File No. 6—Quality Control File

File No. 6, the Quality Control File, contains the following information:

LEFT SIDE-The left side of this file contains various quality control forms and the field adjustment request.

RIGHT SIDE—The right side of the Quality Control File contains the daily quality control inspection report and the quality control plan.

File No. 7—Safety/Environmental File

File No. 7 is the Safety/Environmental File and consists of the following information:

LEFT SIDE—The left side of the Safety/ Environmental File contains the following items:

- Required safety equipment.
- Standup safety lectures.
- Safety reports.
- Accident reports.

RIGHT SIDE—The right side of the Safety/ Environmental File contains the following:

- Safety plan, which you must develop.
- Highlighted EM 385.
- Environmental plan (if applicable).

File No. 8—Plans File

File No. 8 is the Plans File and contains the following information:

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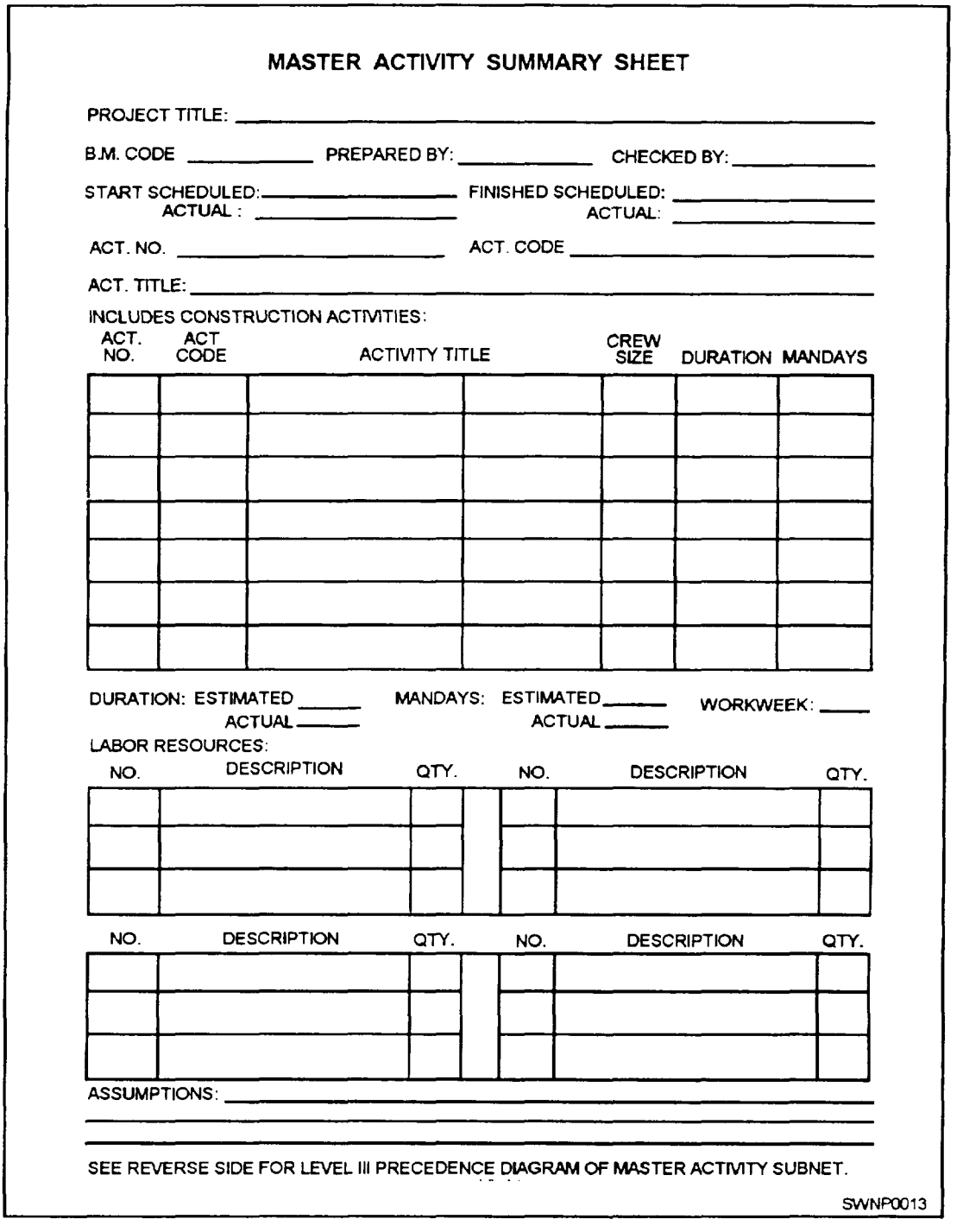


Figure 1-14.—Master Activity Summary Sheet.

LEFT SIDE—The left side contains the following planning documents:

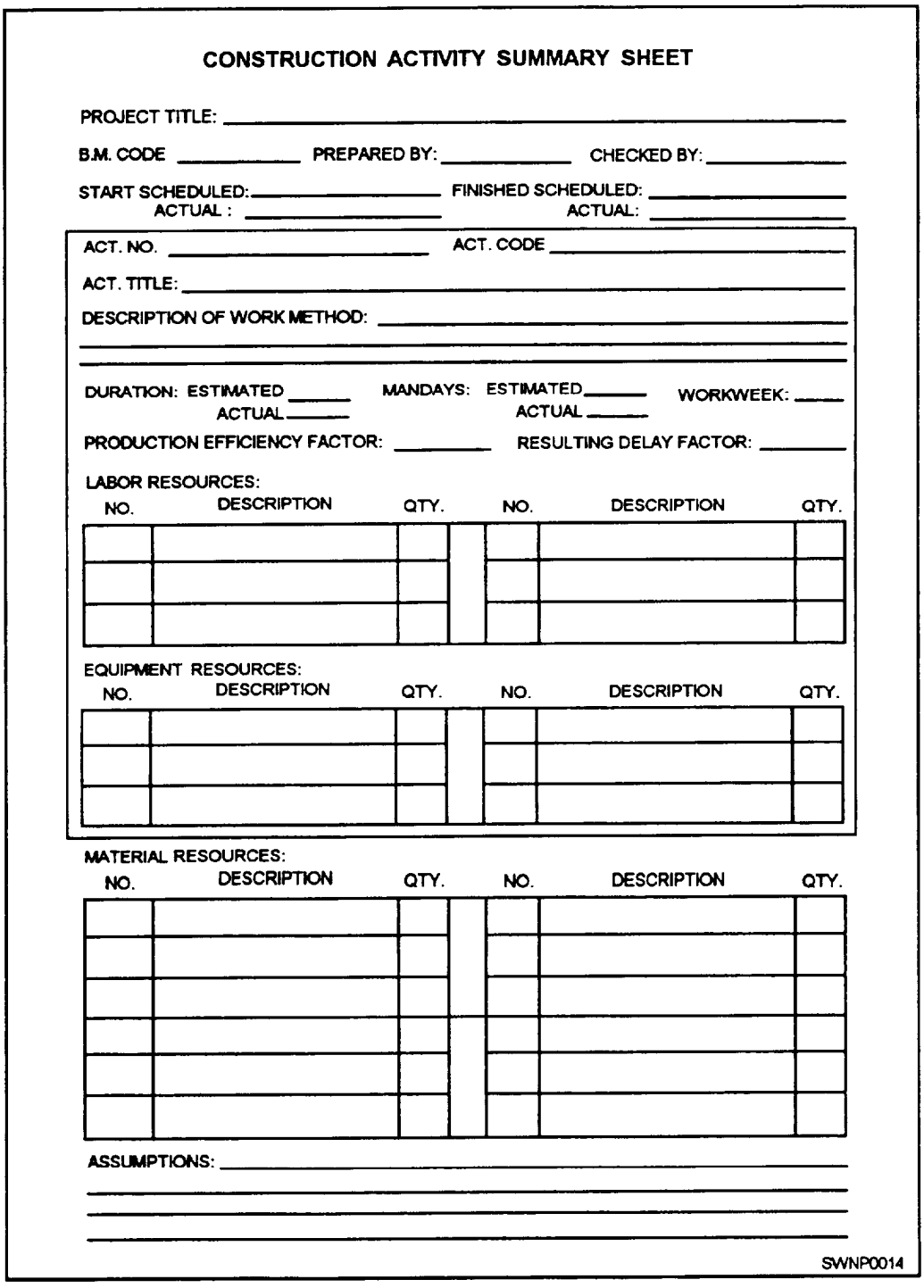
- Site layout.
- Shop drawings.
- Detailed slab layout drawings (if applicable).
- Rebar bending schedule.

RIGHT SIDE—The right side of the Plans File contains the actual project plans. Depending on thickness, plans should be either rolled or folded.

File No. 9—Specifications File

File No. 9 is the Specifications File; it contains the following information:

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CONSTRUCTION ACTIVITY SUMMARY SHEET

PROJECT TITLE: _____

B.M. CODE _____ PREPARED BY: _____ CHECKED BY: _____

START SCHEDULED: _____ FINISHED SCHEDULED: _____
ACTUAL : _____ ACTUAL: _____

ACT. NO. _____ ACT. CODE _____

ACT. TITLE: _____

DESCRIPTION OF WORK METHOD: _____

DURATION: ESTIMATED _____ MANDAYS: ESTIMATED _____ WORKWEEK: _____
ACTUAL _____ ACTUAL _____

PRODUCTION EFFICIENCY FACTOR: _____ RESULTING DELAY FACTOR: _____

LABOR RESOURCES:

NO.	DESCRIPTION	QTY.	NO.	DESCRIPTION	QTY.

EQUIPMENT RESOURCES:

NO.	DESCRIPTION	QTY.	NO.	DESCRIPTION	QTY.

MATERIAL RESOURCES:

NO.	DESCRIPTION	QTY.	NO.	DESCRIPTION	QTY.

ASSUMPTIONS: _____

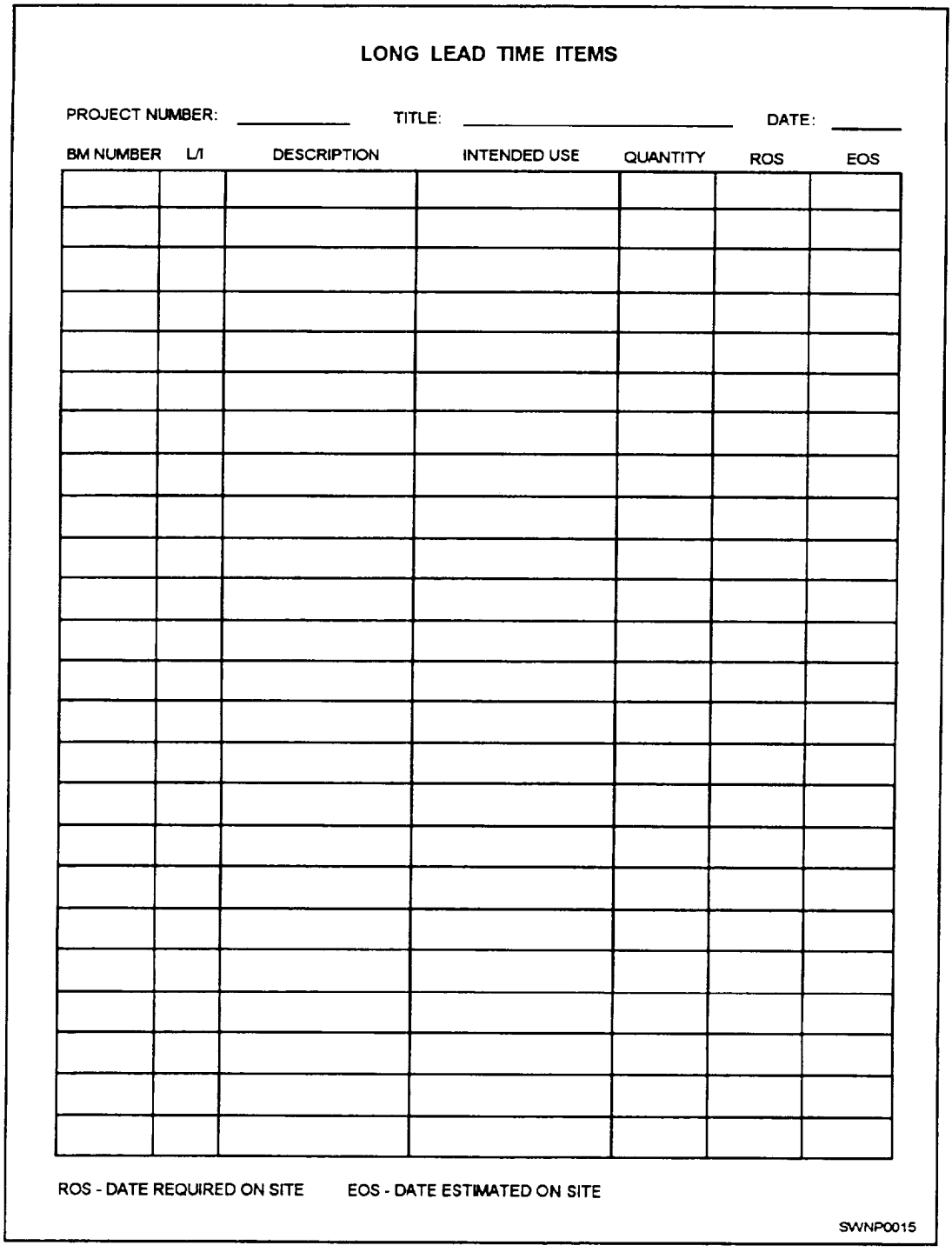
SWNP0014

Figure 1-15.—Construction Activity Summary Sheet

LEFT SIDE—The left side of this File is reserved for technical data.

RIGHT SIDE—The right side of the Specifications File has highlighted project specifications.

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LONG LEAD TIME ITEMS

PROJECT NUMBER: _____ TITLE: _____ DATE: _____

BM NUMBER	L/I	DESCRIPTION	INTENDED USE	QUANTITY	ROS	EOS

ROS - DATE REQUIRED ON SITE EOS - DATE ESTIMATED ON SITE

SWNP0015

Figure 1-16.—Long Lead Time Item Work Sheet.

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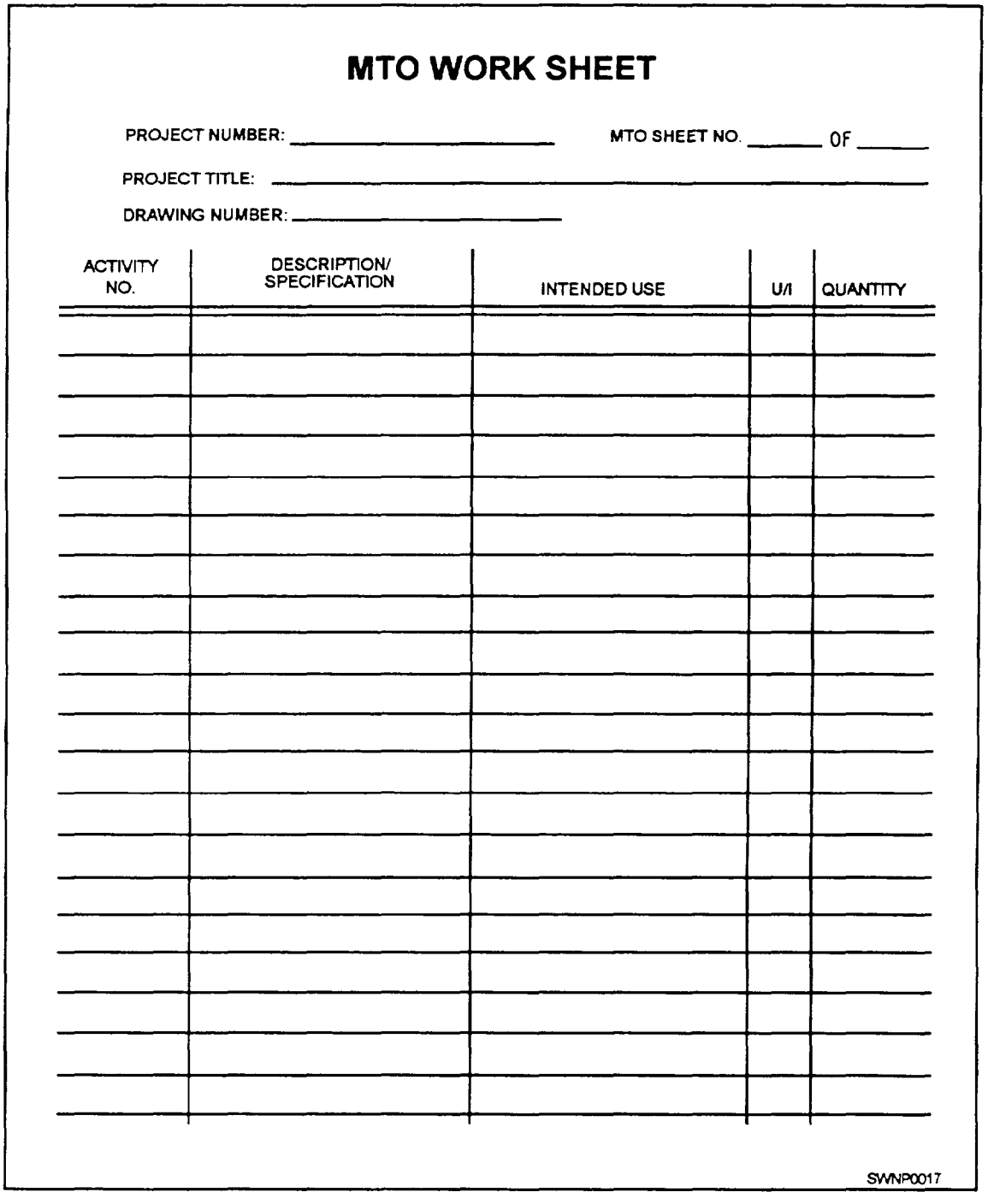
BM/MTO COMPARISON WORK SHEET

ACTIVITY NO.	MATL DESCRIPTION	U/I	BM & LI NO.	BM QTY	MTO QTY	DIFF	REMARKS

SWNP0016

Figure 1-17.—Bill of Material/Material Takeoff Comparison Work Sheet.

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MTO WORK SHEET

PROJECT NUMBER: _____ MTO SHEET NO. _____ OF _____

PROJECT TITLE: _____

DRAWING NUMBER: _____

ACTIVITY NO.	DESCRIPTION/ SPECIFICATION	INTENDED USE	U/I	QUANTITY

SWNP0017

Figure 1-18.—Material Takeoff Work Sheet.

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CHAPTER 2

LAYOUT AND FABRICATION OF SHEET-METAL AND FIBER-GLASS DUCT

As a Steelworker you are required to operate sheet-metal tools and to apply basic sheet-metal layout techniques. In many Naval Construction Force (NCF) projects, sheet metal is used to protect the exterior of buildings by using flashing, gutters, and at times, complete sheet-metal roofing systems. Other items made from sheet metal are dust collection systems, machinery guards, lockers, and shelving.

Although many of the parts and fittings used in sheet-metal work are stock items, which are simply installed or assembled, Steelworkers are required to fabricate parts and fittings frequently in the shop or to modify them to fit irregularities in the project design. Therefore, you must have knowledge not only in laying out patterns but also have the skills required to cut, bend, shape, assemble, and install the finished sheet-metal products. This chapter describes some of the methods of measuring, marking, cutting, forming, and joining as well as installing sheet-metal sections, duct systems, and fiber-glass ducts. In addition, the use of various hand tools and power tools required in sheet-metal layout and fabrication is provided.

SHEET-METAL LAYOUT AND CUTTING TOOLS AND EQUIPMENT

Numerous types of layout tools, cutting tools, and forming equipment are used when working with sheet metal. This section will describe the uses of the layout and cutting tools and the operation of the forming equipment.

LAYOUT TOOLS

The LAYOUT of metal is the procedure of measuring and marking material for cutting, drilling, or welding. Accuracy is essential in layout work. Using erroneous measurements results in a part being fabricated that does not fit the overall job. This is a waste of both time and material. In most cases, you should use shop drawings, sketches, and blueprints to obtain the measurements required to fabricate the job being laid out. Your ability to read and work from blueprints and sketches is paramount in layout work. If you require information on blueprints, you will find chapters 1-3 and 8 of *Blueprint Reading and Sketching*, NAVEDTRA 10077-F1, an excellent reference.

Layout tools are used for laying out fabrication jobs on metal. Some of the more common layout tools that you will use in performing layout duties are as follows: scriber, flat steel square, combination square, protractor, prick punch, dividers, trammel points, and circumference rule.

Scriber

Lines are scribed on sheet metal with a SCRATCH AWL, coupled with a STEEL SCALE or a STRAIGHTEDGE. To obtain the best results in scribing, hold the scale or straightedge firmly in place, and set the point of the scriber as close to the edge of the scale as possible by tilting the scriber outward. Then exert pressure on the point and draw the line, tilting the tool slightly in the direction of movement (fig. 2-1). For short lines, use the steel scale as a guide. For longer lines, use a circumference rule or a straightedge. When you have to draw a line between two points, prick punch each point. Start from one prick punch mark and scribe toward the center.

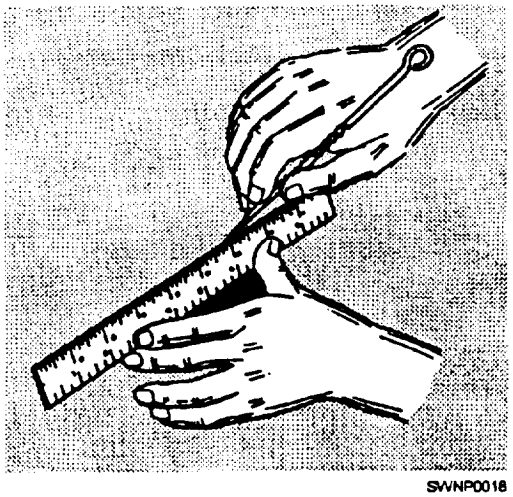


Figure 2-1—Scribing a line.

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Complete the line by scribing from the other prick punch mark in the opposite direction.

Flat Steel Square

The FLAT STEEL SQUARE is a desirable tool for constructing perpendicular or parallel lines. In the method of layout, known as parallel line development, the flat steel square is used to construct lines that are parallel to each other as well as perpendicular to the base line. This procedure is shown in figure 2-2. Simply clamp the straightedge firmly to the base line. Slide the body of the square along the straightedge, and then draw perpendicular lines through the desired points.

Before using the flat steel square or at least at periodic intervals, depending on usage, see that you check it for accuracy, as shown in figure 2-3. When the square is off, your work will be off correspondingly no matter how careful you are.

Combination Square

The COMBINATION SQUARE can be used to draw a similar set of lines, as shown in figure 2-4. An edge of the metal upon which you are working is used as the base line, as shown in the figure. One edge of the head of the combination square is 90 degrees and the other edge is 45 degrees. Combination squares are

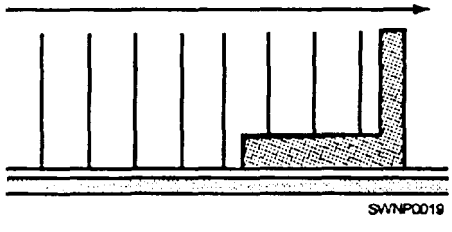


Figure 2-2.—Using a swuare to cinstruct perpendicular and parallel lines.

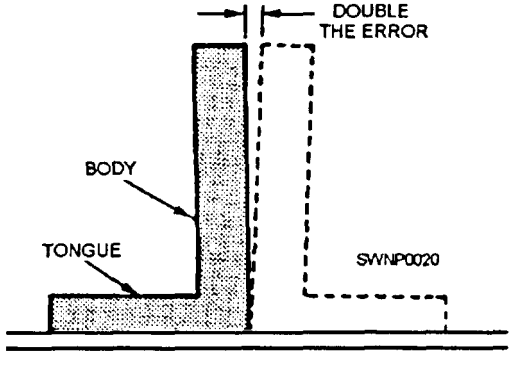


Figure 2-3.—Checking a square for accuracy.

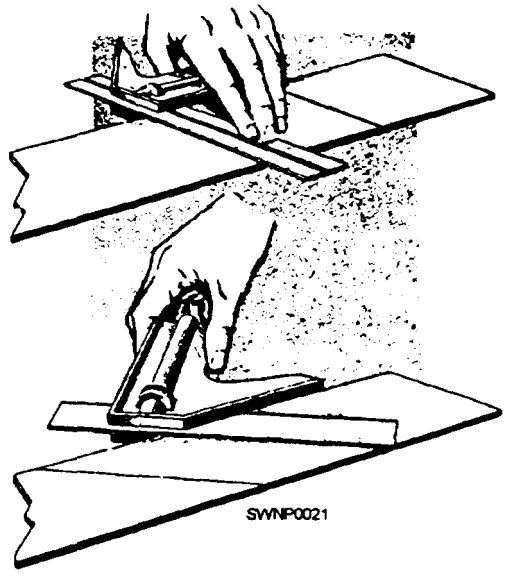


Figure 2-4.—Using the combination square

delicate instruments and are of little value if you handle them roughly. Store your squares properly when you have finished using them. Keep them clean and in tiptop shape, and you will be able to construct 90-degree angles, 45-degree angles, and parallel lines without error.

Protractor

To construct angles other than 45 degrees or 90 degrees, you will need a PROTRACTOR. Mark the vertex of the angle of your base line with a prick punch. Set the vertex of your protractor on the mark and then scribe a V at the desired angle (assume 700). Scribe the line between the vertex and the point located by the V, and you have constructed an angle of 70 degrees.

Prick Punch

When you locate a point and mark it with the PRICK PUNCH, be sure to use alight tap with a small ball peen hammer, ensuring it is on the precise spot intended to mark. The smaller the mark you make (so long as it is visible), the more accurate that mark becomes.

Dividers

You should use DIVIDERS to scribe arcs and circles, to transfer measurements from a scale to your layout, and to transfer measurements from one part of the layout to another. Careful setting of the dividers is of utmost importance. When you transfer a

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measurement from a scale to the work, set one point of the dividers on the mark and carefully adjust the other leg to the required length, as shown in figure 2-5.

To scribe a circle, or an arc, grasp the dividers between the fingers and the thumb, as shown in figure 2-6. Place the point of one leg on the center, and swing the arc. Exert enough pressure to hold the point on center, slightly inclining the dividers in the direction in which they are being rotated.

TrammelPoints

To scribe a circle with a radius larger than your dividers, you should select TRAMMEL POINTS. The method of adjusting the points, as shown in figure 2-7, is to set the left-hand point on one mark, slide the right-hand point to the required distance, and tighten the thumbscrew. The arc, or circle, is then scribed in the same manner as with the dividers.

Constructing a 90-degree, or right, angle is not difficult if you have a true, steel square. Suppose that you have no square or that your square is off and you need a right angle for a layout. Breakout your dividers, a scriber, and a straightedge. Draw a base line like the one labeled AB in figure 2-8. Set the dividers for a distance greater than one-half AB; then, with A as a center, scribe arcs like those labeled C and D. Next, without changing the setting of the dividers, use B as a center, and scribe another set of arcs at C and D. Draw a line through the points where the arcs intersect and you have erected perpendiculars to line AB, forming four 90-degree, or right, angles. You have also bisected or divided line AB into two equal parts.

Constructing a right angle at a given point with a pair of dividers is a procedure you will find useful when making layouts. Figure 2-9 shows the method for constructing a right angle at a given point.

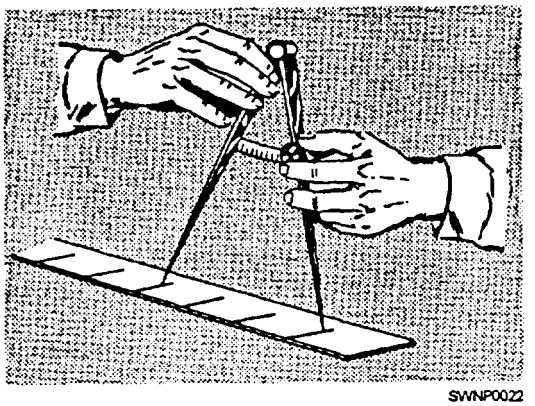


Figure 2-5.—Setting the dividers

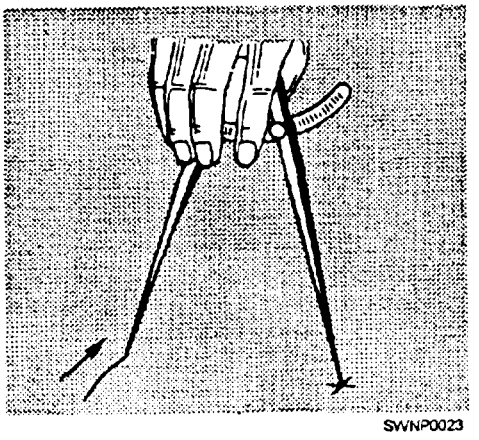


Figure 2-6.—Scribing an acr/circle with dividers

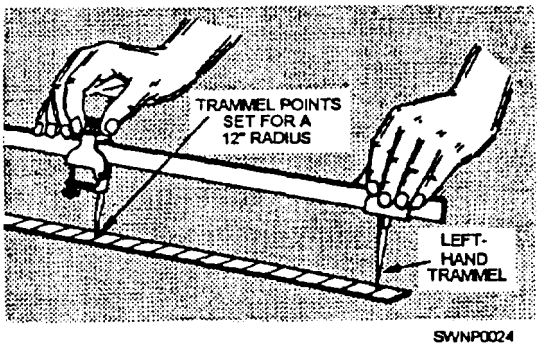


Figure 2-7.—Setting trammel points.

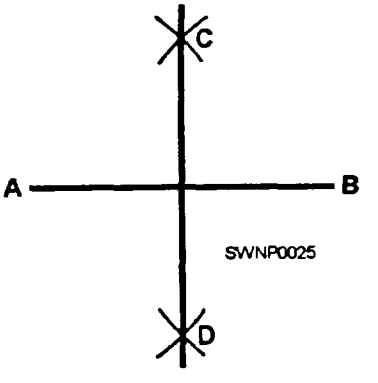


Figure 2-8.—Constructing a 90-degree angle by bisecting a line.

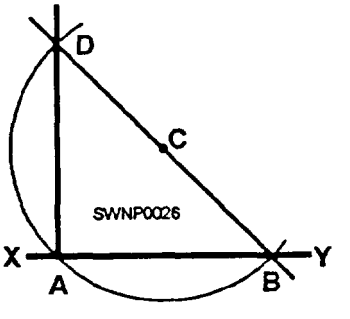


Figure 2-9.—Constructing a 90-degree angle at a given point

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Imagine that you have line XY with A as a point at which you need to fabricate a perpendicular to form a right angle. Select any convenient point that lies somewhere within the proposed 90-degree angle. In figure 2-9 that point is C. Using C as the center of a circle with a radius equal to CA, scribe a semicircular arc, as shown in figure 2-9. Lay a straightedge along points B and C and draw a line that will intersect the other end of the arc at D. Next, draw a line connecting the points D and A and you have fabricated a 90-degree angle. This procedure may be used to form 90-degree comers in stretch-outs that are square or rectangular, like a drip pan or a box.

Laying out a drip pan with a pair of dividers is no more difficult than fabricating a perpendicular. You will need dividers, a scriber, a straightedge, and a sheet of template paper. You have the dimensions of the pan to be fabricated: the length, the width, and the height or depth. Draw a base line (fig. 2-10). Select a point on this line for one comer of the drip pan layout. Erect a perpendicular through this point, forming a 90-degree angle. Next, measure off on the base line the required length of the pan. At this point, erect another perpendicular. You now have three sides of the stretch-out. Using the required width of the pan for the other dimensions, draw the fourth side parallel to the base line, connecting the two perpendiculars that you have fabricated.

Now, set the dividers for marking off the depth of the drip pan. You can use a steel scale to measure off the correct radius on the dividers. Using each comer for a point, swing a wide arc, like the one shown in the second step in figure 2-10. Extend the end and side lines as shown in the last step in figure 2-10 and complete the stretch-out by connecting the arcs with a scriber and straightedge.

Bisecting an arc is another geometric construction that you should be familiar with. Angle ABC (fig. 2-11) is given. With B as a center, draw an arc cutting the sides of the angle at D and E. With D and E as centers and a radius greater than half of arc DE, draw arcs intersecting at F. A line drawn from B through point F bisects angle ABC.

Two methods used to divide a line into a given number of equal parts are shown in figure 2-12. When the method shown in view A is to be used, you will need a straightedge and dividers. In using this method, draw line AB to the desired length. With the dividers set at any given radius, use point A as center and scribe an arc above the line. Using the same radius and B as center, scribe an arc below the line as shown. From

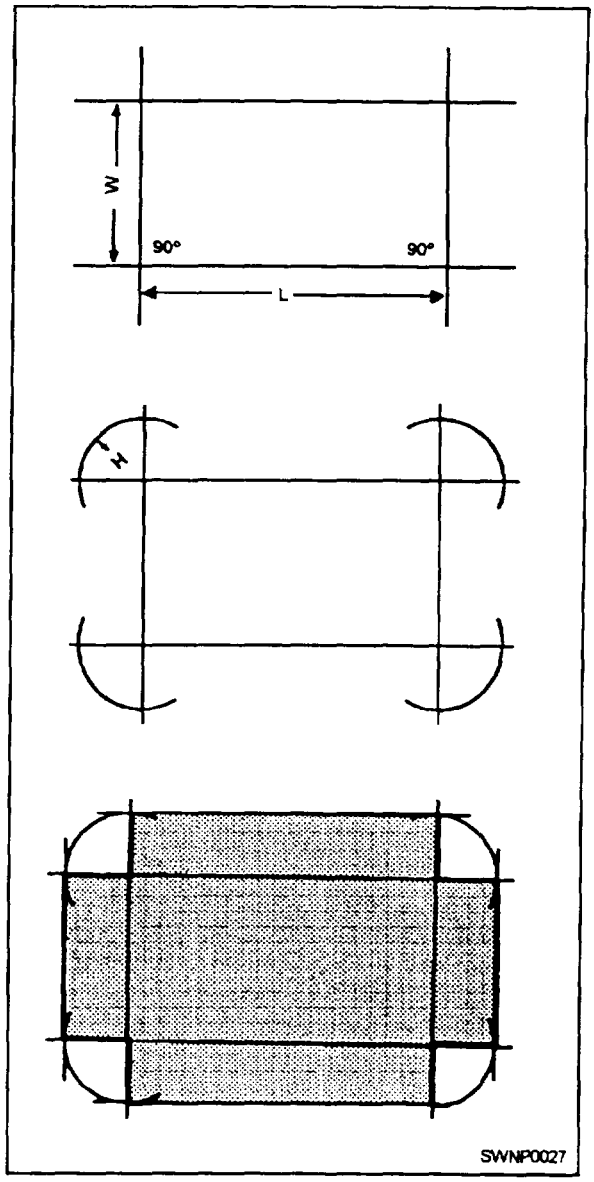


Figure 2-10.—Laying out a drip pan with dividers.

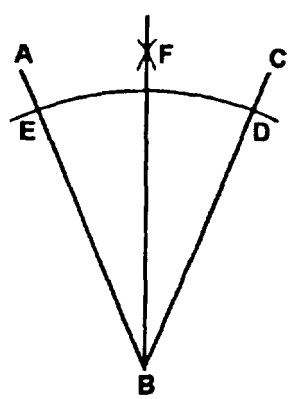


Figure 2-11.—Bisecting an arc.

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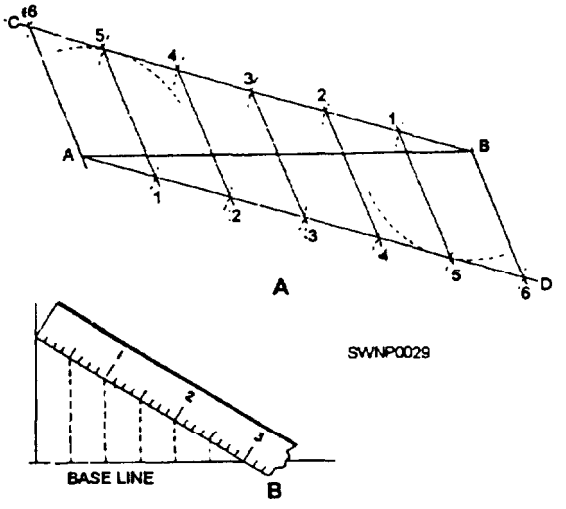


Figure 2-12.—Two methods used to divide a line into equal parts.

point A, draw a straight line tangent to the arc that is below point B. Do the same from point B. With the dividers set at any given distance, start at point A and step off the required number of spaces along line AD using tick marks-in this case, six. Number the tick marks as shown. Do the same from point B along line BC. With the straightedge, draw lines from point 6 to point A, 5 to 1, 4 to 2, 3 to 3, 2 to 4, 1 to 5, and B to 6. You have now divided line AB into six equal parts.

When the method shown in view B of figure 2-12 is used to divide a line into a given number of equal parts, you will need a scale. In using this method, draw a line at right angles to one end of the base line. Place the scale at such an angle that the number of spaces required will divide evenly into the space covered by the scale. In the illustration (view B, fig. 2-12) the base line is 2 1/2 inches and is to be divided into six spaces. Place the scale so that the 3 inches will cover 2 1/2 inches on the base line. Since 3 inches divided by 6 spaces = 1/2 inch, draw lines from the 1/2-inch spaces on the scale perpendicular to the base line. Incidentally, you may even use a full 6 inches in the scale by increasing its angle of slope from the baseline and dropping perpendiculars from the full-inch graduation to the base line.

To divide or step off the circumference of a circle into six equal parts, just set the dividers for the radius of the circle and select a point of the circumference for a beginning point. In figure 2-13, point A is selected for a beginning point. With A as a center, swing an arc through the circumference of the circle, like the one shown at B in the illustration. Use B, then, as a point, and swing an arc through the circumference at C. Continue to step off in this manner until you have divided the circle into six equal parts. If the points of intersection between the arcs and the circumference are connected as shown in figure 2-13, the lines will intersect at the center of the circle, forming angles of 60 degrees.

If you need an angle of 30 degrees, all you have to do is to bisect one of these 60-degree angles by the method described earlier in this chapter. Bisect the 30-degree angle and you have a 15-degree angle. You can construct a 45-degree angle in the same manner by bisecting a 90-degree angle. In all probability, you will have a protractor to lay out these and other angles. But just in case you do not have a steel square or protractor, it is a good idea to know how to construct angles of various sizes and to erect perpendiculars.

Many times when laying out or working with circles or arcs, it is necessary to determine the circumference of a circle or arc. For the applicable mathematical formula, refer to appendix II of this text.

Circumference Rule

Another method of determining circumference is by use of the circumference rule. The upper edge of the circumference rule is graduated in inches in the same manner as a regular layout scale, but the lower edge is graduated, as shown in figure 2-14. The lower edge gives you the approximate circumference of any circle within the range of the rule. You will notice in figure 2-14 that the reading on the lower edge directly below the 3-inch mark is a little over 9 3/8 inches. This

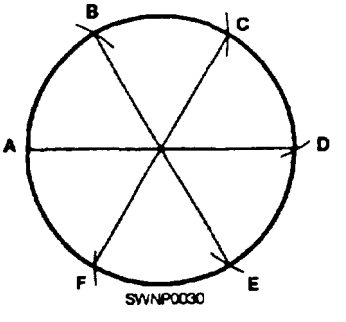


Figure 2-13.—Dividing a circle into six equal parts

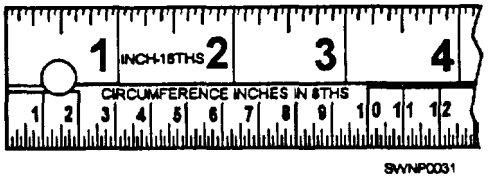


Figure 2-14.—Circumference rule.

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reading would be the circumference of a circle with a diameter of 3 inches and would be the length of a stretch-out for a cylinder of that diameter. The dimensions for the stretch-out of a cylindrical object, then, are the height of the cylinder and the circumference.

CUTTING TOOLS

Various types of HAND SNIPS/HAND SHEARS are used for cutting and notching sheet metal. Hand snips are necessary because the shape, construction, location, and position of the work to be cut frequently prevents the use of machine-cutting tools.

Hand snips are divided into two groups. Those for straight cuts are as follows: straight snips, combination snips, bulldog snips, and compound lever shears. Those for circular cuts are as follows: circle, hawk's bill, aviation, and Trojan snips. These snips are shown in figure 2-15. The following is a brief description of each type of snip.

STRAIGHT SNIPS (fig. 2-15, view A) have straight jaws for straight line cutting. To ensure strength, they are not pointed. These snips are made in various sizes and the jaws may vary from 2 to 4 1/2 inches. The overall length will also vary from 7 to 15 3/4 inches. The different size snips are made to cut different thicknesses of metal with 18 gauge steel as a minimum for the larger snips. These snips are available for right- or left-hand use.

COMBINATION SNIPS (fig. 2-15, view B) have straight jaws for straight cutting but the inner faces of the jaws are sloped for cutting curves as well as irregular shapes. These snips are available in the same sizes and capacities as straight snips.

BULLDOG SNIPS (fig. 2-15, view C) are of the combination type, They have short cutting blades with long handles for leverage. The blades are inlaid with special alloy steel for cutting stainless steel. Bulldog snips can cut 16 gauge mild steel. The blades are 2 1/2 inches long and the overall length of the snip varies from 14 to 17 inches.

COMPOUND LEVER SHEARS (fig. 2-15, view D) have levers designed that give additional leverage to ease the cutting of heavy material. The lower blade is bent to allow the shears to be inserted in a hole in the bench or bench plate. This will hold the shear in an upright position and make the cutting easier. The cutting blades are removable and can be replaced. The capacity is 12 gauge mild steel. It has cutting blades that are 4 inches long with an overall length of 34 1/2 inches.

CIRCLE SNIPS (fig. 2-15, view E) have curved blades and are used for making circular cuts, as the name implies. They come in the same sizes and capacities as straight snips and either right- or left-hand types are available.

HAWK'S BILL SNIPS (fig. 2-15, view F) are used to cut a small radius inside and outside a circle. The narrow, curved blades are beveled to allow sharp turns without buckling the sheet metal. These snips are useful for cutting holes in pipe, in furnace hoods, and in close quarters work. These snips are available with a 2 1/2-inch cutting edge and have an overall length of either 11 1/2 or 13 inches and have a 20 gauge mild steel capacity.

AVIATION SNIPS (fig. 2-15, view G) have compound levers, enabling them to cut with less effort. These snips have hardened blades that enable them to cut hard material. They are also useful for cutting circles, for cutting squares, and for cutting compound curves and intricate designs in sheet metal. Aviation snips come in three types: right hand, left hand, and straight. On right-hand snips, the blade is on the left and they cut to the left. Left-hand snips are the opposite. They are usually color-coded in keeping with industry standards-green cuts right, red cuts left, yellow cuts straight. Both snips can be used with the right hand. The snips are 10 inches long and have a 2-inch cut and have a 16 gauge mild steel capacity.

TROJAN SNIPS (fig. 2-15, view H) are slim-bladed snips that are used for straight or curved cutting. The blades are small enough to allow sharp turning cuts without buckling the metal. These snips can be used to cut outside curves and can also be used in place of circle snips, hawk's bill snips, or aviation snips when cutting inside curves. The blades are forged high grade steel. These snips come in two sizes: one has a 2 1/2-inch cutting length and a 12-inch overall length and the other has a 3-inch cutting length and a 13-inch overall length, They both have a 20 gauge capacity.

Modern snips are designed to cut freely with a minimum curling of the metal. The snips are generally held in the right hand at right angles to the work (fig, 2-16). Open the blades widely to obtain maximum leverage. Do not permit the ends to close completely at the end of a cut or a rough

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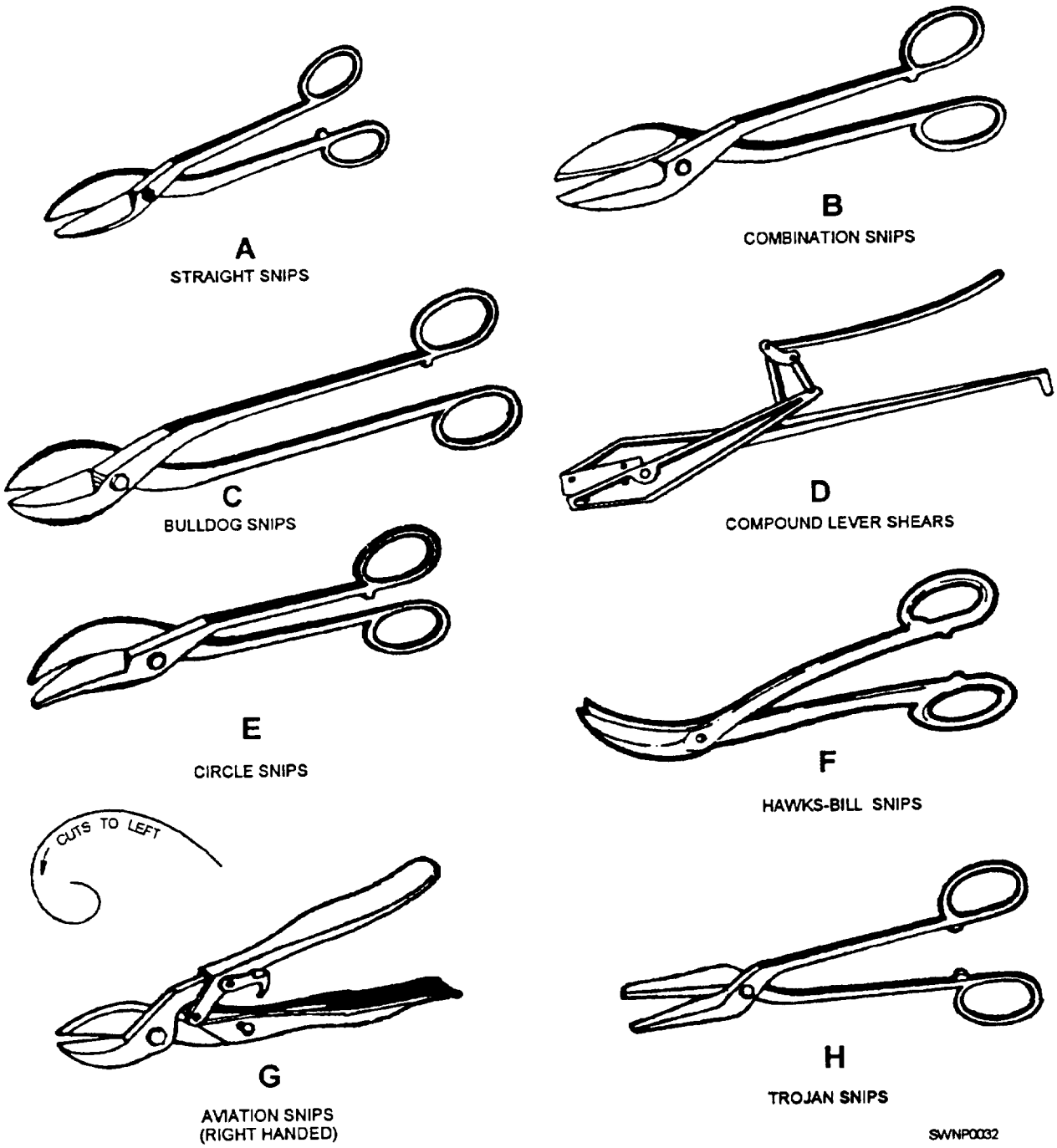


Figure 2-15.—Hand snips.

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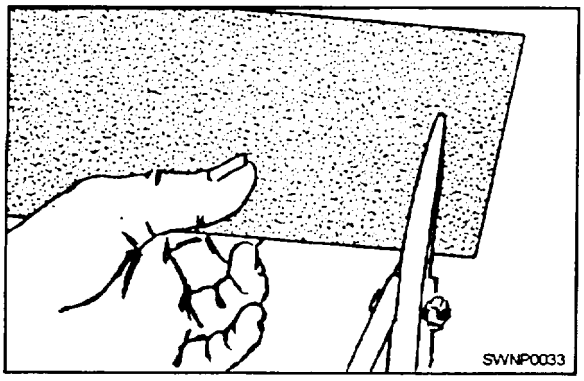


Figure 2-16.—Proper method of cutting with snips.

edge will result. Cut circular sections from the right side (fig. 2-17).

When making internal circular cuts, you make a small opening near the center of the opening, insert the snips, and cut from the upper side, gradually increasing the radius of the cut until the opening is completed (fig. 2-18).

Large sheet-metal sections are cut on SQUARING SHEARS that are discussed later in this chapter.

The COMBINATION NOTCHER, COPER, and SHEAR (fig. 2-19) is ideal for notching corners or the edge of sheet metal. The blades are adjustable for conventional notching or for piercing, starting inside the blank.

PORTABLE POWER SHEARS make it possible to do production work. They are designed to do straight or circular cutting (fig. 2-20).

Small diameter openings can be made with a SOLID PUNCH (fig. 2-21) or a HOLLOW PUNCH

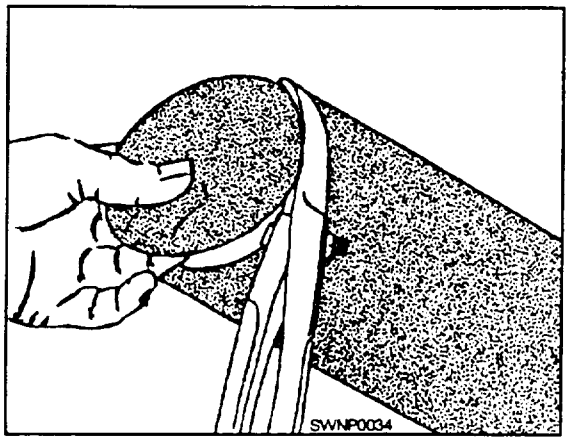


Figure 2-17.—Making a circular cut.

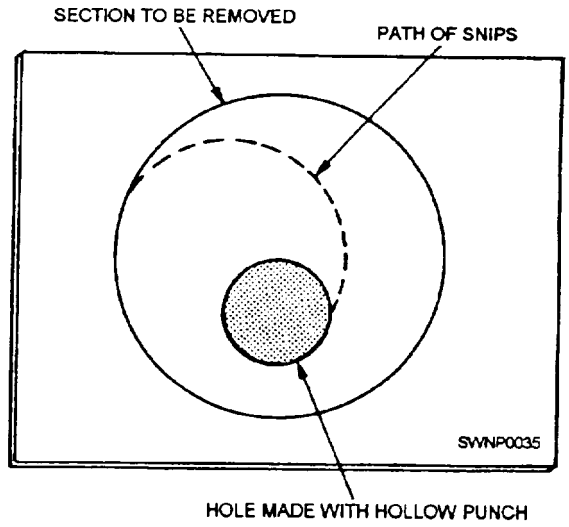


Figure 2-18.—Making an internal circular cut.

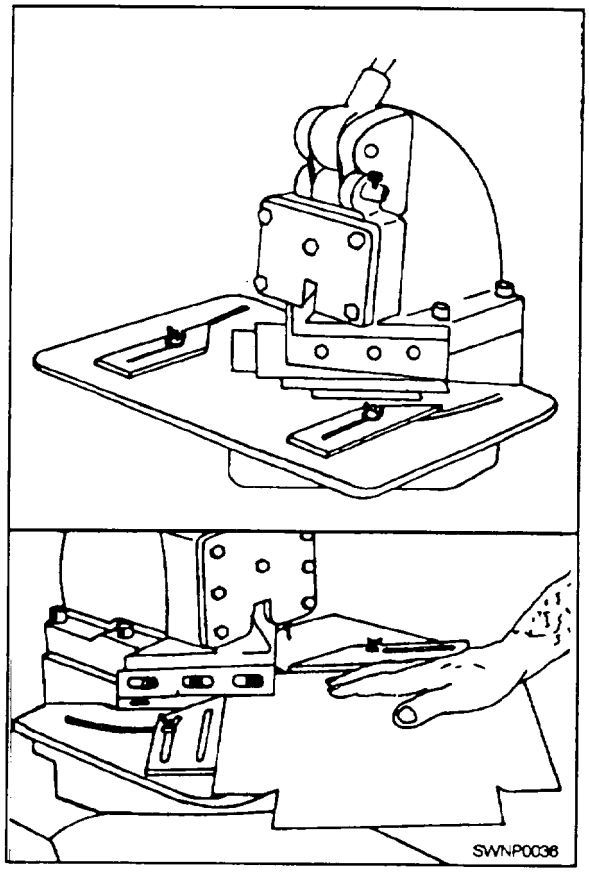


Figure 2-19.—Combination notcher, coper, and shear.

(fig. 2-22). Locate the position of the hole; select the correct size punch and hammer; then place the metal section on a lead cake or on the end grain of a block of hard wood (fig. 2-23). Strike the punch firmly with

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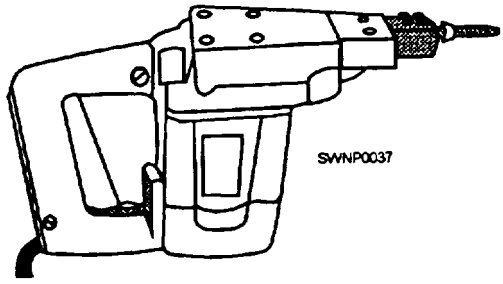


Figure 2-20.—Portable power shears



Figure 2-21.—Solid punch.

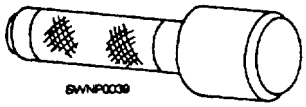


Figure 2-22.—Hollow punch.

the hammer. Turn the punched section over so the burred section is up, then smooth it with a mallet.

FOOT-ACTUATED SQUARING SHEARS (fig. 2-24) make it possible to square and trim large sheets. Do not attempt to cut metal heavier than the designed capacity of the shears. The maximum capacity of the machine is stamped on the manufacturer's

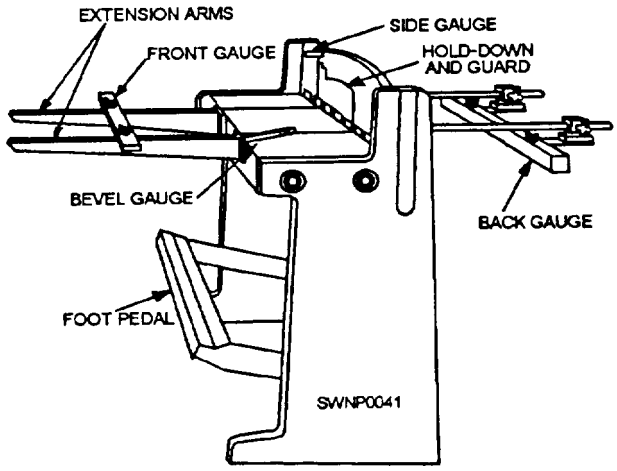


Figure 2-24.—Foot-actuated squaring shears.

specification plate on the front of the shears. Check the gauge of the metal against this size with a SHEET-METAL GAUGE (fig. 2-25). This figure shows the gauge used to measure the thickness of metal sheets. The gauge is a disc-shaped piece of metal, having slots of widths that correspond to the U.S. gauge numbers from O to 36. Each gauge number is marked on the front and the corresponding decimal equivalent marked on the back.

Do NOT cut wire, band iron, or steel rods with the squaring shears.

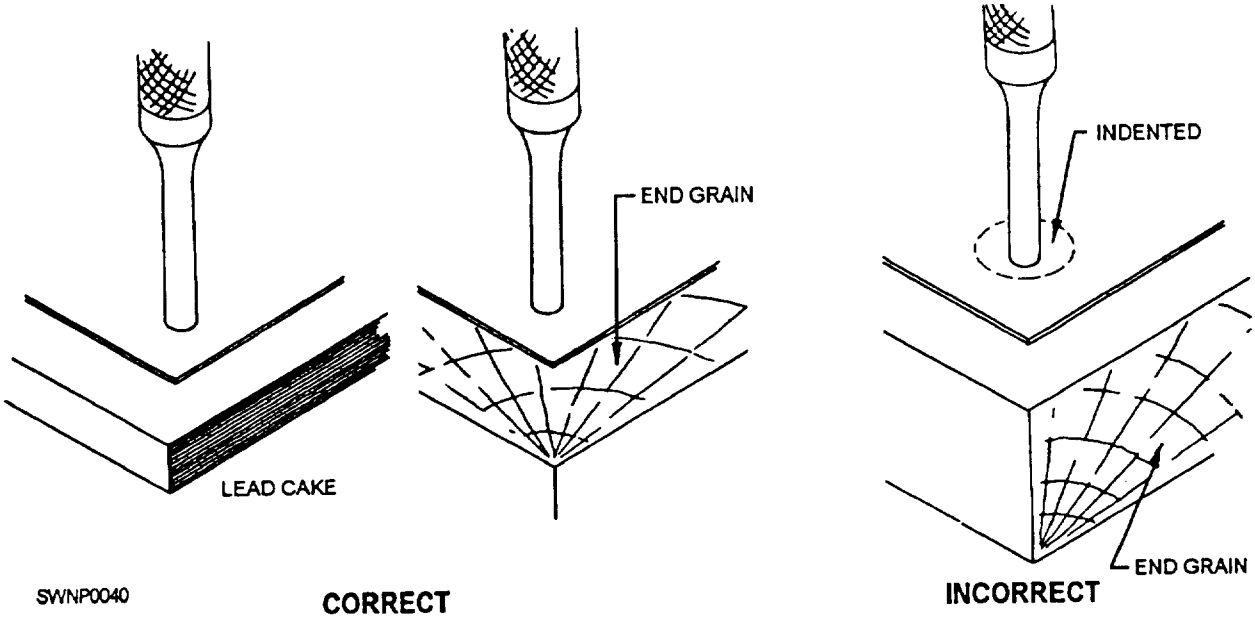
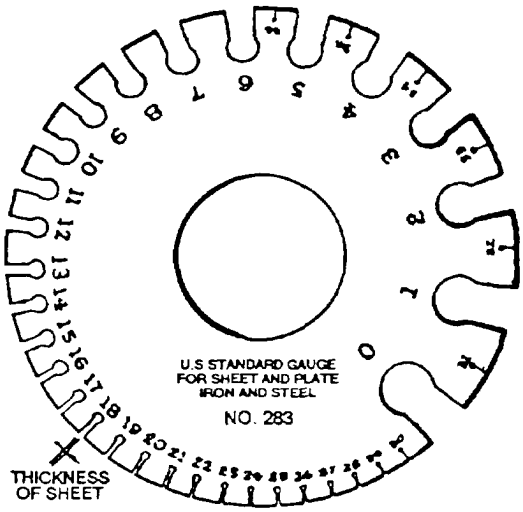


Figure 2-23.—Correct method of backing sheet metal for making a hole with a punch.

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U.S. STANDARD GAUGE

Figure 2-25.—Sheet-metal guage.

The length of the cut is determined by the position of the BACK GAUGE when the metal is inserted from the front of the shears. The FRONT GAUGE controls the length of the cut when the metal sheet is inserted from the rear. The front gauge is seldom used and is usually removed from the shears. A BEVEL GAUGE permits angular cuts to be made.

To make a cut, set the back gauge to the required dimension by using the graduated scale on the top of the extension arms or on the graduated section on the bed top. Hold the piece firmly against the SIDE GAUGE with both hands until the HOLD-DOWN comes into position, and apply pressure to the FOOT PEDAL.

NOTE: KEEP HANDS CLEAR OF THE BLADE AND FEET FROM BENEATH THE FOOT PEDAL.

RING AND CIRCULAR SHEARS (fig. 2-26) are intended for cutting inside and outside circles in sheet metal. The CLAMPING HEAD is positioned for the desired diameter and the blank is inserted. Lower the CUTTING DISC and make the cut.

SHEET-METAL BENDING AND FORMING EQUIPMENT

Sheet metal is given three-dimensional shape and rigidity by bending. Sheet metal can be formed by hand or with various special tools and machines. several techniques are described in the following sections.

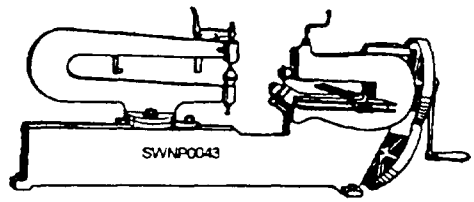


Figure 2-26.—Ring and circular shears

Stakes

METAL STAKES allow the sheet-metal craftsman to make an assortment of bends by hand Stakes come in a variety of shapes and sizes. The work is done on the heads or the horns of the stakes. They are machined, polished, and, in some cases, hardened Stakes are used for finishing many types of work; therefore, they should NOT be used to back up work when using a chisel. The following is an assortment of the most common stakes that are used within the NCF and Public Works Departments (fig. 2-27):

1. SQUARE STAKES (fig. 2-27, view A) have square-shaped heads and are used for general work Three types are used: the coppersmith square stake with one end rounded, the bevel edge square stake that is offset, and the common square stake. Some of the edges are beveled and this allows them to be used for a greater variety of jobs.

2. The CONDUCTOR STAKE (fig. 2-27, view B) has cylindrical horns of different diameters and is used when forming, seaming, and riveting pieces and parts of pipes.

3. The HOLLOW MANDREL STAKE (fig. 2-27, view C) has a slot in which a bolt slides allowing it to be clamped firmly to a bench. Either the rounded or the flat end can be used for forming, seaming, or riveting. There are two sizes available with an overall length of either 40 or 60 inches.

4. The BLOW HORN STAKE (fig. 2-27, view D) has two horns of different tapers. The apron end is used for shaping blunt tapers and the slender-tapered end is used for slightly tapered jobs.

5. The BEAKHORN STAKE (fig. 2-27, view E) is a general-purpose stake. The stake has a round-tapered horn on one end and a square-tapered horn on the other end. This stake is used for riveting and shaping round or square work

6. The DOUBLE-SEAMING STAKE WITH FOUR INTERCHANGEABLE HEADS (fig. 2-27, view F) has two shanks and either one can be installed

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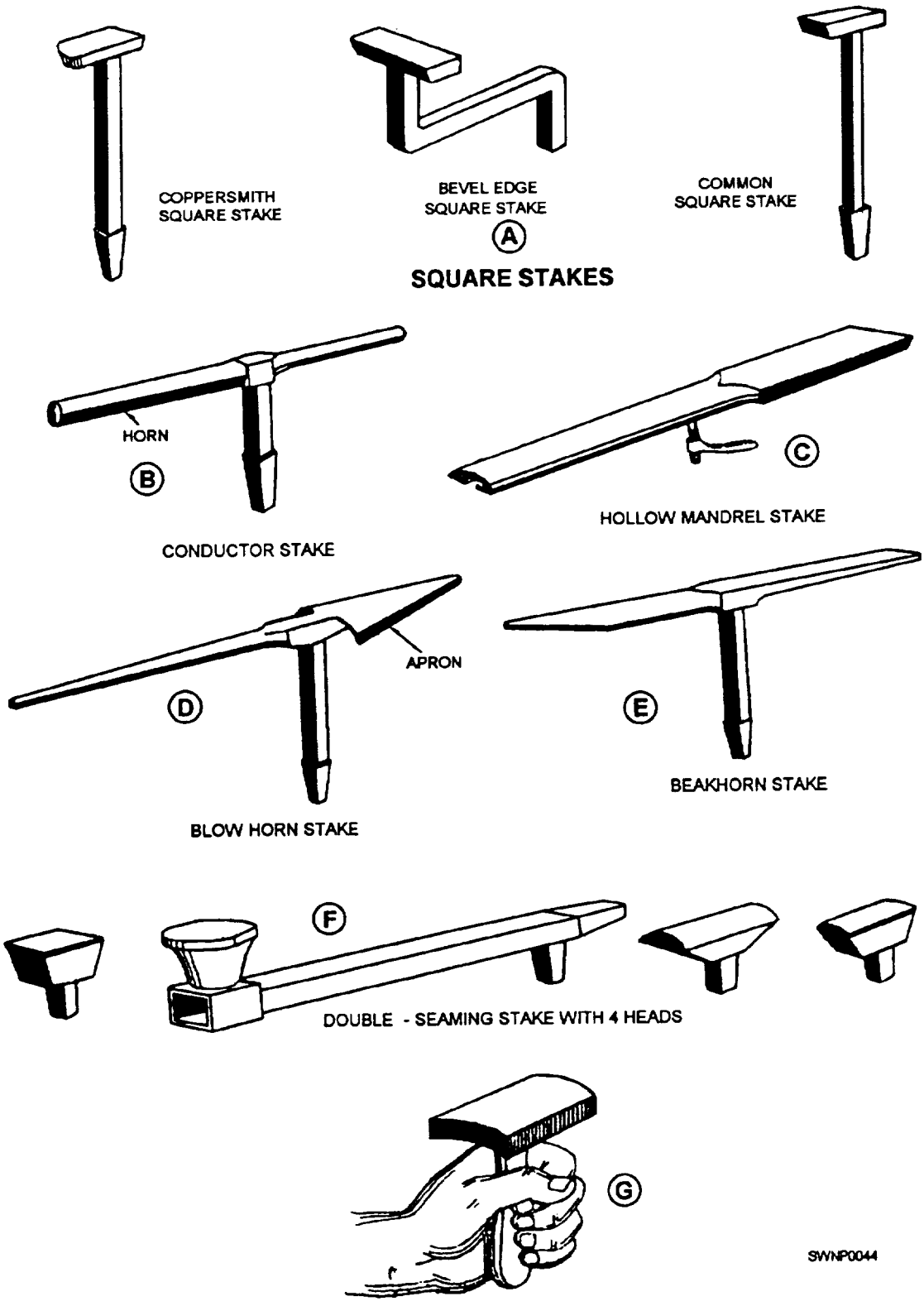


Figure 2-27.—Metal stakes

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in a bench plate, allowing the stakes to be used vertically or horizontally. This stake is used for double seaming large work of all types and for riveting.

7. The HAND DOLLY (fig. 2-27, view G) is a portable anvil with a handle that is used for backing up rivet heads, double seams, and straightening.

Other Forming Tools

Stakes are designed to fit in a BENCH PLATE (fig. 2-28). The bench plate is a cast-iron plate that is affixed to a bench. It has tapered holes of different sizes that support the various stakes that can be used with the plate. Additionally, there is another type of bench plate that consists of a revolving plate with different size holes which can be clamped in any desired position.

The SETTING HAMMER (fig. 2-29) has a square, flat face and the peen end is single-tapered. The peen is for setting down an edge. The face is used to flatten seams. Setting hammers vary in size from 4 ounces to 20 ounces and their use is determined by the gauge of the metal and the accessibility of the work.

A WOOD MALLET (fig. 2-30) provides the necessary force for forming sheet metal without marring the surface of the metal.

Narrow sections can be formed with the HAND SEAMER (fig. 2-31). Its primary use is for turning a flange, for bending an edge, or for folding a seam. The width of the flange can be set with the knurled knobs on the top of the jaw.

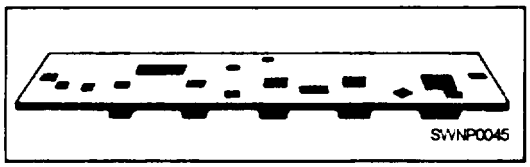


Figure 2-28.—Bench plate.

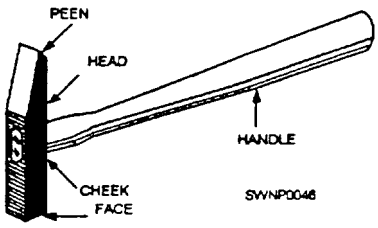


Figure 2-29.—Setting hamer.

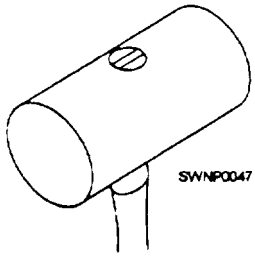


Figure 2-30.—Wood mallet

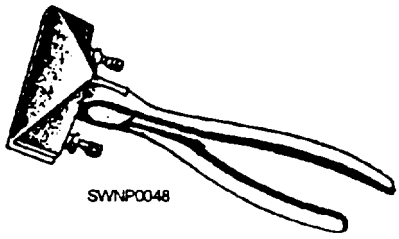


Figure 2-31.—Hand seamer.

Forming and Bending Machines

Many machines have been designed to perform precise sheet-metal bending operations. They include the bar folder, several types of brakes, roll forming machines, and combination rotary machines. These machines are described next.

BAR FOLDER.— The BAR FOLDER (fig. 2-32) is designed to bend sheet metal, generally 22 gauge or lighter. Bar folders are used for bending edges of sheets at various angles, for making channel shape (double-right angle folds), and for fabricating lock seams and wired edges. Narrow channel shapes can be formed but reverse bends cannot be bent at close distances. The width of the folder edge is determined by the setting of the DEPTH GAUGE (fig. 2-33). The sharpness of the folded edge, whether it is to be sharp for a hem or seam or rounded to make a wire edge, is determined by the position of the WING (fig. 2-34). Right-angle (90°) and 45-degree bends can be made by using the 90-degree and 45-degree ANGLE STOP.

Hemmed edges are made in the following manner (fig. 2-35):

1. Adjust the depth gauge for the required size, and position the wing for the desired fold sharpness.

2. Set the metal in place, setting it lightly against the gauge fingers.

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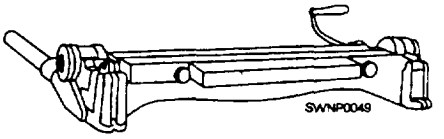


Figure 2-32.—Bar folder.

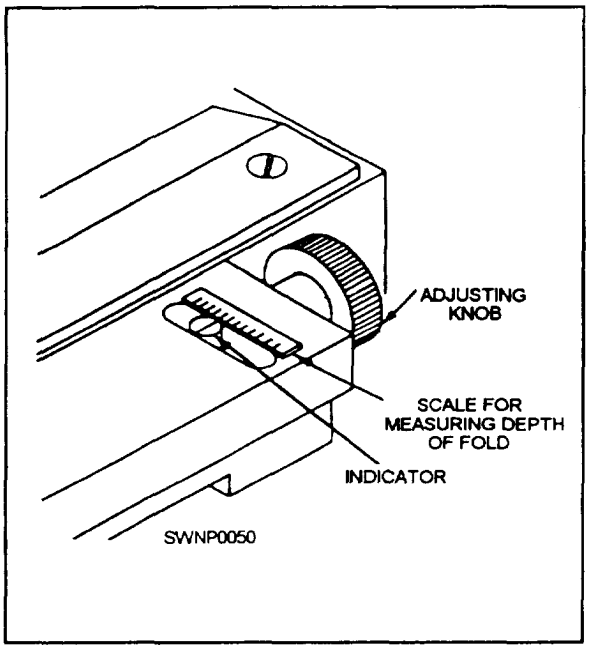


Figure 2-33.—Fold size depth gauge.

3. With the left hand holding the metal, pull the handle as far forward as it will go. Return the handle to its original position.

4. Place the folded section on the beveled section of the blade, as close to the wing as possible. Flatten the fold by pulling the handle forward rapidly.

BRAKES.— Large sheet-metal sections are formed by using bending brakes. These machines produce more uniform bends than can be made by hand and require significantly less effort. The two most commonly used brakes are the cornice brake and the finger brake.

A CORNICE BRAKE is shown in figure 2-36. Two adjustments have to be made before using the machine.

1. Adjust the UPPER JAW or CLAMPING BAR vertically for the gauge of sheet metal to be bent. The clamping device holds the work solidly in position, provided it is correctly adjusted. For example, if the clamping device is set for 18 gauge sheet metal and you

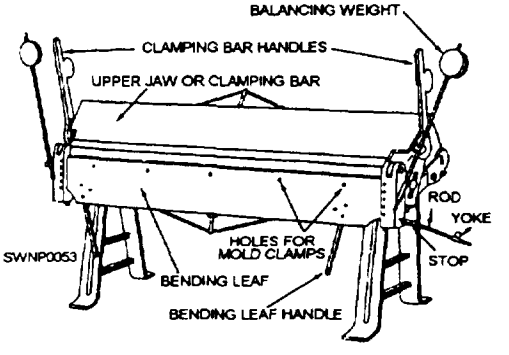


Figure 2-36.—Cornice brake.

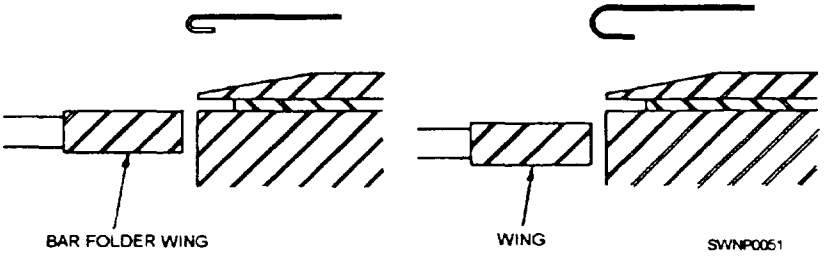


Figure 2-34.—Wing setting determines the tightness of fold.

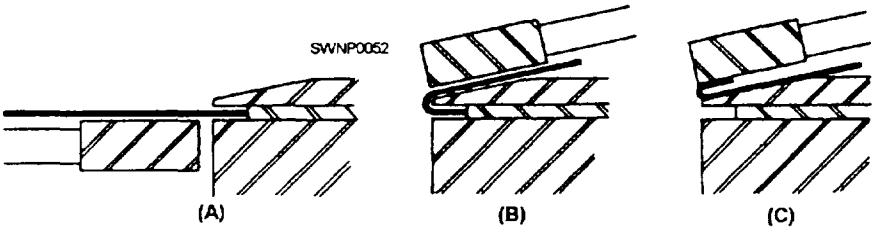


Figure 2-35.—Making a hemmed edge.

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bend 24 gauge sheet metal at that setting, the sheet will slip and the bend will be formed in the wrong position. When you try to bend 18 gauge sheet metal when the machine is set for 24 gauge sheet metal, you can break the clamping bar handle. The pressure to lock the clamping bar should NEVER be too strong. With a little practice you will be able to gauge the pressure correctly.

2. Adjust the upper jaw horizontally to the correct position for the thickness of the metal and for the radius of the bend to be made.

CAUTION

If the upper jaw is adjusted to the exact thickness of the metal, the bend will be sharp or it will have practically no bend radius. If it is set for more than the thickness of the metal, the bend will have a larger radius; if the jaw is set for less than the thickness of the metal, the jaws of the machine may be sprung out of alignment and the edges of the jaws may be damaged.

After these two adjustments have been made, the machine is operated as follows:

1. Scribe a line on the surface of the sheet metal to show where the bend will be.

2. Raise the upper jaw with the clamping handle and insert the sheet in the brake, bringing the scribed line into position even with the front edge of the upper jaw.

3. Clamp the sheet in position. Ensure that the scribed line is even with the front edge of the upper jaw. The locking motion will occasionally shift the workpiece.

4. Once you are satisfied that the metal is clamped correctly, the next step is to lift the bending leaf to the required angle to form the bend. If you are bending soft and/or ductile metal, such as copper, the bend will be formed to the exact angle you raised the bending leaf. If you are bending metal that has any spring to it, you will have to raise the bending leaf a few degrees more to compensate for the spring in the metal. The exact amount of spring that you will have to allow for depends on the type of metal you are working with.

5. Release the clamping handle and remove the sheet from the brake.

The brake is equipped with a stop gauge, consisting of a rod, a yoke, and a setscrew. You use this to stop the bending leaf at a required angle. This feature is useful when you have to fabricate a large number of pieces with the same angle. After you have made your first bend to the required angle, set the stop gauge so that the bending leaf will not go beyond the required angle. You can now fabricate as many bends as you need.

The cornice brake is extremely useful for making single hems, double hems, lock seams, and various other shapes.

It is impossible to bend all four sides of a box on a conventional brake. The FINGER BRAKE, sometimes referred to as a BOX AND PAN BRAKE (fig. 2-37), has been designed to handle this exact situation . The upper jaw is made up of a number of blocks, referred to as "fingers." They are various widths and can easily be positioned or removed to allow all four sides of a box to be bent. Other than this feature, it is operated in the same manner as a cornice brake.

ROLL FORMING MACHINE.— When cylinders and conical shapes are being formed, no sharp bends are obviously required; instead, a gradual curve has to be formed in the metal until the ends meet. Roll forming machines have been invented to accomplish this task. The simplest method of forming these shapes is on the SLIP ROLL FORMING MACHINE (fig. 2-38). Three rolls do the forming (fig. 2-39). The two front rolls are the feed rolls and can be adjusted to accommodate various thicknesses of metal. The rear roll, also adjustable, gives the section the desired curve. The top roll pivots up to permit the cylinder to be removed without danger of distortion. Grooves are machined in the two bottom

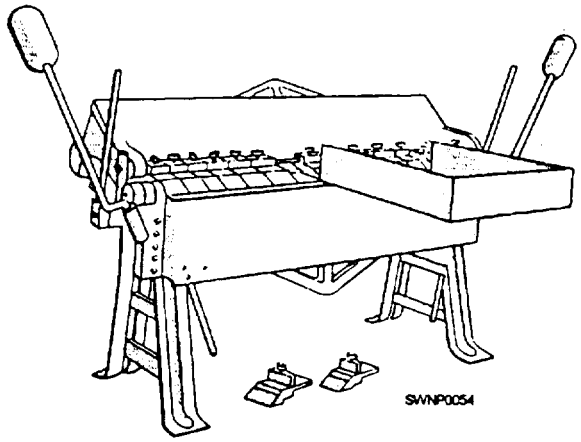


Figure 2-37.—Finger brake.

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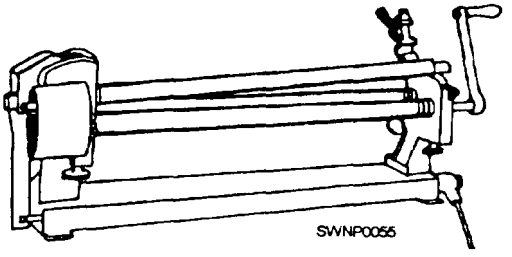


Figure 2-38.—Slip roll forming machine.

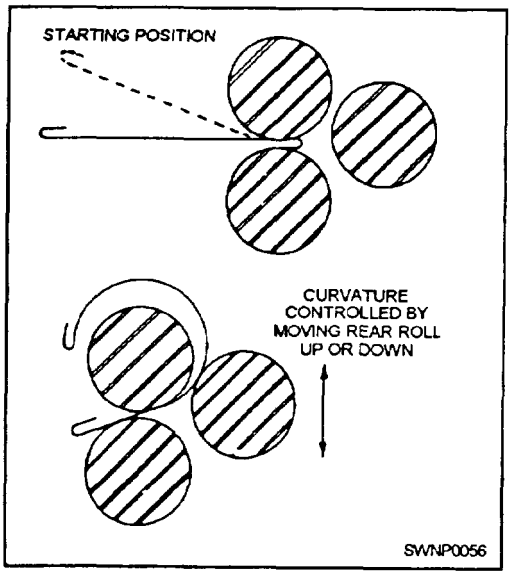


Figure 2-39.—Forming cylinders on rolling forms.

rolls for the purpose of accommodating a wired edge when forming a section with this type edge or for rolling wire into a ring.

COMBINATION ROTARY MACHINE.—Preparing sheet metal for a wired edge, turning a burr, beading, and crimping are probably the most difficult of sheet-metal forming operations to perform. When production dictates, large shops will have a machine for each operation. However, a COMBINATION ROTARY MACHINE (fig. 2-40) with a selection of rolls will prove acceptable for most shop uses.

Wiring an Edge.—The wire edge must be applied to tapered shapes after they are formed. This is accomplished by turning the edge on the rotary machine. Gradually, lower the upper roll until the groove is large enough for the wire. The edge is pressed around the wire with the rotary machine (fig. 241).

The wire edge can be finished by hand if a rotary machine is not available. The edge is formed on the

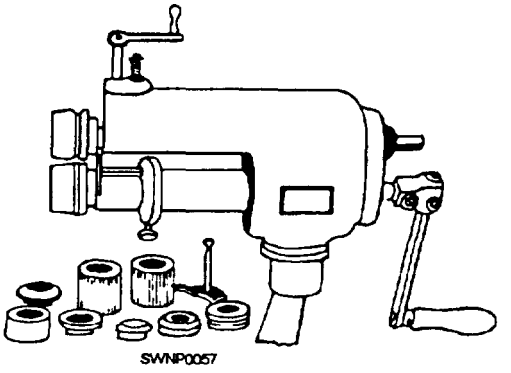
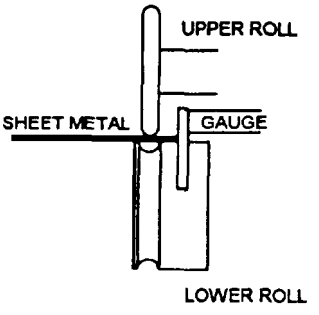


Figure 2-40.—Combination rotary machine with extra forming rolls.



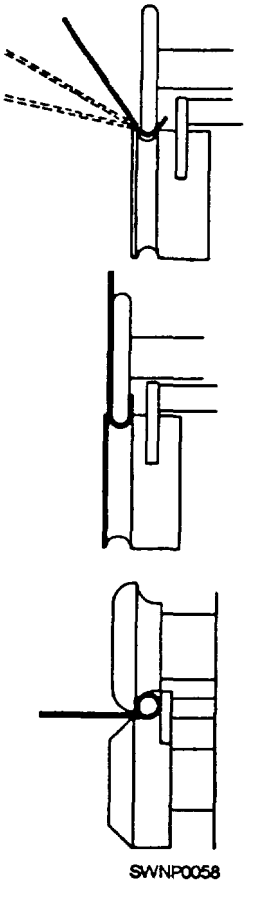


Figure 2-41.—Turning a wire edge with a rotary machine.

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bar folder and forced into place around the wire with a setting hammer or pliers (fig. 2-42).

Turning a Burr.— A BURR, in sheet-metal language, is a narrow flange turned on the circular section at the end of a cylinder (fig. 2-43). Before you cut the section, remember that additional material must be added to the basic dimensions of the object for the burr. Figure 2-44 shows how to calculate the additional material.

After the rotary machine has been adjusted to turn the proper size burr, the work is placed in position and the upper roll lowered. Make one complete revolution of the piece, scoring the edge lightly. Lower the upper roll a bit more, creating more pressure, and make another turn. Continue this operation, raising the disc slightly after each turn until the burr is turned to the required angle (fig. 2-45).

This procedure is also used to turn the burr on the bottom of the cylinder for a double seam (fig. 2-46). The two pieces are snapped together, the burr set down, and the seam completed (fig. 2-47).

NOTE: Because turning a burr is a difficult operation, you should turn several practice pieces to develop your skill before turning the burr on the actual piece to be used.

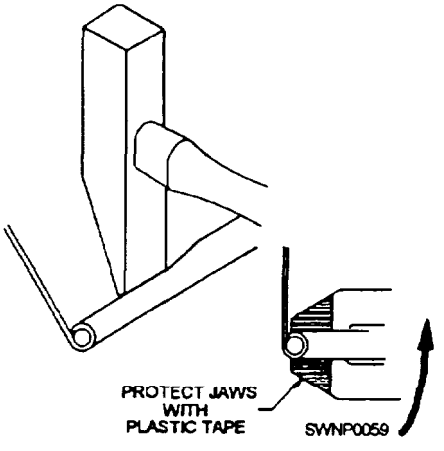


Figure 2-42.—Setting a wire edge with a setting hammer or pliers.

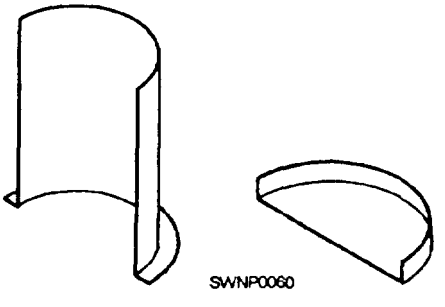


Figure 2-43.—Burrs turned on a cylindrical section.

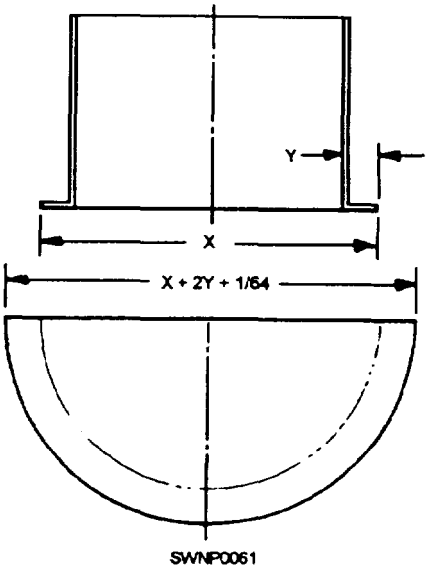


Figure 2-44.—Calculating the material needed for a double seam.

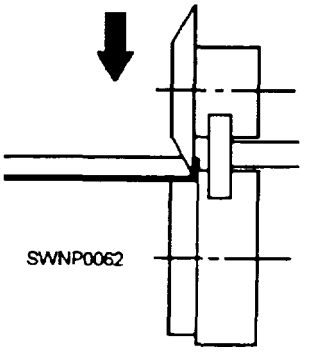


Figure 2-45.—Turning a burred edge.

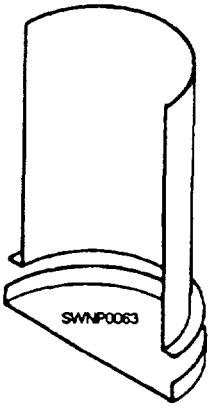


Figure 2-46.—Fitting burred sections together.

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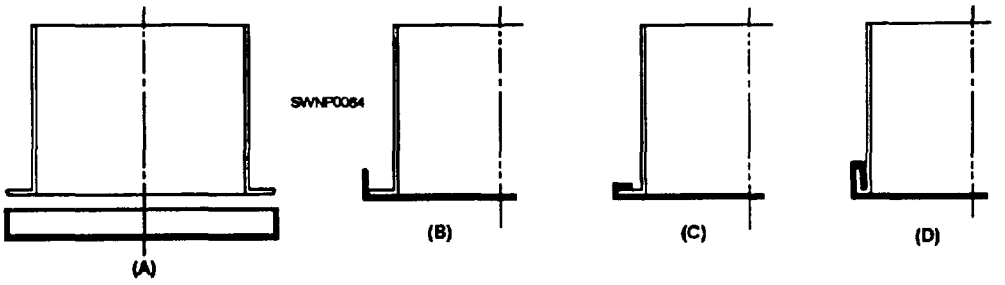


Figure 2-47.—Making a double seam on a cylindrical section.

Beading. — BEADING (fig. 2-48) is used to give added stiffness to cylindrical sheet-metal objects for decorative purposes, or both. It can be a simple bead or an ogee (S-shaped) bead. They are made on the rotary machine using beading rolls.

Crimping.— CRIMPING (fig. 2-49) reduces the diameter of a cylindrical shape, allowing it to be slipped into the next section. This eliminates the need for making each cylinder with a slight taper.

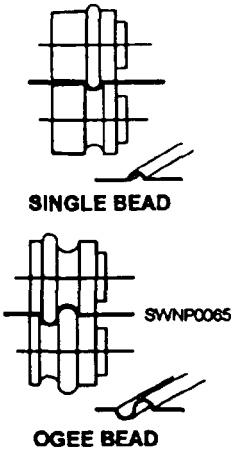


Figure 2-48.—Turning a bead with a rotary machine.

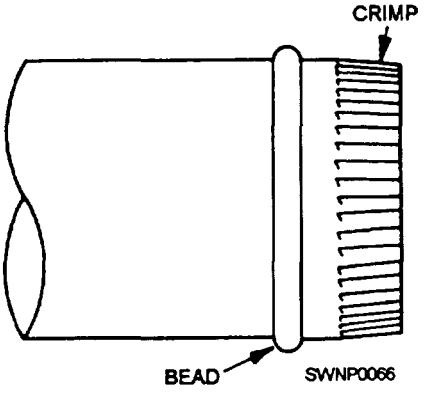


Figure 2-49.—A crimped section.

SHEET-METAL DEVELOPMENT

In sheet-metal development work, some fabrication or repair jobs can be laid out directly on sheet metal. This development procedure, known as SCRATCHING, is used when the object to be made requires little or no duplication.

When a single part is to be produced in quantity, a different development procedure is used. Instead of laying out directly on the metal, you will develop a PATTERN, or TEMPLATE, of the piece to be fabricated and then transfer the development to the metal sheet. The second development procedure is what we are primarily concerned with in this section.

Special attention is given to the three primary procedures commonly used in developing sheet-metal patterns. They are parallel line, radial line, and triangular development. We will also discuss the fabrication of edges, joints, seams, and notches.

PARALLEL LINE DEVELOPMENT

Parallel line development is based upon the fact that a line that is parallel to another line is an equal distance horn that line at all points. Objects that have opposite lines parallel to each other or that have the same cross-sectional shape throughout their length are developed by this method

To gain a clear understanding of the parallel line method, we will develop, step by step, a layout of a truncated cylinder (fig. 2-50). Such apiece can be used

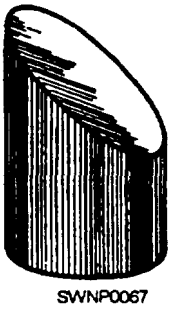


Figure 2-50.—Truncated cylinder.

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as one half of a two-piece 0degree elbow. This piece of sheet metal is developed in the following procedure:

1. First, draw a front and bottom view by orthographic projection (fig. 2-51, view A).

2. Divide half the circumference of the circle (fig. 2-51, view A) into a number of equal parts. The parts should be small enough so that when straight lines are drawn on the development or layout between division points, they will approximate the length of the arc. Project lines from these points to the front view, as shown in figure 2-51, view B. These resulting parallel lines of the front view are called ELEMENTS.

3. Lay off the base line, called the STRETCH-OUT LINE, of the development to the right of the front view, as shown in figure 2-51, view C.

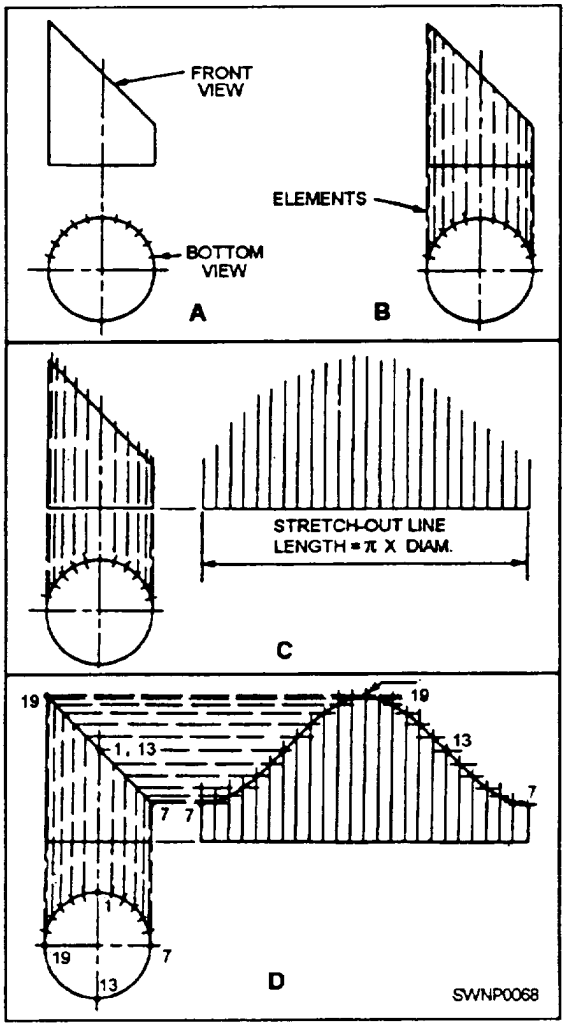


Figure 2-51.—Development of a truncated cylinder.

4. Divide the stretch-outline into twice the number of equal parts equal to each division of the circumference on the half circle of the orthographic view (fig. 2-51, view C).

5. Erect perpendicular lines at each point, as shown in figure 2-51, view C.

6. Using a T-square edge, project the lengths of the elements on the front view to the development (fig. 2-51, View D).

7. Using a curve (french or other type), join the resulting points of intersection in a smooth curve.

When the development is finished, add necessary allowances for warns and joints, then cut out your patterns.

RADIAL LINE DEVELOPMENT

The radial line method of pattern development is used to develop patterns of objects that have a tapering form with lines converging at a common center.

The radial line method is similar in some respects to the parallel line method. Evenly spaced reference lines are necessary in both of these methods. But, in parallel line development, the reference lines are parallel—like a picket fence. In radial line development, the reference lines radiate from the APEX of a cone—like the spokes of a wheel.

The reference lines in parallel line development project horizontally. In radial line development, the reference lines are transferred from the front view to the development with the dividers.

Developing a pattern for the frustum of a right cone is a typical practice project that will help you get the feel of the radial line method. You are familiar with the shape of a cone. A right cone is one that, if set big-side-down on a flat surface, would stand straight up. In other words, a centerline drawn from the point, or vertex, to the base line would form right angles with that line. The frustum of a cone is that part that remains after the point, or top, has been removed.

The procedure for developing a frustum of a right cone is given below. Check each step of the procedure against the development shown in figure 2-52.

1. Draw a cone ABC with line ED cutting the cone in such a way that line ED is parallel to the base line BC. EDCB is called a frustum.

2. With center O and radius OB, draw the half-plan beneath the base line BC. Divide the

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half-plan into an equal number of parts and number them as shown.

3. With vertex A as a center and with dividers, set a distance equal to AC and draw an arc for the stretch-out of the bottom of the cone.

4. Set the dividers equal to the distance of the step-offs on the half-plan and step off twice as many spaces on the arcs as on the half-plan; number the step-offs 1 to 7 to 1, as shown in the illustration (fig. 2-52).

5. Draw lines connecting A with point 1 at each end of the stretch-out. This arc, from 1 to 7 to 1, is equal in length to the circumference of the bottom of the cone.

6. Now, using A for a center, set your dividers along line AC to the length of AD. Scribe an arc through both of the lines drawn from A to 1.

The area enclosed between the large and small arcs and the number 1 line is the pattern for the frustum of a cone. Add allowance for seaming and edging and your stretch-out is complete.

TRIANGULAR DEVELOPMENT

Triangulation is slower and more difficult than parallel line or radial line development, but it is more practical for many types of figures. Additionally, it is the only method by which the developments of warped surfaces may be estimated. In development by triangulation, the piece is divided into a series of triangles as in radial Line development. However, there is no one single apex for the triangles. The problem becomes one of finding the true lengths of the varying oblique lines. This is usually done by drawing a true, length diagram.

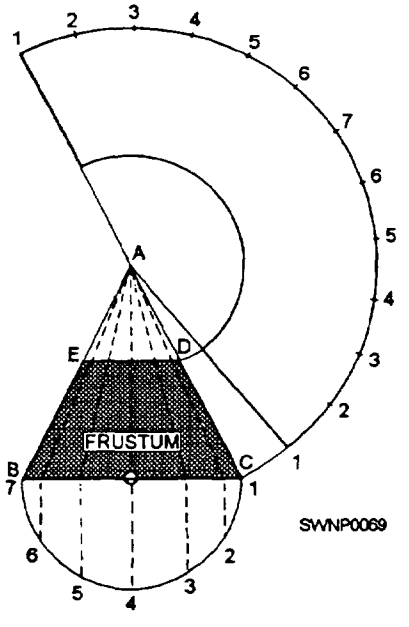


Figure 2-52.—Radial line development of a frustum of a cone.

An example of layout using triangulation is the development of a transition piece.

The steps in the triangulation of a warped transition piece joining a large, square duct and a small, round duct are shown in figure 2-53. The steps are as follows:

1. Draw the top and front orthographic views (view A, fig. 2-53).

2. Divide the circle in the top view into a number of equal spaces and connect the division points with AD (taken from the top part of view D, fig. 2-53) from point A. This completes one fourth of the development. Since the piece is symmetrical, the remainder of the development may be constructed using the lengths from the first part.

It is difficult to keep the entire development perfectly symmetrical when it is built up from small triangles. Therefore, you may check the overall symmetry by constructing perpendicular bisectors of AB, BC, CD, and DA (view E, fig. 2-53) and converging at point O. From point O, swing arcs a and b. Arc a should pass through the numbered points, and arc b should pass through the lettered points.

FABRICATION OF EDGES, JOINTS, SEAMS, AND NOTCHES

There are numerous types of edges, joints, seams, and notches used to join sheet-metal work. We will discuss those that are most often used.

Edges

Edges are formed to enhance the appearance of the work, to strengthen the piece, and to eliminate the cutting hazard of the raw edge. The kind of edge that you use on any job will be determined by the purpose, by the sire, and by the strength of the edge needed.

The SINGLE-HEM EDGE is shown in figure 2-54. This edge can be made in any width. In general, the heavier the metal, the wider the hem is made. The allowance for the hem is equal to its width (W in fig. 2-54).

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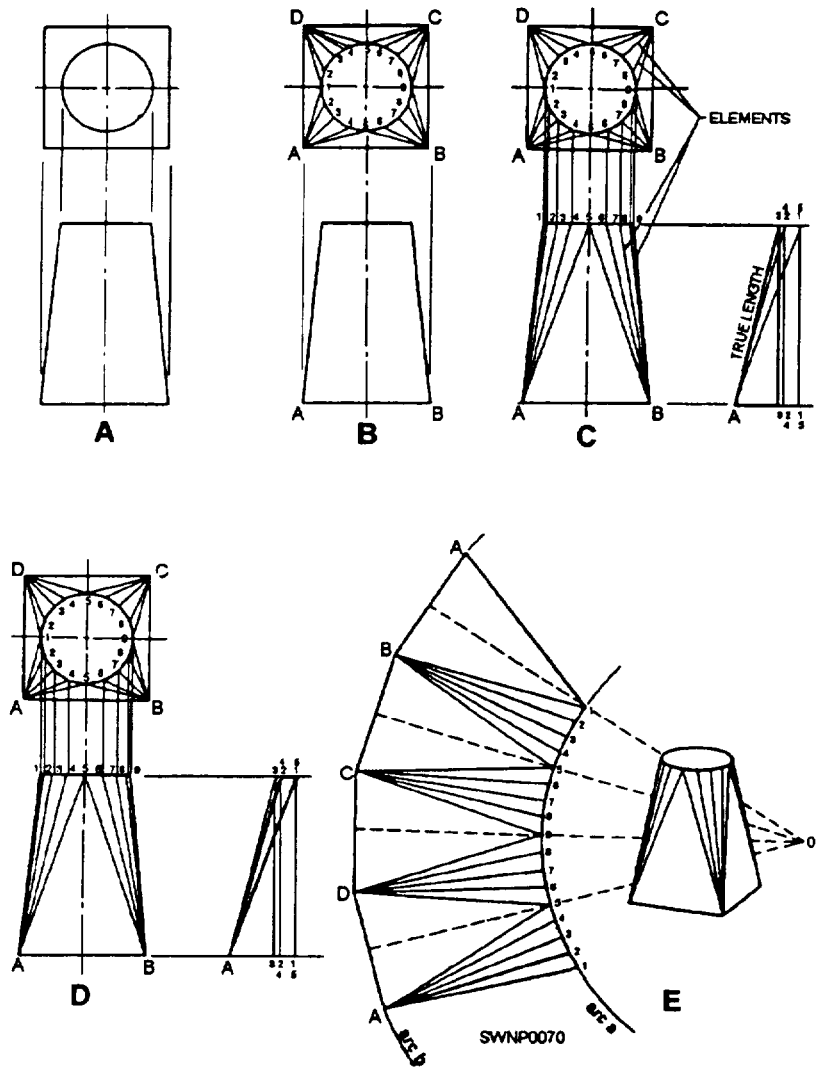


Figure 2-53.—Traingular development of a transition piece.

The DOUBLE-HEM EDGE (fig. 2-55) is used when added strength is needed and when a smooth edge is required inside as well as outside. The allowance for the double-hem edge is twice the width of the hem.

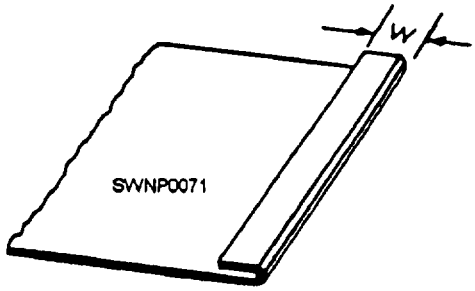


Figure 2-54.—Single-hem edge.

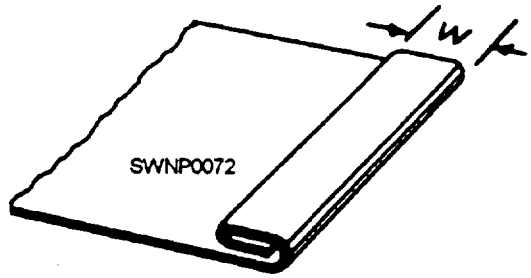


Figure 2-55.—Double-hem edge

A WIRE EDGE (fig. 2-56) is often specified in the plans, Objects, such as ice-cube trays, funnels, garbage pails, and other articles, formed from sheet metal are fabricated with wire edges to strengthen and stiffen the jobs and to eliminate sharp edges, The

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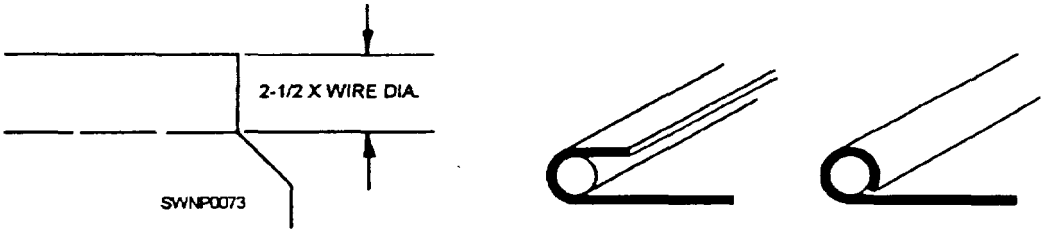


Figure 2-56.—Development of a truncated cylinder.



Figure 2-57.—Making a grooved seam joint.

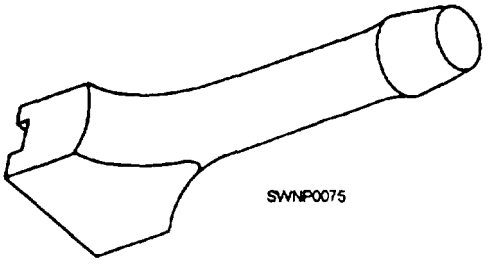


Figure 2-58.—Hand groover.

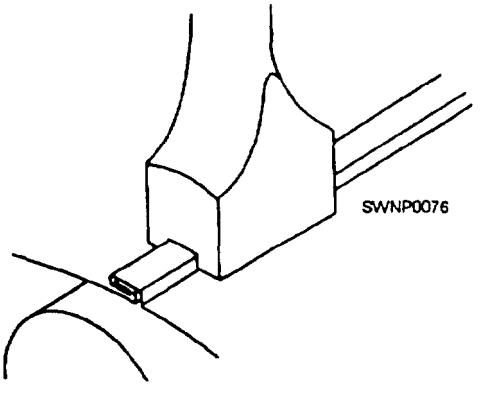


Figure 2-59.—Locking a grooved seam with a hand groover.

allowance for a wire edge is 2 1/2 times the diameter of the wire used As an example, you are using wire that has a diameter of 1/8 inch. Multiply 1/8 by 2 1/2 and your answer will be 5/16 inch, which you will allow when laying out sheet metal for making the wire edge.

Joints

The GROOVED SEAM JOINT (fig. 2-57) is one of the most widely used methods for joining light- and medium-gauge sheet metal. It consists of two folded edges that are locked together with a HAND GROOVER (fig. 2-58).

When making a grooved seam on a cylinder, you fit the piece over a stake and lock it with the hand groover (fig. 2-59). The hand groover should be approximately 1/16 inch wider than the seam. Lock the seam by making prick punch indentions about 1/2 inch in from each end of the seam.

The CAP STRIP SEAM (fig. 2-60, view A) is often used to assemble air-conditioning and heating ducts. A variation of the joint, the LOCKED CORNER SEAM (fig. 2-60, view B), is widely accepted for the assembly of rectangular shapes.

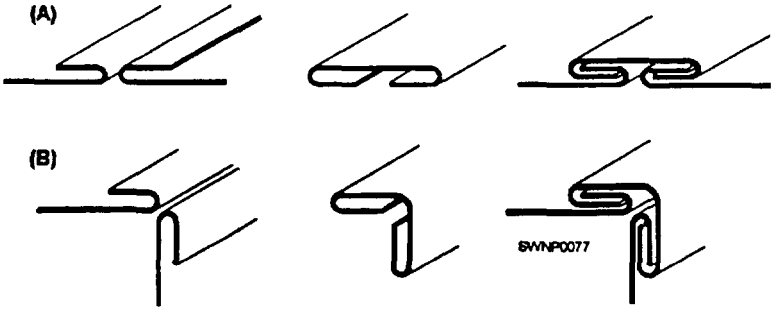


Figure 2-60.—(A) Cap strip seam, (B) Locked corner seam

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A DRIVE SLIP JOINT is a method of joining two flat sections of metal. Figure 2-61 is the pattern for the drive slip. End notching and dimensions vary with application and area practice on all locks, seams, and edges.

"S" joints are used to join two flat surfaces of metal. Primarily these are used to join sections of rectangular duct. These are also used to join panels in air housings and columns.

Figure 2-62 shows a flat "S" joint. View A is a pattern for the "S" cleat. View B is a perspective view of the two pieces of metal that form the flat "S" joint. In view C, note the end view of the finished "S" joint.

Figure 2-63 shows a double "S" joint. View B is the pattern for the double "S" cleat. View A is one of two pieces of metal to be joined. Note the cross section of a partially formed cleat and also the cross section of the finished double "S" joint. his is a variation of

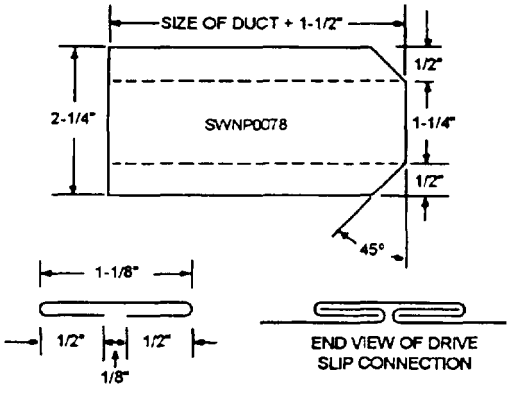


Figure 2-61.—Drive slip pattern and connections

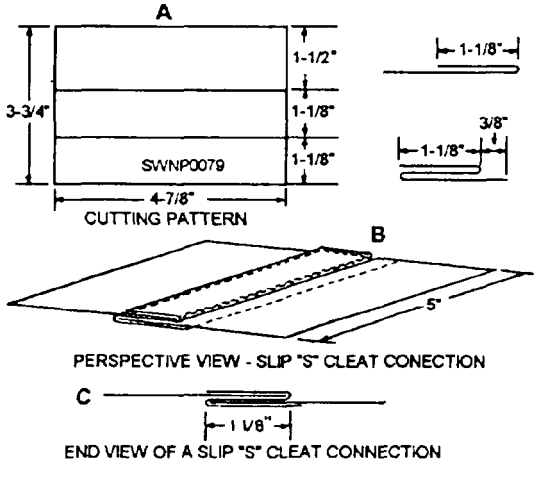


Figure 2-62.—"S" joint or slip pattern and connections.

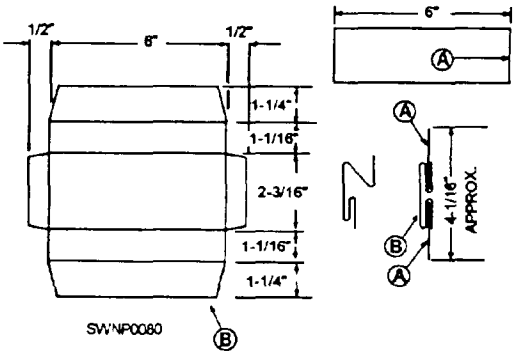


Figure 2-63.—Double "S' joint (cleat) pattern.

the simple flat "S" and it does not require an overlap of metals being joined.

Figure 2-64 shows a standing "S" joint. View B is the pattern for the standing "S" cleat. View A is one of the two pieces of metal to be joined. Note the cross section of the finished standing "S" cleat and standing "S" joint.

Seams

Many kinds of seams are used to join sheet-metal sections. Several of the commonly used seams are shown in figure 2-65. When developing the pattern, ensure you add adequate material to the basic dimensions to make the seams. The folds can be made by hand; however, they are made much more easily on a bar folder or brake. The joints can be finished by soldering and/or riveting.

When developing sheet-metal patterns, ensure you add sufficient material to the base dimensions to make the seams. Several types of seams used to join sheet-metal sections are discussed in this section.

There are three types of lap seams: the PLAIN LAP seam, the OFFSET LAP seam, and the CORNER LAP seam (fig. 2-66). Lap seams can be joined by drilling and riveting, by soldering, or by both riveting and soldering. To figure the allowance for a lap seam, you must first know the diameter of the rivet that you plan to use. The center of the rivet must be set in from the edge a distance of 2 1/2 times its diameter; therefore, the allowance must be five times the diameter of the rivet that you are using. Figure 2-67 shows the procedure for laying out a plain lap and a comer lap for seaming with rivets (d represents the diameter of the rivets). For comer seams, allow an additional one sixteenth of an inch for clearance.

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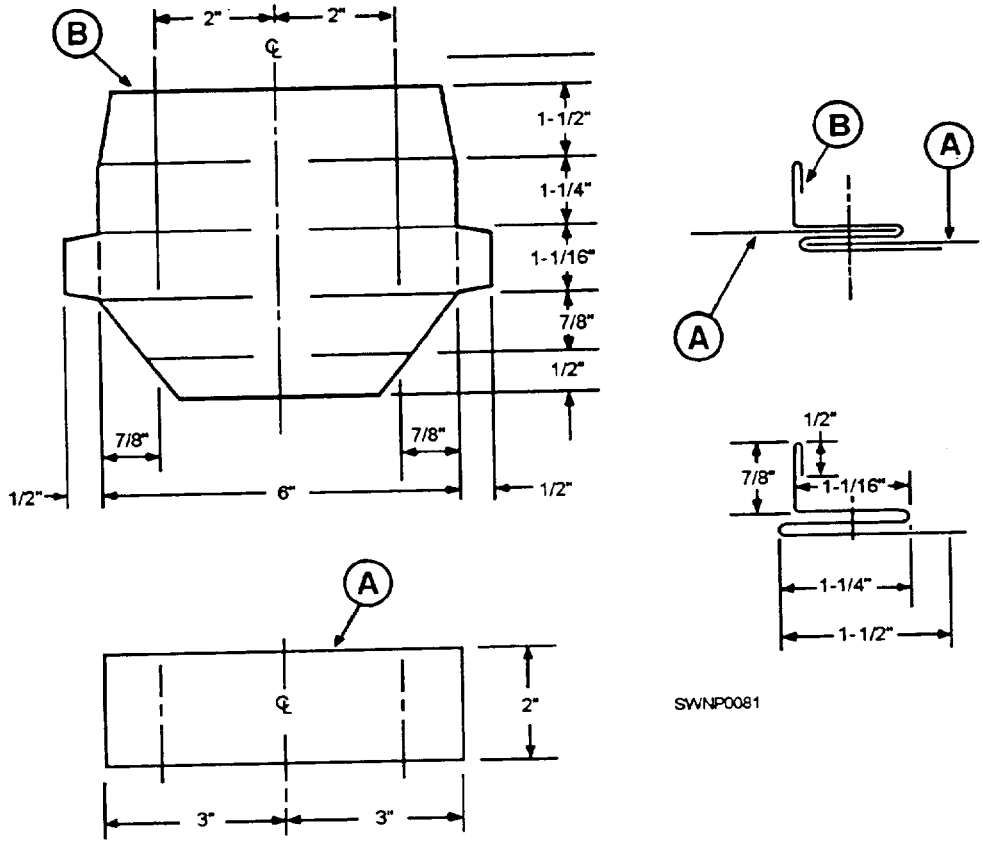


Figure 2-64.—Standing "S" cleat pattern.

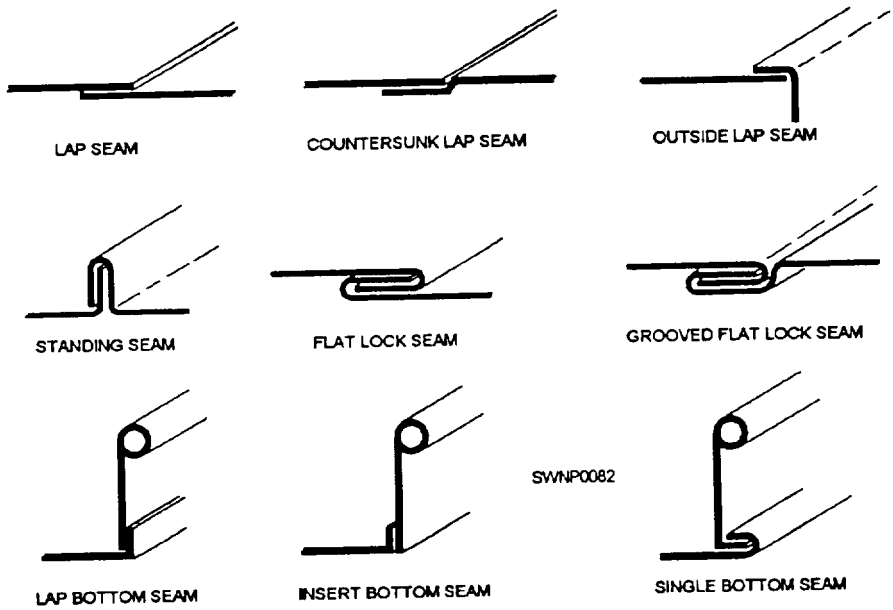


Figure 2-65.—Common sheet-metal seams.

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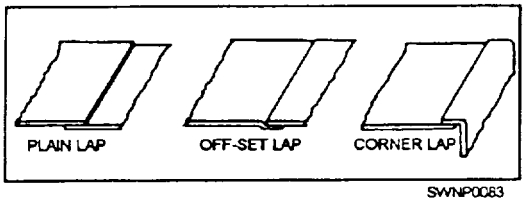


Figure 2-66.—Lap seams

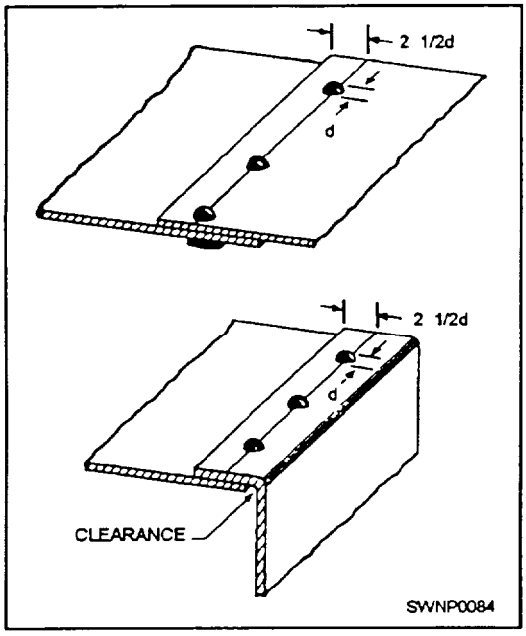


Figure 2-67.—Layout of lap seams for riveting.

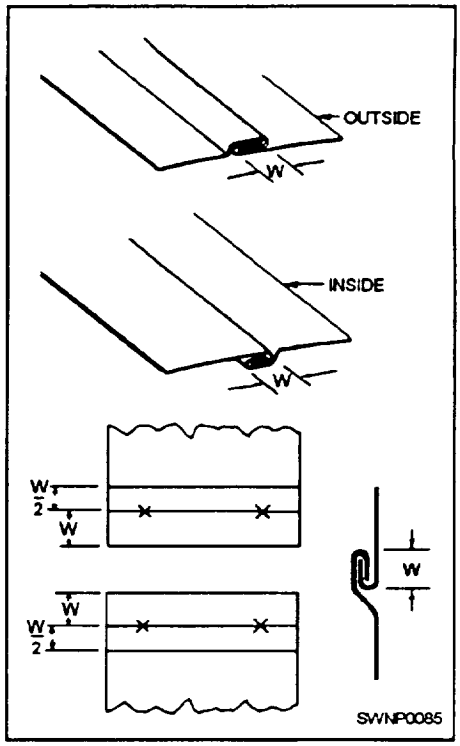


Figure 2-68.—Grooved seams

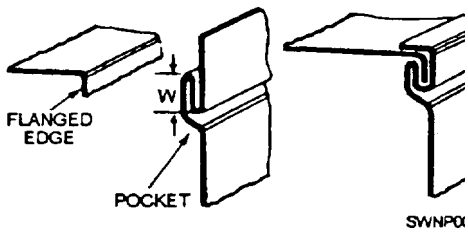


Figure 2-69.—Pittsburgh lock seam.

GROOVED SEAMS are useful in the fabrication of cylindrical shapes. There are two types of grooved seams-the outside grooved seam and the inside grooved seam (fig. 2-68). The allowance for a grooved seam is three times the width (W in fig. 2-68) of the lock, one half of this amount being added to each edge. For example, if you are to have a 1/4-inch grooved seam, 3 x 1/4 = 3/4 inch, or the total allowance; 1/2 of 3/4 inch = 3/8 inch, or the allowance that you are to add to each edge.

The PITTSBURGH LOCK SEAM (fig. 2-69) is a comer lock seam. Figure 2-69 shows a cross section of the two pieces of metal to be joined and a cross section of the finished seam. This seam is used as a lengthwise seam at comers of square and rectangular pipes and elbows as well as fittings and ducts. This seam can be made in a brake but it has proved to be so universal in use that special forming machines have been designed and are available. It appears to be quite complicated, but like lap and grooved seams, it consists of only two pieces. The two parts are the flanged, or single, edge and the pocket that forms the lock The pocket is formed when the flanged edge is inserted into the pocket, and the extended edge is turned over the inserted edge to complete the lock. The method of assembling and locking a Pittsburgh seam is shown in figures 2-70 and 2-71.

The allowance for the pocket is W + W + 3/16 inch. W is the width or depth of the pocket. The width of the flanged edge must be less than W. For example, if you are laying out a 1/4-inch Pittsburgh leek seam (fig. 2-72), your total allowance should be 1/4 + 1/4 + 3/16 inch, or 11/16 inch for the edge on which you are laying out the pocket and 3/16 inch on the flanged edge.

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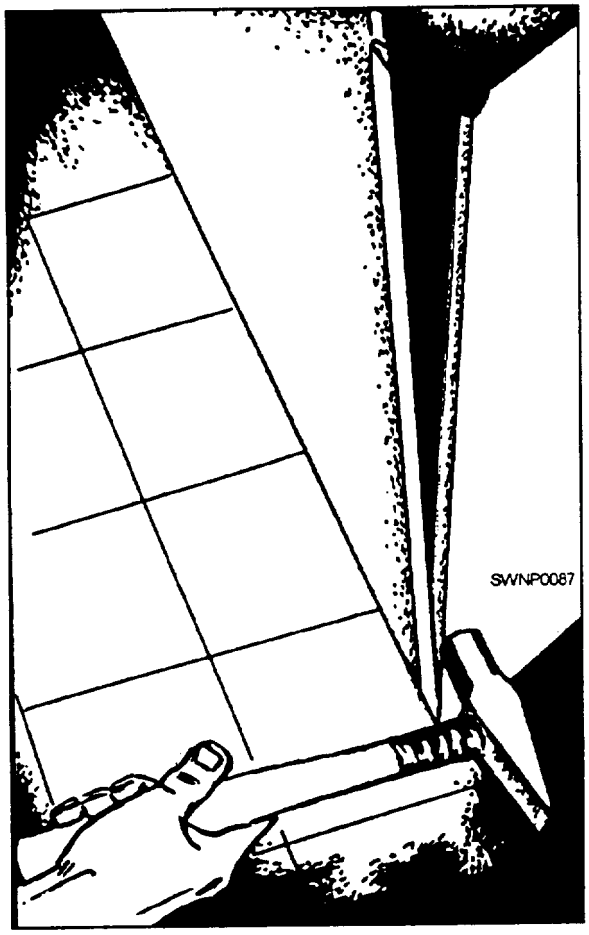


Figure 2-70.—Assembly of a Pittsburgh lock seam

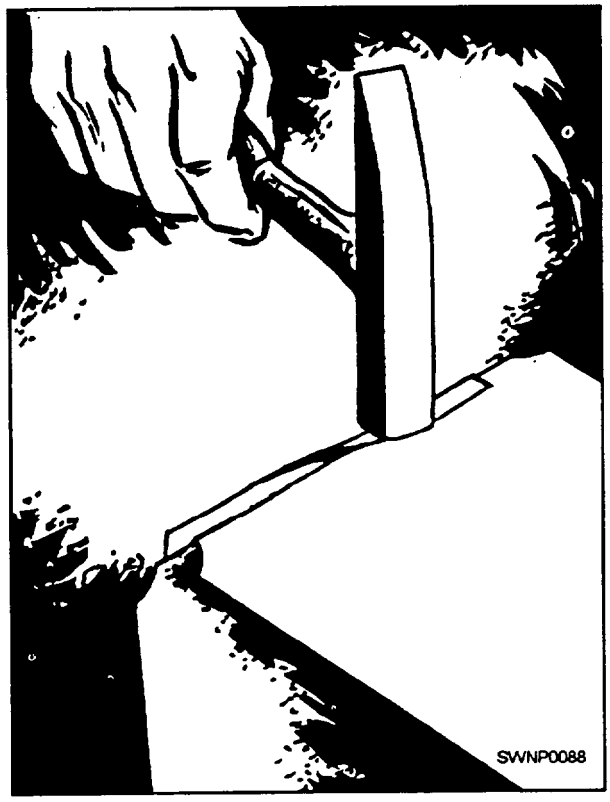


Figure 2-71.—Closing a Pittsburgh lock seam

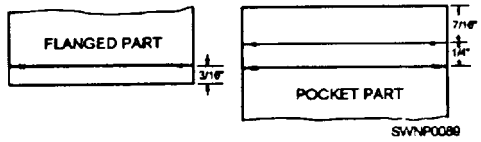


Figure 2-72.—Layout of a 1/4-inch Pittsburgh lock seam.

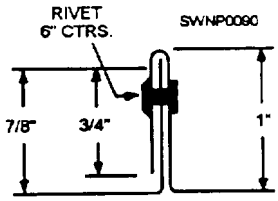


Figure 2-73.—Cross section of a standing seam.

STANDING SEAMS are used for joining metals where extra stiffness is needed, such as roofs, air housing, ducts, and so forth. Figure 2-73 is a cross section of the finished standing seam. Dimensions and rivet spacing will vary with application.

Standing seams used when stiffening is required are as follows: The SPREADER DRIVE CAP, the POCKET SLIP, and the GOVERNMENT LOCK (fig. 2-74) are seams frequently used in large duct construction where stiffeners are required.

The DOVETAIL SEAM is used mainly to join a round pipe/fitting to a flat sheet or duct. This seam can be made watertight by soldering. Figure 2-75 shows the pattern for forming a dovetail seam and an example of its use.

Notches

Notching is the last but not the least important step to be considered when you are getting ready to lay out a job. Before you can mark a notch, you will have to lay out the pattern and add the seams, the laps, or the stiffening edges. If the patterns are not properly notched, you will have trouble when you start forming, assembling, and finishing the job.

No definite rule for selecting a notch for a job can be given. But as soon as you can visualize the assembly of the job, you will not have any trouble determining the shape and size of the notch required

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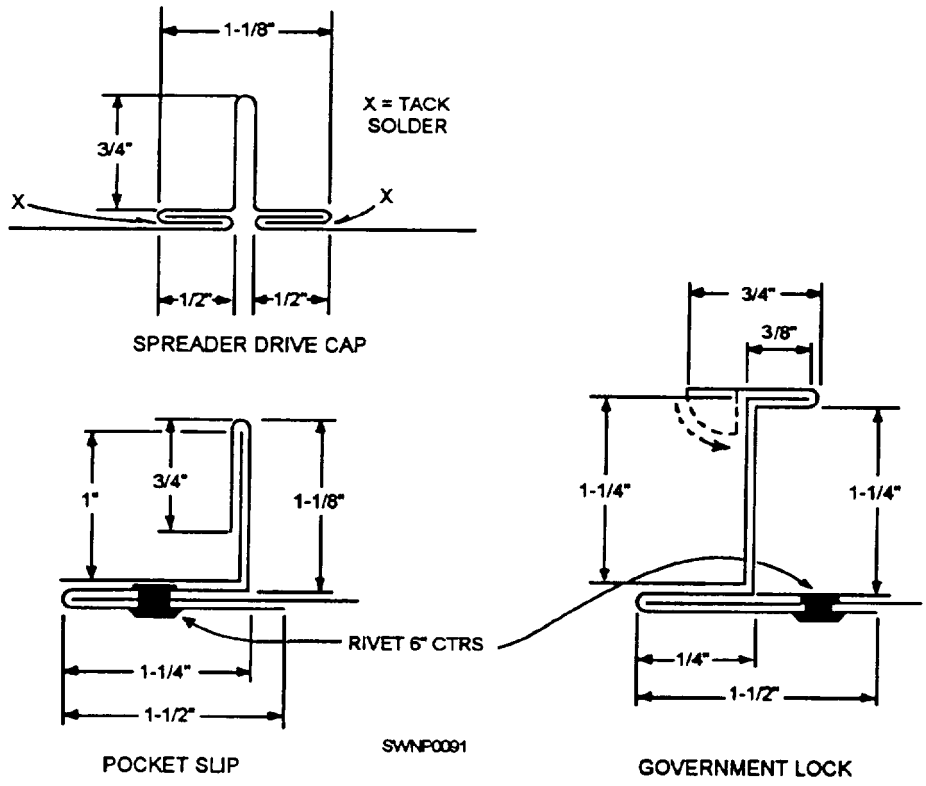


Figure 2-74.—Miscellaneous seam.

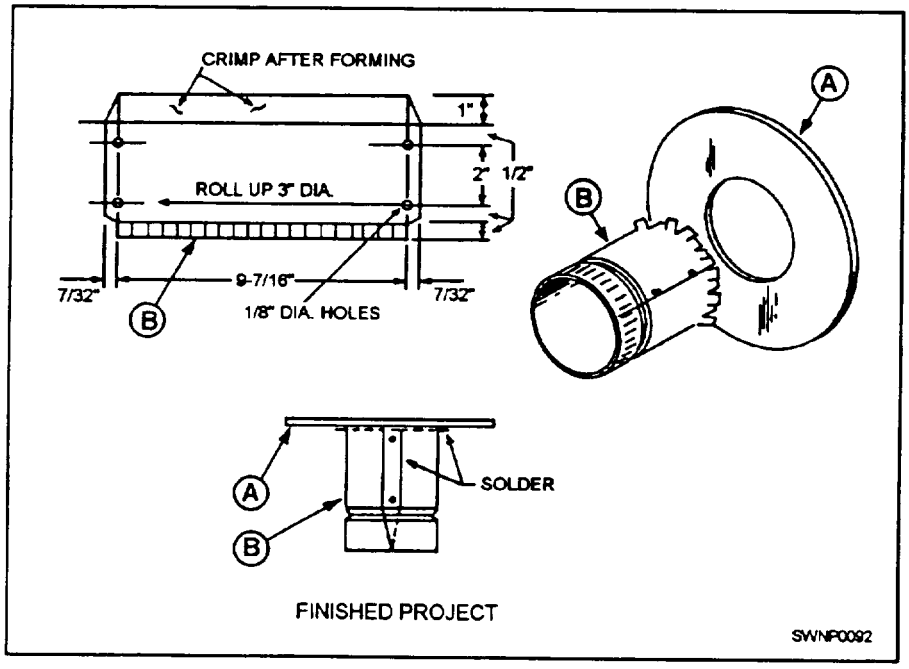


Figure 2-75.—Dovetail lock seam

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for the job. If the notch is made too large, a hole will be left in the finished job. If the notch is too small or not the proper shape, the metal will overlap and bulge at the seam or edge. Do not concern yourself too much if your first notches do not come out as you expected—practice and experience will dictate size and shape.

A SQUARE NOTCH (fig. 2-76) is likely the first you will make. It is the kind you make in your layout of a box or drip pan and is used to eliminate surplus material This type of notch will result in butt comers. Take a look around the shop to see just how many different kinds of notches you can see in the sheet-metal shapes.

SLANT NOTCHES are cut at a 45-degree angle across the comer when a single hem is to meet at a 90-degree angle. Figure 2-77 shows the steps in forming a slant notch.

A V NOTCH is used for seaming ends of boxes. You will also use a full V notch when you have to construct a bracket with a toed-in flange or for similar construction. The full V is shown in figure 2-78.

When you are making an inside flange on an angle of less than 90 degrees, you will have to use a modification of the full V notch to get flush joints. The angle of the notch will depend upon the bend angle. A modified V notch is shown in figure 2-79.

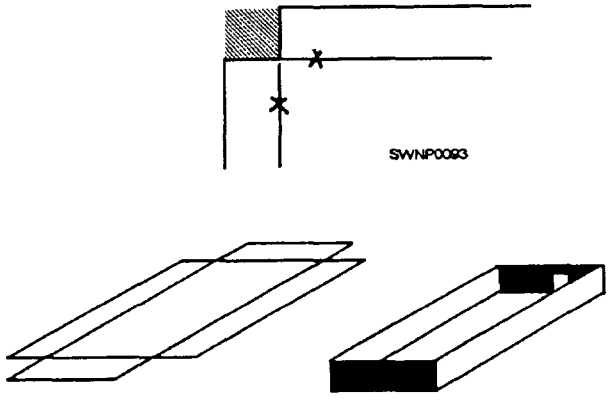


Figure 2-76.—Square notch.

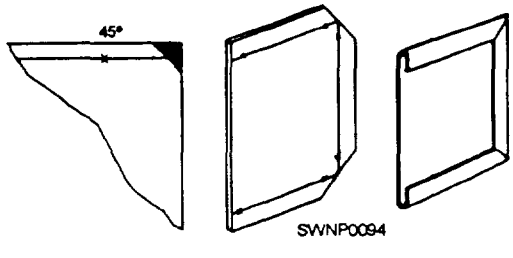


Figure 2-77.—Slant notch.

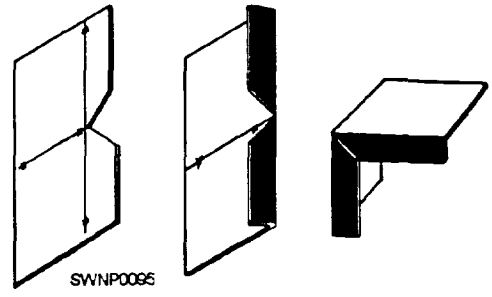


Figure 2-78.—V notch.

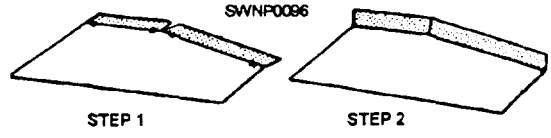


Figure 2-79.—Modified V notch.

A WIRE NOTCH is a notch used with a wire edge. Its depth from the edge of the pattern will be one wire diameter more than the depth of the allowance for the wire edge (2 1/2 d), or in other words, 3 1/2 times the diameter of the wire (3 1/2 d). Its width is equal to 1 1/2 times the width of the seam (1 1/2 w). That portion of the notch next to the wire edge will be straight. The shape of the notch on the seam will depend on the type of seam used, which, in figure 2-80, is 45 degrees for a grooved seam.

Most of your work will require more than one type of notch, as shown in figure 2-80, where a wire notch was used in the forming of a cylindrical shape joined by a grooved seam. In such a layout, you will have to notch for the wire edge and seam.

JOINING AND INSTALLING SHEET-METAL DUCT

After the sheet metal has been cut and formed, it has to be joined together. Most sheet-metal seams are locked or riveted but some will be joined by torch brazing or soldering. Lock seams are made primarily by the forming processes that have already been given.

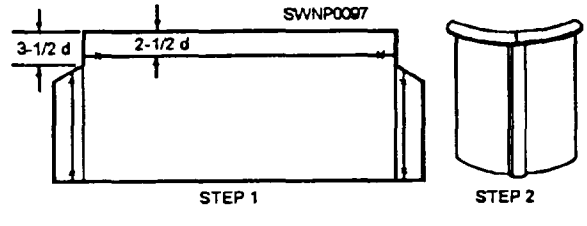


Figure 2-80.—Wire notch in a cylindrical layout.

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Torch brazing and soldering are discussed in *Steelworker,* volume 1, chapter 6. This section deals only with joining sheet-metal seams by either metal screws or rivets.

METAL SCREWS

Different types of metal screws are available for sheet-metal work. The most common type in use is the MACHINE SCREW. Machine screws are normally made of brass or steel. They will have either a flathead or a roundhead and are identified by their number size, threads per inch, and length; for example, a 6 by 32 by 1 inch screw indicates a number 6 screw with 32 threads per inch and 1 inch in length.

SELF-TAPPING SHEET-METAL SCREWS are another common type of screw. Most screws of this type will be galvanized and are identified by their number size and length. These screws form a thread as they are driven (fig. 2-81), as the name implies.

THREAD-CUTTING SCREWS (fig. 2-82) are different from self-tapping screws in that they actually cut threads in the metal. They are hardened and are used to fasten nonferrous metals and join heavy gauge sheet metal.

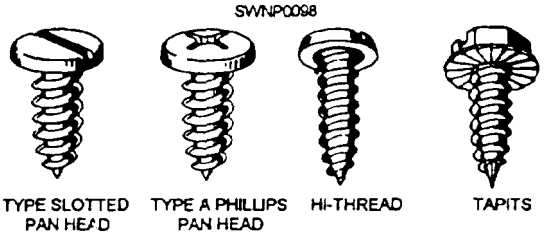


Figure 2-81.—Self-tapping sheet-metal screws

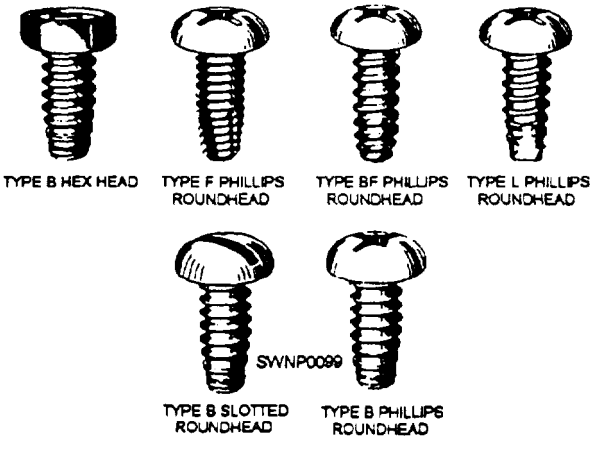


Figure 2-82.—Thread-cutttng screws.

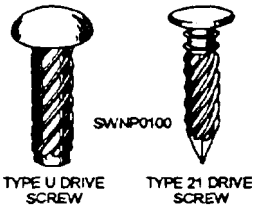


Figure 2-83.—Drive screws.

DRIVE SCREWS (fig. 2-83) are simply hammered into a drilled or punched hole of the proper size to make a permanent fastening.

RIVETS

Rivets are available in many different materials, sizes, and types. Rivets, made of steel, copper, brass, and aluminum, are widely used. Rivets should be the same material as the sheet metal that they join.

TINNERS' RIVETS of the kind shown in figure 2-84 are used in sheet-metal work more than any other type of rivet. Tinners' rivets vary in size from the 8-ounce rivet to the 16-pound rivet. This size designation signifies the weight of 1,000 rivets. If 1,000 rivets weigh 8 ounces, each rivet is called an 8-ounce rivet. As the weight per 1,000 rivets increases, the diameter and length of the rivets also increase. For example, the 8-ounce rivet has a diameter of 0.089 inch and a length of 5/32 inch, while the 12-pound rivet has a diameter of 0.259 inch and a length of 1/2 inch. For special jobs that require fastening several layers of metal together, special rivets with extra, long shanks are used. Table 2-1 is a guide for selecting rivets of the proper size for sheet-metal work.

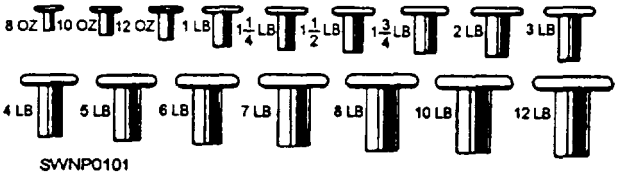


Figure 2-84.—Tinners' rivets.

Table 2-1.—Guide for Selecting Rivet Size for Sheet-Metal Work

Gauge of sheet metal	Rivet size (weight in pounds per 1,000 rivets)
26	1
24	2
22	2 1/2
20	3
18	3 1/2
16	4

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When you are joining sheet metal that is greater than two thicknesses, remember that the shank of the rivet should extend 1 1/2 times the diameter of the rivet. This will give you adequate metal to form the head.

Rivet spacing is given on the blueprint or drawing you are working from. If the spacing is not given, space the rivets according to the service conditions the seam must withstand. For example, if the seam must be watertight, you will need more rivets per inch than is required for a seam that does not have to be watertight. No matter how far apart the rivets are, there must be a distance of 2 1/2 times the rivet diameter between the rivets and the edge of the sheet. This distance is measured from the center of the rivet holes to the edge of the sheet.

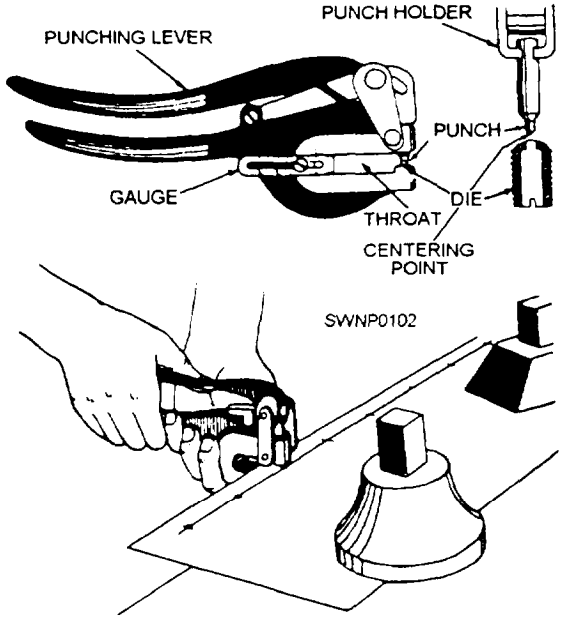


Figure 2-85.—Hand punch.

After you have determined the size and spacing of the rivets, mark the location of the centers of the rivet holes. Then make the holes by punching or by drilling. If the holes are located near the edge of the sheet, a hand punch, similar to the one shown in figure 2-85, can be used to punch the holes. If the holes are farther away from the edge, you can use a deep-threaded punch (either hand operated or power driven) or you can drill the holes. The hole must be slightly larger than the diameter of the rivet to provide a slight clearance.

Riveting involves three operations-drawing, upsetting, and heading (fig. 2-86). A rivet set and a riveting hammer are used to perform these operations. The method for riveting sheet metal follows:

1. Select a rivet set that has a hole slightly larger than the diameter of the rivet.

2. Insert the rivets in the holes and rest the sheets to be joined on a stake or on a solid bench top with the rivet heads against the stake or bench top.

3. Draw the sheets together by placing the deep hole of the rivet set over the rivet and striking the head of the set with a riveting hammer. Use a light hammer for small rivets, a heavier hammer for larger rivets.

4. When the sheets have been properly drawn together, remove the rivet set. Strike the end of the rivet LIGHTLY with the riveting hammer to upset the end of the rivet. Do not strike too hard a blow, as this would distort the metal around the rivet hole.

5. Place the heading die (dished part) of the rivet set over the upset end of the rivet and form the head. One or two hammer blows on the head of the rivet set will be enough to form the head on the rivet.

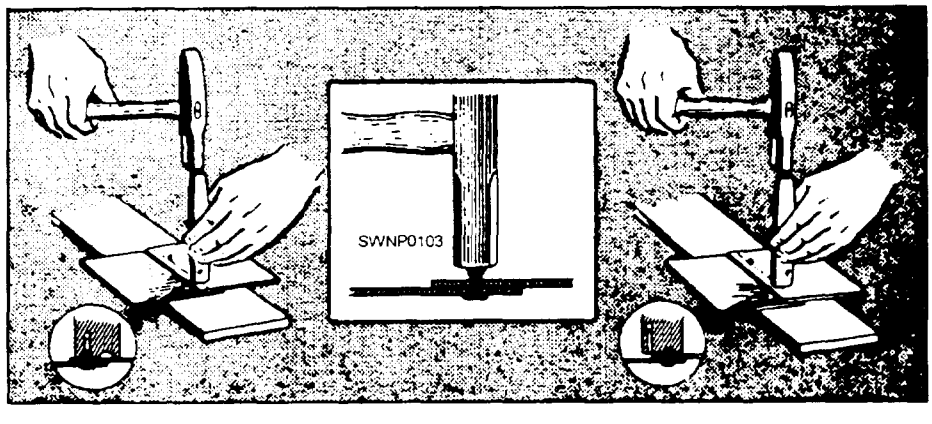


Figure 2-86.—Drawing, upsetting, and heading a rivet.

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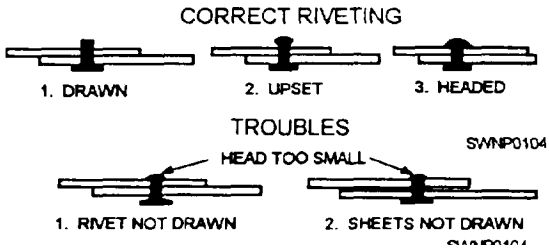


Figure 2-87.—Correct and incorrect riveting.

A correctly drawn, upset, and headed rivet is shown in the top part of figure 2-87. The lower part of this figure shows the results of incorrect riveting.

An addition to sheet-metal rivets are the pop rivets shown in figure 2-88. These pop rivets are high-strength, precision-made, hollow rivets assembled on a solid mandrel that forms an integral part of the rivet. They are especially useful for blind fastening-where there is limited or no access to the reverse side of the work.

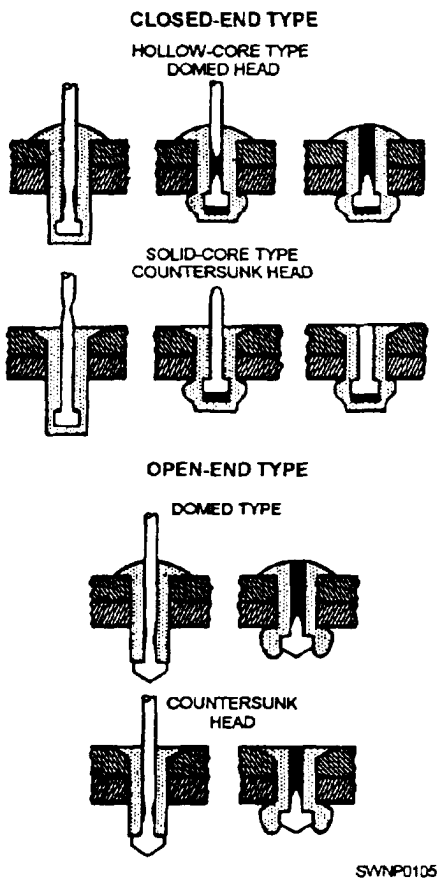


Figure 2-88.—Pop rivets.

Pop rivets provide simplicity and versatility. 'hey are simple and easy to use in complicated installations. Expensive equipment or skilled operators are not required. Just drill a hole, insert, and set the pop rivet from the same side, and high riveting quality and strength are easily and quickly accomplished.

Two basic designs of pop rivets are used: closed end and open end. The closed-end type fills the need for blind rivets that seal as they are set. They are gastight and liquidtight, and like the open-end type, they are installed and set from the same side. As the rivet sets, a high degree of radial expansion is generated in the rivet body, providing effective hole-filing qualities.

The open-end type of pop rivet resembles a hollow rivet from the outside. Because the mandrel head stays in the rivet body, the mandrel stem seals to a certain degree, but it is not liquidtight.

Figure 2-89 shows two of the tools used for setting the pop rivets. These tools are lightweight and very easily used. For example, when using the small hand tool, you need only to insert the mandrel of the rivet in the nosepiece, squeeze the handle (usually three times), and the rivet is set. To operate the scissors-type tool, fully extend the lever linkage or gatelike mechanism and insert the rivet mandrel into the nosepiece of the tool. Insert the rivet into the piece being riveted. Apply firm pressure to the tool, ensuring that the nosepiece remains in close contact with the rivet head. Closing the lever linkage retracts the gripping mechanism, which withdraws the mandrel. The rivet is set when the mandrel head breaks.

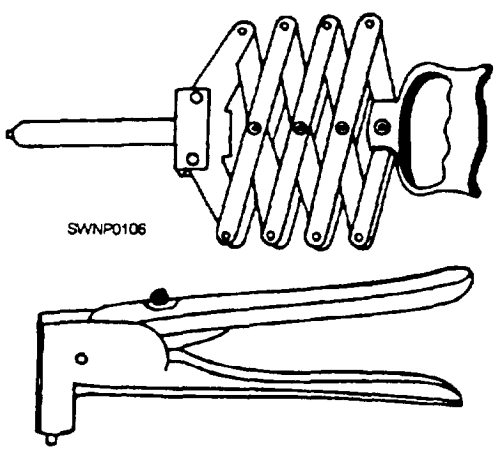


Figure 2-89.—Pop rivet toots.

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Before inserting another rivet in the tool, be sure that the broken mandrel has been ejected from the tool. This can be done by fully extending the lever linkage and allowing the mandrel to fall clear.

The scissors or expandable type of tool is unique because it can reach hard-to-get-at areas and can set the rivets with ease. This tool is particular] y useful for installing ventilation ducting.

RIVETED SEAMS

Riveted seams are used for joining metals and have numerous applications.

Figure 2-90 shows the pattern of one of two pieces to be joined by lap and rivet. Note the cross section of the finished seam.

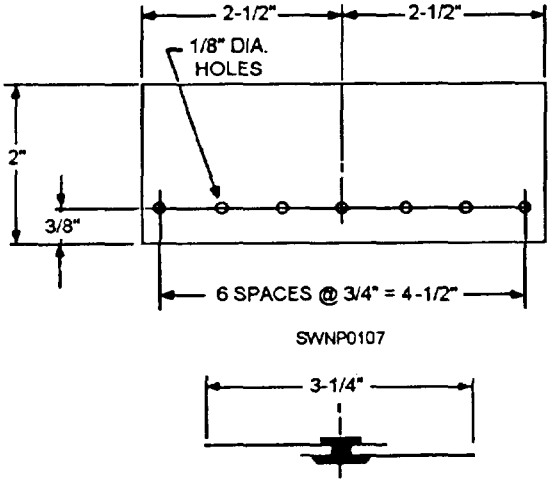


Figure 2-90.—Pattern for riveted lap seam.

Figure 2-91 shows the patterns for constructing a lapped and riveted comer seam. View A is the pattern for one piece and view B is the other. Note the cross section through the completed seam.

Frequent use is made of lapped and riveted seams in joining round pipe sections.

SHEET-METAL DUCT SYSTEMS

With the advent of high-tech equipment, such as computers and other specialized electronic equipment, air-conditioning systems are incorporated more than ever into many Naval Construction Force (NCF) construction projects. Many of the structures are designed for long-life usage instead of temporary buildings with a short time use. There are also some advanced base functional components (ABFC) which incorporate heating, ventilating, and air-conditioning systems (HVAC) within the facility design.

HVAC systems require close coordination between ratings. Air conditioning, air handling, and heating units are normally installed by an Utilitiesman, and the electrical connections are accomplished by a Construction Electrician. These items must be installed before the ductwork installation phase begins. The Steelworker must also coordinate with the Builder assigned to the project to ensure that all openings in walls and floors are sufficient to accommodate ducts, diffusers, and vents.

Sheet-metal HVAC systems require knowledgeable workers to fabricate and install the various ducts and

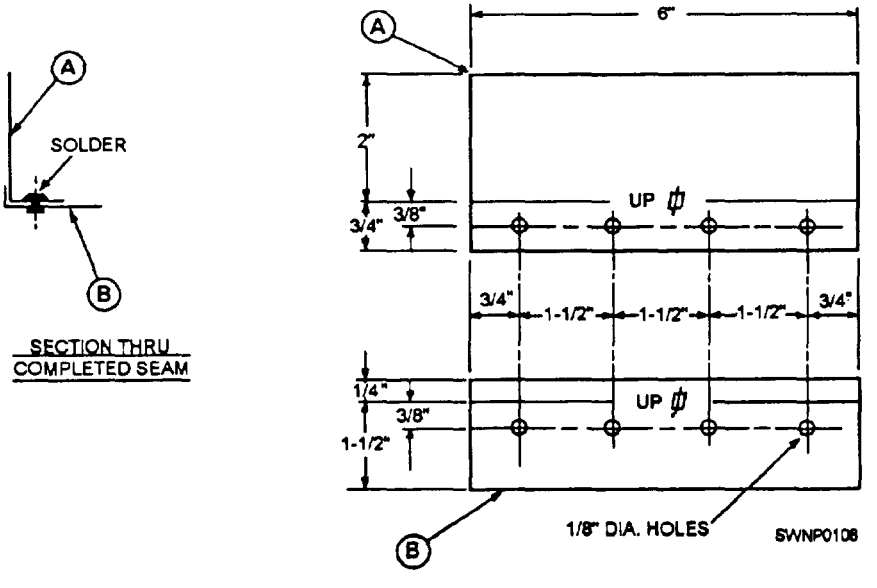


Figure 2-91.—Riveted seam for tapped and riveted corner seam.

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fittings needed in a complete heating, ventilating, and air-conditioning system. The Steelworker must be very versatile because the most difficult part of sheet-metal work is the installation of a product that has been built in a shop and is installed on a site at a later time.

All of the variables and problems that occur during the installation process cannot be covered here; however, this section will cover some of the different hanging and connecting systems used by the sheet-metal worker. The type of connecting system used depends upon where the duct system is installed, its size, how many obstructions there are, and also, what type of structure the system is hanging from or connected to.

SHOP PROCEDURES

The small sheet metal shops in the NCF or in a Public Works Department are normally tasked with single fabrication jobs for an NCF project or small repair projects. These shops usually employ a small number of Steelworkers as part of a multi-shop environment. The senior Steelworker assigned to a shop is tasked with the plan development and estimating of materials. The layout Steelworker makes up most of the fittings in the shop and is responsible for stockpiling patterns and tracings on standard fittings used for sheet-metal duct systems.

NOTE: You should fabricate an entire job at the shop, rather than deliver an incomplete system to the jobsite.

SHOP DRAWINGS

A shop drawing is a plan view or an elevation view of a fitting, duct, or other object that is drawn either by the freehand sketch method or by using drafting instruments. It maybe useful to get assistance from an Engineering Aid for complex duct systems or fittings. One of the better methods is to draw a complete set of standard fittings and then add the required dimensions to fit the job.

The dimensions shown on the views of a shop drawing are finished dimensions. Once the finished dimensions have been determined, one-half inch must be added to each end to obtain the raw size of the pattern. This dimension produces a cut size dimension. The type of material, gauge number, and type of seam may be added to the shop drawing if desired. Usually these are specified on the drawings and on the pattern sheets.

DUCT MATERIAL

Metal sheets, wire, band iron, and angle iron are the most widely used materials in sheet-metal fabrication. The types of metal sheets are plain, flat sheets and ribbed sheets or corrugated sheets. The sheets are made of such materials as black iron, galvanized iron, tin plate, copper, aluminum, stainless steel, or Monel. Galvanized and black iron sheets are the most commonly used material in sheet-metal work.

The thickness of a sheet is designated by a series of numbers called gauges. Iron and steel sheets are designated by the U.S. standard gauge which is the accepted standard in the United States.

REINFORCEMENT AND SUPPORT

The recommended gauge thicknesses of sheet metal used in a standard ventilating and air-conditioning system with normal pressure and velocities are shown in table 2-2. Where special rigidity or stiffness is required, ducts should be constructed of metal two gauges heavier than those given in the table. All insulated ducts 18 inches or greater on any flat side should be cross broken, as shown in figure 2-92. Cross breaking maybe omitted if the duct is insulated with approved rigid type of insulation and sheet metal two gauges heavier is used.

The maximum length of any section of ductwork will not exceed 7 feet 10 inches; this measurement allows individual sections to be fabricated from an 8-foot sheet of metal with a 2-inch allowance for connection tabs. If lengths of 7 feet 10 inches are considered too long for a specific job, it is recommended that the duct system be constructed with sections of 3-foot 9-inch multiples.

Many duct systems run into unplanned obstructions, particularly in renovation work, such as electrical connections and wiring, structural members,

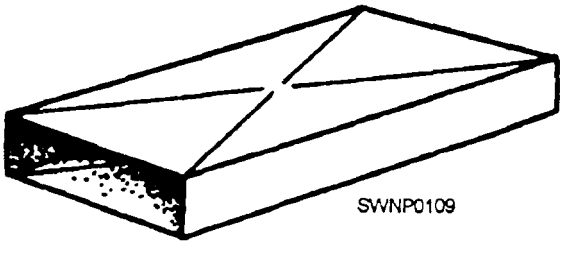


Figure 2-92.—Cross-broken flat surfaces

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Table 2-2.—Recommended Gauges for Sheet-Metal Duct Construction

Aluminum B. & S. gauge	Steel U.S. std. gauge	Maximum side, inches	Type of transverse joint connections	Bracing
24	26	up to 12	S-drive, pocket or bar slips, on 7-ft. 10-in. centers	None.
		13 to 24	S-drive, pocket or bar slips, on 7-ft, 10-in. centers.	None.
22	24	25 to 30	S-drive, 1-in. pocket or 1-in. bar slips, on 7-ft. 10-in. centers.	1-× 1-× 1/8-in. angles 4 ft. from joint.
		31 to 40	Drive, 1-in. pocket or 1-in. bar slips, on 7-ft. 10-in. centers.	1-× 1-× 1/8-in. angles 4 ft. from joint.
20	22	41 to 60	1 1/2-in. angle connections, or 1 1/2-in. bar slips with 1 3/8-in. × 1/8-in. bar reinforcing on 7-ft. 10-in. centers.	1 1/2-× 1 1/2-× 1/8-in. angles 4 ft. from joint.
18	20	61 to 60	1 1/2-in. angle connections, or 1 1/2-in. bar slips 3-ft. 9-in. maximum centers with 1 3/8-× 1/8-in. bar reinforcing.	1 1/2-× 1 1/2-× 1/8-in. diagonal angles, or 1 1/2-× 1 1/2-× 1/8-in. angles 2 ft. from joint.
16	18	91 and up	2-in. angle connections or 1 1/2-in. bar slips 3-ft 9-in. maximum centers with 1 3/8- × 1/8-in. bar reinforcing.	1 1/2-× 1 1/2-× 1/8-in. diagonal angles, or 1 1/2-× 1 1/2-× 1/8-in. angles 2 ft. from joint.

and piping systems. These obstructions must be avoided by fabricating the duct system to go around the obstacles. Do NOT run obstructions through duct systems because it creates turbulence that reduces the efficiency of the system. When the obstruction is an electrical obstruction, you should ensure all power is off and safety checked. When running the duct through an obstruction is absolutely unavoidable, the turbulence can be reduced by enclosing the obstruction in a streamlined collar (fig. 2-93).

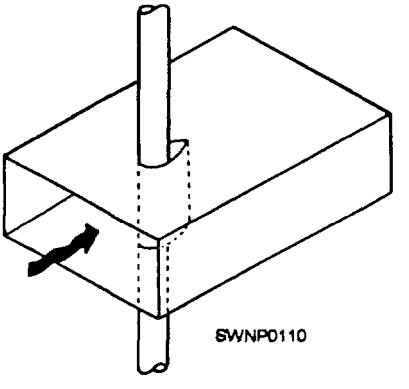


Figure 2-93.—Easement around an obstruction in ducts.

FLEXIBLE CONNECTIONS

Most duct systems are connected to either a heating or a cooling system. These systems are general] y electric motor driven to move air through the duct system. Therefore, all inlet and outlet duct connections to all fans or other equipment that may create vibration should be made with heavy canvas, as shown in figure 2-94.

The most common method of making connections between duct sections and fittings is the method of

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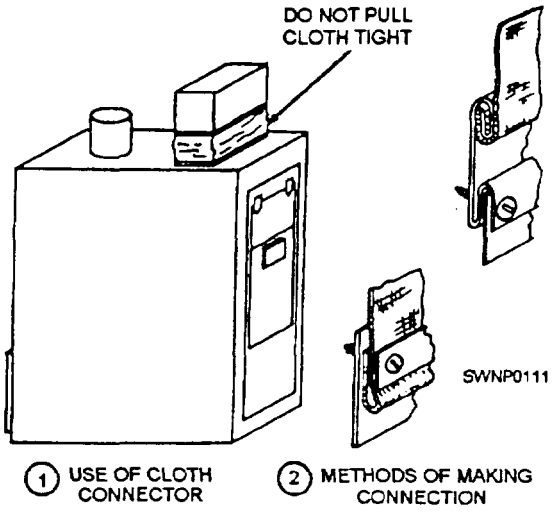


Figure 2-94.—Flexible duct connection.

combining two S slips and two drive slips (fig. 2-95). S slips are first placed on two opposite edges of one of the sections or fittings to be joined. These S slips are applied to the widest dimension of the duct (fig. 2-96). The second section or fitting is then inserted into the slips, and the two sections are held together by inserting drive slips along the opposite sides [fig. 2-97). After the drive slips are driven home, they are locked in place by bending the ends of the drive slip over the comer of the S slips to close the comer and leek the drive slips in place (fig. 2-98), completing the joint shown in figure 2-99.

HANGING DUCT FROM PURLINS OR BEAMS

Most of the ductwork Steelworkers install, modify, or repair are in pre-engineered buildings or repairs to more permanent type of ducting in buildings, such as barracks and base housing.

The most common installation method is hanging the duct from purlins or beams in the hidden area of a

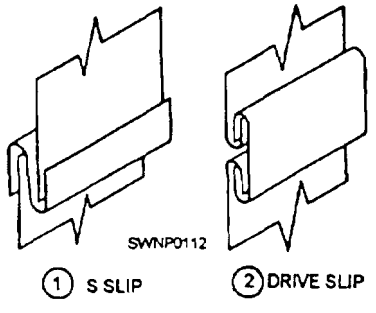


Figure 2-95.—Methods of connecting ducts,

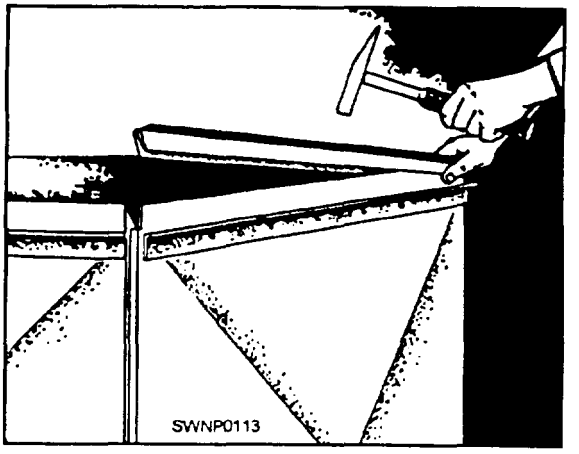


Figure 2-96.—Placing S slips for S-and-drive connection.

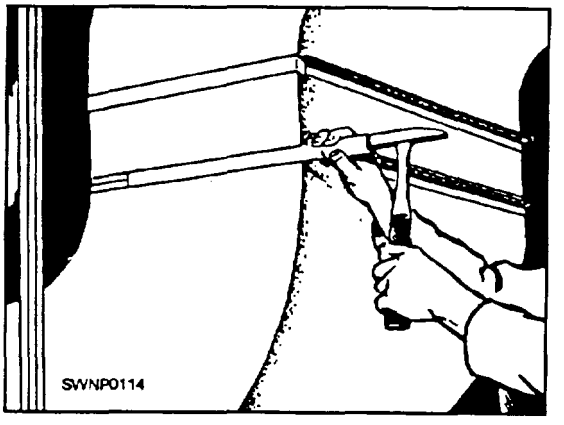


Figure 2-97.—Inserting drive slips.

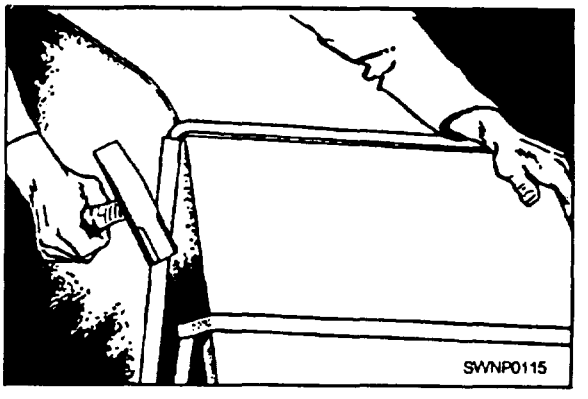


Figure 2-98.—Bending drive slips to complete the Joint.

roof or below a ceiling. Figure 2-100 shows one such system when the duct is running parallel to the structural member. These systems require that angle be installed between the beams so that the hanger straps can be installed on both sides of the duct. Normally, 2-inch by 2-inch by 1/8-inch angle is

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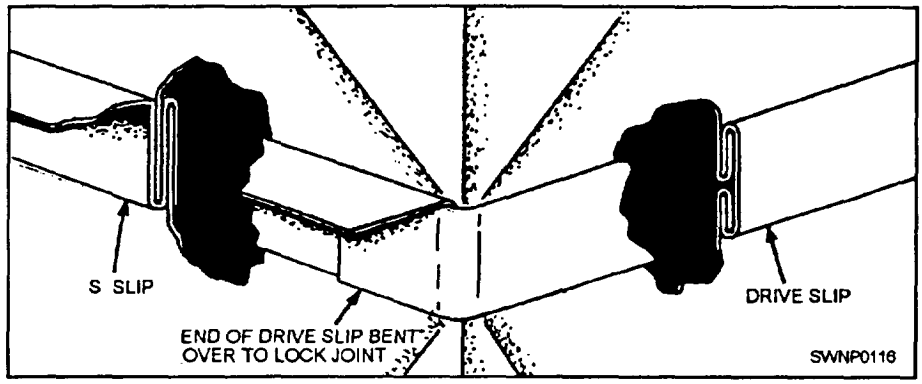


Figure 2-99.—Completed S-and-drive connection.

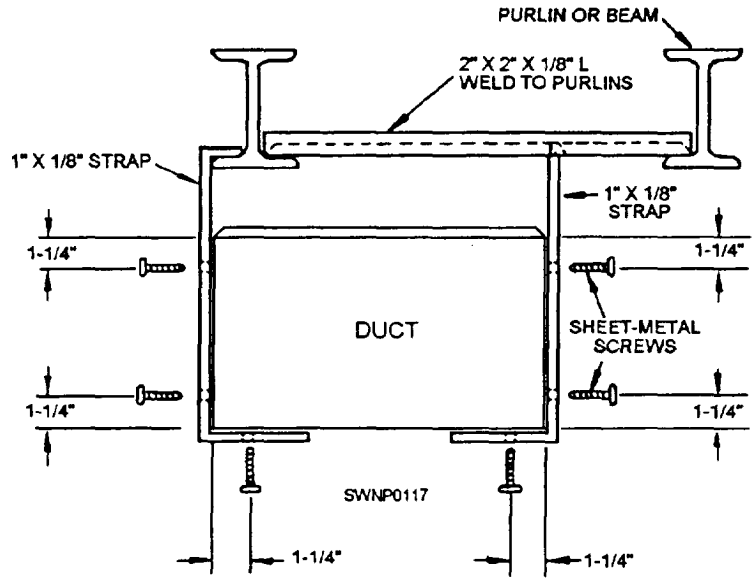


Figure 2-100.—Duct running parallel to purlins or beams.

sufficient. However, if the duct is of a very large size, a larger angle may be required.

The straps that are used as hangers may be fabricated from 1/8-inch plate. In a normal installation, a 1 inch by I/S-inch strap will suffice. All straps must be connected to the ductwork with sheet-metal screws. On all government work, it is required that the screws be placed 1 1/4 inches from all edges, as illustrated in the figure which shows that the duct system hanging from angle rails and that all angles be either bolted or tack-welded to purlins or beams.

Strap hangers may be hung directly on purlins or beams when the duct is running transverse] y or across the purlins or beams, as shown in figure 2-101. However, the strap hangers must be twisted to turn 90

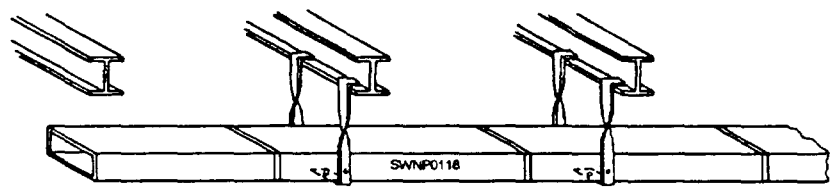


Figure 2-101.—Strap hangers from purlins.

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degrees onto the flange of the beam or purlin. Again, the standard 7 feet 10 inches maximum span required between hangers applies. Also, the hanger screws standard will apply. The hanger span may be shortened to fit the job requirements.

For heavier or larger systems, an installation similar to that shown in figure 2-102 maybe required. This system is hung entirely on angle rails and the straps are fabricated into one-piece units. This system is by far the neatest looking and is normally used when the duct system is exposed.

Installing a duct system under a built-up steel roof (fig. 2-103) is accomplished by hanging the duct system with all-thread bolts and 2-inch by 2-inch by 1/8-inch angles. The all-thread bolt protrudes through the steel decking and is bolted from the top with a large washer and bolt, which extends down alongside the duct into the 2-inch by 2-inch angles which is also bolted from under the angle. This system allows for adjustment of height. Also notice that the all-the ad bolt extends into the top flat of the apex of the steel roof decking. This is required because connecting the all-thread bolt to the bottom valley of the steel deck will reduce the structural strength of the decking and may also cause water leaks.

FIBER-GLASS DUCT SYSTEMS

Throughout the Naval Construction Force (NCF) fiber-glass duct is becoming common on jobsites. It has the advantage of added insulating value, ease of fabrication and handling, as well as installation, and making it useful where traffic and handling/abuse are restricted.

DUCT CHARACTERISTICS

Fiber-glass ducts are manufactured of molded fiber-glass sheets covered with a thin film coating of aluminum, although thin vinyl or plastic coatings are sometimes used. In the NCF, we are primarily concerned with aluminum coated duct. Because it is fabricated of glass fibers, it is inherently insulated; therefore, it is used where insulation is a requirement.

Fiber-glass ducts can be molded into various shapes for special applications. The desired shapes can be ordered from the manufacturer's stock In the NCF, for all but special purposes, the duct is supplied in the flat form of a board that has V grooves cut into the inner surfaces to allow folding to fabricate rectangular sections (fig. 2-104, view A). The ends of the board is molded so when a rectangular/square duct is formed two sections of the same size will fit together in a shiplap joint (fig. 2-104, view C). This joint ensures a tight connection coupled with a positive alignment.

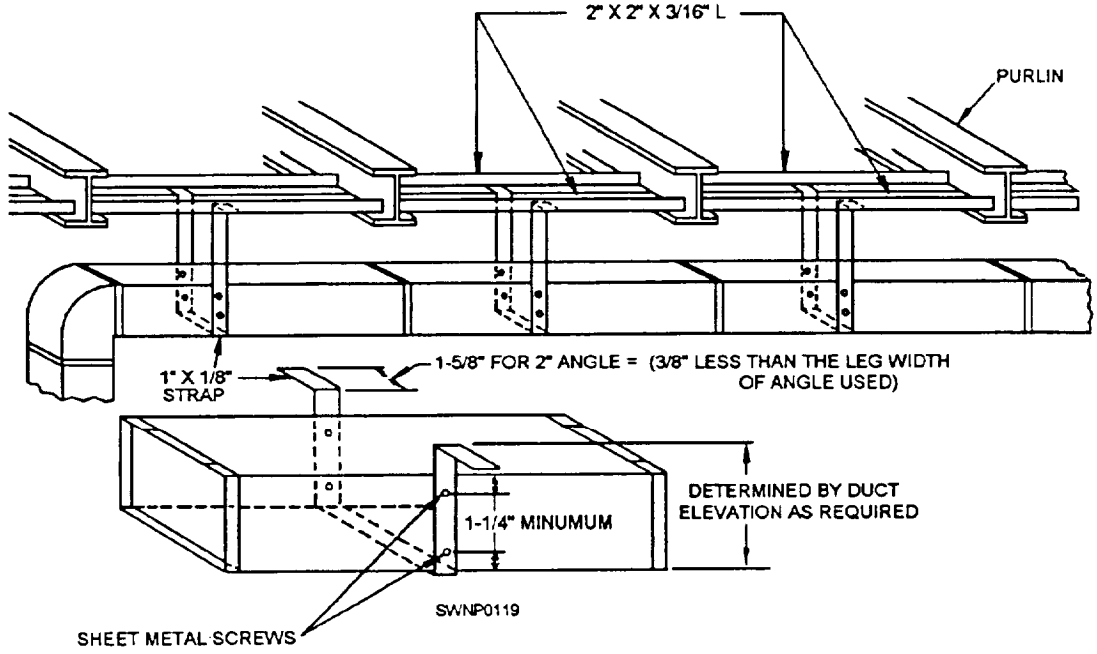


Figure 2-102.—Duct system with strap hangers from angle rails transverse to purlti

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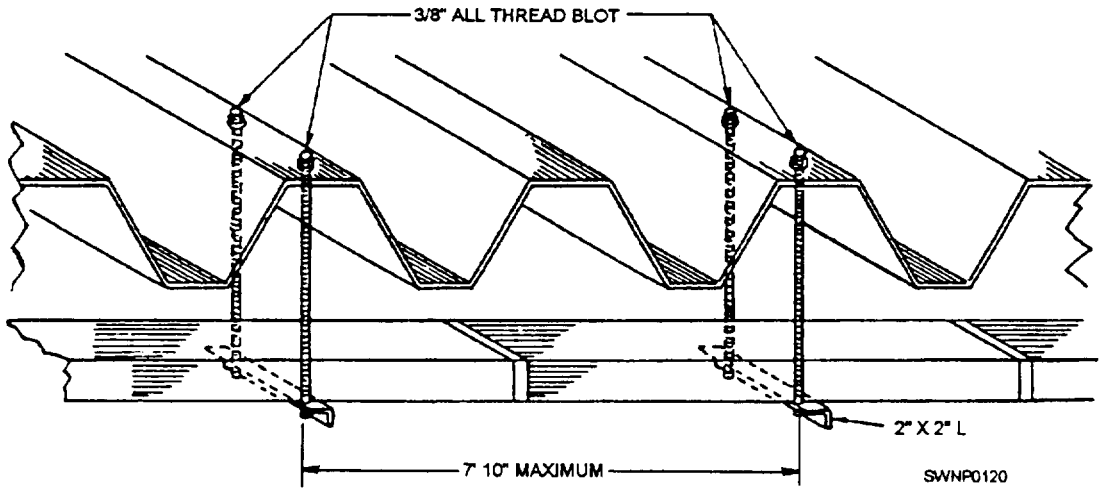


Figure 2-103.—Duct installed to a built-up steel roof.

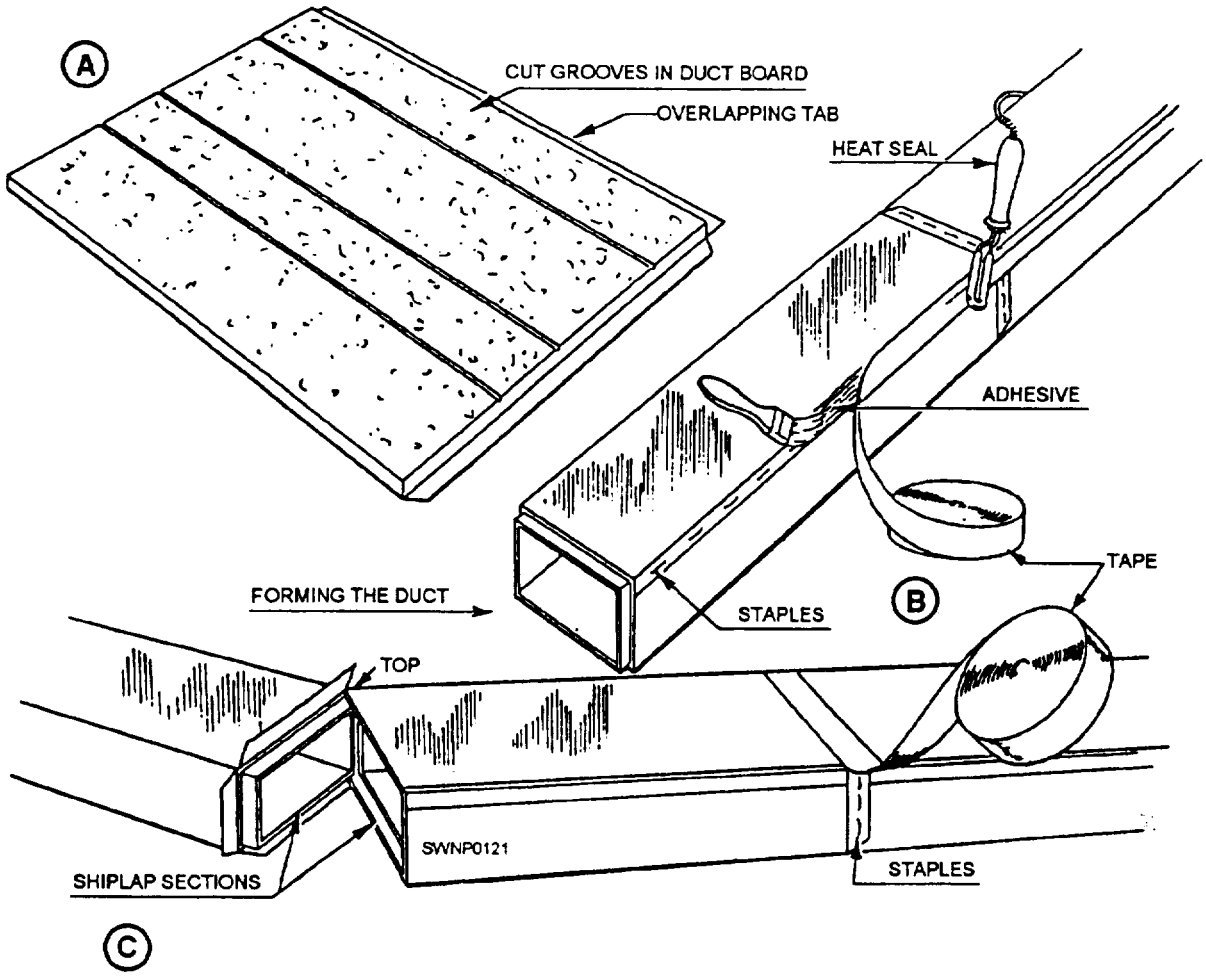


Figure 2-104.—Fabricating rectangular/square fiber-glass duct from duct board.

Of extreme importance is the selection of the proper board size to fabricate the duct before cutting and grooving. In all applications the inside diameter of the duct is the determining factor of the board size. Use table 2-3 to determine board size.

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Table 2-3.—Duct Board Length Selection Chart

	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
6	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76
7	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78
8	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80
9	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82
10	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84
11	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86
12	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
13	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90
14	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92
15	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94
16	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96
17	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98
18	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
19	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102
20	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104
21	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106
22	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108
23	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
24	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112
25	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114
26	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116
27	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118
28	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120
29	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120	
30	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120		
31	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120			
32	84	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120				
33	86	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120					
34	88	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120						
35	90	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120							
36	92	94	96	98	100	102	104	106	108	110	112	114	116	118	120								
37	94	96	98	100	102	104	106	108	110	112	114	116	118	120									
38	96	98	100	102	104	106	108	110	112	114	116	118	120										
39	98	100	102	104	106	108	110	112	114	116	118	120											
40	100	102	104	106	108	110	112	114	116	118	120												
41	102	104	106	108	110	112	114	116	118	120													
42	104	106	108	110	112	114	116	118	120														
43	106	108	110	112	114	116	118	120															
44	108	110	112	114	116	118	120																
45	110	112	114	116	118	120																	
46	112	114	116	118	120																		
47	114	116	118	120																			
48	116	118	120																				
49	118	120																					
50	120																						

*For 1 1/2-inch board—ADD 4 INCHES to these dimensions.

*For 2-inch board—ADD 8 INCHES to these dimensions.

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NOTE: Within a heating system, the use of fiber-class duct is restricted by the adhesive used to affix the protective outer coating to the fiber glass. Check the specifications and ensure that it will not fail when exposed to heat over 250 degrees.

FABRICATION

To fabricate a rectangular/square duct, you must first measure the duct board accurately. Next, the grooves must be cut. Ensure they are at the proper locations and cut straight because this allows the board to be folded to create the desired rectangular/square shape. When cutting the board, you will need to leave an overlapping tab that is pulled tight and stapled (fig. 2-104, view A). Tape is then applied and the joint is heat-sealed (fig. 2-104, view B). Joints between sections are fabricated by pulling the shiplap end sections together and finished by stapling, taping, and heat sealing the joint (fig. 2-104, view C).

INSTALLATION

The very nature of fiber-glass duct requires that it be supported with 1-inch by 1/16-inch galvanized steel strap hangers. These must be supplied or fabricated to fit the duct precisely whether the duct be rectangular/square or round. Rectangular/square ducts up to 24 inches (span) can be supported on 8-foot centers. Ducts larger than 24 inches must be supported on 4-foot centers. For round ducts the supports must not be less than 6-foot centers.

SAFETY

Some of the safety precautions applicable to sheet-metal tools and equipment have been mentioned throughout this chapter. Here are a few additional precautions that should be carefully observed when you are working with sheet metal.

1. Sheet metal can cause serious cuts. Handle it with care. Wear steel reinforced gloves whenever feasible.

2. Treat every cut immediately, no matter how minor.

3. Remove all burrs from the metal sheet before attempting to work on it further.

4. Use a brush to clean the work area. NEVER brush metal with your hands.

5. Use tools that are sharp.

6. Keep your hands clear of the blade on all squaring shears.

7. A serious and painful foot injury will result if your foot is under the foot pedal of the squaring shears when a cut is made.

8. Do not run your hands over the surface of sheet metal that has just been cut or drilled. Painful cuts can be received from the burrs.

9. Get help when large pieces of sheet metal are being cut. Keep your helper well clear of the shears when you are making the cut.

10. Keep your hands and fingers clear of the rotating parts on forming machines.

11. Place scrap pieces of sheet metal in the scrap box.

12. Always remember to keep a clean shop. GOOD HOUSEKEEPING is the key to a safe shop.

13. Do not use tools that are not in first-class condition-hammer heads loose on the handle, chisels with mushroomed heads, power tools with guards removed, and so forth.

14. Wear goggles when in the shop.

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CHAPTER 3

STRUCTURAL STEEL TERMS / LAYOUT AND FABRICATION OF STEEL AND PIPE

Structural steel is one of the basic materials used in the construction of frames for most industrial buildings, bridges, and advanced base structures. Therefore, you, as a Seabee Steelworker, must have a thorough knowledge of various steel structural members. Additionally, it is necessary before any structural steel is fabricated or erected, a plan of action and sequence of events be set up. The plans, sequences, and required materials are predetermined by the engineering section of a unit and are then drawn up as a set of blueprints. This chapter describes the terminology applied to structural steel members, the use of these members, the methods by which they are connected, and the basic sequence of events which occurs during erection.

STRUCTURAL STEEL MEMBERS

Your work will require the use of various structural members made up of standard structural shapes manufactured in a wide variety of shapes of cross sections and sizes. Figure 3-1 shows many of these various shapes. The three most common types of structural members are the W-shape (wide flange), the S-shape (American Standard I-beam), and the C-shape (American Standard channel). These three types are identified by the nominal depth, in inches, along the web and the weight per foot of length, in pounds. As an example, a W 12 x 27 indicates a W-shape (wide flange) with a web 12 inches deep and a weight of 27 pounds per linear foot. Figure 3-2 shows the cross-sectional views of the W-, S-, and C-shapes. The difference between the W-shape and

OLD SYMBOL	OLD ILLUSTRATED USE	DESCRIPTION	EXAMPLE	NEW SYMBOL	NEW ILLUSTRATED USE
WF	24WF76	W-SHAPE (WIDE FLANGE)		W	W24 X 76
BP	14BP73	BEARING PILE		BP	BP14 X 73
I	15I 42.9	S-SHAPE (AMERICAN STD I-BEAM)		S	S15 X 42.9
⌴	9 ⌴ 13.4	C-SHAPE (AMERICAN STD CHANNEL)		C	C9 X 13.4
M	8 X 8M34.3	M-SHAPE (MISC SHAPES OTHER THAN W, BP, S, & C)		M	M8 X 34.3
M	8M17				M8 X 17
Jr	Jr 7Jr.5.5				M7 X 5.5
⌴	12 X 4 ⌴ 44.5	MC-SHAPE (CHANNELS OTHER THAN AMERICAN STD)		MC	MC12 X 45
Jr ⌴	10Jr ⌴ 84				MC12 X 12.6
L	L 3 X 3 X 1/4	ANGLES: EQUAL LEG		L	3 X 3 X L 3 X 3 X 1/4
L	L 7 X 4 X 1/2	UN-EQUAL LEG		L	L 7 X 4 X 1/2
ST	ST5WF10.5	TEES, STRUCTURAL: CUT FROM W-SHAPE		WT	WT12 X 38
		CUT FROM S-SHAPE		ST	ST12 X 38
		CUT FROM M-SHAPE		MT	MT12 X 38
PL	PL18X1/2X2'-6"	PLATE		PL	PL 1/2 X 18" X 30"
BAR	BAR 2 1/2 X 1/4	FLAT BAR		BAR	BAR 2 1/2 X 1/4
O	O6	PIPE, STRUCTURAL			PIPE 4 STD PIPE 4X-STRG PIPE 4 XX-STRG

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Figure 3-1.—Structural shapes and designations.

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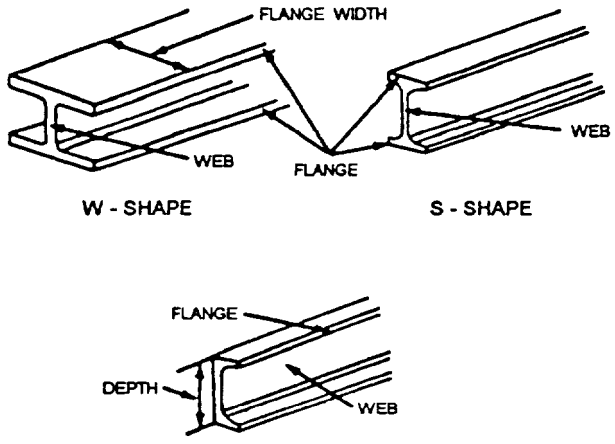


Figure 3-2.—Structural shapes.

the S-shape is in the design of the inner surfaces of the flange. The W-shape has parallel inner and outer flange surfaces with a constant thickness, while the S-shape has a slope of approximately 17' on the inner flange surfaces. The C-shape is similar to the S-shape in that its inner flange surface is also sloped approximately 17'.

The W-SHAPE is a structural member whose cross section forms the letter H and is the most widely used structural member. It is designed so that its flanges provide strength in a horizontal plane, while the web gives strength in a vertical plane. W-shapes are used as beams, columns, truss members, and in other load-bearing applications.

The BEARING PILE (HP-shape) is almost identical to the W-shape. The only difference is that the flange thickness and web thickness of the bearing pile are equal, whereas the W-shape has different web and flange thicknesses.

The S-SHAPE (American Standard I-beam) is distinguished by its cross section being shaped like the letter I. S-shapes are used less frequently than W-shapes since the S-shapes possess less strength and are less adaptable than W-shapes.

The C-SHAPE (American Standard channel) has a cross section somewhat similar to the letter C. It is especially useful in locations where a single flat face without outstanding flanges on one side is required. The C-shape is not very efficient for a beam or column when used alone. However, efficient built-up members may be constructed of channels assembled together with other structural shapes and connected by rivets or welds.

An ANGLE is a structural shape whose cross section resembles the letter L. Two types, as illustrated in figure 3-3, are commonly used: an equal-leg angle and an unequal-leg angle. The angle is identified by the dimension and thickness of its legs; for example, angle 6 inches x 4 inches x 1/2 inch. The dimension of the legs should be obtained by measuring along the outside of the backs of the legs. When an angle has unequal legs, the dimension of the wider leg is given first, as in the example just cited. The third dimension applies to the thickness of the legs, which al ways have equal thickness. Angles may be used in combinations of two or four to form main members. A single angle may also be used to connect main parts together.

Steel PLATE is a structural shape whose cross section is in the form of a flat rectangle. Generally, a main point to remember about plate is that it has a width of greater than 8 inches and a thickness of 1/4 inch or greater.

Plates are generally used as connections between other structural members or as component parts of built-up structural members. Plates cut to specific sizes may be obtained in widths ranging from 8 inches to 120 inches or more, and in various thicknesses. The edges of these plates may be cut by shears (sheared plates) or be rolled square (universal mill plates).

Plates frequently are referred to by their thickness and width in inches, as plate 1/2 inch x 24 inches. The length in all cases is given in inches. Note in figure 3-4 that 1 cubic foot of steel weighs 490 pounds. his weight divided by 12 gives you 40.8, which is the weight (in pounds) of a steel plate 1 foot square and 1 inch thick The fractional portion is normally dropped and 1-inch plate is called a 40-pound plate. In practice, you may hear plate referred to by its approximate weight per square foot for a specified thickness. An example is 20-pound plate, which indicates a 1/2-inch plate. (See figure 3-4.)

The designations generally used for flat steel have been established by the American Iron and Steel Institute (AISI). Flat steel is designated as bar, strip,

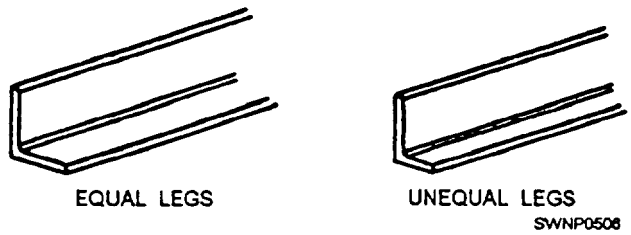


Figure 3-3.—Angles.

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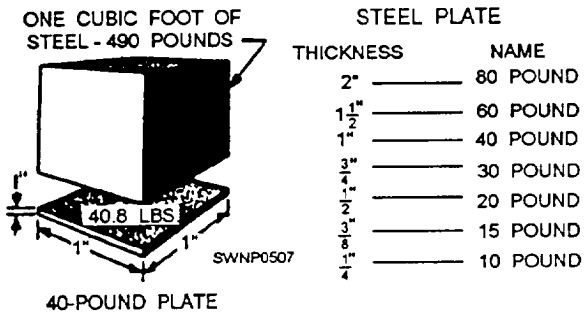


Figure 3-4.—Weight and thickness of steel plate.

sheet, or plate, according to the thickness of the material, the width of the material, and (to some extent) the rolling process to which it was subjected. Table 3-1 shows the designations usually used for hot-rolled carbon steels. These terms are somewhat flexible and in some cases may overlap.

The structural shape referred to as a BAR has a width of 8 inches or less and a thickness greater than 3/16 of an inch. The edges of bars usually are rolled square, like universal mill plates. The dimensions are expressed in a similar manner as that for plates; for instance, bar 6 inches x 1/2 inch. Bars are available in a variety of cross-sectional shapes—round, hexagonal, octagonal, square, and flat. Three different shapes are illustrated in figure 3-5. Both squares and rounds are commonly used as bracing members of light structures. Their dimensions, in inches, apply to the side of the square or the diameter of the round.

Now that you have been introduced to the various structural members used in steel construction, let us develop a theoretical building frame from where you, the Steelworker, would start on a project after all the earthwork and footings or slab have been completed. Remember this sequence is theoretical and may vary

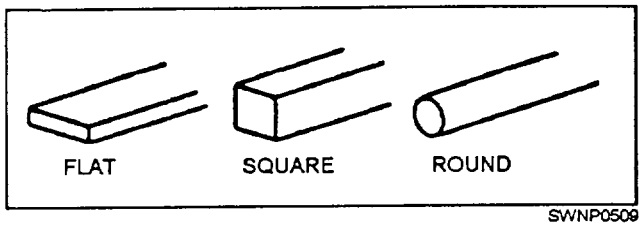


Figure 3-5.—Bars.

somewhat, depending on the type of structure being erected.

ANCHOR BOLTS

Anchor bolts (fig. 3-6) are cast into the concrete foundation. They are designed to hold the column bearing plates, which are the first members of a steel frame placed into position. These anchor bolts must be positioned very carefully so that the bearing plates will be lined up accurately.

BEARING PLATES

The column bearing plates are steel plates of various thicknesses in which holes have been either drilled or cut with an oxygas torch to receive the

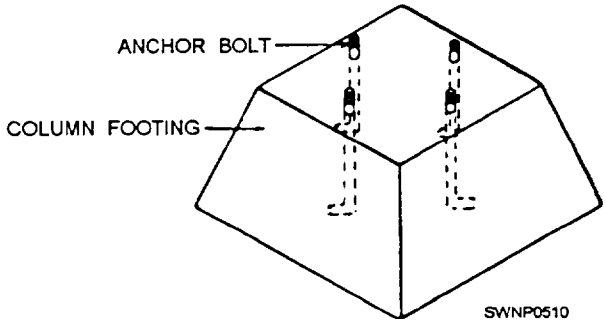


Figure 3-6.—Anchor bolts.

Table 3-1.—Plate, Bar, Strip, and Sheet designation

THICKNESS *(Inches)*	WIDTH *(Inches)*					
	TO 3½ INCLUSIVE	OVER 3½ TO 6	OVER 6 TO 8	OVER 8 TO 12	OVER 12 TO 48	OVER 48
0.2300 and THICKER	BAR					PLATE
0.2299 and 0.2031		STRIP				
0.2030 and 0.1800						
0.1799 and 0.0449						
0.0448 and 0.0344					SHEET	
0.0343 and 0.0255						
0.0254 and THINNER						

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anchor bolts (fig. 3-7). The holes should be slightly larger than the bolts so that some lateral adjustment of the bearing plate is possible. The angle connections, by which the columns are attached to the bearing plates, are bolted or welded in place according to the size of the column, as shown in figure 3-8.

After the bearing plate has been placed into position, shim packs are set under the four comers of each bearing plate as each is installed over the anchor bolts, as shown in figure 3-9. The shim packs are 3- to 4-inch metal squares of a thickness ranging from 1 1/6 to 3/4 inch, which are used to bring all the bearing

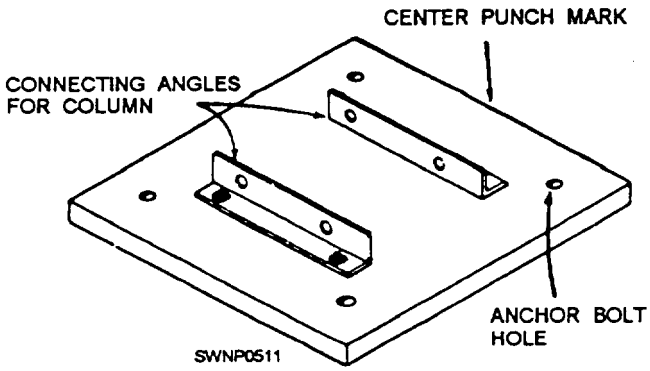


Figure 3-7.—Column bearing plate.

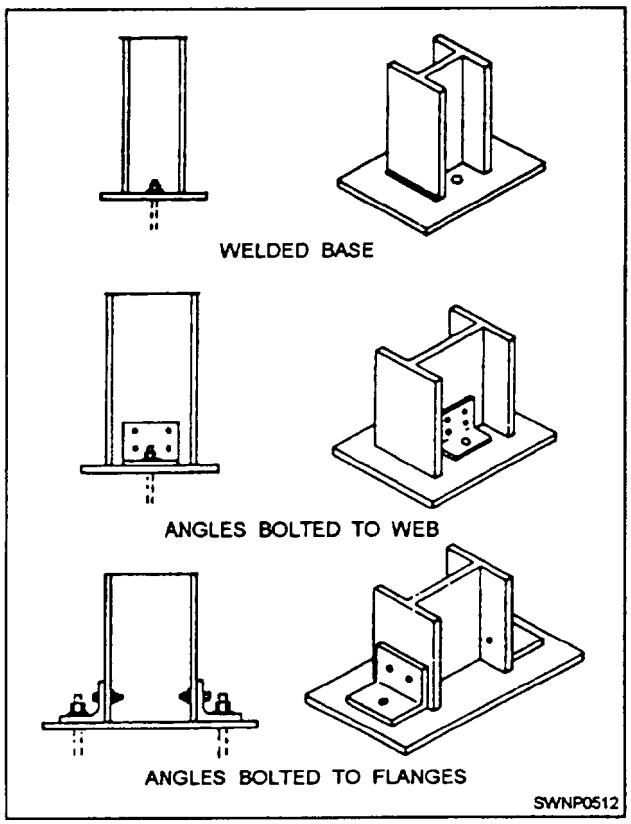


Figure 3-8.—Typical column to baseplate connections.

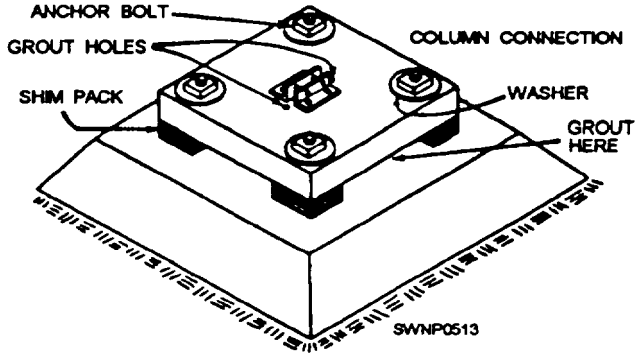


Figure 3-9.—Leveled bearing plate.

plates to the correct level and to level each bearing plate on its own base.

The bearing plates are first leveled individually by adjusting the thickness of the shim packs. This operation may be accomplished by using a 2-foot level around the top of the bearing plate perimeter and diagonally across the bearing plate.

Upon completion of the leveling operation, all bearing plates must be brought either up to or down to the grade level required by the structure being erected All bearing plates must be lined up in all directions with each other. This may be accomplished by using a surveying instrument called a builder's level. String lines may be set up along the edges and tops of the bearing plates by spanning the bearing plates around the perimeter of the structure, making a grid network of string lines connecting all the bearing plates.

After all the bearing plates have been set and aligned, the space between the bearing plate and the top of the concrete footing or slab must be filled with a hard, nonshrinking, compact substance called GROUT. (See fig. 3-9.) When the grout has hardened the next step is the erection of the columns.

COLUMNS

Wide flange members, as nearly square in cross section as possible, are most often used for columns. Large diameter pipe is also used frequentl y (fig. 3-10), even though pipe columns often present connecting difficulties when you are attaching other members. Columns may also be fabricated by welding or bolting a number of other rolled shapes, usually angles and plates, as shown in figure 3-11.

If the structure is more than one story high, it may be necessary to splice one column member on top of another. If this is required, column lengths should be

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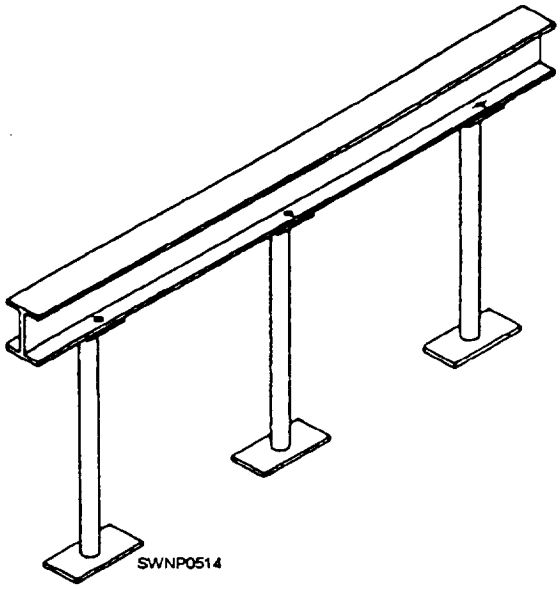


Figure 3-10.—Girder span on pipe columns.

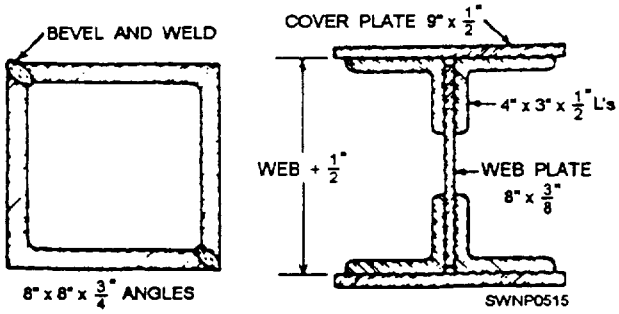


Figure 3-11.—Built-up column section.

such that the joints or splices are 1 1/2 to 2 feet above the second and succeeding story levels. This will ensure that the splice connections are situated well above the girder or beam connections so that they do not interfere with other second story work.

Column splices are joined together by splice plates which are bolted, riveted, or welded to the column flanges, or in special cases, to the webs as well. If the members are the same size, it is common practice to butt one end directly to the other and fasten the splice plates over the joint, as illustrated in figure 3-12. When the column size is reduced at the joint, a plate is used between the two ends to provide bearing, and filler plates are used between the splice plates and the smaller column flanges (fig. 3-13).

GIRDERS

Girders are the primary horizontal members of a steel frame structure. They span from column to

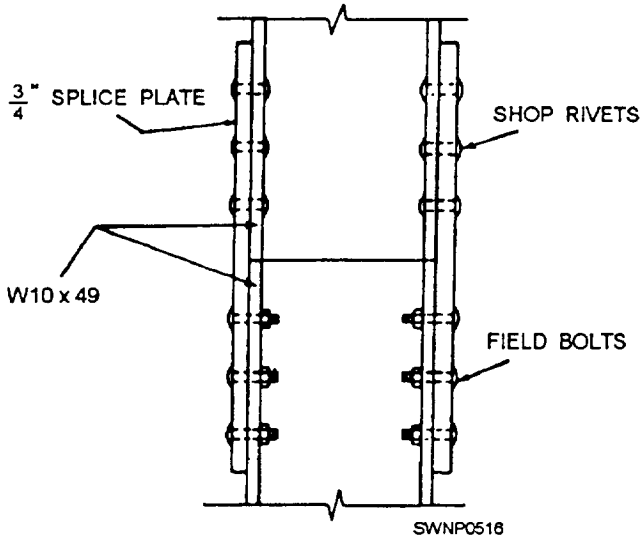


Figure 3-12.—Column splice with no size change.

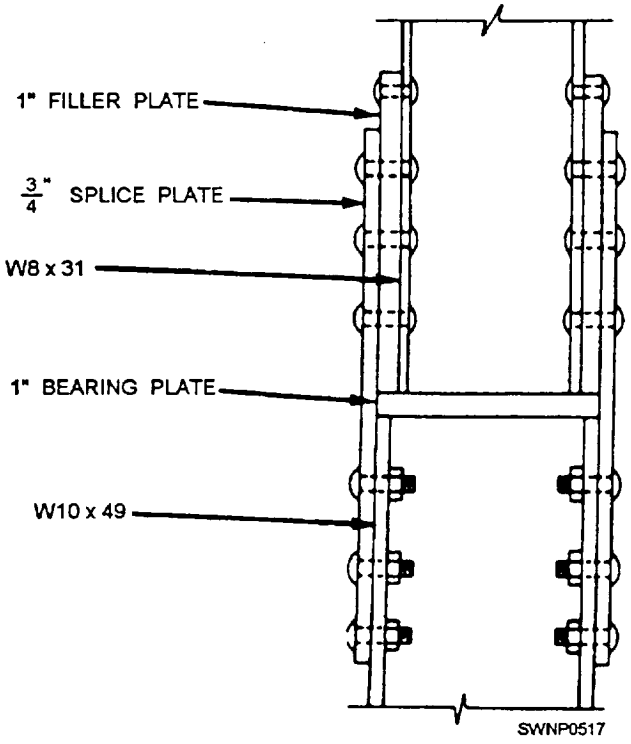


Figure 3-13.—Column splice with change in column size.

column and are usually connected on top of the columns with CAP PLATES (bearing connections), as shown in figure 3-14. An alternate method is the seated connection (fig. 3-15). The girder is attached to the flange of the column using angles, with one leg extended along the girder flange and the other against the column. The function of the girders is to support the intermediate floor beams.

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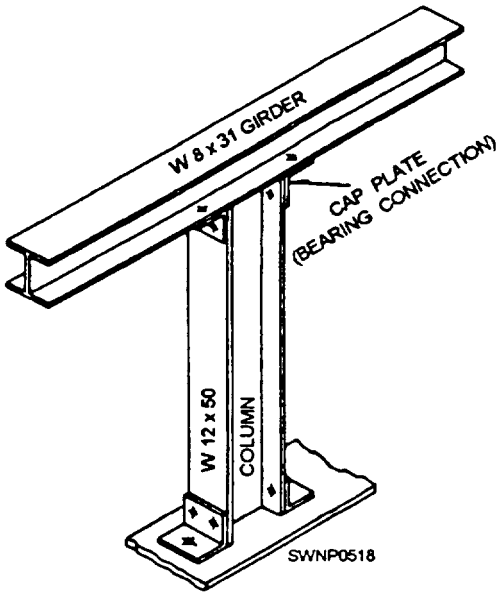


Figure 3-14.—Girder span on a wide flange column.

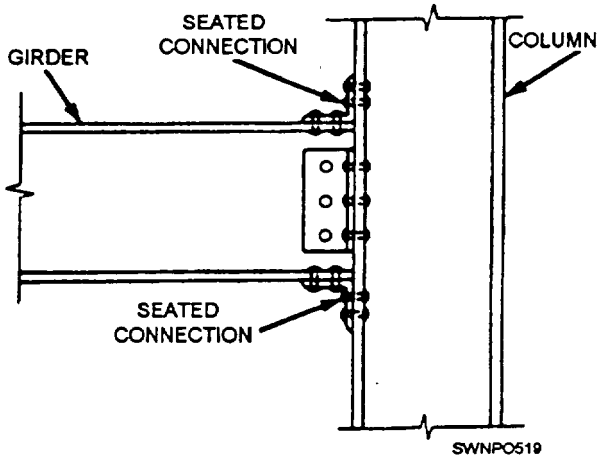


Figure 3-15.—Seated connections.

BEAMS

Beams are generally smaller than girders and are usually connected to girders as intermediate members or to columns. Beam connections at a column are similar to the seated girder-to-column connection. Beams are used generally to carry floor loads and transfer those loads to the girders as vertical loads. Since beams are usually not as deep as girders, there are several alternative methods of framing one into the other. The simplest method is to frame the beam between the top and bottom flanges on the girder, as shown in figure 3-16. If it is required that the top or bottom flanges of the girders and beams be flush, it is necessary to cut away (cope) a portion of the upper or lower beam flange, as illustrated in figure 3-17.

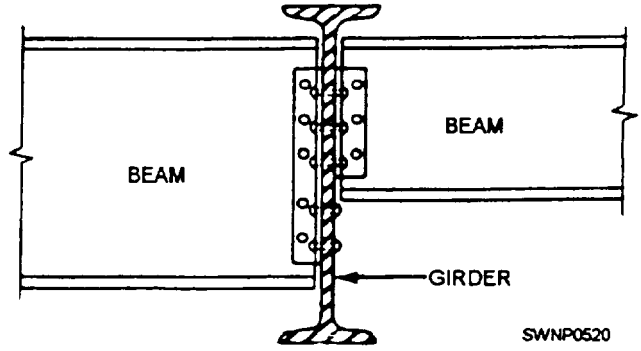


Figure 3-16.—Column splice with no size change

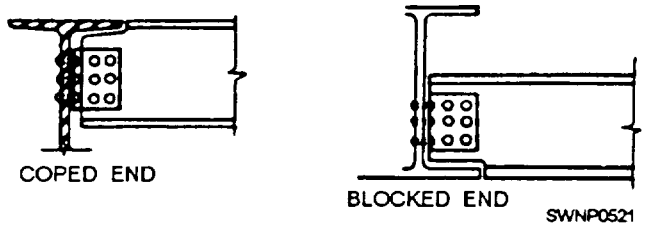


Figure 3-17.—Coped and blocked beam ends.

BAR JOIST

Bar joists form a lightweight, long-span system used as floor supports and built-up roofing supports, as shown in figure 3-18. Bar joists generally run in the same direction as a beam and may at times eliminate the need for beams. You will notice in figure 3-19 that bar joists must have a bearing surface. The span is from girder to girder. (See fig. 3-20.)

Prefabricated bar joists designed to conform to specific load requirements are obtainable from commercial companies.

TRUSSES

Steel trusses are similar to bar joists in that they serve the same purpose and look somewhat alike. They are, however, much heavier and are fabricated almost entirely from structural shapes, usually angles and T-shapes. (See fig. 3-21.) Unlike bar joists, trusses can be fabricated to conform to the shape of almost any roof system (fig. 3-22) and are therefore more versatile than bar joists.

The bearing surface of a truss is normally the column. The truss may span across the entire building from outside column to outside column. After the trusses have been erected, they must be secured between the BAYS with diagonal braces (normally

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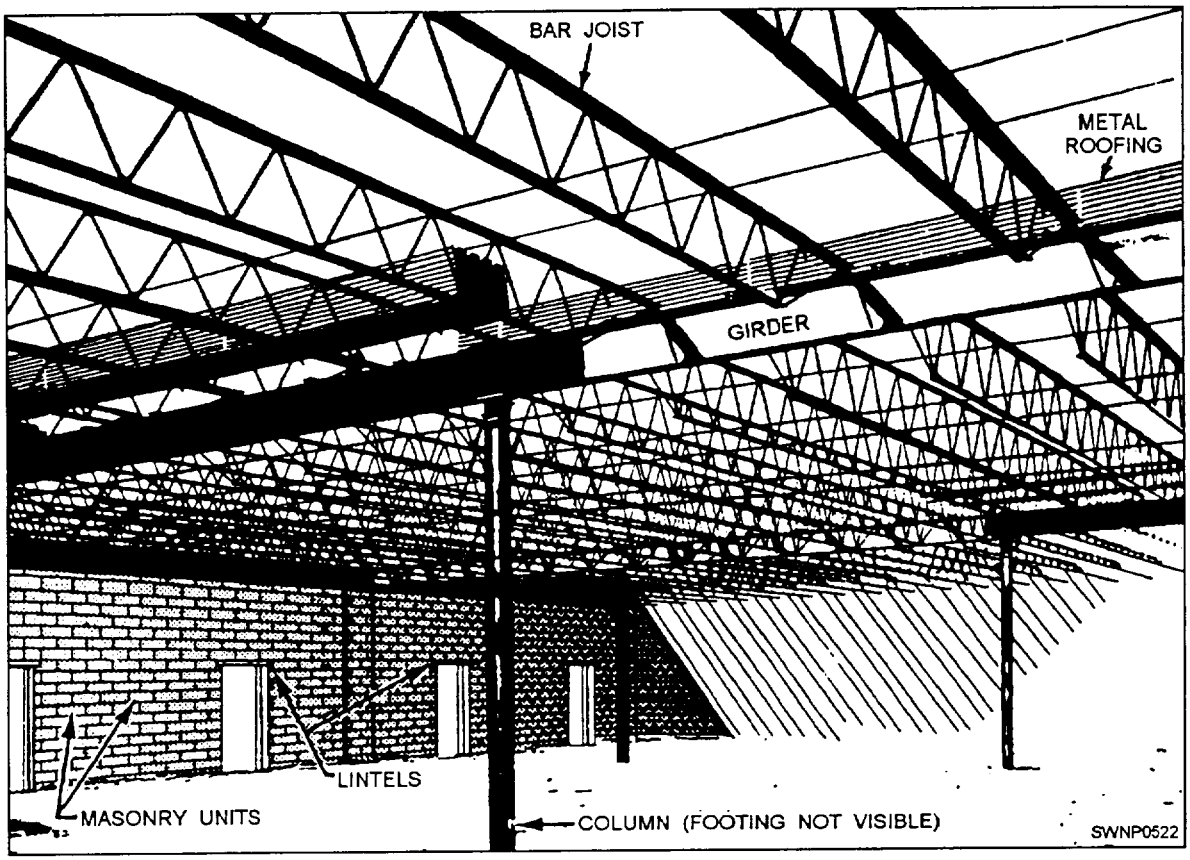


Figure 3-18.—Clearspan bar joists (girder to girder) ready to install roof sheeting.

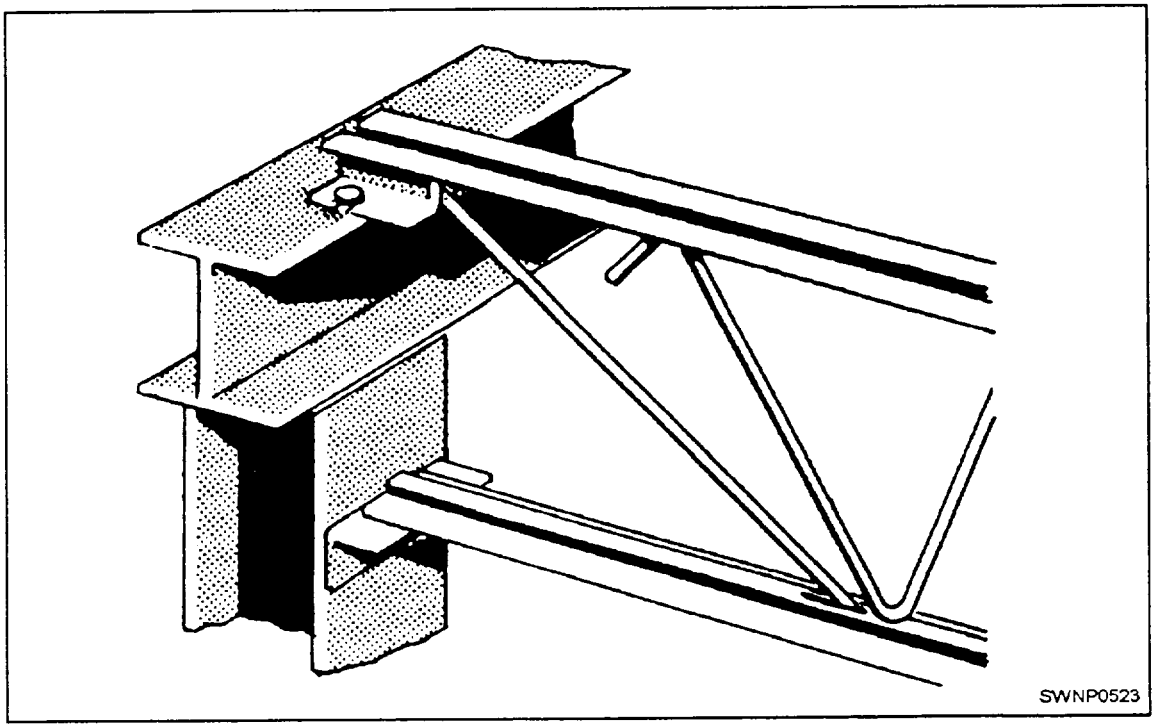


Figure 3-19.—Bar joists seat connection.

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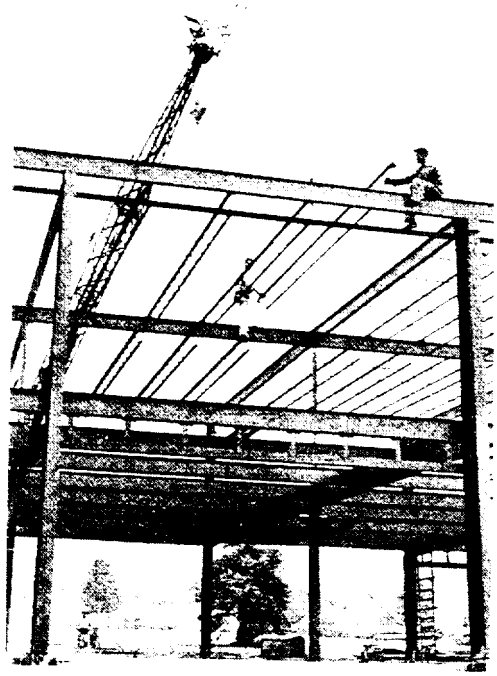


Figure 3-20.—Installing bar Joists girder to girder.

round rods or light angles) on the top chord plane (fig. 3-23) and the bottom chord plane (fig. 3-24). After these braces are installed, a sway frame is put into place. (See fig. 3-25.)

PURLINS, GIRTS, AND EAVE STRUTS

Purlins are generally lightweight and channel-shaped and are used to span roof trusses. Purlins receive the steel or other type of decking, as shown in figure 3-26, and are installed with the legs of the channel facing outward or down the slope of the roof. The purlins installed at the ridge of a gabled roof are referred to as RIDGE STRUTS. The purlin units are placed back to back at the ridge and tied together with steel plates or threaded rods, as illustrated in figure 3-27.

The sides of a structure are often framed with girts. These members are attached to the columns horizontally (fig. 3-28). The girts are also channels, generally the same size and shape as roof purlins. Siding material is attached directly to the girts.

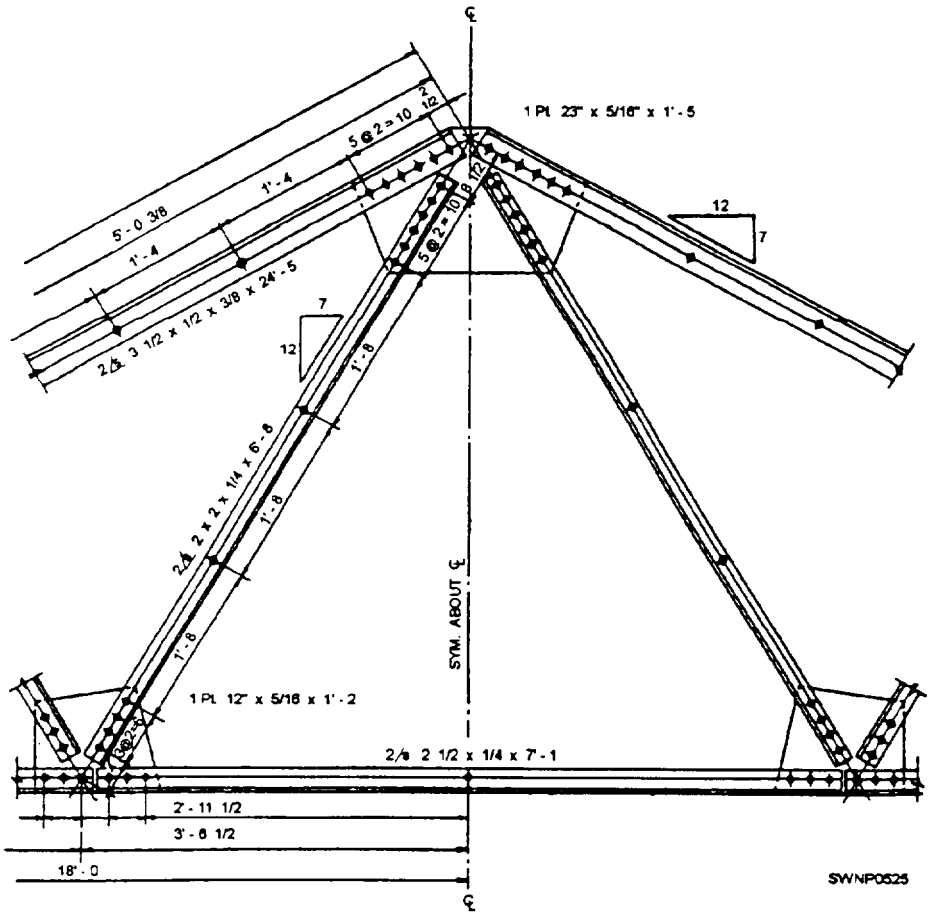


Figure 3-21.—Steel truss fabricated from angle-shaped members.

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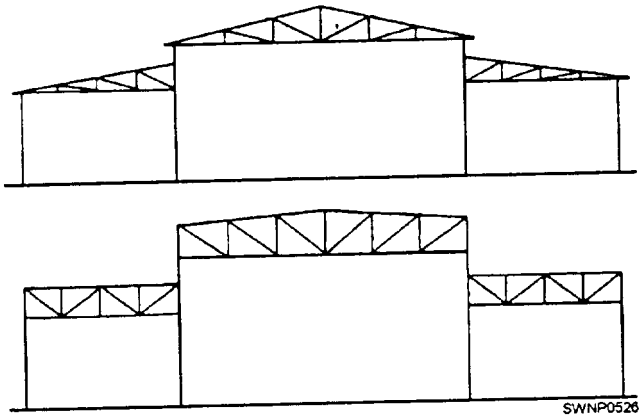


Figure 3-22.—Different styles of truss shapes.

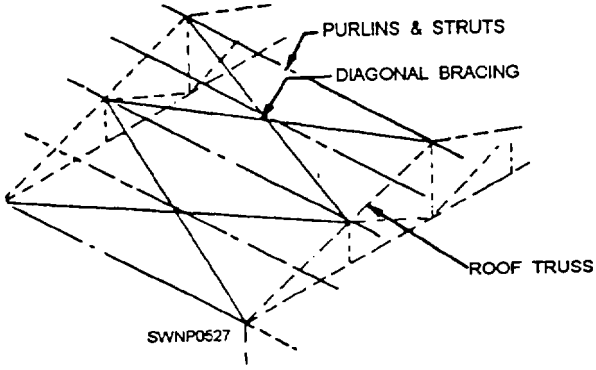


Figure 3-23.—Diagonal braces-top chord plane.

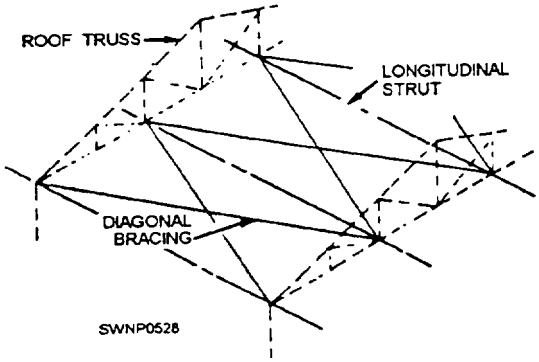


Figure 3-24.—Diagonal braces-bottom chord plane.

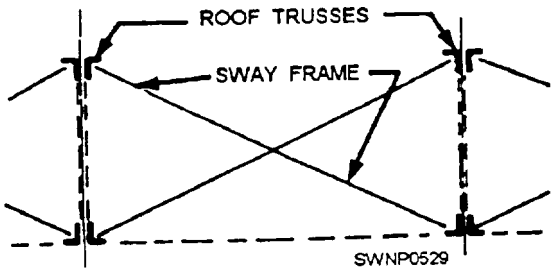


Figure 3-25.—Sway frame.

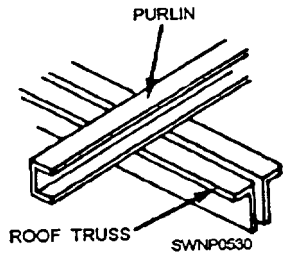


Figure 3-26.—Roof purlin.

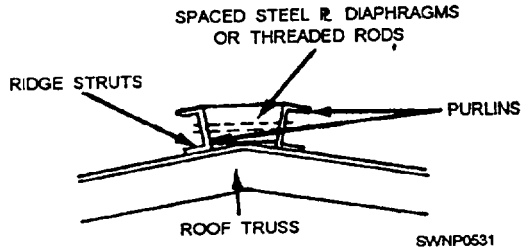


Figure 3-27.—Ridge struts.

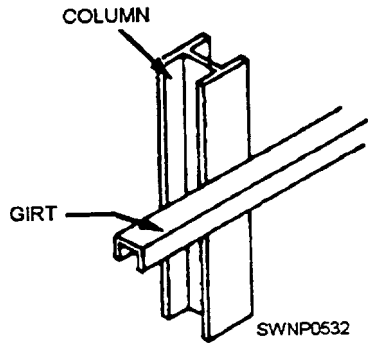


Figure 3-28.—Wall girt.

Another longitudinal member similar to purlins and girts is an cave strut. This member is attached to the column at the point where the top chord of a truss and the column meet at the cave of the structure. (See fig. 3-29.)

There are many more steelworking terms that you will come across as you gain experience. If a term is

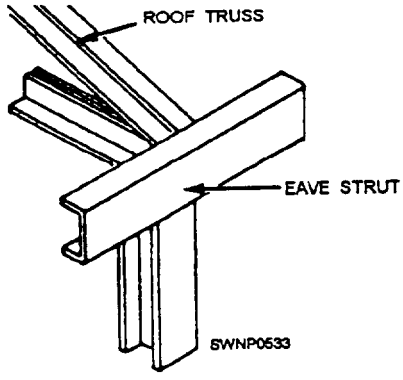


Figure 3-29.—Eave strut.

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used that you do not understand, ask someone to explain it or look it up in the manuals and publications available to you.

Steelworkers are required to lay out and fabricate steel plate and structural steel members. Assignments you can expect to be tasked with include pipe layout and fabrication projects of the type required on a tank farm project. Plate layout procedures are similar to those for sheet metal (see chapter 2). There are some procedures of plate fabrication however, that are fundamentally different, and they are described in this chapter. Steelworkers are also tasked to construct and install piping systems designed to carry large quantities of liquids for long distances.

FABRICATING PLATE AND STRUCTURAL MEMBERS

Steel plate is much thicker than sheet steel and is more difficult to work with and form into the desired shapes. Before fabricating anything with steel, you must take into consideration certain factors and ensure they have been planned for. First, ensure adequate lighting is available to enable you to see the small marks you will be scratching on the steel. Second, ensure all tools you need are available and accessible at the work area. Also, ensure you have an accurate field sketch or shop drawing of the item to be fabricated.

LAYOUT OF STEEL PLATE

When laying out steel plate, you should have the following tools: an adequate scale, such as a combination square with a square head, an accurate protractor, a set of dividers, a prick punch, a center punch, and a ball peen hammer.

When layout marks are made on steel, you must use a wire brush to clean them and remove the residue with a brush or rag. Then paint the surface with a colored marking compound. Aerosol spray is very good because it allows the paint to fall only in the areas to be laid out and also because it produces a thin coat of paint that will not chip or peel off when lines are being scribed.

When appropriate, the layout lines can be drawn on steel with a soapstone marker or a similar device. However, remember that the markings of many of these drawing devices can burn off under an oxygas flame as well or be blown away by the force of oxygen from the cutting torch. These conditions are undesirable and can ruin an entire fabrication job. If using soapstone or a similar marker is your only option, be sure to use a punch and a ball peen hammer to make marks along the cut lines. By "connecting the dots," you can ensure accuracy.

Plan material usage before starting the layout on a plate. An example of proper plate layout and material usage is shown in figure 3-30. Observe the material used for the cooling box. It will take up slightly more than half of the plate. The rest of the material can then be used for another job. This is only one example, but the idea is to conserve materials. An example of poor layout is shown in figure 3-31. The entire plate is used up for this one product, wasting material, increasing the cost and layout time of the job.

The layout person must have a straight line or straightedge that he or she refers all measurements to. This straightedge or line can be one edge of the work that has been finished straight; or it can be an outside straight line fastened to the work, such as a straightedge clamped to the work. Once the reference line has been established, you can proceed with the layout using the procedures described in chapter 2.

When the layout is complete, the work should be checked for accuracy, ensuring all the parts are in the

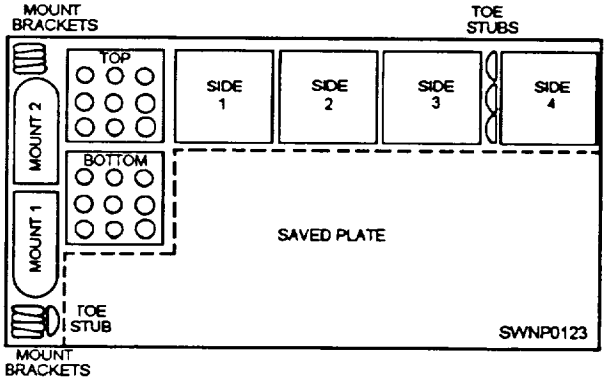


Figure 3-30.—Proper plate steel cooling box layout.

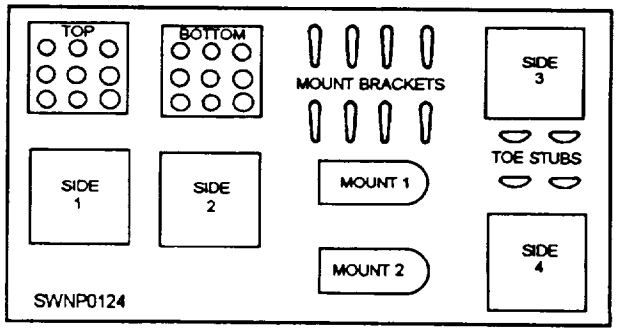


Figure 3-31.—Improper plate steel cooling box layout.

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layout and the measurements are correct. After determining that the layout is accurate, the layout person should center punch all cutting lines. This ensures accurate cutting with either a torch or shears. The work can be checked after cutting because each piece will have one half of the center punch marks on the edge of the material. Remember, always cut with the kerf of the torch on the outside edge of the cutting lines.

LAYOUT OF STRUCTURAL SHAPES

Structural shapes are slightly more difficult to lay out than plate. This is because the layout lines may not be in view of the layout person at all times. Also, the reference line may not always be in view.

Steel beams are usually fabricated to fit up to another beam. Coping and slotting are required to accomplish this. Figure 3-32 shows two W 10 x 39 beams being fitted up. Beam A is intersecting beam B at the center. Coping is required so beam A will butt up to the web of beam B; the connecting angles can be welded to the web, and the flanges can be welded together.

A cut 1 1/8 inches (2.8 cm) long at 45 degrees at the end of the flange cope will allow the web to fit up under the flange of beam B and also allow for the fillet. The size of the cope is determined by dividing the flange width of the receiving beam in half and then subtracting one half of the thickness of the web plus 1/16 inch. This determines how far back on beam A the cope should be cut.

When two beams of different sizes are connected, the layout on the intersecting beam is determined by whether it is larger or smaller than the intersected beam. In the case shown in figure 3-33, the

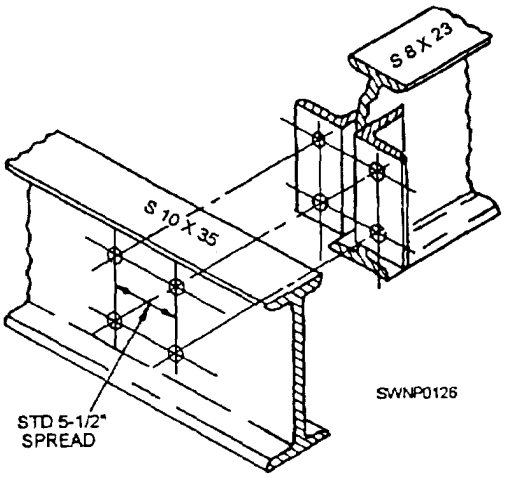


Figure 3-33.—Typical framed construction, top flange flush.

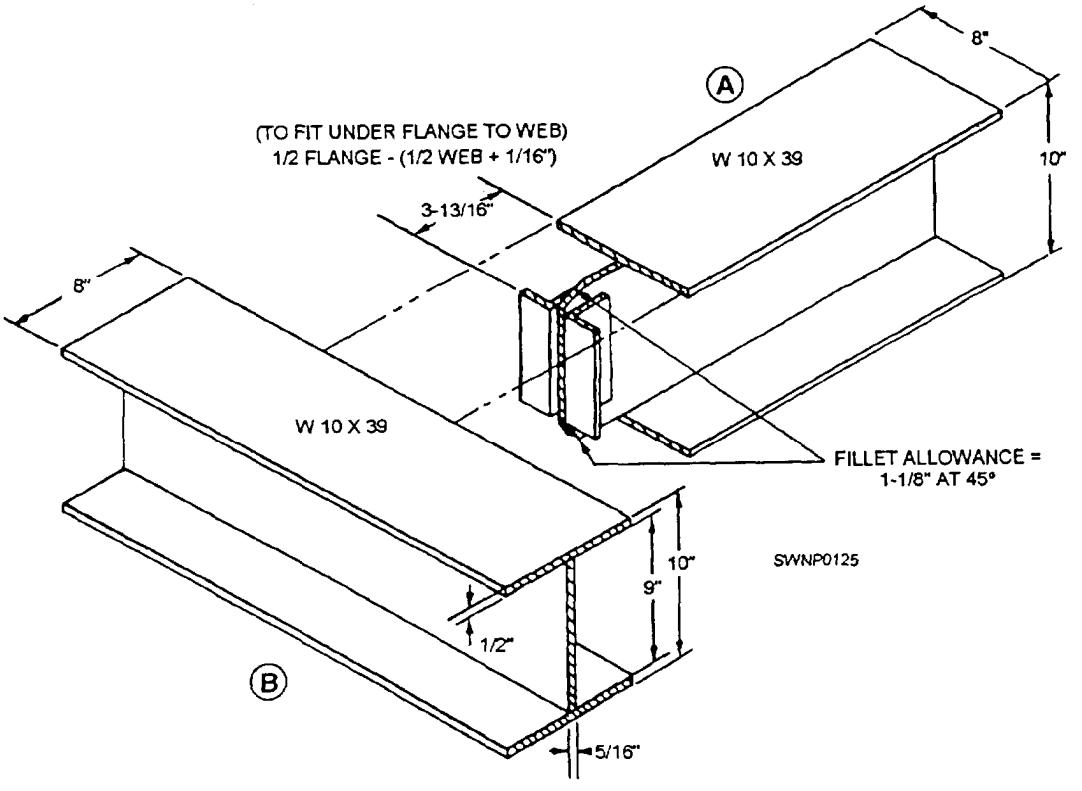


Figure 3-32.—Fabrication and fit-up for joining two beams of the same size.

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intersecting beam is smaller; therefore, only one flange is coped to fit the other. The top flanges will be flush. Note that the angles on this connection are to be bolted, rather than welded.

CONNECTION ANGLE LAYOUT

A very common connection with framed construction is the connection angle. The legs of the angles used as connections are specified according to the surface to which they are to be connected. The legs that attach to the intersecting steel to make the connections are termed *web legs.* The legs of the angles that attach to the supporting or intersected steel beam are termed *outstanding legs.* The lines in which holes in the angle legs are placed are termed *gauge lines.* The distances between gauge lines and known edges are termed gauges. An example of a completed connection is shown in figure 3-34. The various terms and the constant dimensions for a standard connection angle are shown in figure 3-35.

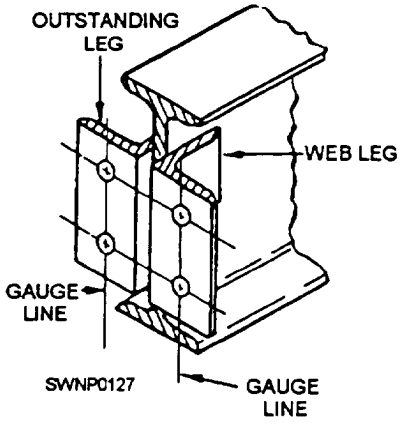


Figure 3-34.—gauge lines.

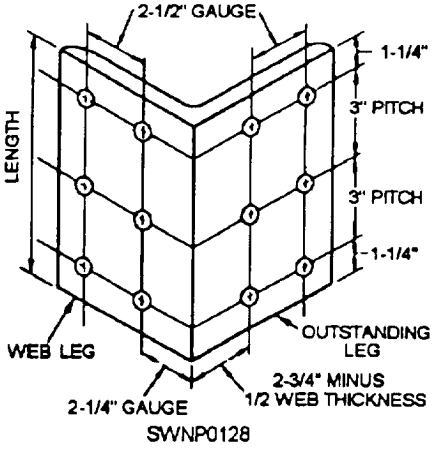


Figure 3-35.—Standard layout for connection angle using 4-inch by 4-inch angle

The distance from the heel of the angle to the first gauge line on the web leg is termed the *web leg gauge.* This dimension has been standardized at 2 1/4 inches (5.6 cm). THIS DIMENSION IS CONSTANT AND DOES NOT VARY.

The distance from the heel of the angle to the first gauge line on the outstanding leg is called the outstanding leg gauge. This dimension varies as the thickness of the member, or beam, varies. This variation is necessary to maintain a constant 5 1/2-inch-spread dimension on the angle connection.

The outstanding leg gauge dimension can be determined in either one of the following two ways:

1. Subtract the web thickness from 5 1/2 inches (13.8 cm) and divide by 2.

2. Subtract 1/2 of the web thickness from 2 3/4 inches.

The distance between holes on any gauge line is called pitch. This dimension has been standardized at 3 inches (7.5 cm).

The end distance is equal to one half of the remainder left after subtracting the total of all pitch spaces from the length of the angle. By common practice, the angle length that is selected should give a 1 1/4-inch (3-cm) end distance.

All layout and fabrication procedures are not covered in this section. Some examples are shown in figure 3-36. Notice that the layout and fabrication yard has a table designed to allow for layout, cutting, and welding with minimum movement of the structural members. The stock materials are stored like kinds of materials.

The table holds two columns being fabricated out of beams with baseplates and cap plates. Angle clips for seated connections (fig. 3-37) should be installed before erection,

CUTTING AND SPLICING BEAMS

At times, the fabricator will be required to split a beam to make a tee shape from an I shape. This is done by splitting through the web. The release of internal stresses locked up in the beams during the manufacturer's rolling process causes the split parts to bend or warp as the beams are being cut unless the splitting process is carefully controlled.

The recommended procedure for cutting and splitting a beam is first to cut the beam to the desired length and then proceed as follows:

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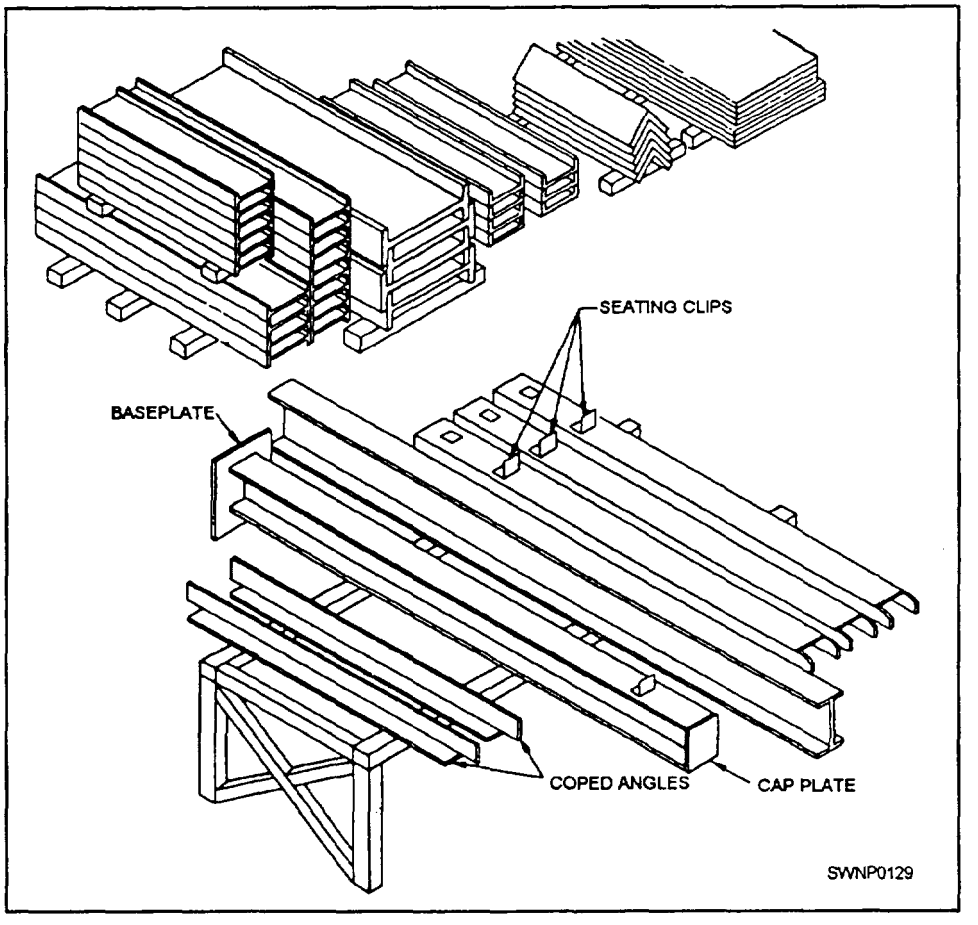


Figure 3-36.—Prefab table and steel storage.

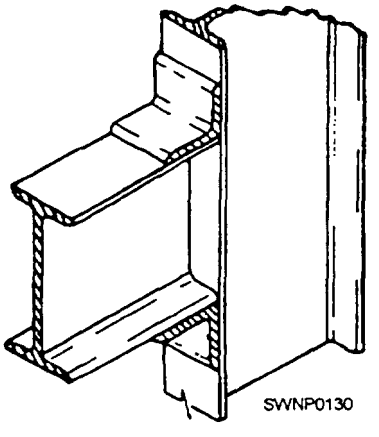


Figure 3-37.—Seated connection.

1. Make splitting cuts about 2 feet (60 cm) long, leaving 2 inches (5 cm) of undisturbed metal between all cuts and at the end of the beam (fig. 3-38). As the cut is made, cool the steel behind the torch with a water spray or wet burlap.

2. After splitting cuts have been made and the beam cooled, cut through the metal between the cuts, starting at the center of the beam and working toward the ends, following the order shown in figure 3-38.

The procedure for splitting abeam also works very well when splitting plate and is recommended when making bars from plate. Multiple cuts from plate can be made by staggering the splitting procedure before cutting the space between slits. If this procedure is used, ensure that the entire plate has cooled so that the bars will not warp or bend.

TEMPLATES

When a part must be produced in quantity, a template is made first and the job laid out from the template. A template is any pattern made from sheet metal, regular template paper, wood, or other suitable material, which is used as a guide for the work to be done. A template can be the exact size and shape of the corresponding piece, as shown in figure 3-39,

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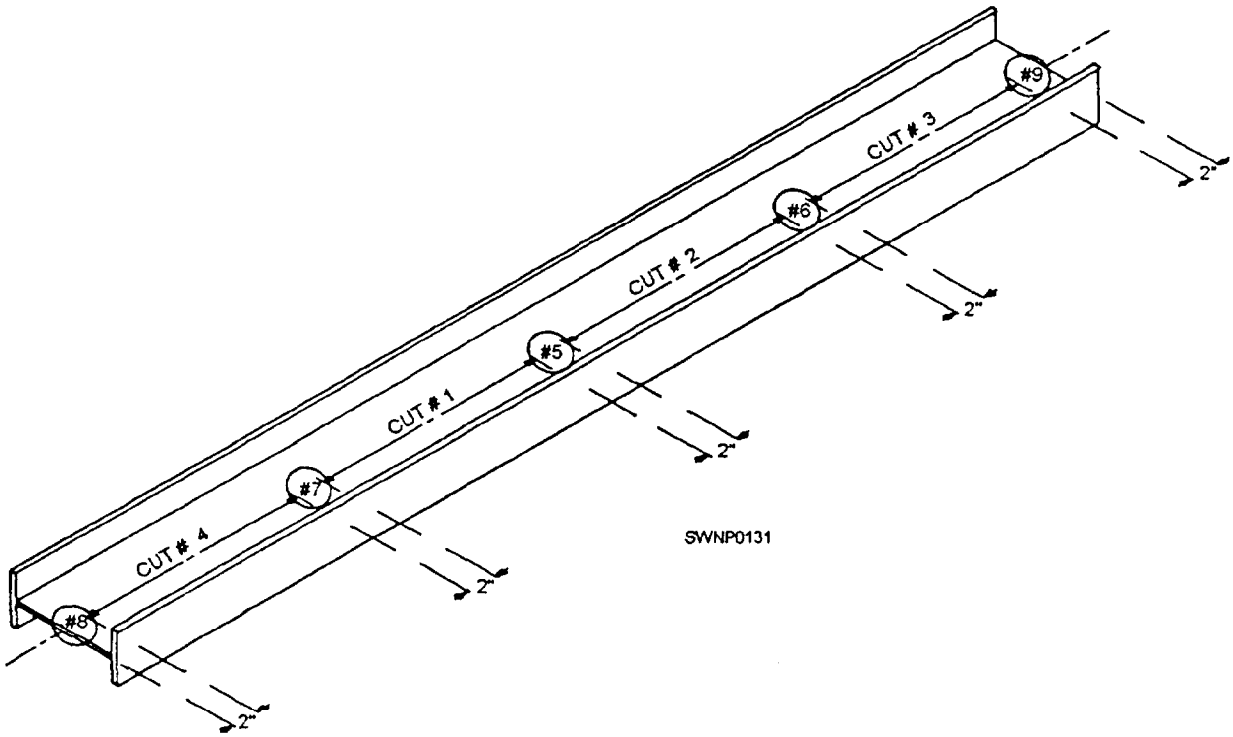


Figure 3-38.—Cuttiug order for splitting a beam.

views 1 and 2, or it may cover only the portions of the piece that contain holes or cuts, as shown in views 3 and 4. When holes, cuts, and bends are to be made in a finished piece, pilot holes, punch marks, and notches in the template should correspond exactly to the desired location in the finished piece. Templates for short members and plates are made of template paper of the same size as the piece to be fabricated. Templates for angles are folded longitudinal] y, along the line of the heel of the angle (fig. 3-39, view 3).

Accurate measurements in making templates should be given careful attention. Where a number of parts are to be produced from a template, the use of inaccurate measurements in making the template obviously would mean that all parts produced from it will also be wrong.

Template paper is a heavy cardboard material with a waxed surface. It is well adapted to scribe and divider marks. A combination of wood and template paper is sometimes used to make templates. The use of wood or metal is usually the best choice for templates that will be used many times.

For long members, such as beams, columns, and truss members, templates cover only the connections. These templates may be joined by a wooden strip to ensure accurate spacing (fig. 3-39, views 1 and 2). They may also be handled separately with the template for each connection being clamped to the member after spacing, aligning, and measuring.

In making templates, the same layout tools discussed earlier in this chapter are used. The only exception is that for marking lines, a pencil or Patternmaker's knife is used. When punching holes in a template, keep in mind that the purpose of the holes is to specify location, not size. Therefore, a punch of a single diameter can be used for all holes. Holes and cuts are made prominent by marking with paint.

Each template is marked with the assembly mark of the piece it is to be used with, the description of the material, and the item number of the stock material to be used in making the piece.

In laying out from a template, it is important that the template be clamped to the material in the exact position. Holes are center punched directly through the holes in the template (fig. 3-40), and all cuts are marked. After the template is removed, the marks for cuts are made permanent by rows of renter punch marks.

It is important that each member or individual piece of material be given identifying marks to

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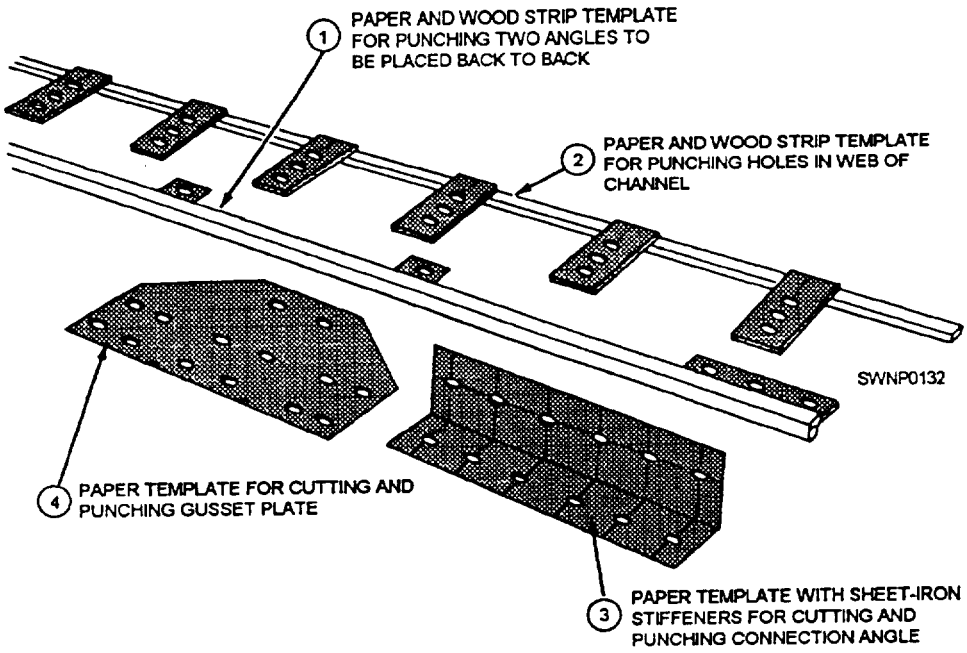


Figure 3-39.—Paper and combination templates.

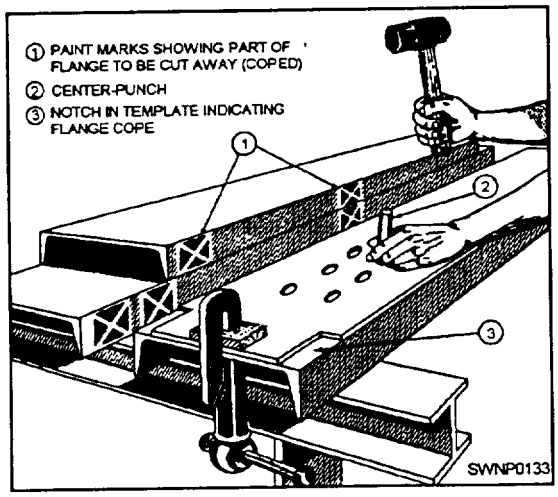


Figure 3-40.—Use of template in laying out a steel channel.

correspond with marks shown on the detail drawing (fig. 3-41).

The ERECTION MARK of a member is used to identify and locate it for erection. It is painted on the completed member at the left end, as shown on the detail drawing, and in a position so that it will be right side up when the member is right side up in the finished structure.

An ASSEMBLY MARK is painted on each piece on completion of its layout so that the piece can be identified during fabrication and fitting up with other pieces to form a finished member.

PIPE FITTING AND LAYOUT OPERATIONS

Lack of templates, charts, and mathematical formulas need not hinder you in pipe layout. In emergencies, welded pipe of equal diameter can be laid out in the field quickly and easily. By using the methods described here and a few simple tools, you can lay out branches and Y connections as well as turns of any angle, radius, and number of segments. The few simple tools required are both readily available and familiar to the Steelworker through almost daily use. A framing square, a bevel protractor with a 12-inch (20-cm) blade, a spirit level, a spring steel wraparound (or tape), a center punch, a hammer, and a soapstone will meet all needs. (A stiff strip of cardboard or a tin sheet about 3 inches [7.5 cm] wide also makes a good wraparound.) For purposes of our discussion, the long part of the framing square is referred to as the BLADE and the short part as the TONGUE.

LAYOUT OPERATIONS

Two methods of pipe layout are commonly used. They are the one-shot method and the shop method. The ONE-SHOT method is used in the field. With this

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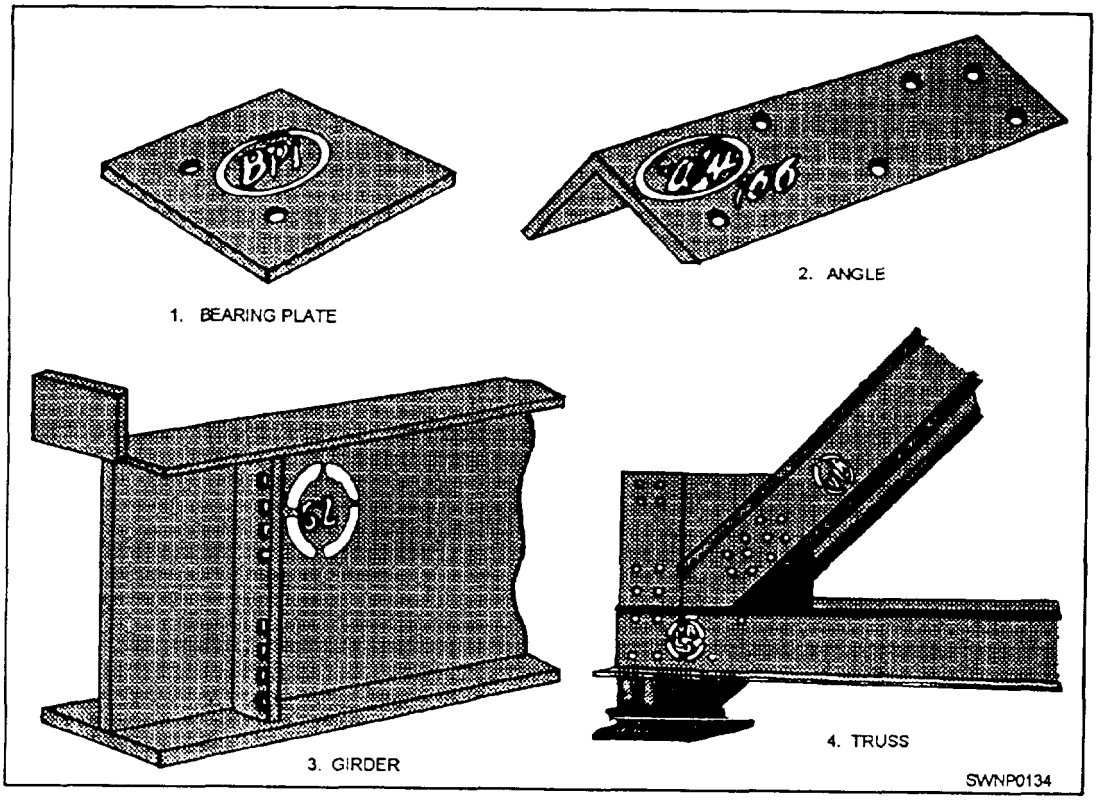


Figure 3-41.—Erection and assembly marks.

method, you use hand tools and make your layout on the pipe to be cut. The one-shot method is so named because you only use it once. In the SHOP METHOD you will make templates for pieces that are going to be duplicated in quantity. As an example, a job order comes into the shop for 25 pieces of 6-inch (15-cm) pipe-all cut at the same angle. Obviously, it would be time consuming to use the one-shot method to produce 25 pieces; hence the shop method is used for laying out. Patterns can be made of template paper or thin-gauge sheet metal. The major advantage of thin-gauge sheet metal templates is when you are finished with them they can be stored for later use.

Keep in mind that all pipe turns are measured by the number of degrees by which they turn from the course set by the adjacent straight section. The angle is measured between the center line of the intersecting sections of pipe. Branch connections are measured in angle of turnaway from the main line. For example, a 60-degree branch is so-called because the angle between the center line of the main pipe and the center line of the branch connection measures 60 degrees. Turns are designated by the number of degrees by which they deviate from a straight line.

QUARTERING THE PIPE

Inlaying out any joint, the first step is to establish reference points or lines from which additional measurements or markings can be made. This is done by locating a center line and dividing the outside circumference of the pipe into 90-degree segments, or quarters. The framing square, the spirit level, and the soapstone are used in these procedures in the following manner: Block the pipe so it cannot move or roll; then place the inside angle of the square against the pipe and level one leg. One point on the centerline is then under the scale at a distance of half the outside diameter of the pipe from the inside angle of the square (fig. 3-42). Repeating at another part of the pipe will

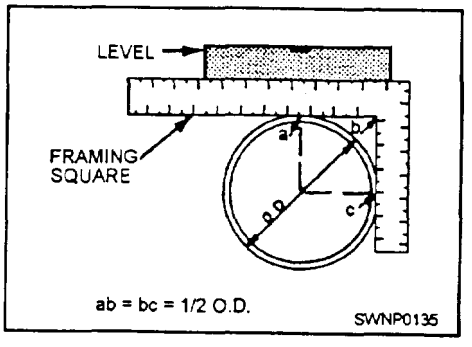


Figure 3-42.—Locating the top and side quarter points.

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locate two points and hence the center line. By this same method, the quarter points also may be located This operation is a must before any layout with the field method.

If you are using a long piece of pipe and are going to cut both ends in addition to the square, you will need a piece of carpenter's chalk line with a plumb bob on each end and two 24- or 36-inch (60- or 90-cm)-flat steel rules (depending on the diameter of the pipe) to locate the top and the bottom center lines. Figure 3-43 shows a plumb bob and rules being used to locate the top and the bottom center lines.

Another one-shot method of quartering pipe is to take a strip of paper and wrap it around the pipe and tear or cut the part that overlaps. The ends should touch. Remove the paper from the pipe and fold it in half, as shown in figure 3-44, view A. Then double the strip once again, as shown in view B. This will divide your strip into four equal parts. Place the strip of paper around the pipe. At the crease marks and where the ends meet, mark the pipe with soapstone and your pipe will be quartered.

TEMPLATE FOR TWO-PIECE TURN

The fact that a length of pipe with square ends can be fabricated by wrapping a rectangular section of plate into a cylindrical form makes available a method (known as parallel forms) of developing pipe surfaces, and hence developing the lines of intersection between

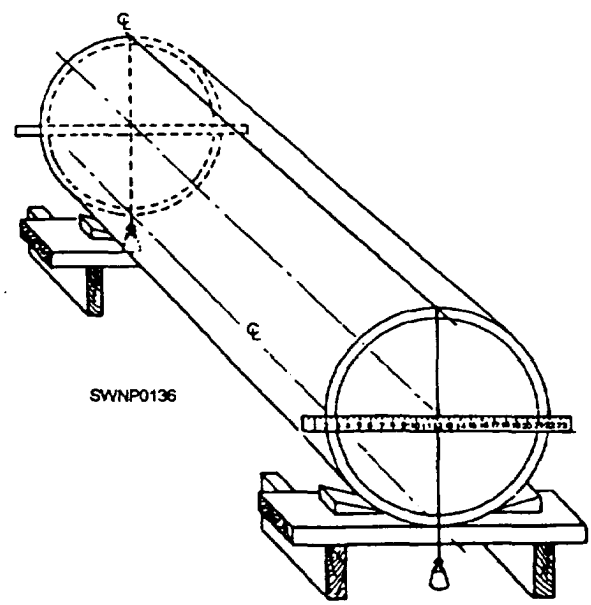


Figure 3-43.—Locating the top and the bottom center lines.

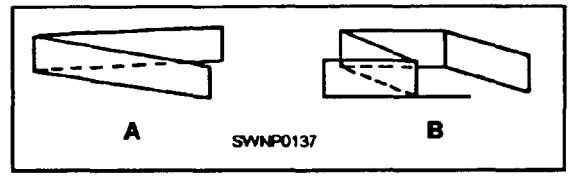


Figure 3-44.—Folding a tip of paper for use in quartering pipe.

pipe walls. Based on this principle, wraparound templates can be made for marking all manner of pipe fittings for cutting preparatory to welding.

The development of a template is done in practice by dividing the circumference (in the end view) of the pipe into a specific number of equal sections. These sections are then projected onto the side view of the desired pipe section. The lengths of the various segments that make up the pipe wall may then be laid out, evenly spaced, on a base line. This line is, in effect, the unwrapped circumference (fig. 3-45). If the template developed in figure 3-45, view C, is wrapped around the pipe with the base line square with the pipe, the curved line, a-b-c-d-e-f-, and so forth, will locate the position for cutting to make a 90-degree, two-piece turn. Draw a circle (fig. 3-45, view A) equal to the outside diameter of the pipe and divide half of it into equal sections. The more sections, the more accurate the final result will be. Perpendicular to the centerline and bisected by it, draw line AI equal to the O.D. (view B). To this line, construct the template angle (TA) equal to one half of the angle of turn, or, in this case, 45 degrees. Draw lines parallel to the centerline from points a, b, c, and so forth, on the circle and mark the points where these lines intersect line a-i with corresponding letters. As an extension of AI but a little distance from it, draw a straight line equal to the pipe circumference or that of the circle in view A. This line (view C) should then be divided into twice as many equal spaces as the semicircle, a-b-c-, and so forth, and lettered as shown. Perpendiculars should then be erected from these points. Their intersections with lines drawn from the points on a-i in view B, parallel to the base line in view C, determine the curve of the template.

SIMPLE MITER TURN

After quartering the pipe, proceed to make a simple miter turn. Locate the center of the cut (fig. 3-46, point c) in the general location where the cut is to be made. Use a wraparound to make line a-b completely around the pipe at right angles to the center

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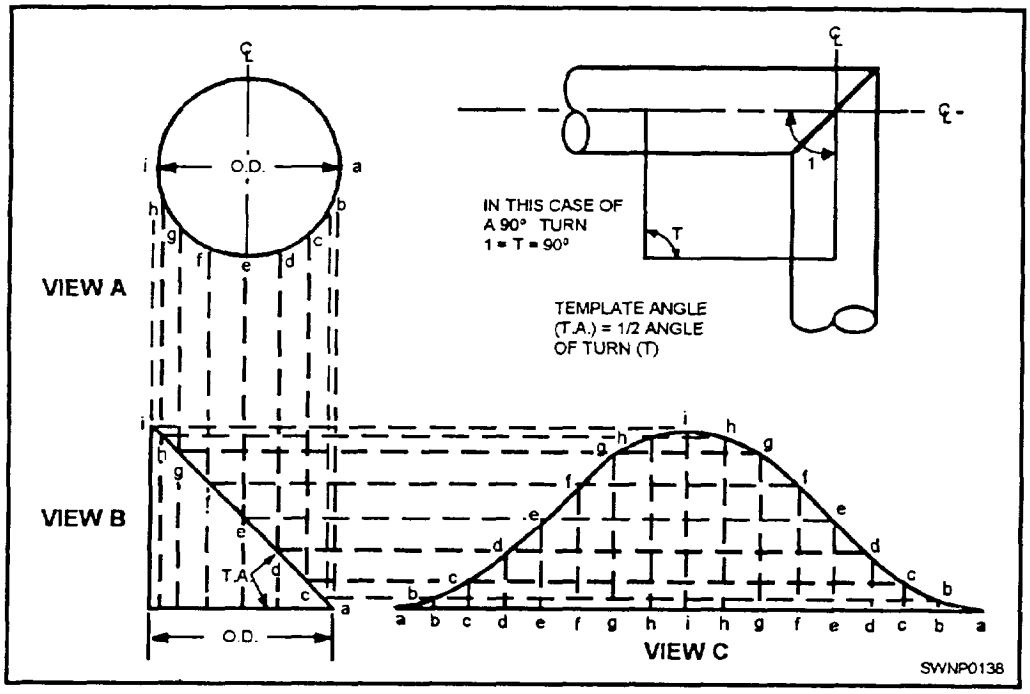


Figure 3-45.—Principles of template layout.

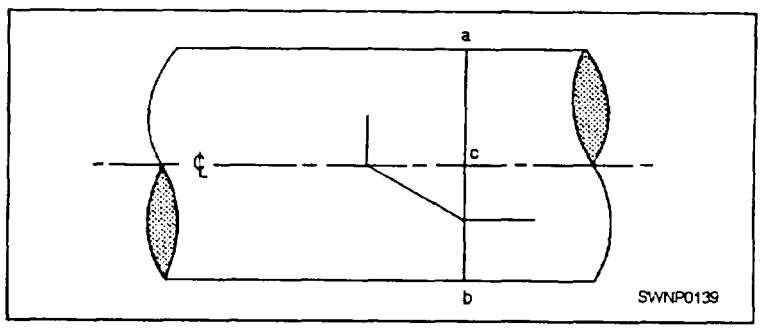


Figure 3-46.—Simple miter turn.

and quarter lines. This establishes a base line for further layout work.

When you are measuring, treat the surface of the pipe as if it were a flat surface. Use a flat-steel rule or tape, which will lie against the surface without kinks, even though it is forced to follow the contour of the pipe. These angles can also be checked for accuracy by sighting with the square.

Use the protractor and square to determine the proper cutback for the desired angle of the miter turn. Start with the protractor scale set at zero so that the flat surface of the protractor and the blade are parallel. You can now set the protractor for the number of degrees desired. After you have the correct setting, lock the blade. Place the protractor on the square with the bottom blade on the outside diameter of the pipe. Now read up to the cutback on the vertical blade of the square. You must be sure that the flat surface of the protractor is flush against the blade of the square (fig. 3-47). The outside radius of the pipe should have been determined during the quartering operation.

After you have obtained the cutback measurement, mark one half of this measurement off along the center line on top of the pipe. From the opposite side of the base line, measure off the same

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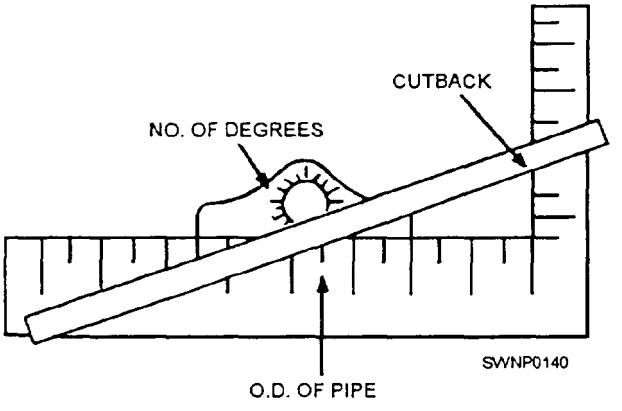


Figure 3-47.—Finding the cutback.

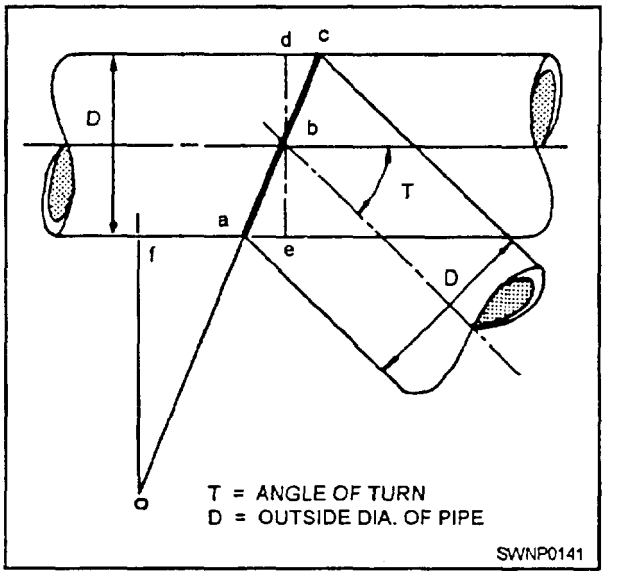


Figure 3-48.—To locate cut on a pipe for any angle two-piece turn.

distance along the bottom quarter line. Make punch marks with the center punch on each side of the line, along the side quarter lines. These marks will make it easy to align the pipe for welding after the joint is cut. Use the spring steel wraparound and pull the loop to the cutback point. Next, draw a chalk line over the top half of the pipe through the first cutback point. **(NOTE:** Do not allow the wraparound to twist or kink, and hold the chalk at a right angle to the wraparound while marking the pipe.) Now roll the pipe one-half turn and mark a chalk line in the same way around the bottom half of the pipe.

TWO-PIECE TURN

If a template is not available, you may determine the dimensions and markings for the cut necessary for a two-piece welded turn of any angle between 1 degree and 90 degrees by making a full-sized drawing, as shown in figure 3-48.

Draw the center lines intersecting at b by using the angle of turn T and then draw the outlines of the pipes by using the center lines and the diameter D. These will intersect at a and c. By laying the pipe over the drawing so that point b will coincide with that determined by construction details, you can draw the lines a-b and c-b in preparation for miter cutting and beveling.

After being prepared for welding, one section of pipe should be rotated through 180 degrees to form the desired angle, and then it should be tack-welded. Spacing should be slightly greater at the inside of the turn.

WELDED TEE

To lay out the template for cutting the branch and header for a 90-degree tee with header and branch of equal diameter, draw the side and end view, as shown in figure 3-49, views A and B.

In making the template for the branch in figure 3-49, view A, draw lines 1-5 at 45 degrees to the center line. Lay off distance 1-P equal to twice the thickness of the pipe wall and draw the smooth curve s-P-s. Now, project point P from view A to view B and draw the lines P-t radially. At a distance above point t equal to the thickness of the header wall, draw a-t horizontally, and vertical lines a-a and t-t. With lower points a as center, swing arcs r-s. Using the intersections of these arcs as centers and with the same radius, draw the curved lines a-be-d-e arid e d-c-b-a.

Divide the outside circumference of the branch top into equal parts and draw the vertical lines b-b, c-c, and so forth. Also, draw the horizontal base line a-a.

Lay off the unwrapped circumference (fig. 3-49, view D), and divide each half of it into the same number of equal parts as the branch semicircumference. In view D, you should plot the distances a-a, b-b, and so forth, from view B. This gives the distances from the base line to the branch curve of the intersection and determines the location of the branch template.

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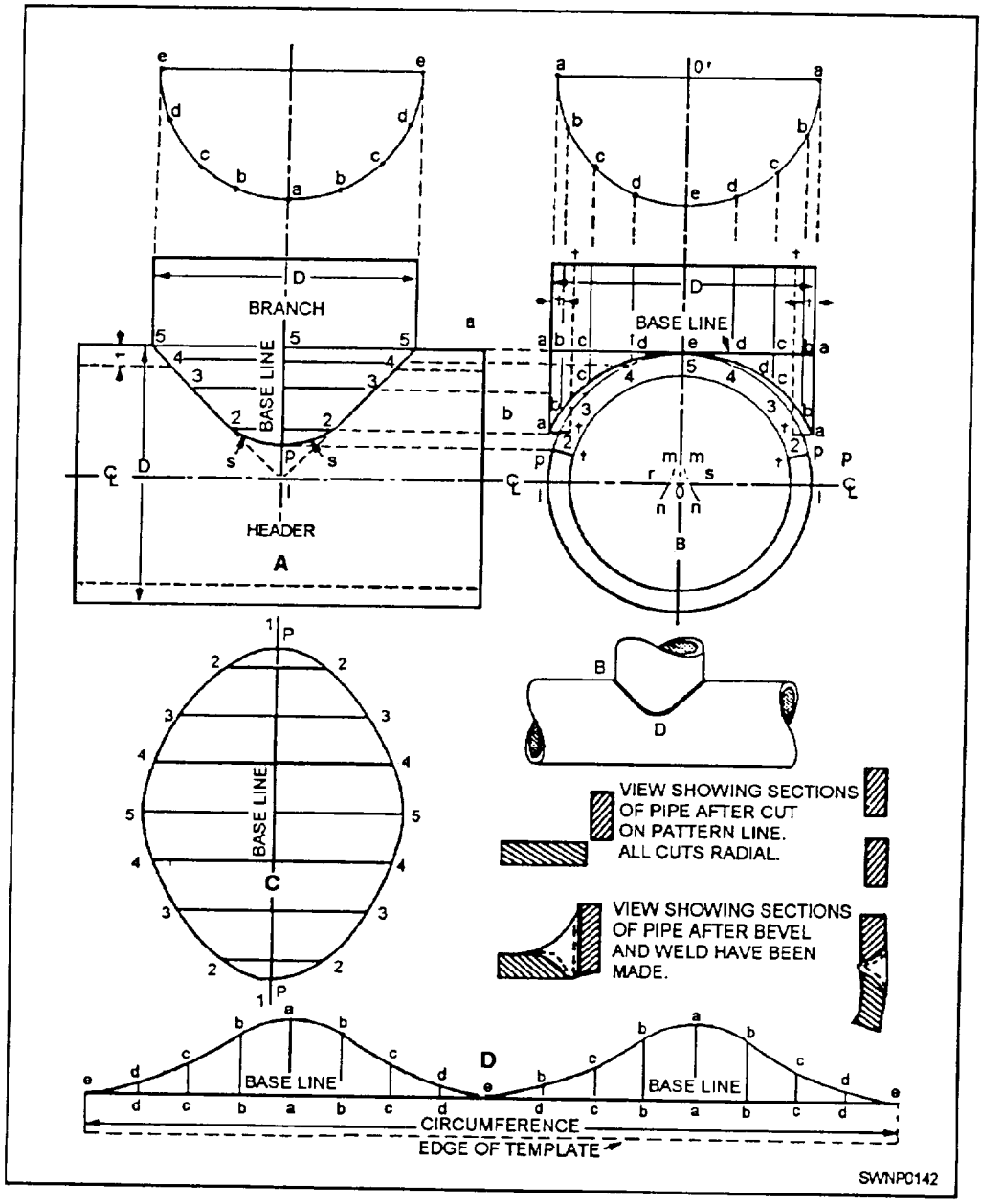


Figure 3-49.—90-degree tee.

To make the template for the hole in the header, divide the circumference of the header into equal parts, as at points 1, 2, 3, and so forth. Next, project these points across to view A (fig, 3-49), as shown. As in view C, lay off the line 1-5-1 equal to one half of the circumference of the header, and divide it into the same number of equal parts as was done on the header. Locate point P, a distance from 1 in view C equal to 1-P in view B. With this point P and the distances 5-5, 4-4, and so forth, in view A, plotted as shown in view C, the curve of the template is located.

BRANCH CONNECTIONS

Branch to header connections (fig. 3-50) at any angle of 45 degrees to 90 degrees can be fabricated in equal diameter pipe by the following procedures. (Note that angles less than 45 degrees can be made, but a practical limitation is imposed by the difficulty of welding the crotch section.)

First, quarter both sections of pipe as before. hen locate the center line of the intersection (point B) on the header and draw line GF around the pipe at this

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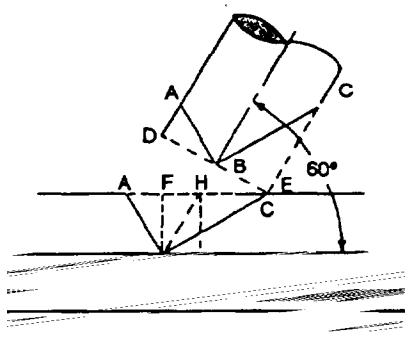


Figure 3-50.—Branch connections

point. Set the diameter FG on the blade of the square. Set and lock the protractor atone fourth of the number of degrees of turnaway from the header (in the example, 1/4 of 60° = 15°). With the blade along FG, the frost cutback measurement, FA, will be indicated on the tongue of the square. Measure off this distance along the center line of the header from line FG and mark point A. As described before, join point A with the points of intersection of line FG and the two side quarter lines to outline the first cut.

With the same protractor setting, flip the square and mark point H. Distance FH is equal to FA. FH is the first portion of the second cutback measurement. With the same settings and with the square upside down (as compared to before), locate point I the same way you located point H.

Now, set the protractor to one half of the number of degrees of turnaway from the header (in the example, 1/2 of 60° = 30°). With the blade set to the diameter, the second portion, HD, of the second cutback measurement will be indicated on the tongue. The second cutback measurement is the total distance FC. Connect points C and B and connect C with the point, which corresponds to B, on the quarter line on the opposite side of the header. This outlines the second cut and completes the marking of the header.

Use the same two cutback measurements to lay out the end of the branch. Branch cutback distance DA is equal to header cutback distance FA. Branch cutback distance EC is equal to header cutback distance FC. If the branch end is square, make cutback measurements from the end, rather than marking in a circumferential line. Make all cuts as before, and level and join the branch and header by welding.

WELDED TEE (BRANCH SMALLER THAN THE HEADER)

One of the best types of joint for a 90-degree branch connection where the branch is smaller than the header is obtained by inserting the smaller branch pipe through the wall down to the inner surface of the header. The outside surface of the branch intersects the inside surface of the header at all points. When the header is properly beveled this type of intersection presents a very desirable vee for welding. In ease templates or template dimensions are not available, the line of cut on both header and branch can be located by other methods, but the use of templates is recommended.

In the first method, the square end of the branch should be placed in the correct position against the header and the line of intersection marked with a flat soapstone pencil (fig. 3-51). Since radial cutting is used in this case and since the outer branch wall should intersect the inner header wall, point B should be located on both sides of the branch a distance from A equal to slightly more than the header wall thickness. A new line of cut is then marked as a smooth curve through the points, tapering to the first line at the top of the header. Following radial cutting, the joint should then be beveled

The branch should be slipped into the hole until even with point B to locate the line of cut on the branch. A soapstone pencil may then be used to mark the line for radial cutting. No beveling is necessary.

A second method for larger diameter pipe is shown in figure 3-52. After the centerlines have been drawn, the branch should be placed against the header, as shown. By means of a straightedge, the distance between A and the header wall is determined, and this measurement above the header is transferred to the branch wall, as represented by the curved line a-b-c.

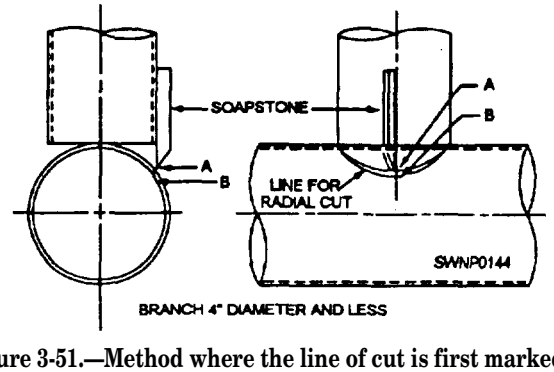


Figure 3-51.—Method where the line of cut is first marked on main.

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After this line is radially cut, the branch maybe used to locate the line of cut on the header, allowing for the intersection of the outer branch wall and inner header wall as before. This line should be radially cut, followed by beveling.

In making an eccentric branch connection the extreme case being where the side of the branch is even with the side of the header, a similar procedure is followed, as shown in figure 3-53.

THREE-PIECE Y CONNECTION

The entire procedure for fabrication of an equal diameter, three-piece Y connection is based on individual operations already described. As the first step, quarter the end of the three pieces of pipe and apply circumferential lines. When the three pieces are welded together to form the Y, there will be three center lines radiating from a common point.

The open angle between each pair of adjacent center lines must be decided, for each of these angles will be the angle of one of the branches of the Y. As shown in figure 3-54, these open angles determine the angle of adjoining sides of adjacent branches. Thus half of the number of degrees between center lines A and B are included in each of the adjoining cutbacks between these two branches. The same is true with respect to the other angles and cutbacks between

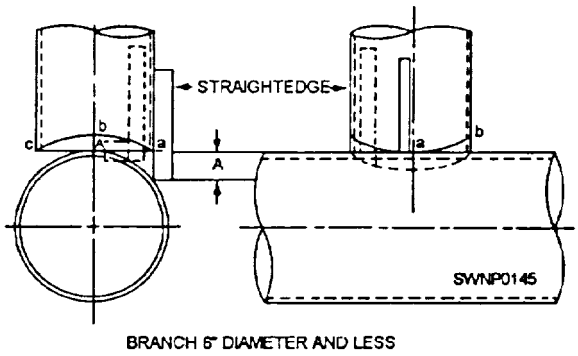


Figure 3-52.—Line of cut is first marked on branch with this method.

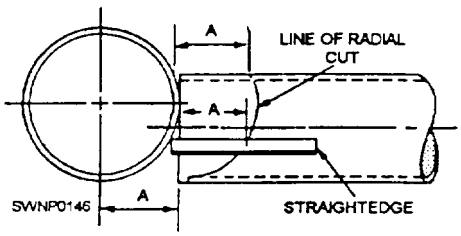


Figure 3-53.—Marking cut on branch for eccentric branch connection.

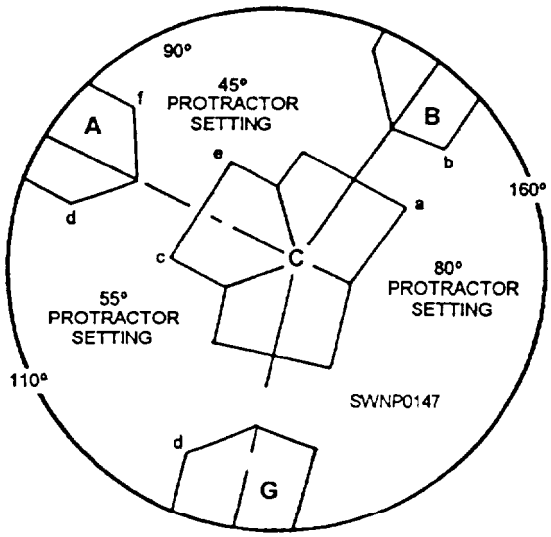


Figure 3-54.—Three-piece Y connection.

center lines, Moreover, each piece of pipe must have a combination of two angles cut on the end.

To determine the amount of cutback to form an angle of the Y, set the protractor at one half of the open angle between adjacent branch center lines. Place the protractor on the square, crossing the outside radius measurement of the pipe on the tongue of the square, and read the cutback distance off the blade of the square. Mark off this distance on one side quarter line on each of the two pieces that are to be joined. Then mark the cutback lines. Repeat this procedure for the other two angles of the Y, taking care to combine the cutbacks on each pipe end. Three settings of the protractor determine all cutbacks.

An alternate method for determining each cutback is to treat two adjacent branches as a simple miter turn. Subtract the number of degrees of open angle between center lines from 180 degrees and set the protractor at one half of the remaining degrees. Cross the outside radius measurement on the tongue. Mark one side of each adjoining pipe section. Repeat for the other two branches. Take care to combine the proper cutbacks on each pipe end. Set the protractor for each open angle of the Y connection.

The computations and measurements for the layout (fig. 3-54) are shown in table 3-1. The pipe is 12 inches in diameter and has a radius of 6 inches (15 cm)

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Table 3-2.—Computations and Measurement for a Y Connection.

	ACB	ACG	BCG
Open angle between center lines	90 deg.	110 deg.	160 deg.
Protractor setting (half of each angle)	45 deg.	55 deg.	80 deg.
Cutbacks	6"	4 1/8"	1 1/16"
Center lines	A	B	G
Paired cutback measurements (inches)	fe = 6" cd = 4 1/8"	ab = 1 1/16" fe = 6"	ab = 1 1/16" cd = 4 1/8"

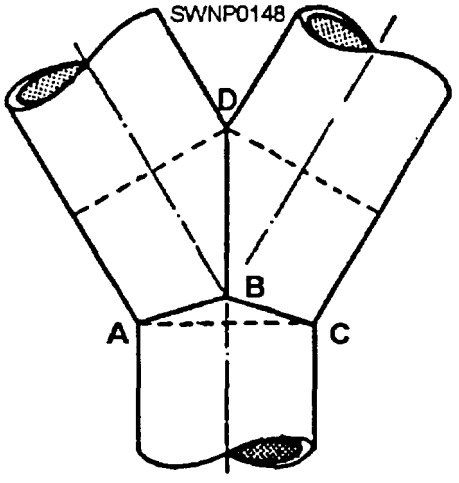


Figure 3-55.—True Y.

LAYOUT OF A TRUE Y

In laying out pipe for the fabrication of a true Y without the use of templates or tables, a full-sized drawing of the intersection (fig. 3-55) should be made. 'he intersection of the center lines of the three pipes will locate point B, and lines from B to the intersections of the pipe walls will locate points A, C, and D. From these points the pipe maybe marked for cutting. Miter cutting, followed by suitable beveling, is necessary in preparing the pipe for welding.

TEMPLATE LAYOUT FOR TRUE Y BRANCHES AND MAIN LINES

Inlaying out a template for a true Y, a drawing of the intersection should be made, as shown in figure 3-56, view A. After drawing the lines of intersection, the same essential methods as for other templates are followed. Note that here it is suggested the equally divided semicircumferences are more conveniently placed directly on the base line. The distances from the base line to the line of intersection plotted on the unwrapped base line determine the template.

ORANGE PEEL HEAD

A number of different types of heads are used in welded pipe construction. Here, we are interested in one general type, the ORANGE PEEL, since it will often concern you in your work. A main advantage of the orange peel is that it has high strength in resisting internal pressure.

If templates or tables are not available for making an orange peel head, a reasonably accurate marking can be secured by the following procedure for laying out a template.

The number of arms to make an orange peel head should be the minimum number which can be easily bent over to form the head. Five arms and welds are the recommended minimum for any pipe; this number should be increased for larger sizes of pipe. Dividing the circumference by 5 is a good method for deciding the number of arms, provided, there are at least 5.

To lay out the template, draw the side and end views (fig. 3-57). Divide the pipe circumference in view B into the same number of equal parts as it is planned to have welds, and draw the radial lines o-a, o-b, and so on. Project the points a, b, and so on, in this view.

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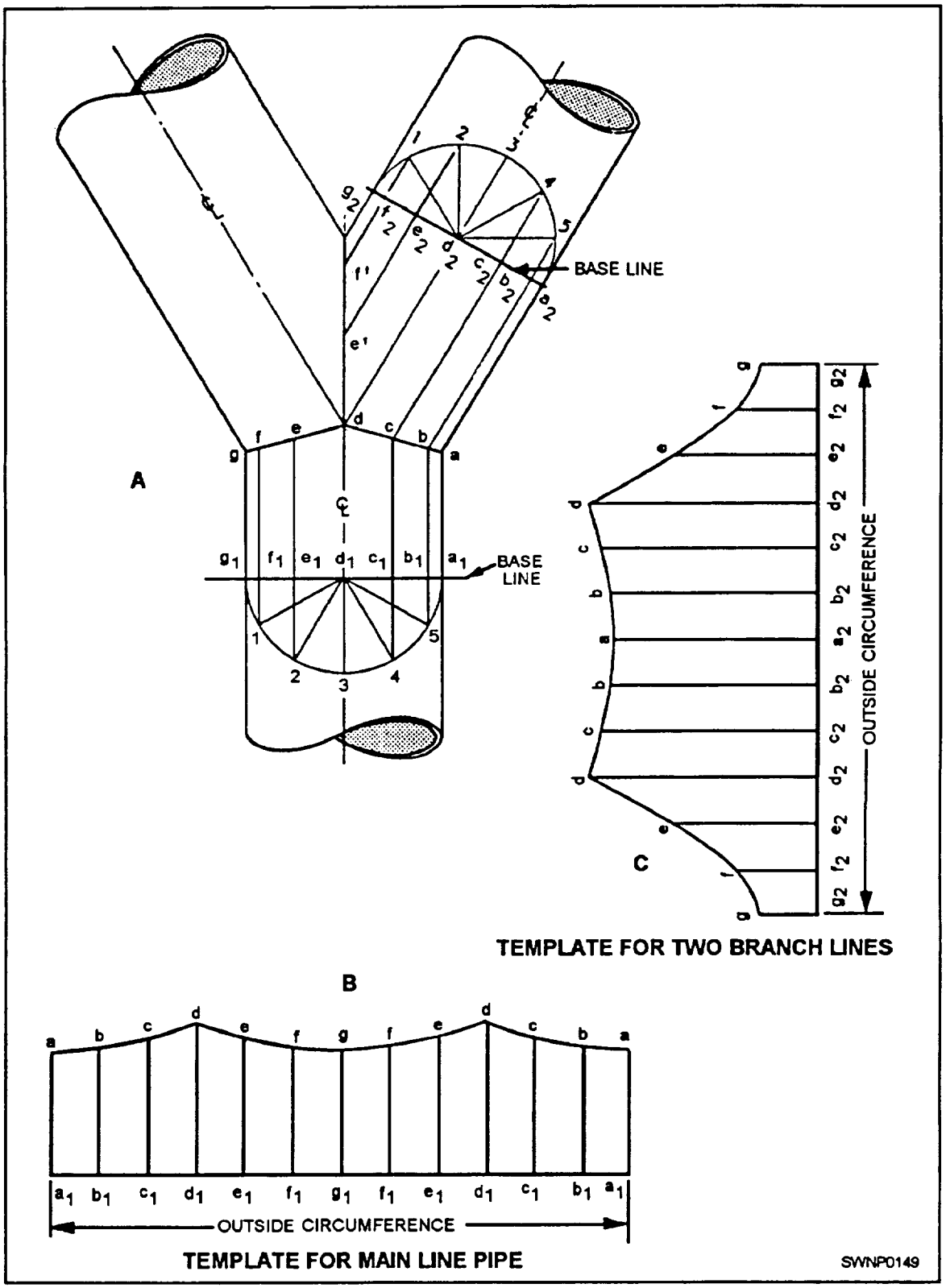


Figure 3-56.—Template for true Y branches and main of equal diameter.

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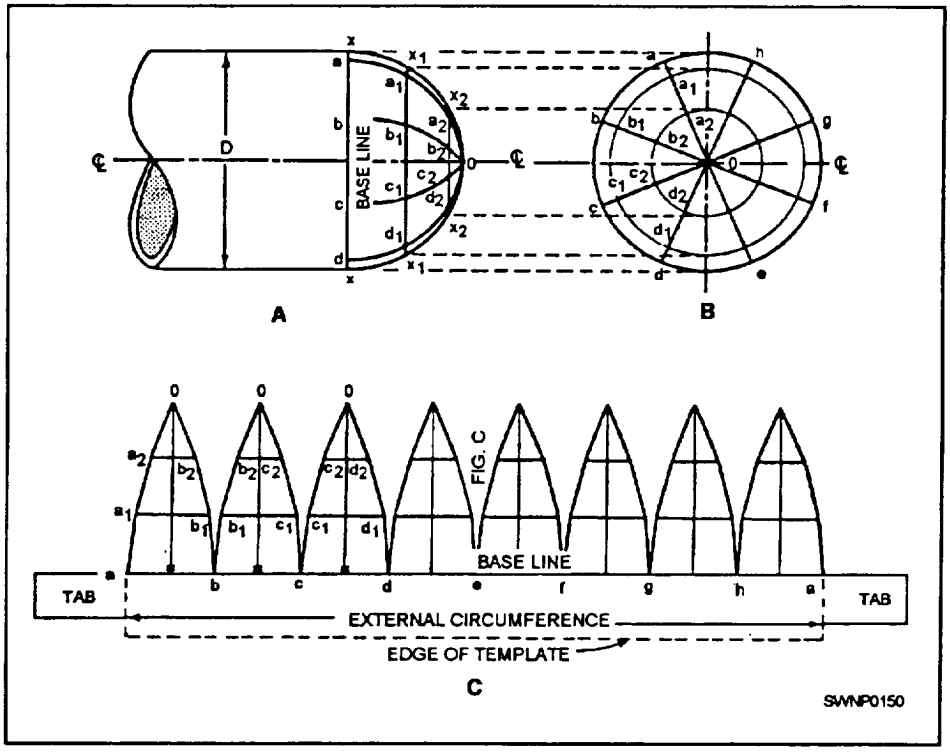


Figure 3-57.—Orange peel head.

Now, divide x-o-x into equal parts-in this case, 6. Then draw the lines x1-x1 and x2x2. These represent the concentric circles in view B. In laying out the template, the distances a-b, b-c, a1-b1, a2-b2, and so on, are taken from view B. The distances x+,x-xl, x-x2, b-b1, and so on, are taken from view A. It is not actually necessary to draw views A and B since all the values can be determined by a simple computation. All cutting should be radial followed by a beveling cut.

A one-shot field method of making an orange peel is shown in figure 3-58. This method can be used when you are going to make only one orange peel. Incidentally, the tables shown in figure 3-58 will help to lineup your template better.

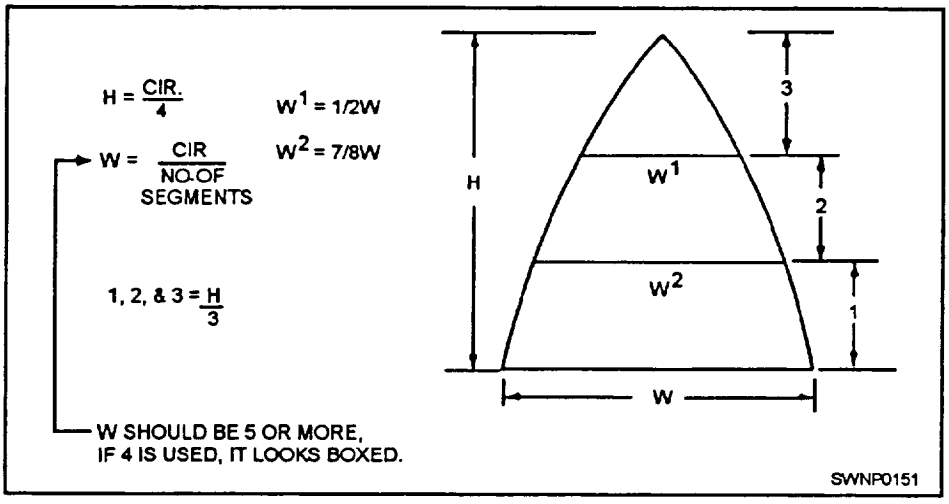


Figure 3-58.—A field method of making an orange peel.

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PIPE CUTTING

Cutting pipe is not much different than cutting structural shapes, except that you must always keep in mind that the cut will either be radial or miter. The gas cutting torch is used to cut pipe fittings for welding. Procedures relating to the use of the cutting torch are given in volume 1, chapter 4. The torch maybe hand operated, or it maybe mounted on a mechanical device for more accurate control.

Cutting machines may be used to prepare many fittings without the use of templates. These machines cut and bevel the pipe in one operation-the bevel extending for the full pipe wall thickness. When the pipe is cut by hand, beveling is done as a second operation.

For many types of welded fittings, a RADIAL cut is required before beveling. Radial cutting simply means that the cutting torch is held so it is perpendicular to the interior center line at all times. In other words, the cutting orifice always forms a continuation of a radius of the pipe, making the cut edge square with the pipe wall at every point. Figure 3-59 shows radial cutting. Except in the case of the blunt bull plug, for which the radial cut provides the proper vee, the radial cut should be followed by a beveling cut for pipe with 3/1 6 inch (4.8 mm) or more wall thickness.

In MITER cutting the torch tip is held so that the entire cut surface is in the same plane. The miter cut is followed by a beveling cut, leaving a 1/32- to 1/16-inch (.8 to 1.6-mm) nose at the inner wall. Figure 3-60 shows miter cutting.

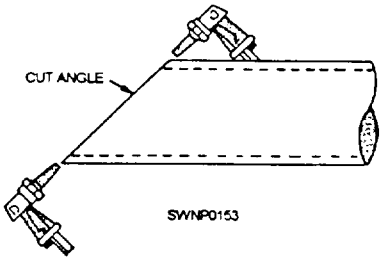


Figure 3-60.—Miter cutting.

PIPE BENDING

Any piping system of consequence will have bends in it. When fabricating pipe for such a system, you can make bends by a variety of methods, either hot or cold, and either manual] y or on a power-bending machine. Cold bends in pipe are usually made on a bending machine. Various types of equipment are available, ranging from portable handsets to large hydraulically driven machines that can cold bend pipe up to 16 inches (40.64 cm) in diameter. You will be concerned primarily with hot bending techniques, using a bending slab or using a method known as wrinkle bending.

TEMPLATES

Whatever method you use to bend pipe, you should normally have some pattern that represents the desired shape of the bend. Templates made from wire or small, flexible tubing can be invaluable in preparing new installations as well as in repair work, When properly made, they will provide an exact guide to the bend desired.

One of the simple types of bend template is the center line template. A centerline template is made to

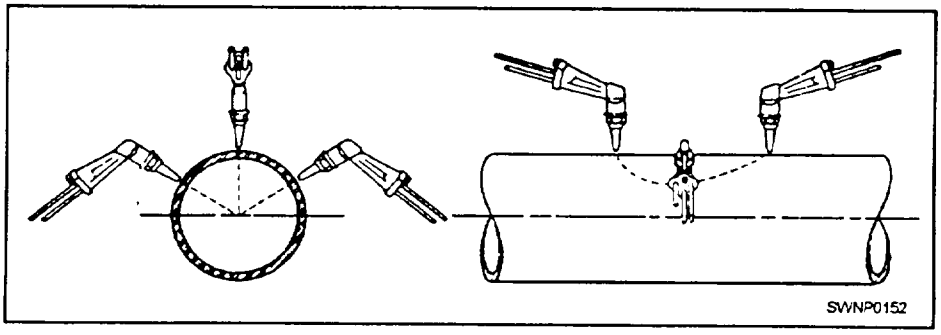


Figure 3-59.—Radial cutting.

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conform to the bend or bends of the pipe to be made. It is used to lay off the bend area on the pipe and as a guide during the pipe or tube bending operation. Figure 3-61 shows the use of a center line template. These templates are made of wire, or rod, and are shaped to establish the center line of the pipe to be installed. The ends of the wire are secured to special clamps, called flange spiders. A clearance disc, which must be the same diameter as the pipe, is used if there is any doubt about the clearance around the pipe.

HOT BENDS

Hot bends are accomplished on a bending slab (fig. 3-62). This slab requires little maintenance beyond a light coating of machine oil to keep rust in check.

As a preliminary step in hot bending, pack the pipe with dry sand to prevent the heel or outside of the bend from flattening. If flattening occurs, it will reduce the cross-sectional area of the pipe and restrict the flow of fluid through the system.

Drive a tapered, wooden plug into one end of the pipe. Place the pipe in a vertical position with the plugged end down, and fill it with dry sand. Leave just enough space at the upper end to take a second plug. To ensure that the sand is tightly packed, tap the pipe continually with a wooden or rawhide mallet during the filling operation. The second plug is identical with the first, except that a small vent hole is drilled through its length; this vent permits the escape of any gases (mostly steam) that may form in the packed pipe when heat is applied. No matter how dry the sand may appear, there is always a possibility that some moisture is present. This moisture will form steam that will expand and build up pressure in the heated pipe unless some means of escape is provided. If you do not provide a vent, you will almost certainly blow out one of the plugs before you get the pipe bent.

When you have packed the pipe with sand, the next step is to heat the pipe and make the bend. Mark the bend area of the pipe with chalk or soapstone, and heat it to an even red heat along the distance indicated from A to B in figure 3-63. Apply heat to the bend area frost on the outside of the bend and then on the inside. When an even heat has been obtained, bend the pipe to conform to the wire template. The template is also used to mark the bend area-on the pipe.

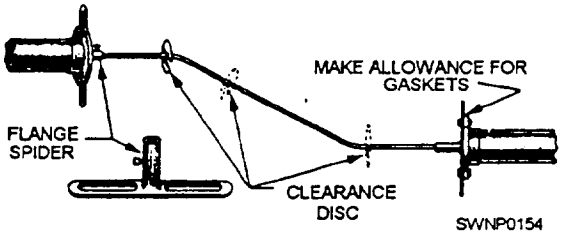


Figure 3-61.—Center line template.

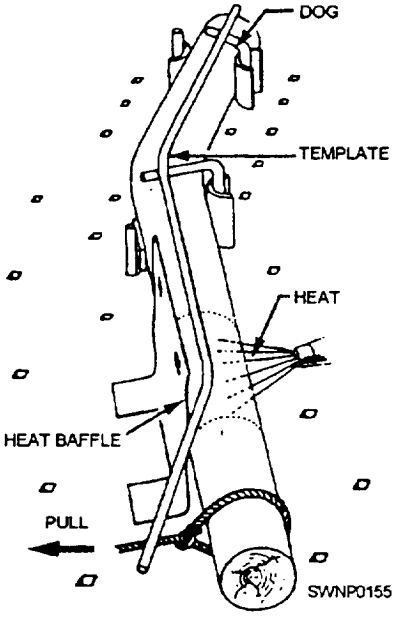


Figure 3-62.—Bending on a slab.

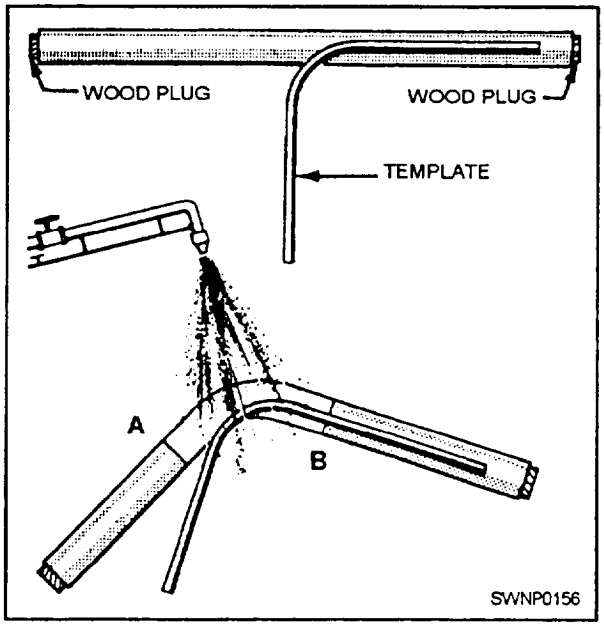


Figure 3-63.—Heating and bending pipe to conform to wire template.

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The main problem you will have in bending copper tubing and pipe is preventing wrinkles and flat spots. Wrinkles are caused by compression of the pipe wall at the throat (inside) of the bend. Flat spots are caused by lack of support for the pipe wall, by stretch in the heel (outside) of the bend, or by improper heating.

If the pipe is properly packed and properl y heated, wrinkles and flat spots can be prevented by bending the pipe in segments so that the stretch is spread evenly over the whole bend area. When a pipe is bent, the stretch tends to occur at the middle of the bend. If the bend area is divided into a number of segments and then bent in segments, the stretch will occur at the center of each segment and thus be spread more evenly over the bend area. Another advantage of bending in segments is that this is almost the only way you can follow a wire template accurately.

When bending steel and some other piping materials, you can control wrinkles and flat spots by first overbending, the pipe slightly and then pulling the end back (fig. 3-64).

Hot bends are made on a bending slab (fig. 3-64). The pull to make the bend is exerted in a direction parallel to the surface of, the bending slab. The necessary leverage for forming the bend is obtained by using chain falls, by using block and tackle, or by using a length of pipe that has a large enough diameter to slip over the end of the packed pipe. Bending pins and hold-down clamps (dogs) are used to position the bend at the desired location.

Be sure to wear asbestos gloves when working on hot bending jobs. Pins, clamps, and baffles often have to be moved during the bending operation. These items absorb heat radiated from the pipe as well as from the torch flame. You cannot safely handle these bending accessories without proper gloves.

Each material has its peculiar traits, and you will need to know about these traits to get satisfactory results. The following hints for bending different materials should prove helpful:

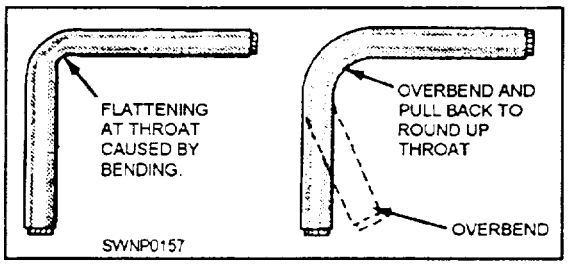


Figure 3-64.—Overbending to correct flattening of pipe.

WROUGHT IRON—Wrought iron becomes brittle when hot, so always use a large bend radius. Apply the torch to the throat of the bend instead of to the heel.

BRASS—Do not overbend, as brass is likely to break when the bend direction is reversed.

COPPER—Hot bends may be made in copper, although the copper alloys are more adaptable to cold bending. This material is one that is not likely to give any trouble.

ALUMINUM—Overbending and reverse bending do not harm aluminum, but because there is only a small range between the bending and melting temperature, you will have to work with care. Keep the heat in the throat at all times. You will not be able to see any heat color, so you must depend on "feel" to tell you when the heat is right for bending. You can do this by keeping a strain on the pipe while the bend area is being heated. As soon as the bend starts, flick the flame away from the area. Play it back and forth to maintain the bending temperature and to avoid overheating.

CARBON-MOLYBDENUM and CHROMIUM-MOLYBDENUM—These maybe heated for bending, if necessary, but caution must be exercised so as not to overheat the bend area. These types of metal are easily crystallized when extreme heat is applied. Pipes made from these materials should be bend cold in manual or power-bending machines.

WRINKLE BENDS

It may seem odd that after describing precautions necessary to keep a bend free of wrinkles, we next describe a method which deliberately produces wrinkles as a means of bending the pipe. Nevertheless, you will find the wrinkle-bending technique a simple and direct method of bending pipe, and perhaps in man y pipe-bending situations, the only convenient method. This would particularly be the case if no bending slab were available or if time considerations did not permit the rather lengthy sand-packing process.

Basically, wrinkle bending consists of a simple heating operation in which a section of the pipe is heated by a gas welding torch. When the metal becomes plastic (bright red color), the pipe is bent SLIGHTLY, either by hand or by means of tackle

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rigged for that purpose. The unheated portion forms the heel (outside) of the bend, while the wrinkle is formed at the throat (inside) of the bend due to compression.

It should be understood that the pipe should not be bent through very large angles (12 degrees being considered the maximum for one wrinkle) to avoid the danger of the pipe buckling. The procedure in making a large bend is to make several wrinkles, one at a time. If, for example, you want to produce a bend of 90 degrees, a minimum of eight separate wrinkles could be made. Figure 13-65 shows a 90-degree bend made with ten separate wrinkles. The formula to determine the number of wrinkles is to divide the degrees per wrinkle required into the degrees of the bend required.

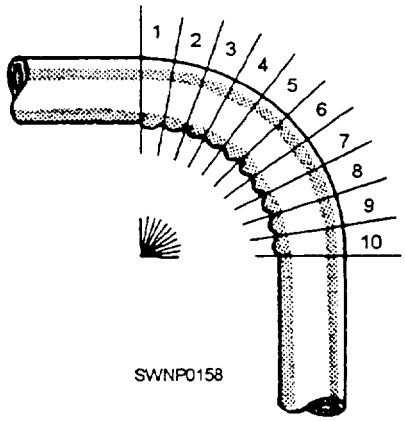


Figure 3-65.—90-degree bend made with ten separate wrinkles.

Wrinkle bending has been successful on pipe of more than 20 inches in diameter. Experience has shown that, for 7-inch-diameter pipe and over, more complete and even heating is accomplished using two welding torches, rather than one. In any event, the heating procedure is the same-the torch or torches being used to heat a strip approximately two thirds of the circumference of the pipe (fig. 3-66). The heated strip need not be very wide (2 to 3 inches, or 5.08 to 7.62 cm, is usually sufficient) since the bend will only be through 12 degrees at most. The heated portion, as we have noted, is the part which will compress to become the inside of the bend. The portion which is not heated directly will form the outside of the bend.

The technique most often used to bend the pipe, once it has been heated, is simple and straightforward. The pipe is merely lifted up by hand (or by tackle), while the other end is held firmly in position.

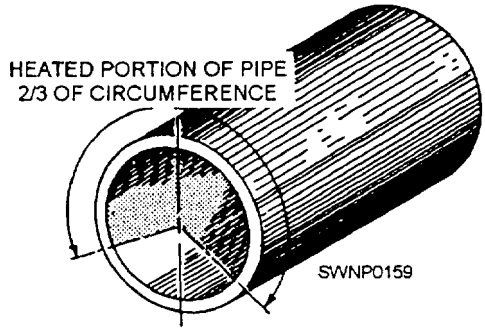


Figure 3-66.—Part of pipe heated before wrinkle bending.

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Chapter 4

FIBER LINE

Starting with this chapter, we explore another major area of steelworking skills-the erection and assembly of steel structure. Steelworkers require tools to hoist and maneuver the steel members into place to erect a structure of any magnitude. These hoisting tools range from uncomplicated devices, such as tripods and gin poles, to more complex mechanisms, such as cranes and motor-powered derricks. Whatever the case, one of the most important components of these hoisting mechanisms is the fiber line or wire rope that must be attached to and hold the load to be hoisted and maneuvered. Before you, as a Steelworker, can become skilled in the supervision of hoisting devices, you must first understand the use and maintenance of fiber line and wire rope.

FIBER LINE

This chapter and the next are designed to familiarize you with the different types of fiber line and wire rope commonly used by Steelworkers. We also discuss knots, bends, hitches, clips, and fittings and describe how they are used. Other topics discussed include the handling and care of fiber line and wire rope, making splices in fiber line, and methods of determining safe working loads.

TYPES OF NATURAL FIBER LINES

Vegetable fibers commonly used in the manufacture of line include manila, sisal, hemp, coir, and cotton.

Manila

Manila is a strong fiber that comes from the leaf stems of the stalk of the abaca plant, which belongs to the banana family. The fibers vary in length from 4 to 12 feet in the natural state. The quality of the fiber and its length give manila line relatively high elasticity, strength, and resistance to wear and deterioration. A good grade of manila is cream in color, smooth, clean, and pliable. Poorer grades of manila are characterized by varying shades of brown. In many instances, the manufacturer treats the line with chemicals to make it more mildew resistant, which increases the quality of the line. Manila line is generally the standard item of issue because of its quality and relative strength.

Sisal

The next best line-making fiber is sisal. It is made from two tropical plants—sisalana and henequen. The fiber is similar to manila, but lighter in color. It is grown in the East Indies, Africa, and Central America. Sisal fibers are usually 26 to 40 inches (65 cm to 1 m) long but are only about 80 percent as strong as manila fibers. Sisal line withstands exposure to seawater exceptionally well. It is frequently used in towing, mooring, and similar purposes.

Hemp

Hemp is a tall plant that provides useful fibers for making line and cloth. It is cultivated in the United States, Russia, Italy, and South America. Hemp was used extensively before the introduction of manila. Throughout the Navy the principal use is for small stuff, ratline, marline, and spun yarn. Since hemp absorbs tar much better than the hard fibers, these fittings are invariably tarred to male them water resistant. The term *small stuff* is used to describe small cordage that a layman may call string, yarn, or cords. Tarred hemp has about 80 percent of the strength of untarred hemp. Of these tarred fittings, marline is the standard item of issue.

Coir

Coir line is a light line made from the fiber of coconut husks and is light enough to float on water. A resilient rough line, it has about one fourth of the strength of hemp; therefore, the use of coir is restricted to small lines.

Cotton

Cotton line is a smooth white line that stands much bending and running. Cotton is not widely used in the Navy except, in some cases, for small lines.

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TYPES OF SYNTHETIC FIBER LINES

Although natural fiber line is normally used, a number of synthetic fibers are also used to make line. The synthetic fibers used to fabricate line include the following: nylon, Kevlar, Orion, and Dacron.

Of the types of line made from synthetic fibers, nylon is the one used the most. The primary benefit of using nylon line is that the breaking (tensile) strength of nylon line is nearly three times that of manila line. An additional benefit of using nylon line is that it is waterproof and has the ability to resume normal length after being stretched and absorbing shock. It also resists abrasion, rot, decay, and fungus growth.

FABRICATION OF LINE

The fabrication of line consists essentially of three twisting operations. First, the FIBERS are twisted to the right to form the YARNS. Second, the yarns are twisted to the left to form the STRANDS. Third, the strands are twisted to the right to form the LINE. Figure 4-1 shows you how the fibers are grouped to form a three-strand line.

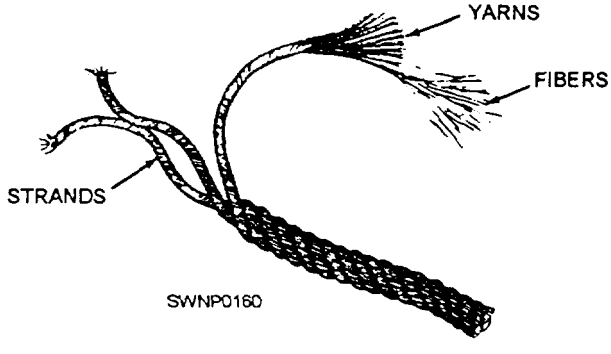


Figure 4-1.—Fabrication of line.

The operations just described are standard procedure. The product produced is known as a RIGHT-LAID line. The process is sometimes reversed, then you have what is known as a LEFT-LAID line. In either instance, the principle of opposite twists must always be observed. One reason for this is to keep the line tight or stable and prevent the elements from unlaying when a load is suspended on it. Another reason for twisting the elements of a line in opposite directions is to prevent moisture penetration.

TYPES OF LAYS OF LINE

There are three types of lays of fiber line with which you should be familiar. They are the HAWSER-LAID, SHROUD-LAID, and CABLE-LAID lines. Each type is shown in figure 4-2.

Hawser-Laid Line

Hawser-laid line generally consists of three strands twisted together, usually in a right-hand direction.

Shroud-Laid Line

Ordinarily, a shroud-hid line is composed of four strands twisted together in a right-hand direction around a center strand or core. This core is usually of the same material but smaller in diameter than the four strands. You will find that shroud-laid line is more pliable and stronger than hawser-laid line. You will also find that shroud-laid line has a strong tendency to kink. In most instances, it is used on sheaves and drums. This not only prevents kinking but also makes use of its pliability and strength.

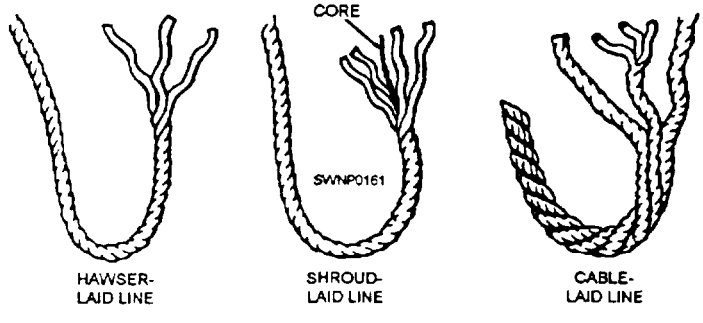


Figure 4-2.—Lays of line.

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Cable-Laid Line

Cable-laid line usually consists of three right-hand hawser-laid lines twisted together in a left-hand direction. This type is especially useful in heavy construction work, because if it tends to untwist, it will tighten any regular right-hand screw connection to which it may be attached; hence, its use provides an added safety feature.

SIZE DESIGNATION OF LINE

The size of a line larger than 1 3/4 inches (44.5 mm) in circumference is generally designated by its circumference in inches. A 6-inch (15-cm) manila line, for instance, would be constructed of manila fibers and measure 6 inches (15 cm) in circumference. Line is available up to 16 inches (40 cm) in circumference, but 12 inches (30 cm) is normally the largest line carried in stock. Anything larger is used only on special jobs (fig. 4-3).

Line 1 3/4 inches (44.5 mm) or less in circumference is called SMALL STUFF, and size is usually designated b y the number of threads (or yarns) that make up each strand. You may find 6- to 24-thread small stuff, but the most common sizes are 9- to 21-thread (fig. 4-3). You may hear some small stuff designated by name without reference to size. One such type is MARLINE-a tarred, two-strand, left-laid hemp. Marline is the small stuff you used the most for seizing. When you need something stronger than marline, use a tarred, three-strand, left-laid hemp, called HOUSELINE.

MANILA LINE

SOME COMMONLY USED SIZES	*CIRCUMFERENCE		NOMINAL DIAMETER
	INCHES	MILLIMETERS	
	3/4	19.05	1/4
	1	25.40	5/16
	1-1/8	28.58	3/8
	1-1/4	31.76	7/16
	1-1/2	38.10	1/2
	1-3/4	44.45	9/16
	2	50.80	5/8
	3	76.20	1
	4	101.6	1-1/4
	5	127.0	1-8/16
	6	152.4	2

* SIZE IS DESIGNATED BY THE CIRCUMFERENCE

SWNP0162

Figure 4-3.—Size designation of line.

If you ever order line, you may find that you have to order it by diameter. The catalog may also use the term rope (rather than line).

ROPE YARNS for temporary seizings, whippings, and lashings are pulled from large strands of old line that has outlived its usefulness. Pull your yarn from the middle, away from the ends, or it will get fouled.

HANDLING AND CARE OF FIBER LINE

If you expect the fiber line you work with to give safe and dependable service, make sure it is handled and cared for properly. Procedures for the handling and care of fiber line are as follows:

- CLEANLINESS is part of the care of fiber line. NEVER drag a line over the ground nor over rough or dirty surfaces. The line can easily pick up sand and grit that can work into the strands and wear the fibers. If a line does get dirty, use water only to clean it. Do NOT use soap because it takes oil out of the line.

- AVOID pulling a line over sharp edges because the strands may break. When you have a sharp edge, place chafing gear, such as a board, folded cardboard or canvas, or part of a rubber tire, between the line and the sharp edge to prevent damaging the line.

- NEVER cut a line unless you have to. When possible, always use knots that can be untied easily.

Fiber line contracts, or shrinks, if it gets wet. If there is not enough slack in a wet line to permit shrinkage, the line is likely to overstrain and weaken. If a taut line is exposed to rain or dampness, make sure that the line, while still dry, is slackened to allow for the shrinkage.

When nylon line is properly handled and maintained, it should last more than five times longer than manila line subjected to the same use. Nylon line is also lighter, more flexible, less bulky, and easier to handle and store than manila line. When nylon line is wet or frozen, it loses little strength. Additional y, nylon line is resistant to mildew, rotting, and attack by marine borers.

If a nylon line becomes slippery because of grease, it should be cleaned with light oils, such as kerosene or diesel oil.

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Uncoiling Line

New line is coiled, bound, and wrapped in burlap. This protective covering should not be removed until the line is to be used because it protects the line during storage and prevents tangling. To open, remove the burlap wrapping and look inside the coil for the end of the line. This should be at the bottom of the coil. If it is not, turn the coil over so that the end will be at the bottom. Pull the end of the line up through the center of the coil (fig. 4-4). As the line comes up through the coil, it will unwind in a counterclockwise direction.

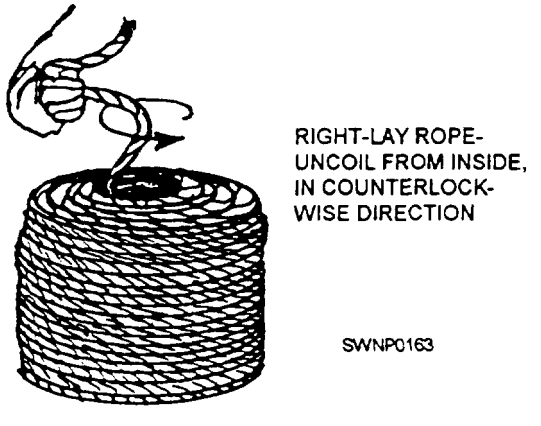
Uncoiling Nylon Line

Do not uncoil new nylon line by pulling the ends up through the eye of the coil. Avoid coiling nylon in the same direction all the time, or you could unbalance the lay.

Making Up Line

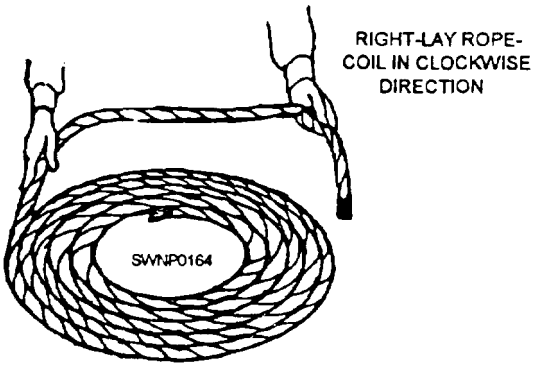
After the line has been removed from the manufacturer's coil, it may be MADE UP (that is, prepared for storage or for use) by winding on a reel. It may also be made up by cooling down, faking down, or blemishing down.

To COIL DOWN a line simply means to lay it in circles, roughly one on top of the other (fig. 4-5). Line should always be coiled in the same direction as the lay-clockwise for right lay and counterclockwise for left lay. When a line has been coiled down, one end is ready to run off. This is the end that went down last and is now on top. If, for some reason, the bottom end must go out first, you will have to turn your coil over to free it for running.



UNCOILING A NEW COIL OF FIBER ROPE

Figure 4-4.—Uncoiling line.



COILING OF A FIBER ROPE AFTER BEING USED

Figure 4-5.—Colling down line after use

Whipping a Line

The term whipping refers to the process of securing the ends of a line to prevent the strands from unlaying and the yams from separating or fraying. It will not increase the size of the line enough to prevent the fitting of the blocks or openings through which it must pass. Whippings are made with fine twine.

Figure 4-6 shows the steps to follow in applying a whipping. Make a loop in the end of the twine and place the loop at the end of the line, as shown in the figure. Wind the standing part around the line covering the loop of the whipping. Leave a small loop uncovered, as shown. Pass the remainder of the standing end up through the small loop and pull the dead end of the twine, thus pulling the small loop and the standing end back towards the end of the line underneath the whipping. Pull the dead end of the twine until the loop with the standing end through it reaches a point midway underneath the whipping. Trim both ends of the twine closeup against the loops of the whipping.

Before cutting a line, place two whippings on the line 1 or 2 inches apart and make the cut between the whippings, as shown in figure 4-7. This procedure prevents the ends from untwisting after they are cut.

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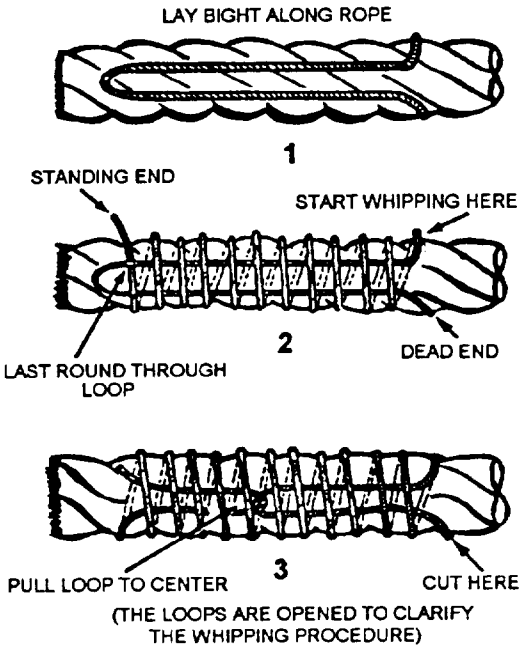


Figure 4-6.—Whipping a line.

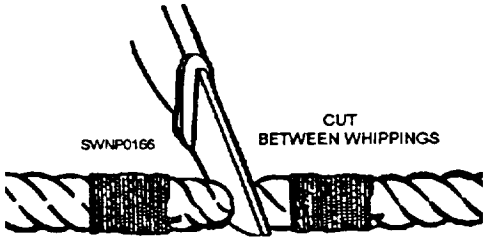


Figure 4-7.—Cutting a line between whipping.

Inspecting Line

The exterior appearance of fiber line is not always a good indication of its internal condition. Line softens with use, and dampness, heavy loads, fraying, breaking or broken strands, and dragging over rough surfaces all contribute to line weakening and failure. Also, overloading a line can cause it to part and heavy damage to material, equipment, and serious injury to personnel can result. For these reasons, line should be inspected carefully at regular intervals to determine whether it is safe for use.

The interior of a line can be checked by untwisting the strands slightly. Line that is mildewed gives off a musty odor. Broken strands or yams usually can be spotted immediately by a trained observer. You will want to look carefully to ensure there is no dirt or sawdust-like material inside the line. The presence of dirt or other foreign matter indicates possible damage to the internal structure of the line. In line having a central core, the core should not break away in small pieces upon examination. If this occurs, it indicates that the line has been overloaded. Additionally, a decrease in line circumference is usually a sure sign that an excessive strain has been applied to the line.

For a thorough inspection, a line should be examined at several places. After all, only one weak spot—anywhere in the line-makes the entire line weak. As a final check if the line appears to be satisfactory in all aspects, pull out a couple of fibers from the line and try to break them. Sound fibers show a strong resistance to breakage.

If an inspection discloses any unsatisfactory conditions in a line, destroy it or cut it into small pieces as soon as possible. This precaution will prevent the possibility of the defective line being used for hoisting purposes, but save the small pieces for miscellaneous uses on the jobsite.

As with manila, nylon line is measured by circumference. Nylon, as manila, usually comes on a reel of 600 to 1,200 feet, depending upon the size.

Storing Line

When fiber line is to be stored, certain precautions must be taken to safeguard the line against deterioration. A line should never be stored when wet. Always dry the line well before placing it in storage.

After being used, a line should be coiled down in a clockwise direction (assuming it is a right-hand lay). Should the line be kinked from excessive turns, remove them by the procedure known as "thorough footing." This is accomplished by coiling the line down counterclockwise and then pulling the bottom end of the coil up and out the middle of the coil. If the line is free of kinks as it leaves the coil, make it up in the correct manner. If the line is still kinked, repeat the process before making up the line for storage.

Where you store line deserves careful consideration. Line deteriorates rapidly if exposed to prolonged dampness; therefore, it is important that the storage area is dry, unheated, and well-ventilated. To permit proper air circulation, place the line in loose coils on a wood grating platform about 6 inches (15 cm) above the floor. You can also hang the line in loose coils on a wooden peg. Avoid continuous exposure of line to sunlight because excessive sunlight can damage the

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line. Do not store nylon line in strong sunlight. Cover it with tarpaulins.

As a final precaution, line should NEVER be exposed to lime, acids, or other chemicals, or even stored in a room containing chemicals. Even the fumes may severely damage the line.

STRENGTH OF FIBER LINE

Overloading a line poses a serious safety threat to personnel It is also likely to result in heavy losses through damage to material and equipment. To avoid overloading, you must know the strength of the line with which you are working. This involves three factors: breaking strength, safe working load, and safety factor.

Breaking Strength

The term *breaking strengfh* refers to the tension at which the line will break apart when an additional load is applied. The breaking strength of the various lines has been determined through tests made by line manufacturers, and tables have been established to provide this information. In the absence of a manufacturer's table, a rule of thumb for finding the breaking strength of manila line is as follows:

C squared x 900 = BS

In this rule, C = circumference in inches and BS = breaking strength in pounds. The circumference is squared and the figure obtained is then multiplied by 900 to find BS. With a 3-inch line, for example, you will get a BS of 8,100 pounds. This was figured as follows:

3 x 3 x 900 = 8,100 lb

When the line is measured in centimeters, the breaking strength can be figured in kilograms. The same equation is used with only the constant being changed to 64.8 (vice 900). The breaking strength in kilograms is figured as follows:

7.5 cm x 7.5 cm x 64.8 = 3,645 kg

The breaking strength of manila line is higher than that of an equal-size sisal line. This is because of the difference in strength of the two fibers. The fiber from which a particular line is constructed has a definite bearing on its breaking strength.

Safe Working Load

Briefly defined, the safe working load of a line is the load that can be applied without causing damage to the line. Remember that the safe working load of a line is considerably less than the breaking strength. A wide margin of difference between breaking strength and safe working load is necessary to allow for such factors as additional strain imposed on the line by jerky movements in hoisting or bending over sheaves in a pulley block

You may not always have a chart available to tell you the safe working load for a particular size line. Fortunately, there is a rule of thumb with which you can determine the safe working load (SWL).

SWL = C squared x 150

SWL = the safe working load in pounds

C = the circumference of the line in inches

To determine the SWL, simply take the circumference of the line, square it, and then multiply by 150. For example, for a 3-inch line, here is how the rule works:

3 x 3 x 150= 1,350 lb

Thus the safe working load of a 3-inch line is 1,350 pounds.

In the metric system, the rule is as follows:

SWL = C squared x 10.8

SWL = the safe working load in kilograms

C = the circumference of the line in centimeters

Substituting in the equation for a 3-inch line the centimeter equivalent of 3 inches (3 inches = 7.5 cm), the formula becomes the following:

7.5 cm x 7.5 cm x 10.8 = 607.5 kg

Thus the safe working load of a line 7.5 cm in circumference is equal to 607.5 kg.

NOTE: 10.8 is the metric constant equivalent to 150 in the decimal system.

If the line is in good shape, add 30 percent to the calculated SWL. If it is in bad shape, subtract 30 percent from the SWL. In the example given above for the 3-inch line, adding 30 percent to the 1,350 pounds would give you a safe working load of 1,755 pounds. On the other hand, subtracting 30 percent from the 1,350 pounds would leave you a safe working load of 945 pounds.

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Remember that the strength of a line will decrease with age, use, and exposure to excessive heat, boiling water, or sharp bends. Especially with used line, these and other factors affecting strength should be given careful consideration and proper adjustment made in the breaking strength and safe working load capacity of the line. Manufacturers of line provide tables to show the breaking strength and safe working load capacity of line. You will find such tables useful in your work; however, you must remember that the values given in manufacturers' tables apply to NEW LINE used under favorable conditions. For that reason, you must PROGRESSIVELY REDUCE the values given in the manufacturers' tables as the line ages or deteriorates with use.

The safety factor of a line is the ratio between the breaking strength and the safe working load. Usually a safety factor of 4 is acceptable, but this is not always the case. In other words, the safety factor will vary, depending on such things as the condition of the line and circumstances under which it is to be used. While the safety factor should never be less than 3, it often must be well above 4 (possibly as high as 8 or 10). For best, average, or unfavorable conditions, the safety factors indicated below are usually suitable.

Best condition (new line): 4.

Average condition (line used, but in good condition): 6.

Unfavorable condition (frequently used line, such as running rigging): 8.

Breaking Strength of Nylon Line

The breaking strength of nylon line is almost three times that of manila line of the same size. The rule of thumb for the breaking strength of nylon line is as follows:

BS = C squared x 2,400

NOTE: The symbols in this rule are the same as those for fiber line in both the English and metric systems.

Application of the formula: determine the BS for a 2 1/2-inch nylon line in both pounds and kilograms:

Solution: BS = 2.5 x 2.5 x 2,400 = 15,000 pounds or BS = 6.35 cm x 6.35 cm x 172.8 = 6,967 kilograms

NOTE: The constant for the metric system is 172.8.

Nylon line can withstand repeated stretching to this point with no serious effects. When nylon line is underload, it thins out. Under normal safe working loads, nylon line will stretch about one third of its length. When free of tension, it returns to its normal size.

When nylon line is stretched more than 40 percent, it is likely to part. The stretch is immediately recovered with a snapback that sounds like a pistol shot .

WARNING

The snapback of a nylon line can be as deadly as a bullet. This feature is also true for other types of lines, but overconfidence in the strength of nylon may lead one to underestimate its backlash; therefore, ensure that no one stands in the direct line of pull when a heavy strain is applied to a line.

The critical point of loading is 40-percent extension of length; for example, a 10-foot length of nylon line would stretch to 14 feet when underload. Should the stretch exceed 40 percent, the line will be in danger of parting.

Nylon line will hold a load even though a considerable number of strands are abraded. Ordinarily, when abrasion is localized the line maybe made satisfactory for reuse by cutting away the chafed section and splicing the ends.

KNOTS, BENDS, AND HITCHES

The term *knot* is usually applied to any tie or fastening formed with a cord, rope, or line. In a general sense, it includes the words *bends* and *hitches.*

Line Parts

A BEND is used to fasten two lines together or to fasten a line to a ring or loop. A HITCH is used to fasten a line around a timber or spar, so it will hold temporarily but can be readily untied. Many ties, which are strictly bends, have come to be known as knots; hence, we will refer to them as knots in this discussion.

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Knots, bends, and hitches are made from three fundamental elements: a bight, a loop, and a round turn. Observe figure 4-8 closely and you should experience no difficulty in making these three elements. Note that the free or working end of a line is known as the RUNNING END. The remainder of the line is called the STANDING PART.

NOTE: A good knot is one that is tied rapidly, holds fast when pulled tight, and is untied easily. In addition to the knots, bends, and hitches described in the following paragraphs, you may have need of others in steelworking. When you understand how to make those covered in this chapter, you should find it fairly easy to learn the procedure for other types.

Overhand Knot

The OVERHAND KNOT is considered the simplest of all knots to make. To tie this knot, pass the hose end of a line over the standing part and through the loop that has been formed. Figure 4-9 shows you what it looks like. The overhand knot is often used as a part of another knot. At times, it may also be used to keep the end of a line from untwisting or to form a knob at the end of a line.

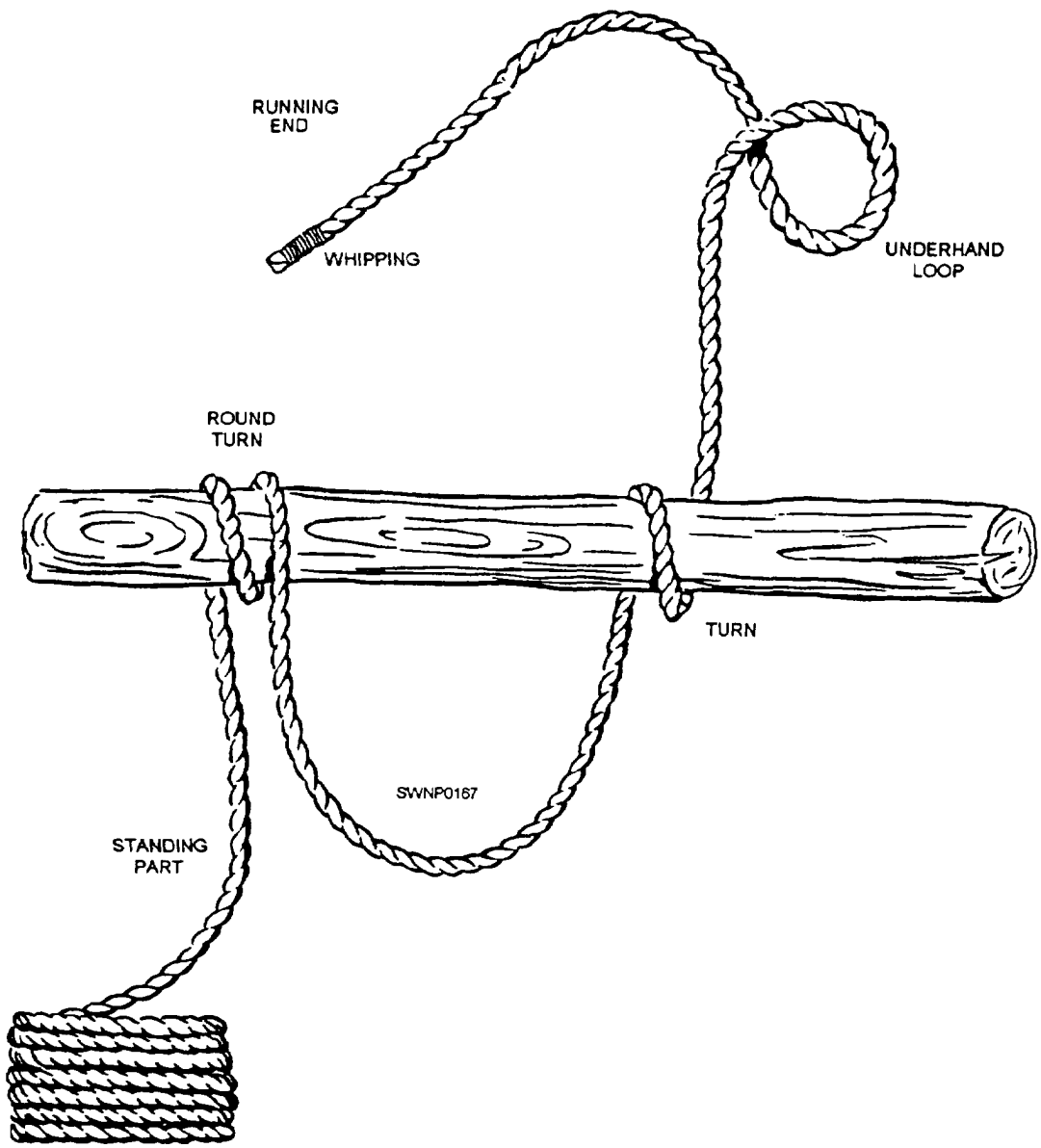


Figure 4-8.—Elements of knots, bends, and hitches

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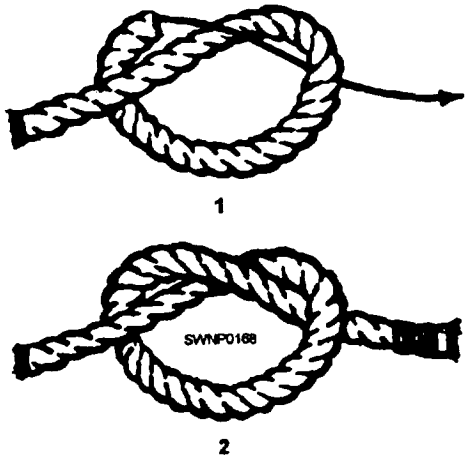


Figure 4-9.—Overhand knot.

Figure-Eight Knot

The FIGURE-EIGHT KNOT is used to form a larger knot than would be formed by an overhand knot in the end of a line (fig. 4-10). A figure-eight knot is used in the end of a line to prevent the end from slipping through a fastening or loop in another line. To make the figure-eight knot, make a loop in the standing part, pass the running end around the standing part, back over one side of the loop and down through the loop, and pull tight.

Square Knot

The SQUARE KNOT, also called the REEF KNOT, is an ideal selection for tying two lines of the same size together so they will not slip. To tie a square knot, first bring the two ends of the line together and make an overhand knot. Then form another overhand knot in the opposite direction, as shown in figure 4-11.

NOTE: A good rule to follow for a square knot is left over right and right over left.

When tying a square knot, make sure the two overhand knots are parallel. This means that each running end must come out parallel to the standing part of its own line. If your knot fails to meet this test, you have tied what is known as a "granny." A granny knot should NEVER be used; it is unsafe because it will slip under strain. A true square knot instead of slipping under strain will only draw tighter.

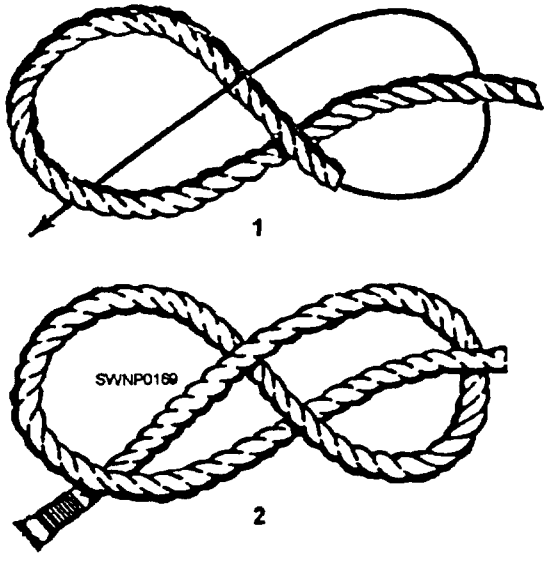


Figure 4-10.—Figure-eight knot

Sheepshank

The SHEEPSHANK is generally thought of as merely a means to shorten a line, but, in an emergency, it can also be used to take the load off a weak spot in the line. To make a sheepshank, form two bights

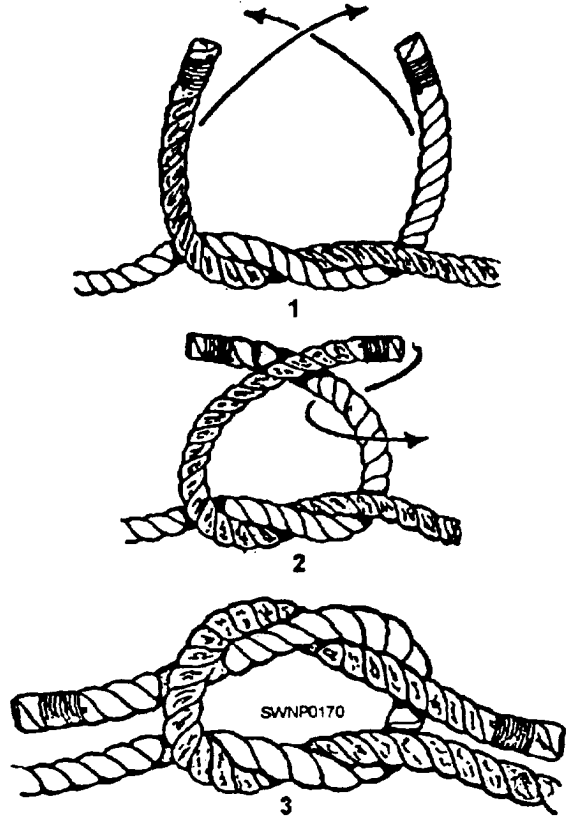


Figure 4-11.—Square knot.

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(fig. 4-12, view 1). Then take a half hitch around each bight (views 2 and 3). In case you are using the sheepshank to take the load off a weak spot, make sure the spot is in the part of the line indicated by the arrow in view 2.

Bowline

The BOWLINE is especially useful when you need a temporary eye in the end of a line. It will neither slip nor jam and can be untied easily. To tie a bowline, follow the procedure shown in figure 4-13.

The FRENCH BOWLINE is sometimes used to lift or hoist injured personnel. When the french bowline is used for this purpose, it has two loops which are adjustable, so even an unconscious person can be lifted safely. One loop serves as a se at for the person, while the other loop goes around the body under the person's arms. The weight of the person keeps both loops tight and prevents the person from falling. The procedure to follow in making the french bowline is shown in figure 4-14.

Spanish Bowline

The SPANISH BOWLINE is useful in rescue work, especially as a substitute for the boatswain's chair. It may also be used to give a twofold grip for lifting a pipe or other round object in a sling. Many people prefer the spanish bowline to the french bowline because the bights are set and will not slip

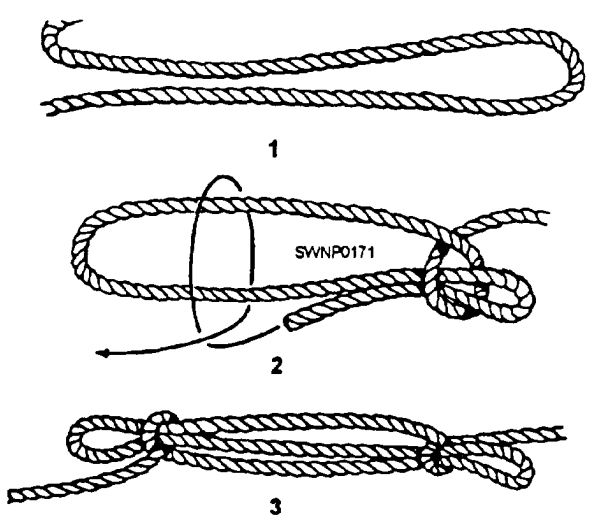


Figure 4-12.—Sheepshank.

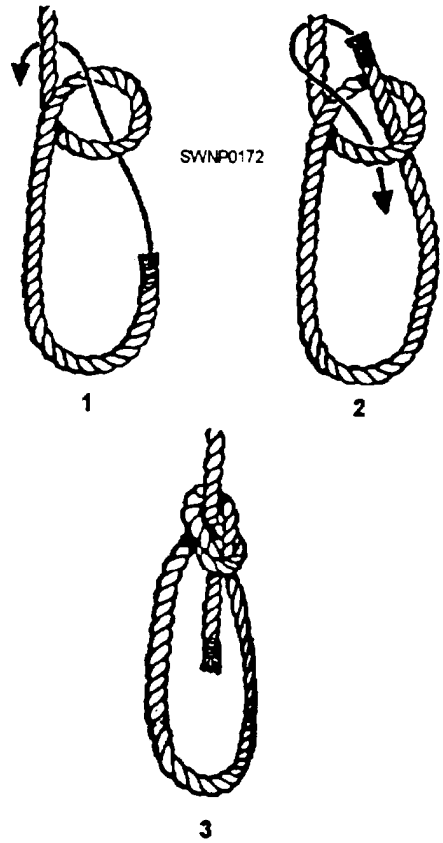


Figure 4-13.—Bowline.

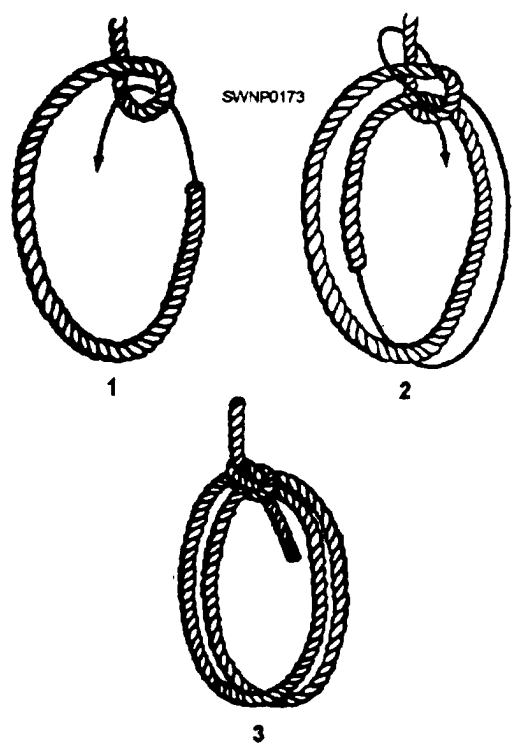


Figure 4-14.—French bowline.

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back and forth (as in the french bowline) when the weight is shifted.

To tie a spanish bowline, take a bight and bend it back away from you (fig. 4-15, view 1), forming two bights. Then lap one bight over the other (view 2). Next, grasp the two bights where they cross at (a) in view 2. Fold this part down toward you, forming four bights (view 3). Next, pass bight (c) through bight (e) and bight (d) through bight (f) (view 4). The complete knot is shown in view 5.

Running Bowline

The RUNNING BOWLINE is a good knot to use in situations that call for a lasso. To form this knot, start by making a bight with an overhand loop in the running end (fig. 4-16, view 1). Now, pass the running end of the line under and around the standing part and then under one side of the loop (view 2). Next, pass the running end through the loop, under and over the side of the bight, and back through the loop (view 3).

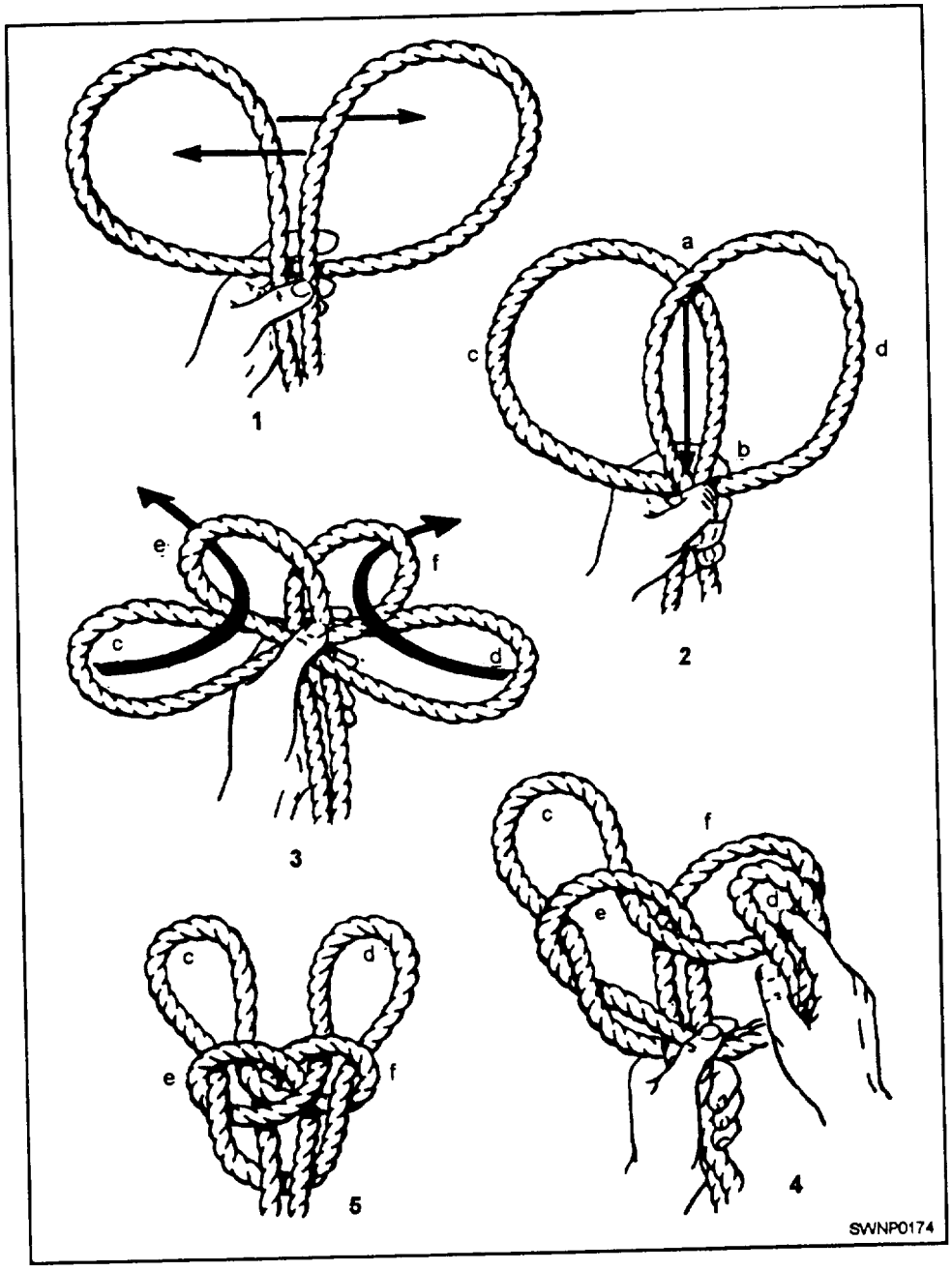


Figure 4-15.—Spanish bowline

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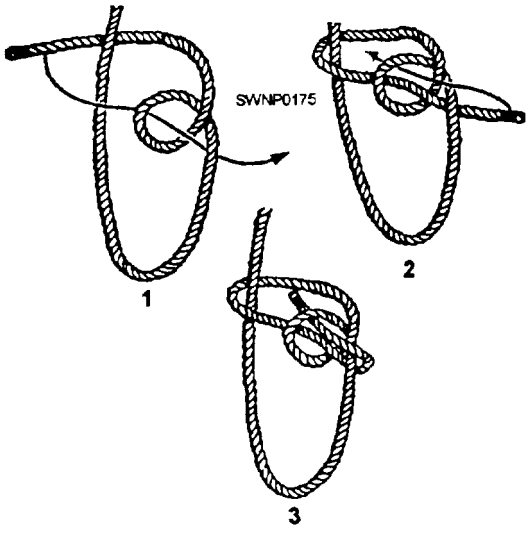


Figure 4-16.—Running bowline.

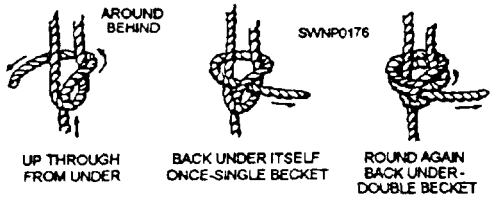


Figure 4-17.—Becket bend.

Becket Bend

An especially good knot for bending together two lines that are unequal in size is the type known as the BECKET BEND. The simple procedure and necessary instructions for tying a becket, single and double, are given in figure 4-17.

Clove Hitch

When it comes to bending to a timber or spar or anything that is round or nearly round, the familiar CLOVE HITCH is an ideal selection. Figure 4-18 shows how this knot is made. A clove hitch will not jam or pull out; however, if a clove hitch is slack, it might work itself out, and for that reason, it is a good idea to make a HALF HITCH in the end, as shown in figure 4-19, view 1. A half hitch never becomes a whole hitch. Add a second one and all you have is two half hitches, as shown in figure 4-19, view 2.

The SCAFFOLD HITCH is used to support the end of a scaffold plank with a single line. To make the scaffold hitch, lay the running end across the top and around the plank, then up and over the standing

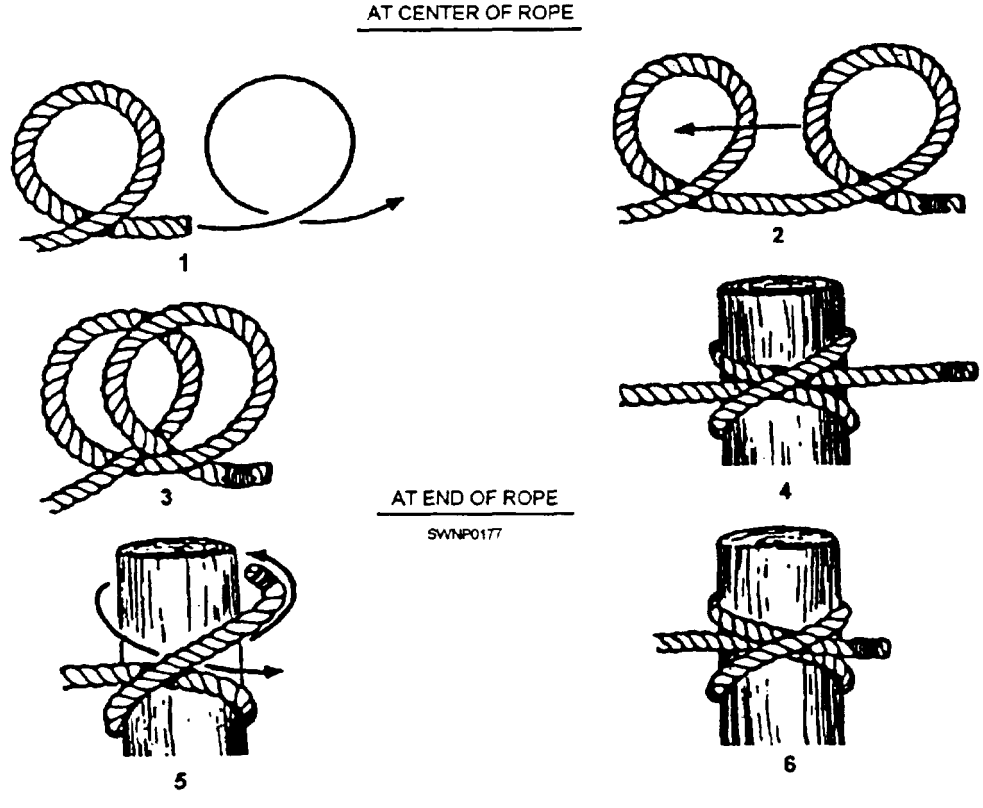


Figure 4-18.—Clove hitch.

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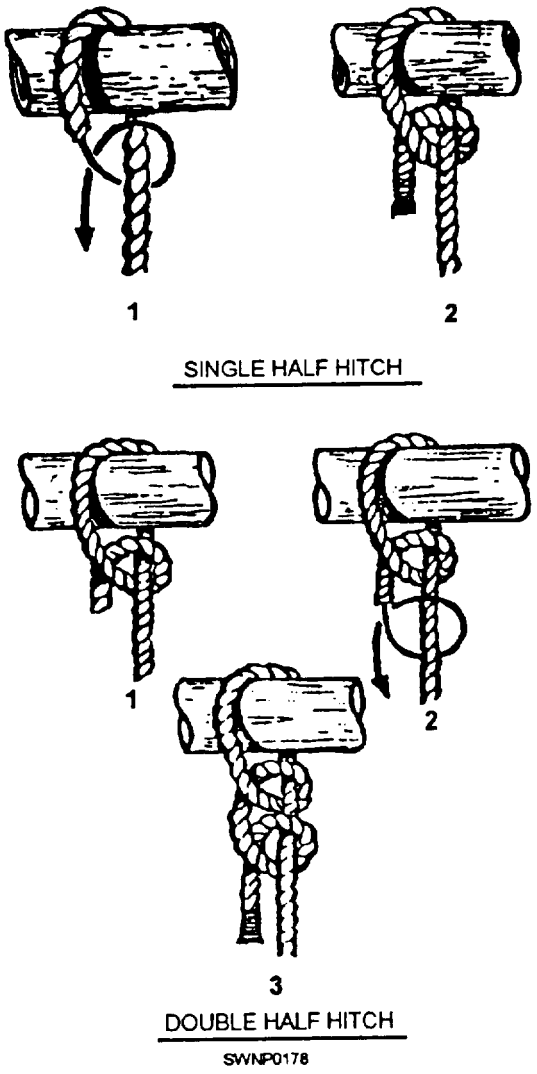


Figure 4-19.—Half hitch.

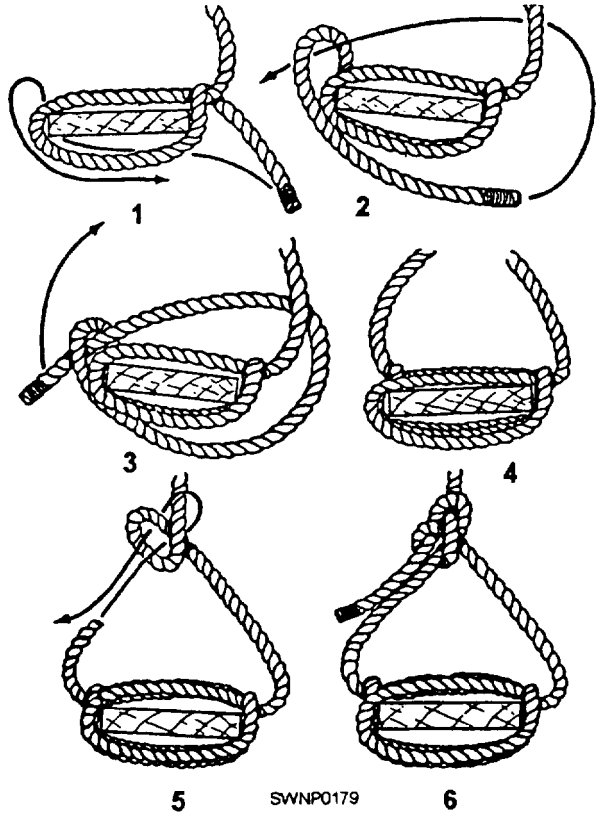


Figure 4-20.—Scaffold hitch.

part (fig. 4-20, view 1). Bring a doubled portion of the running end back under the plank (view 2) to form a bight at the opposite side of the plank. The running end is taken back across the top of the plank (view 3) until it can be passed through the bight. Make a loop in the standing part (view 4) above the plank. Pass the running end through the loop and around the standing part and back through the loop (view 5).

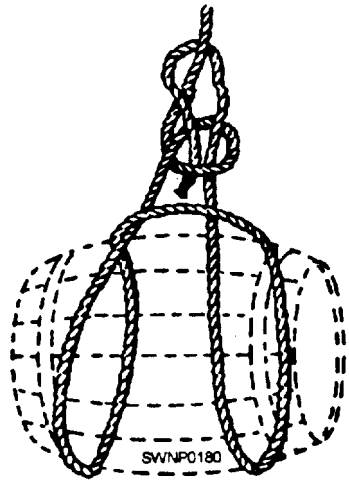


Figure 4-21.—Barrel hitch.

Barrel Hitch

A BARREL HITCH can be used to lift a barrel or other rounded object that is either in a horizontal or a vertical position. To sling a barrel horizontally (fig. 4-21), start by making a bowline with a long bight. Then bring the line at the bottom of the bight up over the sides of the bight. To complete the hitch, place the two "ears" thus formed over the end of the barrel.

To sling a barrel vertically, pass the line under the bottom of the barrel, bring it up to the top, and then form an overhand knot (fig. 4-22, view 1). While maintaining a slight tension on the line, grasp the two

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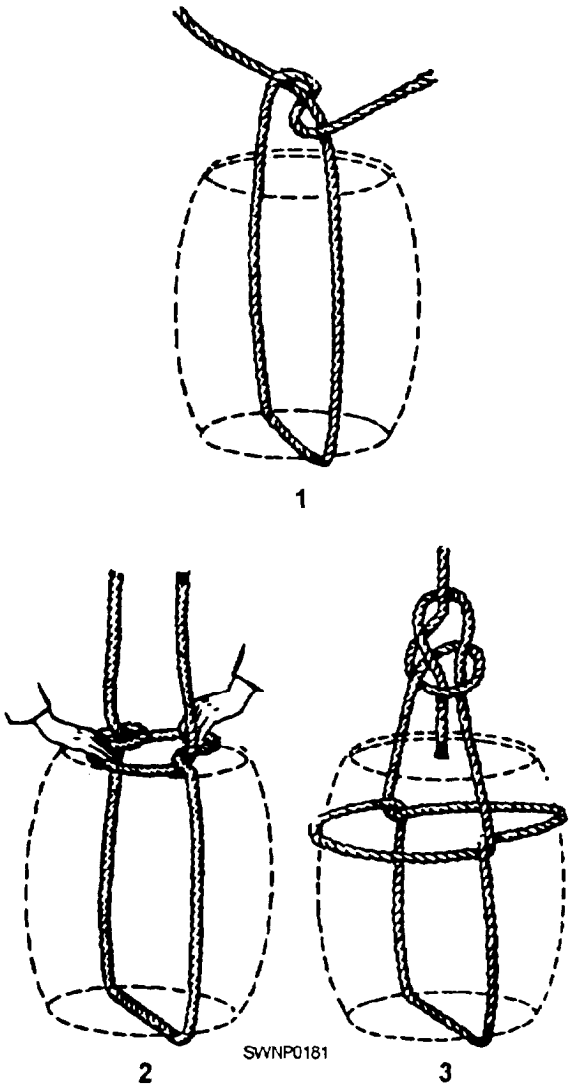


Figure 4-22.—A vertical barrel hitch.

parts of the overhand knot (fig. 4-22, view 2) and pull them down over the sides of the barrel. Finally, pull the line snug and make a bowline over the top of the barrel (fig. 4-22, view 3).

SPLICING FIBER LINE

When it is necessary to join lengths of line, a splice, rather than a knot, should be used. A properly made short splice will retain up to 100 percent of the strength of the line, while a knot will retain only 50 percent.

"Splicing" means the joining of two separate lines. It also means the retracing of the unlaid strand of the line back through its own strands in the standing part of the line.

Four general types of splices in fiber line are commonly used in rigging work. They are the eye splice, short splice, long splice, and back splice. Once you learn how to make one type, the others should not be difficult.

Eye Splice

The principal use of an EYE SPLICE is to make an eye in the end of a line. The eye is useful in fastening the line to a ring or hook. It can also be made up with a thimble. A thimble is a grooved ring that may be set in the eye of a line to prevent chafing. The eye splice is estimated as being 90 percent as strong as the line itself.

To make an eye splice, you UNLAY (untwist) the strands in the end of your line about five turns, and splice them into the standing part of the line by TUCKING the unlaid strands from the end into the standing part. An original round of tucks plus two more complete rounds is enough for an ordinary eye splice.

With large lines, you must whip the ends of your strands before you start; otherwise, they will frazzle out and cause you trouble. Large lines must also be seized at the point where unlaying stops or you will have trouble working them. With any lineup to about 2 inches (50 mm), you can open the strands in the standing part with your fingers.

With larger lines, you use the fid. A fid is a tapered and pointed tool made from maple, hickory, or other hardwood. Figure 4-23 shows you the knack of working the fid in making an eye splice. Lay your line out along the deck with the end to your right. Bend it back until your eye is the size you want it, and shove the fid through the standing part at the right spot to raise the top strand. Shove the fid through the rope AWAY from you with your right hand as you hold the line with your left. Take the raised strand with your

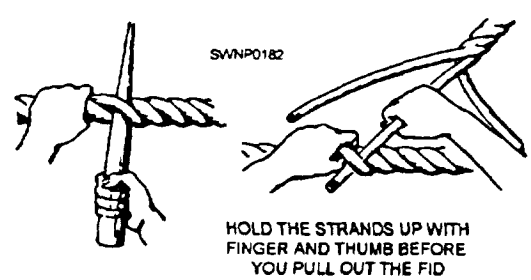


Figure 4-23.—Working the fid

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left finger and thumb and hold it up while you pull out the fid. Drop the fid, pick up the proper strand in the end, and tuck it through the raised strand from outboard TOWARD you, as shown in the figure.

Your first round of tucks must be taken in proper order or you will come out all fouled up. Separate the strands in the end and hold them up, as shown in figure 4-24, view 1. The middle strand facing you always tucks first. Be sure you keep the right-hand strand (view 2) on the side of the line which is toward you. You tuck that one next, over the strand you just tucked the other one under, and under the strand just below it (view 3).

Now turn the whole thing over. You can see (view 4) that you now have only one strand from the end left untucked, and only one strand in the standing part that does not already have a strand under it. Be sure you tuck your last strand also from outboard toward you, as shown in view 5.

The first round of tucks is the big secret. The rest is easy. Simply tuck each strand from the end over the strand of the standing part which it is now above, and under the next strand below that one, until you have

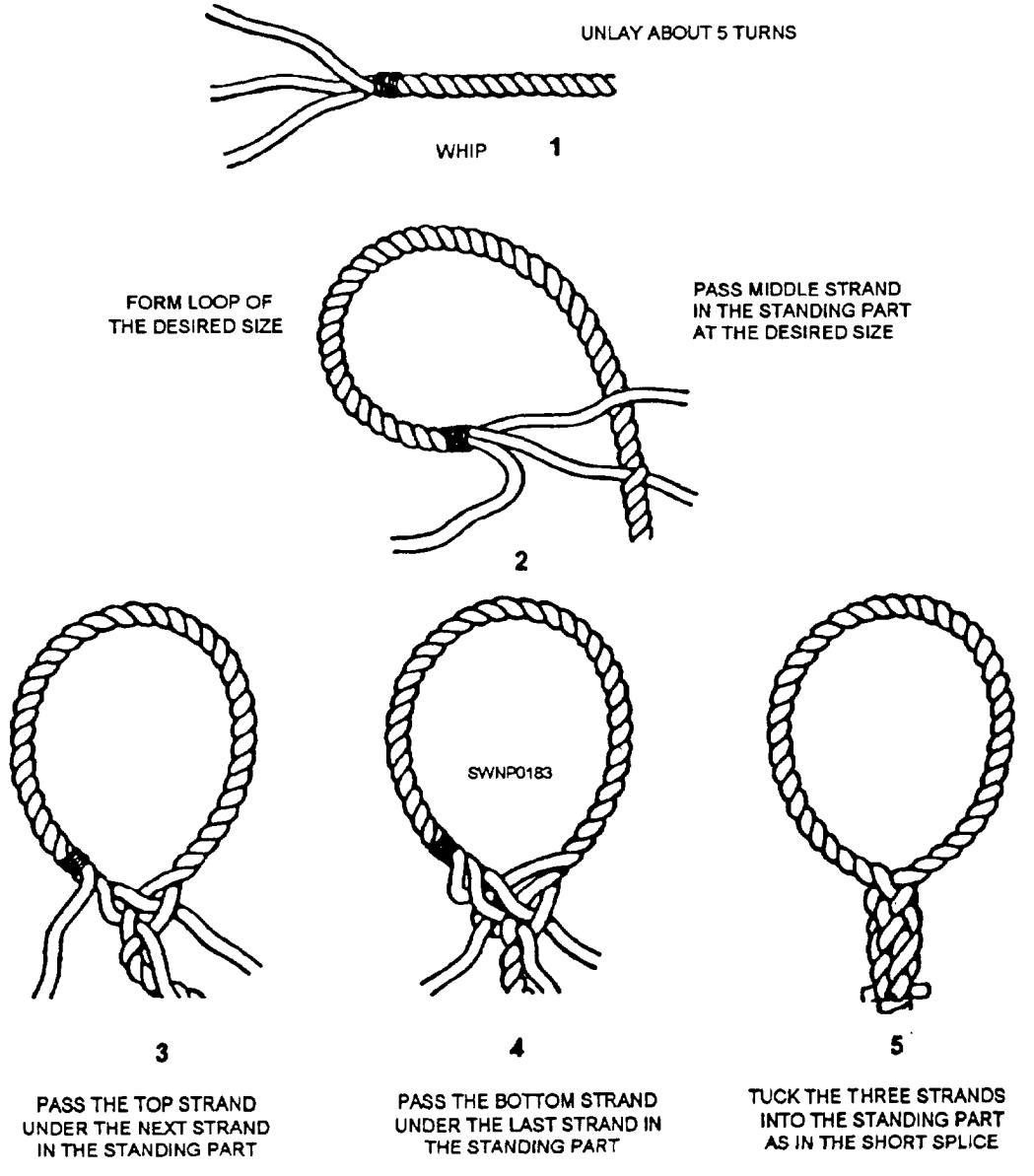


Figure 4-24.—Making an eye splice.

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tucked each strand twice more besides the original tuck. Three tucks to each strand in all is enough.

Short Splice

In a SHORT SPLICE, the ends of a line are joined together or the ends of two different lines are joined, causing an increase in the diameter of the line for a short distance. This splice should NOT be used where the increase in the diameter of the line would affect operation. One purpose for which you may find the short splice especially useful is in making endless slings. It is also used for making straps. Slings and straps are made of pieces of line with their own ends short-spliced together. Where possible, a short splice, rather than a long splice, should be used. The reason is that the short splice requires less line and can be fashioned quicker than the long splice.

In making a short splice, unlay both ends of the lines about seven turns (fig. 4-25, view 1) and put a temporary whipping on each of the loose strands. The next step involves "marrying" the ends together. In marrying, the technique is to interlace the loose strands of one line with the loose strands of the other line. When this is completed properly, each loose strand should be between the two loose strands of the other line. With the strands in this manner, start making the tucks, following the principle of "over one and under one" (view 2). One side of the splice car be made with three tucks, and then the other side will be made identically. Three complete tucks of each

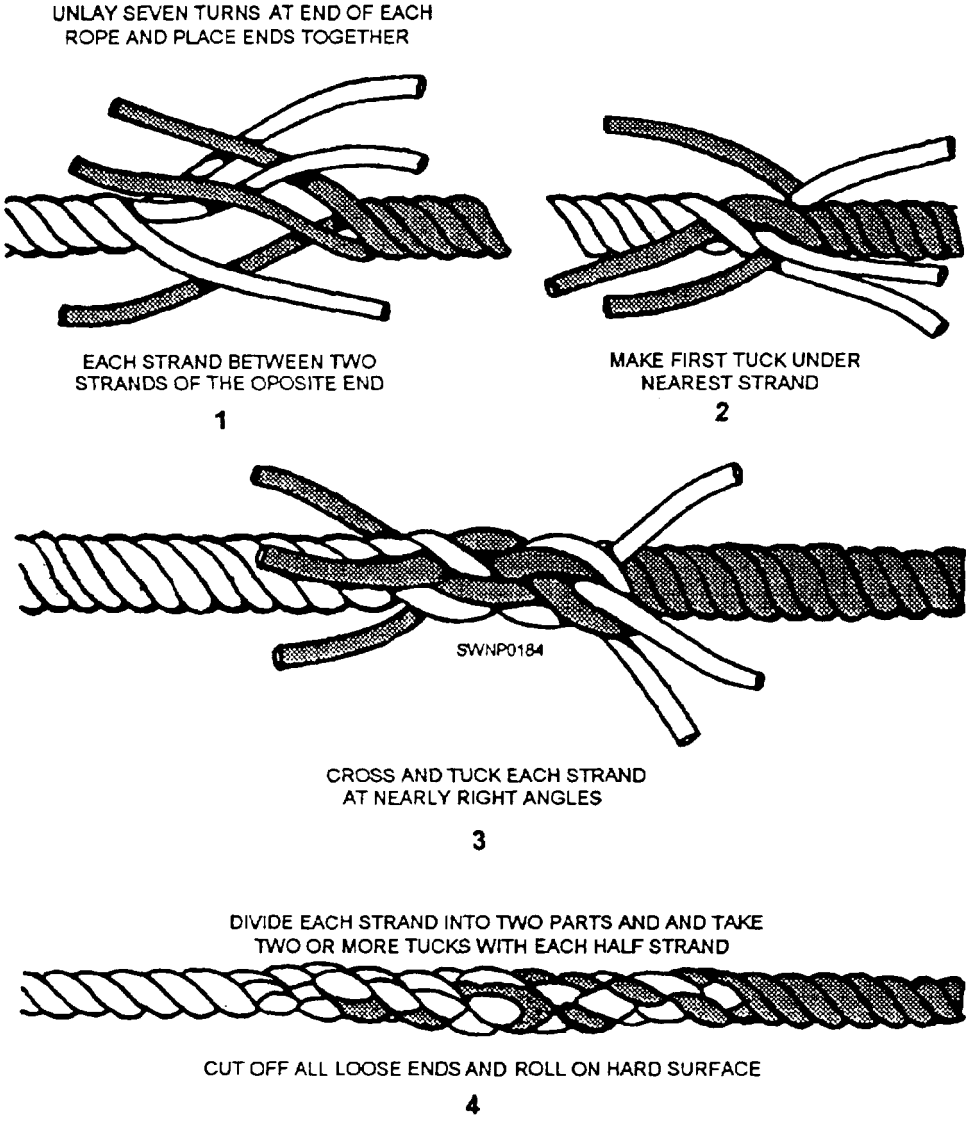


Figure 4-25.—Making a short splice.

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strand should be sufficient to ensure a safe splice (view 3). As a finishing touch, cut off all loose ends and roll and pound the splice on a hard surface (view 4).

Long Splice

In a LONG SPLICE, either the ends of a line are joined together or the ends of two different lines are joined without increasing the diameter of the line. The strength of a properly made long splice will be equal to that of the line itself. The long splice is ideal for joining two lines where the line will be run over pulleys in a block. A short-spliced line would not serve this purpose since the diameter of the line at the point of splicing is larger than that of the remaining portion and may not pass over the pulleys in the block properly. The long splice also has a neater appearance than the short splice.

To make a long splice, unlay the ends about 15 turns and arrange the strands as shown in figure 4-26, view 1. Using two opposing strands, begin unlaying one and follow immediately laying its opposing strand tight into the left groove (fig. 4-26, view 2). Be sure you choose the correct pairs of strands for opposites. This is important. To determine the correct pair, try laying one of the tucking ends into the opposite standing line. The strand that this tucking end tends to push out and replace will be the correct opposing strand. In the process of replacing one strand with its opposing tucking end, keep a close watch on the marriage back at the starting place. If the other loose tucking ends are allowed too much freedom, they will divorce themselves from the original marriage. This creates quite a puzzle for the splicer due to the fact that the lines do not fit up correctly, and no matter which two strands are chosen, the splicer seems to end up with a stranger between them or else the last tucking ends have two strands between them. Therefore, it is important to keep the marriage intact when replacing

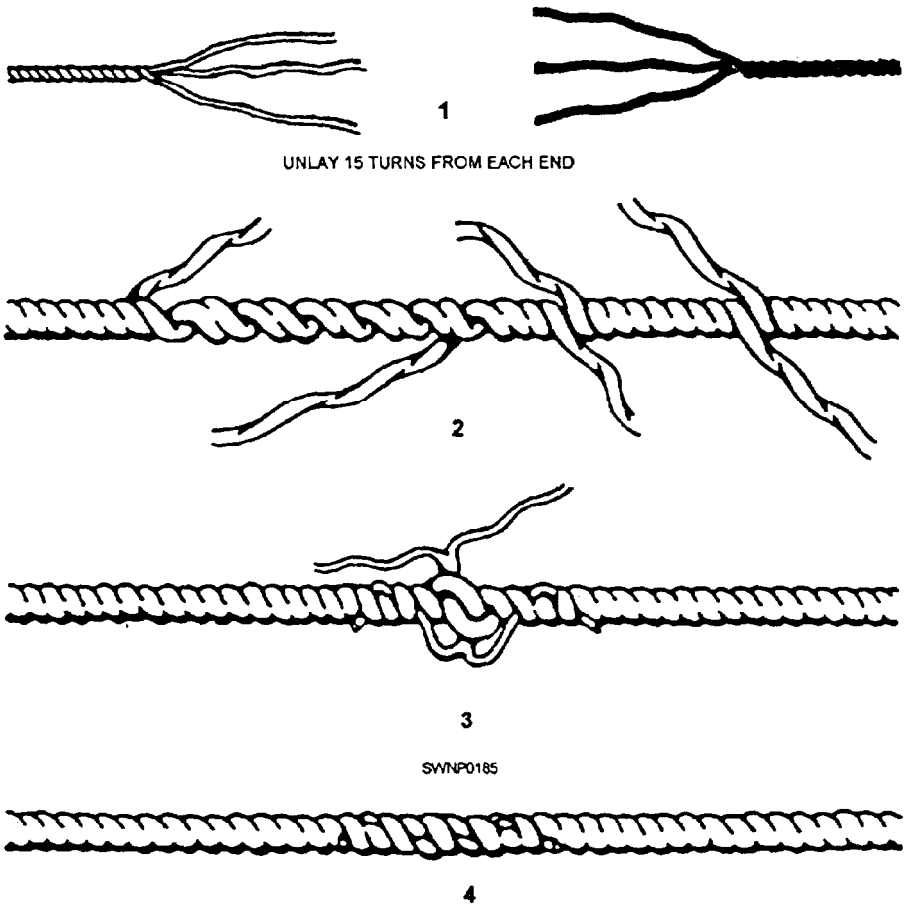


Figure 4-26.—Making a long splice.

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one strand with another. Cut off all the remainders of the ends close up, then roll and pound the line so the tucks will settle in tight. As soon as you have gone far enough with the first tucking end to have its end left to make an overhand knot and two tucks, stop and tie the ends together. This procedure must be done in the correct direction; the ends must stand out away from the standing part, not alongside.

Now, select two more opposing strands from the marriage in the same manner as before. Be careful to pick the correct two strands. Proceed to unlay and replace (DOWN TIGHT) as you did the first pair-this time in the opposite direction. When the proper place is reached, tie a knot (view 3).

You now have two opposing strands with which you have nothing to do but make an overhand knot. If at this point there happens to be a standing strand running between them, a wrong choice has been made in choosing opposing strands (pairs) during one of the first two steps. The solution is to bring one or the other of these first two back and redo it with the correct pair. When completed, the splice should look similar to the example shown in view 4.

After all three overhand knots have been correctly tied, then start tucking all the loose ends over one and under one, twice each. Cut off all the remainders of the ends close up, then roll and pound the line so the tucks will settle in tight. When completed, the splice will look like view 4.

Back Splice

In a BACK SPLICE, the strands at the end of a line are spliced back into its own strands. This splice is used to prevent a line from unlaying or unraveling when an enlargement at the end of the line is not objectionable.

The back splice starts from a crown knot. The procedure for making aback splice is shown in figure 4-27.

After you have hauled the crown down tight by heaving on each of the three strands, proceed to lay up the back splice. This merely requires splicing the three loose strands back into the line, following the same principle as with the eye and short splice—over one and under one.

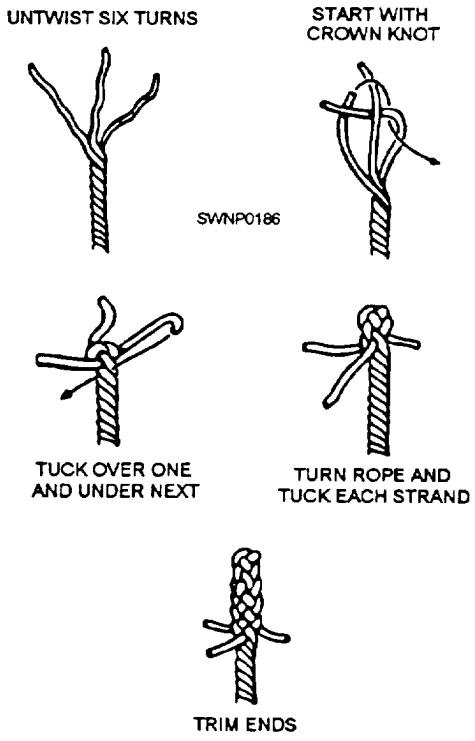


Figure 4-27.—Making a back splice

Because the back splice leaves a lump in the line, it should not be used where there is a possibility of the enlarged end hanging up, as might be the case if it were run through hoisting blocks.

SPLICING NYLON LINE

Nylon line can hold a load even when many strands are abraded. Normal] y, when abrasion is local, the line may be restored to use by cutting away the chafed section and splicing the ends. Chafing and stretching do not necessarily affect the load-carrying ability of nylon line.

The splicing of nylon line is similar to that of manila; however, friction tape is used instead of seizing stuff for whipping the strands and line. Because it is smooth and elastic, nylon line requires at least one tuck more than does manila. For heavy loads, a back tuck should be taken with each strand.

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CHAPTER 5

WIRE ROPE

Wire rope is stronger, lasts longer, and is much more resistant to abrasion than fiber line. Because of these factors, wire rope is used for hoisting tasks that are too heavy for fiber line to handle. Also, many of the movable components on hoisting devices and attachments are moved by wire rope.

Wire rope is an intricate device made up of a number of precise moving parts. The moving parts of wire rope are designed and manufactured to maintain a definite relationship with one another. This relationship ensures that the wire rope has the flexibility and strength crucial to professional and safe hoisting operations.

WIRE ROPE

This chapter discusses the construction, the characteristics and specifications, and the criteria used for the selection of wire rope. The related attachments and the proper handling procedures for wire rope are also discussed.

NOTE: In the Navy, you may hear wire rope referred to as wire or rope but never as line.

WIRE ROPE CONSTRUCTION

Wire rope is composed of three parts: wires, strands, and core (fig. 5-1). A predetermined number of wires of the same or different size are fabricated in a uniform arrangement of definite lay to form a strand. The required number of strands is then laid together symmetrically around the core to form the wire rope.

Wires

The basic component of the wire rope is the wire. The wire may be made of steel, iron, or other metal in various sizes. The number of wires to a strand varies,

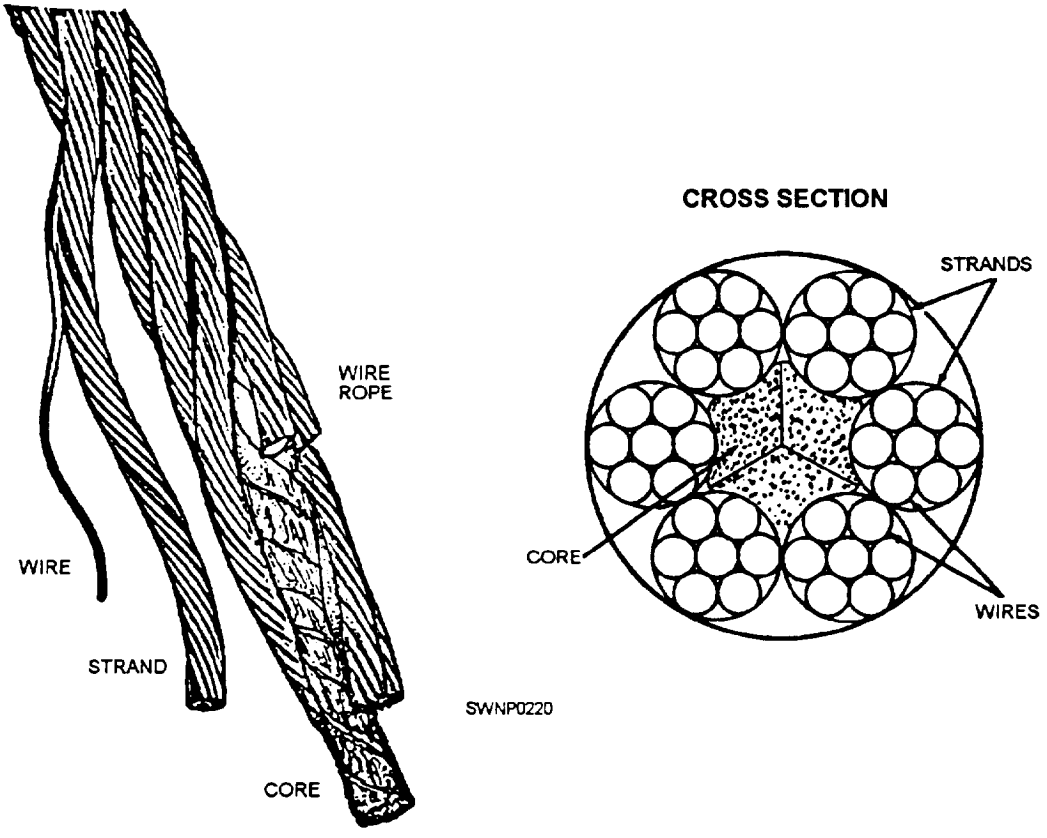


Figure 5-1.—Fabrication of wire rope

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depending on what purpose the wire rope is intended. Wire rope is designated by the number of strands per rope and the number of wires per strand. Thus a 1/2-inch 6 by 19 wire rope has six strands with 19 wires per strand. It has the same outside diameter as a 1/2-inch 6 by 37 wire rope that has six strands with 37 wires (of smaller size) per strand.

Strands

The design arrangement of a strand is called the construction. The wires in the strand may be all the same size or a mixture of sizes. The most common strand constructions are Ordinary, Scale, Warrington, and Filler (fig. 5-2).

- Ordinary construction wires are all the same size.
- Scale is where larger diameter wires are used on the outside of the strand to resist abrasion and smaller wires are inside to provide flexibility.
- Warrington is where alternate wires are large and small to combine great flexibility with resistance to abrasion.
- Filler is where small wires fill in the valleys between the outer and inner rows of wires to provide good abrasion and fatigue resistance.

Core

The wire rope core supports the strands laid around it. The three types of wire rope cores are fiber, wire strand, and independent wire rope (fig. 5-3).

- A fiber core maybe a hard fiber, such as manila, hemp, plastic, paper, or sisal. The fiber core offers the advantage of increased flexibility. It also serves as a cushion to reduce the effects of sudden strain and act as an oil reservoir to lubricate the wire and strands (to reduce friction). Wire rope with a fiber core is used when flexibility of the rope is important.
- A wire strand core resists more heat than a fiber core and also adds about 15 percent to the strength of the rope; however, the wire strand core makes the wire rope less flexible than a fiber core.
- An independent wire rope core is a separate wire rope over which the main strands of the rope are laid. This core strengthens the rope, provides support against crushing, and supplies maximum resistance to heat.

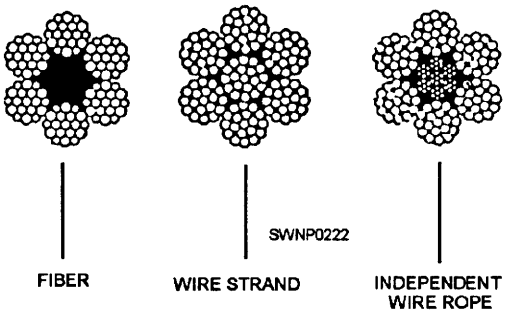


Figure 5-3.—Core construction.

When an inspection discloses any unsatisfactory conditions in a line, ensure the line is destroyed or cut into small pieces as soon as possible. This precaution prevents the defective line from being used for hoisting.

Wire rope may be manufactured by either of two methods. When the strands or wires are shaped to conform to the curvature of the finished rope before laying up, the rope is termed *preformed wire rope*.

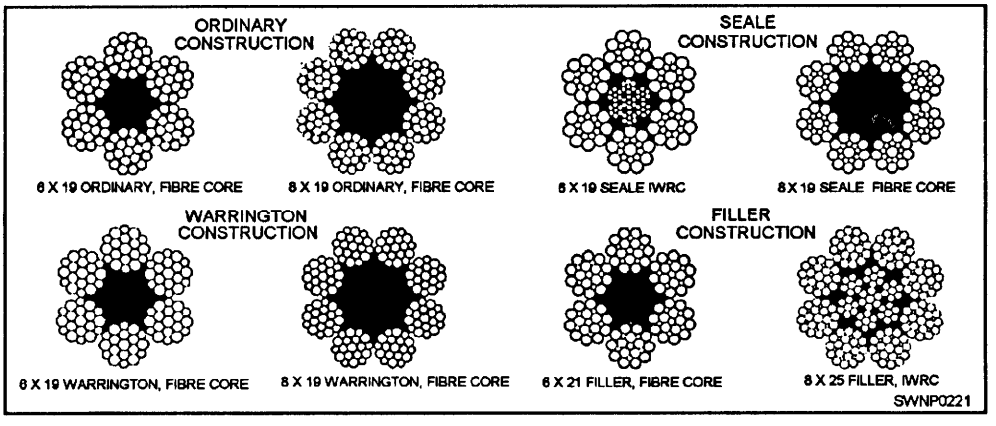


Figure 5-2.—Common strand construction.

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When they are not shaped before fabrication, the wire rope is termed *nonpreformed wire rope.*

The most common type of manufactured wire rope is preformed. When wire rope is cut, it tends not to unlay and is more flexible than nonpreformed wire rope. With nonpreformed wire rope, twisting produces a stress in the wires; therefore, when it is cut or broken, the stress causes the strands to unlay.

WARNING

When wire rope is cut or broken, the almost instantaneous unlaying of the wires and strands of nonpreformed wire rope can cause serious injury to someone that is careless or not familiar with this characteristic of the rope.

GRADES OF WIRE ROPE

The three primary grades of wire rope are mild plow steel, plow steel, and improved plow steel.

Mild Plow Steel Wire Rope

Mild plow steel wire rope is tough and pliable. It can stand repeated strain and stress and has a tensile strength (resistance to lengthwise stress) of from 200,000 to 220,000 pounds per square inch (psi). These characteristics make it desirable for cable tool drilling and other purposes where abrasion is encountered.

Plow Steel Wire Rope

Plow steel wire rope is unusually tough and strong. This steel has a tensile strength of 220,000 to 240,000 psi. Plow steel wire rope is suitable for hauling, hoisting, and logging.

Improved Plow Steel Wire Rope

Improved plow steel wire rope is one of the best grades of rope available and is the most common rope used in the Naval Construction Force (NCF). Improved plow steel is stronger, tougher, and more resistant to wear than either mild plow steel or plow steel. Each square inch of improved plow steel can stand a strain of 240,000 to 260,000 pounds; therefore, this wire rope is especially useful for heavy-duty service, such as cranes with excavating and weight-handling attachments.

LAYS OF WIRE ROPE

The term lay refers to the direction of the twist of the wires in a strand and the direction that the strands are laid in the rope. In some instances, both the wires in the strand and the strands in the rope are laid in the same direction; and in other instances, the wires are laid in one direction and the strands are laid in the opposite direction, depending on the intended use of the rope. Most manufacturers specify the types and lays of wire rope to be used on their piece of equipment. Be sure and consult the operator's manual for proper application.

The five types of lays used in wire rope are as follows:

- Right Regular Lay: In right regular lay rope, the wires in the strands are laid to the left, while the strands are laid to the right to form the wire rope.

- Left Regular Lay: In left regular lay rope, the wires in the strands are laid to the right, while the strands are laid to the left to form the wire rope. In this lay, each step of fabrication is exactly opposite from the right regular lay.

- Right Lang Lay: In right lang lay rope, the wires in the strands and the strands in the rope are laid in the same direction; in this instance, the lay is to the right.

- Left Lang Lay: In left lang lay rope, the wires in the strands and the strands in the rope are also laid in the same direction; in this instance, the lay is to the left (rather than to the right as in the right lang lay).

- Reverse Lay: In reverse lay rope, the wires in one strand are laid to the right, the wires in the nearby strand are laid to the left, the wires in the next strand are laid to the right, and so forth, with alternate directions from one strand to the other. Then all strands are laid to the right.

The five different lays of wire rope are shown in figure 5-4.

LAY LENGTH OF WIRE ROPE

The length of a wire rope lay is the distance measured parallel to the center line of a wire rope in that a strand makes one complete spiral or turn around the rope. The length of a strand lay is the distance measured parallel to the centerline of the strand in that one wire makes one complete spiral or turnaround the

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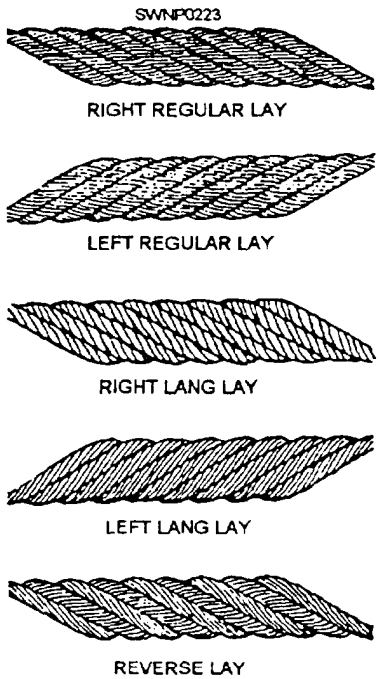


Figure 5-4.—Lays of wire rope.

strand. Lay length measurement is shown in figure 5-5.

CLASSIFICATION OF WIRE ROPE

The primary types of wire rope used by the NCF consist of 6, 7, 12, 19, 24, or 37 wires in each strand. Usually, the wire rope has six strands laid around the core .

The two most common types of wire rope, 6 by 19 and 6 by 37, are shown in figure 5-6. The 6 by 19 type (having six strands with 19 wires in each strand) is the stiffest and strongest construction of the type of wire rope suitable for general hoisting operations. The 6 b y 37 wire rope (having six strands with 37 wires in each strand) is flexible, making it suitable for cranes and similar equipment where sheaves are smaller than

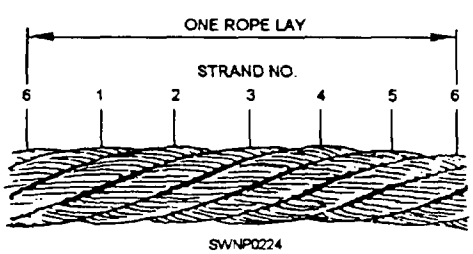


Figure 5-5.—Lay length of wire rope.

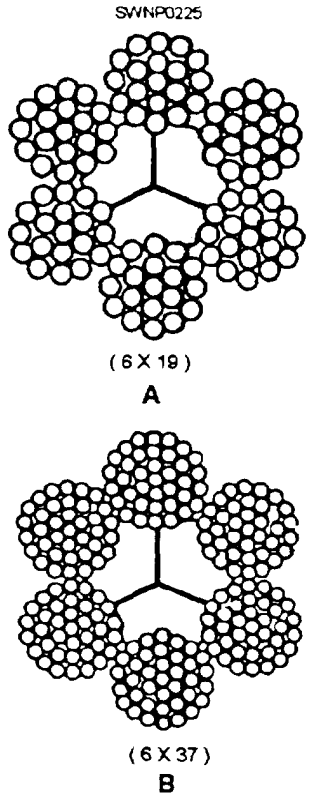


Figure 5-6.—A. 6 by 19 wire rope; B. 6 by 37 wire rope.

usual. The wires in the 6 by 37 are smaller than the wires in the 6 by 19 wire rope and, consequently, will not stand as much abrasive wear.

WIRE ROPE SELECTION

Several factors must be considered when you select a wire rope for use in a particular type of operation. Manufacture of a wire rope that can withstand all of the different types of wear and stress, it is subjected to, is impossible. Because of this factor, selecting a rope is often a matter of compromise. You must sacrifice one quality to have some other more urgently needed characteristic.

Tensile Strength

Tensile strength is the strength necessary to withstand a certain maximum load applied to the rope. It includes a reserve of strength measured in a so-called factor of safety.

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Crushing Strength

Crushing strength is the strength necessary to resist the compressive and squeezing forces that distort the cross section of a wire rope, as it runs over sheaves, rollers, and hoist drums when under a heavy load. Regular lay rope distorts less in these situations than lang lay.

Fatigue Resistance

Fatigue resistance is the ability to withstand the constant bending and flexing of wire rope that runs continuously on sheaves and hoist drums. Fatigue resistance is important when the wire rope must be run at high speeds. Such constant and rapid bending of the rope can break individual wires in the strands. Lang lay ropes are best for service requiring high fatigue resistance. Ropes with smaller wires around the outside of their strands also have greater fatigue resistance, since these strands are more flexible.

Abrasion Resistance

Abrasion resistance is the ability to withstand the gradual wearing away of the outer metal, as the rope runs across sheaves and hoist drums. The rate of abrasion depends mainly on the load carried by the rope and the running speed. Generally, abrasion resistance in a rope depends on the type of metal that the rope is made of and the size of the individual outer wires. Wire rope made of the harder steels, such as improved plow steel, has considerable resistance to abrasion. Ropes that have larger wires forming the outside of their strands are more resistant to wear than ropes having smaller wires that wear away more quickly.

Corrosion Resistance

Corrosion resistance is the ability to withstand the dissolution of the wire metal that results from chemical attack by moisture in the atmosphere or elsewhere in the working environment. Ropes that are put to static work, such as guy wires, maybe protected from corrosive elements by paint or other special dressings. Wire rope may also be galvanized for corrosion protection. Most wire ropes used in crane operations must rely on their lubricating dressing to double as a corrosion preventive.

MEASURING WIRE ROPE

Wire rope is designated by its diameter, in inches. The correct method of measuring the wire rope is to measure from the top of one strand to the top of the strand directly opposite it. The wrong way is to measure across two strands side by side.

To ensure an accurate measurement of the diameter of a wire rope, always measure the rope at three places, at least 5 feet apart (fig. 5-7). Use the average of the three measurements as the diameter of the rope.

NOTE: A crescent wrench can be used as an expedient means to measure wire rope.

WIRE ROPE SAFE WORKING LOAD

The term *safe working load* (SWL) of wire rope is used to define the load which can be applied that allows the rope to provide efficient service and also prolong the life of the rope.

The formula for computing the SWL of a wire rope is the diameter of the rope squared, multiplied by 8.

D x D x 8 = SWL (in tons)

Example: The wire rope is 1/2 inch in diameter. Compute the SWL for the rope.

The first step is to convert the 1/2 into decimal numbers by dividing the bottom number of the fraction into the top number of the fraction: (1 divided by 2 = .5.) Next, compute the SWL formula: (.5 x .5 x 8 = 2 tons.) The SWL of the 1/2-inch wire rope is 2 tons.

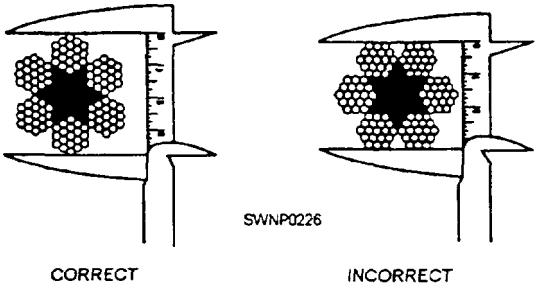


Figure 5-7.—Correct and incorrect methods of measuring wire rope.

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CAUTION

Do NOT downgrade the SWL of wire rope because it is old, worn, or in poor condition. Wire rope in these conditions should be cut up and discarded.

WIRE ROPE FAILURE

Some of the common causes of wire rope failure are the following:

- Using incorrect size, construction or grade
- Dragging over obstacles
- Improper lubrication
- Operating over sheaves and drums of inadequate size
- Overriding or cross winding on drums
- Operating over sheaves and drums with improperly fitted grooves or broken flanges
- Jumping off sheaves
- Exposure to acid fumes
- Use of an improperly attached fitting
- Grit being allowed to penetrate between the strands, causing internal wear
- Being subjeted to severe or continuing overload

WIRE ROPE ATTACHMENTS

Attachments can be put on a wire rope to allow it to be attached to other ropes; for example, pad eyes, chains, or equipment.

END FITTINGS

Some end fittings that are easily and quickly changed are wire rope clips, clamps, thimbles, wedge sockets, and basket sockets. Generally these attachments permit the wire rope to be used with greater flexibility than a more permanent splice would allow. These attachments allow the same wire rope to be made in numerous different arrangements.

Wire Rope Clips

Wire rope clips are used to make eyes in wire rope, as shown in figure 5-8. The U-shaped part of the clip with the threaded ends is called the U-bolt; the other

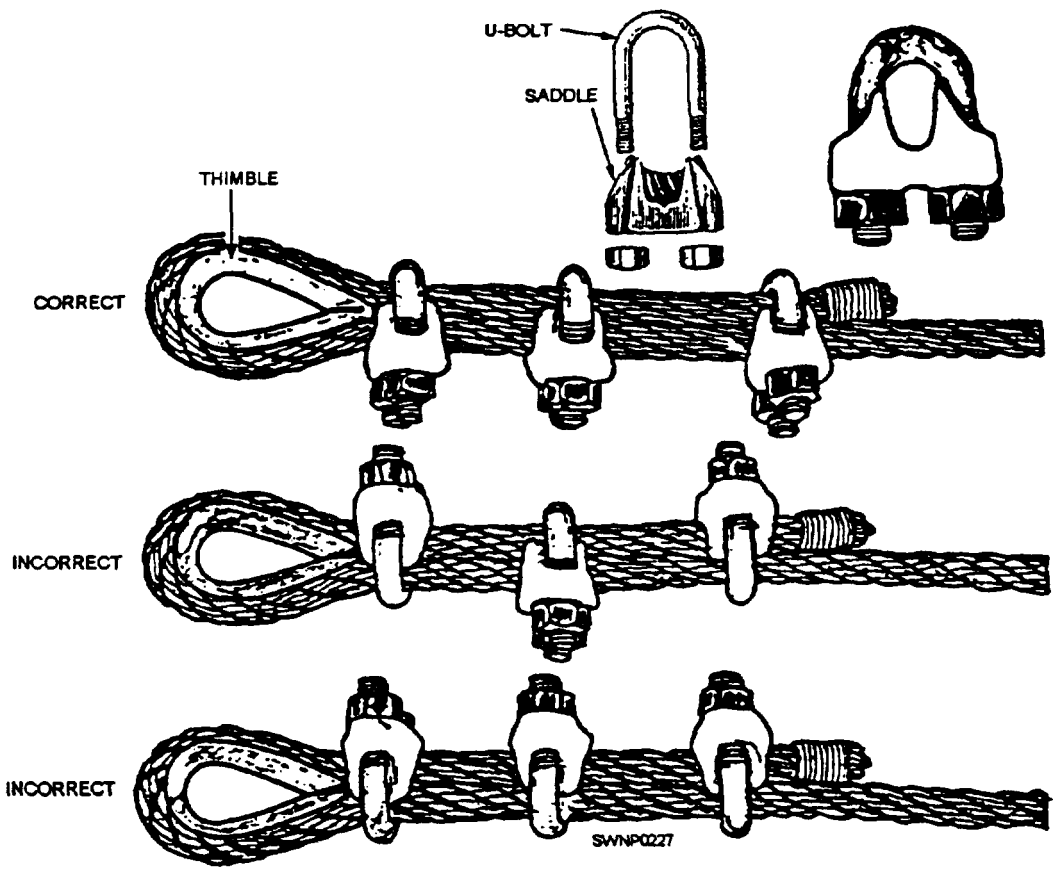


Figure 5-8.—Wire rope clips

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part is called the saddle. The saddle is stamped with the diameter of the wire rope that the clip will fit. Always place a clip with the U-bolt on the bitter (dead) end, not on the standing part of the wire rope. When clips are attached incorrectly, the standing part (live end) of the wire rope will be distorted or have smashed spots. A rule of thumb to remember when attaching a wire rope clip is to "NEVER saddle a dead horse."

Two simple formulas for figuring the number of wire rope clips needed are as follows:

3 x wire rope diameter+ 1 = Number of clips

6 x wire rope diameter= Spacing between clips

Another type of wire rope clip is the twin-base clip, often referred to as the universal or two clamp (fig. 5-9). Both parts of this clip are shaped to fit the wire rope; therefore, the clip cannot be attached incorrectly. The twin-base clip allows a clear 360-degree swing with the wrench when the nuts are being tightened.

Wire Rope Clamps

Wire rope clamps (fig. 5-10) are used to make an eye in the rope with or without a thimble; however, a clamp is normally used without a thimble. The eye will have approximately 90 percent of the strength of the rope. The two end collars should be tightened with wrenches to force the wire rope clamp to a good, snug fit. This squeezes the rope securely against each other.

Thimble

When an eye is made in a wire rope, a metal fitting, called a thimble, is usually placed in the eye (fig. 5-8). The thimble protects the eye against wear. Wire rope eyes with thimbles and wire rope clips can hold approximately 80 percent of the wire rope strength.

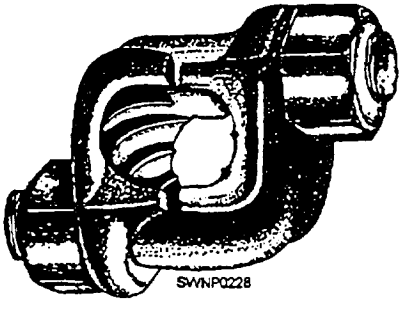


Figure 5-9.—Twin-base wire rope clip.

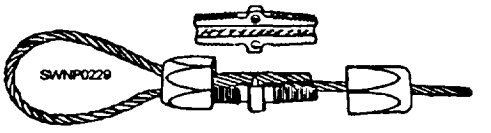


Figure 5-10.—Wire rope.

After the eye made with clips has been strained, the nuts on the clips must be retightened. Checks should be made now and then for tightness or damage to the rope cause by the clips.

Wedge Socket

A wedge socket end fitting (fig. 5-11) is used in situations that require the fitting to be changed frequently. For example, the attachment used most often to attach dead ends of wire ropes to pad eyes, or like fittings, on cranes and earthmoving equipment is the wedge socket. The socket is applied to the bitter end of the wire rope. Fabricated in two parts, the wedge socket has a tapered opening for the wire rope and a small wedge to fit into the tapered socket. The loop of wire rope must be installed in the wedge socket, so the standing part of the wire rope will form a nearly direct line to the clevis pin of the fitting. When a wedge socket is assembled correctly, it tightens as a load is placed on the wire rope.

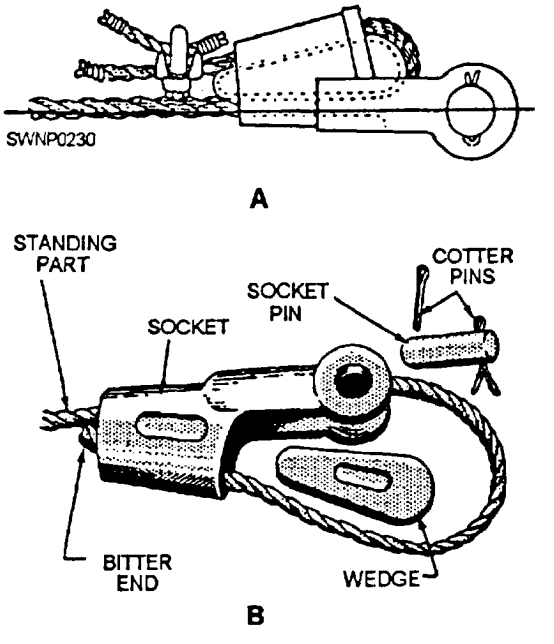


Figure 5-11.—A. Wedge socket B. Parts of a wedge socket.

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NOTE: The wedge socket efficiency is approximately two thirds of the breaking strength of the wire rope due to the crushing action of the wedge.

Basket Socket

A basket socket is normally attached to the end of the rope with either molten zinc or babbitt metal; therefore, it is a permanent end fitting. In all circumstances, dry or poured, the wire rope should lead from the socket in line with the axis of the socket.

DRY METHOD.— The basket socket can also& fabricated by the dry method (fig. 5- 12) when facilities are not available to make a poured fitting; however, its strength will be reduced to approximately one sixth of that of a poured zinc connection.

POURED METHOD.—– The poured basket socket (fig. 5-13) is the preferred method of basket socket assembly. Properly fabricated, it is as strong as the rope itself, and when tested to destruction, a wire rope will break before it will pull out of the socket. When molten lead is used vice zinc, the strength of the connection must be approximate] y three fourths of the strength of a zinc connection

Permanent eyes in wire rope slings can also be made in 3/8- to 5/8-inch (9.5 to 15.9-mm) wire rope by using the nicopress portable hydraulic splicing tool and oval sleeves. The nicopress portable splicing tool (fig. 5-14) consists of a hand-operated hydraulic pump connected to a ram head assembly. Included as a part of the tool kit are interchangeable compression dies for wire sizes 3/8, 7/16, 1/2, 9/16, and 5/8 inch (9.5, 11.1, 12.7, 14.3, and 15.9 mm). The dies are in machined halves with a groove size to match the oval sleeve and the wire rope being spliced. The oval sleeves (fig. 5-15) are available in plain copper or zinc-plated copper.

To make an eye splice, pick an oval sleeve equal to the size of the wire rope being spliced. Slide the sleeve over the bitter end of the length of rope, then form an eye and pass the bitter end through the end again (fig. 5-16). Next, place the lower half of the compression die in the ram head assembly. Place the oval sleeve in this lower half and drop in the upper half of the die. Fully insert the thrust pin that is used to hold the dies in place when making the swage. Start pumping the handle and continue to do so until the dies meet. At this time the overload valve will pop off, and a 100-percent efficient splice is formed (fig. 5-17). Retract the plunger and remove the swaged splice.

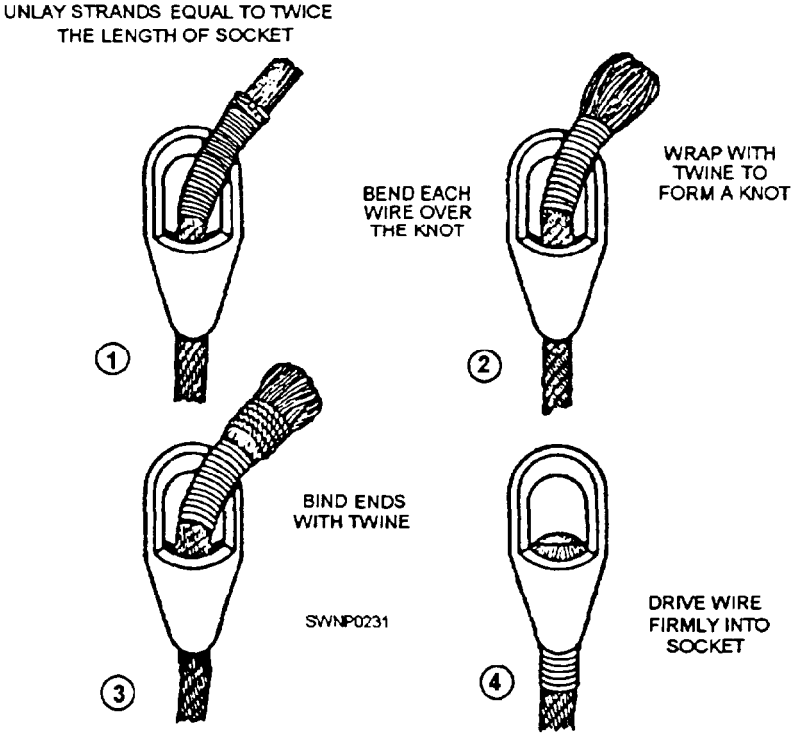


Figure 5-12.—Attaching a basket socket by the dry method.

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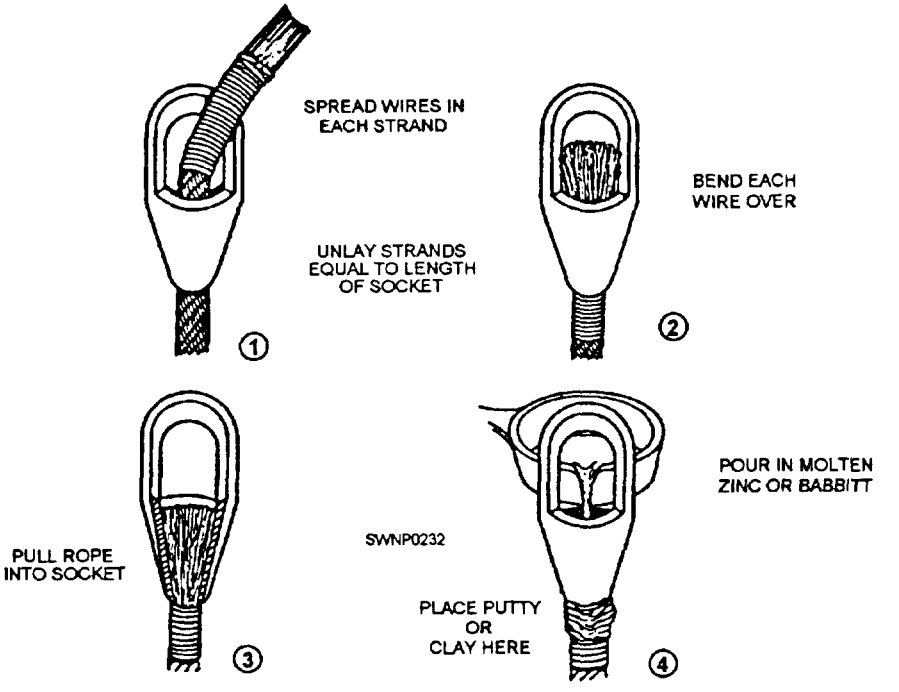


Figure 5-13.—Attaching a basket socket by the pouring method.

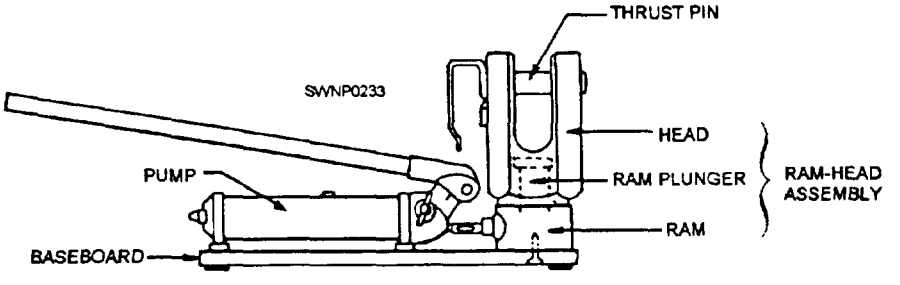


Figure 5-14.—Nicopress portable splicing tool.

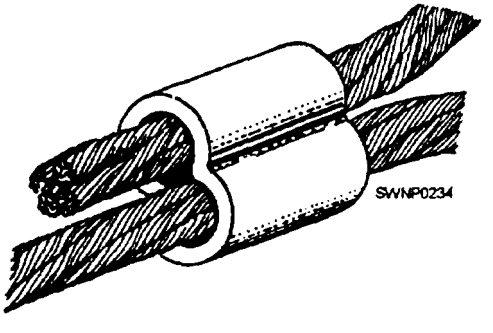


Figure 5-15.—Oval sleeve.

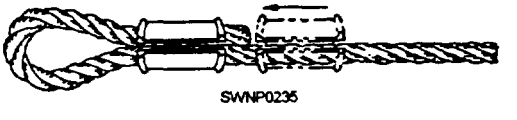


Figure 5-16.-Starting an eye splice using an oval sleeve.

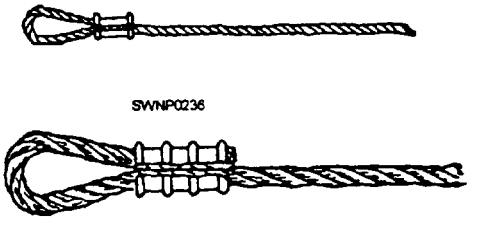


Figure 5-17.—Completed eye splice using an oval sleeve.

Check the swage with the gauge supplied in each die set (fig. 5-18). This process represents a savings in time over the eye formed by using wire rope clips.

Additionally, lap splices can be made with nicopress oval sleeves (fig. 5-19). Usually, two sleeves are needed to create a full-strength splice. A short

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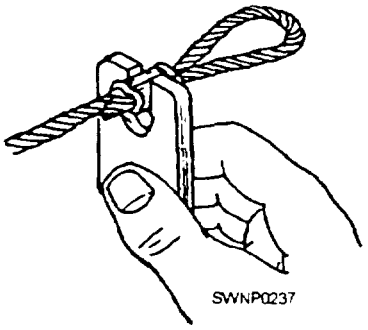


Figure 5-18.—Swage gauge.



Figure 5-19.—Lap splice using a nicopress oval sleeve.

space should be maintained between the two sleeves, as shown. The lap splice should be tested before being used.

HANDLING AND CARE OF WIRE ROPE

To render safe, dependable service over a maximum period of time, you should take good care and upkeep of the wire rope that is necessary to keep it in good condition. Various ways of caring for and handling wire rope are listed below.

Coiling and Uncoiling

Once anew reel has been opened, it may be coiled or faked down, like line. The proper direction of coiling is counterclockwise for left lay wire rope and clockwise for right lay wire rope. Because of the general toughness and resilience of wire, it often tends to resist being coiled down. When this occurs, it is useless to fight the wire by forcing down the turn because the wire will only spring up again. But if it is thrown in a back turn, as shown in figure 5-20, it will lie down proper] y. A wire rope, when faked down, will run right off like line; but when wound in a coil, it must always be unwound.

Wire rope tends to kink during uncoiling or unreeling, especially if it has been in service for a long time. A kink can cause a weak spot in the rope that wears out quicker than the rest of the rope.

A good method for unreeling wire rope is to run a pipe, or rod, through the center and mount the reel on drum jacks or other supports, so the reel is off the ground (fig. 5-21, view A). In this way, the reel will turn as the rope is unwound, and the rotation of the

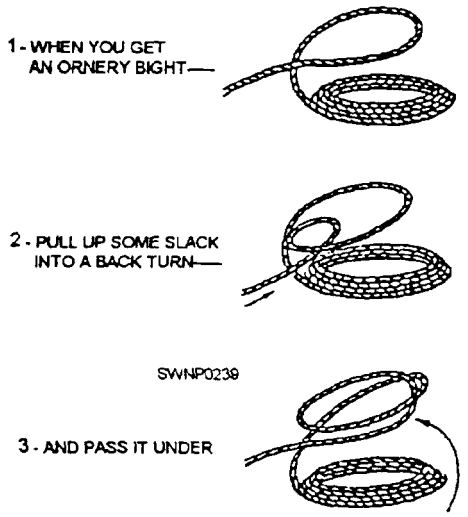


Figure 5-20.—Throwing a back turn.

reel helps keep the rope straight. During unreeling, pull the rope straight forward and avoid hurrying the operation. As a safeguard against kinking, NEVER unreel wire rope from a reel that is stationary.

To uncoil a small coil of wire rope, simply stand the coil on edge and roll it along the ground like a wheel, or hoop (fig. 5-21, view B). NEVER lay the coil flat on the floor or ground and uncoil it by pulling on the end because such practice can kink or twist the rope.

Kinks

One of the most common types of damage resulting from the improper handling of wire rope is the development of a kink. A kink starts with the formation of a loop (fig. 5-22).

A loop that has not been pulled tight enough to set the wires, or strands, of the rope into a kink can be removed by turning the rope at either end in the proper direction to restore the lay, as shown in figure 5-23. If this is not done and the loop is pulled tight enough to cause a kink (fig. 5-24), the kink will result in irreparable damage to the rope (fig. 5-25).

Kinking can be prevented by proper uncoiling and unreeling methods and by the correct handling of the rope throughout its installation.

Reverse Bends

Whenever possible, drums, sheaves, and blocks used with wire rope should be placed to avoid reverse or S-shaped bends. Reverse bends cause the individual wires or strands to shift too much and increase wear and fatigue. For a reverse bend, the drums and blocks affecting

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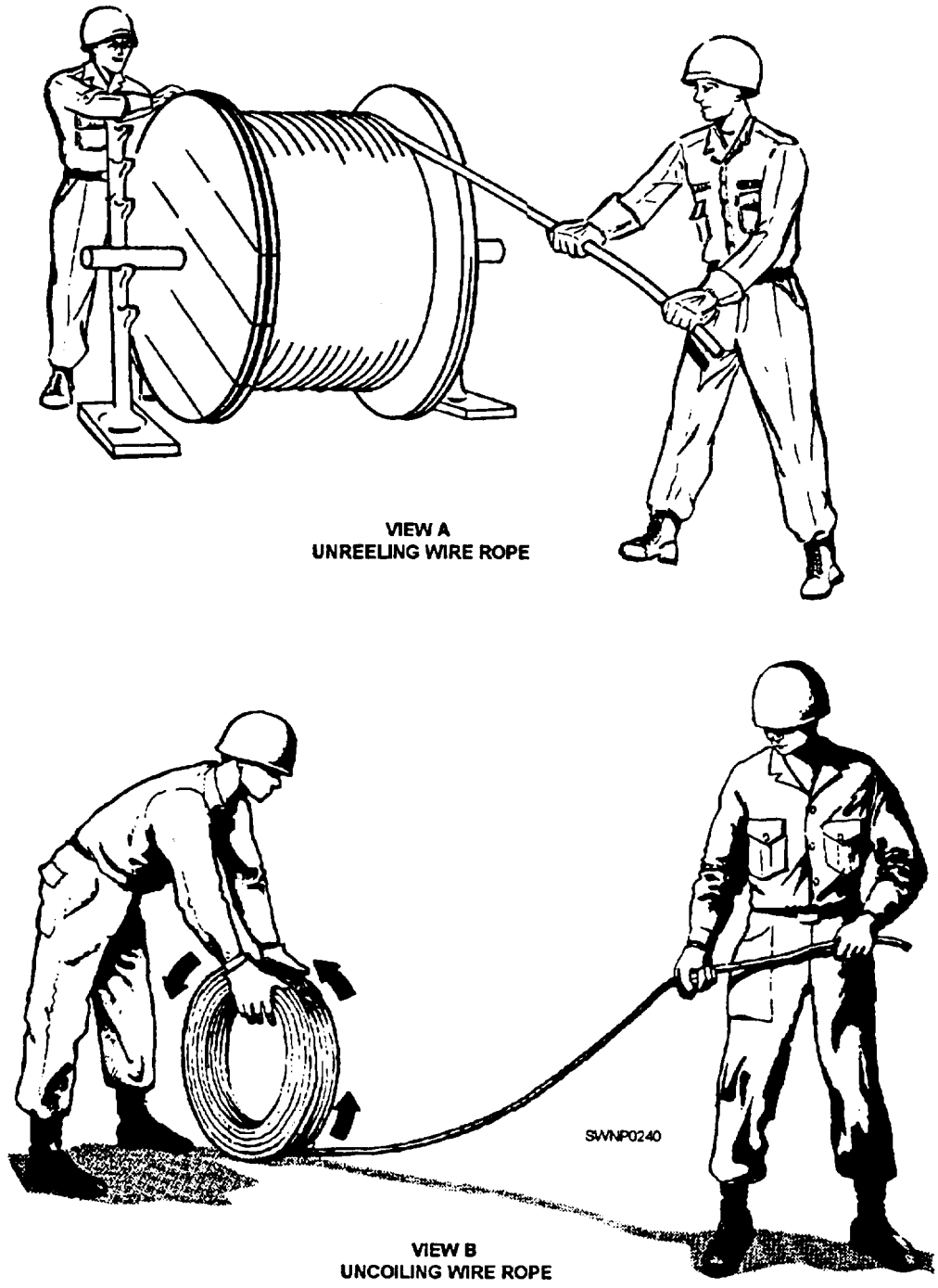


Figure 5-21.—A. Unreeling wire rope; B. Uncoiling wire rope.

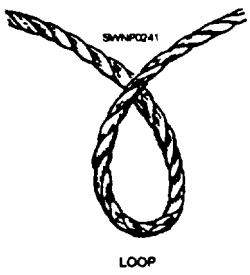


Figure 5-22.—A wire rope loop.

the reversal should be of a larger diameter than ordinarily used and should be spaced as far apart as possible.

Sizes of Sheaves

The diameter of a sheave should never be less than 20 times the diameter of the wire rope. An exception is 6 by 37 wire for a smaller sheave that can be used because this wire rope is more flexible.

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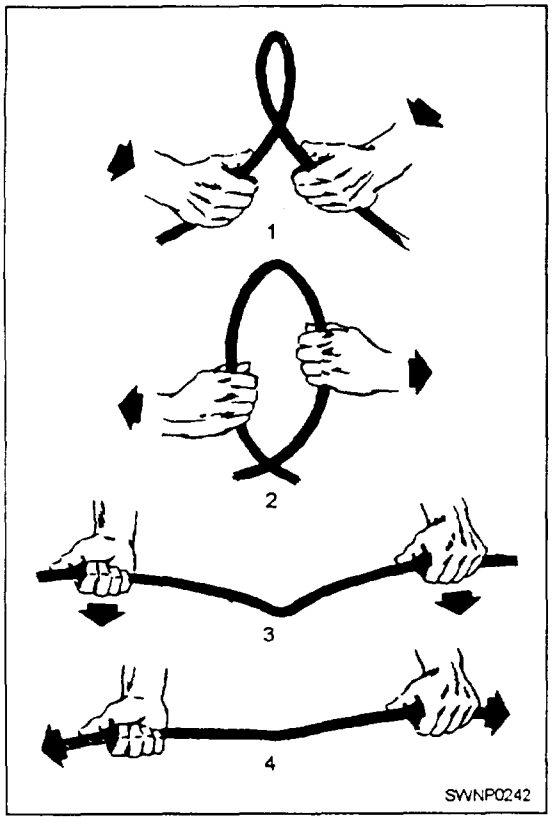


Figure 5-23.—The correct way to remove a loop in a wire rope

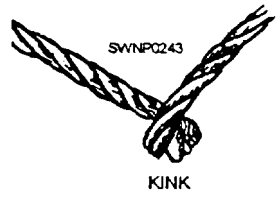


Figure 5-24.—A wire rope kink.



Figure 5-25.—Kink damage.

The chart shown in table 5-1 can be used to determine the minimum sheave diameter for wire rope of various diameters and construction.

Seizing and Cutting

The makers of wire rope are careful to lay each wire in the strand and each strand in the rope under uniform tension. When the ends of the rope are not secured properly, the original balance of tension is disturbed and maximum service cannot be obtained because some strands can carry a greater portion of the load than others. Before cutting steel wire rope, place seizing on each side of the point where the rope is to be cut, as shown in figure 5-26.

Table 5-1.—Suggested Mininum Tread Diameter of sheaves and Drums

Rope diameter in inches	Minimum tread diameter in inches for given rope construction*			
	6 × 7	6 × 19	6 × 37	8 × 19
1/4	10 1/2	8 1/2	- - -	6 1/2
3/8	15 3/4	12 3/4	6 3/4	9 3/4
1/2	21	17	9	13
5/8	26 1/4	21 1/4	11 1/4	16 1/4
3/4	31 1/2	25 1/2	13 1/2	19 1/2
7/8	36 3/4	29 3/4	15 3/4	22 3/4
1	42	34	18	26
1 1/8	47 1/4	38 1/4	20 1/2	29 1/4
1 1/4	52 1/2	42 1/2	22 1/2	32 1/2
1 1/2	63	51	27	39
*Rope construction is in strands times wires per strand.				

A rule of thumb for determining the size, number, and distance between seizing is as follows:

1. The number of seizing to be applied equals approximately three times the diameter of the rope.

Example: 3- x 3/4-inch-diameter rope = 2 1/4 inches. Round up to the next higher whole number and use three seizings.

2. The width of each seizing should be 1 to 1 1/2 times as long as the diameter of the rope.

Example: 1- x 3/4-inch-diameter rope= 3/4 inch. Use a 1-inch width of seizing.

3. The seizing should be spaced a distance equal to twice the diameter of the wire rope.

Example: 2- x 3/4-inch-diameter rope = 1 1/2 inches. Space the seizing 2 inches apart.

A common method used to make a temporary wire rope seizing is as follows:

Wind on the seizing wire uniformly, using tension on the wire. After taking the required number of turns, as shown in step 1, twist the ends of the wires

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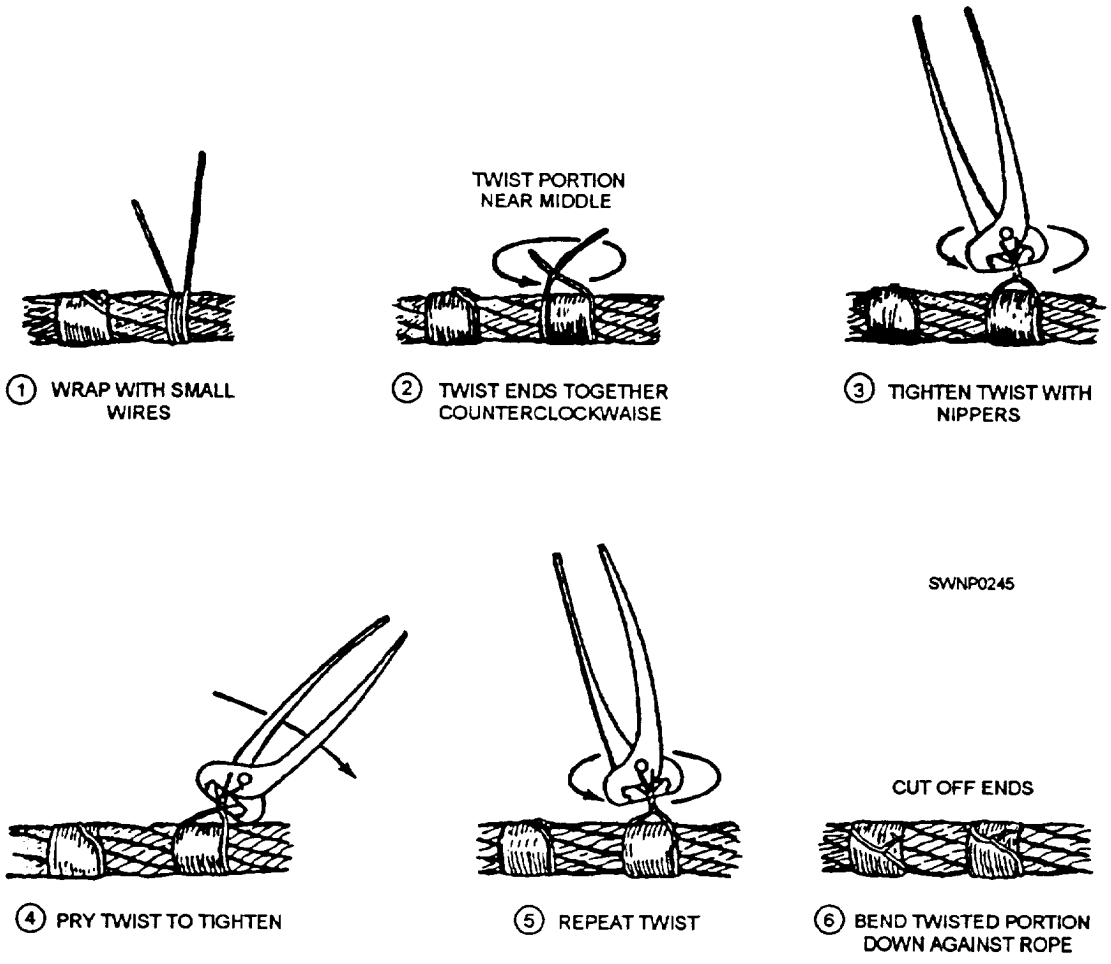


Figure 5-26.—Seizing wire rope.

counterclockwise by hand, so the twisted portion of the wires is near the middle of the seizing, as shown in step 2. Grasp the ends with end-cutting nippers and twist up the slack, as shown in step 3. Do not try to tighten the seizing by twisting. Draw up on the seizing, as shown in step 4. Again twist up the slack, using nippers, as shown in step 5. Repeat steps 4 and 5 if necessary. Cut the ends and pound them down on the rope, as shown in step 6. When the seizing is to be permanent or when the rope is 1 5/8 inches or more in diameter, use a serving bar, or iron, to increase tension on the seizing wire when putting on the turns.

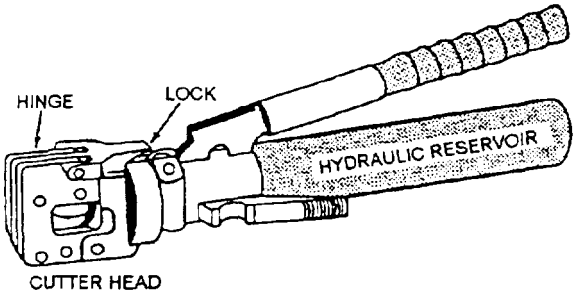
Wire rope can be cut successfully by a number of methods. One effective and simple method is to use a hydraulic type of wire rope cutter, as shown in figure 5-27. Remember that all wire should be seized before it is cut. For best results in using this method, place the rope in the cutter, so the blade comes between the two central seizings. With the release valve closed, jack the blade against the rope at the location of the cut and continue to operate the cutter until the wire rope is cut.

INSPECTION

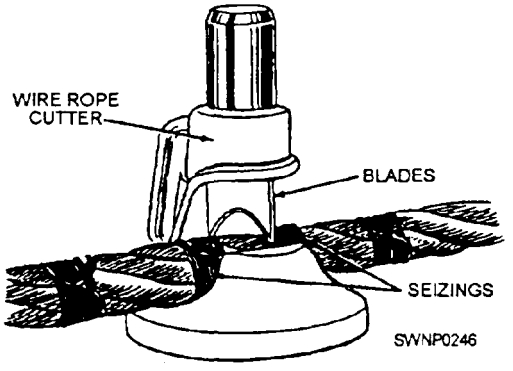
Wire rope should be inspected at regular internals, the same as fiber line. The frequency of inspection is determined by the use of the rope and the conditions under which it is used.

Throughout an inspection, the rope should be examined carefully for fishhooks, kinks, and worn and corroded spots. Usual] y breaks in individual wires will be concentrated in areas where the wire runs continually over the sheaves or bend onto the drum. Abrasion or reverse and sharp bends cause individual wires to break and bend back These breaks are known as fishhooks. When wires are slightly worn but have broken off squarely and stick out all over the rope, that condition is usually caused by overloading or rough handling. If the breaks are confined to one or two

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VIEW A
HYDRAULIC



VIEW B
HAMMER

Figure 5-27.—Types of wire rope cutters: A. Hydraulic; B. Hammer.

strands, then the strength of the rope maybe seriously reduced. When 4 percent of the total number of wires in the rope are found to have breaks within the length of one lay of the rope, the rope is considered unsafe. Consider the rope unsafe when three broken wires are found in one strand of 6 by 7 rope, six broken wires in one strand of 6 b y 19 rope, or nine broken wires in one strand of 6 by 37 rope.

Overloading a rope will reduce the diameter. Additionally, failure to lubricate wire rope will reduce the diameter. This occurs because the hemp core will eventually dry out and collapse or shrink. The surrounding strands are therefore deprived of support, and the strength and dependability of the rope are equally reduced. Rope that is 75 percent of its original diameter should be removed from service.

When wide-spread pitting and corrosion of the wires are visible through inspection, the rope should be removed from service. Special care should be taken to examine the valleys and small spaces between the strands for rust and corrosion. Since corrosion is normally caused by improper, infrequent, or no lubrication, the internal wires of the rope are often subject to extreme friction and wear. This type of internal and often invisible destruction of the wires is one of the most frequent causes of unexpected and sudden wire rope failure. To safeguard against this occurring, you should always keep the rope well lubricated and handle and store it properly.

CLEANING AND LUBRICATING WIRE ROPE

Wire rope should always be cleaned carefully before lubrication. Scraping or steaming removes most of the dirt and grit that has accumulated on used wire rope. Rust should be removed at regular intervals by wire brushing. The objective of cleaning is to remove all foreign material and old lubricant from the valleys between the strands as well as the spaces between the outer wires. This allows the new lubricant to flow into the rope.

Wire rope bending around hoist drums and sheaves will wear like any other metal article, so lubrication is just as important to an operating wire rope as it is to any other piece of working machinery. For a wire rope to work right, the wires and strands must be free to move. Friction from corrosion or lack of lubrication shortens the service life of wire rope.

Deterioration from corrosion is more dangerous than that from wear because corrosion ruins the inside wires—a process hard to detect by inspection. Deterioration caused by wear can be detected by examining the outside wires of the wire rope because these wires become flattened and reduced in diameter as the wire rope wears.

Both internal and external lubrication protects a wire rope against wear and corrosion. Internal lubrication can be properly applied only when the wire rope is being manufactured, and manufacturers customarily coat every wire with a rust-inhibiting lubricant, as it is laid into the strand. The core is also lubricated in manufacturing,

Lubrication that is applied in the field is designed not only to maintain surface lubrication but also to prevent the loss of the internal lubrication provided by the manufacturer. The Navy issues an asphaltic petroleum oil that must be heated before using. This lubricant is known as Lubricating Oil for Chain, Wire Rope, and Exposed Gear and comes in two types:

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• Type I, Regular: Does not prevent rust and is used where rust prevention is not needed; for example, elevator wires used inside are not exposed to the weather but need lubrication.

• Type II, Protective: A lubricant and an anticorrosive that comes in three grades: grade A, for cold weather (60°F and below); grade B, for warm weather (between 60°F and 80°F); and grade C, for hot weather (80°F and above).

The oil, issued in 25-pound and 35-pound buckets and in 100-pound drums, can be applied with a stiff brush, or the wire rope can be drawn through a trough of hot lubricant, as shown in figure 5-28. The frequency of application depends upon service conditions; as soon as the last coating has appreciably deteriorated, it should be renewed.

A good lubricant to use when working in the field, as recommended by COMSECOND/COMTHIRD NCBINST 11200.11, is a mixture of new motor oil and diesel fuel at a ratio of 70-percent oil and 30-percent diesel fuel. The NAVFAC P-404 contains added information on additional lubricants that can be used.

Never lubricate wire rope that works a dragline or other attachments that normally bring the wire rope in contact with soils. The reason is that the lubricant will pick up fine particles of material, and the resulting abrasive action will be detrimental to both the wire rope and sheave.

As a safety precaution, always wipe off any excess when lubricating wire rope, especially with hoisting equipment. Too much lubricant can get into brakes or clutches and cause them to fail. While in use, the motion of machinery may sling excess oil around over crane cabs and onto catwalks, making them unsafe.

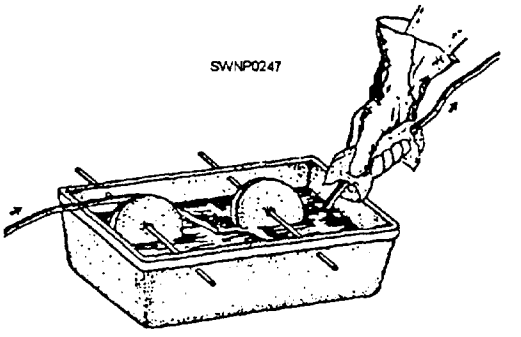


Figure 5-28.—Trough method of lubricating wire rope

STORAGE

Wire rope should never be stored in an area where acid is or has been kept. This must be stressed to all hands. The slightest trace of acid or acid fumes coming in contact with wire rope will damage it at the contact spot. Wire that has given way has been found many times to be acid damaged.

It is paramount that wire rope be cleaned and lubricated properly before placing it in storage. Fortunately, corrosion of wire rope can be virtually eliminated if lubricant is applied properly and sufficient protection from the weather is provided, Remember that rust, corrosion of wires, and deterioration of the fiber core will significantly reduce the strength of wire rope. Although it is not possible to say exactly the loss due to these effects, it is certainly enough to take precautions against.

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CHAPTER 6

RIGGING

Rigging is the method of handling materials using fiber line, wire rope, and associated equipment. Fiber line and wire rope were discussed in chapters 4 and 5. We will now discuss how these materials and equipment can be used in various tackle and lever arrangements to form the fundamental rigging necessary to move heavy loads. Additionally, we discuss the makeup of block and tackle, reeving procedures, and common types of tackle arrangements. Information is also provided on other common types of weight-handling devices, such as slings, spreaders, pallets, jacks, planks and rollers, blocking and cribbing, and scaffolds.

SAFETY is paramount in importance. You will be briefed throughout this chapter on safety measures to be observed as it pertains to the various operations or particular equipment we are discussing. Also, formulas are given for your use in calculating the working loads of various weight-moving devices, such as hooks, shackles, chains, and so on. SAFE rigging is the critical link in the weight-handling process.

BLOCK AND TACKLE

The most commonly used mechanical device is block and tackle. A block (fig. 6-1) consists of one or more sheaves fitted in a wood or metal frame supported by a shackle inserted in the strap of the block. A **tackle** is an assembly of blocks and lines used to gain a mechanical advantage in lifting and pulling.

The mechanical advantage of a machine is the amount the machine can multiply the force used to lift or move a load. The strength of an individual determines the weight he or she can push or pull. The ability to push or pull is referred to as the amount of force the individual can exert. To move any load heavier than the force you can exert requires the use of a machine that can provide a mechanical advantage to multiply the force you can apply. If you use a machine that can produce a push or pull on an object that is 10 times greater than the force you apply, the machine has a mechanical advantage of 10. For example, if the downward pull on a block-and-tackle assembly requires 10 pounds of force to raise 100 pounds, the assembly has a mechanical advantage of 10.

In a tackle assembly, the line is reeved over the sheaves of blocks. The two types of tackle systems are simple and compound. A simple tackle system is an assembly of blocks in which a single line is used (fig. 6-2, view A). A compound tackle system is an assembly of blocks in which more than one line is used (fig. 6-2, view B).

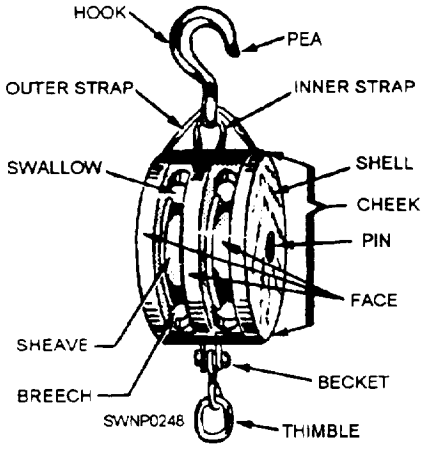


Figure 6-1.—Parts of a fiber line block.

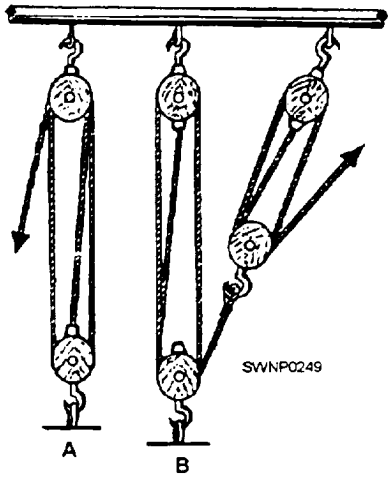


Figure 6-2.—Tackles: A. Simple tackle; B. Compound tackle.

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The terms used to describe the parts of a tackle (fig. 6-3) and various assemblies of tackle are as follows:

- The block(s) in a tackle assembly change(s) the direction of pull, provides mechanical advantage, or both.
- The fall is either a wire rope or fiber line reeved through a pair of blocks to form a tackle.
- The hauling part of the fall leads from the block upon which the power is exerted.
- The fixed (or standing) block is the end which is attached to a becket.
- The movable (or running) block of a tackle is the block attached to a fixed objector support. When a tackle is being used, the movable block moves and the fixed block remains stationary.
- The frame (or shell), made of wood or metal, houses the sheaves.
- The sheave is a round, grooved wheel over which the line runs. Usually the blocks have one, two, three, or four sheaves. Some blocks have up to eleven sheaves.
- The cheeks are the solid sides of the frame or shell.
- The pin is a metal axle that the sheave turns on. It runs from cheek to cheek through the middle of the sheave.

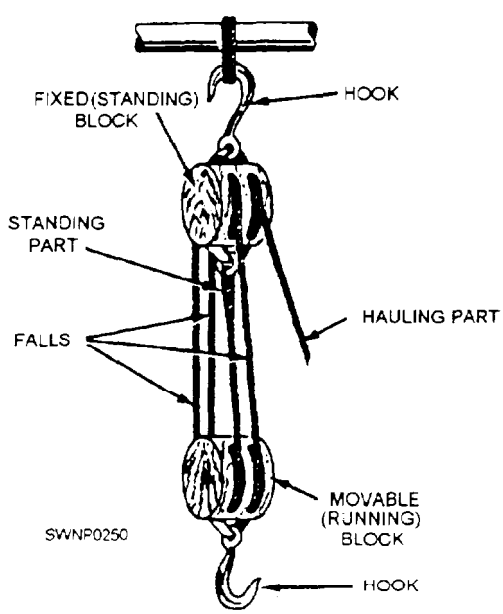


Figure 6-3.—Parts of a tackle.

- The becket is a metal loop formed at one or both ends of a block; the standing part of the line is fastened to the becket.
- The straps inner and outer) hold the block together and support the pin on which the sheaves rotate.
- The shallow is the opening in the block through which the line passes.
- The breech is the part of the block opposite the swallow.
- To overhaul means to lengthen a tackle by pulling the two blocks apart.
- To round in means to bring the blocks of a tackle toward each other, usually without a load on the tackle (opposite of overhaul).
- The term two blocked means that both blocks of a tackle are as close together as they can go. You may also hear this term called block and block.

BLOCK CONSTRUCTION

Blocks are constructed for use with fiber line or wire rope. Wire rope blocks are heavily constructed and have large sheaves with deep grooves. Fiber line blocks are generally not as heavily constructed as wire rope blocks and have smaller sheaves with shallow, wide grooves. A large sheave is needed with wire rope to prevent sharp bending. Since fiber line is more flexible and pliable, it does not require a sheave as large as the same size that wire rope requires,

According to the number of sheaves, blocks are called **SINGLE, DOUBLE, OR TRIPLE** blocks. Blocks are fitted with a number of attachments, such as hooks, shackles, eyes, and rings. Figure 6-4 shows

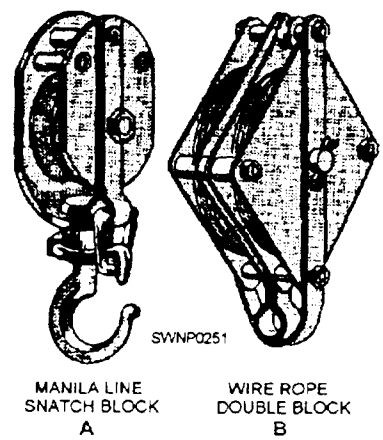


Figure 6-4.—Heavy-duty blocks.

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two metal framed, heavy-duty blocks. Block A is designed for manila line, and block B is for wire rope.

BLOCK TO LINE RATIO

The size of a fiber line block is designated by the length in inches of the shell or cheek. The size of standard wire rope block is controlled by the diameter of the rope. With nonstandard and special-purpose wire rope blocks, the size is found by measuring the diameter of one of its sheaves in inches.

Use care in selecting the proper size line or wire for the block to be used. If a fiber line is reeved onto a tackle whose sheaves are below a certain minimum diameter, the line becomes distorted which causes unnecessary wear. A wire rope too large for a sheave tends to be pinched which damages the sheave. Also, the wire will be damaged because the radius of bend is too short. A wire rope too small for a sheave lacks the necessary bearing surface, puts the strain on only a few strands, and shortens the life of the wire.

With fiber line, the length of the block used should be about three times the circumference of the line. However, an inch or so either way does not matter too much; for example, a 3-inch line may be reeved onto an 8-inch block with no ill effects. Normally, you are more likely to know the block size than the sheave diameter; however, the sheave diameter should be about twice the size of the circumference of the line used.

Wire rope manufacturers issue tables that give the proper sheave diameters used with the various types and sizes of wire rope they manufacture. In the absence of these, a rough rule of thumb is that the sheave diameter should be about 20 times the diameter of the wire. Remember, with wire rope, it is the diameter, rather than circumference, and this rule refers to the diameter of the sheave, rather than to the size of the block, as with line.

TYPES OF BLOCKS

A **STANDING BLOCK** is a block that is connected to a fixed object.

A **TRAVELING BLOCK** is a block that is connected to the load that is being lifted. It also moves with the load as the load is moved.

A **SNATCH BLOCK** (fig. 6-5) is a single sheave block fabricated so the shell opens on one side at the base of the hook to allow a rope to slip over the sheave without threading the end through the block. Snatch

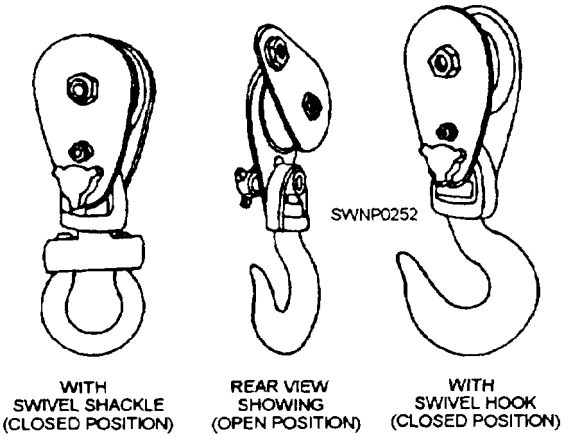


Figure 6-5.—Snatch blocks.

blocks are used when it is necessary to change the direction of pull on the line.

REEVING BLOCKS

To reeve blocks in simple tackle, you must first lay the blocks a few feet apart. The blocks should be placed down with the sheaves at right angles to each other and the becket bends pointing toward each other.

To start reeving, lead the standing part of the falls through one sheave of the block that has the greatest number of sheaves. Begin at the block fitted with the becket. Next pass the standing part around the sheaves from one block to the other, making sure no lines are crossed until all sheaves have a line passing over them. Now secure the standing part of the falls at the becket of the block having the fewest number of sheaves, using a becket hitch for temporary securing or an eye splice for permanent securing.

When blocks have two or more sheaves, the standing part of the fall should be led through the sheave closest to the center of the block. This places the strain on the center of the block and prevents the block from toppling and the lines from being chafed and cut through by rubbing against the edges of the block.

Falls are normally reeved through 8-inch or 10-inch wood or metal blocks, in such away as to have the lower block at right angles to the upper. Two 3-sheave blocks are the traditional arrangement, and the method of reeving is shown in figure 6-6. The hauling part has to go through the middle sheave of the upper block or the block will tilt to the side and the falls will jam under load.

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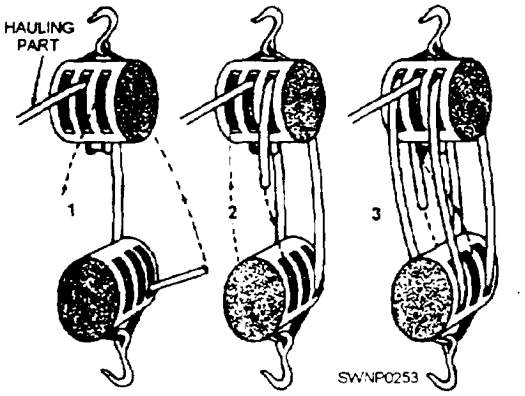


Figure 6-6.—Reeving two 3-sheave blocks.

If a 3- and 2-sheave block rig is used, the method of reeving is almost the same (fig. 6-6), but the becket for the deadman must be on the lower instead of the upper block.

You reeve the blocks before you splice in the becket thimble, or you will have to reeve the entire fall through from the opposite end. For the sake of appearance, if the becket block has a grommet, it is better to take it out and substitute a heart-shaped thimble. Splice it with a tapered eye splice, and worm, parcel, and serve the splice if you want a sharp-looking job.

TYPES OF TACKLE

SINGLE-WHIP tackle consists of one single sheave block (tail block), attached to a support with a line passing over the sheave (fig. 6-7). It has a mechanical advantage of 1, and if a load of 50 pounds were to be lifted, it would require 50 pounds of force to lift it, plus allowance for friction.

A **RUNNER** is a single sheave movable block that is free to move along the line for which it is rove. It has a mechanical advantage of 2.

A **GUN TACKLE** is made up of two single sheave blocks (fig. 6-8). The name of the tackle originated when it was being used in the old days of muzzle-loading guns. After the guns were fired and reloaded, this tackle was used to haul the guns back to the battery.

A gun tackle has a mechanical advantage of 2. Therefore, to lift a gun weighing 200 pounds requires a force of 100 pounds without considering friction.

By inverting any tackle, you should gain a mechanical advantage of 1. This occurs because the number of parts at the movable block has increased.

By inverting a gun tackle, as an example, you should gain a mechanical advantage of 3 (fig. 6-9). When a tackle is inverted, the direction of pull is always difficult. This can be overcome easily by using a snatch block, It changes the direction of pull but does not increase the mechanical advantage.

A **SINGLE-LUFF TACKLE** consists of a double and a single block (fig. 6-10). This type of tackle has a mechanical advantage of 3.

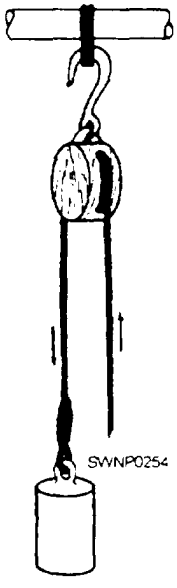


Figure 6-7.—A single-whip tackle.

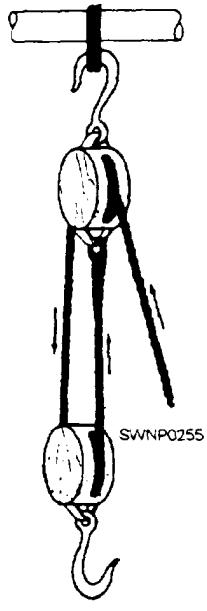


Figure 6-8.—A gun tackle.

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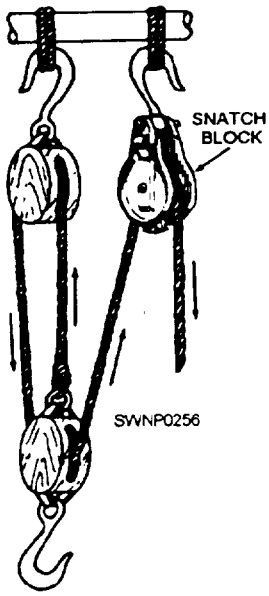


Figure 6-9.—An inverted gun tackle.

A **TWOFOLD PURCHASE** tackle consists of two double blocks (fig. 6-11). It has a mechanical advantage of 4.

A **DOUBLE-LUFF** tackle consists of a triple block and a double block (fig. 6-12). It has a mechanical advantage of 5.

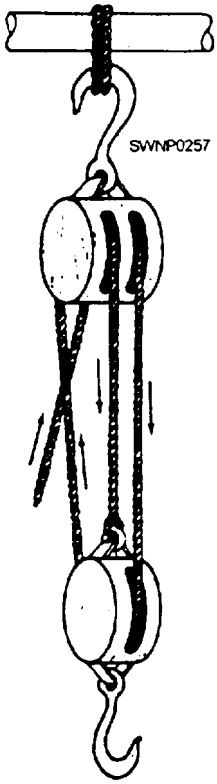


Figure 6-10.—A single-luff tackle.

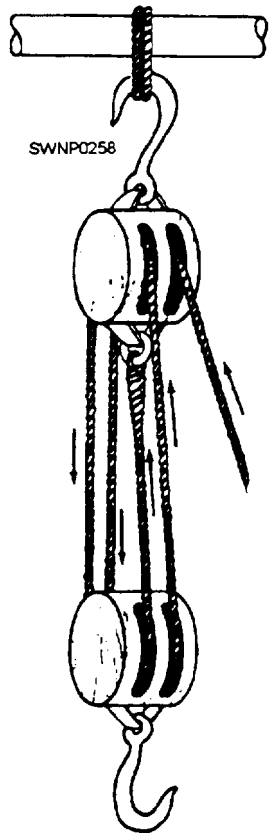


Figure 6-11.—A twofold purchase.

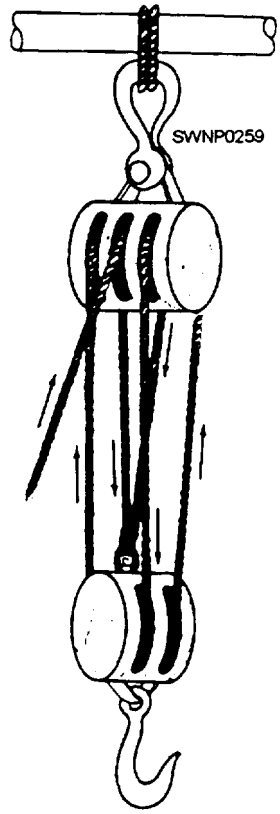


Figure 6-12.—A double-luff tackle.

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A **THREEFOLD PURCHASE** consists of two triple blocks and has a mechanical advantage of 6 (fig. 6-13).

A **COMPOUND TACKLE** is a rigging system using more than one line with two or more blocks. Compound systems are made up of two or more simple systems. The fall line from one simple system is secured to the hook on the traveling block of another simple system, which may have one or more blocks.

To determine the mechanical advantage of a compound tackle system, you must determine the mechanical advantage of each simple system in the compound system. Next, multiply the individual advantages to get the overall mechanical advantage. As an example, two inverted luff tackles, each has a mechanical advantage of 4. Therefore, the mechanical advantage of this particular compound system is 4 x 4 = 16.

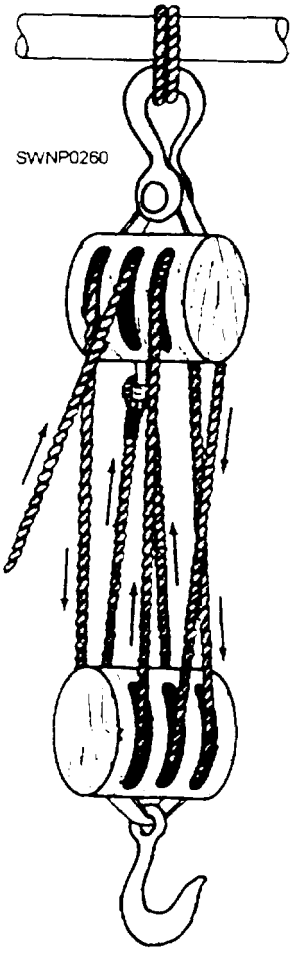


Figure 6-13.—A threefold purchase.

ALLOWANCE FOR FRICTION

Because of friction, some of the force applied to tackle is lost. Friction develops in tackle by the lines rubbing against each other or the shell of the block. It is also caused by the line passing over the sheaves or by the rubbing of the pin against the sheaves. Each sheave in the tackle system is expected to create a resistance equal to 10 percent of the weight of the load. Because of fiction, a sufficient allowance for loss must be added to the weight being moved in determining the power required to move the load.

As an example, you have to lift a 1,000-pound load with a twofold purchase. To determine the total force needed to lift the load, you take 10 percent of 1,000 pounds, which is 100 pounds. This figure is multiplied by 4 (the number of sheaves), which gives you 400 pounds. This value is added to the load; therefore, the total load is 1,400 pounds. This figure is divided by 4, the mechanical advantage of a twofold purchase, which results in 350 pounds being the force required to move the load.

BLOCK SAFETY

- Safety rules you should follow when using blocks and tackle are as follows:

- Always stress safety when hoisting and moving heavy objects around personnel with block and tackle.

- Always check the condition of blocks and sheaves before using them on a job to make sure they are in safe working order. See that the blocks are properly greased. Also, make sure that the line and sheave are the right size for the job.

- Remember that sheaves or drums which have become worn, chipped, or corrugated must not be used because they will injure the line. Always find out whether you have enough mechanical advantage in the amount of blocks to make the load as easy to handle as possible.

- You must NOT use wire rope in sheaves and blocks designed for fiber line. They are not strong enough for that type of service, and the wire rope will not properly fit the sheaves grooves. Likewise, sheaves and blocks built for wire rope should NEVER be used for fiber line.

SLINGS

Slings are widely used for hoisting and moving heavy loads. Some types of slings come already made. Slings may be made of wire rope, fiber line, or chain.

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SLINGS AND RIGGING GEAR KITS

The NCF has slings and rigging gear in the battalion Table of Allowance to support the rigging operations and the lifting of CESE. The kits 80104, 84003, and 84004 must remain in the custody of the supply officer in the central toolroom (CTR). The designated embarkation staff and the crane test director monitor the condition of the rigging gear. The rigging kits must be stored undercover.

WIRE ROPE SLINGS

Wire rope slings offer advantages of both strength and flexibility. These qualities make wire rope adequate to meet the requirements of most crane hoisting jobs; therefore, you will use wire rope slings more frequently than fiber line or chain slings.

FIBER LINE SLINGS

Fiber line slings are flexible and protect the finished material more than wire rope slings; however, fiber line slings are not as strong as wire rope or chain slings. Also, fiber line is more likely to be damaged by sharp edges on the material being hoisted than wire rope or chain slings.

CHAIN SLINGS

Chain slings are frequently used for hoisting heavy steel items, such as rails, pipes, beams, and angles. They are also handy for slinging hot loads and handling loads with sharp edges that might cut the wire rope.

Chain sizes, inspection, safe working load, and handling and care will be discussed after wire rope and fiber line, as their characteristics have been discussed in previous chapters.

USING WIRE ROPE AND FIBER LINE SLINGS

Three types of fiber line and wire rope slings commonly used for lifting a load are the **ENDLESS,** the **SINGLE LEG,** and the **BRIDLE** slings.

An **ENDLESS SLING,** usually referred to by the term *sling,* can be made by splicing the ends of a piece of fiber line or wire rope to form an endless loop. An endless sling is easy to handle and can be used as a **CHOKER HITCH** (fig. 6-14).

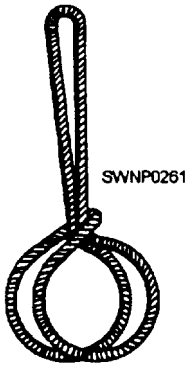


Figure 6-14.—Endless sling rigged as a choker hitch.

A **SINGLE-LEG SLING,** commonly referred to as a strap, can be made by forming a spliced eye in each end of a piece of fiber line or wire rope. Sometimes the ends of a piece of wire rope are spliced into eyes around thimbles, and one eye is fastened to a hook with a shackle. With this arrangement, the shackle and hook are removable.

The single-leg sling maybe used as a choker hitch (fig. 6-15, view A) in hoisting by passing one eye through the other eye and over the hoisting hook. The single-leg sling is also useful as a double-anchor hitch (fig. 6-15, view B). The double-anchor hitch works

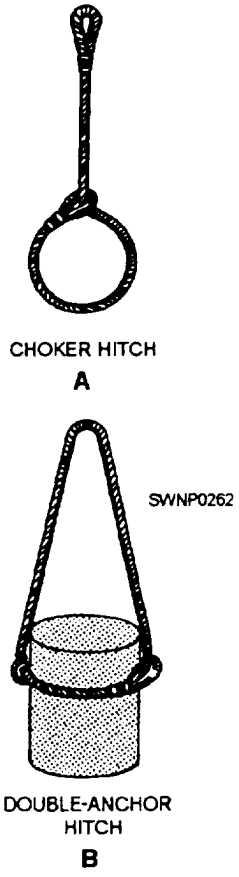


Figure 6-15.—Methods of using single-leg slings.

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well for hoisting drums or other cylindrical objects where a sling must tighten itself under strain and lift by friction against the sides of the object.

Single-leg slings can be used to make various types of **BRIDLES.** Three common uses of bridles are shown in figure 6-16. Either two or more single slings may be used for a given combination.

The bridle hitch provides excellent load stability when the load is distributed equally among each sling leg, the load hook is directly over the center of gravity of the load, and the load is raised level. The use of bridle slings requires that the sling angles be carefully determined to ensure that the individual legs are not overloaded.

NOTE: It is wrong to conclude that a three- or four-leg bridle will safely lift a load equal to the safe load on one leg multiplied by the number of legs. This is because there is no way of knowing that each leg is carrying its share of the load.

With a four-legged bride sling lifting a rigid load, it is possible for two of the legs to support practically the full load while the other two legs only balance it. COMSECOND/COMTHIRDNCB strongly recommend that the rated capacity for two-leg bridle slings listed in the COMSECOND/COMTHIRDNCBINST 11200.11 be used also as the safe working load for three- or four-leg bridle hitches.

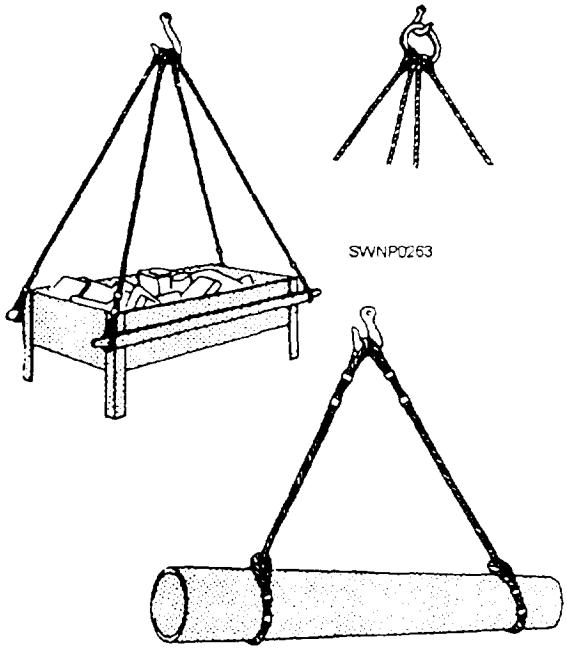


Figure 6-16.—Multi-legged bridle stings.

SLING INSPECTION

All slings must be visually inspected for obvious unsafe conditions before each use. A determination to remove slings from service requires experience and good judgment, especially when evaluating the remaining strength in a sling after allowing for normal wear. The safety of the sling depends primarily upon the remaining strength. Wire rope slings must be immediately removed from service if any of the following conditions are present:

- Six randomly distributed broken wires in one rope lay or three broken wires in one strand in one lay
- Wear or scraping on one third of the original diameter of outside individual wires
- Kinking, crushing, bird caging, or any other damage resulting in distortion of the wire rope structure
- Evidences of heat damage
- 1 End attachments that are cracked, deformed, or worn
- Hooks that have an obviously abnormal (usually 15 percent from the original specification) throat opening, measured at the narrowest point or twisted more than 10 degrees from the plane of the unbent hook
- Corrosion of the wire rope sling or end attachments

To avoid confusion and to eliminate doubt, you must not downgrade slings to a lower rated capacity. A sling must be removed from service if it cannot safely lift the load capacity for which it is rated. Slings and hooks removed from service must be destroyed by cutting before disposal. This ensures inadvertent use by another unit.

When a leg on a multi-legged bridle sling is unsafe, you only have to destroy the damaged or unsafe leg(s). Units that have the capability may fabricate replacement legs in the field, provided the wire rope replacement is in compliance with specifications. The NCF has a hydraulic swaging and splicing kit in the battalion Table of Allowance (TOA). The kit, 80092, contains the tools and equipment necessary to fabricate 3/8- through S/S-inch sizes of wire rope slings. Before use, all fabricated slings must be proof-tested as outlined in the COMSECOND/COMTHIRDNCBINST 11200.11.

PROOF TESTING SLINGS

All field-fabricated slings terminated by mechanical splices, sockets, and pressed and swaged

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terminals must be proof-tested before placing the sling in initial service.

The COMSECOND/COMTHIRDNCBINST 11200.11 has rated capacity charts enclosed for numerous wire rope classifications. You must know the diameter, rope construction, type core, grade, and splice on the wire rope sling before referring to the charts. The charts provide you the vertical-rated capacity for the sling. The test weight for single-leg bridle slings and endless slings is the vertical-rated capacity (V. R. C.) multiplied by two or (V.R.C. x 2 = sling test weight).

The test load for multi-legged bridle slings must be applied to the individual legs and must be two times the vertical-rated capacity of a single-leg sling of the same size, grade, and wire rope construction. When slings and rigging are broken out of the TOA for field use, they must be proof-tested and tagged&fore being returned to CTR for storage.

Check fiber line slings for signs of deterioration caused by exposure to the weather. Ensure none of the fibers have been broken or cut by sharp-edged objects.

SLING SAFE WORKING LOADS

There are formulas for estimating the loads in most sling configurations. These formulas are based on the safe working load of the single-vertical hitch of a particular sling. The efficiencies of the end fittings used also have to be considered when determining the capacity of the combination.

The formula used to compute the safe working load (SWL) for a **BRIDLE HITCH** with two, three, or four legs (fig. 6-17) is SWL (of single-vertical hitch) times H (Height) divided by L (Length) times 2 = SWL. When the sling legs are not of equal length, use the smallest H/L measurement. This formula is for a two-leg bridle hitch, but it is strongly recommended it also be used for the three- and four-leg hitches.

NOTE: Do NOT forget it is wrong to assume that a three- or four-leg hitch can safely lift a load equal to the safe load on one leg multiplied by the number of legs.

Other formulas are as follows:

Single-basket hitch (fig. 6-18):

For vertical legs:

SWL = SWL (of single-vertical hitch) x 2.

For inclined legs:

SWL = SWL (of single-vertical hitch) x H divided by L x 4.

Double-basket hitch (fig. 6-19):

For vertical legs:

SWL = SWL (of single-vertical hitch) x 4.

For inclined legs:

SWL = SWL (of single-vertical hitch) x H divided by L x 4.

Single-choker hitch (fig. 6-20):

For sling angles of 45 degrees or more:

SWL = SWL (of single-vertical hitch) x 3/4 (or .75).

Sling angles of less than 45 degrees are not recommended; however, if they are used, the formula is as follows:

SWL = SWL (of single-vertical hitch) x A/B.

Double-choker hitch (fig. 6-21):

For sling angle of 45 degrees or more:

SWL = SWL (of single-vertical hitch) x 3 divided by 4 x H divided by L x 2.

Sling angles of less than 45 degrees:

SWL = SWL (of single-vertical hitch) x A divided by B x H divided by L x 2.

When lifting heavy loads, you should ensure that the bottom of the sling legs is fastened to the load to prevent damage to the load. Many pieces of equipment have eyes fastened to them during the process of manufacture to aid in lifting. With some loads, though, fastening a hook to the eye on one end of each sling leg suffices to secure the sling to the load.

Use a protective pad when a fiber line or wire rope sling is exposed to sharp edges at the comers of a load. Pieces of wood or old rubber tires are fine for padding.

SLING ANGLE

When using slings, remember that the greater the angle from vertical, the greater the stress on the sling legs. This factor is shown in figure 6-22.

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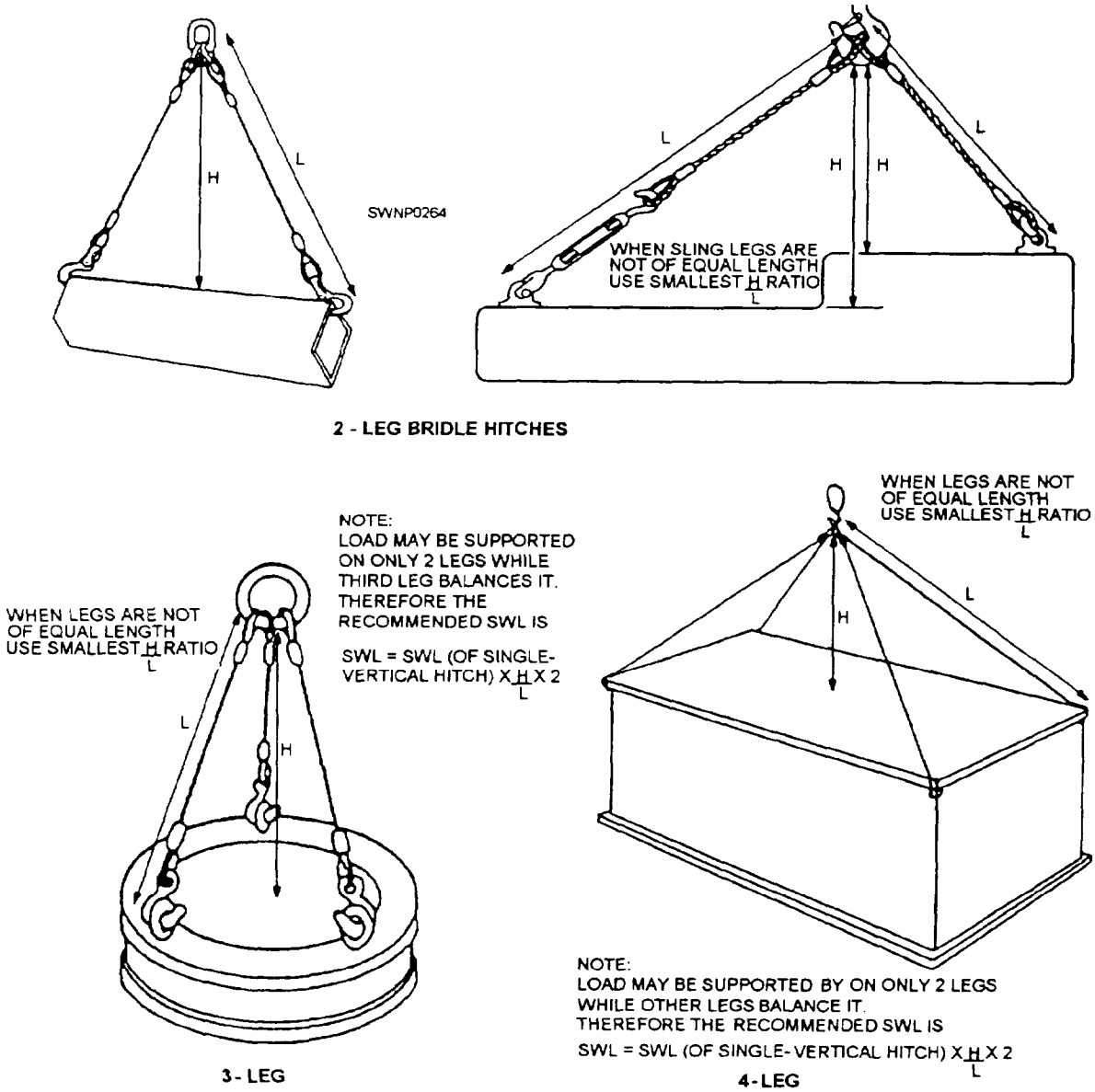


Figure 6-17.—Determination of bridle hitch sling capacity.

The rated capacity of any sling depends on the size, the configuration, and the angles formed by the legs of the sling and the horizontal. A sling with two legs used to lift a 1,000-pound object will have 500 pounds of the load on each leg when the sling angle is 90 degrees. The load stress on each leg increases as the angle decreases. For example, if the sling angle is 30 degrees when lifting the same 1,000-pound object, the load is 1,000 pounds on each leg. Try to keep all sling angles greater than 45 degrees; sling angles approaching 30 degrees are considered extreme] y hazardous and must be avoided.

STORAGE

Wire rope slings and associated hardware must be stored either in coils or on reels, hung in the rigging loft, or laid on racks indoors to protect them from corrosive weather and other types of damage, such as kinking or being backed over. Slings are not to be left out at the end of the workday.

CHAINS

Chains are made up of links fastened through each other. Each link is fabricated of wire bent into an oval and welded together. The weld usually causes a slight

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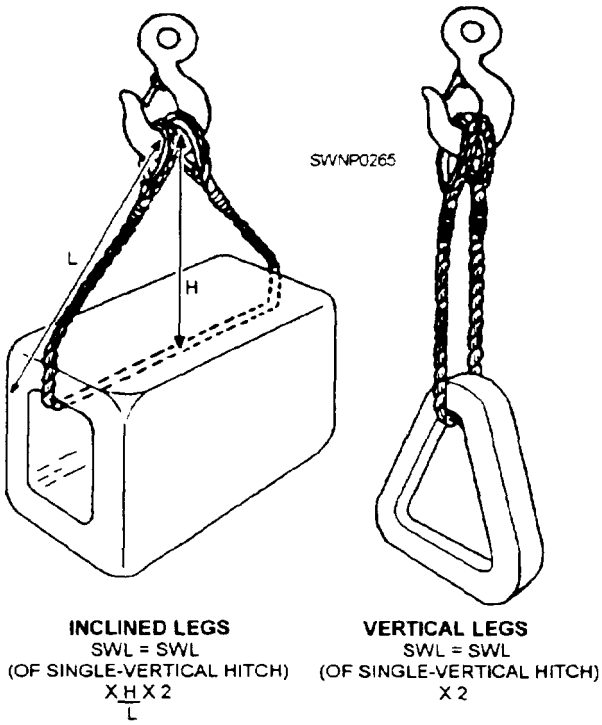


Figure 6-18.—Determination of single-basket hitch sting capacity.

bulge on the side or end of the link. Chain size refers to the diameter, in inches, of the wire used to fabricate the chain.

In the NCF, never use a chain when it is possible to use wire rope. **Chain does not give any warning that it is about to fail.** Wire rope, on the other hand, fails a strand at a time, giving you warning before failure actually occurs.

NOTE: Although chain gives no warning of failure, it is better suited than wire rope for some jobs. Chain is more resistant to abrasion, corrosion, and heat. Additionally, use chains to lift heavy objects with sharp edges that could cut wire or are hot. When chain is used as a sling, it has little flexibility but grips the load well.

CHAIN INSPECTION

First, you must be aware that chains normally stretch under excessive loading and individual links will be bent slightly. Therefore, bent links are a warning that the chain has been overloaded and may fail suddenly under load. Before lifting with a chain, make sure the chain is free from twists and kinks. A twisted or kinked chain placed under stress could fail even when handling a light load. Additionally, ensure that the load is properly seated in the hook (not on the point) and that the chain is free from nicks or other damage. Avoid sudden jerks in lifting and lowering the load, and always consider the angle of lift with a sling chain bridle.

The strength of any chain is negatively affected when it has been knotted, overloaded, or heated to temperatures above 500°F.

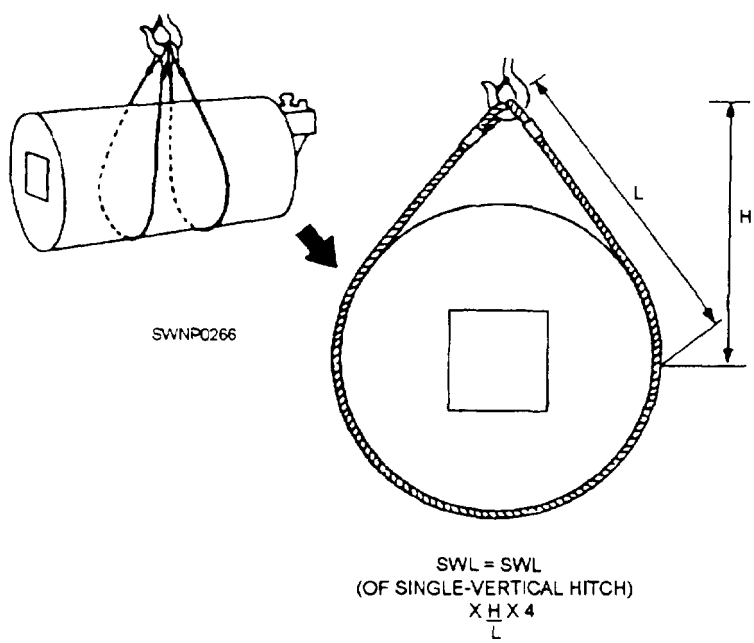


Figure 6-19.—Determination of double-basket hitch sling capacity.

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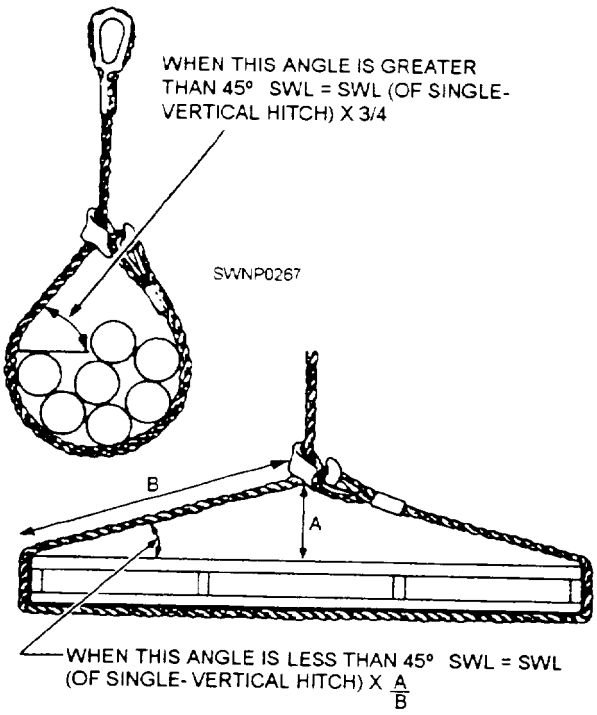


Figure 6-20.—Determination of single-choker hitch sling capacity.

CHAIN SAFE WORKING LOADS

To determine the safe working load on a chain, apply a factor of safety to the breaking strength. The safe working load is ordinarily one-sixth of the breaking strength, giving a safety factor of 6 (table 6-1).

The capacity of an open link chain can be approximated by using the following rule of thumb:

$$SWL = 8D^2 \times 1 \text{ ton}$$

Where:

D = Smallest diameter measured in inches

SWL = Safe working load in tons

Example:

Using the rule of thumb, the safe working capacity of a chain with a diameter of 3/4 inch is as follows:

$$SWL = 8D^2 = 8\ (3/4)^2 = 4.5 \text{ tons (or 9,000 lbs)}$$

These figures assume the load is being applied in a straight pull, rather than an impact. An impact load is when an object is suddenly dropped for a distance

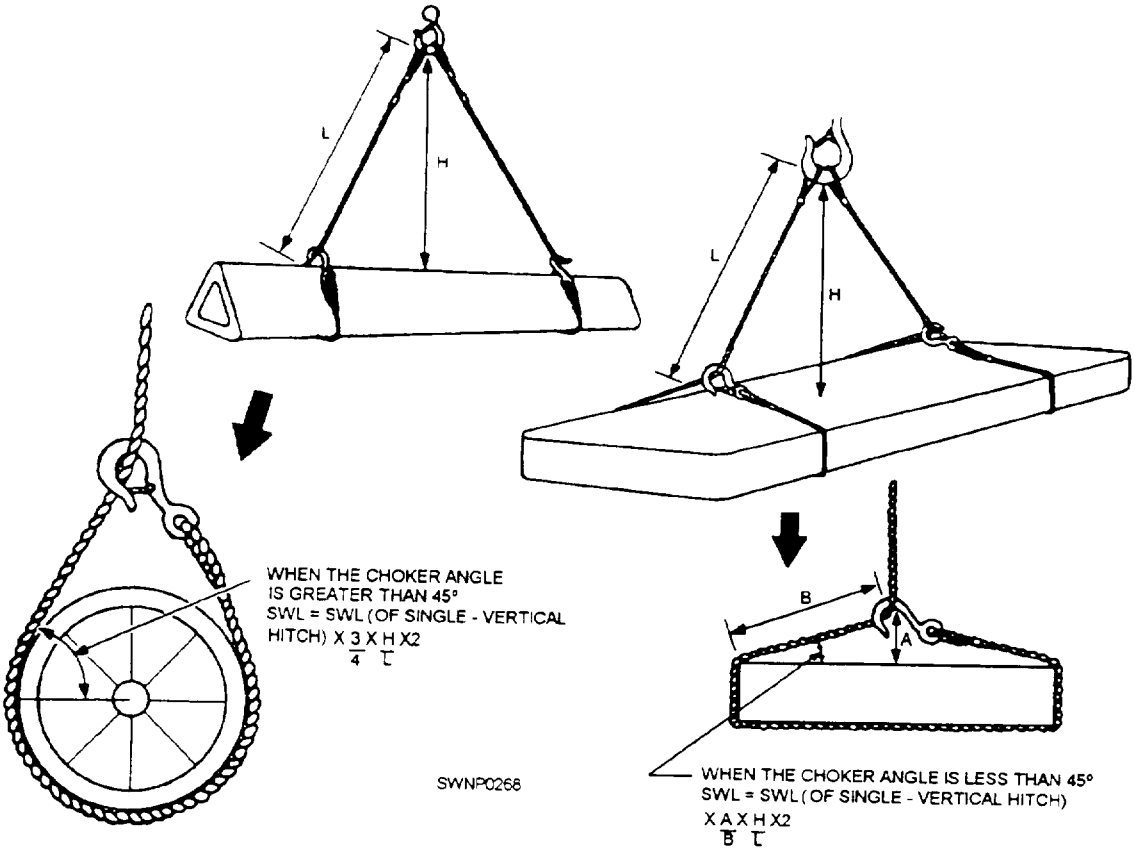


Figure 6-21.—Determination of double-choker hitch sling capacity.

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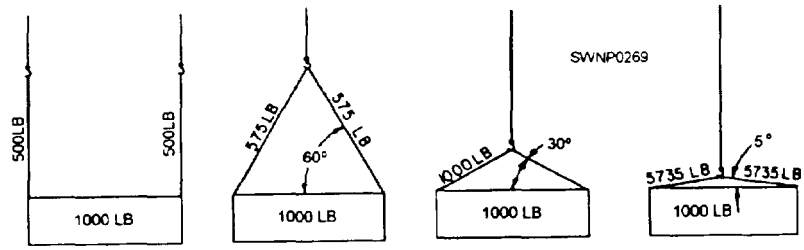


Figure 6-22.—Stress on slings at various vertical angles.

Table 6-1.—Safe Working Load of Chains

Size*	Approximate weight per linear foot in pounds	Safe working load in pounds			
		Common iron	High grade iron	Soft steel	Special steel
1/4——	0.8	512	563	619	1,240
3/8——	1.7	1,350	1,490	1,650	3,200
1/2——	2.5	2,250	2,480	2,630	5,250
5/8——	4.3	3,470	3,810	4,230	7,600
3/4——	5.8	5,070	5,580	6,000	10,500
7/8——	8.0	7,000	7,700	8,250	14,330
1 ——	10.7	9,300	10,230	10,600	18,200
1 1/8——	12.5	9,871	10,858	11,944	21,500
1 1/4——	16.0	12,186	13,304	14,634	26,300
1 3/8——	18.3	14,717	16,188	17,807	32,051
*** Size listed is the diameter in inches of one side of a link.**					

and stopped. The impact load is several times the weight of the load.

HANDLING AND CARE OF CHAIN

When hoisting heavy metal objects using chain for slings, you should insert padding around the sharp comers of the load to protect the chain links from being cut.

Store chains in a clean, dry place where they will not be exposed to the weather. Before storage, apply a light coat of lubricant to prevent rust.

Do NOT perform makeshift repairs, such as fastening links of a chain together with bolts or wire. When links become worn or damaged, cut them out of the chain, then fasten the two nearby links together with a connecting link. After the connecting link is closed, welding makes it as strong as the other links. For cutting small-sized chain links, use bolt cutters. To cut large-sized links, use a hacksaw.

Inspect the chain to ensure it is maintained in a safe, operating condition. A chain used continuously for heavy loading should be inspected frequently. Chain is less reliable than manila or wire rope slings because the links may crystallize and snap without warning.

Examine the chain closely link by link and look for stretch, wear, distortion, cracks, nicks, and gouges. Wear is usually found at the ends of the links where joining links rub together. If you find wear, lift each link and measure its cross section.

NOTE: Remove chains from service when any link shows wear more than 25 percent of the thickness of the metal.

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Replace any link that shows cracks, distortion, nicks, or cuts. However, if a chain shows stretching or distortion of more than 5 percent in a five-link section, discard and destroy the entire chain.

Remove chains from service when any link shows signs of binding at juncture points. This binding condition indicates that the sides of the links have collapsed as a result of stretching.

Before lifting with a chain, first place dunnage between the chain and the load to provide a gripping surface. For hoisting heavy metal objects with a chain, always use chaffing gear around the sharp comers on the load to protect the chain links from being cut. As chafing gear, use either planks or heavy fabric. In handling rails or a number of lengths of pipe, make a round turn and place the hook around the chain, as shown in figure 6-23.

ADDITIONAL LIFTING EQUIPMENT

In addition to block and tackle, slings, and chains, hooks, shackles, and beam clamps are also used for lifting objects and material.

HOOKS

There are two types of hooks available: the slip hook and the grab hook (fig. 6-24).

Slip Hooks

Slip hooks are made so the inside curve of the hook is an arc of a circle. They are used with wire rope, chains, and fiber line. Chain links can slip through a slip hook so that the loop formed in the chain can tighten under a load.

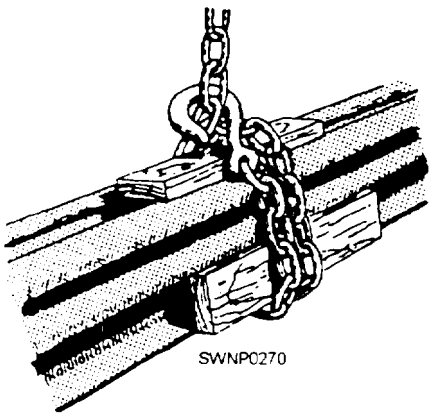


Figure 6-23.—Chain sting.

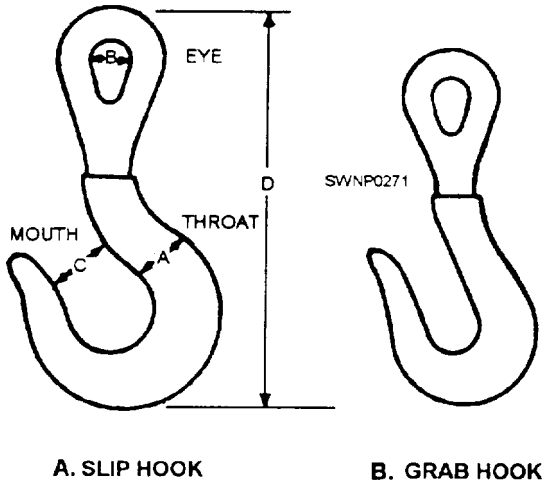


Figure 6-24.—Hooks: A. Slip; B. Grab.

Grab Hooks

Grab hooks have an inside curve that is almost U-shaped so that the hook will slip over a link edgeways and not allow the next link to slip past. Grab hooks have a much more limited range of use than slip hooks. They are used exclusively when the loop formed in the chain is not intended to close around the load.

Mousing a Hook

As a rule, a hook should always be moused as a safety measure to prevent slings or line from coming off. Mousing also helps prevent the straightening of a hook but does not add to the strength of the hook. To mouse a hook (fig. 6-25) after the sling is on the hook you should wrap the wire or small stuff 8 or 10 turns around the two sides of the hook. Mousing is then

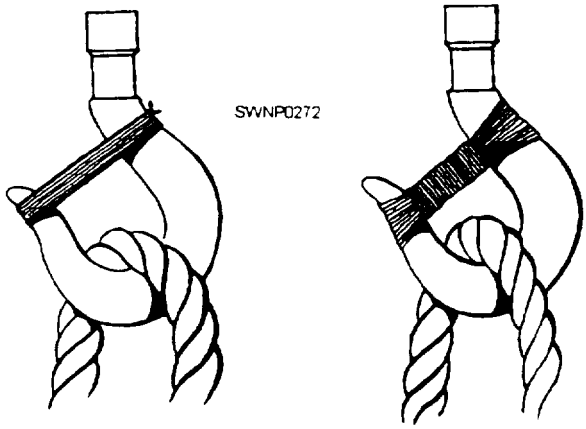


Figure 6-25.—Mousing a hook.

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completed by winding several turns around the wire or small stuff and tying the ends securely.

Inspection of Hooks

Hooks should be inspected at least once a month, but those used for heavy and continuous loading should be inspected more frequently. Attention must be given to the small radius fillets at the neck of the hooks for any deviation for the original inner arc. Additionally, each hook must be examined for small dents, cracks, sharp nicks, worn surfaces, or distortions. If any of these defects are present, the hook must be discarded.

Hook Strength

Hooks normally fail by straightening. If any deviation of the inner arc of a hook is evident, it indicates that the hook has been overloaded. Evidence of overloading a hook is easy to detect, so it is customary to use a hook that is weaker than the chain it is attached to. Using this system, distortion of the hook will occur before the hook is overloaded. Any distorted, cracked, or badly worn hook is dangerous and should be discarded immediately.

The safe working load of a hook can be formulated by using the following rule of thumb:

SWL = 2/3 x D^2 x 1 ton. D is the diameter (in inches) of the hook where the inside of the hook starts to arc (fig. 6-26).

Below is an example of the safe working capacity of a hook with a diameter of 5/8 inch:

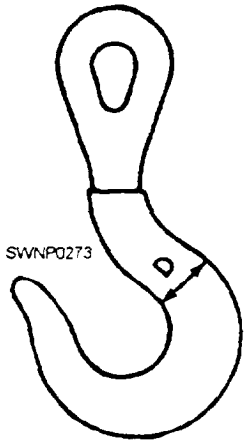


Figure 6-26.—Hook diameter.

D^2 = 5/8 X 5/8= 25/64

SWL = 2/3 x 25/64 x 1 ton= 25/96= 0.2604 ton

0.2604 ton x 2,000 pounds/ton= 520.8 pounds

In the metric system, the formula for the safe working load for hooks is as follows: SWL = .46 x D^2 x 1 tonne

Below is an example of the safe working capacity of a hook having a diameter of 1.59 cm.

D = 1.59 cm

D^2 = 2.52 cm^2

SWL= .046 x 2.52 cm^2 x 1 tome = .116 tonne

SHACKLES

Shackles (fig. 6-27) should be used for loads too heavy for hooks to handle. They provide a useful way of attaching, hauling, and lifting a load without tying directly to the object with a line, wire rope, or chain. Additionally, they can be attached to wire rope, line, or chain.

Safe Working Load of Shackles

The formula for computing the safe working load for a shackle is as follows:

SWL = 3D^2 x 1 ton

Example:

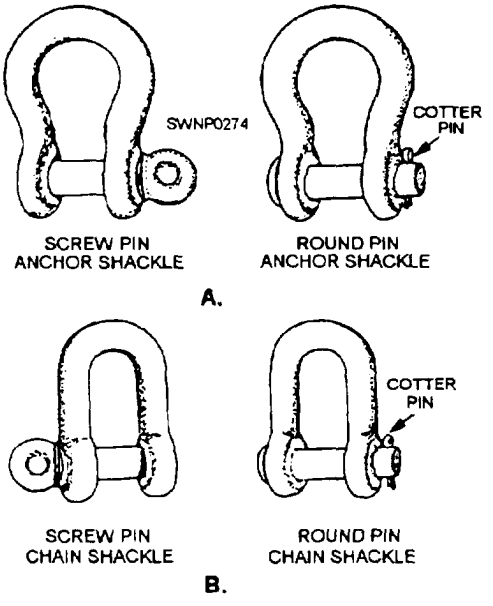


Figure 6-27.—Two types of shackles: A. Anchor; B. Chain.

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D = 5/8 (See fig. 6-28)

D^2 = 5/8 X 5/8= 25/64

SWL = 3 X 25/64 x 1 ton = 75/64 x 1 ton=1.1719 tons

The SWL in pounds = 1.1719 x 2,000 pounds = 2,343.8 pounds

In the metric system, the formula for the safe working load

for shackles is as follows:

SWL = .417 X D^2 X 1 tonne

Example:

D= 1.59cm

D^2= 1.59 X 1.59 = 2.52

SWL = .417 x 2.52 x 1 tonne

SWL = 1.05 tomes

NOTE: A hook or a shackle can actually lift more than these formulas allow. These formulas give you the safe working load **UNDER ANY CONDITIONS.**

Mousing Shackles

Mouse shackles whenever there is danger of the shackles pin working loose or coming out due to vibration. To mouse a shackle properly, you take several turns with seizing wire through the eye of the pin and around the bow of the shackle. Figure 6-29 shows what a properly moused shackle looks like.

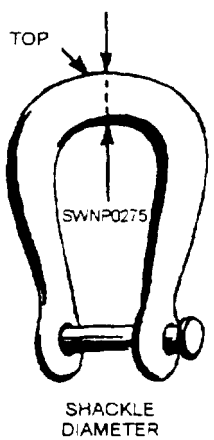


Figure 6-28.—Shackle diameter.



Figure 6-29.—Mousing a shackle.

BEAM CLAMPS

Steelworkers are required to move and handle many steel beams and steel shapes. When off-loading steel from vehicles and storing for further use, beam clamps are much more practical than using slings or chokers, especially when the flanges are the only available parts of the load. Figure 6-30 shows three different types of beam clamps. View A shows a clamp designed for use on a beam with a flat flange, either an I or an H. The clamp in view B may be used on beams with a circular cross-sectional area or where only one side of the flange is accessible. View C shows a clamp that is useful for connection to a column with a snatch block attached. The clamps shown can all be fabricated in the shop or field.

Hooks, shackles, and beam clamps must have the rated capacities and SWL permanently stenciled or stamped on them. OSHA identification tags can be acquired at no cost from COMTHIRDNCB DET, Port Hueneme, California, or COMSECONDNCB DET, Gulfport, Mississippi. Metal dog tags are authorized providing the required information is stamped onto the tags.

OTHER LIFTING EQUIPMENT

Other devices used for moving equipment are as follows: spreader bars, pallets, jacks, planks and rollers, blocks and cribbing, and scaffolds.

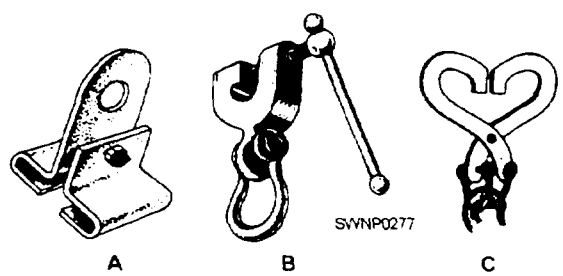


Figure 6-30.—Types of beam clamps.

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SPREADER BARS

In hoisting with slings, spreader bars are used to prevent crushing and damaging the load. Spreader bars are short bars, or pipes, with eyes fastened to each end. By setting spreader bars in the sling legs above the top of the load (fig. 6-31), you change the angle of the sling leg and avoid crushing the load, particularly in the upper portion.

Spreader bars are also used in lifting long or oversized objects to control the sling angle, as shown in figure 6-32. When spreader bars are used, make sure you do not overload the end connection. A spreader bar has a rated capacity that is the same as hooks and shackles. A good rule of thumb is the thickness of the spreaders end connection should be the same as the thickness of the shackle pin.

PALLETS

Cargo pallets coupled with slings are an immense advantage on jobs that involve moving a lot of small items (fig. 6-33). Spreader bars can be used often to avoid damaging the pallet and the load. The pallet supplies a small platform on which a number of items can be placed and then moved as a whole instead of piece by piece. Palletizing is clearly easier and faster than moving each item by itself.

Commonly, packages of the same size are palletized together, and when shipped, remain on the pallet until they are used up. You may not have the luxury of having excess pallets at your job site; however, you need to have several to work efficiently. One can be loaded as the prior loaded one is being lifted. After each pallet is unloaded, the hoist will return for reloading. With two pallets, you are able to maintain a steady flow of material. One set of slings will be able to handle any number of pallets.

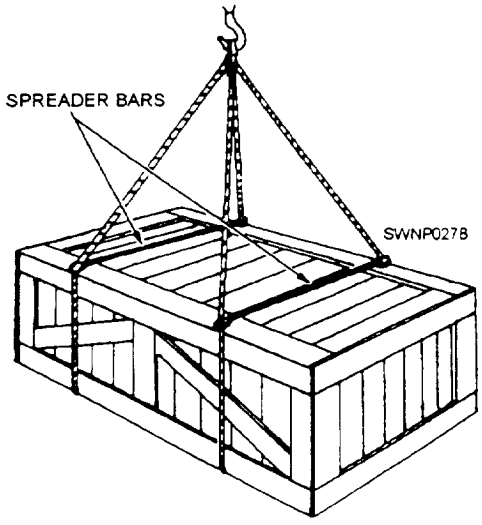


Figure 6-31.—Using spreader bars.

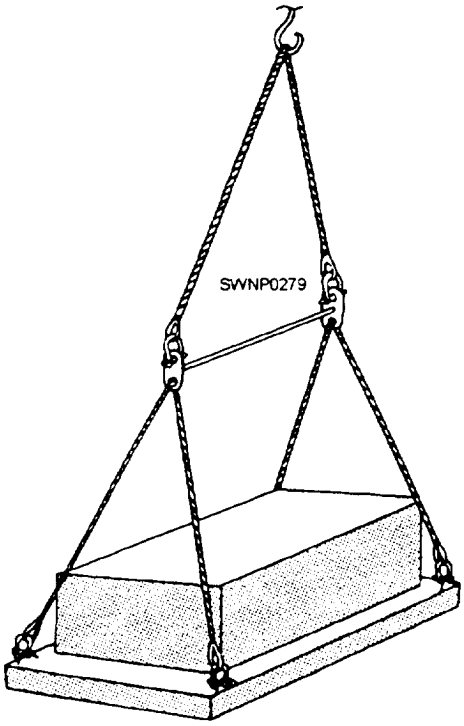


Figure 6-32.—Spreader bar used with an oversized load.

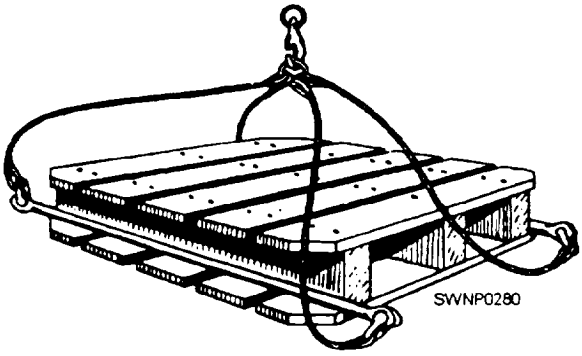


Figure 6-33.—Cargo pallet.

JACKS

To be able to place cribbing, skids, and rollers, you need to be able lift a load a short distance. Jacks are designed and built for this purpose. Jacks are also used for precise placement of heavy loads, such as beams, or for raising and lowering heavy loads a short

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distance. There are a number of different styles of jacks available; however, only heavy-duty hydraulic jacks or screw jacks should be used. The number of jacks used is determined by the weight of the load and the rated capacity of the jacks. Ensure the jacks have a solid footing and are not susceptible to slipping.

Jacks are available in capacities from 5 to 100 tons. Small capacity jacks are normally operated through a rack bar or screw, and large capacity jacks are usually operated hydraulically (fig. 6-34).

The types of jacks used by Steelworkers are as follows:

1. Ratchet lever jacks are rack bar jacks having a rated capacity of 15 tons. These jacks have a foot lift by which loads close to the base of the jack can be engaged (fig. 6-34, view A).

2. Steamboat ratchets (often referred to as pushing and pulling jacks) are ratchet screw jacks of 10-ton-rated capacity with end fittings that permit pulling parts together or pulling them apart. They are primarily used for tightening lines or lashings and for spreading or bracing parts in bridge construction (fig. 6-34, view B).

3. Screw jacks have a rated capacity of 12 tons. They are approximately 13 inches high when closed and have a safe rise of 7 inches. These jacks are used for general purposes, including steel erection (fig. 6-34, view C).

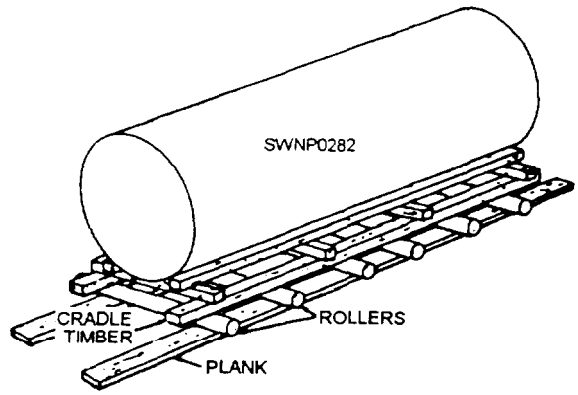


Figure 6-35.—Use of planks and rollers.

4. Hydraulic jacks are available in many different capacities and are used for general purposes (fig. 6-34, view D).

PLANKS AND ROLLERS

Planks and rollers provide you with an excellent means of moving heavy loads across the ground on a jobsite or the floor of a shop (fig. 6-35).

Oak planks are appropriate for most operations involving plank skids. Planks 15 feet long and 2 to 3 inches thick should be suitable. They distribute the weight of a load and also provide a smooth runway surface in which to skid the load along or in which to use rollers to ease the effort required to move the load.

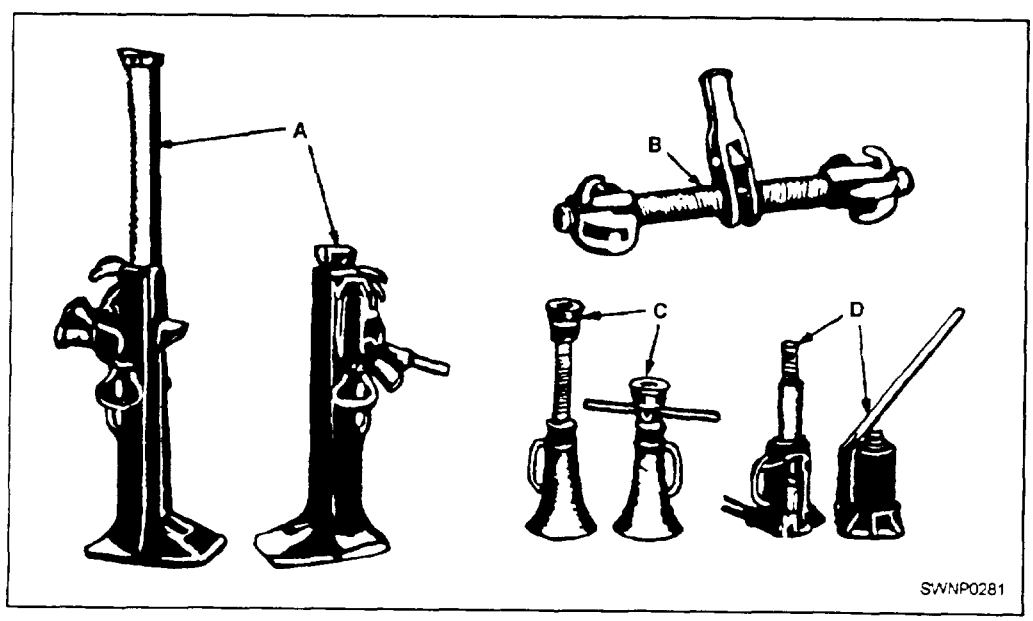


Figure 6-34.—Mechanical and hydraulic jacks: A. Ratchet lever jack with foot lift; B. Steamboat ratchet; C. Screw Jack; D. Hydraulic jack.

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Timber skids (planks) are placed longitudinally under heavy loads to distribute the weight over a greater area. (See fig. 6-35.) The angle of the skids must be kept low to prevent the load from drifting or getting out of control. Skids can be greased only when horizontal movement is involved. **Extreme care must be exercised.** In most circumstances greasing is inherently dangerous, as it can cause the load to drift sideways suddenly, causing injuries to personnel and damage to equipment.

Hardwood or pipe rollers can be used in conjunction with plank skids for moving heavy loads into position. Planks are placed under the rollers to provide a smooth continuous surface to enable them to roll easily. The rollers must be smooth and round to aid in the ease of movement and long enough to pass completely under the load. The load should be supported by longitudinal wooden members to provide a smooth upper surface for the rollers to roll on. The skids placed underneath must form continuous support. Normal practice is to place four to six rollers under the load to be moved. Several rollers are to be placed in front of the load and the load is then slowly rolled onto these rollers. As the load passes the rollers that are left clear of the load they are then picked up and moved in front of the load. This creates a continuous path of rollers. Turns can be made using rollers; but, first the front rollers must be inclined slightly in the direction of the turn and the rear of the rollers in the opposite direction. This inclination of the rollers can be made by striking them sharply with a sledge hammer. Rollers can be fabricated and set on axles in side beams as a semipermanent conveyor for lighter loads. Permanent metal roller conveyors are available (fig. 6-36) and are normally fabricated in sections which can be joined together.

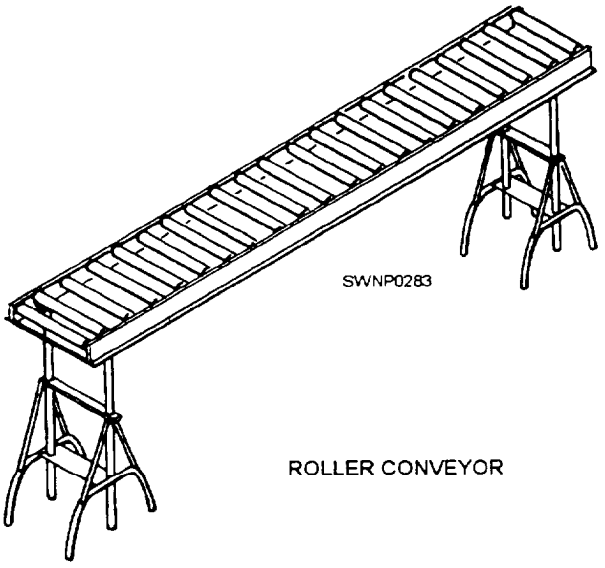


Figure 6-36.—Permanent metal roller conveyor.

BLOCKING AND CRIBBING

Block timbers are commonly used to provide a foundation for heavy loads or jacks. Cribbing must be used when a heavy weight must be supported at a height greater than blocking can provide. Cribbing is made up by aligning timber in tiers that run in alternate directions (fig. 6-37). Blocking and cribbing is often necessary as a safety measure to keep an object stationary to prevent accidents and injury to personnel working near these heavy objects.

When selecting blocking as a foundation for jacks, ensure it is sound and large enough to support the load safely. It *must* be free from grease and thoroughly dry.

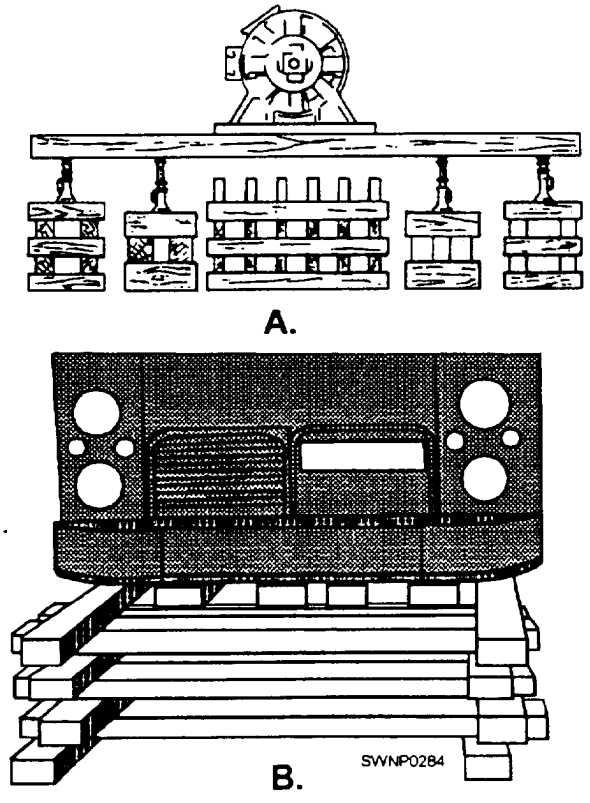


Figure 6-37.—Examples of the use of cribbing.

Additionally, it *must* be placed firmly on the ground with the load (pressure) distributed evenly.

A firm and level foundation is a paramount requirement where cribbing is used. Also, equally as

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critical is that the bottom timbers be placed so they rest evenly and firmly on the ground.

Cribbing is desirable when lifting loads by jacking stages. This procedure requires blocking to be placed under the jacks, lifting the load to the maximum height the jacks can safely accommodate, placing the cribbing under the load in alternating tiers, *with no personnel under the load,* and then lowering the load onto the cribbing.

When cribbing is not high enough or at the correct height, build up the blocking under the jacks until the jacks can bear against the load while in their lowered position. Raise the jacks again to their maximum safe height and lower onto the added cribbing. This procedure can be repeated as many times as necessary to build up the cribbing to the desired height.

SCAFFOLDS

The term *scaffold* refers to a temporary elevated platform used to support personnel and materials, for immediate usage, throughout the course of construction work. You will use scaffolds in performing various jobs which cannot be done safely from securely placed ladders. We will take a brief look at a few of the different types of scaffolds which you will need from time to time on the job.

Planking and Runway Scaffold

A planking and runway scaffold shown in figure 6-38 consists of single scaffold planks laid across beams of upper floors or roofs. It is frequently used to provide working areas or runways. Each plank should extend from beam to beam, and not more than a few inches of the planks should extend beyond the end supporting beam. A short overhang is essential to safe practice to prevent personnel from stepping on an unsupported plank and falling from the scaffold. Planks should be thick enough to support the load safely and applied without excessive sagging. When the planking is laid continuously, as in a runway, make sure the planks are laid so that their ends overlap. Single plank runs may be staggered with each plank being offset with reference to the next plank in the run.

Swinging Platform Scaffold

The most commonly used type of swinging scaffolding is the platform scaffold shown in figure 6-39. The swinging platform scaffold consists of a frame with a deck of wood slats. The platform is

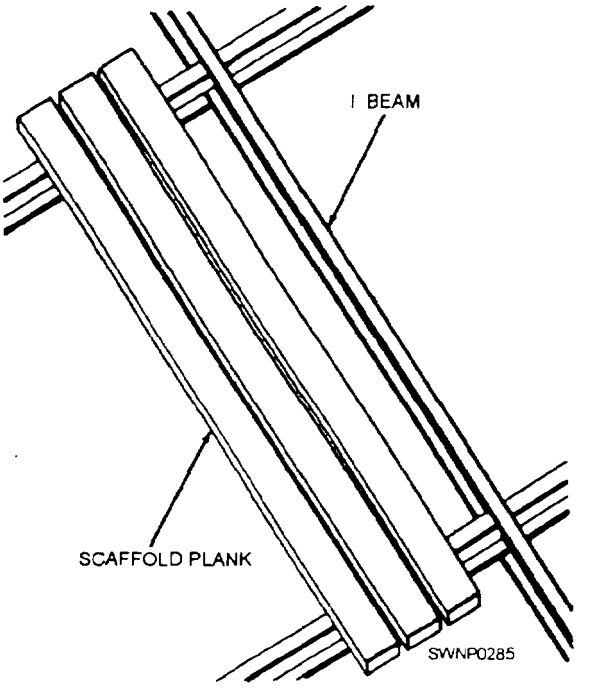


Figure 6-38.—A planking and runway scaffold.

supported near each end by iron rods, called stirrups, which have the lower blocks of fiber line fall attached to them. This tackle arrangement permits the platform to be raised or lowered as required. The tackle and platform are supported by hooks and anchors on the roof of the structure. The fall line of the tackle must be secured to a part of the platform when in final position to prevent it from falling.

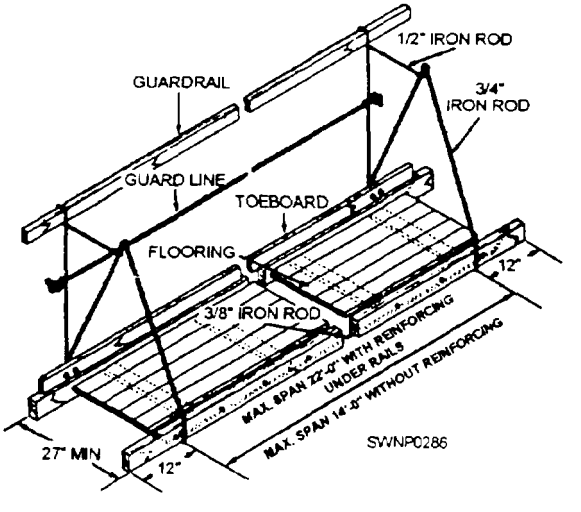


Figure 6-39.—A platform scaffold.

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Needle-Beam Scaffold

A needle-beam scaffold consists of a plank platform resting on two parallel horizontal beams, called needle beams, which are supported by lines from overhead. (See fig. 6-40.)

Needle-beam scaffolds should be used on-l y for the support of personnel doing light work. They are suitable for use by riveting gangs working on steel structures because of the frequent changes of location necessary and the adaptability of this type of scaffold to different situations.

Several types of patent and independent scaffolding are available for simple and rapid assembly, as shown in figure 6-41. The scaffold uprights are braced with diagonal members, and the working level is covered with a platform of planks. All bracing must form triangles, and the base of each column requires adequate footing plates for bearing area on the ground. The patented steel scaffolding is usually erected by placing the two uprights on the ground and inserting the diagonal members. The diagonal members have end fittings, which permit easy assembly. The first tier is set on steel bases on the ground, and a second tier is placed in the same manner on the first tier with the bottom of each upright locked to the top of the lower tier. A third and fourth upright can be placed on the ground level and locked to the first set with diagonal bracing. The scaffolding can be built as high as desired, but high scaffolding should be tied into the main structure.

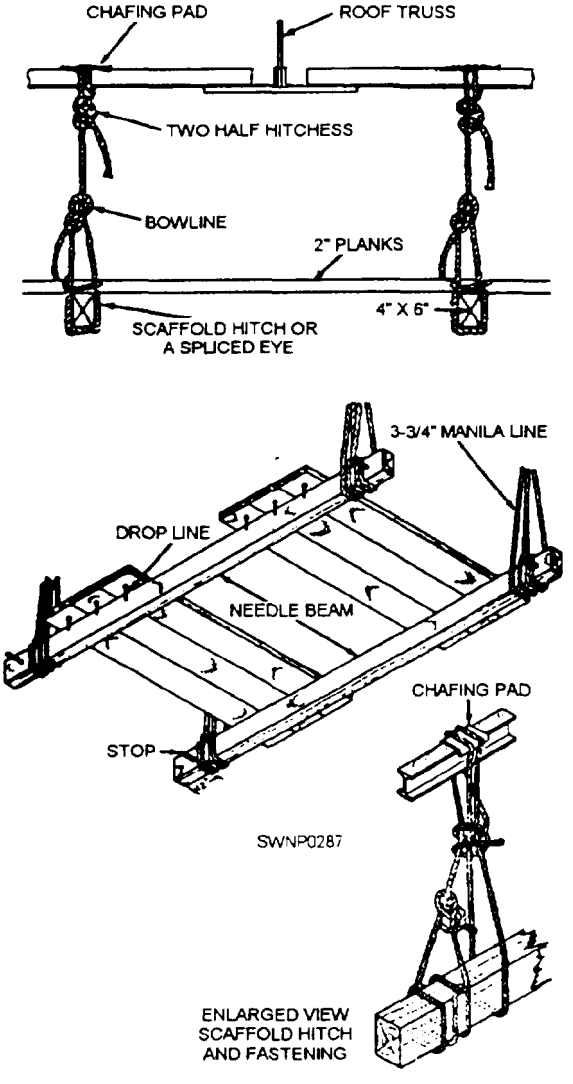


Figure 6-40.—A needle-barn scaffold.

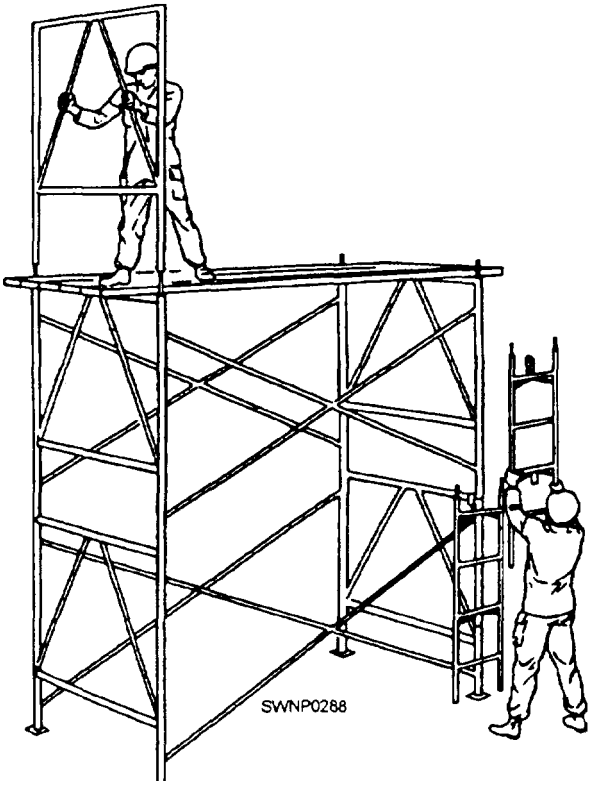


Figure 6-41.—Assembling prefabricated independent scaffolding.

Boatswain's Chair

The boatswain's chair shown in figure 6-42 also comes under the heading of scaffolding. It is sometimes used to provide a seat for a person working above the ground.

The seat of the boatswain's chair should be at least 2 feet long, 1 foot wide, and 1 1/4 inches thick (60 cm

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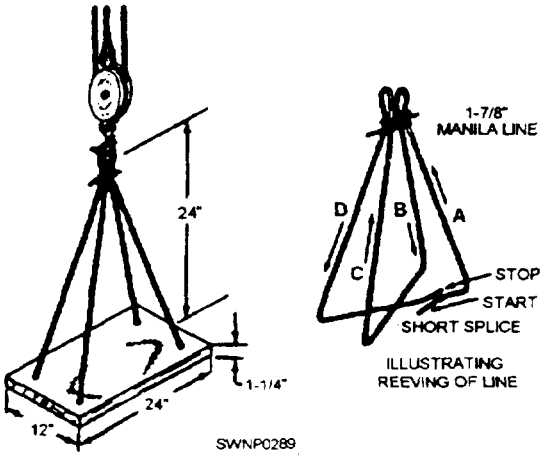


Figure 6-42.—A boatswain's chair.

long, 30 cm wide, and 3.1 cm thick). Make sure you always wear a safety belt when using a boatswain's chair. The safety belt should be attached to a lifeline secured to a fixed object overhead. Use a bowline to secure the lifeline to the person in the chair.

NOTE: A BOATSWAIN' S CHAIR SHOULD BE USED ONLY IF OTHER MEANS ARE NOT AVAILABLE.

Scaffold Safety

When you are using scaffolds, *SAFETY is your NUMBER ONE PRIORITY!* Failure to observe safety precautions can result in serious injury to yourself or coworkers. Some essential safety measures applicable to scaffolds are given here. Use each of them routinely. *THINK SAFETY!* Be a *SAFE WORKER!*

Structural members, support ropes, and scaffold equipment must be inspected carefully each workday before using them on the job. The use of makeshift scaffolds is strictly prohibited.

When personnel are working on a scaffold with other personnel engaged directly above, either the scaffold must have an overhead protective covering or the workers on the lower scaffold must wear Navy-approved, protective hard hats. The purpose is to provide protection against falling material. Where the upper working level is no more than 12 feet (3.6 m) above the lower, hard hats worn by workers on the lower level will satisfy this requirement.

An overhead protective covering consists of a roof of lumber, heavy wire screen, or heavy canvas, depending upon the hazard involved. The covering should extend a suffient distance beyond the edge of the scaffold to catch any material that may fall over the edge. A netting of screen should not be less than No. 18 gauge, U.S. Standard Wire, with a mesh not to exceed 1/2 inch. Screens of heavier wire or smaller mesh should bex used where conditions are such that the No. 18 gauge wire or 1/2-inch mesh will not suppl y adequate protection. Personnel should NOT be required to work underneath a scaffold. Scaffolds erected over passageways, thoroughfares, or locations where persons are working should be provided with side screens and a protective covering. A side screen is a screen paneling from the platform to an intermediate railing or from the platform to the top railing. Screening is formed of No. 16 U.S. gauge wire with 1/2-inch mesh. Screen is used for the purpose of preventing materials, loose or piled, from falling off the scaffolds.

A safe means of access should be provided to all scaffolds by means of standard stairs or fixed ladders. Additionally, ensure that a scaffold is properly secured against swaying.

Personnel should not be permitted on scaffolds which are covered with ice or snow. In such instances, clinging ice must be removed from all guardrails, then the planking sanded or otherwise protected against slipping. Workers should not be permitted on scaffolds during a storm or high wind.

No scaffold should be used for the storage of materials, except that required for the immediate needs of the job. Tools should be placed in containers to prevent their being knocked off and the containers should be secured to the scaffold by line. Always make a special effort to ensure that tools, equipment, material, and rubbish do not accumulate on a scaffold to the point where the safe movement of personnel is jeopardized.

NEVER throw or drop objects or tools from scaffolds. Handlines should be used for raising or lowering objects when they cannot be reached easily and safely by hand. Such things as jumping or throwing material upon a scaffold platform are to be avoided at all times.

Scaffolds must never be overloaded! Furthermore, whenever possible, see that the scaffold load is uniformly distributed and not concentrated at the center of the platform.

Wire ropes and fiber lines used in suspension and swinging scaffolds should be of the best quality steel, manila, or sisal. Manila or sisal line used as lifelines

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should be 1 7/8 inches (51.2 mm) in circumference. Lifelines and safety belts must be used when working on unguarded scaffolds at heights of 10 feet (3 m) and above (as well as on boatswain's chairs, as explained earlier). If working over water, life jackets must be worn.

All scaffolds and scaffold equipment should be maintained in safe condition. Avoid making repairs or alterations to a scaffold or scaffold equipment while in use. Rather than take a chance, NEVER permit personnel to use damaged or weakened scaffolds!

FIELD-ERECTED HOISTING DEVICES

Because of the nature of heavy construction, Steel workers must at times erect heavy structural members when constructing pre-engineered buildings, piers, bridges, and many other components related to Advanced Base Functional Components (ABFC). These members are usually hoisted into position using cranes, forklifts, or other construction equipment. In contingency/ combat operations, however, because of operational commitments this equipment may not be available and structural members must be hoisted without the use of heavy equipment. We will now discuss some of the methods which can be used for the erection process when heavy equipment is not available.

The term *field-erected hoisting device* refers to a device that is constructed in the field, using material available locally, for the purpose of hoisting and moving heavy loads. Basically, it consists of a block-and-tackle system arranged on a skeleton structure consisting of wooden poles or steel beams. The tackle system requires some form of machine power or work force to do the actual hoisting. The three types of field-erected hoisting devices used are *gin poles, tripods, and shears. The* skeleton structure of these devices are anchored to *holdfasts.*

HOLDFASTS

Gin poles, shear legs, and other rigging devices are held in place by means of guy lines anchored to holdfasts. In fieldwork, the most desirable and economical types of holdfasts are natural objects, such as trees, stumps, and rocks. When natural holdfasts of suffient strength are not available, proper anchorage can be provided through the use of man-made holdfasts. These include single picket holdfasts, combination picket holdfasts, combination log picket holdfasts, log deadmen, and steel picket holdfasts.

Natural Types of Holdfasts

When using trees, stumps, or boulders as holdfasts, you should always attach the guys near ground level. The strength of the tree, stump, or boulder size is also an important factor in determining its suit ability as a holdfast. With this thought in mind, NEVER use a dead tree or a rotten stump or loose boulders and rocks. Such holdfasts are unsafe because they are likely to snap or slip suddenly when a strain is placed on the guy, Make it a practice to lash the first tree or stump to a second one (fig. 6-43). This will provide added support for the guy.

Rock holdfasts are made by inserting pipes, crowbars, or steel pickets in holes drilled in solid rock. Using a star drill, drill holes in the rock 1 1/2 to 3 feet apart, keeping them in line with the guy. Remember to drill the holes at a slight angle so the pickets lean away

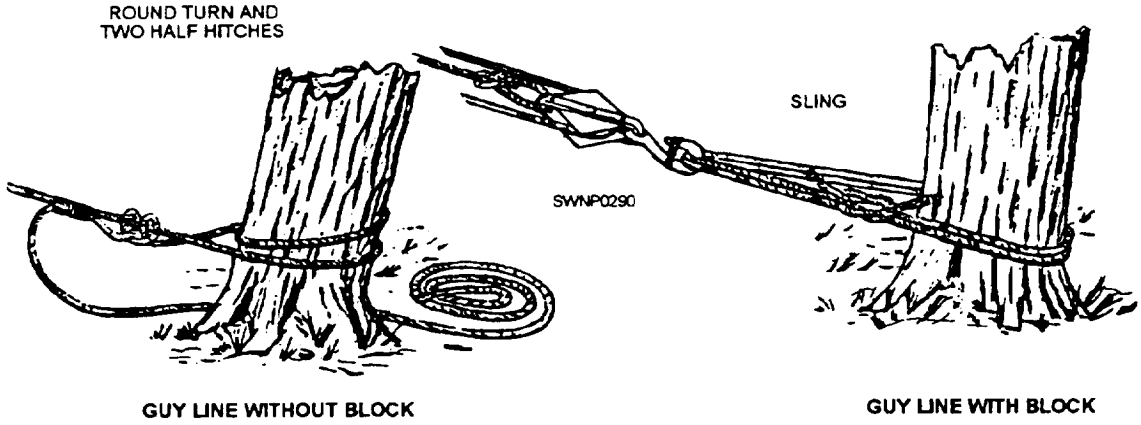


Figure 6-43.—Using trees as a holdfast.

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from the direction of pull. Make the front hole about 1 1/2 to 3 feet deep and the rear hole 2 feet deep (fig. 6-44). After driving pickets into the holes, you should secure the guy to the front picket. Then lash the pickets together with a chain or wire rope to transmit the load.

Single-Picket Holdfasts

Pickets used in the construction of picket holdfasts may be made of wood or steel. A wood picket should be at least 3 inches in diameter and 5 feet long. A single picket holdfast can be provided by driving a picket 3 to 4 feet into the ground, slanting it at an angle of 15 degrees opposite to the pull. In securing a single guy line to a picket, you should take two turns around the picket and then have part of the crew haul in on the guy as you take up the slack. When you have the guy taut, secure it with two half hitches. In undisturbed loam soil, the single picket is strong enough to stand a pull of about 700 pounds.

Combination Picket Holdfast

A **combination picket** holdfast consists of two or more pickets. Figure 6-45 gives you an idea of how to

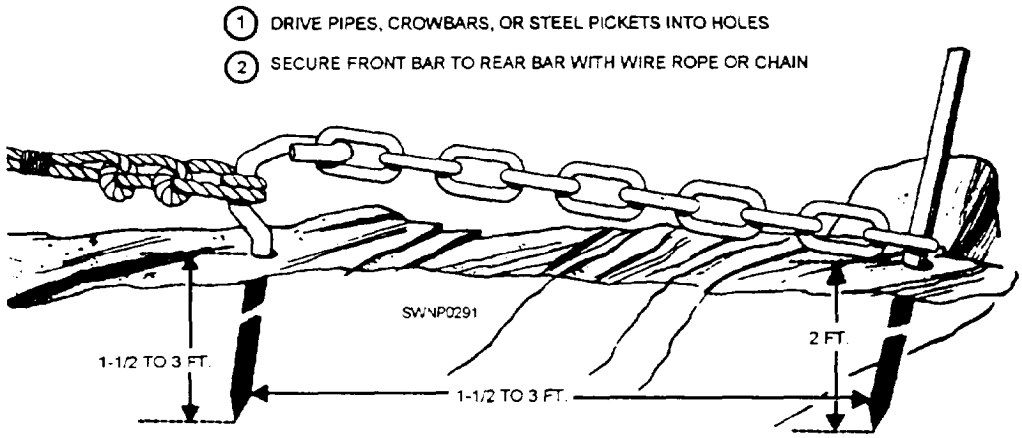


Figure 6-44.—A rock holdfast.

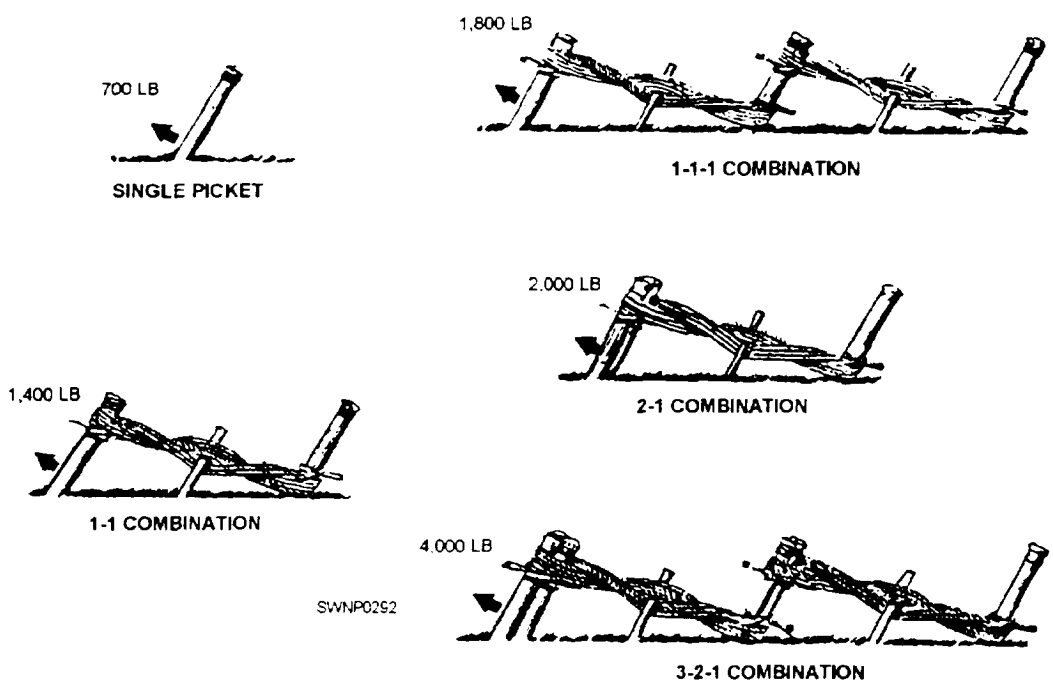


Figure 6-45.—Combination pickets.

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arrange pickets in constructing a 1-1-1 and a 3-2-1 combination picket holdfast.

In constructing the 1-1-1 combination (fig. 6-46), drive three single pickets about 3 feet into the ground, 3 to 6 feet apart, and in line with the guy. For a 3-2-1 combination, drive a group of three pickets into the ground, lashing them together before you secure the guy to them. The group of two lashed pickets follows the first group, 3 to 6 feet apart, and is followed by a single picket. The 1-1-1 combination can stand a pull of about 1,800 pounds, while the 3-2-1 combination can stand as much as 4,000 pounds.

The pickets grouped and lashed together, PLUS the use of small stuff secured onto every pair of pickets, are what make the combination picket holdfasts much stronger than the single holdfasts.

The reason for grouping and lashing the first cluster of pickets together is to reinforce the point where the pull is the greatest. The way small stuff links each picket to the next is what divides the force of pull, so the first picket does not have to withstand all of the strain. Using 12- to 15-thread small stuff, clove hitch it to the top of the first picket. Then take about four to six turns around the first and second pickets, going from the bottom of the second to the top of the first picket. Repeat this with more small stuff from the second to the third picket, and so on, until the last picket has been secured. After this, pass a stake between the turns of small stuff, between EACH pair of pickets, and then make the small stuff taut by twisting it with the stake. Now, drive the stake into the ground.

If you are going to use a picket holdfast for several days, it is best to use galvanized guy wire in place of the small stuff. Rain will not affect galvanized guy wire, but it will cause small stuff to shrink. If the small stuff is already taut, it could break from overstrain.

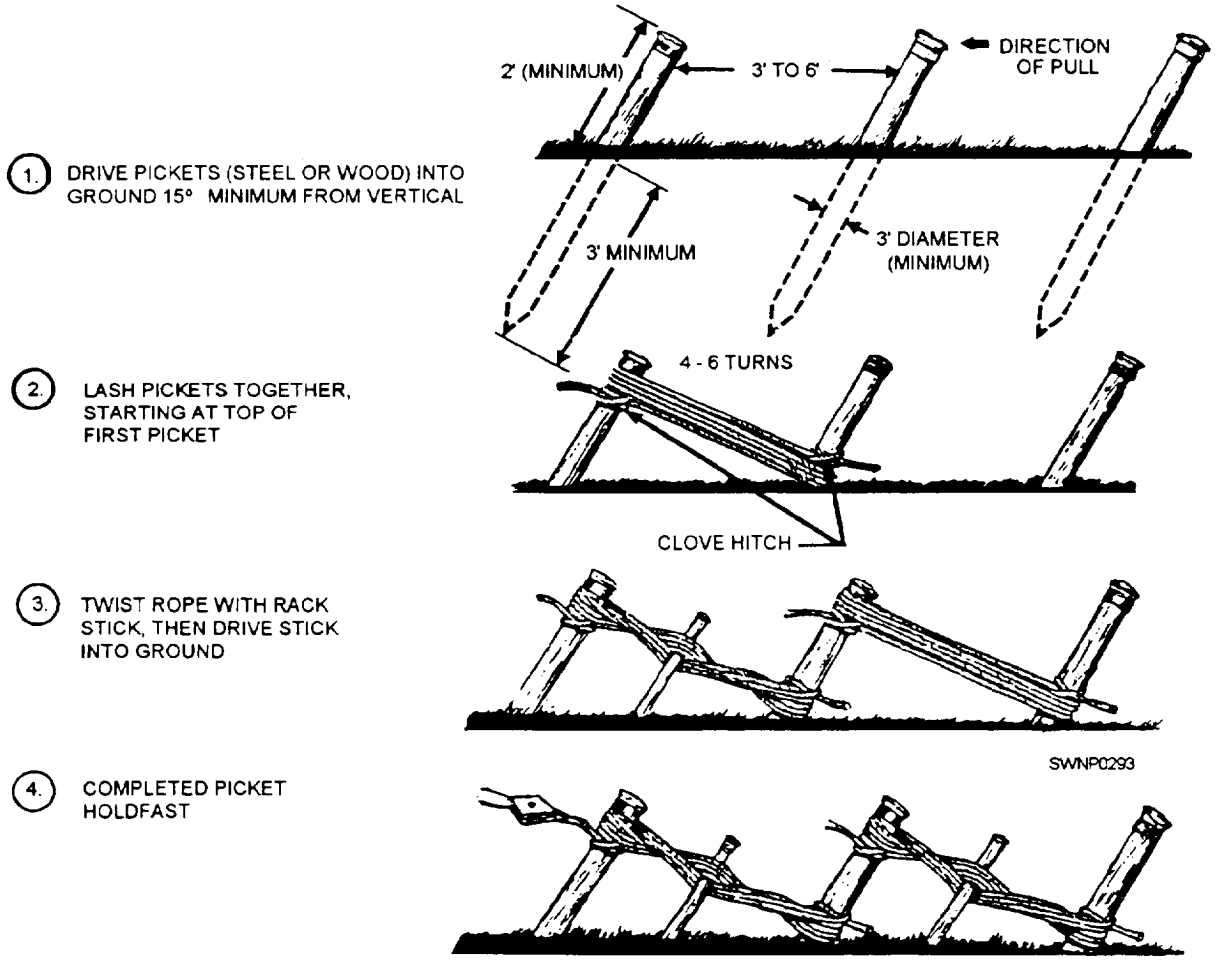


Figure 6-46.—Preparing a 1-1-1 picket holdfast.

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Still, if you must use small stuff, be sure to slack it off before leaving it overnight. You do this by pulling the stake up, untwisting the small stuff once, and then replacing the stake.

Combination Log Picket Holdfast

For heavy loads or in soft- or wet-earth areas, a combination log picket holdfast is frequently used. With this type, the guys are anchored to a log or timber supported against four or six combination picket holdfasts. (See fig. 6-47.) The timber serves as beam and must be placed so that it bears evenly against the front rope of the pickets. Since the holding power of this setup depends on the strength of the timber and anchor line, as well as the holdfast, you must use a timber big enough and an anchor line strong enough to withstand the pull.

Deadman

A deadman provides the best form of anchorage for heavy loads. It consists of a log, a steel beam, a steel pipe, or a similar object buried in the ground with the guy connected to it at its center. (See fig. 6-48.) Because it is buried, the deadman is suitable for use as a permanent anchorage. When you are installing a permanent deadman anchorage, it is a good idea to put a turnbuckle in the guy near the ground to permit slackening or tightening the guy when necessary.

In digging the hole in which to bury the deadman, make sure it is deep enough for good bearing on solid ground. The less earth you disturb in digging, the better the bearing surface will be. You should undercut the bank in the direction toward the guy at an angle of about 15 degrees from the vertical. To increase the bearing surface, drive stakes into the bank at several points over the deadman.

A narrow, inclined trench for the guy must be cut through the bank and should lead to the center of the deadman. At the outlet of the trench, place a short beam or logon the ground under the guy. In securing the guy to the center of the deadman, see that the standing part (that is, the part on which the pull occurs) leads from the bottom of the log deadman. Thus, if the wire rope clips slip under strain, the standing part will rotate the log in a counterclockwise direction, causing the log to dig into the trench, rather than roll up and out. See that the running end of the guy is secured properly to the standing part.

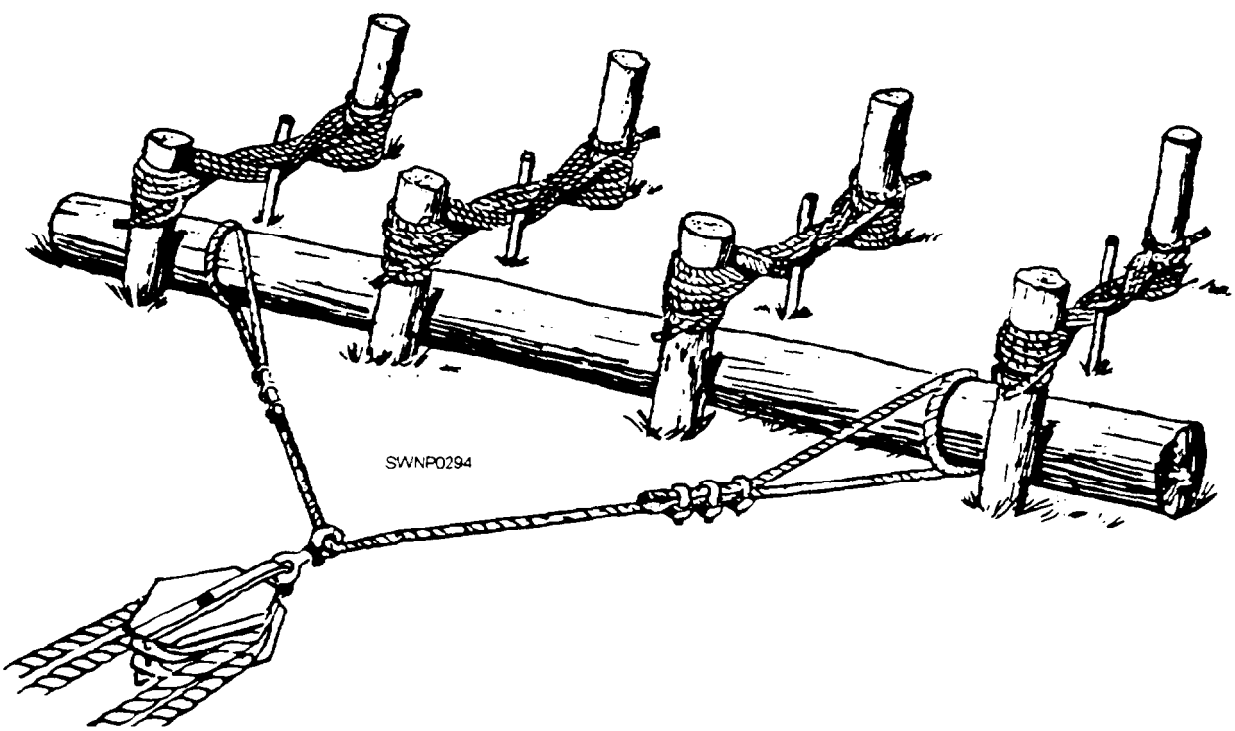


Figure 6-47.—A combination log picket

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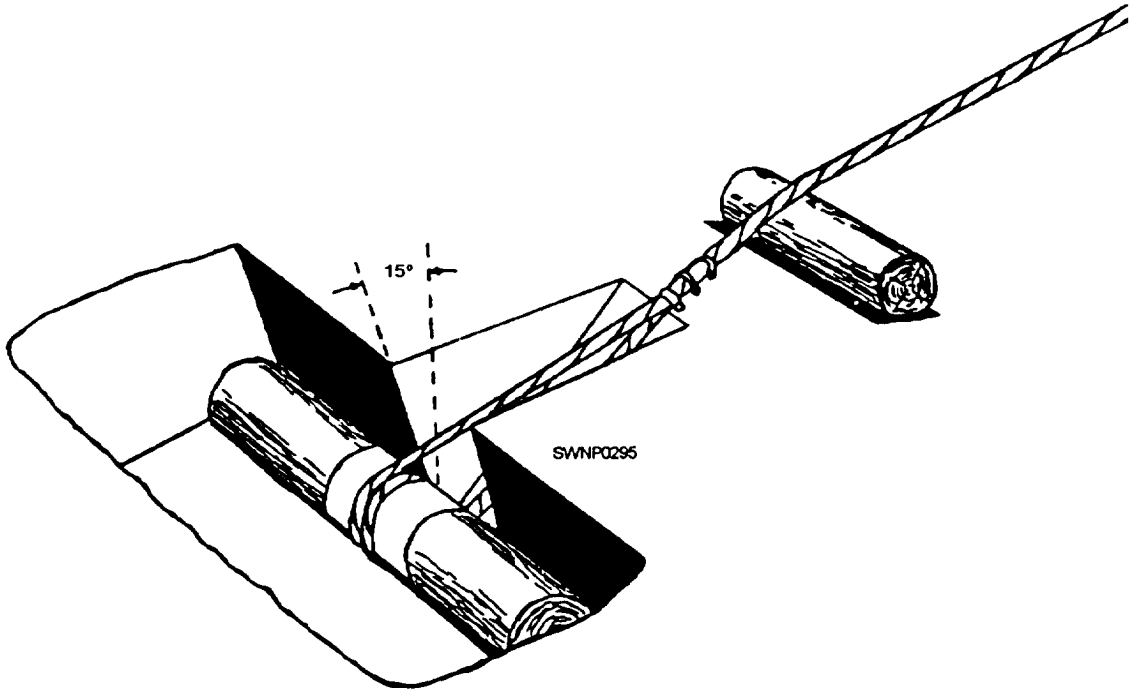


Figure 6-48.—A deadman anchorage for a heavy load.

Steel Picket Holdfast

The steel picket holdfast shown in figure 6-49 consists of steel box plates with nine holes drilled through each and a steel eye welded on the end for attaching the guy. When you are installing this holdfast, it is important to drive steel pickets through the holes in such a manner that will cause them to clinch in the ground. You will find the steel picket holdfast especially useful for anchoring horizontal lines, such as the anchor cable on a pontoon bridge. The use of two or more of the units in combination provides a stronger anchorage than a single unit.

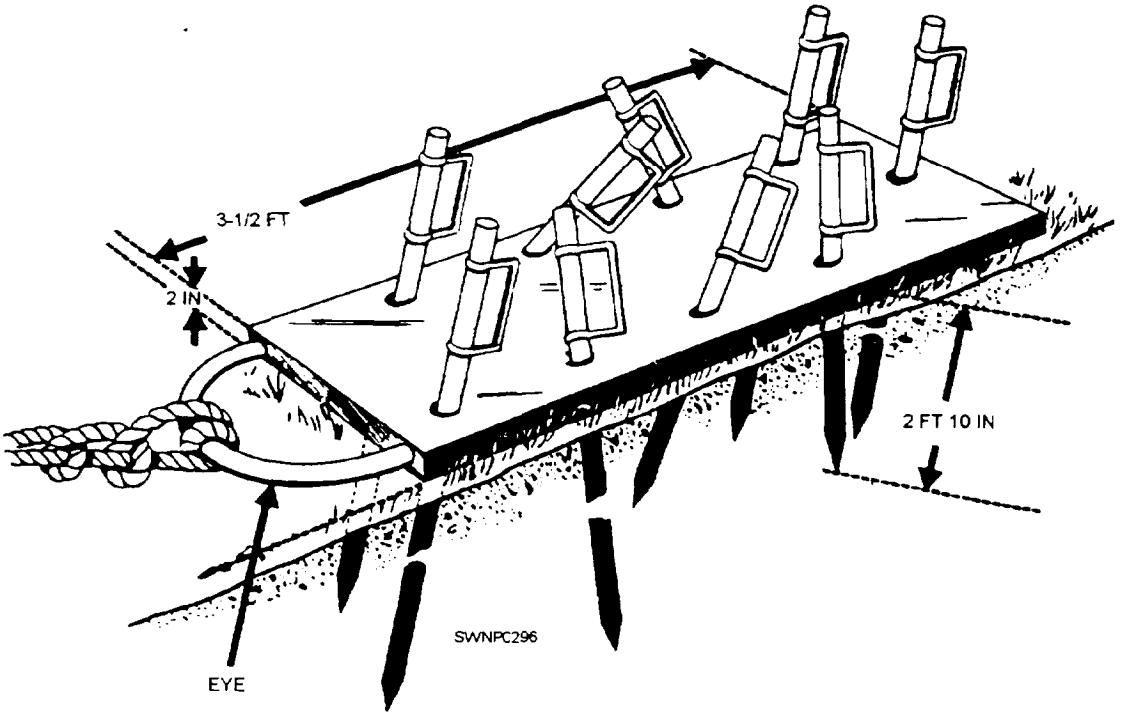
GIN POLES

A gin pole consists of an upright mast which is guyed at the top to maintain it in a vertical or nearly vertical position and is equipped with suitable hoisting tackle. The vertical mast can be timber, a wide-flange steel beam section, a railroad rail, or similar members of suffient strength to support the load being lifted. The load can be hoisted by hand tackle or by the use of hand- or engine-driven hoists. The gin pole is predominately used in erection work because of the ease with which it can be rigged, moved, and operated, and it is suitable for raising loads of medium weight to heights of 10 to 50 feet where only a vertical lift is required. The gin pole can also be used to drag loads horizontally toward the base of the pole in preparation for a vertical lift. It cannot be drifted (inclined) more than 45 degrees from the vertical or seven-tenths the height of the pole, nor is a gin pole suitable for swinging a load horizontal y. The length and thickness of the gin pole depends on the purpose for which it is installed. It should not be longer than 60 times its minimum thickness because of the tendency to buckle under compression. A usable rule is to allow 5 feet of pole for each inch of minimum thickness. Table 6-2 lists values for the use. of spruce timbers as gin poles with allowance for normal stresses in hoisting operations.

NOTE: Safe capacity of each length shears or tripod is seven-eighths of the value given for a gin pole.

1. *Rigging.* When rigging a gin pole, lay out the pole with the base at the exact spot where it is to be erected. To make provisions for the guy lines and tackle blocks, place the gin pole on cribbing for ease of lashing. Figure 6-50 shows the lashing on top of a gin pole and the method of attaching guys. The procedure is as follows:

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ANCHORAGE IS PROVIDED BY NINE STEEL PICKETS
DRIVEN THROUGH HOLES IN THE PLATE

Figure 6-49.—A steel picket holdfast.

Table 6-2.—Safe Capacity of Spruce Timber as Gin Poles in Normal Operations.

Size of timber in inches	Safe capacity in pounds for given length of timber					
	20 feet	25 feet	30 feet	40 feet	50 feet	60 feet
6 dia	5,000	3,000	2,000			
8 dia		11,000	8,000	5,000	3,000	
10 dia	31,000	24,000	16,000	9,000	6,000	
12 dia			31,000	19,000	12,000	9,000
6 x 6	6,000	4,000	3,000			
8 x 8		14,000	10,000	6,000	4,000	
10 x 10	40,000	30,000	20,000	12,000	8,000	
12 x 12			40,000	24,000	16,000	12,000

a. Make a tight lashing of eight turns of fiber rope about 1 foot from the top of the pole, with two of the center turns engaging the hook of the upper block of the tackle. Secure the ends of the lashing with a square knot. Nail wooden cleats (boards) to the pole flush with the lower and upper sides of the lashing to prevent the lashing from slipping.

b. Lay out guy ropes, each one four times the length of the gin pole. In the center of each guy rope,

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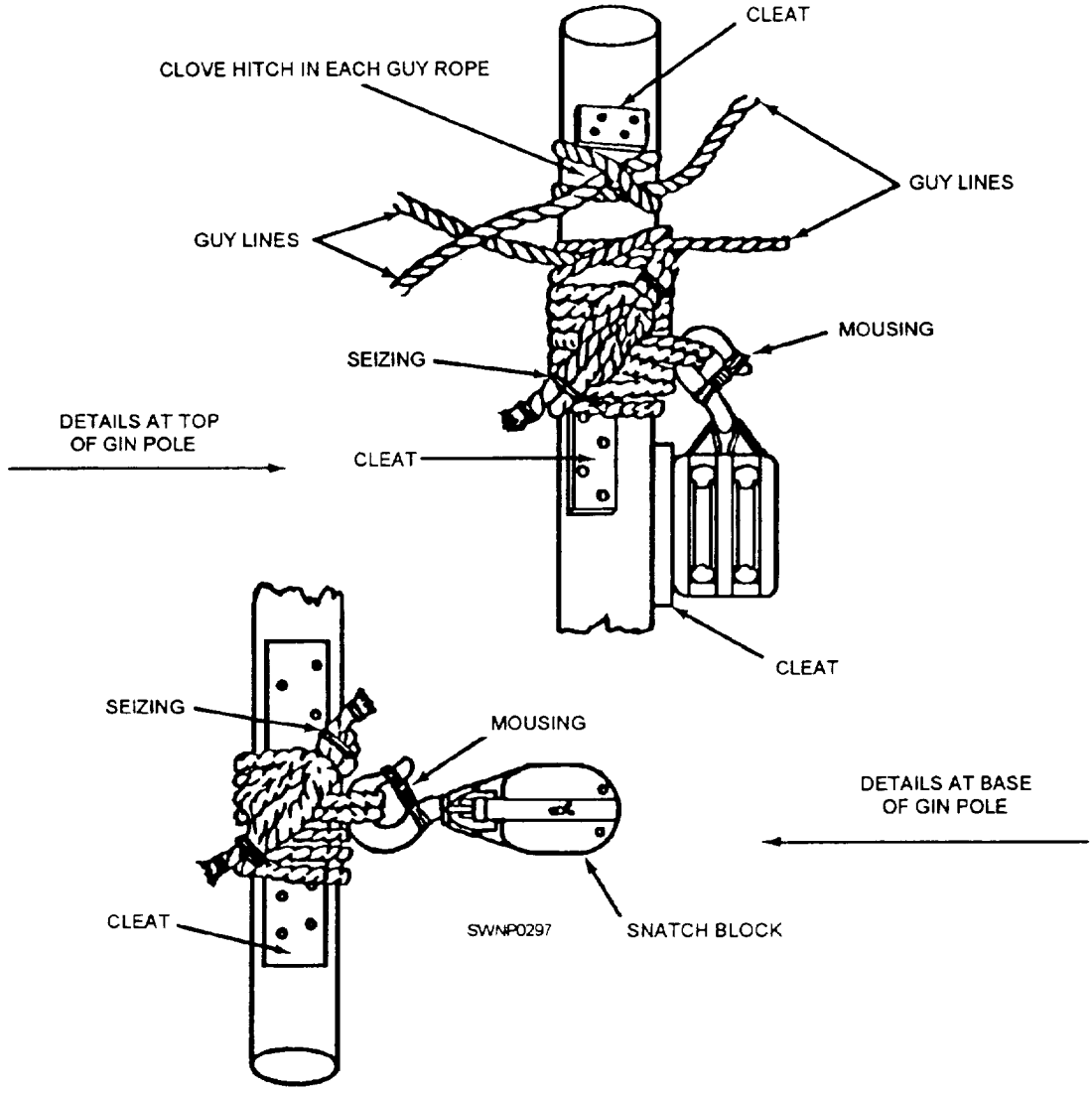


Figure 6-50.—Lashing for a gin pole.

form a clove hitch over the top of the pole next to the tackle lashing, and be sure the guy lines are aligned in the direction of their anchors.

c. Lash a block to the gin pole about 2 feet from the base of the pole, the same as was done for the tackle lashing at the top, and place a cleat above the lashing to prevent slipping. This block serves as a leading block on the fall line which allows a directional change of pull from the vertical to the horizontal. A snatch block is the most convenient type to use for this purpose.

d. Reeve the hoisting tackle and use the block lashed to the top of the pole so that the fall line can be passed through the leading block at the base of the gin pole.

e. Drive a stake about 3 feet from the base of the gin pole. Tie a rope from the stake to the base of the pole below the lashing on the leading block and near the bottom of the pole. This is to prevent the pole from skidding while it is being erected.

f. Check all lines to be sure that they are not tangled. Check all lashings to see that they are made up properly, and see that all knots are tight. Check the hooks on the blocks to see that they are moused properly. The gin pole is now ready to be erected.

2. Erecting. A gin pole 40 feet long can be raised easily by hand, but longer poles must be raised by supplementary rigging or power equipment. Figure 6-51 shows a gin pole being erected. The numbe of men

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needed depends on the weight of the pole. The procedure is as follows:

a. Dig a hole about 2 feet deep for the base of the gin pole.

b. Run out the guys to their respective anchorages and assign a man to each anchorage to control the slack in the guy line with a round turn around the anchorage as the pole is raised. If it has not been done already, install an anchorage for the base of the pole.

c. If necessary, the tackle system used to raise and lower the load can be used to assist in raising the gin pole, but the attaching of an additional tackle system to the rear guy line is preferable. Attach the running block of the rear guy line tackle system (fig. 6-52) to the rear guy line end which at this point is near the base of the gin pole. The fixed or stationary block is then secured to the rear anchor. The fall line should come out of the running block to give greater mechanical advantage to the tackle system. The tackle system is stretched to the base of the pole before it is erected to prevent the chocking of the tackle blocks during the erection of the gin pole.

d. Keep a slight tension on the rear guy line, and *on each of the side guy lines,* haul in on the fall line of the tackle system while eight men (more for larger poles) raise the top of the pole by hand until the tackle system can take control.

e. The rear guy line must be kept under tension to prevent the pole from swinging and throwing all of its weight on one of the side guys.

f. When the pole is in its final position, approximately vertical or inclined as desired make all guys fast to their anchorages with the round turn and two half hitches. It is often advantageous to double the portion of rope used for the half hitches.

g. Open the leading block at the base of the gin pole and place the fall line from the tackle system through it. When the leading block is closed, the gin pole is ready for use. If it is necessary to move (drift) the top of the pole without moving the base, it should be done when there is no load on the pole unless the guys are equipped with tackle.

3. *Operating.* The gin pole is perfectly suited to vertical lifts. It also is used under some circumstances for lifting and pulling at the same time so that the load being moved travels toward the gin pole just off the ground. When used in this manner, a snubbing line of some kind must be attached to the other end of the load being dragged and kept under tension at all times. Tag lines are to be used to control loads being lifted vertically. A tag line is a light line fastened to one end of the load and kept under slight tension during hoisting.

TRIPODS

A tripod consists of three legs lashed or secured at the top. The advantage of the tripod over other rigging installations is its stability, and it requires no guy lines to hold it in place. The disadvantage of a tripod is that the load can be moved only up and down. The load capacity of a tripod is approximately 1 1/2 times that of shears made of the same-size material.

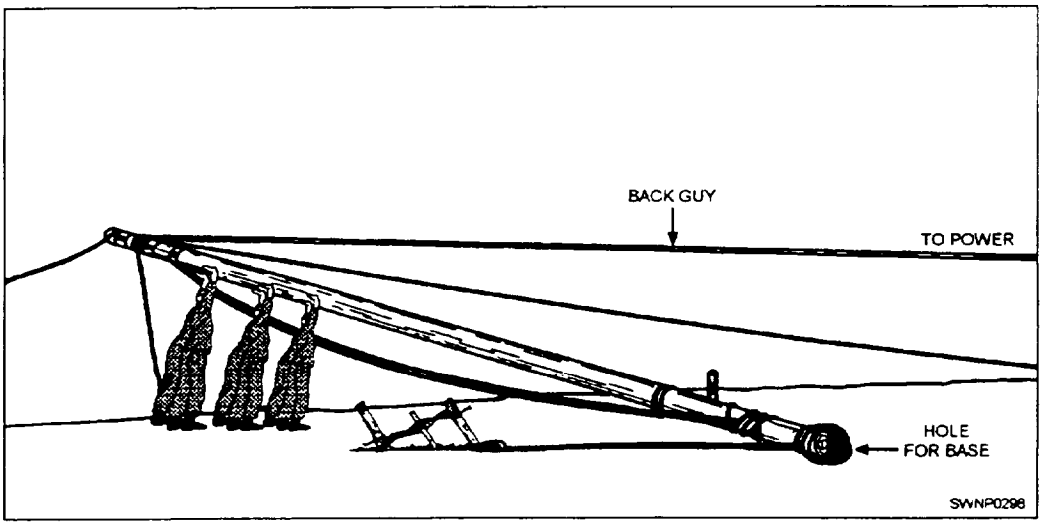


Figure 6-51.—Erecting a gin pole.

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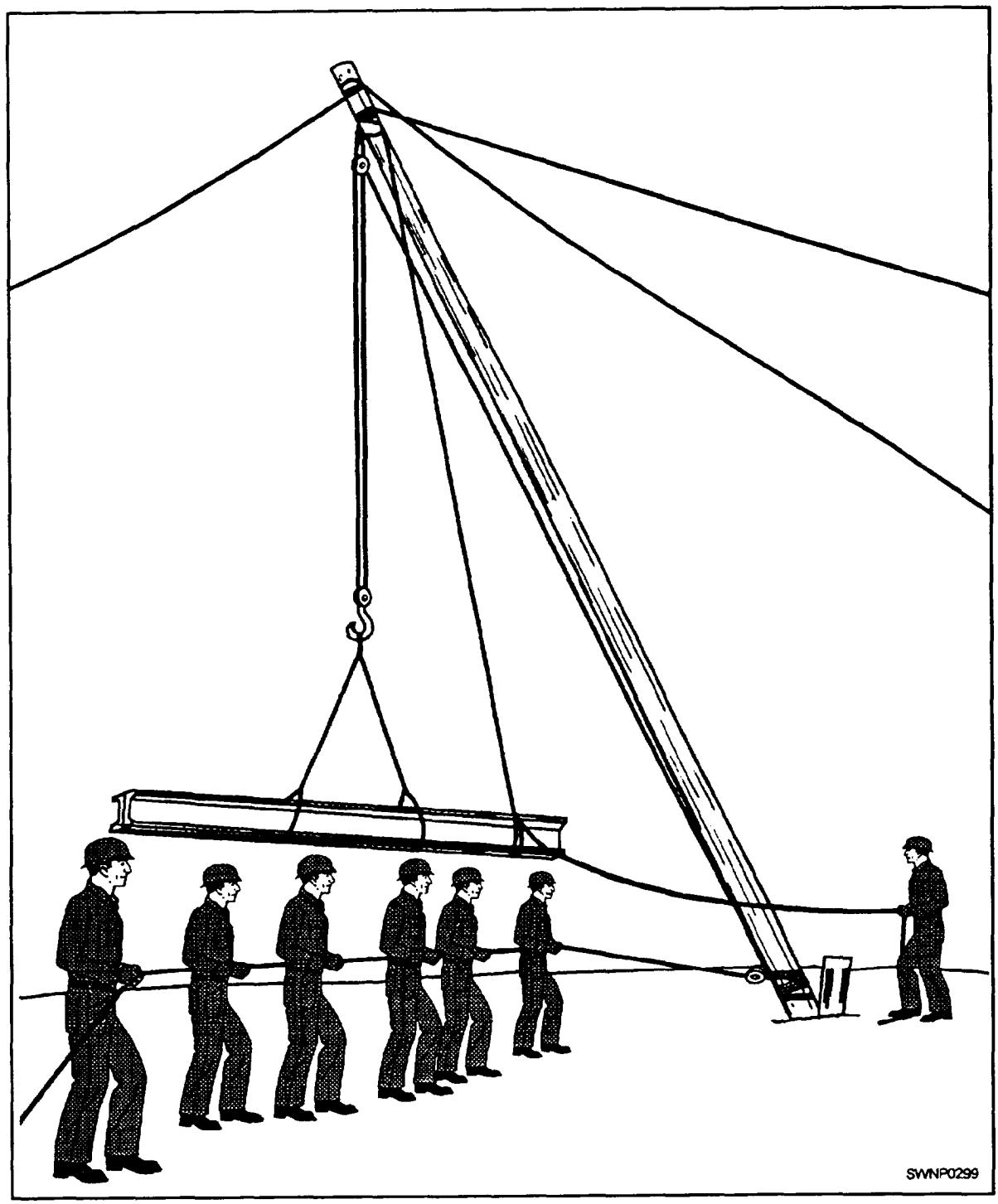


Figure 6-52.—Hoisting with a gin pole.

1. *Rigging.* There are two methods of lashing a tripod, either of which is suitable provided the lashing material is strong enough. The material used for lashing can be fiber rope, wire rope, or chain. Metal rings joined with short chain sections and large enough to slip over the top of the tripod legs also can be used. The method described below is for fiber rope 1 inch in diameter or smaller. Since the strength of the tripod is affected directly by the strength of the rope and the lashing used, more turns than described below should be used for extra heavy loads and fewer turns can be used for light loads.

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Procedure

a. Select three masts of approximately equal size and place a mark near the top of each mast to indicate the center of the lashing.

b. Lay two of the masts parallel with their tops resting on a skid or block and a third mast between the first two, with the butt in the opposite direction and the lashing marks on all three in line. The spacing between masts should be about one half or the diameter of the spars. Leave the space between the spars so that the lashing will not be drawn too tight when the tripod is erected.

c. With a 1-inch rope, make a clove hitch around one of the outside masts about 4 inches above the lashing mark, and take eight turns of the line around the three masts (fig. 6-53). Be sure to maintain the space between the masts while making the turns.

d. Finish the lashing by taking two close frapping turns around the lashing between each pair of masts. Secure the end of the rope with a clove hitch on the center mast just above the lashing. Frapping turns should not be drawn too tight.

Alternate procedure

a. An alternate procedure (fig. 6-54) can be used when slender poles not more than 20 feet long are being used or when some means other than hand power is available for erection.

b. Lay the three masts parallel to each other with an interval between them slightly greater than

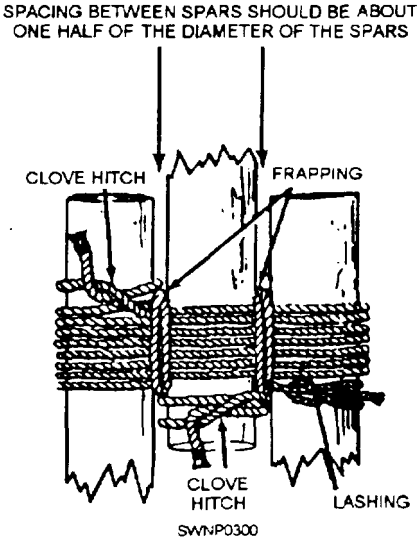


Figure 6-53.—Lashing for a tripod.

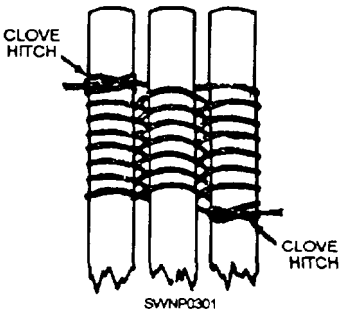


Figure 6-54.—Alternate lashing for a tripod.

twice the diameter of the rope to be used. Rest the tops of the poles on a skid so that the ends project over the skid approximately 2 feet and the butts of the three masts are in line.

c. Put a clove hitch on one outside leg at the bottom of the position the lashing will occupy, which should be approximately 2 feet from the end. Weave the line over the middle leg, under and around the outer leg, under the middle leg, over and around the first leg, and continue this weaving for eight turns. Finish with a clove hitch on the outer leg.

2. *Erecting.* The legs of a tripod in its final position should be spread so that each leg is equidistant (fig. 6-55) from the others. This spread should not be less than one half nor more than two thirds of the length of the legs. Chain, rope, or boards should be used to hold the legs in this position. A leading block for the fall line of the tackle can be lashed to one of the legs. The procedure is as follows:

a. Raise the tops of the masts about 4 feet, keeping the base of the legs on the ground.

b. Cross the two outer legs. The third or center leg then rests on top of the cross. With the legs in this position, pass a sling over the cross so that it passes over the top or center leg and around the other two.

c. Hook the upper block of a tackle to the sling and mouse the hook.

d. Continue raising the tripod by pushing in on the legs as they are lifted at the center. Eight men should be able to raise an ordinary tripod into position.

e. When the tripod legs are in their final position, place a rope or chain lashing between the legs to hold them from shifting.

3. *Erecting Large Tripods.* For larger tripod installations it maybe necessary to erect a small gin pole to raise the tripod into position. Tripods, lashed with the

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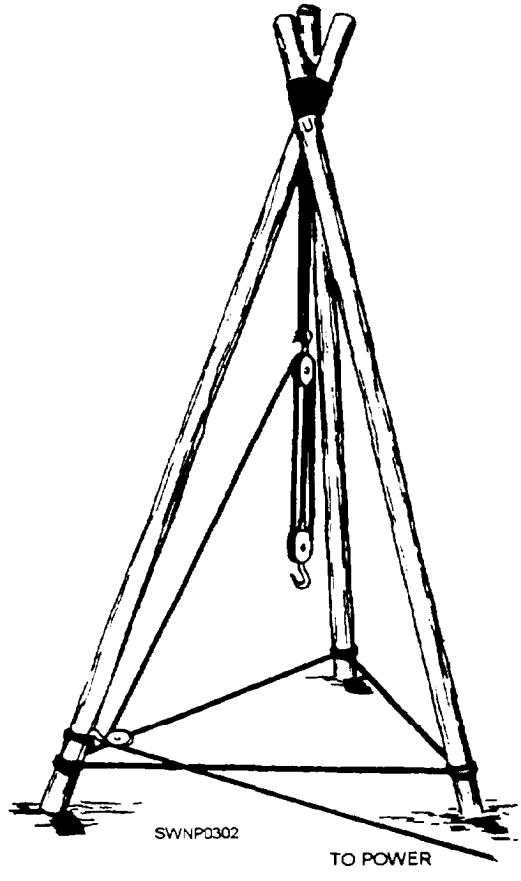


Figure 6-55.—Tripod assembled for use.

three legs laid together, must be erected by raising the tops of the legs until the legs clear the ground so they can be spread apart. Guy lines or tag lines should be used to assist in steadying the legs while they are being raised. The outer legs should be crossed so that the center leg is on the top of the cross, and the sling for the hoisting tackle should pass over the center leg and around the two outer legs at the cross.

SHEARS

Shears, made by lashing two legs together with a rope, is well adapted for lifting heavy machinery or other bulky loads. It is formed by two members crossed at their tops with the hoisting tackle suspended from the intersection. The shears must be guyed to hold it in position. The shears is quickly assembled and erected. It requires only two guys and is adapted to working at an inclination from the vertical. The shear legs can be round poles, timbers, heavy planks, or steel bars, depending on the material at hand and the purpose of the shears. For determining the size of the members to be used, the load to be lifted and the ratio of the length and diameter of the legs are the determining factors. For heavy loads the length-diameter (L/ *d)* ratio should not exceed 60, because of the tendency of the legs to bend, rather than to act as columns. For light work, shears can be improvised from two planks or light poles bolted together and reinforced by a small lashing at the intersection of the legs.

1. *Rigging.* In erection, the spread of the legs should equal about one half of the height of the shears. The maximum allowable drift (inclination) is 45 degrees. Tackle blocks and guys for shears are essential. The guy ropes can be secured to firm posts or trees with a turn of the rope so that the length of the guys can be adjusted easily. The procedure is as follows:

a. Lay two timbers together on the ground in line with the guys with the butt ends pointing toward the back guy and close to the point of erection.

b. Place a large block under the tops of the legs just below the point of lashing (fig. 6-56), and insert a small spacer block between the tops at the same point. The separation between the legs at this point should be equal to one third of the diameter on one leg to make handling of the lashing easier.

c. With sufficient 1-inch rope for 14 turns around both legs, make a clove hitch around one mast, and take 8 turns around both legs above the clove hitch. Wrap the turns tightly so that the lashings are made smooth and without kinks.

d. Finish the lashing by taking two frapping turns around the lashing between the legs and securing the end of the rope to the other leg just below the lashing. For handling heavy loads the number of lashing turns is increased.

2. *Erecting.* Holes should be dug at the points where the legs of the shears are to stand. In case of placement on rocky ground, the base for the shears should be level. The legs of the shears should be crossed and the butts placed at the edges of the holes. With a short length of rope, make two turns over the cross at the top of the shears and tie the rope together to form a sling. Be sure to have the sling bearing against the masts and *not* on the shears lashing entirely. The procedures is as follows:

a. Reeve a set of blocks and place the hook of the upper block through the sling. Secure the sling in the hook by mousing. Fasten the lower block to one of the legs near the butt, so it will be in a convenient

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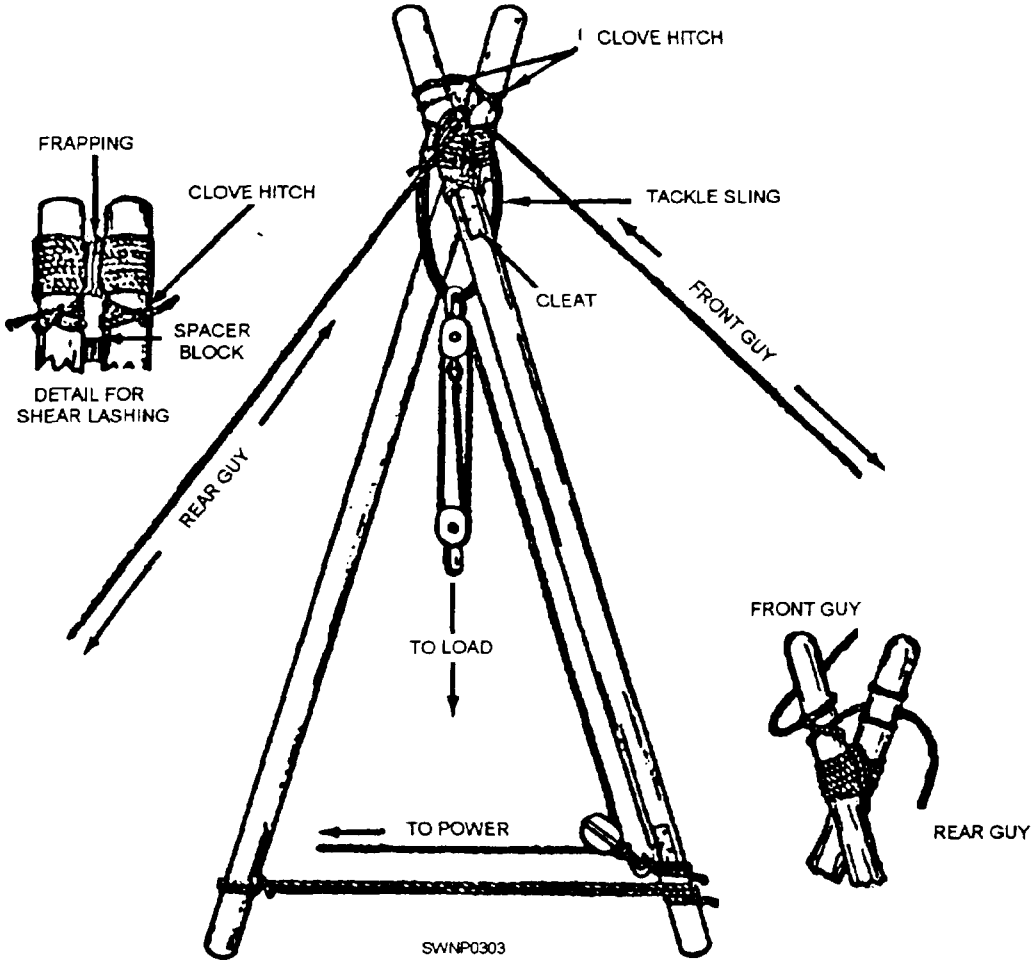


Figure 6-56.—Lashing for shears.

position when the shears have been raised, but will be out of the way during erection.

b. If the shears are to be used on heavy lifts, another tackle is rigged in the base guy near its anchorage. The two guys should be secured to the top of the shears with clove hitches to legs opposite their anchorages above the lashing.

c. Several men (depending on the size of the shears) should lift the top end of the shear legs and "walk" them up by hand until the tackle on the rear guy line can take affect. After this, the shear legs can be raised into final position by hauling in on the tackle. Secure the front guy line to its anchorage before raising the shear legs and keep a slight tension on this line to control movement. (See fig. 6-57.)

d. The legs should be kept from spreading by connecting them with rope chain, or bards. It can be necessary, under some conditions, to anchor each leg of the shears during erection to keep the legs from sliding in the wrong direction.

3. *Operating.* The rear guy is a very important part of the shears rigging, as it is under a considerable strain when hoisting. The front guy has very little strain on it and is used mainly to aid in adjusting the drift and to steady the top of the shears when hoisting or placing the load. It maybe necessary to rig a tackle in the rear guy for handling heavy loads. In operation, the drift (inclination of the shears) desired is set by adjustment of the rear guy, but this should not be done while a load is on the shears. For handling light loads, the fall line of the tackle of the shears can be led straight out of the upper block. When heavy loads are handled, you should lash a snatch block (fig. 6-58) near the base of one of the shear legs to act as a leading block, The fall line should be run through the leading block to a hand- or power-operated winch for heavy loads.

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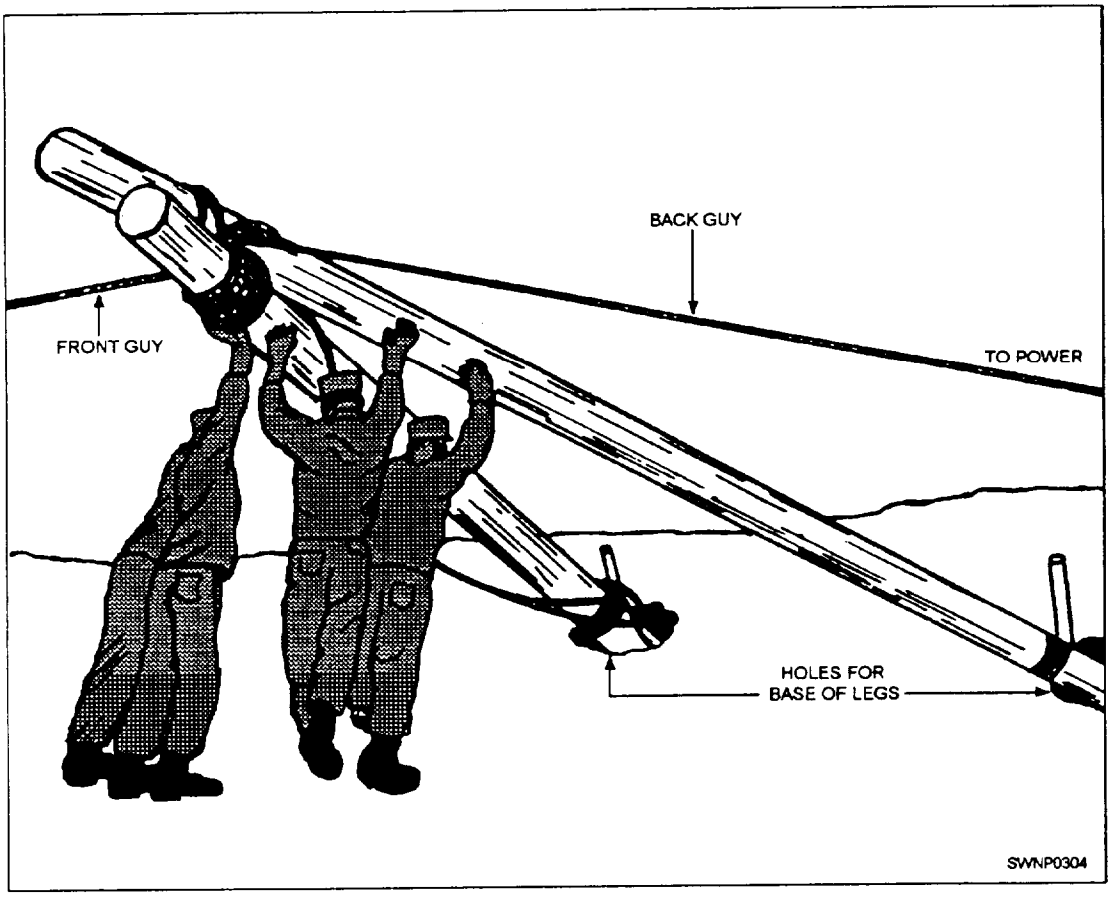


Figure 6-57.—Erecting shears

RIGGING SAFE OPERATING PROCEDURES

All personnel involved with the use of rigging gear should be thoroughly instructed and trained to comply with the following practices:

1. Wire rope slings must not be used with loads that exceed the rated capacities outlined in enclosure (2) of the COMSECOND/COMTHIRDNCBINST 11200.11. Slings not included in the enclosure must be used only according to the manufacturer's recommendation.

2. Determine the weight of a load before attempting any lift.

3. Select a sling with sufficient capacity rating.

4. Examine all hardware, equipment, tackle, and slings before using them and destroy all defective components.

5. Use the proper hitch.

6. Guide loads with a tag line when practical.

7. When using multiple-leg slings, select the longest sling practical to reduce the stress on the individual sling legs.

8. Attach the sling securely to the load.

9. Pad or protect any sharp comers or edges the sling can come in contact with to prevent chaffing.

10. Keep slings free of kinks, loops, or twists.

11. Keep hands and fingers from between the sling and the load.

12. Start the lift slowly to avoid shock loading slings.

13. Keep slings well lubricated to prevent corrosion.

14. Do not pull slings from under a load when the load is resting on the slings; block the load up to remove slings.

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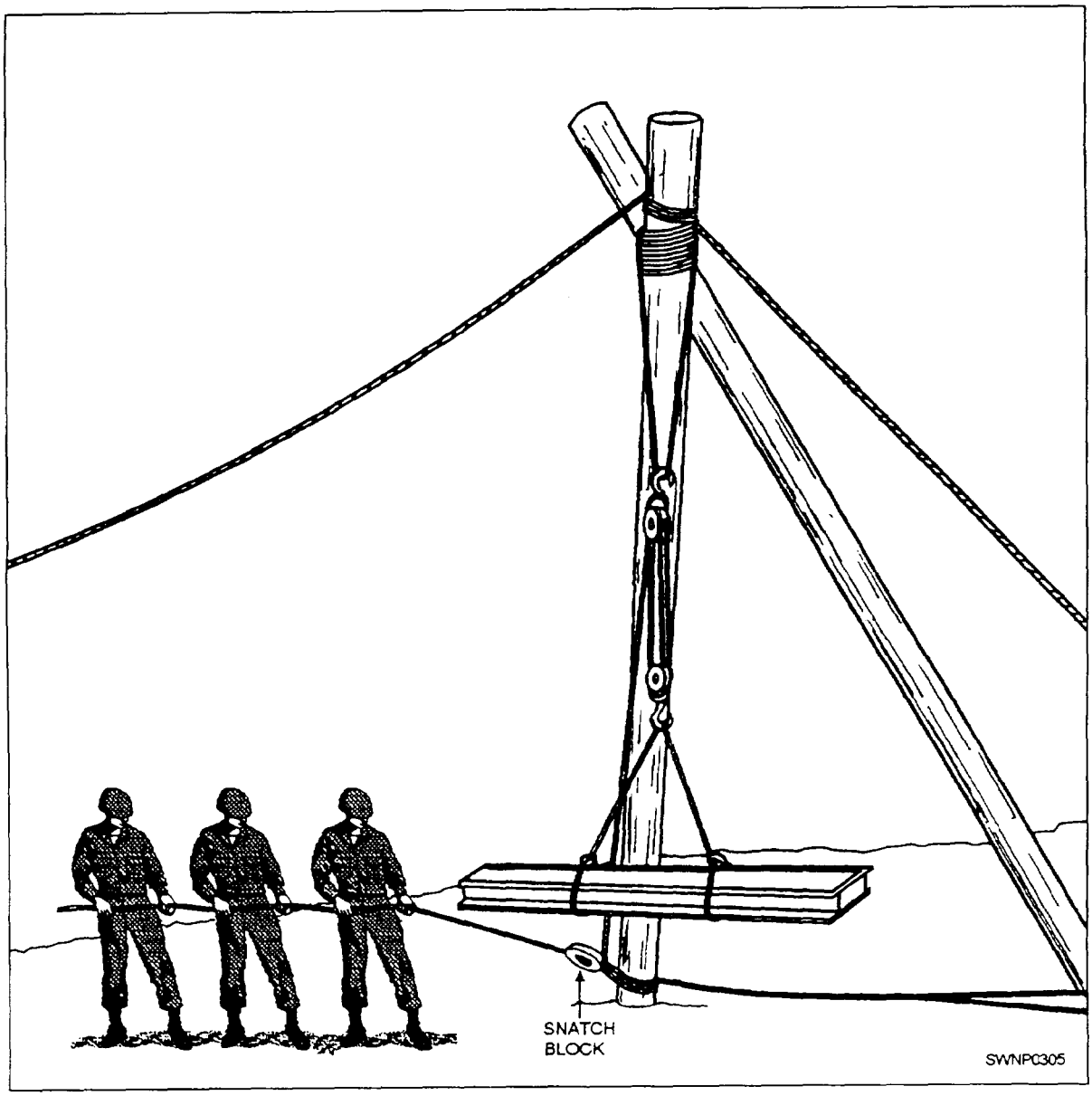


Figure 6-58.—Hoisting with shears.

15. Do not shorten a sling by knotting or using wire rope clips.

16. Do not inspect wire rope slings by passing bare hands over the rope. Broken wires, if present, can cause serious injuries. When practical, leather palm gloves should be worn when working with wire rope slings.

17. Center of Balance. It is very important that in the rigging process that the load is stable. A stable load is a load in which the center of balance of the load is directly below the hook, as shown in figure 6-59. When a load is suspended, it will always shift to that position below the hook. To rig a stable load, establish the center of balance (C/B). Once you have done this, simply swing the hook over the C/B and select the length of slings needed from the hook to the lifting point of the load.

18. When using a multi-legged bridle sling, do not forget it is wrong to assume that a three- or four-leg hitch will safely lift a load equal to the safe load on one leg multiplied by the number of legs. With a four-legged bridle sling lifting a rigid load, it is possible for two of the legs to support practically the full load while the other two only balance it (fig. 6-60).

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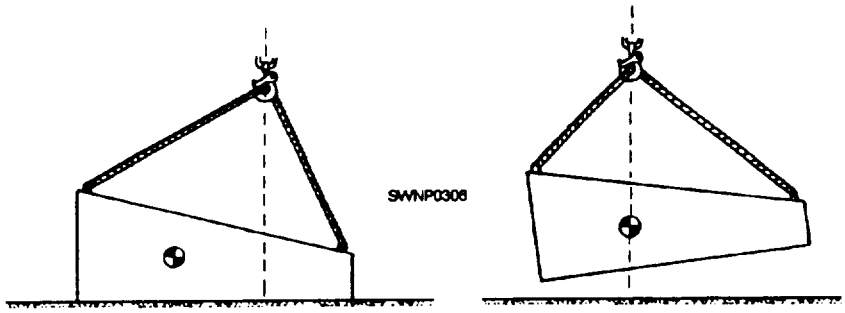


Figure 6-59.—Example of a load shifting when lifted.

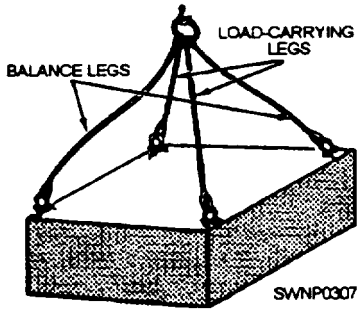


Figure 6-60.—Multi-legged bridle sling lifting a load.

NOTE: If all the legs of a multi-legged sling are not required, secure the remaining legs out of the way, as shown in figure 6-61.

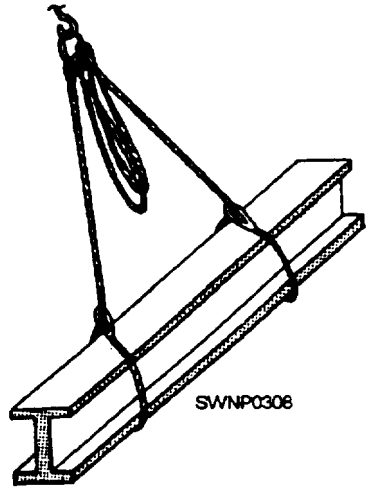


Figure 6-61.—Secure sling legs that are not used.

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CHAPTER 7

REINFORCING STEEL

As a Steelworker, you must be able to cut, bend, place, and tie reinforcing steel. This chapter describes the purpose of reinforcing steel in concrete construction, the types and shapes of reinforcing steel commonly used, and the techniques and tools used by Steelworkers in rebar (reinforcing steel) work. This chapter begins with a presentation of fundamental information about concrete to help you understand rebar work fully.

REINFORCED CONCRETE

As a Steelworker you will be primarily concerned with reinforcing steel placement but you should to some extent, be concerned with concrete as well. Concrete with reinforcing steel added becomes reinforced concrete. Structures built of reinforced concrete, such as retaining walls, buildings, bridges, highway surfaces, and numerous other structures, are referred to as reinforced concrete structures or reinforced concrete construction.

CONCRETE MATERIALS

Concrete is a synthetic construction material made by mixing cement, fine aggregate (usually sand), coarse aggregate (usually gravel or crushed stone), and water in proper proportions. This mixture hardens into a rocklike mass as the result of a chemical reaction between the cement and water. Concrete will continue to harden and gain strength as long as it is kept moist and warm. This condition allows the chemical reaction to continue and the process is known as curing. Durable, strong concrete is made by the correct proportioning and mixing of the various materials and by proper curing after the concrete is placed.

The correct proportioning of the concrete ingredients is often referred to as the mix. The quality of the concrete is largely determined by the quality of the cement-water paste that bonds the aggregates together. The strength of concrete will be reduced if this paste has water added to it. The proportion of water to cement is referred as the water-cement ratio. The water-cement ratio is the number of gallons of water per pounds of cement. High-quality concrete is produced by using the lowest water-cement mixture possible without sacrificing workability.

Because concrete is plastic when it is placed forms are built to contain and form the concrete until it has hardened In short forms and formwork are described as molds that hold freshly placed concrete in the desired shape until it hardens. All the ingredients of the mix are placed in a concrete mixer, and after a thorough mixing, the concrete is transferred by numerous methods, such as by bucket, by wheelbarrow, and so forth, into the formwork in which the reinforcing steel has already been placed.

Concrete reaches its initial set in approximately 1 hour under normal conditions and hardens to its final set in approximately 6 to 12 hours. Before the initial set, concrete must be placed in the forms and vibrated to consolidate it into the formwork and ensure complete coverage of all reinforcing bars. Finish operations, such as smooth troweled finishes, must be performed between initial and final set. After the final set, concrete must be protected from shock, extreme temperature changes, and premature drying until it cures to sufficient hardness. Concrete will be self-supportive in a few days and attain most of its potential strength in 28 days of moist curing. For further information on concrete, refer to *Builder 3 & 2*, Volume 1, NAVEDTRA 12520.

CONCRETE STRENGTH

As stated previously, the strength of concrete is determined by the water-cement ratio. The strength of ready-mixed concrete ranges from 1,500 to about 5,000 pounds per square inch (psi); and, with further attention paid to proportioning, it can go even higher. Under usual construction processes, lower strength concrete will be used in footers and walls and higher strength in beams, columns, and floors. The required strength of concrete on a given project can be found in the project plans and specifications for a specific project.

NOTE: Quality control is important to ensure specific design requirements are met. If the design specifications do not meet minimum standards, structural integrity is compromised and the structure

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is considered unsafe. For this reason, the compressive strength of concrete is checked on all projects.

The strength of the concrete is checked by the use of cylindrical molds that are 6 inches in diameter and 12 inches in height. Concrete samples must be taken on the jobsite from the concrete that is being placed. After being cured for a time period that ranges between 7 to 28 days, the cylinders are "broken to failure" by a laboratory crushing machine that measures the force required for the concrete to fail. For further information on concrete strength and testing, refer to *Engineering Aid 3*, NAVEDTRA 10696, and NAVFAC MO 330. (The MO 330 should be maintained in a battalion's tech library.)

PURPOSES AND TYPES OF REINFORCING STEEL

Reinforced concrete was designed on the principle that steel and concrete act together in resisting force.

Concrete is strong in compression but weak in tension. The tensile strength is generally rated about 10 percent of the compression strength. For this reason, concrete works well for columns and posts that are compression members in a structure. But, when it is used for tension members, such as beams, girders, foundation walls, or floors, concrete must be reinforced to attain the necessary tension strength.

Steel is the best material for reinforcing concrete because the properties of expansion for both steel and concrete are considered to be approximate] y the same; that is, under normal conditions, they will expand and contract at an almost equal rate.

NOTE: At very high temperatures, steel expands more rapidly than concrete and the two materials will separate.

Another reason steel works well as a reinforcement for concrete is because it bonds well with concrete. This bond strength is proportional to the contact surface of the steel to the concrete. In other words, the greater the surface of steel exposed to the adherence of concrete, the stronger the bond. A deformed reinforcing bar adheres better than a plain, round, or square one because it has a greater bearing surface. In fact, when plain bars of the same diameter are used instead of deformed bars, approximately 40 percent more bars must be used.

The rougher the surface of the steel, the better it adheres to concrete. Thus steel with a light, firm layer of rust is superior to clean steel; however, steel with loose or scaly rust is inferior. Loose or scaly rust can be removed from the steel by rubbing the steel with burlap or similar material. This action leaves only the firm layer of rust on the steel to adhere to the concrete.

NOTE: Reinforcing steel must be strong in tension and, at the same time, be ductile enough to be shaped or bent cold.

Reinforcing steel can be used in the form of bars or rods that are either plain or deformed or in the form of expanded metal, wire, wire fabric, or sheet metal. Each type is useful for different purposes, and engineers design structures with those purposes in mind.

Plain bars are round in cross section. They are used in concrete for special purposes, such as dowels at expansion joints, where bars must slide in a metal or paper sleeve, for contraction joints in roads and runways, and for column spirals. They are the least used of the rod type of reinforcement because they offer only smooth, even surfaces for bonding with concrete.

Deformed bars differ from the plain bars in that they have either indentations in them or ridges on them, or both, in a regular pattern. The twisted bar, for example, is made by twisting a plain, square bar cold. The spiral ridges, along the surface of the deformed bar, increase its bond strength with concrete. Other forms used are the round and square corrugated bars. These bars are formed with projections around the surface that extend into the surrounding concrete and prevent slippage. Another type is formed with longitudinal fins projecting from the surface to prevent twisting. Figure 7-1 shows a few of the types of deformed bars available. In the United States, deformed bars are used almost exclusively; while in Europe, both deformed and plain bars are used.

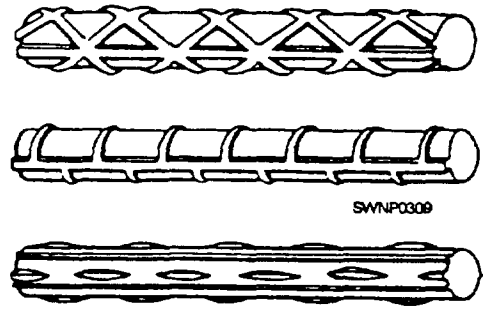


Figure 7-1.—Various types of deformed bars.

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Eleven standard sizes of reinforcing bars are in use today. Table 7-1 lists the bar number, area in square inches, weight, and nominal diameter of the 11 standard sizes. Bars No. 3 through 11 and 14 and 18 are all deformed bars. Table 7-2 lists the bar number, area in square inches and millimeters, weight in pounds per foot as well as kilograms per meter, and nominal diameter of the 8 standard metric sizes. At various sites overseas, rebar could be procured locally and could be metric. Table 7-3 is given for comparison. Remember that bar numbers are based on the nearest number of one-eighth inch included in the nominal diameter of the bar. To measure rebar, you must measure across the round/square portion where there is no deformation. The raised portion of the deformation is not measured when measuring the rebar diameter.

Table 7-1.—U.S. Standard Reinforcing Bars

U.S. Standard Reinforcing Steel Bars				
Bar Size Designation	Area Square Inches	Weight lb Per Foot	Diameter	
			inches	mm
#3	.11	.376	.375	9.53
#4	.20	.668	.500	12.7
#5	.31	1.043	.625	15.88
#6	.44	1.502	.750	19.05
#7	.60	2.044	.875	22.23
#8	.79	2.670	1.000	25.40
#9	1.00	3.400	1.128	28.58
#10	1.27	4.303	1.270	31.75
#11	1.56	5.313	1.410	34.93
#14	2.25	7.650	1.693	43.00
#18	4.00	13.600	2.257	57.33

Table 7-2.—Metric Reinforcing Bars

METRIC REINFORCING STEEL BARS						
BAR SIZE DESIGNATION	AREA		WEIGHT		DIAMETER	
	Sq. Inches	Sq. mm	Lb Per Ft	KG/M	Inches	mm
10m	.16	100	.527	.785	.445	11.3
15m	.31	200	1.054	2.355	.630	16.0
20m	.47	300	1.563	2..355	.768	19.5
25m	.78	500	2.606	3.925	.992	25.2
30m	1.09	700	3.649	5.495	1.177	29.9
35m	1.55	1000	5.213	7.850	1.406	35.7
45m	2.33	1500	7.820	11.775	1.710	43.7
55m	3.88	2500	13.034	19.625	2.220	56.4

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Table 7-3.—Comparison of U.S. Customary and Metric Rebar

U.S. Standard Bar		Metric Bar		Metric Bar is:
Bar Size	Area Sq. Inches	Bar Size	Area Sq. Inches	
#3	.11	10m	.16	45% larger*
#4	.20	10m	.16	20% smaller
#4	.20	15m	.31	55% larger
#5	.31	15m	.31	Same
#6	.44	20m	.47	6.8% larger
#7	.60	20m	.47	22% smaller
#7	.60	.25m	.78	30% larger
#8	.79	25m	.78	1.3% smaller
#9	1.00	30m	1.09	9% larger
#10	1.27	30m	1.09	14% smaller
#10	1.27	35m	1.55	22% larger
#11	1.56	35m	1.55	0.6% smaller
#14	2.25	45m	2.33	3.5% larger
#18	4.00	55m	3.88	3.0% smaller
*NOTE: % Difference is based upon area of rebar in square inches.				

Reinforcing Bars

Reinforcing bars are hot-rolled from a variety of steels in several different strength grades. Most reinforcing bars are rolled from new steel billets, but some are rolled from used railroad-car axles or railroad rails that have been cut into rollable shapes. An assortment of strengths are available.

The American Society for Testing Materials (ASTM) has established a standard branding for deformed reinforcing bars. There are two general systems of bar branding. Both systems serve the basic purpose of identifying the marker size, type of steel, and grade of each bar. In both systems an identity mark denoting the type of steel used is branded on every bar by engraving the final roll used to produce the bars so as to leave raised symbols between the deformations. The manufacturer's identity mark that signifies the mill that rolled the bar is usually a single letter or, in some cases, a symbol. The bar size follows the manufacturer's mark and is followed by a symbol indicating new billet steel (-N-), rolled rail steel (-I-), or rolled axle steel (-A-). Figure 7-2 shows the two-grade marking system.

The lower strength reinforcing bars show only three marks: an initial representing the producing mill, bar size, and type of steel. The high strength reinforcing bars use either the continuous line system or the number system to show grade marks. In the line system, one continuous line is rolled into the 60,000 psi bars, and two continuous lines are rolled into the 75,000 psi bars. The lines must run at least five deformation spaces, as shown in figure 7-2. In the number system, a "60" is rolled into the bar following the steel type of mark to denote 60,000 psi bars, and a "75" is rolled into the 75,000 psi bars.

Expanded Metal and Wire Mesh Reinforcement

Expanded metal or wire mesh is also used for reinforcing concrete. Expanded metal is made by partly shearing a sheet of steel, as shown in view A figure 7-3. The sheet steel has been sheared in parallel

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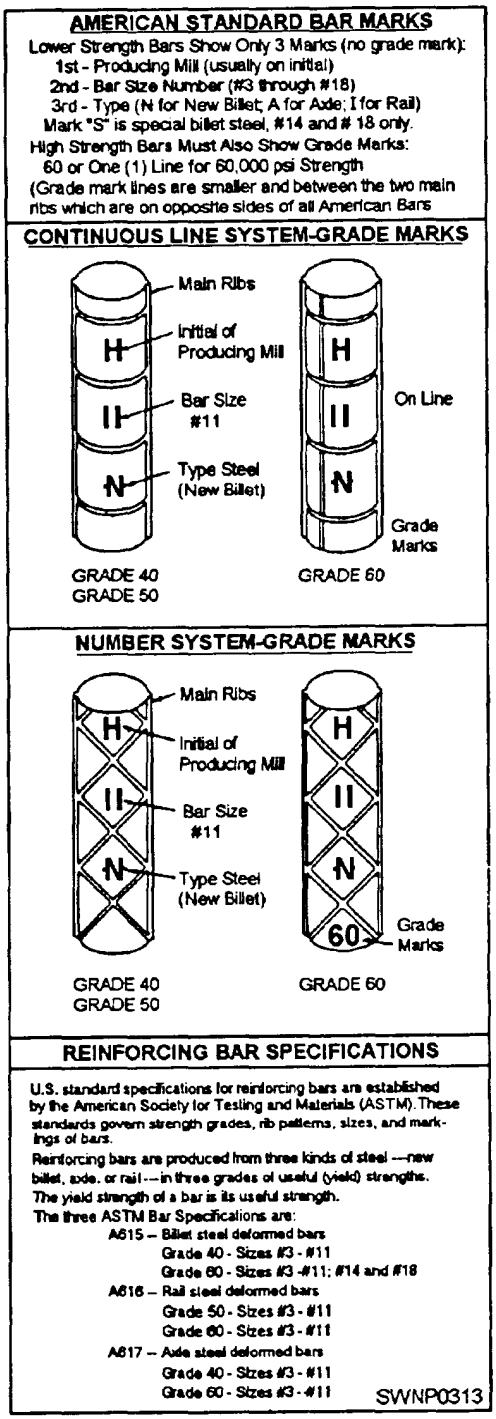


Figure 7-2.—American standard reinforcing bar marks.

lines and then pulled out or expanded to form a diamond shape between each parallel cut. Another type is square, rather than diamond shaped, as shown in view B, figure 7-3. Expanded metal is customarily y used during plastering operations and light reinforcing concrete construction, such as sidewalks and small

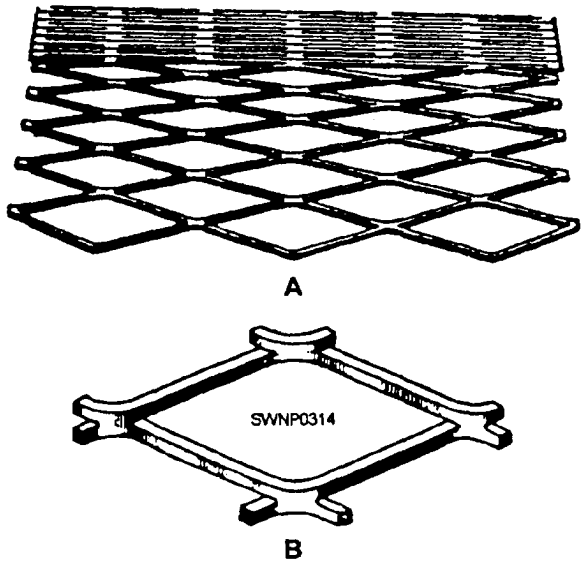


Figure 7-3.—Expanded or diamond mesh steel reinforcement.

concrete pads that do not have to bear substantial weight, such as transformer and air-conditioner pads.

Welded Wire Fabric

Welded wire fabric is fabricated from a series of wires arranged at right angles to each other and electrically welded at all intersections. Welded wire fabric, referred to as WWF within the NCF. has various uses in reinforced concrete construction. In building construction, it is most often used for floor slabs on well-compacted ground. Heavier fabric, supplied mainly in flat sheets, is often used in walls and for the primary reinforcement in structural floor slabs. Additional examples of its use include road and runway pavements, box culverts, and small canal linings.

Four numbers are use-d to designate the style of wire mesh; for example, 6 by 6-8 by 8 (sometimes written 6 x 6 x 8 x 8 or 6 x 6 - W 2.1 x W 2.1). The first number (in this case, 6) indicates the lengthwise spacing of the wire in inches; the second number (in this case, 6) indicates the crosswise spacing of the wire in inches; the last two numbers (8 by 8) indicate the size of the wire on the Washburn and Moen gauge. More recently the last two numbers are a W number that indicates the size of the cross-sectional area in the wire in hundredths of an inch. (See table 7-4.) WWF is currently available within the Navy stock system using the four-digit system, 6 by 6-8 by 8, as of this writing, but if procured through civilian sources, the W system is used.

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Table 7-4—Common Stock Sizes of Welded Wire Fabric

STYLE DESIGNATION		Weight Approximate lb per 100 sq. ft.
Current Designation (by W—Number)	Previous Designation (By Steel Wire Gauge)	
PANELS / SHEETS		
6 x 6 — W 1.4 x W 1.4	6 x 6 — 10 x 10	21
6 x 6 — W 2.1 x W 2.1	6 x 6 — 8 x 8	29
6 x 6 — W 2.9 x W 2.9	6 x 6 — 6 x 6	42
6 x 6 — W 4.0 x W 4.0	6 x 6 — 4 x 4	58
4 x 4 — W 1.4 x W 1.4	4 x 4 — 10 x 10	31
4 x 4 — W 2.1 x W 2.1	4 x 4 — 8 x 8	43
4 x 4 — W 2.9 x W 2.9	4 x 4 — 6 x 6	62
4 x 4 — W 4.0 x W 4.0	4 x 4 — 4 x 4	86
ROLLS		
6 x 6 — W 1.4 x W 1.4	6 x 6 — 10 x 10	21
6 x 6 — W 2,9 x W 2.9	6 x 6 — 6 x 6	42
6 x 6 — W 4.0 x W 4.0	6 x 6 — 4 x 4	58
6 x 6 — W 5.5 x W 5.5	6 x 6 — 2 x 2	80
4 x 4 — W 4.0 x W 4.0	4 x 4 — 4 x 4	86

Light fabric can be supplied in either rolls or flat sheets. Fabric made of wire heavier than W4 should always be furnished in flat sheets. Where WWF must be uniformly flat when placed, fabric furnished in rolls should not be fabricated of wire heavier than W 2.9. Fabricators furnish rolled fabric in complete rolls only. Stock rolls will contain between 700 to 1,500 square feet of fabric determined by the fabric and the producing location. The unit weight of WWF is designated in pounds per one hundred square feet of fabric (table 7-4). Five feet, six feet, seven feet, and seven feet six inches are the standard widths available for rolls, while the standard panel widths and lengths are seven feet by twenty feet and seven feet six inches by twenty feet.

Sheet-Metal Reinforcemat

Sheet-metal reinforcement is used mainly in floor slabs and in stair and roof construction. It consists of annealed sheet steel bent into grooves or corrugations about one-sixteenth inch (1.59 mm) in depth with holes punched at regular intends.

Tension in Steel

Steel bars are strong in tension. Structural grade is capable of safely carrying up to 18,000 psi and intermediate, hard, and rail steel, 20,000 psi. This is the SAFE or WORKING STRESS; the BREAKING STRESS is about triple this.

When a mild steel bar is pulled in a testing machine, it stretches a very small amount with each increment of load. In the lighter loadings, this stretch is directly proportional to the amount of load (fig. 7-4, view A). The amount is too small to be visible and can be measured only with sensitive gauges.

At some pull (known as the YIELD POINT), such as 33,000 psi for mild steel, the bar begins to neck down (fig. 7-4, view B) and continues to stretch perceptibly with no additional load.

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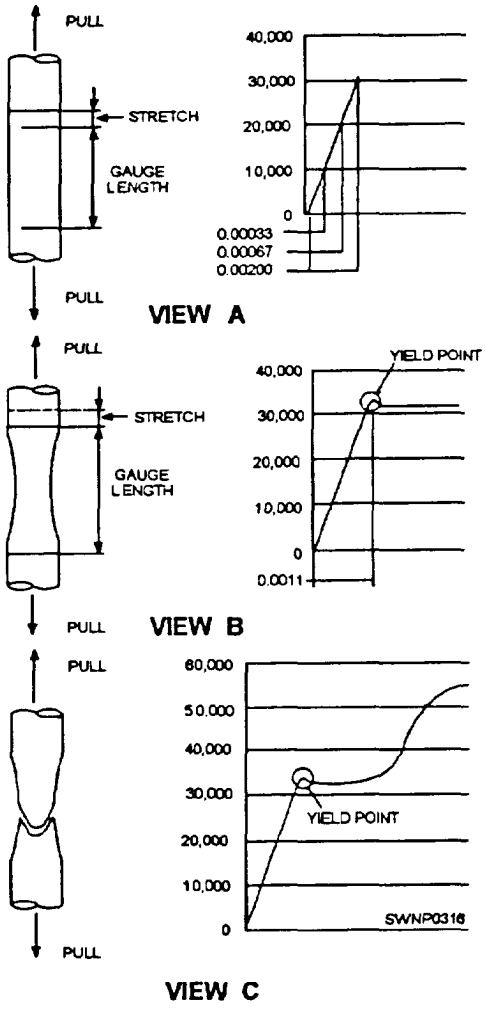


Figure 7-4.—Tension in steel bars.

Then, when it seems the bar will snap like a rubber band it recovers strength (due to work hardening). Additional pull is required (fig. 7-4, view C) to produce additional stretch and final failure (known as the ULTIMATE STRENGTH) at about 55,000 psi for mild steel.

BENDING REINFORCING BARS

The job of bending reinforcing bars is interesting if you understand why bending is necessary. There are several masons. Let us go back to the reason for using reinforcing steel in concrete—the tensile strength and compressive strength of concrete. You might compare the hidden action within a beam from live and dead loads to the breaking of a piece of wood with your knee. You have seen how the splinters next to your knee push toward the middle of the piece of wood when you apply force, while the splinters from the middle to the opposite side pull away from the middle. This is similar to what happens inside the beam.

For instance, take a simple beam (a beam resting freely on two supports near its ends). The dead load (weight of the beam) causes the beam to bend or sag. Now, from the center of the beam to the bottom, the forces tend to stretch or lengthen the bottom portion of the beam. This pad is said to be in tension, and that is where the steel reinforcing bars are needed. As a result of the combination of the concrete and steel, the tensile strength in the beam resists the force of the load and keeps the beam from breaking apart. At the exact center of the beam, between the compressive stress and the tensile stress, there is no stress at all-it is neutral.

In the case of a continuous beam, it is a little different. The top of the beam maybe in compression along part of its length and in tension along another part. This is because a continuous beam rests on more than two supports. Thus the bending of the beam is not all in one direction. It is reversed as it goes over intermediate supports.

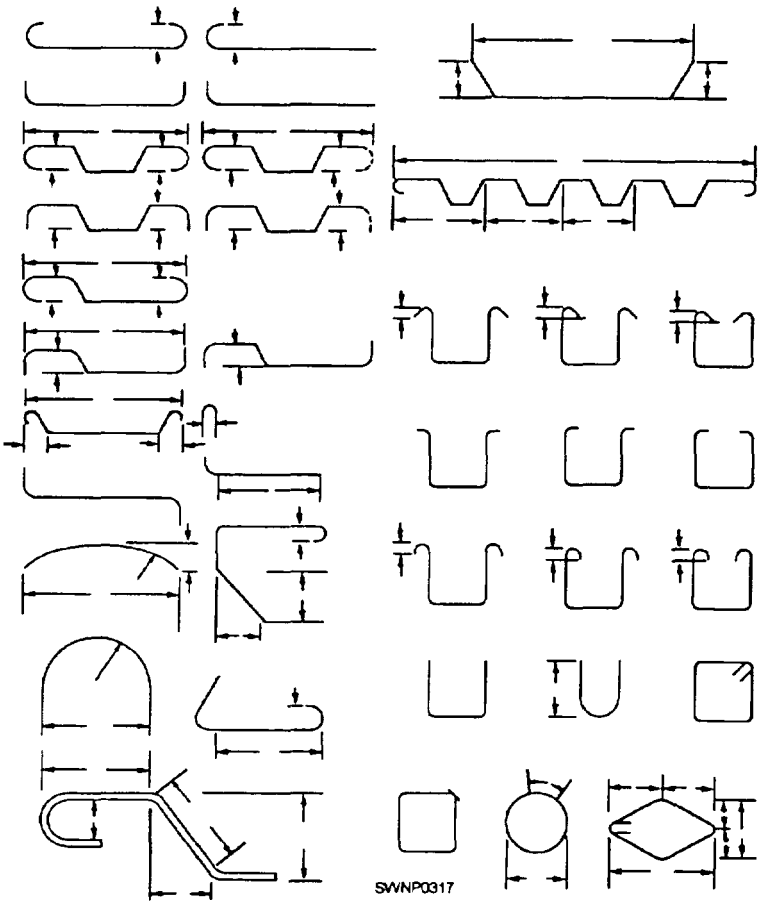
To help the concrete resist these stresses, engineers design the bends of reinforcing steel so that the steel will set into the concrete just where the tensile stresses take place. That is the reason you may have to bend some reinforcing rods in almost a zigzag pattern. The joining of each bar with the next, the anchoring of the bar ends within concrete, and the anchoring by overlapping two bar ends together are some of the important ways to increase and keep bond strength. Some of the bends you will be required to make in reinforcing bars are shown in figure 7-5.

The drawings for a job provide all the information necessary for cutting and bending reinforcing bars. Reinforcing steel can be cut to size with shears or with an oxygas cutting torch. The cutting torch can be used in the field.

Before bending the reinforcing bars, you should check and sort them at the jobsite. Only after you check the bars can you be sure that you have all you need for the job. Follow the construction drawings when you sort the bars so that they will be in the proper order to be bent and placed in the concrete forms. After you have divided the different sizes into piles, label each pile so that you and your crew can find them easily.

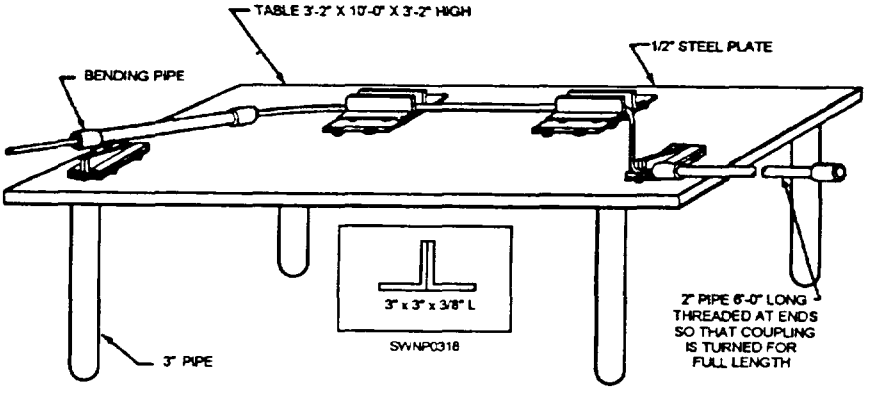
For the job of bending, a number of types of benders can be used. Stirrups and column ties are normally less than No. 4 bar, and you can bend them

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Figure 7-5.—Typical reinforcement bends.



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Figure 7-6.—Bar-bending table.

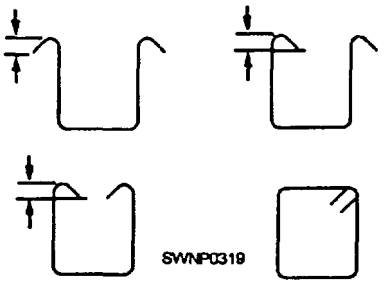
cold by means of the bending table, as shown in figure 7-6. Typical stirrup tie shapes are shown in figure 7-7. Stirrups are used in beams; as shown in figure 7-8. Column ties are shown in position in figure 7-9.

When the bars have to be bent in place, a bending tool, like the one shown in figure 7-10, is effective. By placing the jaws of the hickey on one side of the center of the bend and pulling on the handle, you can produce a smooth, circular bend through almost any angle that is desired.

Bending Guidelines and Techniques

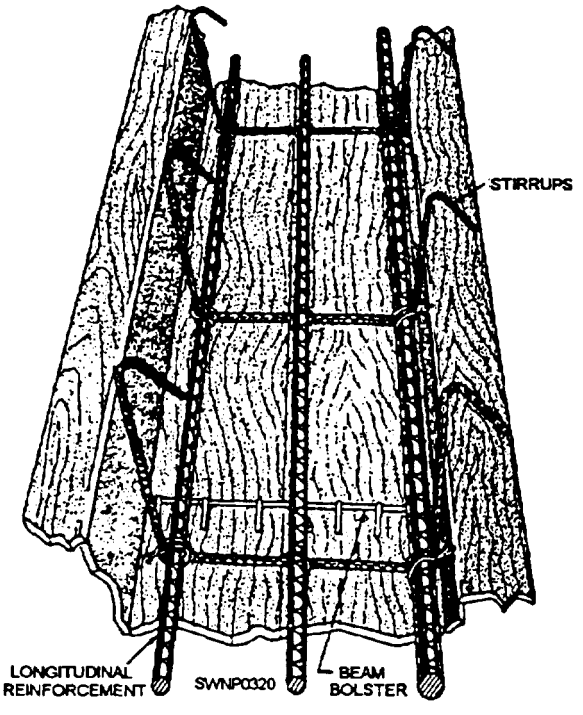
Make bends, except those for hooks, around pins with a diameter of not less than six times the bar diameter for No. 3 through No. 8 bar. If the bar is larger

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Figure 7-7.—Stirrup and column ties.



45.481

Figure 7-8.—Steel in place in a beam

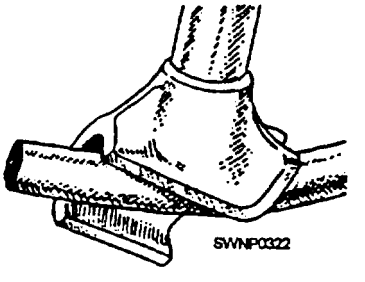
than 1 inch (25.4 mm) (No. 9, No. 10, and No. 11 bar), the minimum pin diameter should be eight times the bar size. For No. 14 through No. 18, the pin diameter should be ten times the diameter of the bar.

To get smooth, sharp bends when bending large rods, slip a pipe cheater over the rod. This piece of pipe gives you a better hold on the rod itself and makes the whole operation smoother. You can heat No. 9 bars and larger to a cherry red before bending them, but make sure you do not get them any hotter. If the steel becomes too hot, it will lose strength, become brittle, and can even crack.



45.482A

Figure 7-9.—Column steel in place.



29.183

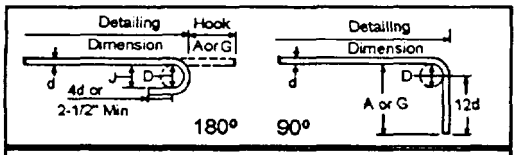
Figure 7-10.—Bending tool.

Bend Diameters

If you do not want your rod to crack while it is being bent, bend it gradually, not with a jerk. Also, do not make your bends too sharp. Bends made on a bar-bending table or block are usually too sharp, and the bar is somewhat weakened. Therefore, certain

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minimum bend diameters have been established for the different bar sizes and for the various types of hooks. These bending details are shown in figure 7-11. You can use many different types of bends. The one you select depends on where you are to place the rods. For example, there are bends on heavy beam and girder bars, bends for reinforcement of vertical columns at or near floor levels, bends for stirrups and column ties, bends for slab reinforcement, and bends for bars or wire for column spiral reinforcement. To save yourself some time and extra work, try to make all bends of one kind at one time instead of remeasuring and resetting the templates on your bending block for different bends.



SIZES OF 180-DEG HOOKS
D = 6d for #3 through #6
D = 8d for #9, #10, and #11
D = 10d for #14 and #18

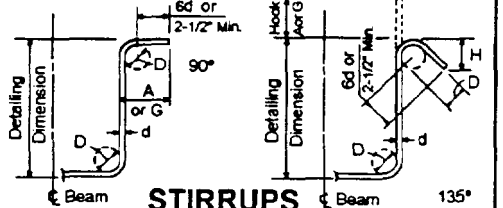
SIZES OF 90-DEG HOOKS
D = 6d for #3 through #6
D = 8d for #9, #10, and #11
D = 10d for #14 and #18

RECOMMENDED END HOOK DIMENSIONS

Bar Size	180° HOOKS All Grades A or G	180° HOOKS All Grades J	90° HOOKS All Grades A or G
#3	5	3	6
#4	6	4	8
#5	7	5	10
#6	8	6	1-0
#7*	10	7	1-2
#8*	11	8	1-4
#9*	1-3	11-1/4	1-7
#10*	1-5	10-1/4	1-10
#11	1-7	1-2-1/4	2-0
#14	2-2	1-8-1/2	2-7
#18	2-11	2-3	3-5

*These sizes - Grade 40 - check availability. Sizes #14 - #18, check availability; no Grade 40 under ASTM.

STIRRUP & TIE HOOKS



RECOMMENDED STIRRUP & TIE HOOK DIMENSIONS
Grades 40-50-60 ksi

Bar Size	D (in.)	90° HOOK Hook A or G	135° HOOK Hook A or G	135° HOOK Approx. H
#3	1-1/2	4	4	2-1/2
#4	2	4-1/2	4-1/2	3
#5	2-1/2	6	5-1/2	3-3/4

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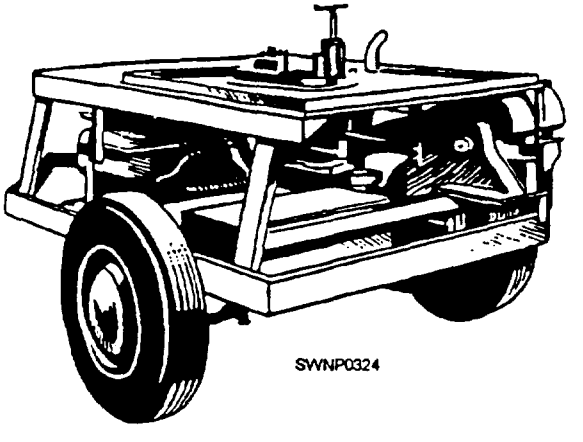
Figure 7-11.—Standard hook details

The Iron master Portable Hydraulic Rod Bender and Shear

The Ironmaster portable hydraulic rod bender and shear (fig. 7-12) can cold-work reinforcing bars into various shapes for use in concrete construction work. The machine is capable of working reinforcing bars up to and including No. 11 bars, which is equivalent in a cross-sectional area to 1 1/4-inch (31.75 mm)-square or 1 1/2-inch (38.1 mm)-round bar.

In addition to all sizes of reinforcing bars, the Ironmaster will also work bars of higher carbon content desired in the fabrication of anchor bolts, and so forth. However, limitations must be imposed when considering bar of 1-inch (25.4 mm) diameter or greater that have a carbon content of greater than 0.18 percent, such as SAE 1020 cold-finished steel. Bars under 1 inch (25.4 mm) in diameter should have a carbon content of no greater than 0.37 percent, such as SAE 1040 C. F. steel.

Although the Ironmaster is powered to work steels of heavier sections than 1 1/2-inch (38.1 mm) reinforcing bar, the manufacturer must place safety limitations on it when considering various alloys and shapes of steel. Users will undoubtedly adapt this versatile machine to perform work other than common bar bending, such as bending flats and angles. However, the primary intention of the manufacturer was to produce a machine for bending concrete reinforcing steel. The manufacturer recommends that the Ironmaster not be used on steels heavier than 1 1/4-inch (31.75 mm)-square or 1 1/2-inch (38.1 mm)-round reinforcing bar.



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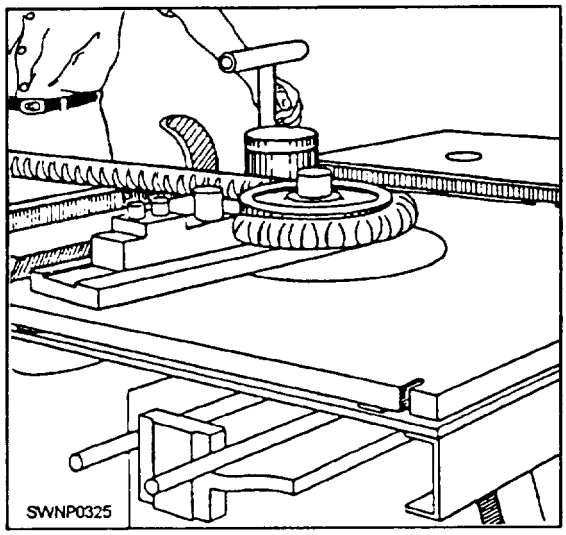
Figure 7-12.—Ironmaster portable hydraulic bender and shear.

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Standard Hook Bending

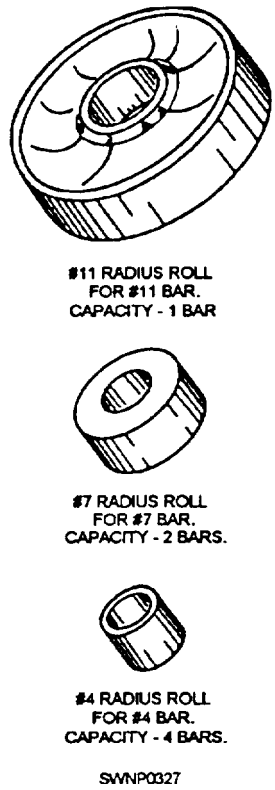
Standard hook bending (fig. 7-13) is accomplished on the turntable section located on top of the machine. Before you start any bending procedure, the turntable must be at the START position as shown in figure 7-14. As an example, when you desire to bend a 180-degree hook in apiece of No. 11 reinforcing bar, setup the machine as shown, using the following: bending cleat with cleat slide and drive pin, main center pin, and No. 11 radius roll. As a safeguard, the radius rolls have been designed to accept only the number of bars specified, suti as No. 7 roll for No. 7 bar (fig. 7-15).

1. Plain the rebar between the cleat slide upright and the radius roll, which is placed over the center pin,



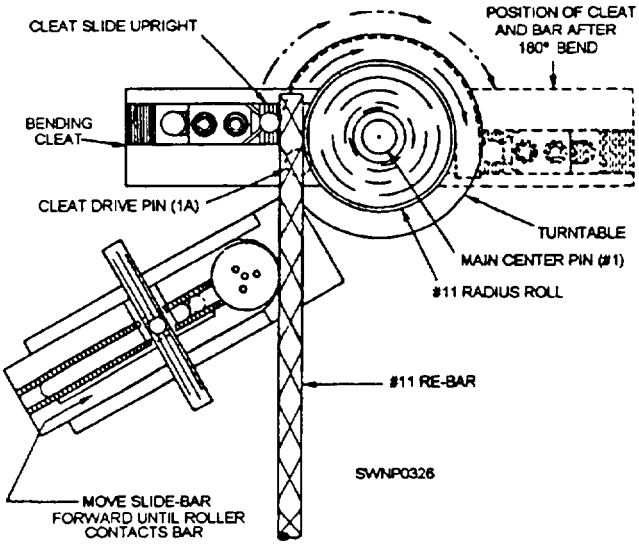
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Figure 7-13.—Ironmaster bar-bending unit.



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Figure 7-15.—Radius rolls for bending rebar on an Ironmaster.



127.283

Figure 7-14.—Example of bending a 180-degree hook with No. 11 rebar.

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with the end of the rebar protruding a sufficient distance for the cleat slide to be upright to engage it where you want the bend to commence.

2. Move the cleat slide to contact the rebar and tighten the locking screws.

3. Move the positioner slide bar until the roller contacts the rebar and tightens the T handle.

4. Set the desired angle 'of bend on the graduated control rod which is under the right side of the working table. This is done by placing the trigger pin of the rear adjustable stop (toward the rear of the machine) in the hole corresponding to the angle of bend, in this case, 180 degrees. This rod is graduated from 5 degrees to 190 degrees at 5-degree intervals.

NOTE: ENSURE THE FRONT ADJUSTABLE STOP TRIGGER PIN IS IN THE "O' HOLE, so the turntable will return to and stop in the START position when retracted after the bend.

5. Advance the engine throttle to operating speed, and move either the rear bending control lever or slide bending control lever to the bend position. This actuates the bend cylinder. The lever will stay in the bending position until the bend is completed, the rack movement disengaging the cylinder, and the levers returning to neutral automatically.

6. To remove the rebar from the machine after the bend is completed, apply light intermittent reverse pressure to the lever until the bar releases from the radius roll. After removal of the hook from the machine, move the lever to the position shown on "retract" to return the turntable to the START position.

Multiple Bending

Multiple bending is accomplished the same way as standard hook bending for bars up to No. 8 simply by placing the bars in the machine one on top of the other.

Table 7-5 shows the bars that may be bent by the Ironmaster and the number of bars it will bend in one operation.

On the side of the machine next to the shear is the shearing support (fig. 7-16). This support holds the bars square between the shear blades and prevents them from "kicking up" during shearing. The upper jaw of the shearing support is adjustable. For bars three-fourths inch and smaller, place this jaw in the LOWER position. For larger bars, use the UPPER position. NEVER SHEAR WITHOUT USING THIS SUPPORT.

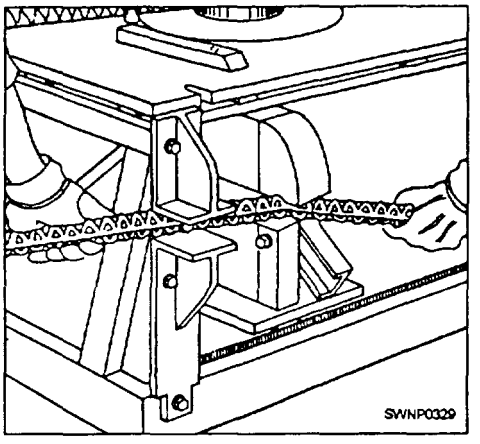
To operate, insert the bar to be cut to the farthest point possible toward the inside of the blades (fig. 7-15), making sure that the blades are in the fully OPEN or RETRACT position. With light downward pressure on the shear control lever, hold the bar in this position until the shear grips. Continue applying pressure downward to the full limit of the lever until the bar is sheared To retract the shear, pull the lever up.

The same-size bar that can be bent can be sheared Multiple shearing, however, can be accomplished only on bars of less than 0.44-square-inch area. When shearing more than one bar at a time, always place the bars side by side in the shear, as shearing with bars piled on top of each other may cause blade failure.

Table 7-5.—Single Operation Multibending

Bar #	Bar Size in Inches	Number of Bars that can be Bent in One Operation
3	3/8rd	6
4	1/2rd	4
5	5/8rd	3
6	3/4rd	3
7	7/8rd	2
8	1 rd	2
9	1 rd	1
10	1 1/8 sq	1
11	1 1/4 sq	1

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Figure 7-16.—Ironmaster bar-cutting unit.

Table 7-6 shows the number of bars that can be sheared at one time.

The care and maintenance of the Ironmaster portable hydraulic rod bender and shear consist primarily of lubrication and cleaning. There are grease fittings on the machine. Keep these points well lubricated with a good grade of grease, but do not overlubricate, as the surplus grease will collect dirt and rust scale from the rebars. When greasing the shear pin, work the shear arm up and down until grease appears between the arm and the side ears. When using the stirrup bending attachment, keep the center pin clean and well lubricated.

Rust scale from the rebar will accumulate in the holes in the turntable and worktable and in the serrations in the bending cleat and roller slide. Keep these cleaned out, particular] y when changing over to or from the stirrup bending attachment or changing a center pin by means of a solvent-soaked rag or brush. Keep the worktable as clean as possible to minimize the amount of rust scale dropping through to the rack and gear.

PLACING AND TYING REINFORCING STEEL

Before you place reinforcing steel in forms, all form oiling should be completed. Oil on reinforcing bars should be avoided because it reduces the bond between the bars and the concrete. Use a piece of burlap to remove rust, mill scale, grease, mud, or other foreign matter from the bars. A light film of rust or mill scale is not objectionable.

Bars are marked to show where they will fit. You may work according to either one of the two most-used systems for marking bars; however, the system you use should agree with the marking system which appears on the engineering or assembly drawings. The two marking systems used are as follows:

1. All bars in one type of member are given the mark of that member. This system is used for column bars, beam bars, footing bars, and so on.

2. The bars are marked in greater detail. These marks show exactly where the bar is to be placed. In addition to the type member (that is, beam (B), wall (W), column (C), and so on), the marks show the floor on which the bars are to be placed and the size and individual number of each particular bar. Instead of showing the bar size by its diameter measurement, the mark shows the bar size in code by eighths. The examples shown below show the second type of marking system.

2B805 2 = second floor
B = beam member
8 = 8/8- or 1 -inch (2.5 cm)-square bar
05 = part of the second floor plan designated by the number 5

2B0605 2 = second floor
B = beam member
06 = 6/8- or 3/4-inch (1.9 cm)-round bar
05 = part of second floor plan designated by the number 5

Tie wire is used to hold rebar in place to ensure that when concrete is placed the bars do not shift out of position. Sixteen gauge wire is used to tie

Table 7-6.—Multishearing

Bar Size	Quantity
3,4,5,6	4
7	3
8	2
9, 10, 11	1

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reinforcing bars. About 12 pounds (5.4 kg) of wire is required to tie an average ton (0.9 tome) of bars.

NOTE: Tie wire adds nothing to the strength of the steel.

A number of different types of ties can be used with reinforcing bars; some are more effective than others. Figure 7-17 shows six types of ties that are identified below according to the letters of the alphabet used to show individual ties.

A. SNAP TIE or SIMPLE TIE. The wire is simply wrapped once around the two crossing bars in a diagonal manner with the two ends on top. These are twisted together with a pair of sidecutters until they are very tight against the bars. Then the loose ends of the wire are cut off. This tie is used mostly on floor slabs.

B. WALL TIE. This tie is made by going about 1 1/2 times around the vertical bar, then diagonally around the intersection, twisting the two ends together until the connection is tight, but without breaking the tie wire, then cutting off the excess. The wall tie is used on light vertical mats of steel.

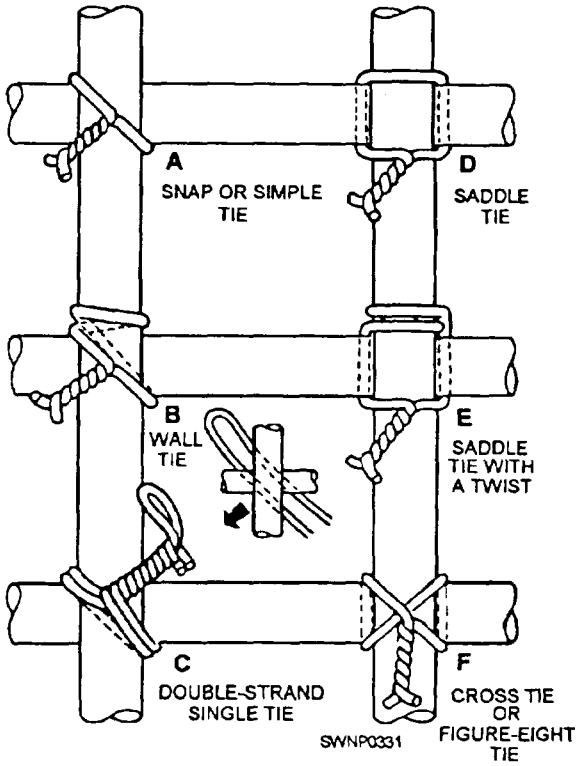
C. DOUBLE-STRAND SINGLE TIE. This tie is a variation of the simple tie. It is especially favored for heavy work

D. SADDLE TIE. The wires pass halfway around one of the ban on either side of the crossing bar and are brought squarely or diagonally around the crossing bar with the ends twisted together and cut off. This tie is used on special locations, such as on walls.

E. SADDLE TIE WITH TWIST. This tie is a variation of the saddle tie. The tie wire is carried completely around one of the bars, then squarely across and halfway around the other, either side of the crossing bars, and finally brought together and twisted either squarely or diagonally across. The saddle tie with twist is used for heavy mats that are to be lifted by a crane.

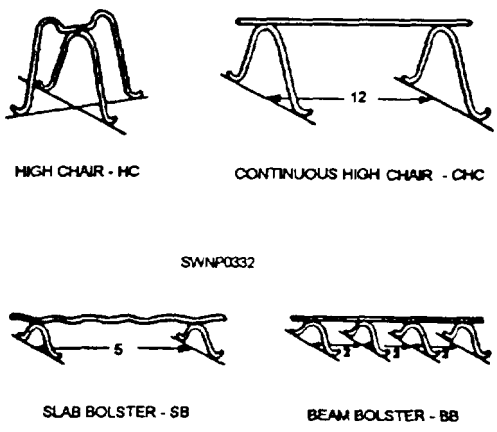
F. CROSS TIE or FIGURE-EIGHT TIE. This type of tie has the advantage of causing little or no twist in the bars.

The proper location for the reinforcing bars is usually given on drawings (table 7-7). In order for the structure to withstand the loads it must carry, place the steel in the position shown. Secure the bars in position in such a way that concrete-placing operations will not move them. This can be accomplished by the use of the reinforcing bar supports shown in figures 7-18, 7-19, and 7-20.



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Figure 7-17.—Six types of ties.



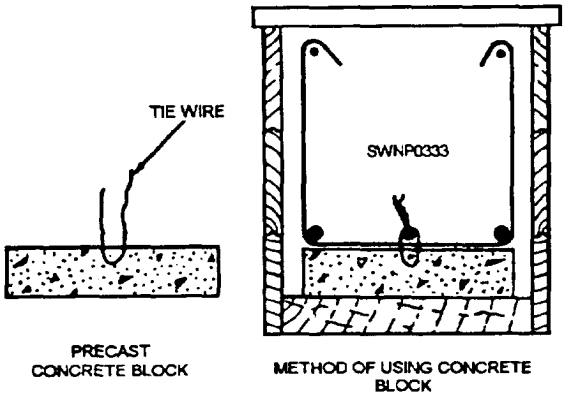
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Figure 7-18.—Reinforcement bar accessories.

The proper coverage of bars in the concrete is very important to protect the bars from fire hazards, possibility of corrosion, and exposure to weather. When not specified, minimum standards given below and in figure 7-21 should be observed.

FOOTINGS-3 inches at the sides where concrete is cast against the earth and on the bottoms of footings or other principal structural members where concrete is deposited on the ground.

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Figure 7-19.—Precast concrete block used for rebar support.

WALLS-2 inches for bars larger than No. 5, where concrete surfaces, after removal of forms, would be exposed to the weather or be in contact with the ground; 1 1/2 inches for No. 5 bars and smaller; 3/4 inch from the faces of all walls not exposed directly to the ground or the weather.

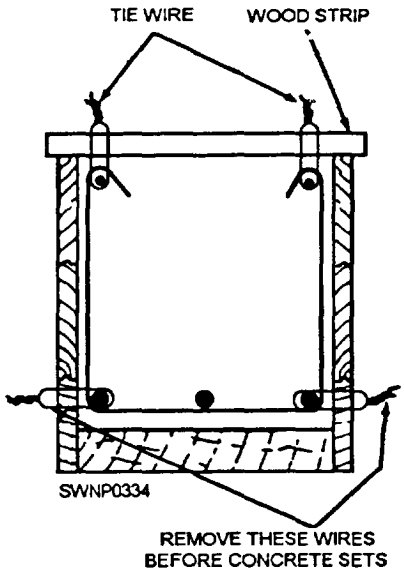
COLUMNS—1 1/2 inches over spirals and ties.

BEAMS AND GIRDERS—1 1/2 inches to the nearest bars on the top, bottom, and sides.

JOISTS AND SLABS—3/4 inch on the top, bottom, and sides of joists and on the top and the bottom of slabs where concrete surfaces are not exposed directly to the ground or the weather.

NOTE: All measurements are from the outside of the bar to the face of the concrete, NOT from the main steel, unless otherwise specified.

Footings and other principal structural members that are against the ground should have at least 3



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Figure 7-20.—Rebar hung in place.

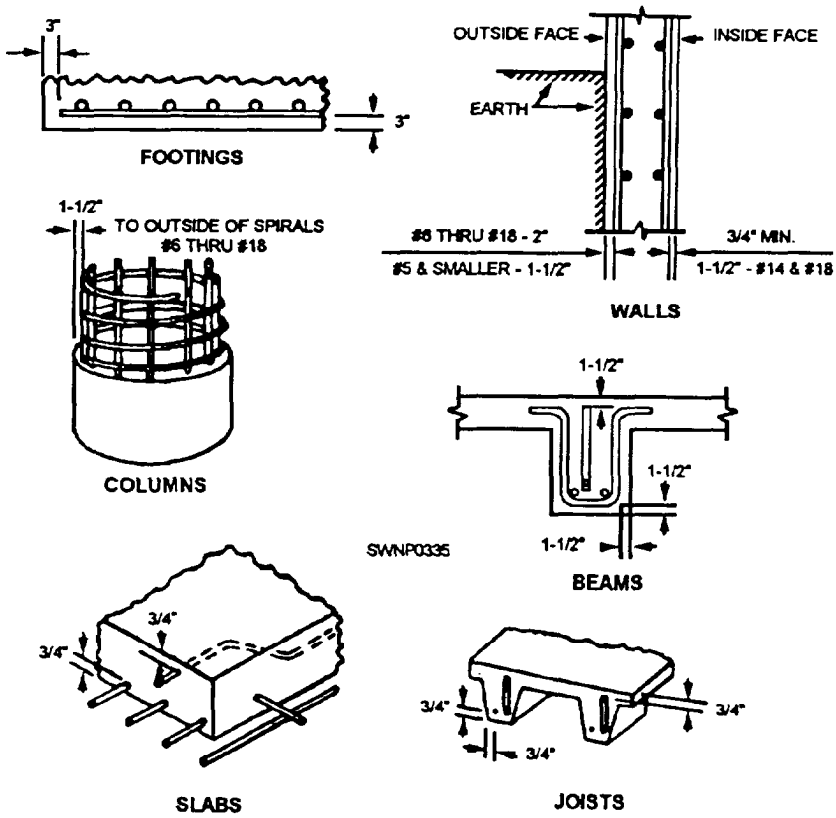
inches (76.2 mm) of concrete between the steel and the ground. If the concrete surface is to be in contact with the ground or exposed to the weather after removal of the forms, the protective covering of concrete over the steel should be 2 inches (50.8 mm). It maybe reduced to 1 1/2inches (38.1 mm) for beams and columns and 3/4 inch (19.5 mm) for slabs and interior wall surfaces, but it should be 2 inches (50.8 mm) for all exterior wall surfaces. This measurement is taken from the main rebar, not the stirrups or the ties.

NOTE: Where splices in reinforcing steel are not dimensioned on the drawings, the bars should be lapped not less than 30 times the bar diameter nor less than 12 inches (table 7-7). The stress in a tension bar

Table 7-7.—Length of Lap Splices in Reinforcing Steel

INCHES OF LAP CORRESPONDING TO NUMBER OF BAR DIAMETERS*											
Number of Diameters	Size of Bars										
	#3	#4	#5	#6	#7	#8	#9	#10	#11	#14	#18
30	12	15	19	23	27	30	34	39	43	51	68
32	12	16	20	24	28	32	36	41	45	55	73
34	13	17	22	26	30	34	39	44	48	58	77
36	14	18	23	27	32	36	41	46	51	61	82
38	15	19	24	29	34	38	43	49	54	65	86
40	15	20	25	30	35	40	46	51	57	68	91
Minimum lap equals 12 inches!											
*Figured to the next larger whole inch											

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Figure 7-21.—Minimum coverage of rebar in concrete.

can be transmitted through the concrete and into another adjoining bar by a lap splice of proper length.

To lap-weld wire fabric/wire mesh, you can use a number of methods, two of which are the end lap and the side lap. In the end lap method, the wire mesh is lapped by overlapping one full mesh, measured from the ends of the longitudinal wires in one piece to the ends of the longitudinal wires in the adjacent piece, and then tying the two pieces at 1-foot 6-inch (45.0 cm) centers with a snap tie. In the side lap method, the two longitudinal side wires are placed one alongside and overlapping the other and then are tied with a snap tie every 3 feet (.9 m).

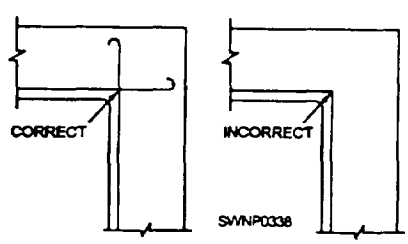
Reinforcing bars are in tension and therefore should never be bent around an inside corner beams. They can pull straight through the concrete cover. Instead, they should overlap and extend to the far face for anchorage with 180-degree hooks and proper concrete coverage (fig. 7-23).

The bars can also be spliced by metal arc welding but only if called for in the plans and specifications. For bars which are placed in a vertical position, a butt weld is preferred. The end of the bottom bar is cut



127.85

Figure 7-22.—Bars spliced by lapping.



145.66X

Figure 7-23.—Correct and Incorrect placement of reinforcement for an inside corner.

square, and the end of the top bar resting on it is cut in a bevel fashion, thus permitting a butt weld. For bars which will bear a load in a horizontal position, a fillet weld is preferred. Usually, the two bars are placed end to end (rather than overlapping), and pieces of flat bar (or angle iron) are placed on either side. Fillet welds are then made where the metals join. The welds are

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made to a depth of one half of the bar diameter and for a length eight times the bar diameter.

The minimum clear distance between parallel bars in beams, footings, walls, and floor slabs should either be 1 inch (25.4 mm) or 1 1/3 times the largest size aggregate particle in the concrete, whichever distance is greater. In columns, the clear distance between parallel bars should be not less than 1 1/2 times the bar diameter or 1 1/2 times the maximum size of the coarse aggregate. Always use the larger of the two.

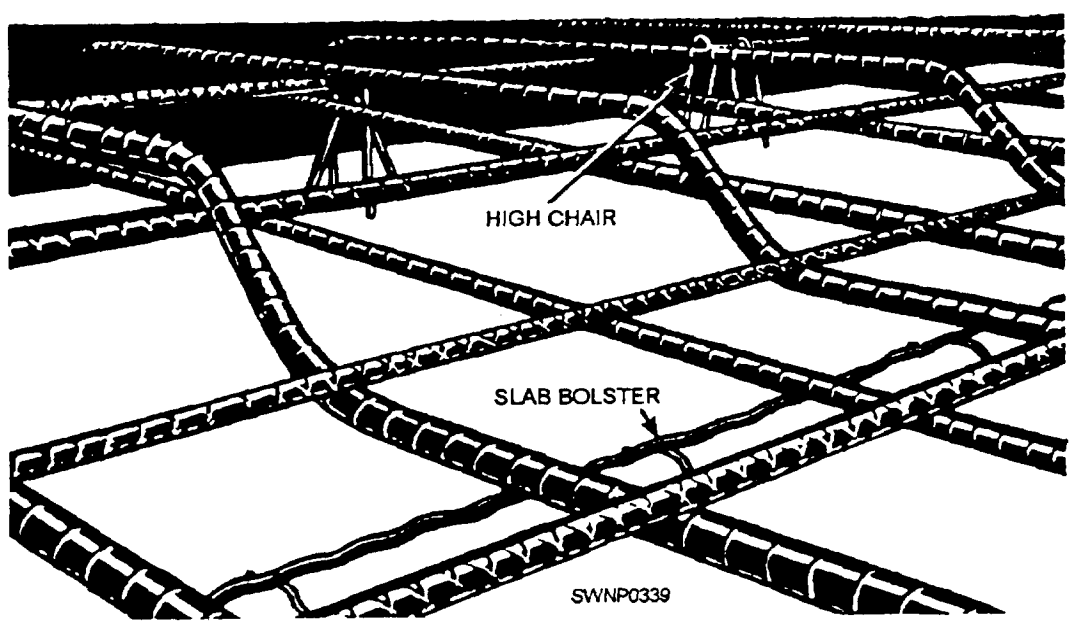
The support for reinforcing steel in floor slabs is shown in figure 7-24. The height of the slab bolster is determined by the required concrete protective cover. Concrete blocks made of sand-cement mortar can be used in place of the slab bolster. Wood blocks should never be used for this purpose. Highchairs (fig. 7-18) can be obtained in heights up to 6 inches (15 cm). When a height greater than 6 inches is required, make the chair out of No. 0, soft, annealed iron wire. To hold the bars firmly in position, you should tie the bars together at frequent intervals where they cross with a snapat.

Steel for column ties may be assembled with the verticals into cages by laying the vertical bars for one side of the column horizontally across a couple of sawhorses. The proper number of ties are slipped over the bars, the remaining vertical bars are added, and then the ties are spaced out as required by the placing plans. All intersections are wired together to make the assembly rigid so that it may be hoisted and set as a unit. Figure 7-25 shows atypical column tie assembly.

After the column is raised, it is tied to the dowels or reinforcing steel carried up from below. This holds it firmly in position at the base. The column form is erected and the reinforcing steel is tied to the column form at 5-foot (4.5-m) intervals, as shown in figure 7-26.

The use of metal supports to hold beam reinforcing steel in position is shown in figure 7-8. Note the position of the beam bolster. The stirrups are tied to the main reinforcing steel with a snap tie. Wherever possible you should assemble the stirrups and main reinforcing steel outside the form and then place the assembled unit in position. Precast concrete blocks, as shown in figure 7-27, maybe substituted for metal supports.

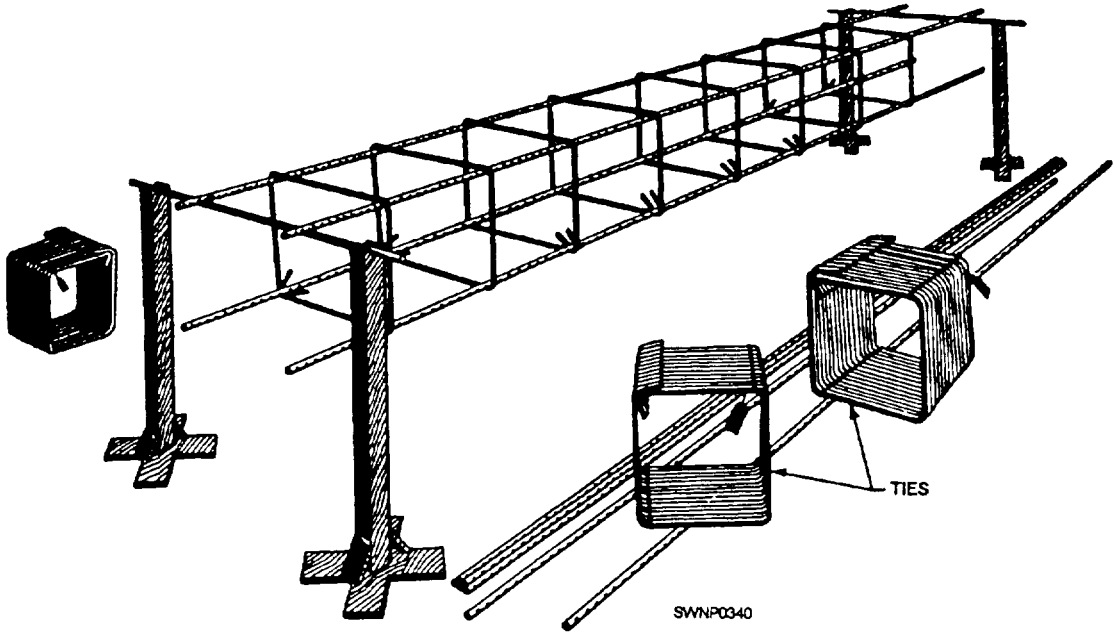
The horizontal and vertical bars are wired securely to each other at sufficiently frequent intervals to make a rigid mat. Tying is required at every second or third intersection, depending upon the size and spacing of bars, but with not less than three ties to any one bar, and, in any case, not more than 4 to 6 feet apart in either direction.



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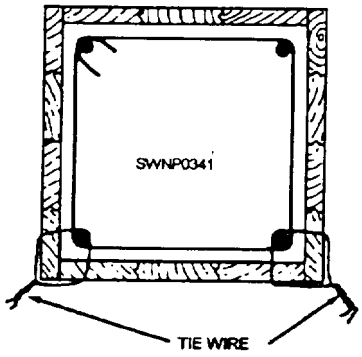
Figure 7-24.—Steel in place in a floor slab.

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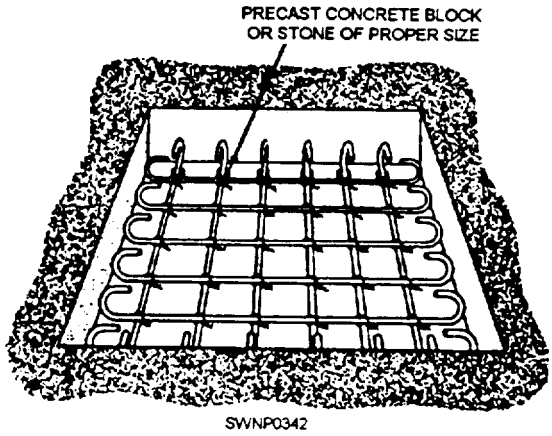
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Figure 7-25.—Column assembly.



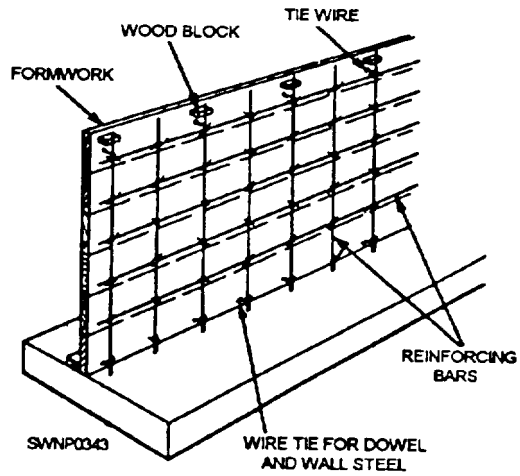
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Figure 7-26.—Method of holding column steel in plain in formwork.



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Figure 7-27.—Steel in place in a footing.



127.88

Figure 7-28.—Steel in place on a wall form

Steel in place in a wall is shown in figure 7-28. The wood block is removed when the form has been filled up to the level of the block For high walls, ties in between the top and bottom should be used.

Steel is placed in footings very much as it is placed in floor slabs. Stones, rather than steel supports, may be used to support the steel at the proper distance above the subgrade. Steel mats in small footings are generally preassembled and placed after the forms have been set. A typical arrangement is shown in figure 7-27. Steel mats in large footings are constructed in place.

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CHAPTER 8

PRE-ENGINEERED STRUCTURES: BUILDINGS, K-SPANS, TOWERS, AND ANTENNAS

As a Steelworker, pre-engineered metal structures are a special interest to you; you are expected to assemble and disassemble them. Rigid-frame buildings, k-spans, steel towers, and antennas are some of the more commonly used structures, particularly at advanced bases overseas.

All pre-engineered structures, discussed in this text, are commercially designed structures, fabricated by civilian industry to conform to the specifications of the armed forces. The advantage of pre-engineered structures is that they are factory-built and designed to be erected in the shortest possible time. Each pre-engineered structure is shipped as a complete building kit including all the necessary materials and instructions to erect it.

Various types of pre-engineered structures are available from numerous manufacturers, such as Strand Corporation, Pasco, and Butler; however, all are similar because each is built to military specifications. It would not be practical to try and include all of the structures that each company fabricates; therefore, in this manual a description of the basic procedures for erecting and dismantling the 40-foot by 100-foot building is provided as an example.

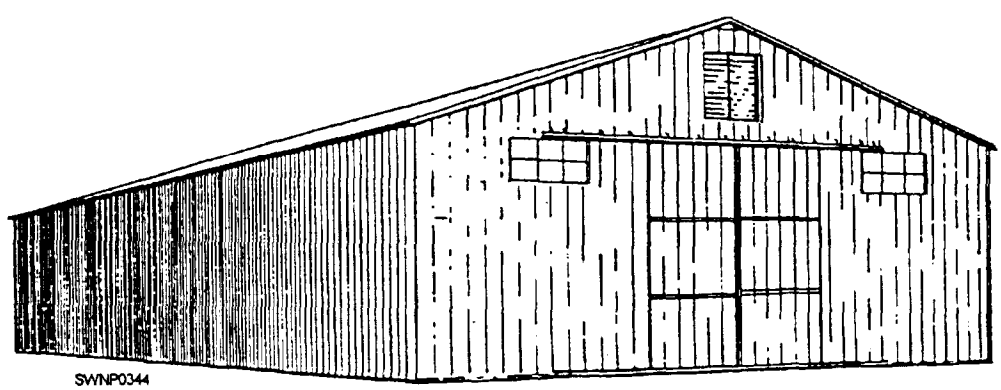
PRE-ENGINEERED BUILDINGS

This chapter introduces you to the design, the structure, and the procedures for the erection of the typical pre-engineered buildings (P.E.B.), the K-spans, the pre-engineered towers, and the antennas.

The basic pre-engineered metal building (fig. 8- 1) **is** 40 feet wide by 100 feet long. Although the unit length of the building is 100 feet, the length can be increased or decreased in multiples of 20 feet, which are called “20-foot bays.” The true building length will be equal to the number of 20-foot bays plus 6 inches; each end bay is 20 feet 3 inches. The building is 14 feet high at the cave and 20 feet 8 inches at the ridge.

Pre-engineered buildings are ideal for use as repair shops or warehouses because they have a large, clear floor area without columns or other obstructions as well as straight sidewalls. This design allows floor-to-ceiling storage of material and wall-to-wall placement of machinery. The column-free interior also permits efficient shop layout and unhindered production flow.

After a building is up, it can be enlarged while in use by "bays", providing additional space under one roof. If desired, buildings can be erected side by side “in multiples.” When a building is no longer needed it can be disassembled, stored, or moved to another location and re-erected because only bolted connections are used. There is no field riveting or welding. The rigid frame is strong. It is designed for



127.121

Figure 8-l.—Completed 40-foot by 100-foot by 14-foot pre-engineered building.

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working loads of 20 pounds per square foot load, plus the dead load, and the load from a 70 mph wind.

The building can be easily modified to varying lengths and purposes by taking out or adding bays or by substituting various foundation and wall sections. A bay is the distance between two column centers or between the end wall and the first column center in from the end wall.

Formulas used to determine the number of bays, frames, and intermediate frames in a building are as follows:

Length divided by 20= number of bays

Bays + 1 = total number of frames

Total number of frames -2 = number of intermediate frames

PRE-ERECTION WORK

Extensive pre-erection work is required before you start the actual erection of a building. After the building site is located and laid out by the Engineering Aids, it will then be cleared and leveled by Equipment Operators. Batter boards are set up in pairs where each comer of the foundation is located. Builders fabricate the forms for concrete while Steelworkers are cutting, bending, tying, and placing reinforcing steel. If this particular building requires underslab utilities (that is, plumbing and electrical service), the Utilitiesman and Construction Electricians will also be on the jobsite. Last, all underslab work must be completed and pass all Quality Control inspections before concrete is placed and finished.

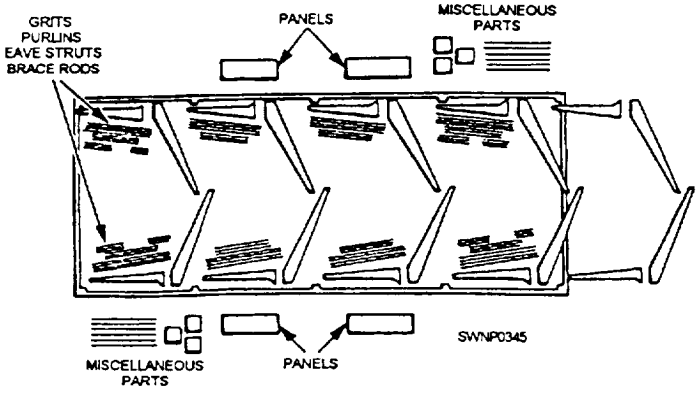
Most importantly (as far as ease of erection is concerned), before the concrete is placed, templates for the anchor bolts are attached to the forms, and the anchor bolts are inserted through the holes in each. Next, the forms are tied to make sure they remain vertical. It must be stressed at this point that the proper placement of the anchor bolts is absolutely critical in the erection of a P.E.B. You will only have a tolerance of plus or minus one eighth of an inch to work with. The threads of the bolts are greased, and the nuts are placed on them to protect the threads. Concrete is poured into the formwork and worked carefully into place around these bolts, so they will remain vertical and in place. Finally, according to the plans and specifications, the slab is poured.

While the foundation is being prepared, the crew leader will assign personnel/crews to perrform various types of preliminary work, such as uncrating and inventorying all material on the shipping list, bolting up rigid-frame assemblies, assembling door eaves, and glazing windows. Box 1 contains the erection manual, the drawings, and an inventory list and should be opened first. If all of the preliminary work is done correctly, the assembly and erection of the entire building is accomplished easily and quickly.

All material, except the sheeting, should be uncrated and laid out in an order] y manner, so the parts can be located easily. Do not uncrate the sheeting until you are ready to install it. When opening the crates, use care not to cause any undue damage to the lumber. This is important since the lumber can be used for sawhorses and various other items around the jobsite.

In most situations, after the building foundation has been prepared, building materials should be placed around the building site new the location where they will be used (fig. 8-2). This action provides the greatest accessibility during assembly.

Girts, purlins, cave struts, and brace rods should be equally divided along both sides of the foundation.



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Figure 8-2.—Material layout

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Panels and miscellaneous parts, which will not be used immediately, should be placed on each side of the foundation on pallets or skids and covered with tarps or a similar type of covering until needed. Parts, making up the rigid-frame assemblies, are laid out ready for assembly and in position for raising.

Care should always be used in unloading materials. Remember that damaged parts will cause delays in getting the job done. To avoid damage, lower the materials to the ground slowly and do not drop them.

Figure 8-3 will help you identify the structural members of the building and their location. Each part has a specific purpose and must be installed in the location called for to ensure a sound structure. NEVER OMIT ANY PART CALLED FOR ON THE DETAILED ERECTION DRAWINGS. Each of the members, parts, and accessories of the building is labeled by stencil, so it is not necessary to guess which one goes where. Refer to the erection plans to find the particular members you need as you work.

ERECTION PROCEDURES

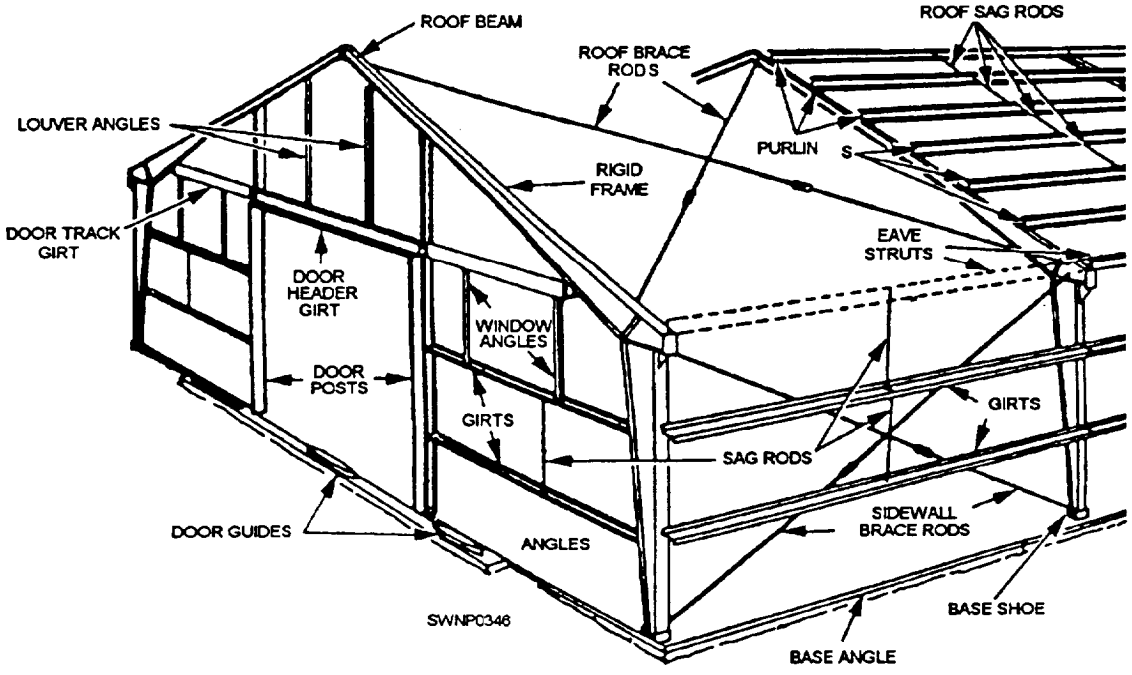
With all pre-erection work completed, inspected, and passed by Quality Control, as well as your inventory completed, you are ready to start erecting the P.E.B. This phase of our discussion will introduce you to the basic erection procedures. The reason for these instructions is to give you a general guide to follow. Keep in mind that the drawings provided by the manufacturer must be followed in all cases, even where the they might differ from information in this training manual. The manufacturer's standard practice is to always pack an erection manual and a set of drawings in the small parts box (Box 1) shipped with each building.

Bolting Rigid Frames

Before bolting up the rigid-frame assembly, clean all the dirt and debris from the top of the foundation, Then lay out and bolt the base shoes firmly to the concrete, using the 5/8-inch black steel washers between the shoes and the nuts. Lay out an assembled column and roof beam at each pair of base shoes (fig. 8-4), using one 3/4-inch by 1 l/2-inch bolt on each side of each base shoe to act as pivots in raising the frame. Use driftpins, if necessary, to line up the holes.

Frame Erection

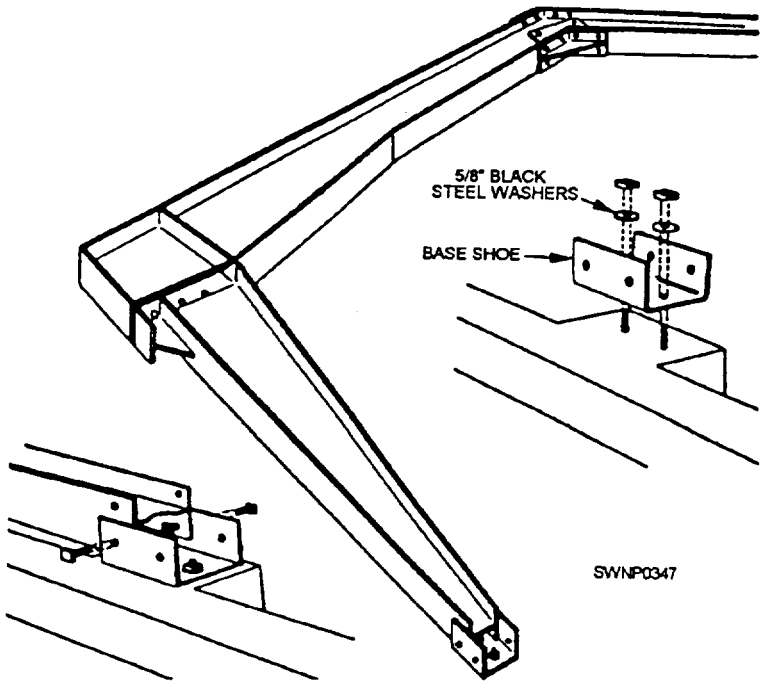
A gin pole (chapter 6) can be used to raise the end frame of the building. To prevent distortion of the



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Figure 8-3.—Structural members of a pre-engineered building.

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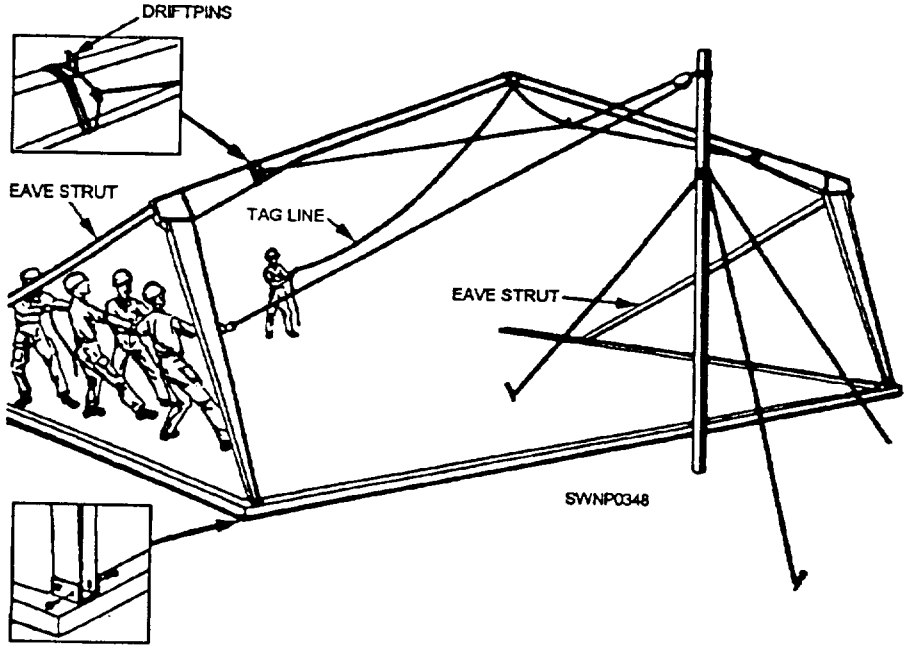


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Figure 8-4.—Frame assembly.

frame when it is being raised, attach a bridle securely to each side of the frame below the splice connection and also to the ridge on the roof beam. Drop a driftpin in the flame, as shown in figure 8-5, to prevent the bridle from slipping up. Set up the gin pole with a block at the top. If a gin pole is not available, take three 2 by 6's, 20 feet long, from the longest shipping crate and nail them together.

Attach a tag line to the name, as shown in figure 8-5. Now, pull the end frame into the vertical position, using a crew of four or five people on the erection line. A tag person should have something to take a couple



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Figure 8-5.—Frame erection.

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of turns around, such as the bumper of a truck. Then, if the frame should go beyond the vertical, the tag person would be able to keep it from falling.

To get the frame started from the ground, it should be lifted by several people and propped up as high as practical. Bolt an cave strut to each column, as shown in figure 8-5. The cave struts allow the frame to be propped at every stage of the lifting. After the frame is in a vertical position, install guy lines and props to it so it cannot move.

Now, raise the second frame in the same way, and hold it vertically in place by installing purlins, girts, and brace rods.

A crane or other suitable type of power equipment can be used to hoist the frames into place where such equipment is available. When power equipment is used, the suggested procedure to comply with is as follows:

1. Raise the columns and bolt them to the base shoes and then brace them in plain.

2. Install all sidewall girts to keep the columns as rigid as possible.

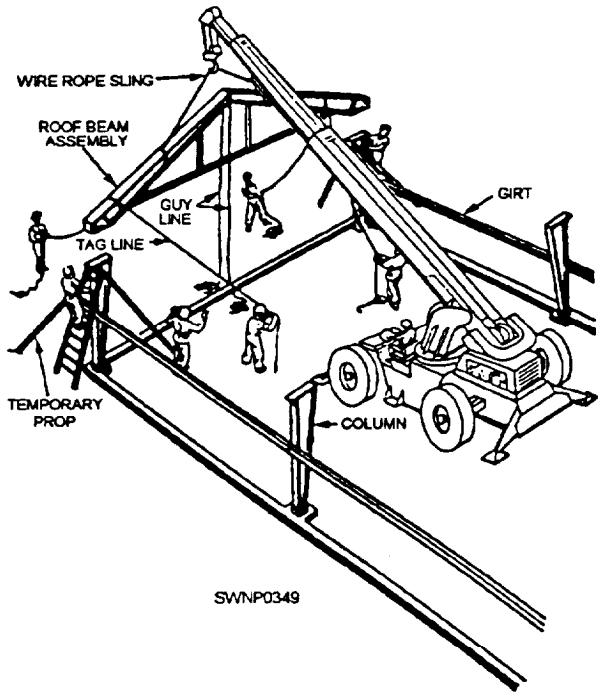
3. Bolt the roof beams together and install the gable posts and end-wall header.

4. Secure the guy lines, and tag lines to the roof beams, as shown in-figure 8-6. Attach a wire rope sling at approximately the center of each roof beam.

5. Hoist the roof beams into position on top of the columns and bolt them in place.

6. When the second rigid-frame section is secured in position, install all of the roof purlins, the gable angles, and the louver angles. Attach the gable clips to the purlins before raising into position.

7. Install the brace rods and align the first bay. THE FIRST BAY MUST BE ALIGNED BEFORE ERECTING ADDITIONAL BAYS.



127.129

Figure 8-6.—Using power equipment.

Brace Rods

Brace rods must be installed in the first bay erected (fig. 8-7). These rods are of paramount importance since the y hold the frames in an upright position. THEY SHOULD NEVER BE OMITTED.

The diagonal brace rods are attached to the frames in the roof and sidewall through the slotted holes provided. Use a half-round brace rod washer and a flat steel washer under the nuts at each end of the rods. With the rods installed, plumb each frame column with the carpenter's spirit level.

Check the distance diagonally from the upper comer of one frame to the lower comer of the adjacent frame. When this distance is the same for each rod, the columns will be plumb. After the sidewall rods are installed, install the roof rods. The length of the roof rods can be adjusted by tightening or loosening the turnbuckle. When the two diagonal measurements are the same, the end bay will be square.

After the two frames have been plumbed and braced square with the diagonal rods (and the purlins, the girts, and the eave struts have been installed), the guy lines or props can be removed and the remaining frames of the building can be erected. To raise the next frame, attach blocks to the last frame raised.

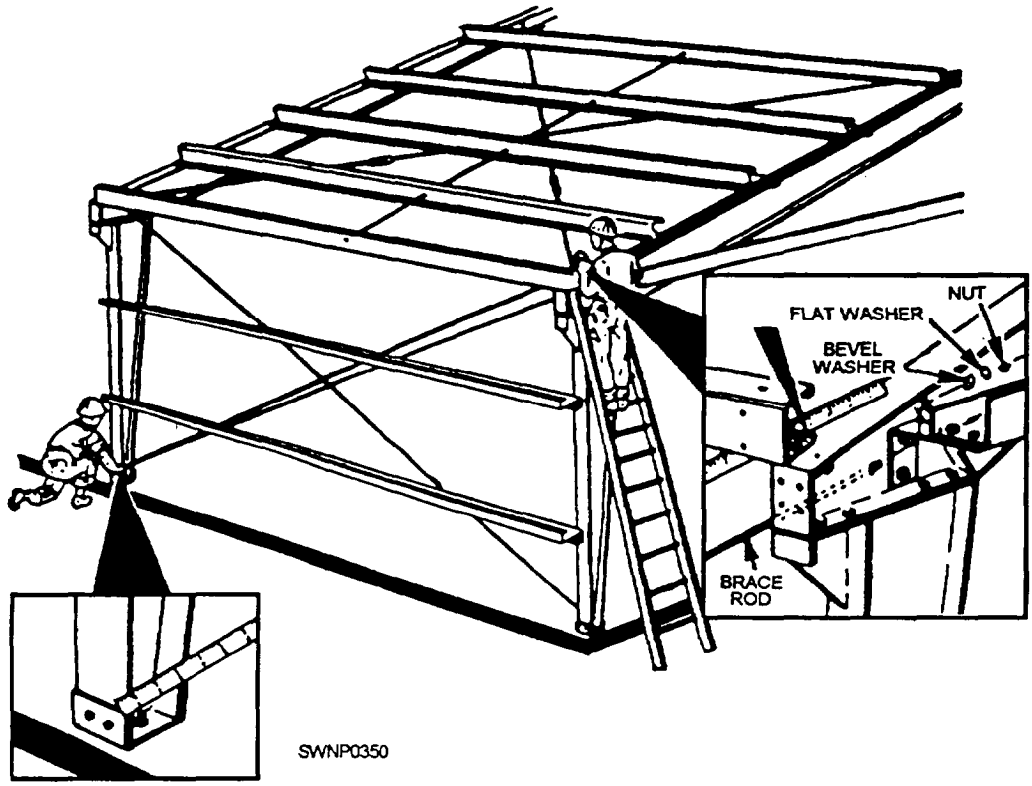
Ž Do not omit the diagonal brace rods that are required in the last bay of the building.

Ž. Be sure and bolt the girts, the purlins, and the cave struts to the inside holes of the end frames.

Ž Install the cave struts, the girts, and the purlins in each bay as soon as a frame is erected.

Ž Exercise care to see that the diagonal brace rods are taut and do not project beyond the flanges of the end frame to interfere with end-wall sheeting.

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Figure 8-7.—Braoe rods.

Sag Rods

Sag rods are used to hold the purlins and the girts in a straight line. First, install the sag rods that connect the two purlins at the ridge of the building. Each rod must be attached from the' top hole of one purlin through the bottom hole of the adjacent purlin. Use two nuts at each end of the sag rods-one on each side of each purlin. Adjust the nuts on these rods, so the purlins are held straight and rigid.

Next, install the sag rods between the purlins below the ridge with the rod attached from the top hole of the upper purlin through the bottom hole of the lower purlin. Use two nuts on each end-one on each side of each purlin. Follow the same procedure with the sidewall sag rods.

Remember that the roof purlins should show a straight line from end to end of the building. Do NOT tighten the sag rods so much that the purlins are twisted out of shape.

Brace Angles and Base Angles

After two or more bays have been erected, part of the erection crew can be assigned to install the diagonal brace angles.

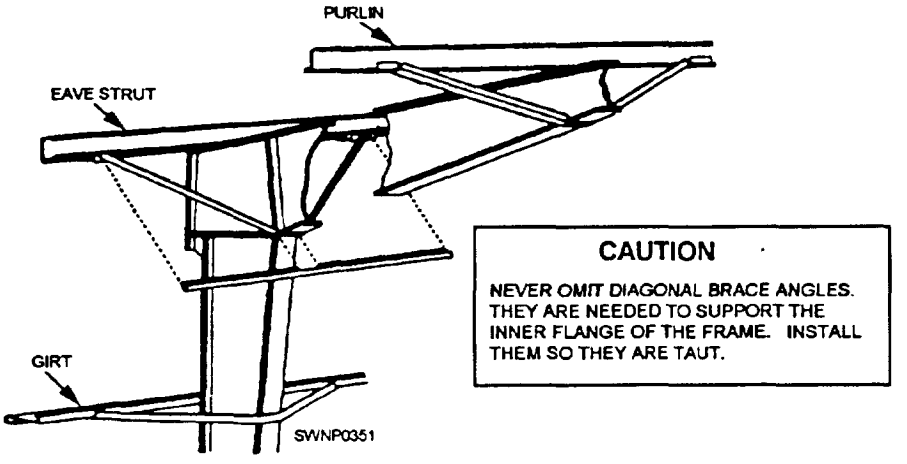
To install the brace angles, lay the notched portion against the frame flange and bend it into position (fig. 8-8). Diagonal brace angles are needed to support the inner flange of the frame. Be sure to install them so that they are taut.

While some members of the crew are installing brace angles, other members can be installing base angles. When assigned this duty, first, sweep off the top of the concrete foundation, so the base angles will set down evenly. Bolt the base angles in place with a flat steel washer under the nut. Leave the nuts loose to permit later adjustments after the wall sheeting has been applied.

End-Wall Framing/Doors/Windows

Refer to the manufacturers' specifications for proper assembly and installation procedures for end-wall framing, doors (both sliding and roll-up), and

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Figure 8-8.—Diagonal brace angles

windows, as these procedures will vary with available building options.

Sheeting

Sheeting, both sidewall and roof, must always be started at the end of the building toward which the prevailing winds blow. This action will ensure that the exterior joint in the side laps is away from the blowing of the prevailing winds. When installing roof sheeting, always use a generous amount of mastic on the upper side of all roof sheets just before moving them to the roof. Turn the sheet over and put a bead of mastic on the lip of one side of the corrugation and along one end (near the end but never more than one 1 inch from the end). Be sure to apply a horizontal bead of mastic between all sheets in the end laps, BELOW THE LAP HOLES. The roof sheets must be dry when mastic is applied. Mastic is extremely important, and care should be exercised whenever applying it to ensure a watertight seal. Apply generous beads, especially at the comers of the sheets. Finally, the ridge cap will be installed ensuring proper watershed. As previous] y stated, the information in this manual is general information common to pre-engineered buildings.

Building Insulation

The pre-engineered building can be insulated by any of several methods. A blanket type of insulation, in 2-foot-wide strips, to match the width of the roof and wall sheets can be installed between the sheets and structural at the same time the sheeting is installed. Or, a hardboard insulation can be applied directly to the inside surface of the structural, attaching it by helix nails or by sheet-metaI screws in holes prepared by drilling of the structural. Or, a wood framing can be prepared, attached to the structural, and a hardboard insulation is nailed to the wood.

Buildings Set Side by Side "In Multiples"

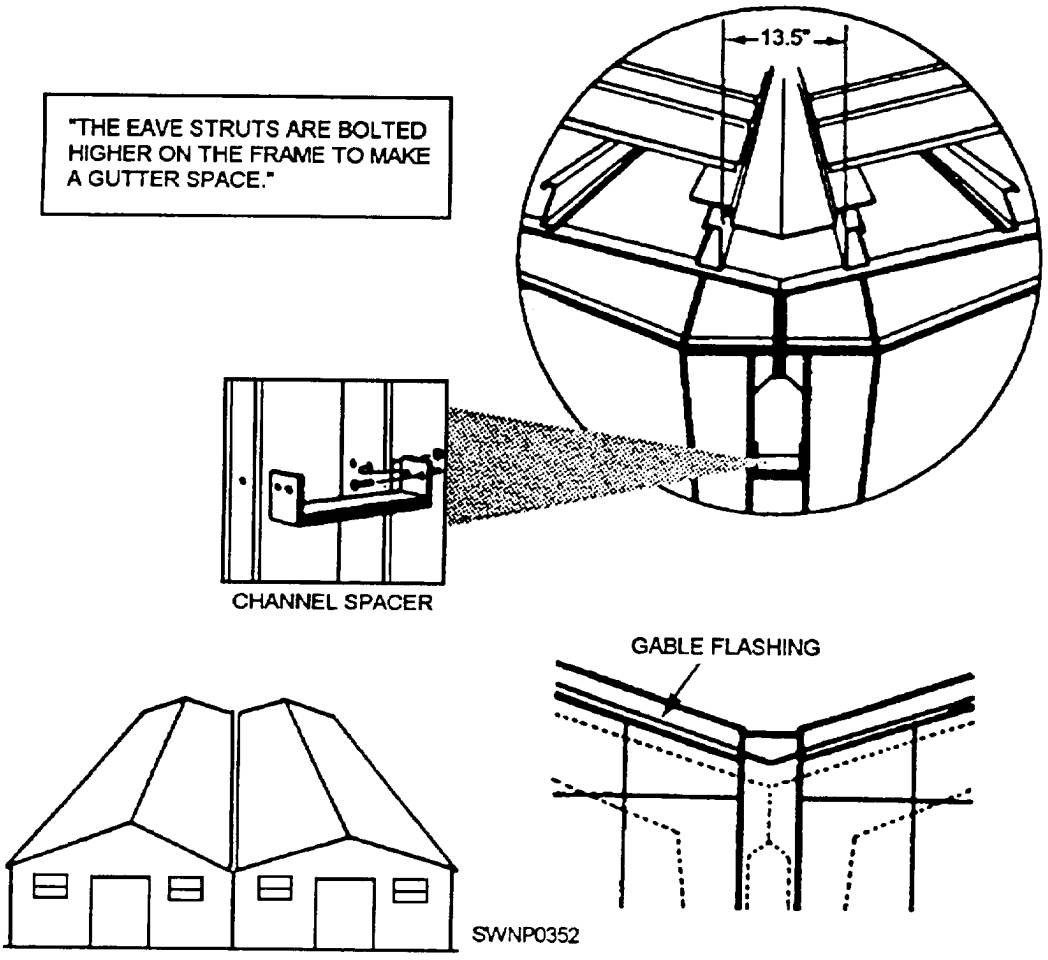
Pre-engineered buildings can easily be set upside by side to increase the working area under one roof. When this is done, the adjacent rigid frames should be bolted back to back with a channel spacer at each girt location (fig. 8-9).

The cave struts are moved up the roof beam to the second set of 11/16-inch-diameter holes to provide a gutter. This arrangement provides a space between cave struts of 13 1/2 inches. A field-fabricated gutter can be installed.

Flat, unpainted galvanized steel of 24-to 26-gauge material should be used for the gutter. A depth of 6 1/4 inches is desirable with the downspouts located as required. Gutter ends should be lapped at least 6 inches and should be braze-welded for watertightness. Note that wall sheets can be used to form a gutter if the outside corrugations are flattened and all of the end laps are braze-welded.

Roof sheets must be cut shorter where they overhang the gutter. The corrugations can be closed with the continuous rubber closure with mastic applied to the top and bottom surfaces of the closure. An alternate method is to flatten the corrugations at the gutter and seal them with a glass fabric stripping set in plastic.

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Figure 8-9.—Buildings side by side.

DISASSEMBLY PROCEDURES

Disassembly of the pre-engineered building should not be difficult once you are familiar with the erection procedures. In disassembling a building, be sure and clearly mark or number all of the parts. Then you will know where the parts go when reassembling the building. The main steps of the disassembly procedures are as follows:

1. Remove the sheeting.
2. Remove the windows, the door leaves, and the end wall.
3. Remove the diagonal brace angles and the sag rods.
4. Remove the braces, the girts, and the purlins.
5. Let down the frames.

K-SPAN BUILDINGS

K-span buildings (fig. 8-10) are a new form of construction within the Seabee community. The intended uses of these buildings are as flexible as the pre-engineered buildings discussed earlier.

ABM 120 SYSTEM

The K-span building system consists of a self-contained, metal building manufacturing plant, known as the ABM 120 System/Automatic Building Machine 120. This machine is mounted on a trailer, forming a type of "mobile factory" (fig. 8-11) that is easily towed to even the remotest construction sites. An important aspect of this machine is that it can be transported by air anywhere in the world easily. In fact. the ABM System has been certified for air transport by the U.S. Air Force in C-130, C-141, and C-5 aircraft.

Once the machine is delivered on site, it can be set up in minutes and turn coils of steel into structural

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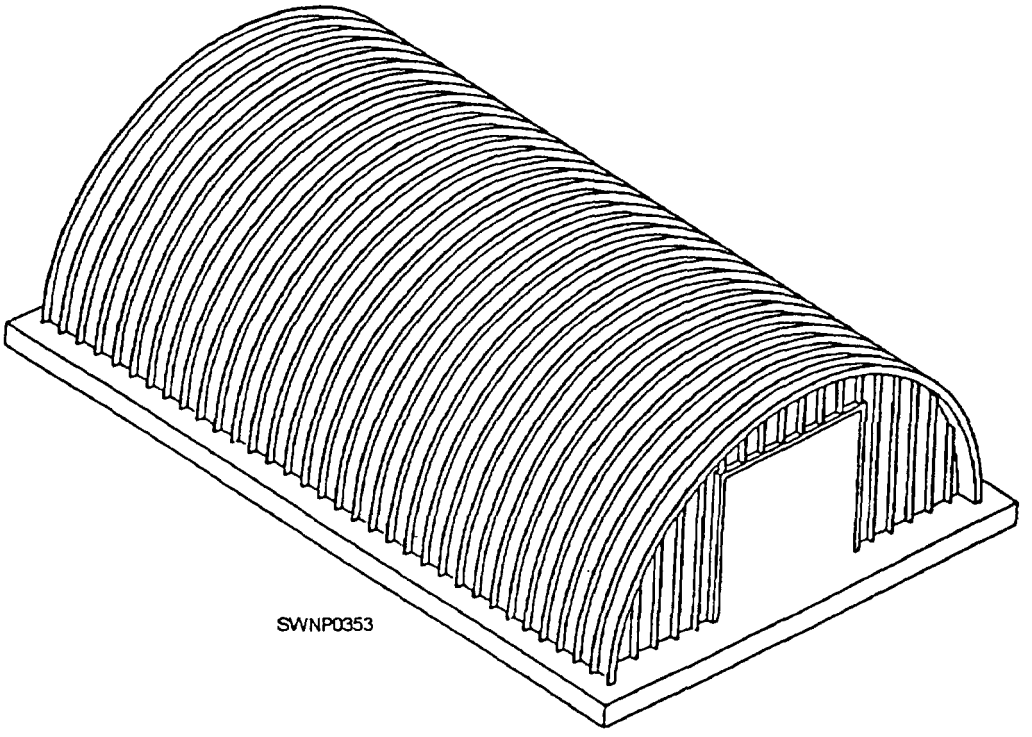


Figure 8-10.—Typical K-span building.

strength arched panels. The panels are then machine seamed together to form an economical and watertight steel structure.

The final shape and strength of the materials used cancels the need for columns, beams, or any other type of interior support. All of the panel-to-panel connections are joined using an electric automatic seaming machine. Because of this, there are no nuts, bolts, or any other type of fastener to slow down construction or create leaks.

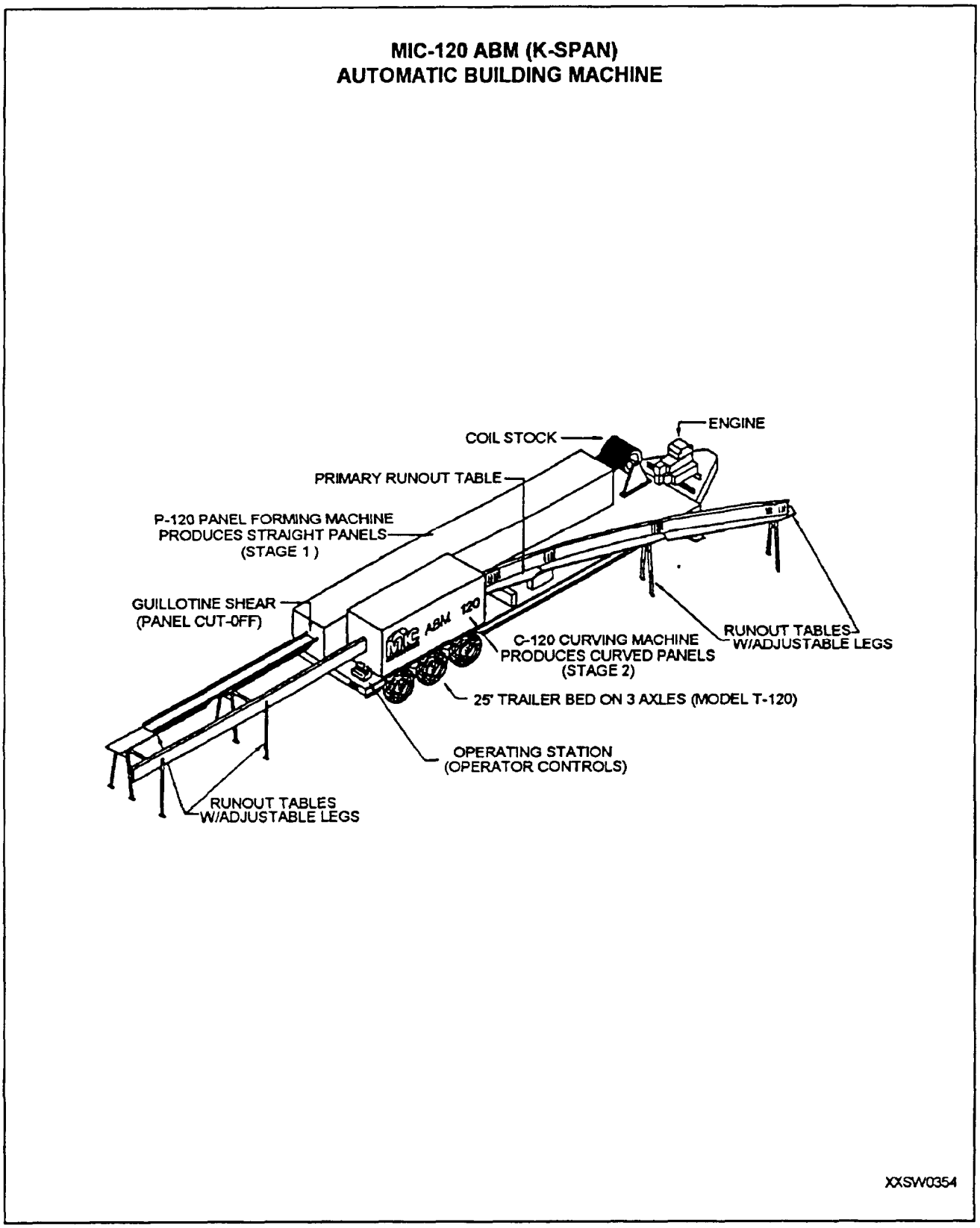
Once delivered to the jobsite, the "on-site" manufacturing abilities of the machine give the ABM operator complete control of fabrication as well as the quality of the building, Training key personnel in the operation of all related K-span equipment is essential. These crew members, once trained, can instruct other members of the crew in the safe fabrication and erection of a K-span. The following section gives you some, but not all, of the key elements associated with K-span construction. As with all equipment, always refer to the manufacturers' manuals.

Operating Instructions

The main component of the K-span system is the trailer-mounted building machine (fig. 8-12). This figure shows the main components of the trailer and the general operating instructions. The primary position is the operator's station at the rear of the trailer (fig. 8-13). The crew member, selected for this position, must have a thorough understanding of the machine operations and the manuals. From that position, the operator controls all of the elements required to form the panels. First, the operator must run the coil stock through the machine to form the panel shape. Next, it is cut off at the correct length. This length is the required length for one arched panel to run continuously from one footer to the other. Last, after the panel is cut to length, it is run back through the machine to give it the correct arch. The operator must remain at the controls at all times. From the placement of the trailer on site to the completion of the curved panel, attention to detail is paramount as with all of the aspects of construction.

As you operate the panel, you will be adjusting the various machine-operating components. Adjustments for the thickness, the radius, and the curving machine MUST be made according to the manuals. Do not permit shortcuts in adjustments. Any variations in adjustments or disregard for the instructions found in the operating manuals will leave you with a pile of useless material or an inconsistent building.

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Figure 8-11.—Automatic Building Machine 120.

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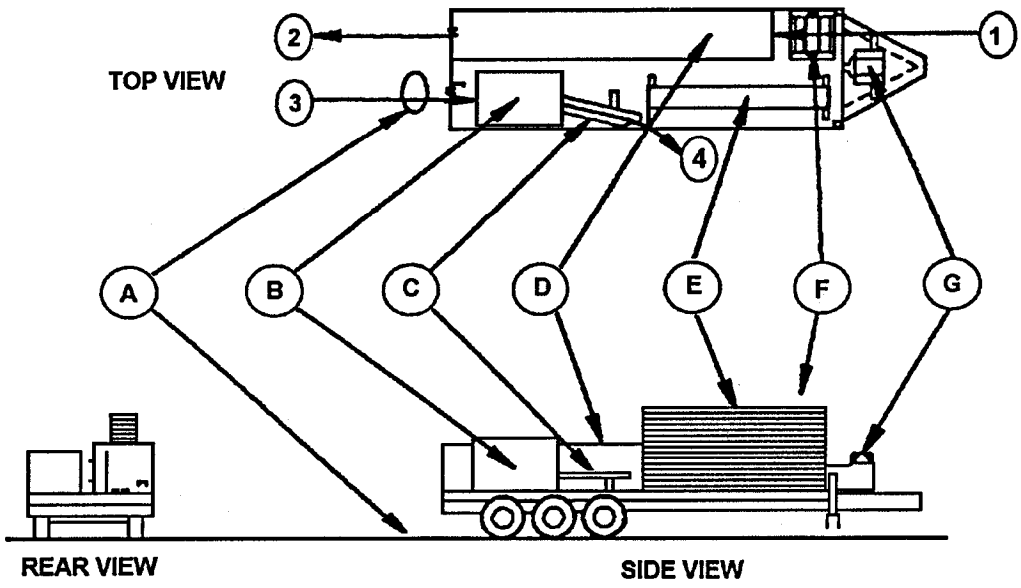


Figure 8-12.—Trailer-mounted machinery.

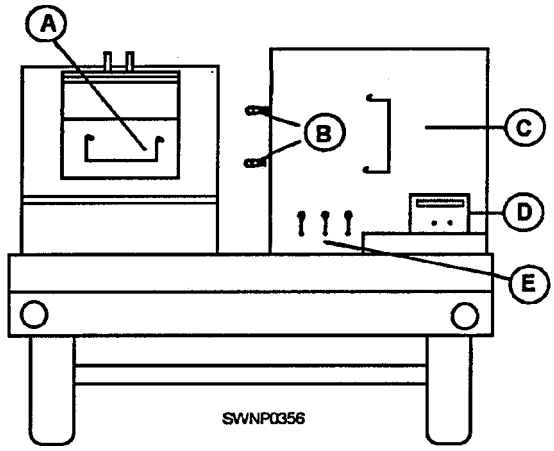


Figure 8-13.—Rear of K-span trailer.

Machinery Placement

Preplanning of the site layout is important to avoid setup problems. Uneven or sloped ground is not a concern as long as the bed of the trailer aligns with the general lay of the existing surface conditions. Using figure 8-14 as a guide when placing the machinery, you should consider factors such as the following:

- Maneuvering room for the towing of the trailer, or leave it attached to the vehicle (as shown at A).
- The length of the unit is 27 feet 8 inches long by 7 feet 4 inches wide (B).
- Allow enough room for run-out stands to hold straight panels. Stands have a net length of 9 feet 6 inches each(C).
- Find point X: From the center of the curve, measure the distance equal to the radius in line with the front of the curved frame. From point X, scribe an arc equal to the radius. This arc will define the path of the curved panel. Add 10 feet for run-out stands and legs (D).
- Storage area required to store the coil stock and access for equipment to load onto the machine (E).

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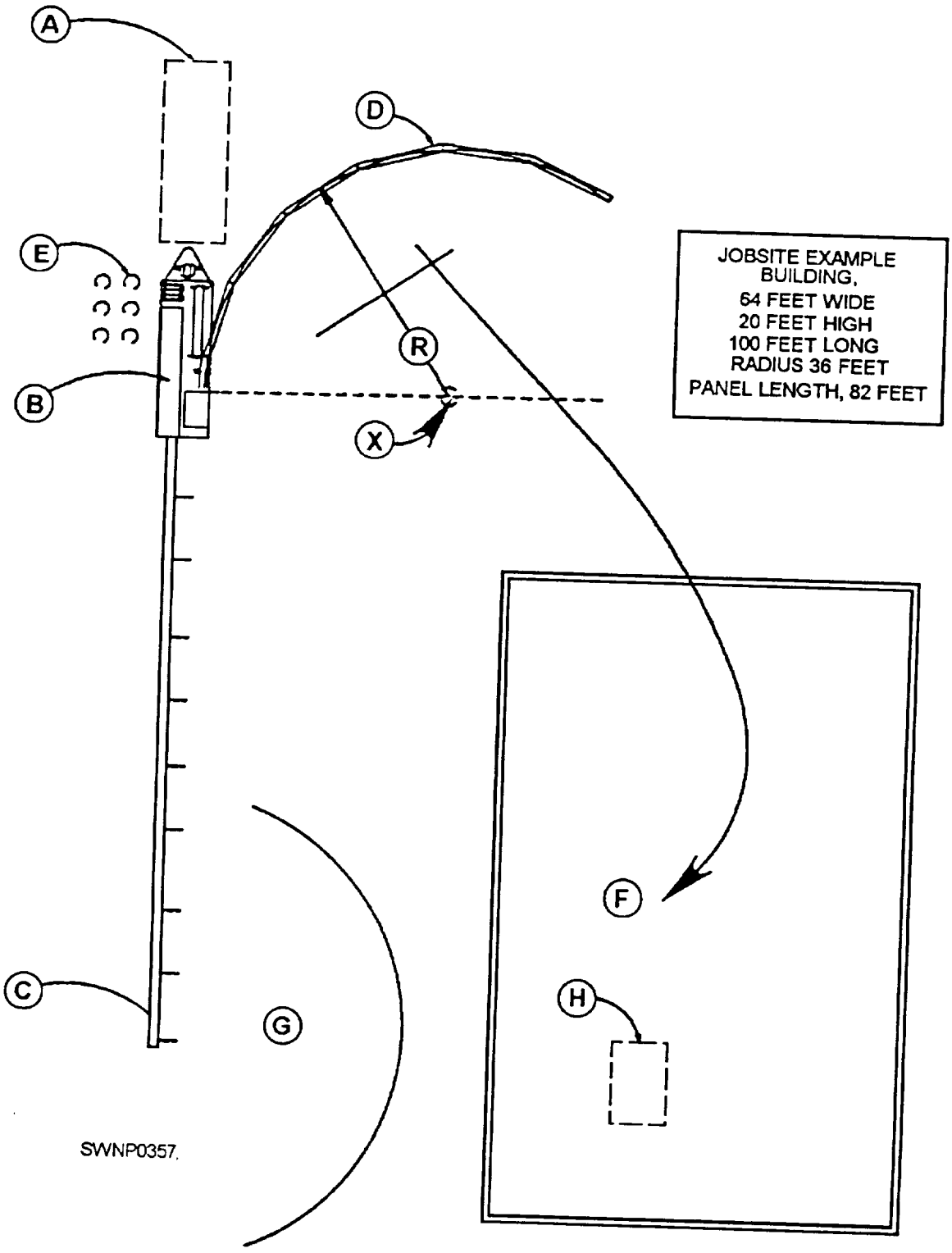


Figure 8-14.—Machinery placement calculations.

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- Direction curved panels must be carried after being formed (F).
- Level area required to lay panels on the ground for seaming. Building will not be consistent if panels are not straight when seaming (G).
- Space required for crane operations (I-I).

Foundations

The design of the foundation for a K-span building depends on the size of the building, the existing soil conditions, and the wind load. The foundations for the buildings are simple and easy to construct. With the even distribution of the load in a standard arch building, the size of the continuous strip footing is smaller and therefore more economical than foundations for more conventional buildings.

The concrete forms and accessories provided are sufficient to form the foundations for a building 100 feet long by 50 feet wide. When a different configuration is required, forms are available from the manufacturer.

The actual footing construction is based, as with all projects, on the plans and specifications. The location of the forms, the placement of the steel, and the psi (pounds per square inch) of the concrete are critical. The building panels are welded to the angle in the footer before the concrete is placed. Because of this operation, all of the aspects of the footer construction must be completely checked for alignment and squareness. Once concrete is placed, there is no way to correct errors.

As mentioned above, forms are provided for the foundation. Using table 8-1 as a guide, figure 8-15 gives you a simple foundation layout by parts designation. As noted in figure 8-15, the cross pipes are not provided in the kit. They must be ordered when the project is being planned and estimated.

Table 8-1.—Concrete Forms Included in Kit

DESCRIPTION (Each set of forms is sufficient to erect a building 100 feet long by 50 feet wide.)	PART NUMBER
Side form panels, 1′ × 10′, 12-gauge steel	F-1
Transition panels, 1′ × 12″, 12-gauge steel	F-2
Transition panels, 1′ × 28″, 12-gauge steel	F-3
End-wall caps, 1′ × 15″, 12-gauge steel	F-4
Sidewall caps, 1′ × 19″, 12-gauge steel	F-5
Filler form, 1′ × 12′, 12–gauge steel	F-6
Sidewall inside stop, 1′ × 12″, 12–gauge steel	F-7
End wall inside stop, 1′ × 12″, 12–gauge steel	F-8
Stakes, 1/4" diameter, bar steel	F-9
All-thread rod, 1/2-13 × 18″	F-10
Hex nuts, 1/2-13	F-11
Hex bolts, 1/8-16 × 1 1/2″	F-12
Hex nuts, 3/8-16	F-13
Flat washers, 1/8″ SAE	F-14

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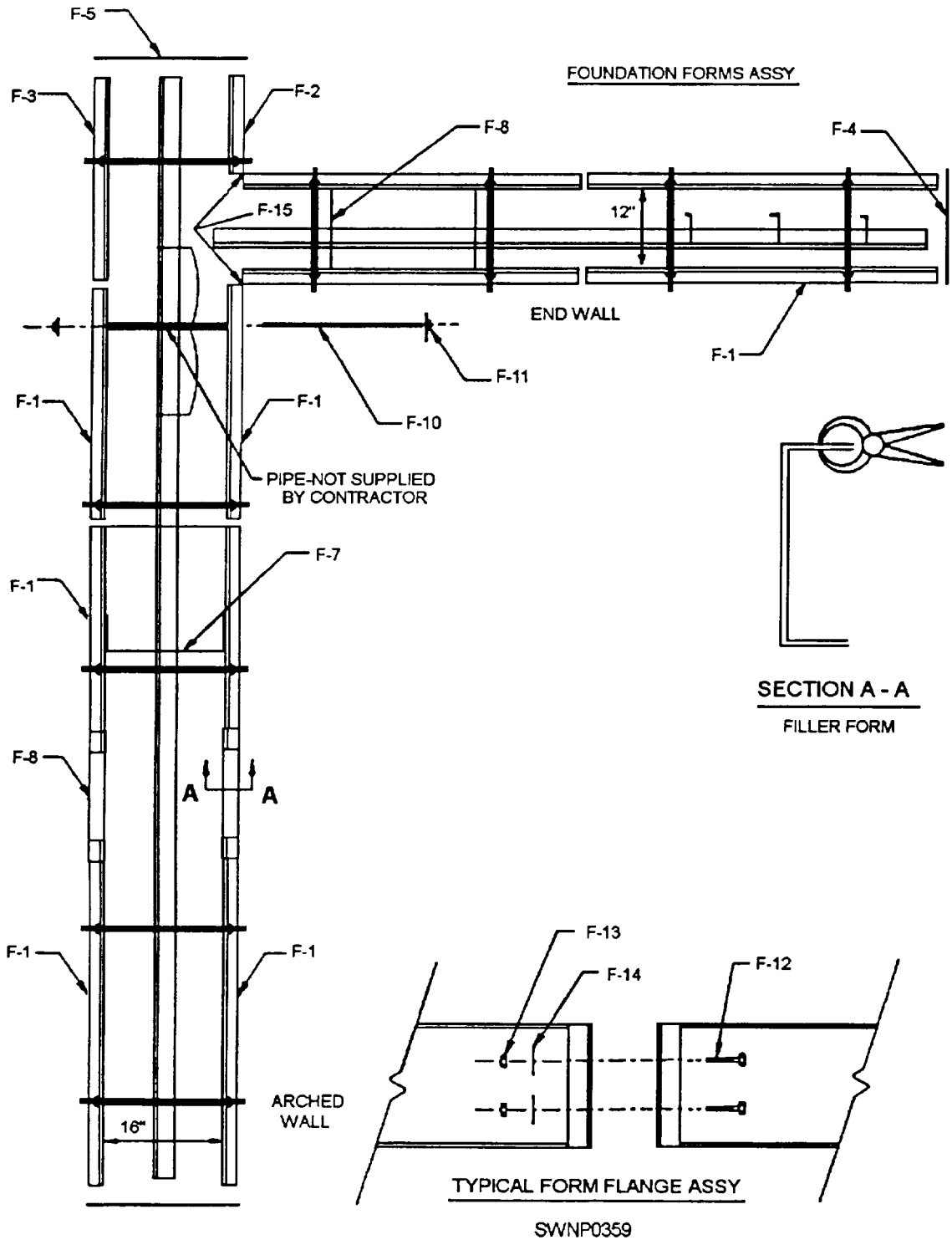


Figure 8-15.—Simple form assembly.

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BUILDING ERECTION

With the placement of the machinery and forming of the building panels in progress, your next considerations are the placement and the weight-lifting capabilities of the crane. Check the weight-lifting chart of the crane for its maximum weight capacity. This dictates the number of panels you can safely lift at the operating distance. As with all crane operations, attempting to lift more than the rated capacity can cause the crane to turn over.

Attaching the spreader bar (fig. 8-16) to the curved formed panels is a critical step; failure to clamp the panel tightly can cause the panels to slip and fail with potential harm to personnel and damage to the panel. With guide ropes attached (fig. 8-17) and personnel manning these ropes, lift the panels for placement. When lifting, lift only as high as necessary, position two men at each free end to guide them in place, and remind crew members to keep their feet from under the ends of the arches. Never attempt lifting any sets of panels in high winds.

Place the first set of panels on the attaching angle of the foundation, and position them so there will be room for the end-wall panels. After positioning the first set of panels, clamp them to the angle, plumb with guide ropes, and secure the ropes to previously anchored stakes. Detach the spreader bar and continue to place the panel sets. Seam each set to standing panels before detaching the spreader bar.

After about 15 panels (three sets) are in place, measure the building length at both ends (just above forms) and at the center of the arch. This measurement will seldom be exactly 1 foot per panel (usually slightly more), but should be equal for each panel. Adjust the ends to equal the center measure. Panels are flexible enough to adjust slightly. Check these measurements periodically during building construction. Because exact building lengths are difficult to predict, the end wall attaching angle on the finishing end of the building should not be put in place until all of the panels are set.

After arches are in place, set the longest end-wall panel in the form, plumb, and clamp it in place. Work from the longest panel outward and be careful to maintain plumb.

When all of the building panels are welded to the attaching angle (fig. 8-18) at 12 inches on center, you are ready to place the concrete. When you are placing the concrete, remember it is extremely important that it be well-vibrated. This action may eliminate voids under all embedded items. As the concrete begins to set, slope the top exterior portion of the concrete cap about 5 inches (fig. 8-19) to allow water to drain away from the building. The elevation and type of the interior floor are not relevant as long as the finish of the interior floor is not higher than the top of the concrete cap.

The K-span building system is similar to other types of pre-engineered or prefabricated buildings in that windows, doors, and roll-up doors can be installed only when erection is completed. When insulation of the building is required, insulation boards (usually 4 by 8 feet) maybe of any semirigid material that can be bent to match the radius of the building. The insulation is installed using clips, as shown in figure 8-20.

When the integrity of the end-wall panels is continuous from ground to roof line, the end walls become self-supporting. The installation of windows (fig. 8-21) and aluminum doors (fig. 8-22) presents no problem because the integrity of the wall system is not interrupted. The installation of the overhead door (fig. 8-23) does present a problem in that it does interrupt the integrity of the wall system. This situation is quickly overcome by the easily installed and adjustable (height and width) doorframe package that supports both the door and end wall. This doorframe package is offered by the manufacturer.

Shown in figure 8-24 are the fundamental steps in constructing a K-span from start to finish.

ABM 240 SYSTEM

There is another type of K-span building, actually referred to as a Super Span by the manufacturer, the ABM 240. Actual construction of the ABM 240 is the same as the ABM 120 (K-span). It can use heavier coil stock and is a larger version. Figure 8-25 is given to show the differences between the two.

Keep in mind that the information provided in this section on the K-span building is basic. During the actual construction of this building, you must consult the manufacturer's complete set of manuals.

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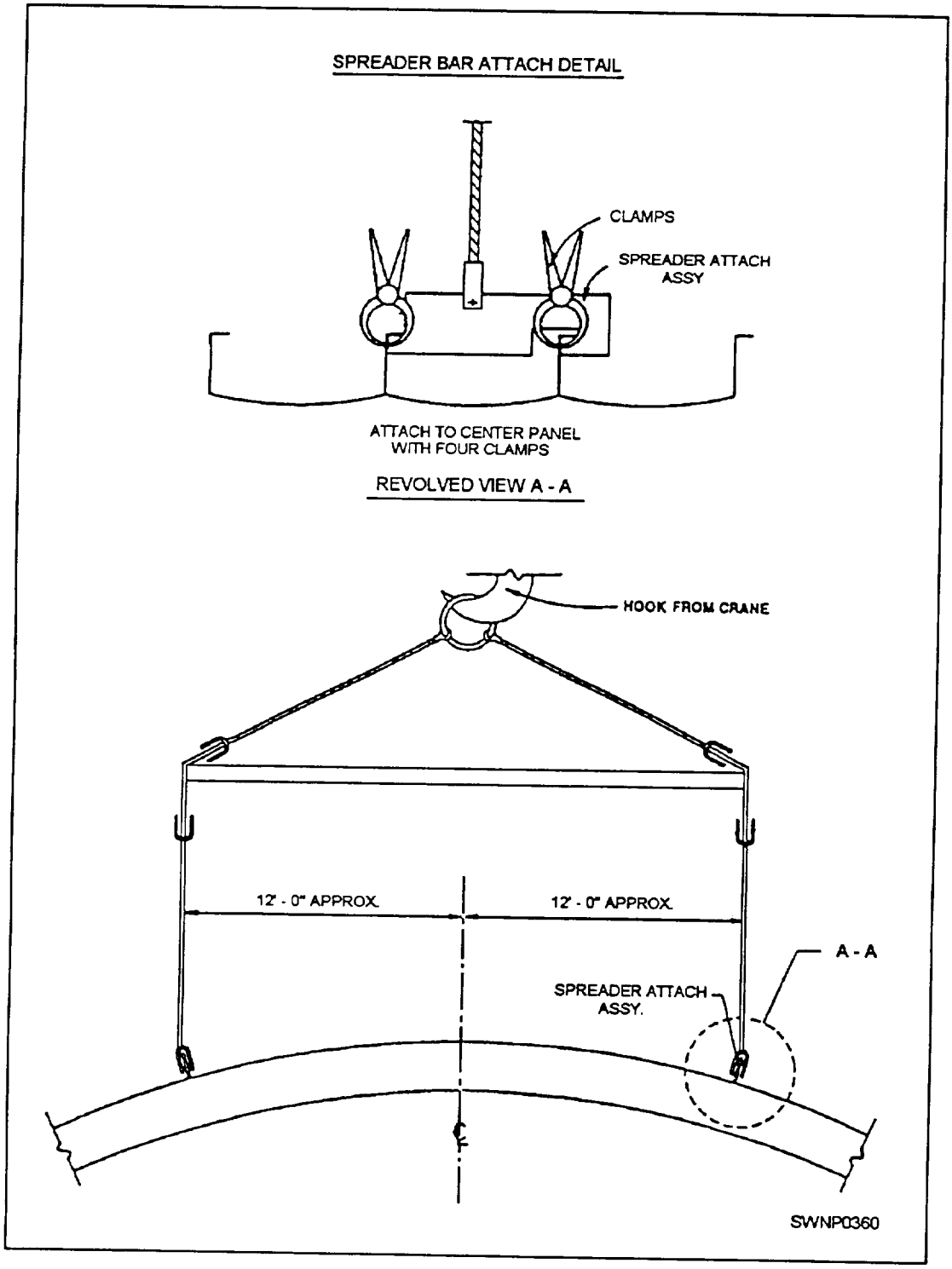


Figure 8-16.—Spreader bar attachment.

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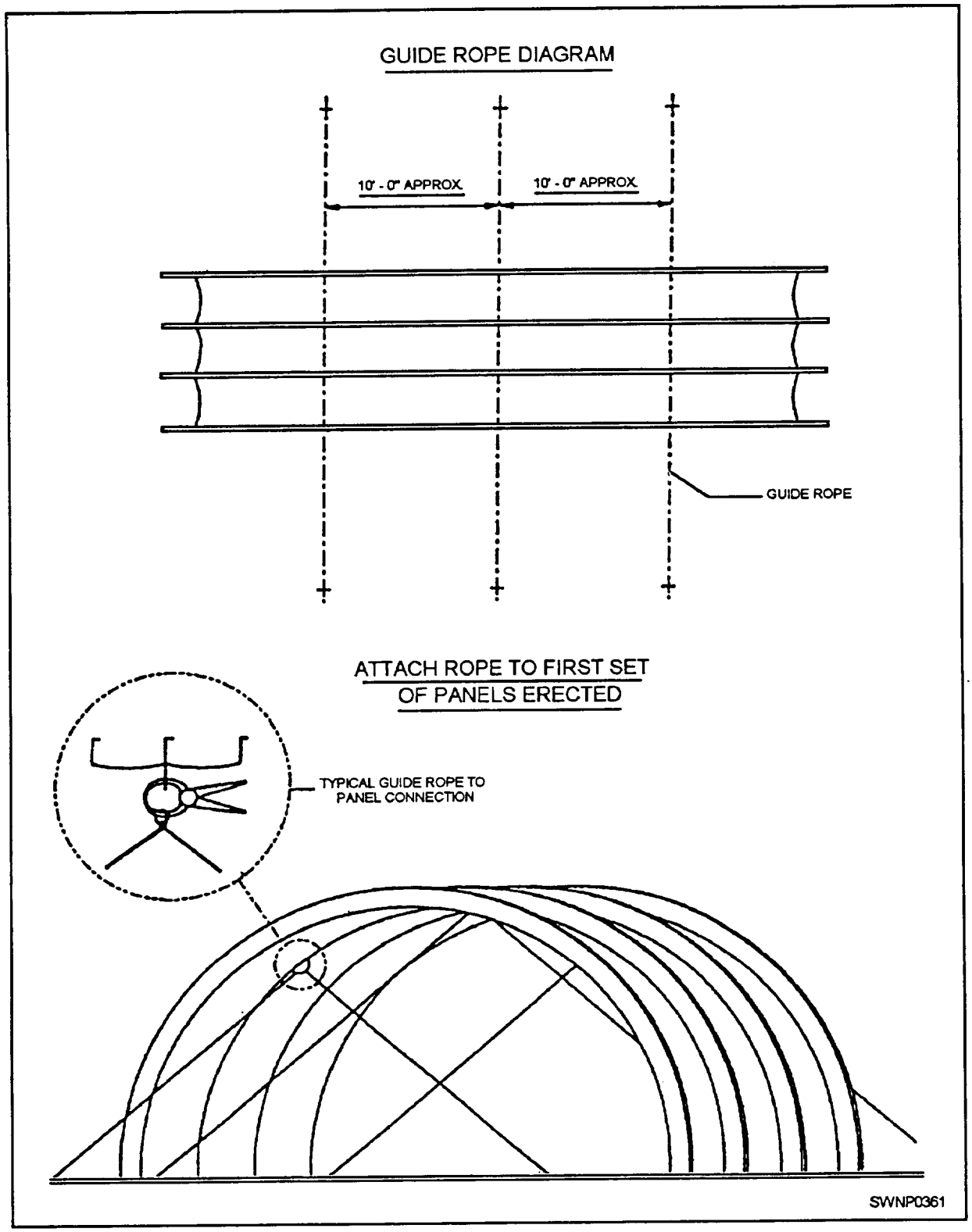


Figure 8-17.—Guide rope diagram.

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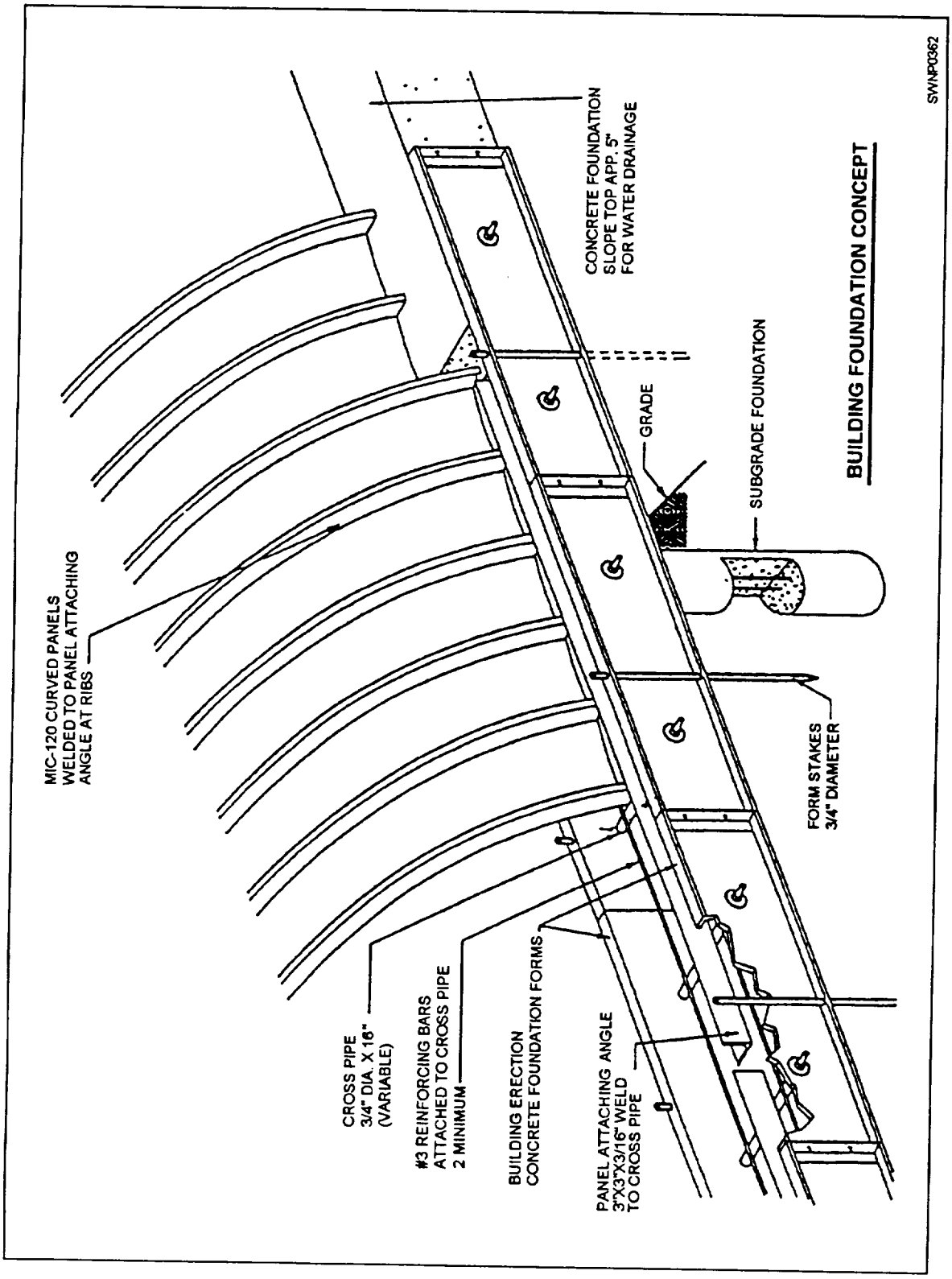


Figure 8-18.—Building foundation concept.

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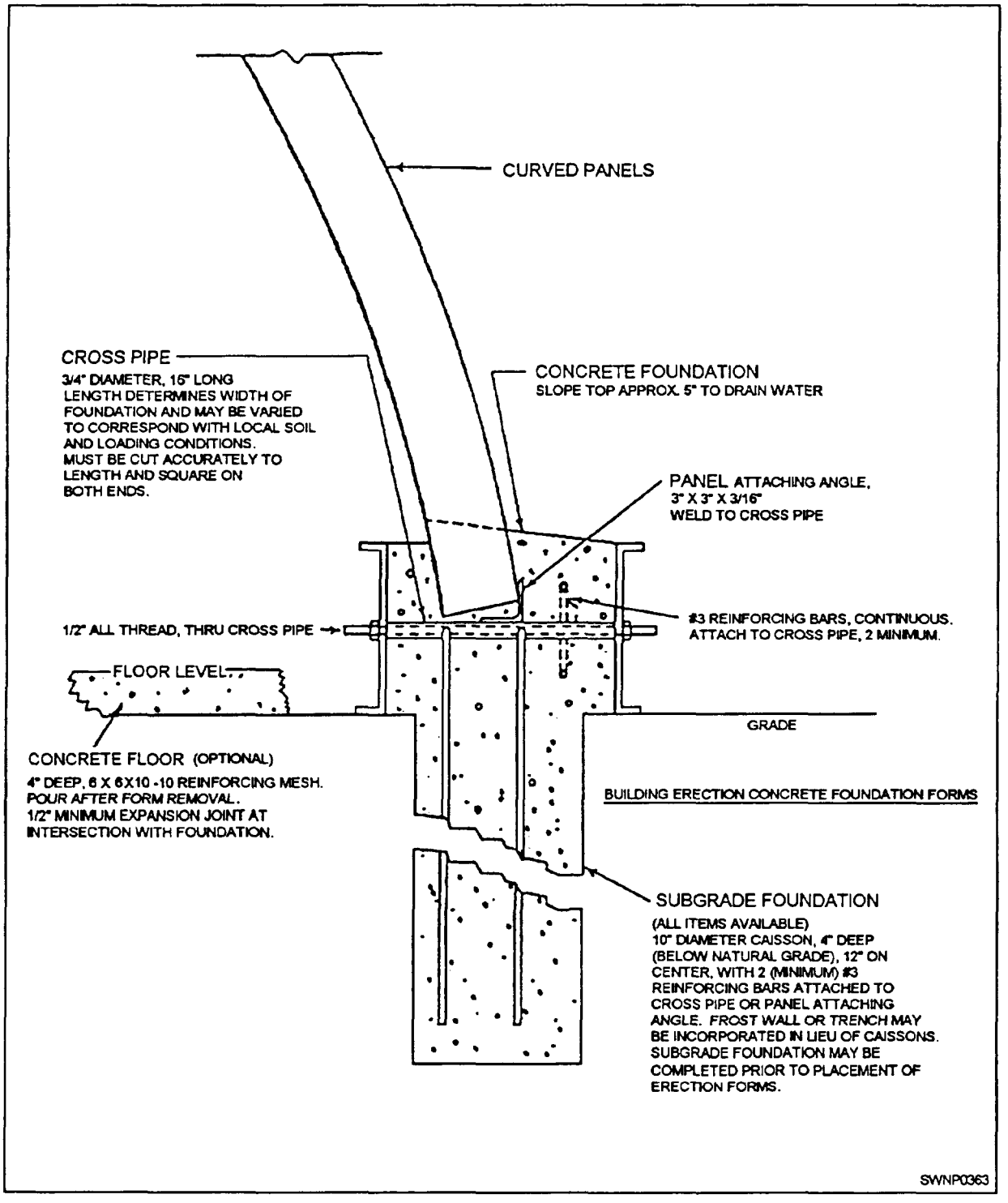


Figure 8-19.—Concrete foundation.

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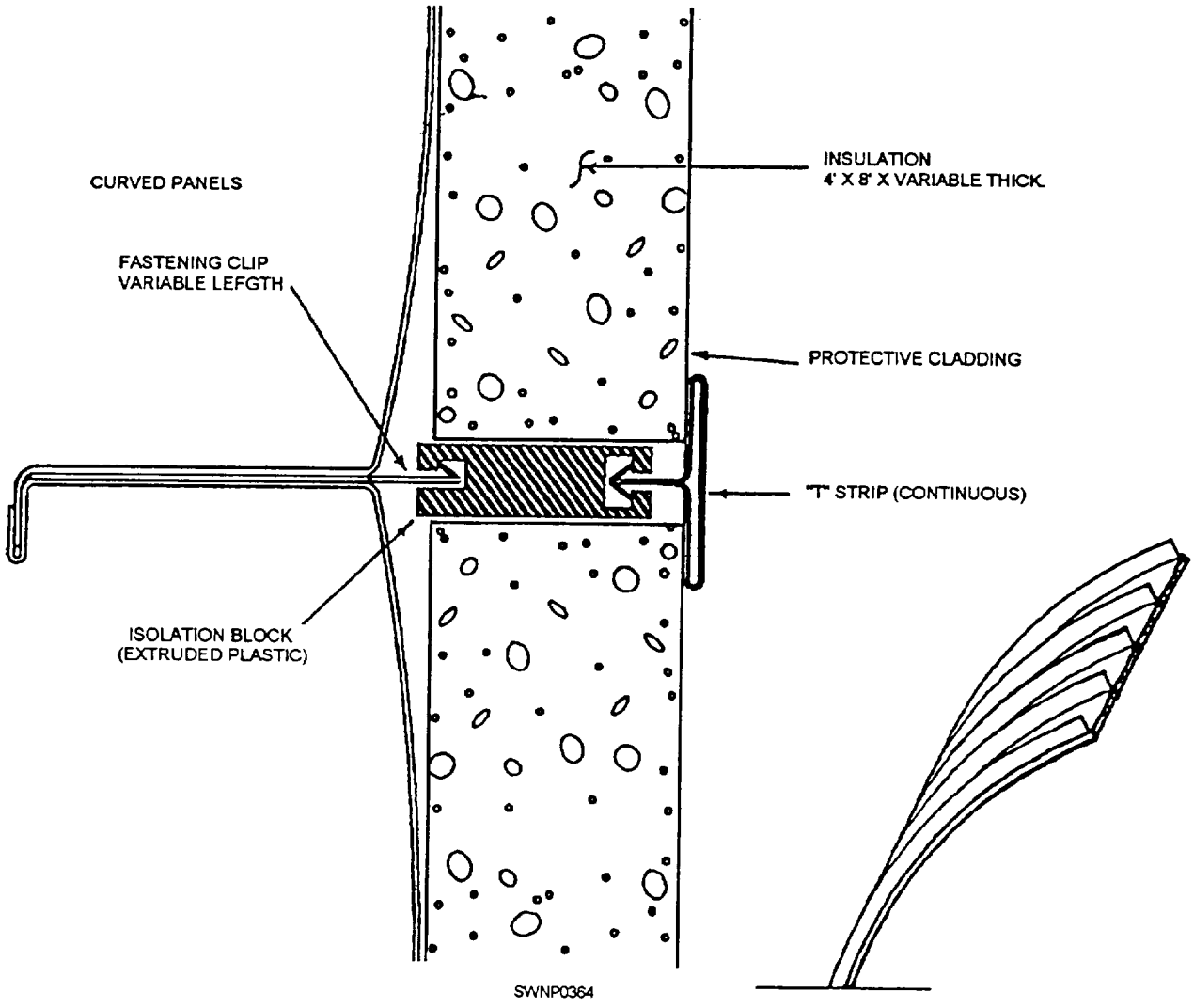


Figure 8-20.—Insulation.

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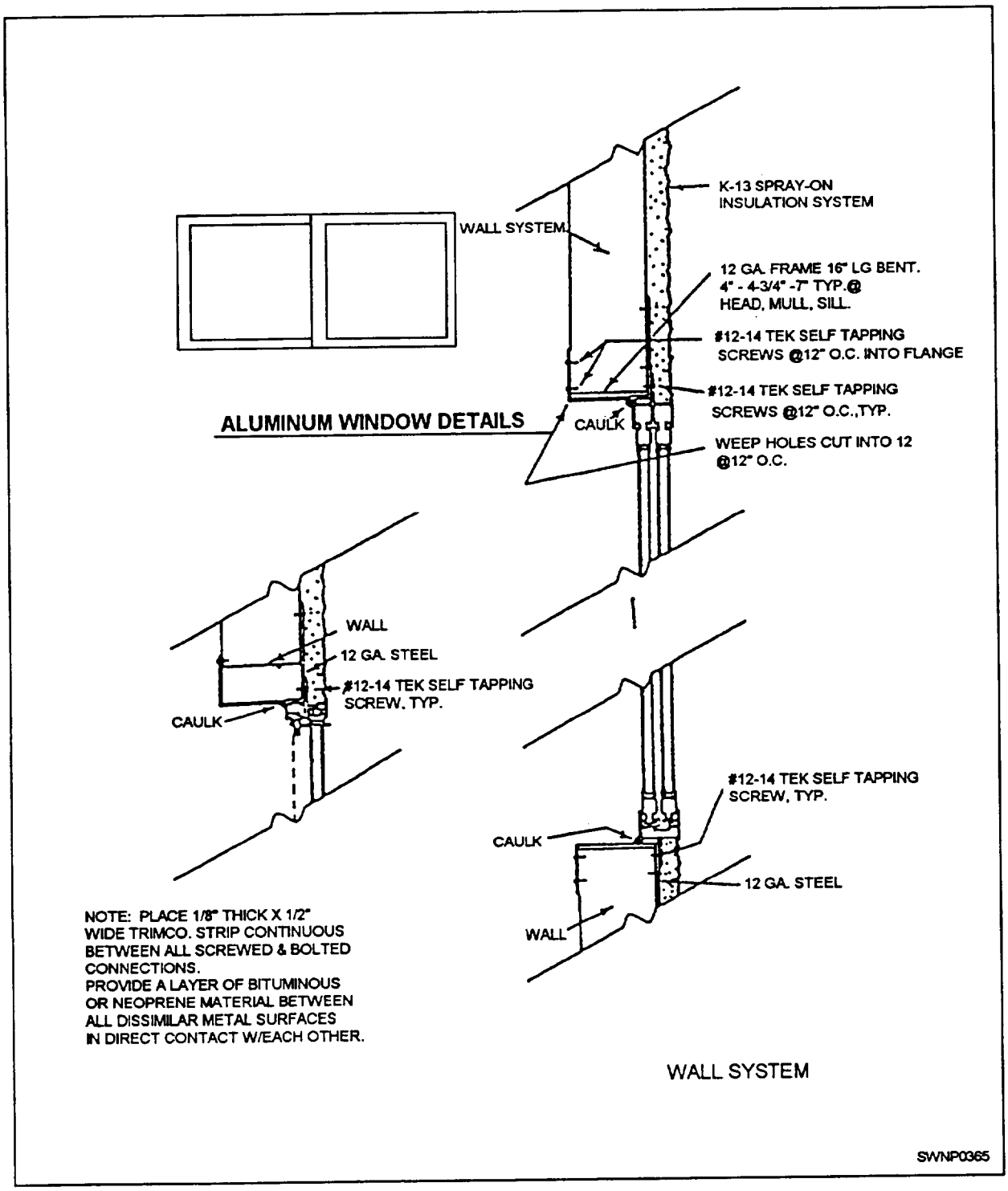


Figure 8-21.—Aluminum window installation.

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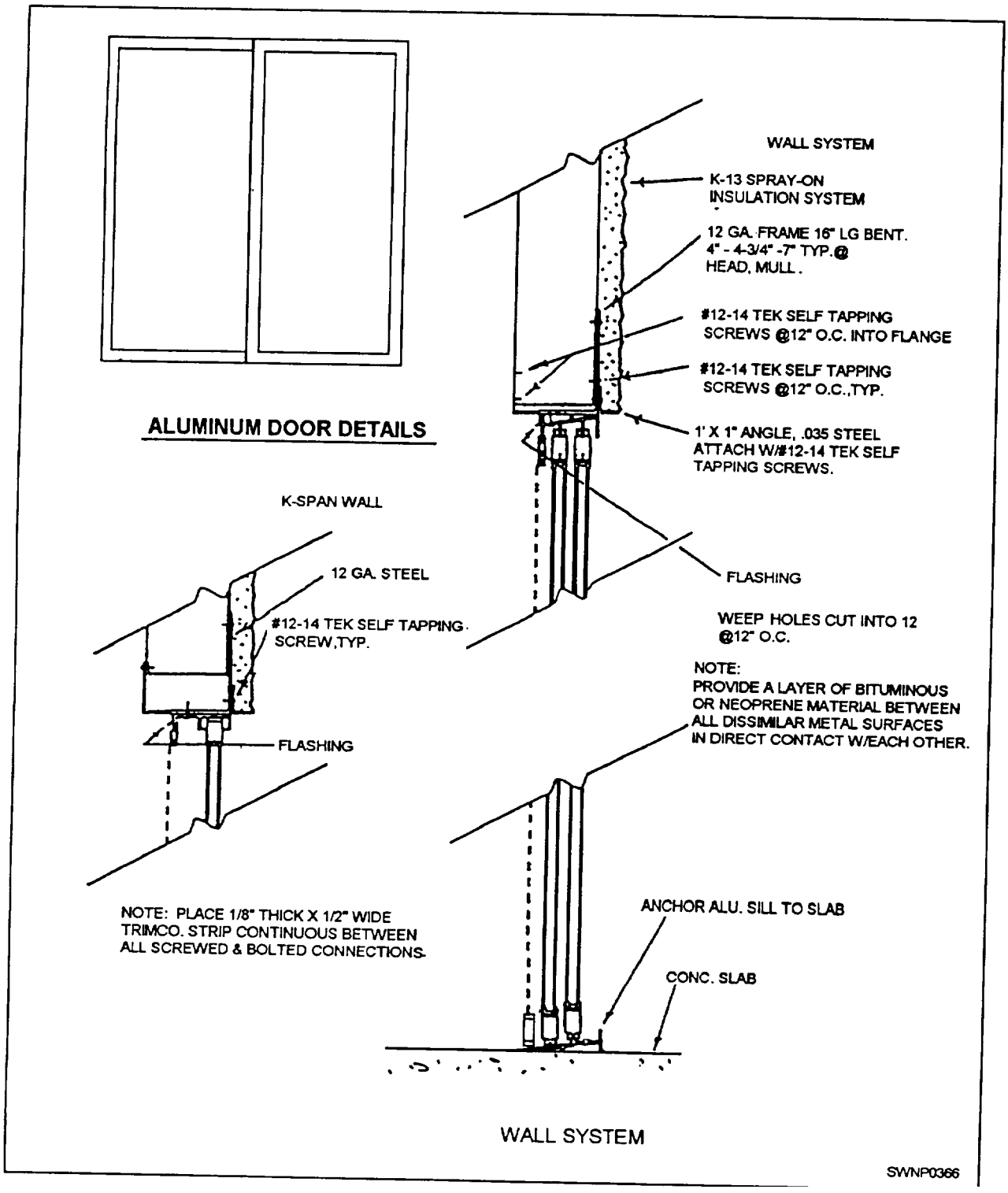


Figure 8-22.—Aluminum door installation.

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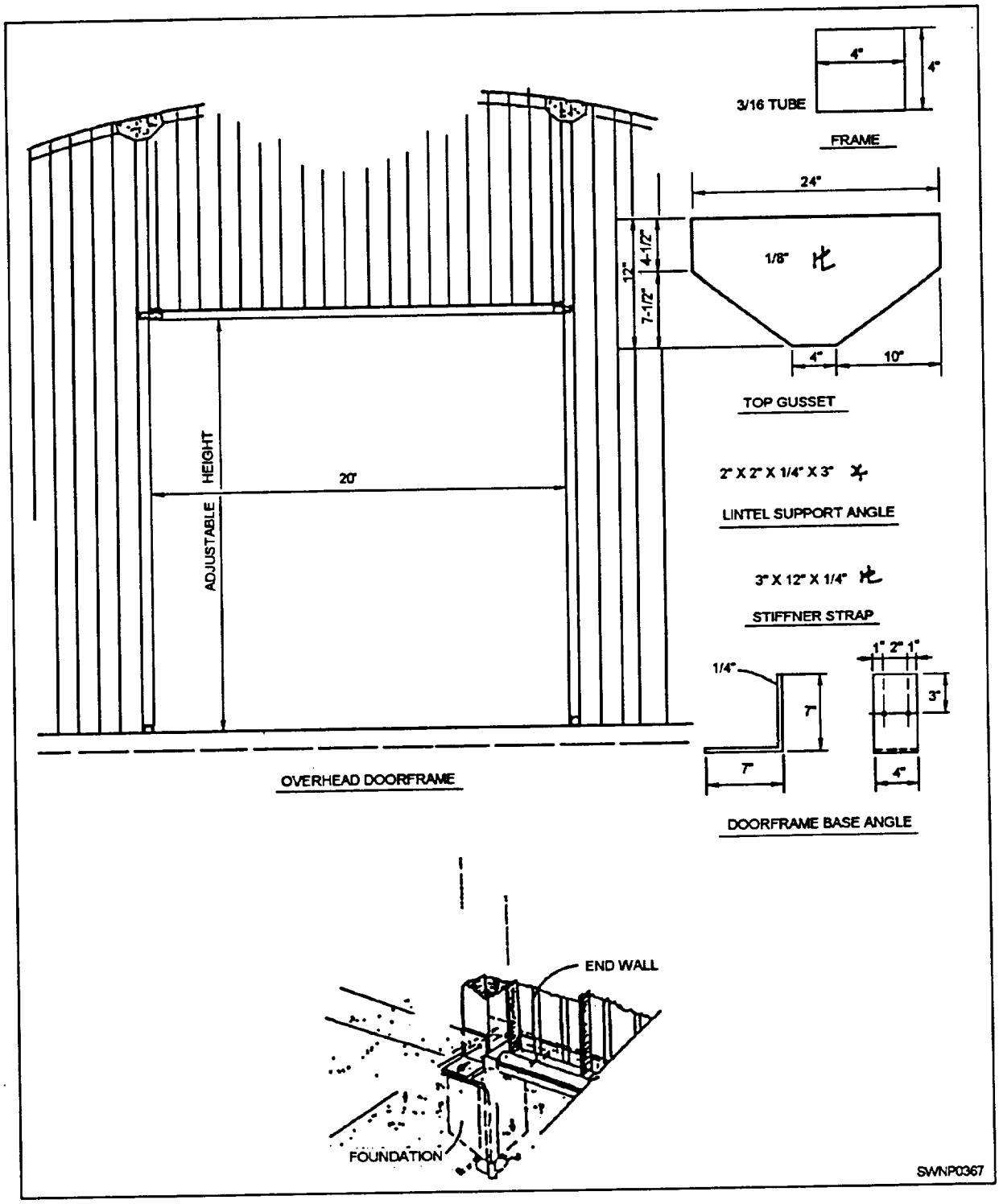


Figure 8-23.—Overhead doorframe.

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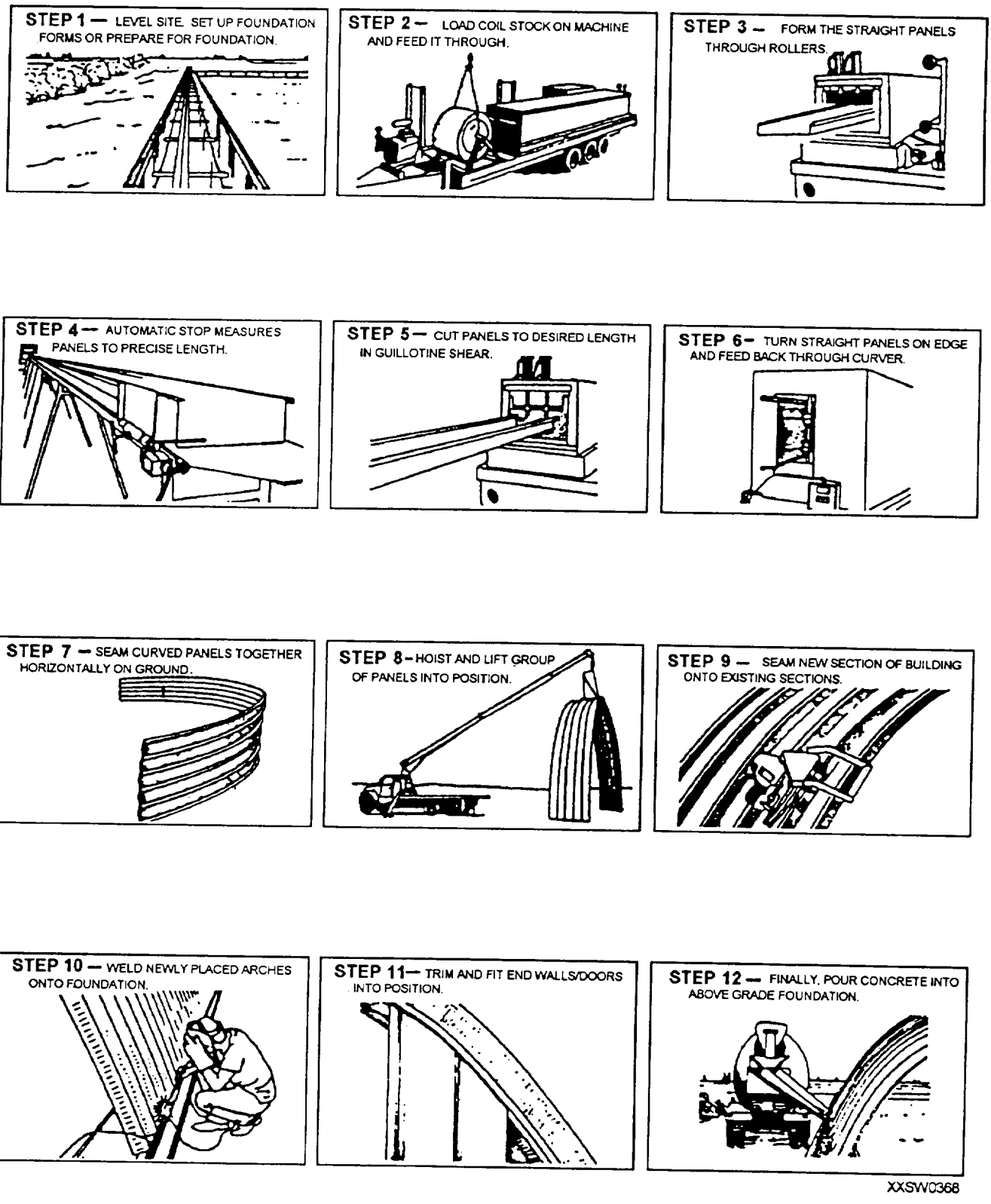


Figure 8-24.—Steps in K-span construction.

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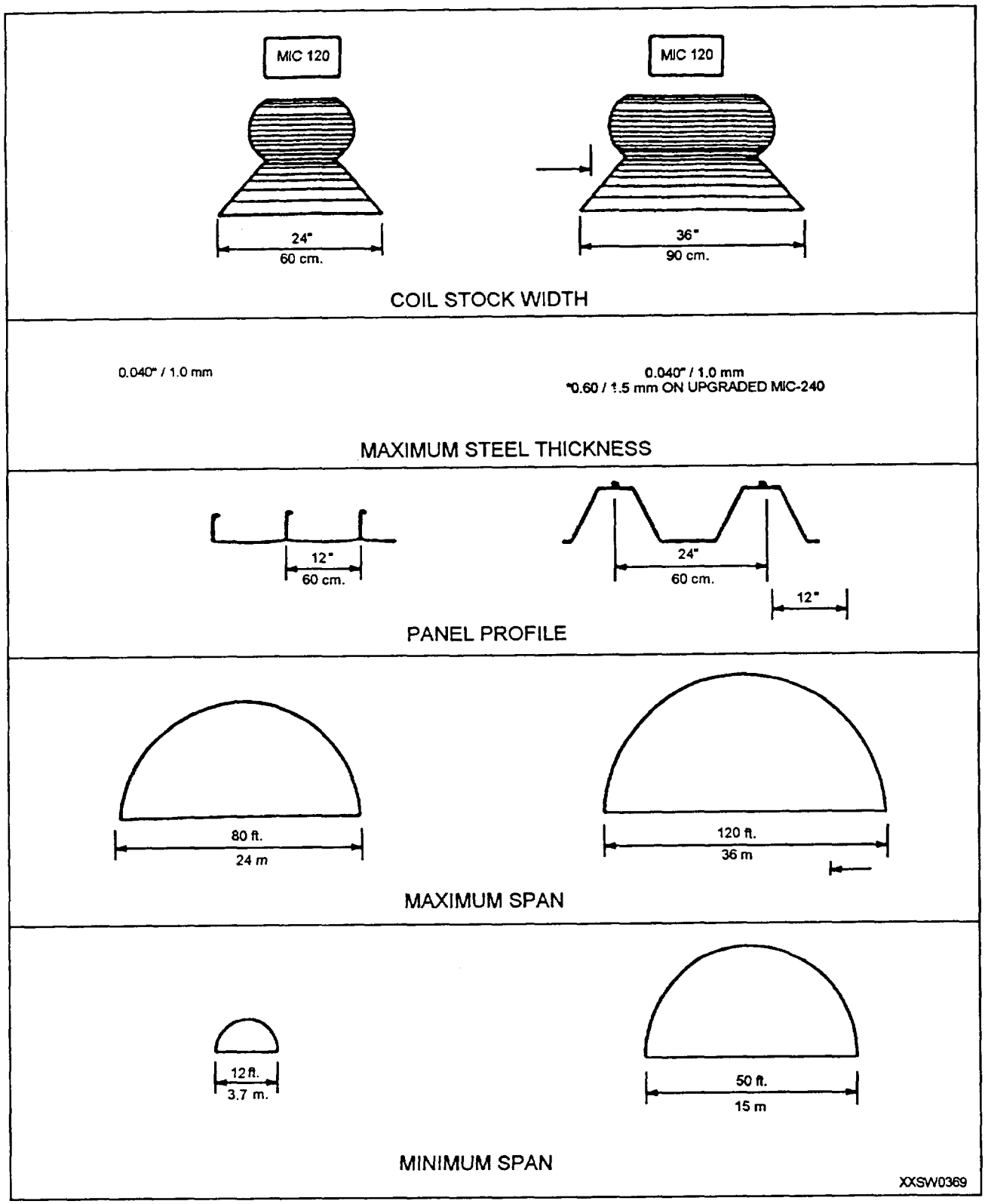


Figure 8-25.—ABM System 120 and 240 comparison chart.

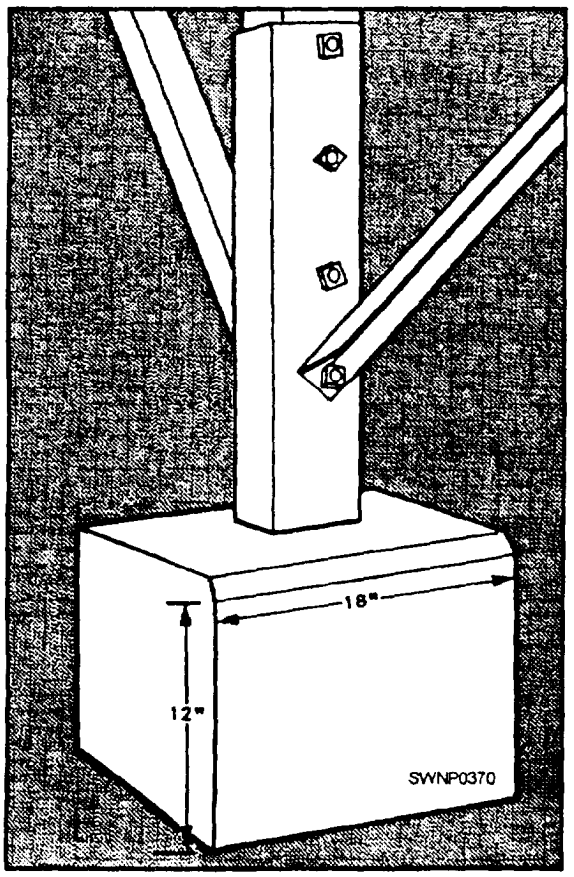
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STEEL TOWERS

Airfield observation towers, harbor shipping control towers, and radio towers are all erected by Steelworkers. These towers are manufactured and packaged according to military specifications. They are shipped with all parts and with plans and specifications.

The framework of the tower is made up of fabricated structural shapes that are bolted together. Anchor angles with baseplates are furnished for setting in the concrete foundation, as shown in figure 8-26. In most cases, the foundation will be built by the Builders. The manufacturer also furnishes square head bolts, lock washers, and nuts. Spud wrenches and driftpins are suppfied for each size of bolt. Field bolts and shipping lists are prepared and packaged with each shipment of a tower.

The tower members are bundled in the most compact manner possible to keep shipping space to a minimum. Erection identification marks and stock list numbers are painted on all of the pieces. All of the nuts, the bolts, and the washers are boxed and identified by painted marks.



127.147

Figure 8-26.—Anchor angles in a concrete foundation.

A check must be made of all of the parts and packages received in a tower shipment. Check them against the shipping list to be sure that no boxes or bundles have been lost, stolen, or misplaced. Also, check to see that none have been damaged When all are accounted for, sort the materials. The drawings tell you what is needed for each section. It is smart planning to lay out all of the materials for each section from the foundation to the top before any erection is started. This will save a lot of time later.

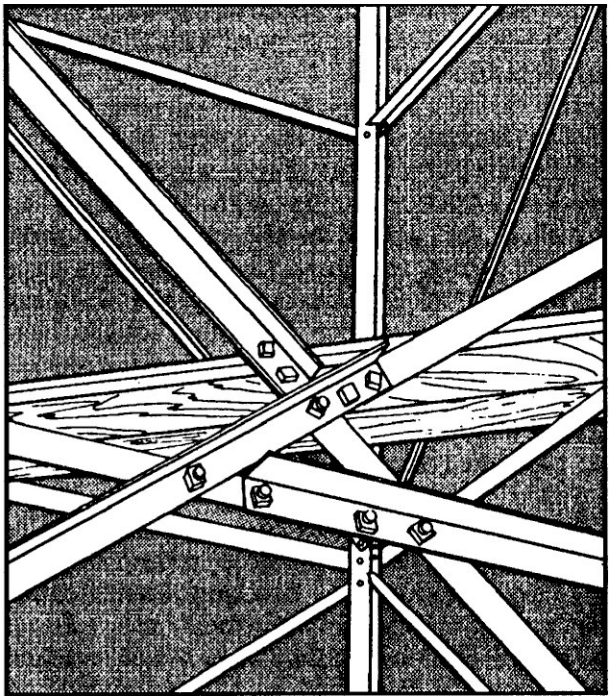
ASSEMBLY AND ERECTION OF SECTIONS

The first section of the tower is assembled on the ground alongside the foundation. Start by assembling the two-column legs on one side of the tower and bolt them loosely, with one bolt each, to two foundation stubs (anchor angle irons); these will act as pivot points. Next, loosely join the angle and the cross braces. Then lift the entire side. A crane or gin pole can be used to rotate it into a vertical position or, if necessary, it can be lifted by hand. Two people can start by lifting the far end and start walking it up. The two others, with handlines, can complete the upward journey.

As the column legs fall into position, use driftpins or spud wrenches to line up the holes with the holes in the anchor angle irons. Then insert the bolts and tighten them. Use spud wrenches for this job. Place lock washers under each nut. When one side is standing in the upright position, repeat the process for the opposite legs. Finally, connect the cross braces on the open sides, and add the cross braces on the inside. When the whole first section, or bay, is in place, tighten the bolts. Figure 8-27 shows the correct connection of diagonal and center horizontal members; notice the alternate connections of the diagonal members at all points,

Use a snatch block and line to lift each piece for the next section. Do not tighten the bolts until the entire section is in place. Then start lifting the pieces for the next section, shifting the snatch block as necessary. When the whole section is in place, tighten the bolts. Repeat this process until the whole framework of the tower is erected. Bolts should be hoisted by handlines in buckets or leather-bottom bolt bags. Figure 8-28 shows a partially completed tower.

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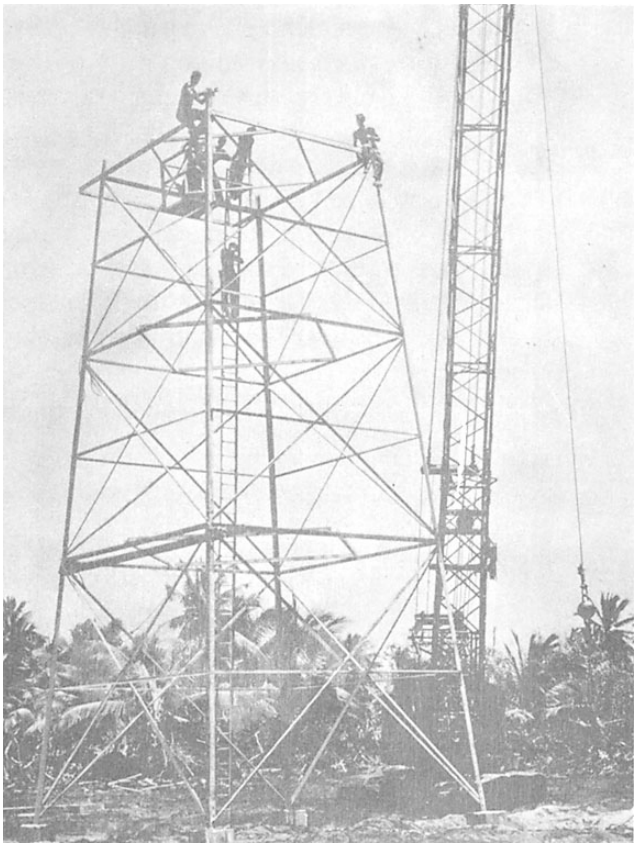
Figure 8-27.—Connection of diagonal and center horizontal members.

The ladder for the tower is assembled on the ground. As the tower is erected, the sections of the ladder are raised in place by handlines. These sections are then bolted in place. The cabin section is made of wood and is constructed by the Builders and raised in place; but, Steelworkers will be called upon to assemble rails and platforms.

After the tower is complete, one or two people must go over all of the bolts, center punching them to lock them in place. These people must also tighten all the nuts and see to it that washers have been inserted under each nut. This can be repeated after a few weeks as a final check. Figure 8-29 shows the top of a completed tower with a control room and with the guys in place.

DISMANTLING A TOWER

Steel towers can be taken down when they are no longer needed and then be erected again at a new location. As the first step in dismantling a tower, remove the guy lines, the electrical conduit for the red warning light for aircraft atop the tower, the platform, and any other accessories. Next, set up your rigging gear so that one leg of the section-preferably the leg that the ladder is connected to—will serve as the gin



29.178.1

Figure 8-28.—Partially erected tower.



29.178.2

Figure 8-29.—Completed tower.

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pole. Proceed to attach a shackle to the top vacant hole in the gusset plate and have a snatch block in the shackle. Open the snatch block and insert the fiber line to be used as a hoist line. Tie a bowline in the end of the line to keep it from slipping through the block Take the line to be used as the tag line and secure one end to the bowline. Now, secure a snatch block to the base of the tower, and run the hoist line from the top snatch block to this block. Be sure the snatch block at the base of the tower is located in a straight line to a source of power. The source of power can be a dump truck, a weapon carrier, or some other vehicle.

NOTE: When using a vehicle as a source of power, you must keep it back far enough so that as it comes forward, it does not arrive at the base of the tower before the load is on the ground.

The tower is dismantled by sections, and the top and second horizontal braces are the first members of the section to be removed. Start by tying the hoist line and tag line to the horizontal braces. Then signal the vehicle operator to back up and take a strain on the hoist line. You are now ready to remove the bolts, holding the horizontal braces in place. After all of the bolts are removed, lower the horizontal braces to the ground. Now, remove the diagonal braces in the same manner.

The next step is to remove the legs of the tower section, except the leg being used as the gin pole. First, shinny up the leg to be dismantled and hang a shackle at the top. Tie the hoist line to the shackle and then come back down the leg. Signal the vehicle operator to take a strain on the hoist line-just enough strain to take up the slack Remove the gusset plate from one side. Remove the remainder of the bolts that hold the leg being removed, leaving the two top bolts in place. Now, take the tag line and secure it with a clove hitch and a half hitch to the bottom of the load. Also, take a turn with the tag line around the horizontal bracing in the section that will be removed next. You should then remove the two top bolts as you slack off on the tag line and take up on the hoist line until the leg is hanging straight up and down against the gin pole. Release the tag line to the personnel on the ground who will guide the load, as it is lowered to the ground. Repeat this process with all of the remaining legs until only the ladder and the leg used as a gin pole are left. To remove the ladder, secure the hoist line to a rung above the center. Remove the bolts and then lower the ladder to the ground.

When you are ready to start dismantling the leg used as the gin pole, shinny up the leg and remove the hoist line from the snatch block. Secure the hoist line to the shackle. Remove the snatch block and hang it in your safety bit. Then come back down the leg to the spliced connection. (Generally, at all spliced connections, there will be horizontal brace connections that can serve as working platforms.) Signal the personnel on the ground to remove the hoist line from the base snatch block; then signal the vehicle operator to take up the slack. Remove the rivets and the gusset plate from one side of the splice. Remove the remaining bolts in the leg. After all of the bolts are removed, ensure that all personnel are clear of where the load will land Remove the top bolt, and release the nut on the other bolt one-quarter turn. Signal the vehicle operator to back up slowly. As the operator backs up, the leg will pivot downward on the bolt and fall against the leg it has been standing upon and which will be used as the gin pole in dismantling the next section. Now, insert the shackle in the top hole of the gusset plate and hang the snatch block in it. Put the hoist line back in both snatch blocks. With the hoist line, throw a half-hitch below the center of the leg. Now secure the tag line. Next, signal the vehicle operator to give a slight strain to take the tension off the bolt. You can then remove the bolt and lower the leg to the ground. This completes the dismantling of an entire section of the tower, so you can proceed to the next section.

Repeat the above procedure with each section until the tower is completely dismantled.

If the tower will be put up again, rather than scrapped, a crew should be assigned to wire brush each member of the tower after it is lowered to the ground In wire brushing, all rust, loose paint, and the like, should be removed from the member. Each member should also be marked. After they are marked, the members should be stored in a orderly manner.

ANTENNA TOWERS

Modem communications in different parts of the world between ships, shore stations, and aircraft, including the United States aerospace efforts, have required that transmitting and receiving facilities be erected all over the globe. Many times the Steelworkers from battalion detachments will be assigned to erect them. This section will describe some of the common communications antenna towers that are erected and the procedures for erecting them.

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GUYED TOWERS

The most commonly used guyed towers are fabricated from steel in untapered sections 10 to 20 feet long. These constant dimensional sections are erected one above the other to form the desired height. Structural stability for this type of tower is provided by attaching guy wires from the tower to ground anchors.

Base supports for guyed towers vary according to the type of tower to be installed. Three commonly used base supports are the tapered tower base, the pivoted tower base, and the composite base. All three are shown in figure 8-30.

A tapered tower base concentrates the load from multiple tower legs to a small area on the foundation.

The pivoted base is used primarily on lightweight structures for ease of tower erection.

A composite base is generally used with heavier towers because it affords much greater supporting strength than the other two types.

Sections for lightweight towers are usually assembled before delivery, to expedite final tower assembly, whereas heavier weight towers must be assembled completely in the field.

Tower bracing should include diagonal bracing and horizontal struts in the plane of each tower face for the full tower height.

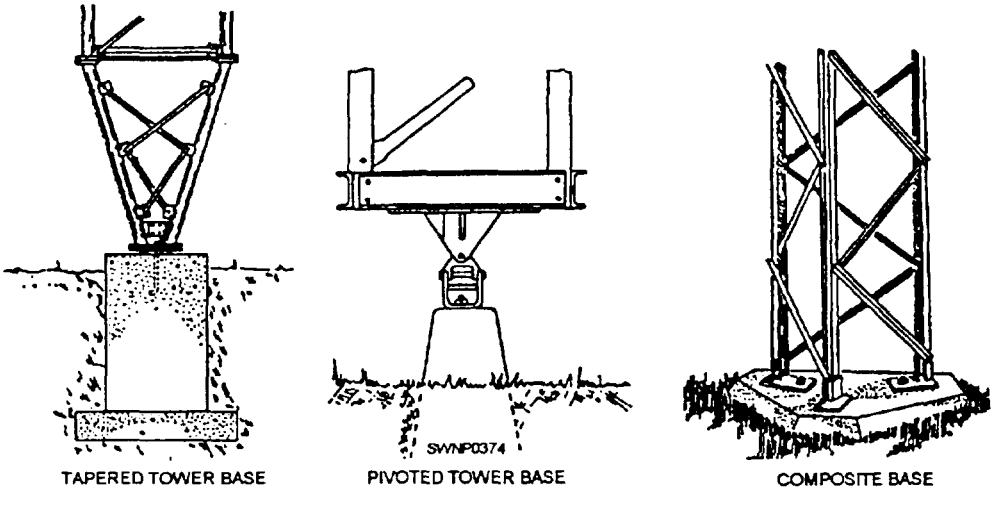
FREESTANDING TOWERS

Freestanding, or self-supporting, steel antenna towers are characterized by heavier construction than guyed towers and by a shape that tapers in toward the top from a wide base. Freestanding towers exert much greater weight-bearing pressure on foundations than most guyed towers. Consequent y, deeper foundations are required (because of the greater size, the weight, and the spread of tower legs) to provide sufficient resistance to the uplift. Each leg of a freestanding tower must be supported by an individual foundation. Figure 8-31 shows a typical individual foundation for a freestanding tower, and figure 8-32 shows a foundation plan for a triangular steel freestanding tower. Bracing and material specifications for these towers are the same as for guyed towers.

TOWER ASSEMBLY

Advance planning for tower assembly and erection is essential for completion of the project safely and correctly. Both the installation plan and the manufacturers' instructions should be studied to gain a complete understanding of the tower assembly and erection methods to be used. The following general procedures and practices should be observed for the assembly and erection of towers:

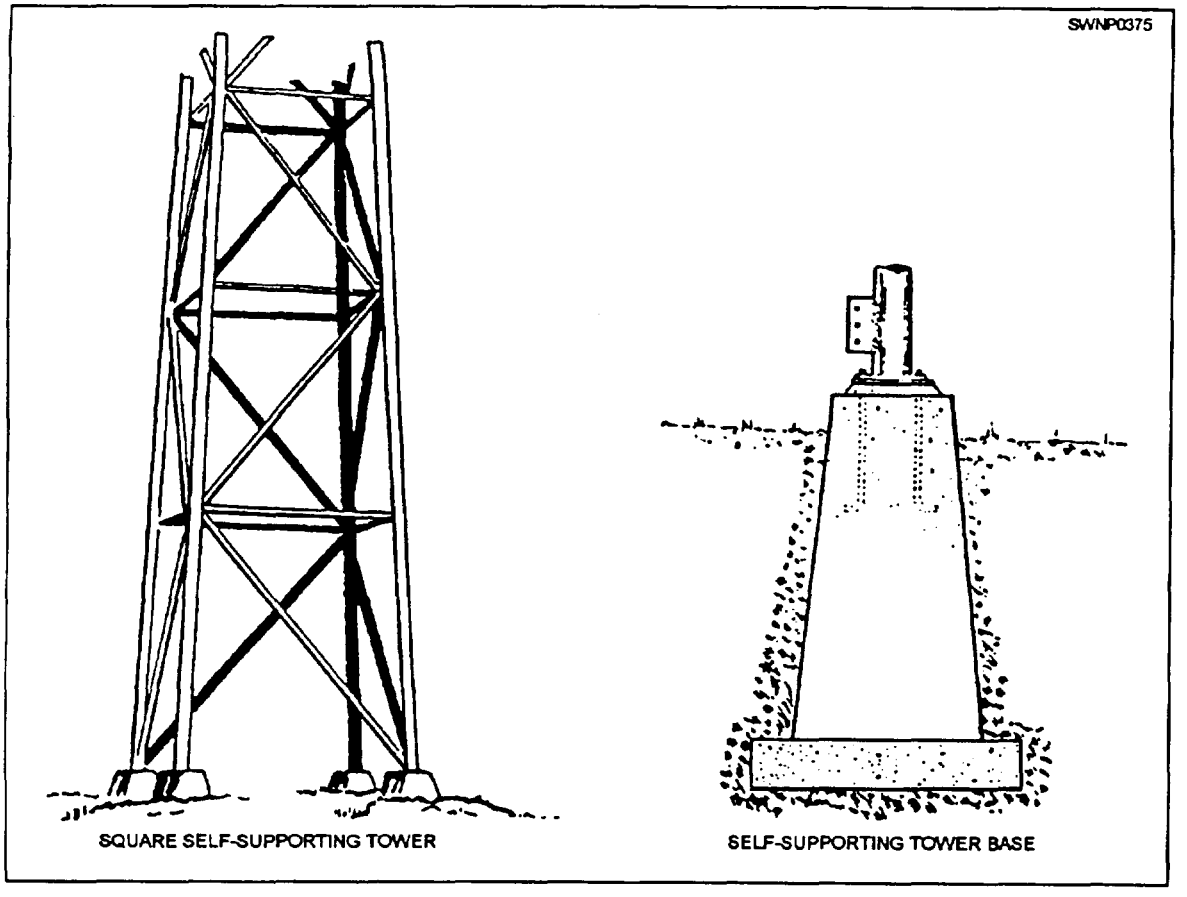
1. Assemble the tower sections on well-leveled supports to avoid building in twists or other deviations. Any such deviations in one section will be magnified by the number of sections in the complete assembly.



127.504

Figure 8-30.—Base support for guyed towers.

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Figure 8-31.—Square self-supporting tower and base.

2. Check all of the surface areas for proper preservation. Cover a11 of the holes and dents in galvanized materials with sinc chromate or another acceptable preservative to prevent deterioration.

3. When high-strength bolts are used in a tower assembly, place a hardened steel washer under the nut or bolt head whichever is to be turned. Care must be exercised not to exceed the maximum torque limit of the bolt. Maximum torque values of several different sizes and types of bolts commonly used in antenna towers are listed in table 8-2.

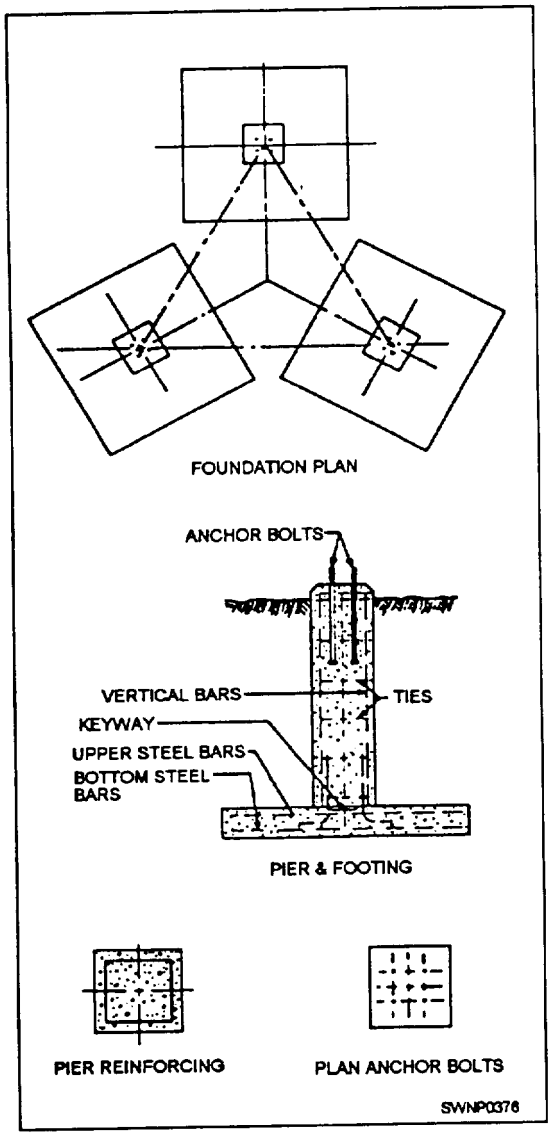
ERECTION OF GUYED TOWERS

The following paragraphs present methods that have been successfully used to erect guyed towers. 'Ihe most practical method for any particular tower

Table 8-2.—Bolt Torques (foot-pounds)

Size	Mild Steel	High-Strength Steel	Aluminum 24 ST-4	Stainless Steel 18-8
3/8″ - 16- - - - - - -	17	- - - - - - -	12	30
3/4″ - 13- - - - - - -	38	105	26	43
5/8″ - 11- - - - - - -	84	205	60	92
3/4″ - 10- - - - - - -	105	370	82	128
7/8″ - 9- - - - - - -	160	530	184	194
1″ - 8- - - - - - -	236	850	- - - - - - -	- - - - - - -
1-1/8″ - 7- - - - - - -	340	1100	- - - - - - -	- - - - - - -
1-1/4″ - 7- - - - - - -	432	1800	- - - - - - -	- - - - - - -

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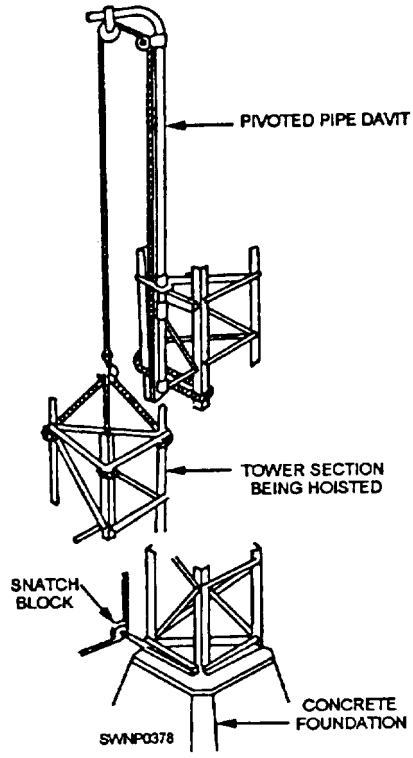
127.506

Figure 8-32.—Triangular tower foundation.

will be determined by the size, the weight, and the construction characteristics of the tower and by the hoisting equipment.

Davit Method

Lightweight guyed towers are frequently erected with a davit hoist that is anchored to the previously erected section, providing a pivoted hoisting arm. The davit arm is swung away from the tower in hoisting the added section and swung centrally over the tower in depositing the section before bolting up the splice plates. Figure 8-33 shows a ground assembled unit being hoisted for connection to a previously erected tower section. A snatch block, secured to the tower base, transmits the hoisting line to a source of power



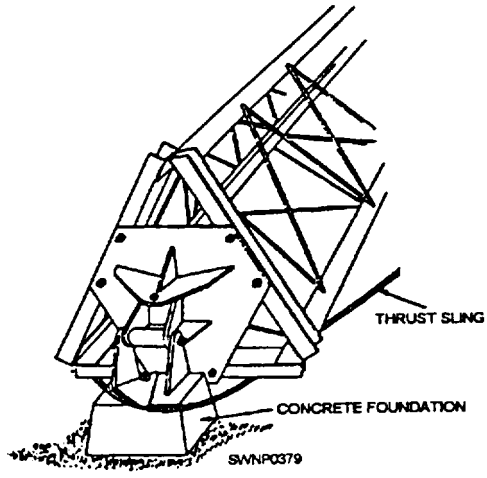
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Figure 8-33.—Typical davit installation.

or hand winch. A tag line, secured to the base of section being hoisted, avoids possible contact with the erected portion of the tower.

Gin Pole Method

Light triangular guyed towers, furnished with a pivoted base, may be completely assembled on the ground and then raised to a vertical position with the aid of a gin pole. Figure 8-34 shows the lower section



127.508

Figure 8-34.—Pivoted tower-hoisting preparation.

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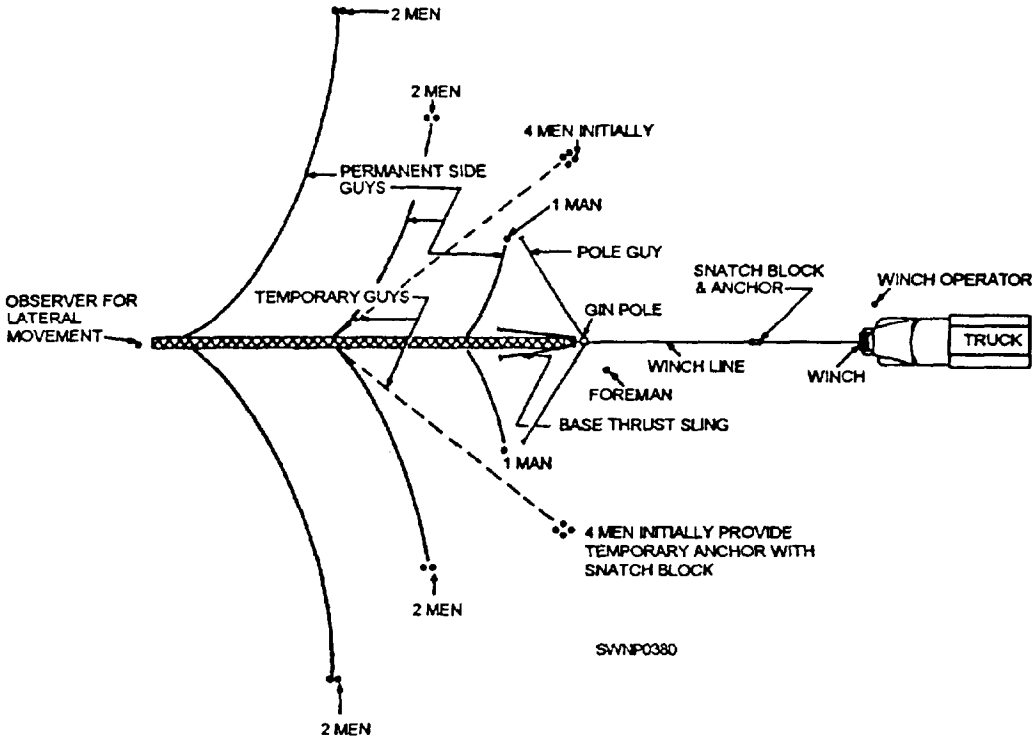
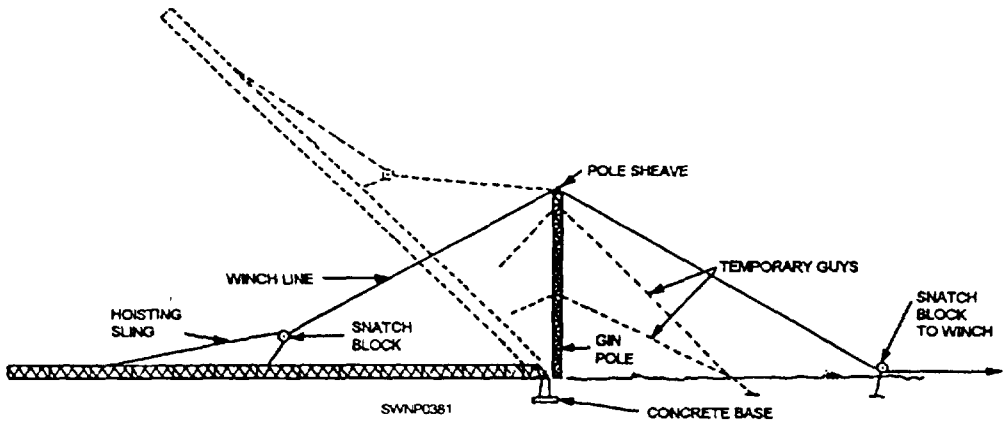


Figure 8-35.—Erection plan for a pivoted tower.

of a tower that has an attached pivoted base in a horizontal position preparatory to hoisting. The thrust sling shown counteracts the thrust on the base foundation from hoisting operations. Rigging operations and location of personnel essential to the raising of a pivoted base tower are detailed in figures 8-35 and 8-36. Light towers in lengths of approximately 80 feet may be raised with a single attachment of the winch line. However, longer towers frequently are too flexible for a single attachment, and, in this case, a hoisting sling, furnished with a snatch block, allows for two points of attachment. The gin pole is mounted close to a concrete tower base and is provided with atop sheave to take the winch line. Permanent guys, attached to the tower at three elevations, are handled by personnel during hoisting operations, as shown in figure 8-35. Temporary rope guys, provided with a snatch block anchored to deadmen, furnish the necessary lateral



127.510

Figure 8-36.—Erection of a pivoted guyed tower.

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stability As the mast approaches a vertical position, the permanent guys are fastened to the guy anchors installed before erection.

Hand Assembly

Erection, without a davit or gin pole, may be accomplished by the assembly of the individual members piece by piece, as the tower is erected. As assembler, you climb inside the tower and work with the lower half of your body inside the previously assembled construction. You then build the web of the tower section around you, as you progress upward. As each member is bolted in place, you should tighten all of the connections immediately so that at no time are you standing on or being supported by any loose member.

GUYING

Temporary guying of steel towers is always necessary where more than one tower section is erected. Under no circumstances should the tower be advanced more than two sections without guying. Permanent guys are to be installed before the temporary ones are removed.

Temporary Guying

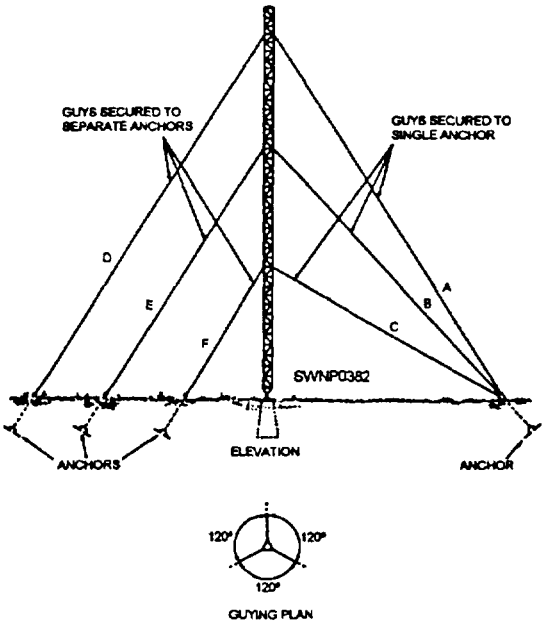
Several materials, including stranded wire, wire rope, and fiber line, are all acceptable for temporary guying. New manila line is the most suitable because of its strength and ease of handling. The size of the guyed material required is determined by the height and weight of the structure to be guyed and by weather conditions at the installation site.

Secure the temporary guys to the permanent guy anchors to temporary type anchors or to any nearby structure that provides the required supporting strength. Leave the temporary guys in place until the structure is permanent y guyed and plumbed.

Permanent Guying

Antenna structures are permanently guyed with steel cables or fiber glass sections to pre-positioned anchors according to the installation plan.

Figure 8-37 shows two methods of guying triangular steel towers. Guys A, B, and C are secured to a single anchor, while guys D, E, and F are secured to individual anchors. Both arrangements are satisfactory. However, the anchor that terminates guys A, B, and C must be capable of withstanding much greater stresses than the individual guy anchor arrangement. Triangular tower guys are arranged so



127.511

Figure 8-37.—Tower-guying arrangements.

that three guys are spaced 120 degrees apart at each level of guying (fig. 8-36). Square towers require four guys spaced 90 degrees apart at each level of guying (fig. 8-37). Square towers require four guys spaced 90 degrees apart at each guying level. The following general elevation requirements apply to guy attachments for towers:

SINGLE-GUY LAYER The cable attachments are placed in position at approximately two thirds of the tower height.

TWO-GUY LAYERS. For towers with two-guy layers, cable attachments are placed in positions at approximately 30 and 80 percent of the tower height.

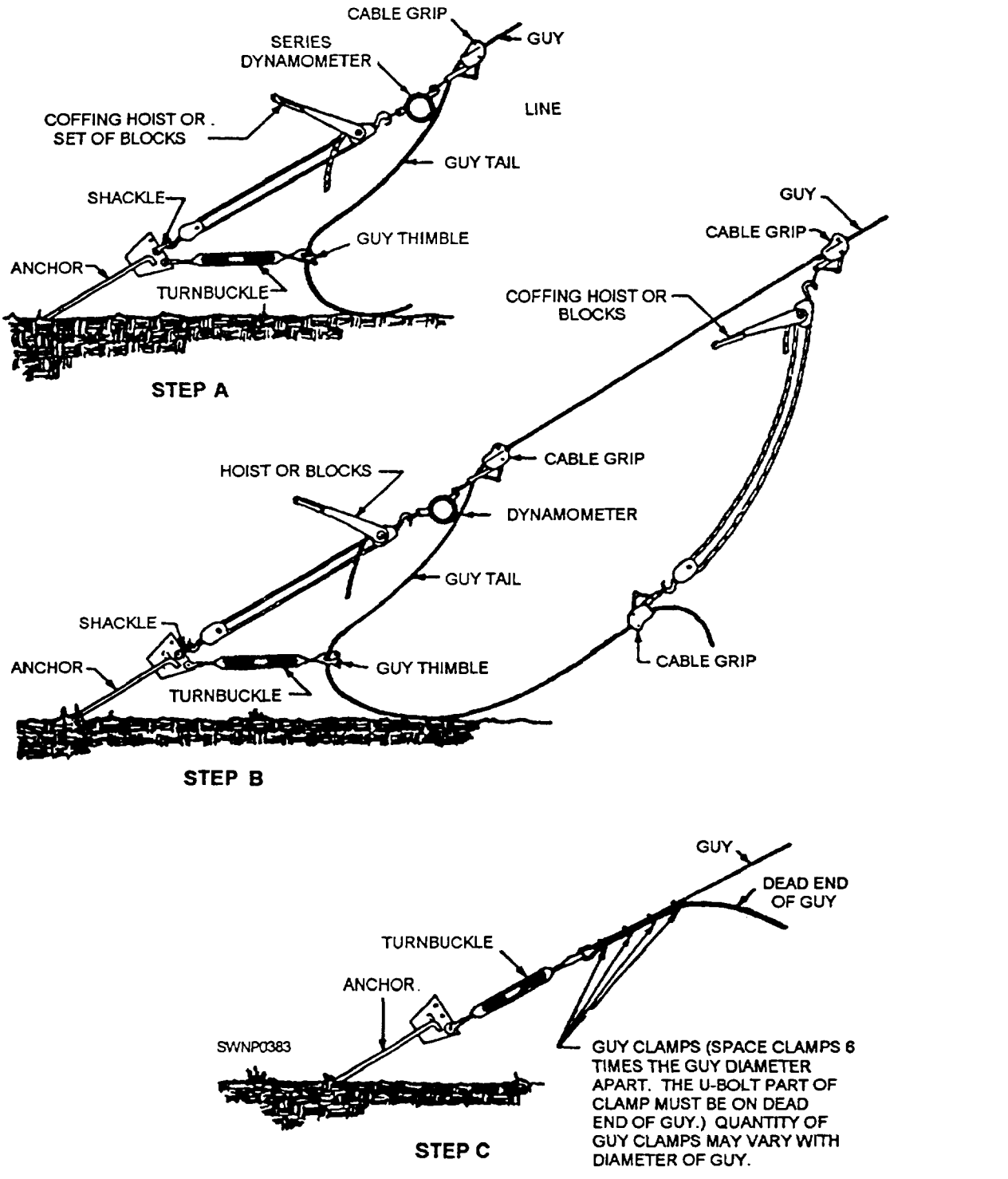
THREE-GUY LAYERS. For towers with three-guy layers, cable attachments are placed in positions at approximately 25,55, and 85 percent of the tower height.

Tower Guy Tension

Setting guy tension and plumbing a tower are done at the same time and only when wind forces are light. Guy tension adjustment and tower plumbing are done as follows:

INITIAL TENSION. All of the guys should be adjusted gradually to the approximate tensions specified in the antenna installation details. If tensions are not specified, guy tension should be adjusted to 10 percent of the breaking strength of the strand of the

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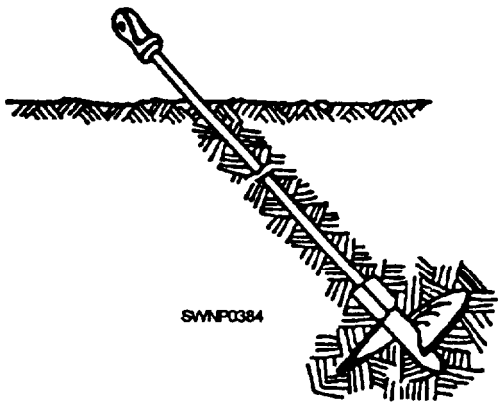
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Figure 8-38.—Final tensioning of guys.

guy. The tension on all of the guys is adjusted after the tower is in a stable, vertical position.

FINAL GUY TENSION. In one procedure used for final tensioning of tower guys, the final tension is measured with a dynamometer, as shown in figure 8-38. Carpenter stoppers or cable grips of the proper skin, designed for the lay of the wire, must be selected for use in the tensioning operation. Any cable grip assembly that grips the wire by biting into the cable

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Figure 8-39—Typical screw anchor.

with gripping teeth could penetrate and damage the protective coating of guy cables and should not be used In step A of figure 8-38, the coffing hoist is shown in series with a dynamometer to measure the tension. A turnbuckle is shown in position to receive the guy tail. In step B, an additional cable grip and hoist or tackle are attached above the cable grip shown instep A. The lower end of this tackle is provided with a second cable grip that is' attached to the guy tail previously threaded through the turnbuckle. The second coffing hoist is operated until sufficient tension is applied to cause the reading on the series dynamometer to fall off. Step C shows the guy in final position secured in place with clamps. With the tower properly plumbed to a vertical position, only one guy at a given level need be tested with the dynamometer.

On some installations, other procedures for tensioning guys may be necessary because of the type of guys and hardware supplied with the antenna. For example, preformed wire helical guy grips are sometimes used for attaching guy wires to the adjusting turnbuckles. In such cases, the techniques used for the guy assembly, the connection of the guy wire to the anchor, and the tension adjustments must be determined for the detailed installation plan or the appropriate antenna technical manual.

Guy Anchors

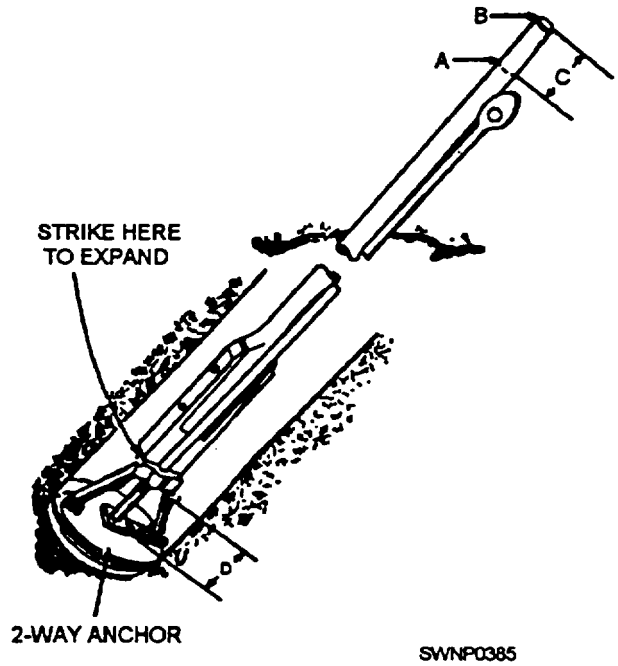
Antenna design and installation plans specify the anchor type, the location, and the hole depth required.

Anchor shafts, or rods, must project above the grade sufficiently to keep all of the connecting guy wire attachments free of vegetation and standing water. Shafts and connecting attachments should be thoroughly cleaned and then coated with a petroleum preservative to retard the effects of weather.

SCREW ANCHOR. The screw anchor shown in figure 8-39 may be used for temporary guying and for anchoring guys for lightweight towers. This anchor is installed by screwing it into the ground in line with the direction the guy will take.

EXPANSION ANCHOR. The expansion anchor shown in figure 8-40 is suitable for practically all guying applications where the soil is firm. This anchor is placed with its expanding plates in the closed position in an auger-drilled inclined hole, not less than 3 feet deep. The plates are expanded into the firm, undisturbed sides of the hole by striking the expanding bar at point B with a hammer and thereby forcing the sliding collar downward the distance D shown in figure 8-40. The anchor installation is completed by backfilling the hole with thoroughly tamped backfill.

CONCRETE ANCHORS. Poured in-place concrete anchors are normally used for high stress applications and where multiple guys are attached to a single anchorage.



LEGEND

A = EXPANDING BAR
B = HAMMER STRIKING POINT
C = MOVEMENT DISTANCE OF EXPANDING BAR
D = MOVEMENT DISTANCE OF SLIDING COLLAR

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Figure 8-40.—Expansion anchor.

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CHAPTER 9

PRE-ENGINEERED STORAGE TANKS

During World War II, steel tanks made possible many operations. During large operations, especially in forward areas, the need for rapid transport and appropriate storage facilities were of major importance. Steel tanks were used to store fuel, diesel oil, gasoline, and water to meet the demand for storage facilities. Ships and planes were supplied from secret tank farms at overseas bases, making possible many of the large invasions of the war in the Pacific.

This chapter will brief you on the procedures to follow in erecting bolted steel tanks including preparation of the foundation for a tank-

STEEL TANKS

Many types of tanks are available. Besides tanks that are constructed of standard mild steel sheets, tanks of galvanized steel sheets and of wrought iron may also be obtained. Tanks may be bolted, riveted, or welded. Bolted and riveted tanks have capacities of up to 10,000 barrels. Welded tanks may hold as many as 50,000 barrels.

Steelworkers are normally concerned with PREFABRICATED BOLTED TANKS. These tanks are composed of steel sheets of a size that is easily transported. Individual pieces are quite light. They can be assembled quickly in the field by crews of relatively untrained men so long as the man in charge understands the details of their construction. Once the tanks are assembled, they will last for 5 or 6 years or longer. A shipment includes all of the bolts, the nuts, the fittings, and the gasket material required for assembly. Drawings and assembly instructions also are provided.

Ten-thousand-barrel tanks are used to store fuel and diesel oil at overseas bases. One-thousand-barrel tanks are used for gasoline storage. Low 5,000-barrel tanks are seldom used for fuel storage where large operations are under way, but they may be used for storage of water. Since a barrel is equal to 42 gallons, you can see that a 10,000-barrel tank is capable of holding 420,000 gallons.

If desired, bolted steel tanks can be dismantled and re-erected at another location. You can obtain re-erection kits that contain new gasket material and extra nuts and bolts. In disassembling a tank, however, workers should make an effort to save all of the items of hardware that can be used again. When taking down a tank, avoid damage to any of the members because the number of re-erections of a tank depend largely upon the care taken during dismantling.

CAUTION

Exercise care when handling plates to avoid bending, dropping, or otherwise damaging the steel. Bent plates will cause problems when the tank is erected, and when used, the result is usually a leaking tank.

TANK FOUNDATIONS

Considerable care should be taken in constructing the GRADE or finished foundation on which the tank is to be erected. Concrete foundations are ordinarily not necessary if the ground is reasonably hard. When the grade is properly prepared and perfectly level, the tank can be joined on an even surface, and, therefore, it is easier to fit up and erect the tank Also, with proper support, the completed tank will be less likely to leak.

Grading

The earth grade should be constructed approximately 1 foot greater in diameter than the diameter of the tank which is to occupy it. The earth must be well-tamped to a firm and smooth surface. Never fill the area for a tank foundation because erosion will, in time, result in a faulty foundation.

Foundation Construction

The tank foundation should be dry, level, and well-drained. A layer of clean gravel or sand on the grade is ideal for this purpose. Tar paper may be spread under the tank as a corrosion-resistant carpet.

When a layer of gravel or sand is used on a grade of firm earth, follow these steps:

1. Drive a peg in the exact center.

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2. Mark this center peg at a point 6 inches from the top) and drive it down in the grade to this mark.

3. Use a wooden straightedge with a carpenter's level attached to set grade stakes about 10 feet apart. Note that, set in this manner, they will protrude 6 inches above the earthen grade.

4. Distribute sand over the whole grade, using shovels and rakes. When the sand just covers the top of each of the stakes and the center peg, the proper level has been reached.

5. Drive the stakes and the center peg all the way down into the earth under the sand. When the tank is filled, the sand will compact, and if the stakes are not driven down, they may cause leaks. Mark the position of the center peg with a temporary pin so that you will be able to position the center of the tank bottom later.

6. To make the surface smooth, use a sweep with a carpenter's level attached. Pin the sweep to the center peg and drag it over the sand, filling in any hollows and smoothing out humps. The sand pad should be at least 4 inches thick and should have a crown of about 1 inch in 10 feet of tank radius; however, the crown should not exceed 6 inches.

When a foundation is properly prepared, many unnecessary problems do not occur during construction of the tank. Just imagine the problems that might occur, both in erection and in subsequent maintenance of a tank, if the foundation were to settle unevenly, throwing the steel plates on one side of the tank slightly out of line. Remember that the walls of the tank—consisting merely of steel plates bolted together-must act as bearing walls to support the roof. So, make sure you have a good foundation before starting to assemble a tank.

BOLTED STEEL TANK ASSEMBLIES

Tanks are assembled by sections, consisting of pieces of various sizes and shapes that combine to form cylindrical structures. Among the most common are the bolted steel tanks, having a capacity of 100, 250, or 500 barrels of liquid Many tank sections serve the same function regardless of tank capacity. However, the number of sections used in each assembly will vary according to capacity. The procedures for assembling and erecting these tanks are similar.

100-Barrel Tank

The 100-barrel tank shown in figure 9-1 is the smallest bolted steel tank. It has a holding capacity of 4,200 gallons of liquid and is made up of preformed and punched metal sections, fastened together with 1/2-inch-diameter bolts. The tank bottom (fig. 9-2) consists of two semicircular halves, bolted together at a lap joint along the center of the tank bottom. This vertical, bolted steel tank has a 9 foot 2 3/4-inch-inside diameter and is 8 feet 1/2 inch high at the sidewall.

SIDE STAVES.— The side staves consist of six curved, vertical sections, arranged in a single ring. The staves are chimed (flanged) at the top and bottom of each section with the left end of each chime offset so the vertical seams overlap. The bottom chime bolt holes are patterned to match the outer edge bolt holes in the tank bottom. The vertical seams have one row of bolt holes.

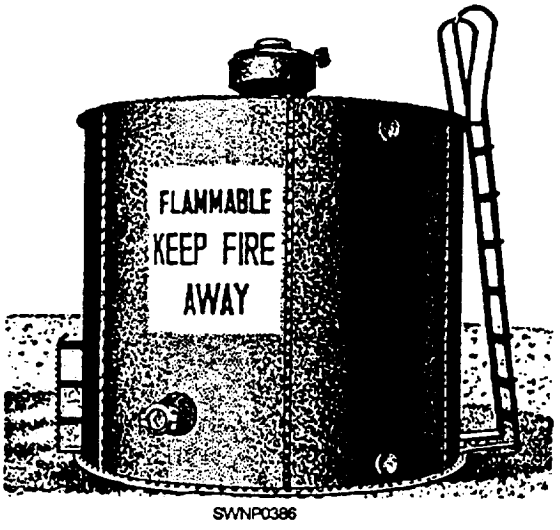


Figure 9-1.—100-barrel capacity, vertical, bolted steel tank.

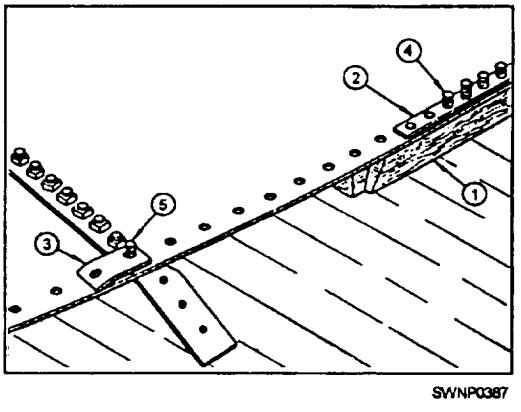


Figure 9-2.—Tank bottom.

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CENTER LADDER SUPPORTS.— The center ladder is the center support for the tank deck. The ladder is adjustable and is used to align the deck section bolt holes and provide the required slope to the tank deck

The ladder consists of two ladder braces, two ladder rails, four ladder steps, steel angles, and a flanged manhole that supports the tank deck

TANK DECK— The tank deck is made up of six sections, extending radially from the tank center ladder support to the top chime of the single ring of side staves. Each deck section has an integral formed flange along its right edge when viewed from the large end toward the small end of the deck section. The flanged side of the deck section acts as a supporting rafter for the deck section. A bolt retainer angle is attached to the inside face of each deck section, flanged to retain the radial seam joint bolts that are installed near the right edge of each deck section.

SPECIAL SECTIONS.— The tank bottom has one special section, fitted with a blind opening. All of the staves are special sections (fig. 9-3). One section is for a cleanout cover, and the other five sections are used for pipe connections. The tank deck has three special sections. One section is for a combination thief hatch and vent, one section has a blind hatch, and one section has a liquid level indicator.

EMERGENCY VENT.— Each tank is equipped with an 8-inch emergency vent, bolted to the top cover of the manhole attached to the top of the center ladder supports.

OUTSIDE LADDER.— Each tank is equipped with an outside ladder for access to the deck The ladder is bolted to the bottom and top chimes of a side stave and is usually located near a tank thief and vent.

250-Barrel Tank

The 250-barrel tank has a capacity of 10,500 gallons of liquid, and the fabrication is similar to the 100-barrel tank. The tank bottom consists of ten wedge-shaped plates, assembled radially around a one-piece center section, as shown in figure 9-4. The inside diameter is 15 feet 4 5/8 inches and is 8 feet 1/2 inch high at the sidewall.

SIDE STAVES.— The side staves consist of ten curved, vertical sections, arranged in a single ring. The staves are chimed (flanged) at the top and bottom of each section with the left end of each chime offset so the vertical seams overlap. The bottom chime bolt holes are patterned to match the outer edge bolt holes in the tank bottom. The vertical seams have one row of bolt holes.

TANK DECK.— The tank deck is made up of ten sections, extending radially from the tank center ladder support to the top chime of the single ring of side staves. Each deck section has an integral formed flange along its right edge when viewed from the large

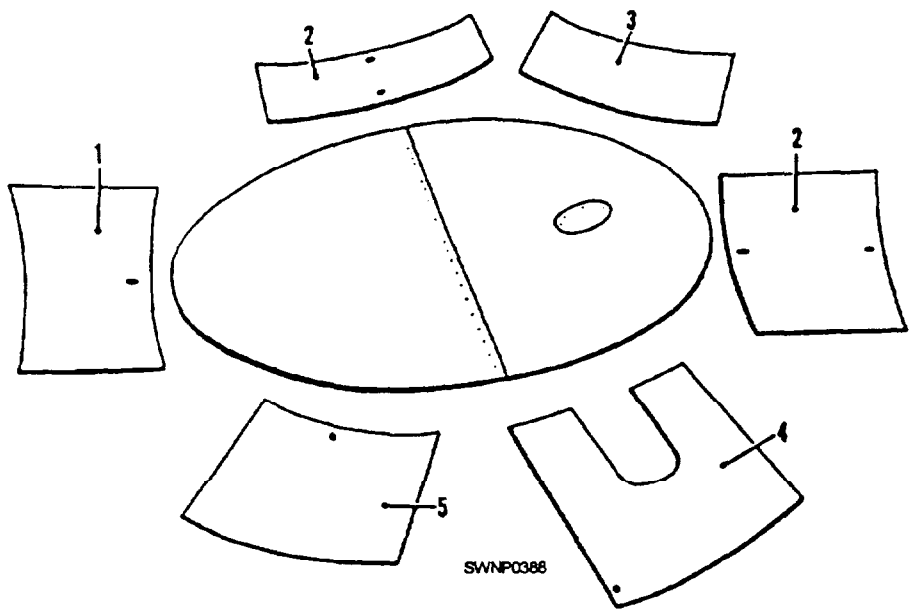


Figure 9-3.—Layout of the staves around the tank bottom.

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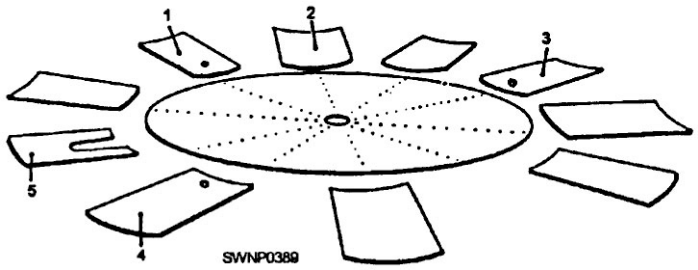


Figure 9-4.—Layout of the staves around the tank bottom, 250-barrel capacity tank.

end toward the small end of the deck section. The flanged side of the deck section acts as a supporting rafter for the deck section. A bolt retainer angle is attached to the inside face of each deck section, flanged to retain the radial seam joint bolts that are installed near the right edge of each deck section.

SPECIAL SECTIONS.— The tank bottom has one special section, fitted with a blind opening. Four of the ten staves are special sections. One section is for a cleanout cover, and the other three sections are used for pipe connections. The tank deck has three special sections. Two sections are used for a combination thief hatch and vent, and one section is used for a liquid level indicator.

EMERGENCY VENT.— An 8-inch vent is bolted to the top cover of the manhole attached to the top of the center ladder supports.

500-BarreI Tank

The 500-barrel tank (fig. 9-5) has a capacity of 21,000 gallons of liquid and is similar to the 250-barrel tank, except that the bottom consists of 14 wedge-shaped plates around a one-piece center section, as shown in figure 9-6. This vertical, bolted

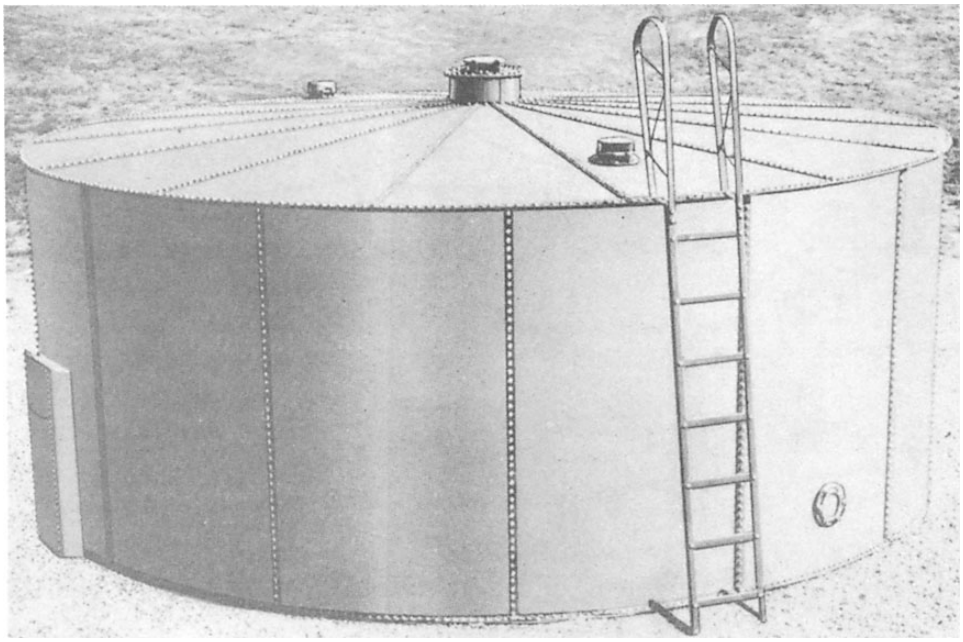


Figure 9-5.—500-barrel capacity vertical, bolted steel tank assembled.

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steel tank has a 21 foot 6 l/2-inch-inside diameter and is 8 feet 1/2 inch high at the sidewall.

SIDE STAVES.— The side staves consist of 14 curved, vertical sections, arranged in a single ring. The staves are chimed (flanged) at the top and bottom of each section with the left end of each chime offset so the vertical seams overlap. The bottom chime bolt holes are patterned to match the outer edge bolt holes in the tank bottom. The vertical seams have one row of bolt holes.

TANK DECK.— The tank deck is made up of 14 sections, extending radially from the tank center ladder support to the top chime of the single ring of side staves. Each deck section has an integral formed flange along its right edge when viewed from the large end toward the small end of the deck section. The flanged side of the deck section acts as a supporting rafter for the deck section. A bolt retainer angle is attached to the inside face of each deck section, flanged to retain the radial seam joint bolts that are installed near the right edge of each deck section. The bolt retainer angle acts as a stiffening member to the deck section flange along the span of the deck section

SPECIAL SECTIONS.— The tank bottom has one special section, fitted with a blind opening. Five of the 14 staves are special sections. One section is for a cleanout cover, and the other four sections are used for pipe connections (fig. 9-6). The tank deck has three special sections. Two sections are used for a thief hatch and relief valve, and one section is used for a liquid indicator.

EMERGENCY VENT.— Each tank is equipped with a 10-inch emergency vent, bolted to the top cover of the manhole attached to the top of the center ladder supports.

ERECTION OF A 500-BARREL TANK

Although similar in design and construction, bolted steel tanks differ mainly in the number of parts required for each different size tank. Therefore, the erection procedures for the 500-barrel tank, described here, can be applied to the other tanks regardless of size.

Center Bottom Plate

The center bottom plate (fig. 9-7) is a circular, flat steel plate. The tank bottom plates are attached to the outer circumference bolting circle. Before installation of the center bottom plate, make sure that it is not warped or broken. Check the bolt holes for bolt clearance. Clean the bolt holes of dirt or other foreign material where the center plate gasket is applied. Drive the center stake below the surface of the foundation and backfill the hole. Place the bolt-retaining boards around the outer circumference of the plate. Position the plate over the center stake. Place the gasket around the bolt circle of the center bottom plate. Insert two 1/2- by 1 l/2-inch bolts in the two bolt hole channel.

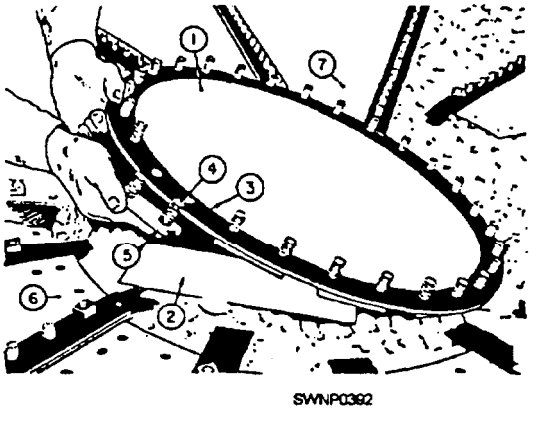


Figure 9-7.—Installation of the gasket the bolts, and the channels on the center bottom plate.

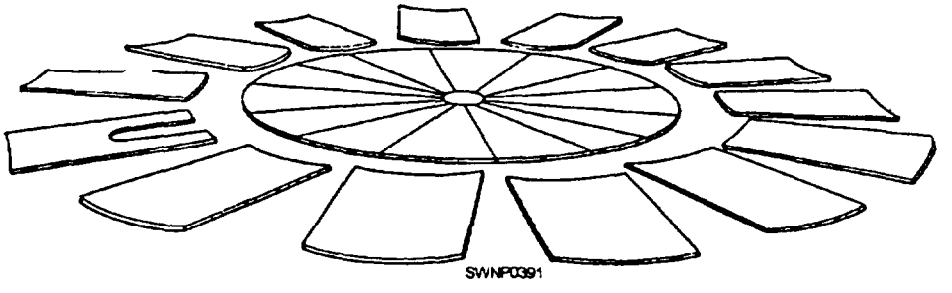


Figure 9-6.—Layout of the staves around the tank bottom, 500-barrel capacity tank.

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Insert the channel assembly through the center bottom plate and gasket.

NOTE: To prevent damage to the gasket, do not use a sharp-edged tool or pipe to force the gasket over the bolts. Use a well-rounded, smooth, mouth tool.

Lay the center bottom plate on the bolt-retaining boards. These boards will prevent movement of the bolts when the bottom plates are installed.

Bottom Plates

The tank bottom consists of 14 tapered, flat steel plates. Thirteen plates are plain, and one is soecial. All of the plates are interchangeable. When the bottom is completely installed, the plate pattern resembles a wheel. The first bottom plate (fig. 9-7, #7) has a bolt channel placed under each radial lap seam with l/2-by 1 l/4-inch bolts (fig. 9-8). A strip gasket is placed along each seam. The seams are identified as right and left, facing the large end.

Starting at the large end of the plate (fig. 9-7), place a bolt channel under the right and left lap seams of the plate. Insert the bolts through all except the end bolt holes in the plate and channel. As the channels are put in place, position the bolt-retaining boards to facilitate installation of the gaskets. Install the gasket along the full length of the right and left lap seams. Allow a l/2-inch bolt hole overlap at each end.

NOTE: When there is a break in the gasket material, the ends should overlap two bolt holes and be cut squarely across the second hole. Putty must be applied to each end of the overlap strip to ensure a leakproof joint.

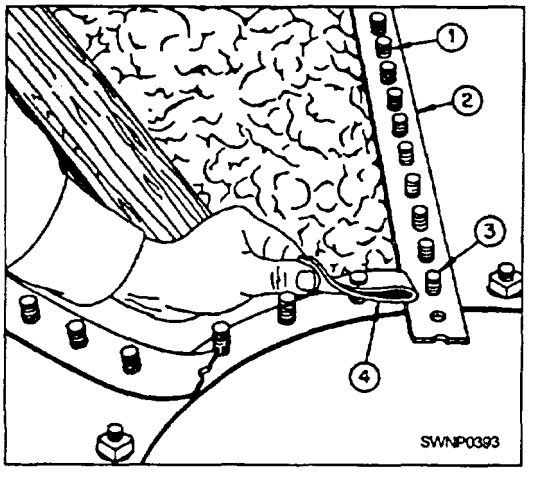


Figure 9-8.—Installation of bottom plates.

Upon the completion of the assembly, move this plate to the approximate installation position on the tank foundation.

Of the 13 intermediate plates, one is an outlet plate, which is assembled with channels and strip gaskets. The channels are placed under the right lap seams. Follow the same assembly procedures as outlined above. In addition, the outlet plate has a blind flange set assembled on it. The above procedure does not apply to the last bottom plate as no further assemblies are made on it. Keep the last bottom plate separated from all of the other plates until it is installed in the tank bottom.

Cut six one-hole gaskets from the strip gasket material (fig. 9-8, #2). Force a one-hole gasket over and against the head of each flange bolt. Insert the bolts through the bolt holes in the inside flange half from the outside face of the flange with the heads of the bolts fitting into the cutouts provided. Lay bolt-retaining boards on the ground. Position the flange assembly with the bolt head resting on the boards. Slip a gasket over the bolts and force it down against the inside face of flange #7, using a round smooth, mouth tool. Work from the ground face of the plate (fig. 9-7, #7) and push the bolts through the bolt holes of the flanged opening. Place blocking under the bolt and flange assembly to hold it in position. Slip a gasket over the bolts and force it down against the inside face of the plate. Slip the outside flange half over the bolts with the machined face of the flange facing the gasket. Apply the nuts to the bolts. lighten the bolts. Remove the plate from the blocking and lay it on the tank foundation

With the first bottom plate in the approximate installation location on the tank foundation, lay the remaining plates around the tank foundation. Proceed with the installation as follows.

FIRST PLATE.— Place the small end of the plate over the center plate bolts (fig. 9-8, #3). Apply finger-tightened catch nuts to the bolts inside the lap seams. Catch nuts are ordinary nuts applied to the bolts to hold the assembled plates in position.

FIRST INTERMEDIATE PLATE.— Wedge-shaped gaskets must be used wherever three plates are joined together. Before installation of the plate, you should place a wedge gasket (fig. 9-8, #4) over the gasket (fig. 9-7, #3) at the right edge of the first plate #7. Face the small end of the plates. Install

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the plate and all of the remaining plates to the left of the first plate or in a counterclockwise direction around the tank foundation. Place the small end of the plate over the bolts (fig. 9-8, #3) with the right lap seam of the plate laid over the bolts (fig. 9-8, #1) in the left lap seam of the plate (fig. 9-7, #7).

Apply finger-tightened catch nuts to the bolts. Follow the same procedure as outlined above. Apply catch nuts to the bolts in the lap seam at intervals of approximately 18 inches.

Do not tighten the catch nuts beyond finger tightness. Each plate must move in the adjustment of the tank bottom to obtain the correct spacing for the installation of the last plate.

REMAINING INTERMEDIATE PLATES.— The remaining intermediate plates are installed following the same procedure as above.

LAST PLATE.— InstaIl the last plate by spacing the lap seams over the lap seams of the next-to-last plate (fig. 9-9, #1) and the first plate (fig. 9-9, #2). Place the small end over the bolts (fig. 9-8, #3). 'Ibis is a vital point in the tank bottom; make sure it is secure against leakage.

INSTALLATION OF WEDGE GASKETS.— Apply a heavy coating of sealing compound to both faces of the two gaskets (fig. 9-9, #3), and install them over the bolts (fig. 9-9, #4). Use a generous amount of sealing compound at the overlap to seal The opening under the small end.

TIGHTENING TANK BOTTOM.— Work from the small end of the plates and remove all of the catch nuts. Install a rubber gasket, a steel recessed washer, and a nut on each of the bolts. This applies to all of the bolts in the tank bottom with the exception of those in the outer circumference (chime) of the tank bottom,

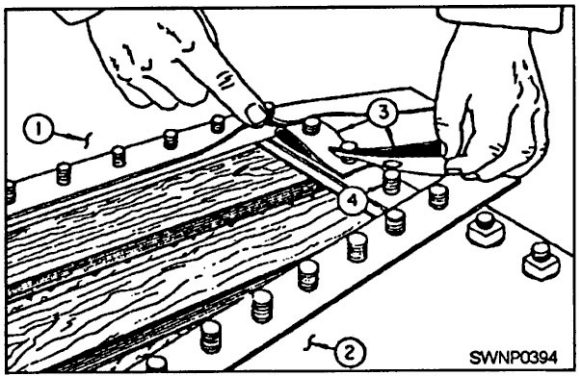


Figure 9-9.—Method of installing the wedge gaskets at the installation of the last bottom plate

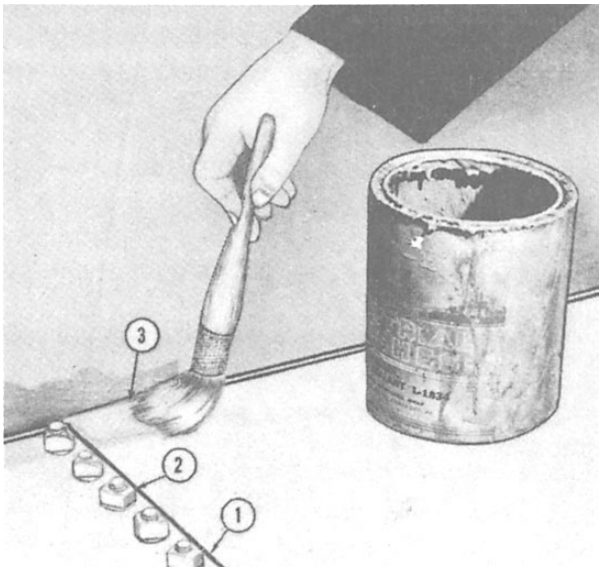


Figure 9-10.—Applytng sealing compound to the bottom chimes of the staves.

which secures the side staves. Tighten all of the bolts in the tank bottom, starting at the small end of the plates.

SEALING SEAMS.— Sweep the bottom clean after tightening the bolts. With the bottom dry, apply a sealing compound to all of the bottom seams (fig. 9-l0).

Side Staves

This is a single ring tank Place all of the center support ladder components and the manhole dome on the bottom just before installing the last stave. This is to prevent them from having to be lifted over the top of the staves later. The top and the bottom flanged edges of the staves are called chimes, and the side edges are called vertical seams. The staves have a single row of bolt holes in each seam.

LAYOUT OF STAVES.— There are five special and nine plain staves in the ring. Place the staves with the opening and pipeline connections in the proper position, then lay out the remaining staves around the perimeter of the bottom. Place the staves with the chimes side down for convenience in preparing them for assembly. The staves are laid out so each straddles a radial seam of the bottom.

Staves have an offset at the top and the bottom. The top is determined by looking at the stave in a

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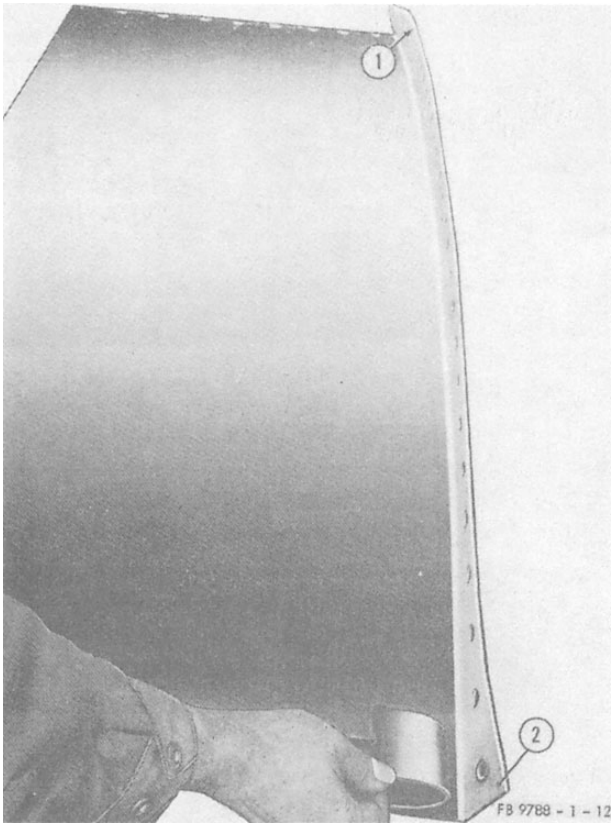


Figure 9-11.—Stave chimes bent.

vertical position from the outside. In proper position, offsets are at the lower left and upper left comer.

DRESSING STAVES.— The end of the chime at the offset and the plain section, top and bottom, must be slightly bent for ease in installation. The end of the chimes at the offsets (fig. 9-11) must be bent inward (towards each other). The end of the plain chimes is bent outward (away from each other). The bends are made with a few sharp blows from a hammer.

Along the right seam of each stave, as it will be put in place with the chimes out, place a strip gasket on the outside at the row of bolt holes. The gasket material comes in rolls and is cut to proper length for each stave. Cut the gasket material so that it covers and projects one bolt hole past the top and the bottom chimes.

Insert 1/2- by 1 l/4-inch bolts through the stave joint channel, the stave, and the gasket, in that order. Omit one bolt about 10 inches from the bottom of the stave and other bolts at about 2-foot intervals, so the driftpins can be inserted to align the staves with one another before bolting them together.

PREPARING OUTER EDGE OF TANK BOTTOM.— AS no channels are used with the bolts inserted through the chime (outer edge) of the bottom, it must be raised to provide clearance to insert and tighten the bolts following installation of the staves.

Raise the chime and block it up with short lengths of 3- by 3- or 4- by 4-inch timbers at equally spaced intervals around the perimeter of the bottom. Set the blocking about 16 inches from the outer edge.

Install the strip gasket to coverall of the bolt holes. When one roll of gasket material is used up and a new one is started, the overlap should extend over two bolt holes. Apply putty at each end of the overlap. Insert a wedge gasket underneath the gasket at the laps formed by the bottom plates.

Insert 1/2- by l-inch bolts through all of the bolt holes in the bottom and the gasket, in that order, except in the lap seams of the bottom. Insert 1/2-by 1 l/2-inch bolts in each lap seam.

Omit the rubber gaskets and steel recessed washers on all of the chime bolts.

FIRST STAVE.— The first stave (fig. 9-12, #l), installed on the bottom, must be the one fitted with a pipe coupling of the same size as the tank supply pipe.

Place the stave over the proper bolts, so the stave straddles a radial seam in the bottom. As a result, each subsequent stave will straddle a radial seam. Install four equally spaced catch nuts to hold the stave in position. Run the nuts down by hand to fasten the stave loosely. The nuts are not tightened until the last stave in the ring is in place.

Two special gaskets are needed. The wedge gasket fills the space by the lap offset at the vertical seam, and a radii gasket is installed underneath the gasket at the bottom and the top chimes of the stave. Radii

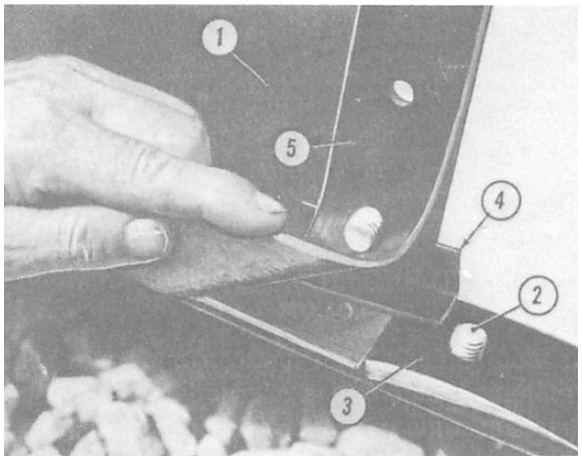


Figure 9-12.—Installing first stave.

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gaskets must be placed between the chimes and the rubber gasket material at the seams, the top, and the bottom of all of the side sheets to ensure a leakproof connection.

SECOND STAVE.— Install the staves in a counterclockwise direction around the bottom. To assist in the installation of this stave, push two or three bolts flush with the gasket in the chime of the bottom to the right of the first stave. Install the rubber gaskets and steel recessed washers on all of the vertical seam bolts.

Set the stave in position with the left seam outside the right seam of the first stave. Use driftpins in the open bolt holes in the stave to align the holes in the stave. Install the nuts only at every sixth or tenth bolt in the row. As the remaining staves are installed, check carefully the position and the tightness of all the radii, the strip, and the wedge gaskets.

REMAINING INTERMEDIATE STAVES.— Face the outside of the second stave and install 11 staves to the right of the second stave or in a counterclockwise direction around the bottom. Assemble the hook ladder, and hook it over the inside of the staves. As the staves are installed, stand on the ladder and fit all of the bolt heads squarely into the channels. All of the bolt heads must be fitted squarely into the stave joint channels to ensure proper tightening of the nuts.

LAST STAVE. — To assist in the installation of this stave, push all of the bolts (fig. 9-12, #2) in the chime of the bottom flush with the gasket to provide clearance for sliding in the last stave. Set the stave in position with the left seam outside the right seam of the next-to-last stave and the right seam inside the left seam of the first stave. Loosen the bottom chime nuts of staves #2 and #3. Lift the first stave #3 slightly, so the bottom chime of the stave #1 slips into place. Use driftpins and align the holes and the bolts in staves #1, #2, and #3. Install the nuts on the bolts in the chime of the bottom. Install 1-by 1 l/2-inch bolts (fig. 9-13, #2) in the third and twentieth bolt holes of the vertical seam, counting down from the top chime of every stave. These are scaffold-mounting bolts. Install the remaining bolts in all of the seams. Install the gaskets and washers with the cup side down over the gaskets

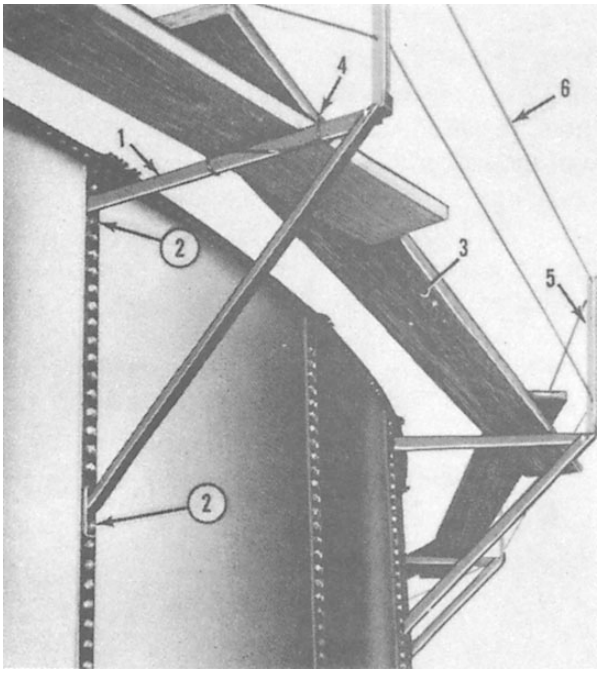


Figure 9-13.—I.ocation of the scaffold around the top chime of the staves.

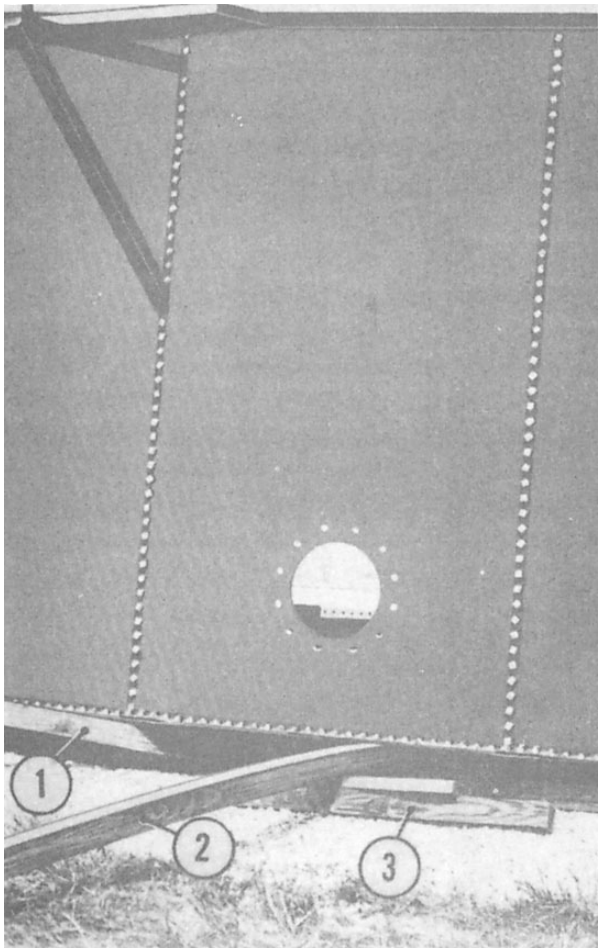


Figure 9-14.—Removing the timber blocking.

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on all of the seam bolts. Apply the nuts with the rounded face down to all of the bolts. Do not tighten.

Tighten all of the chime bolts uniformly. Remove the blocking (fig. 9-14); place it under the chime of the bottom. Use a heavy, long timber as a lever and a short timber as a fulcrum to lift the chime. lighten all of the seam bolts. Be careful not to crush the gaskets. Apply a sealing compound to the inside perimeter of the bottom chimes of the staves.

DRESSING TOP CHIME.— Use the scaffold and install the strip gasket to coverall of the bolt holes (fig. 9-15). When one roll of gasket material is used up and a new one is started, the overlap should extend over two bolt holes. Apply a sealing compound at each end of the overlap. Insert a wedge gasket underneath the gasket at each lap, formed by adjoining staves. Insert 1/2- by l-inch bolts through the chime and gasket, in that order. The gasket will hold the bolts in place.

Ladder Assembly

'he ladder consists of a bolted steel angle section. The top of the ladder is fitted with a manhole dome. The bottom of the ladder is fitted with ladder anchors, flanged, flat steel plates. The small end of the deck plates is bolted to the bottom flange of the manhole dome.

Place two ladder rails (fig. 9-16, #1 and #2) with similar bolting legs facing each other on top of several pieces of blocking of sufficient length to support both rails and spaced wide enough apart to insert a ladder

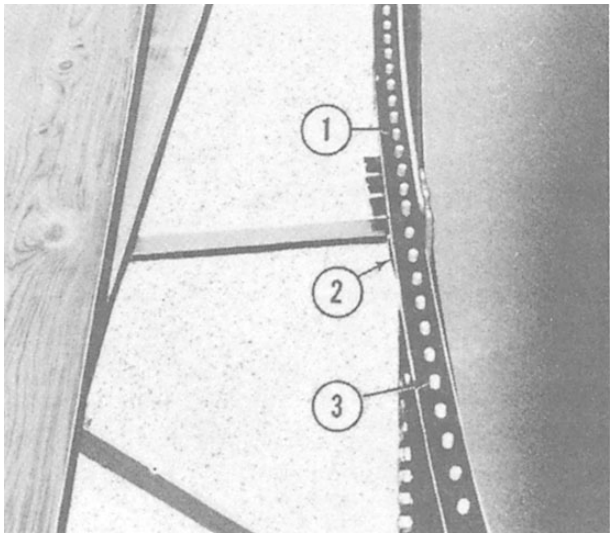


Figure 9-15.—Dressed top chime of the staves

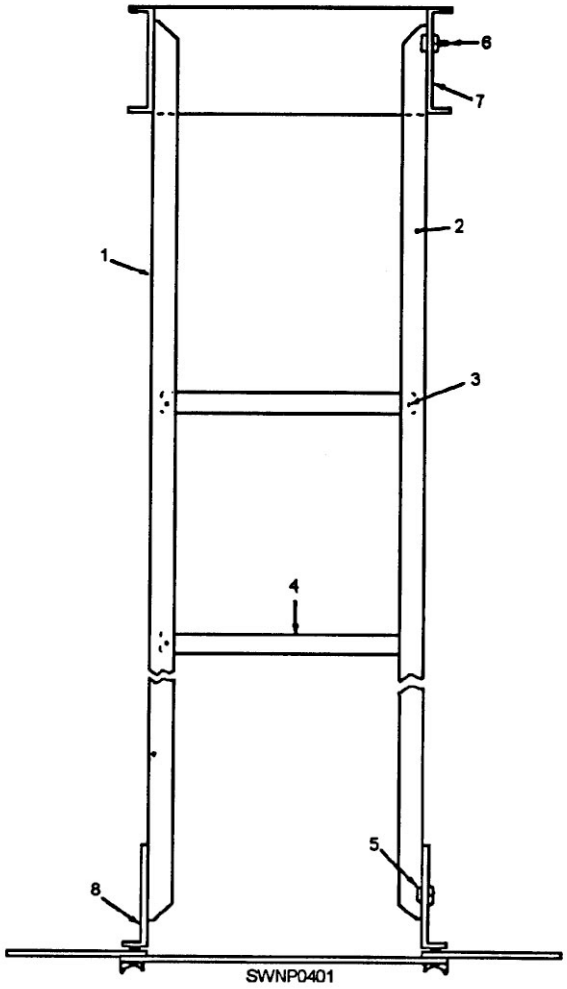


Figure 9-16.—Deck support ladder.

step. Determine which end of the roils will be the bottom. Install the steps from the bottom toward the top of the ladder. Five steps make up the assembled section. Insert 1/2- by l-inch bolts through the ends of the step and rails. Install a nut on each bolt protruding through the rails. Tighten the bolts after all of the steps are installed.

Face the 30 bolt hole flange of the manhole dome and slide it over the top of the rails. Use a driftpin and

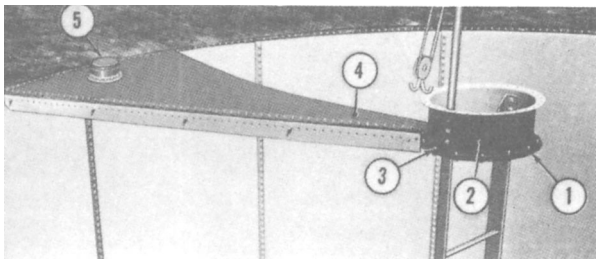


Figure 9-17.—First deck plate installed.

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align the three bolt holes at the top of the rails with similar holes in the side of the dome. Insert 1/2-by 1 Ml-inch bolts through the rails and the dome, in that order. Apply gaskets and washers to the bolts (fig. 9-16, #6). Make sure that the cup side of the washers is facing down over the gaskets. Apply the nuts to the bolts. Make sure that the rounded face of the nut is bearing against the washer. Tighten the bolts. Install a 28 bolt hole gasket (fig. 9-17, #1) on the inside face of the bottom flange of the dome. Insert 1/2- by 1 1/4-inch bolts through the flange and the gasket. The gasket will hold the bolts in place.

Install the ladder anchors (fig. 9-16, #8) at the bottom of the rails. Place the long leg of the anchor over the three bolt holes in the vertical leg of the rails. The short leg of the anchor faces outward. Adjust the outside bolting face of the short leg so it measures 9 feet 5 15/16 inches from the top flange of the dome. Insert two bolts through each anchor and rail. Apply the nuts to the bolts and tighten securely.

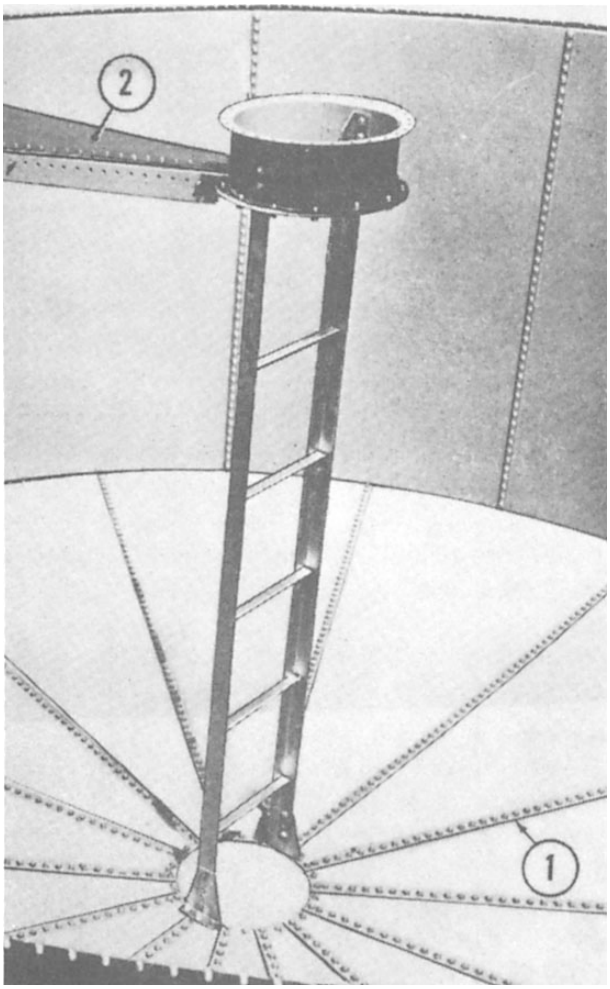


Figure 9-18.—Center support ladder installed.

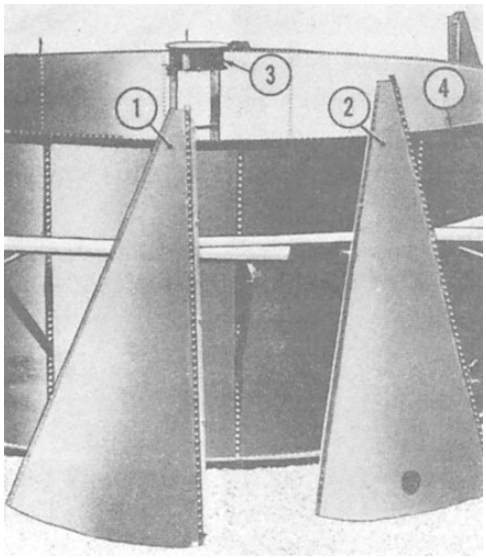


Figure 9-19.—Deck plates ready for installation.

Line up two diametrically opposite lap seams (fig 9-18) in the tank bottom. Remove a nut from each bolt in the lap seams and the first bolt to the right and left of each lap seam. Raise the ladder assembly and se the anchors over the bolts. Apply the nuts and tighten

Top Deck Assembly

The assembled deck consists of 14 tapered, flat steel plates (fig. 9-19) with an integral formed flange along the right lap seam. The seams are identified rig and left, facing the large end All of the plates are interchangeable.

Of the 14 plates, three are special. Two plates a fitted with a tank thief and vent, and one plate is fitted with a liquid level indicator. Each deck plate has deck plate channel and a rafter bolt retainer angle assembled on it. The small end of the plates is bolted to the bottom flange of the dome. The large end bolted to the top chime of the staves.

LAYOUT AND ASSEMBLY OF PLATES.— Lay out the plates around the outer perimeter of the tank foundation. Place the blocking on the ground, spaced to fit inside the confines of the plate. Lay the inside of the flange with the short leg facing outward. Insert four equally spaced bolts through the angle and flange. Apply the nuts to the bolts. Tighten the bolts. Turn the plate over with the flange down. Install a gasket along the full length of the right lap seam. Allow a two bolt hole overlap at each end.

LAYOUT OF ASSEMBLED PLATES.— As the plates are assembled, raise them up and stand them

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against the scaffold, as shown in figure 9-19. Locate each plate so it straddles a vertical seam of the side staves in the approximate installation position, counterclockwise.

ADJUSTMENT OF CENTER SUPPORT LADDER— Check and adjust the ladder to the correct height before the installation of the deck plates. 'he distance from the top of the tank bottom to the outer face of the top flange of the dome is 9 feet 6 9/64 inches. Raise or lower the ladder as required.

Place a jack under one of the ladder steps. Adjust the ladder so that in the final position, one set of the holes in the bottom of the rails line up with the holes in the brace. Lock the jack Insert the bolts through the proper bolt holes in the brace to match the top holes in the rails. Apply the nuts to the bolts. Tighten the bolts. Unlock and remove the jack.

When all of the deck plates have been installed on the tank, check the height to the outer face of the top flange of the manhole dome above the top of the tank bottom. If not the required height, adjust the ladder until it is the correct dimension. Insert the bolts in aligned bolt holes and tighten the nuts.

INSTALLATION OF FIRST DECK PLATE.— The first plate installed should be a plate with a vent (fig. 9-19, #2). The remaining plate, fitted with a vent, must be installed directly across the tank from the first plate with a vent. Attach two rope deck hooks to the small end of the plate while it stands against the scaffold (fig. 9-13). Guide the large end of the plate and pull the plate in place by means of a haul line. Lower the large end of the plate over the proper bolts in the top chime of the staves, so it will straddle a vertical seam. The small end of the plate will drop over the proper bolts. Release the hooks. Apply four equally spaced catch nuts to the bolts through the large end of the plate. One catch nut will be sufficient to hold the small end in place. Do not tighten the bolts.

INSTALLATION OF SECOND DECK PLATE.— Install a gasket over the bolts at the left lap seam of the plate (fig. 9-17, #3 and #4). Face the small end of the plate #4. Install this plate and all of the remaining plates to the left of the first plate or in a counterclockwise direction around the tank Raise the plate. Place the right lap seam of the plate over the bolts in the left lap seam of the first plate #4 and the large end over the proper bolts in the top chime of the staves.

Install the nuts to six equally spaced bolts in the lap seam of the plates. Install the nuts on all of the bolts in the chime. Finger tighten all of the nuts. As the deck will have to be adjusted as the plates are installed, do not tighten any bolts until the deck is completely installed. Raise or lower the center support ladder as required to fit the plates in place.

INSTALLATION OF INTERMEDIATE DECK PLATES.— There are 12 intermediate plates. The special plates remaining are installed to suit field conditions.

LAST DECK PLATE.— Raise the last deck plate before the next-to-last plate is installed Raise the right lap seam of the first deck plate (fig. 9-20, #l). This is necessary to permit the installation of the last plate.

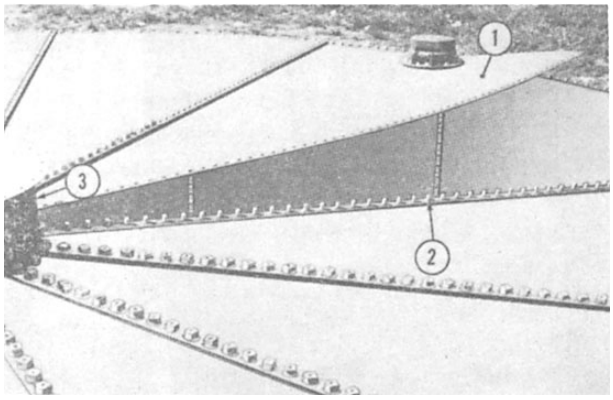


Figure 9-20.—Installing last deck plate.

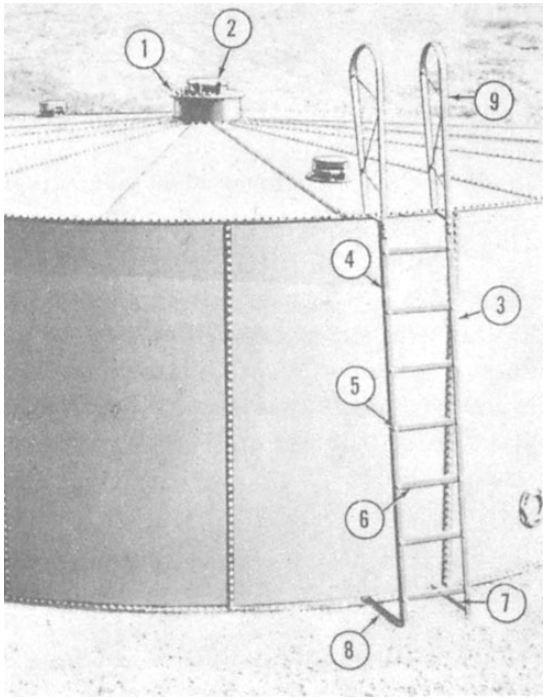


Figure 9-21.—Outside ladder installed.

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The left lap seam of the last plate slips under the right lap seam of the first plate. The right lap seam of the last plate is placed over the bolts in the left lap seam of the next-to-last plate installed.

Make the necessary adjustments in the deck if the last plate fails to fit properly. Remove the nuts temporarily installed on all of the bolts in the plate lap seams. Install a rubber gasket, a steel recessed washer, and a nut on all of the bolts except on the bolts in the top chime of the staves. Install any missing nuts on the chime bolts. Make sure that the rounded head of the nut is against the plate and washers and that the cupped side of the washer is facedown covering the rubber gasket. Tighten the bolts. Remove the scaffold. Install the gaskets, the washers, and the nuts to all of the bolts in the vertical seams. Return the brackets and the posts to the tank erection tool set.

MANHOLE COVER— If this tank is used for water storage, omit the emergency vent valve (fig. 9-21). Install the manhole cover with the blind flange hatch set after installation of the manhole air intake.

Install a 30 bolt hole gasket on the top flange of the dome. Insert 1/2- by 1 l/2-inch bolts through the flange and gasket, in that order. The gasket will hold the bolts in place. Install a 30 bolt hole manhole cover (fig. 9-21, #1) over the bolts. Install the gasket, the washer, and the nut on all of the bolts. Install the washer and the nut as above. Tighten the bolts.

Emergency Vent Valve

The emergency vent valve consists of a one-piece, flanged, round, cast steel body, fitted with lugs for a hinged vent. The vent is a one-piece, round, cast steel body, fitted with a lifting handle and hinge lugs. The vent comes attached to the flanged body hinges and seals the deck opening.

Place the manhole cover gasket over the bolt holes at the opening in the cover (fig. 9-21, #l). Insert l/2- by 1 1/2-inch bolts through two bolt hole channels. Work through the l0-inch hole and insert the bolts through the cover and the gasket. Install the vent valve (fig. 9-21, #2) over the bolts. Apply the nuts to the bolts. Tighten the bolts.

Manhole Air Intake

The manhole air intake consists of a one-piece, round, flanged sheet steel dust restrictor ring, a one-piece, round, fabricated steel bar, an inside screen ring, and a copper insect screen. The insect screen is attached to the screen ring by two outside rings, formed from steel bars. Flange bolts, inserted through the manhole cover, a dust restrictor ring, and steel pipe sleeve spacers attach the air intake to the manhole dome.

Wrap the insect screen around the outside of the inside screen ring. Join the ends of the screen with the copper wire weave. Install an outside screen ring at the top and the bottom of the insect screen to hold it in place. Make sure the screen is not knocked out of position. Tighten the bolts.

Install the screen ring on the top flange of the dome (fig. 9-20, #3). Insert the flange bolts through the cover, the dust restrictor ring, the steel pipe sleeve spacers, and the top flange of the dome (fig. 9-20, #3), in that order. Apply the nuts to the bolts and tighten.

Place the manhole cover gasket over the bolt holes at the opening in the cover. Insert 1/2- by 1 l/2-inch bolts through the two bolt hole channels. Work through the l0-inch hole and insert the bolts through the cover and the gasket. Install the blind hatch flange over the bolts. Apply the nuts to the bolts. Tighten the bolts.

Outside Ladder

The outside ladder consists of one bolted steel angle section. The top of the ladder is attached to the deck by two fabricated steel handrails. Two bolted steel angle braces support the ladder at the bottom chime of a stave.

Place the left side ladder section and the right side ladder section with similar bolting legs facing each other on top of several pieces of blocking of sufficient length to support both sections and spaced wide enough apart to install a ladder step (fig. 9-21, #6).

Select the bottom end of the ladder. Seven steps make up the assembled section. Insert 1/2- by l-inch bolts through the ends of the step and the sections, in that order. Install a nut on each bolt protruding through the sections. Tighten the bolts after all of the steps are installed. Install the braces at the bottom of the section.

The leg with three bolt holes near each end of the braces is attached at the outside face of the vertical legs of the sections. Insert a bolt through the end bolt hole in the sections and the brace. Install the nuts on the bolts. Finger tighten the bolts. Install the handrails at the top of the sections. Insert the bolts through the horizontal legs of the sections and the rails, in that order. Install the nuts to the bolts. Tighten the bolts.

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Use the temporary ladder while you are installing the outside ladder.

Place the assembled ladder where it is convenient to thief and vent at the outer perimeter of the deck. Lift the ladder and set the end bolt holes of the braces (fig. 9-21, #7 and #8) over the bolts in the bottom chime of the staves. Mark the bolts. From the top of the temporary ladder, mark the bolts in the outer perimeter of the deck covered by rails. Set the outside ladder aside. Remove the nuts from the bolts. Set the outside ladder back over the bolts. Install the nuts on the bolts. lighten the bolts. Tighten the bolts by attaching the braces to the bottom of the ladder. Remove and disassemble the temporary ladder.

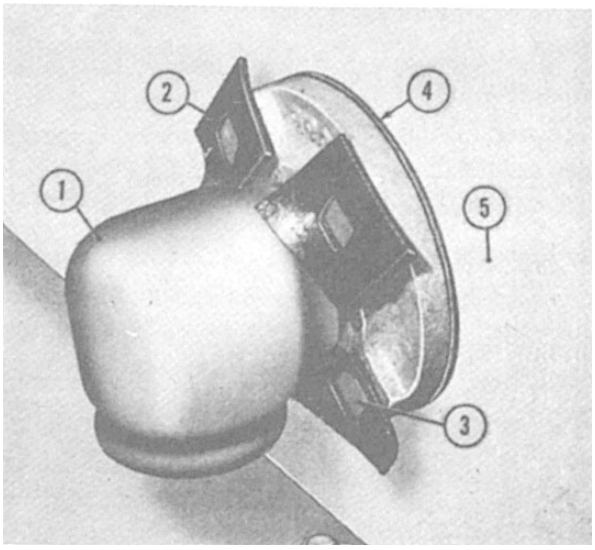


Figure 9-22.—One-piece flanged elbow installed on the inside of the tank.

Water Drawoff Valve

The valve assembly consists of a commercial 2-inch bronze valve made up in a cast-iron flange with a gasket installed outside the tank. A one-piece, flanged cast steel elbow with a gasket is installed inside the tank. The valve and elbow bolt together through the side of the tank

FLANGED ELBOW.— Install the elbow (fig. 9-22, #1) inside the tank on the stave. Cut four one-hole gaskets. Force the gaskets over the bolts. Insert the bolts through the flange of the elbow. Place the blocking under the heads of the bolts. Force a gasket over the bolts. Turn the inlet of the elbow toward the tank bottom. Insert the bolts through the stave. Install the nuts temporarily on two bolts while you are assembling the valve. Remove the nuts before installation of the valve.

DRAWOFF VALVE.— Hold the elbow (fig. 9-22, #1) in position inside the tank. Install a gasket (fig. 9-23, #1) over the bolts. Install the outside flange over the bolts. Install the nuts on the bolts. Tighten the bolts. Install the made-up valve inside the flange. With

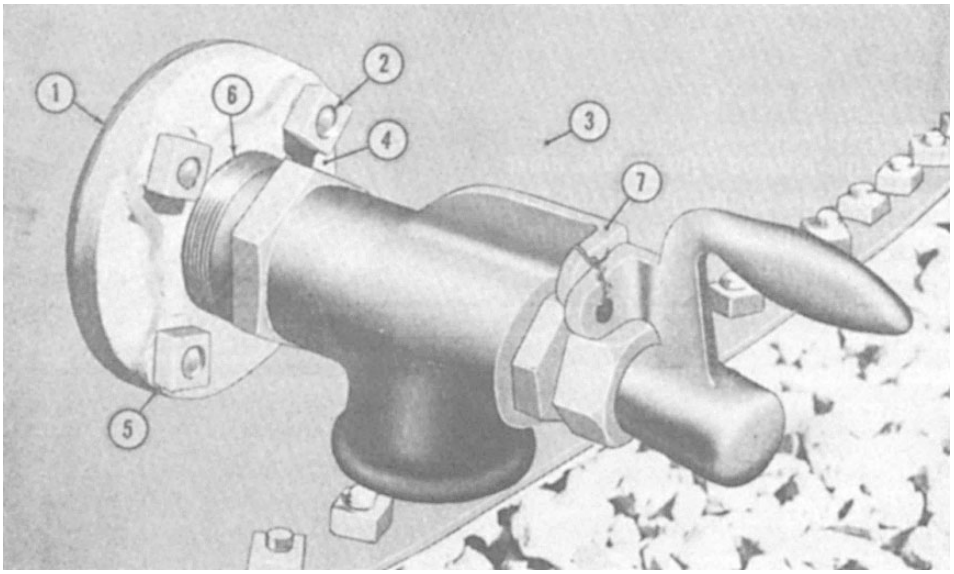


Figure 9-23.—Water drawoff valve installed on the outside of the tank.

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the threads tight, the valve outlet must be facing the ground.

Tank Outlets

The outlet assembly consists of an elbow, fabricated, made up with a flange, inside, cast iron, and a gasket installed inside the tank An adapter, fabricated, steel pipe, made up with a flange, outside, cast iron, and a gasket are installed outside the tank The outlet end of the adapter is sealed with a cap (malleable iron), held in place by a bolted split coupling (malleable iron). The adapter and elbow are bolted together through the side of the tank.

Cleanout Cover and Frame

Special bolt channels are installed inside the tank at the top and sides of the cleanout opening. Gaskets are installed over the bolts outside the tank.

The frame is a fabricated, rectangular shaped, flanged steel sheet that is flanged all of the way around, both front and back. The back flanges are radiused to fit the outside of the tank. The holes in the bottom flange are punched to fit the tank chime.

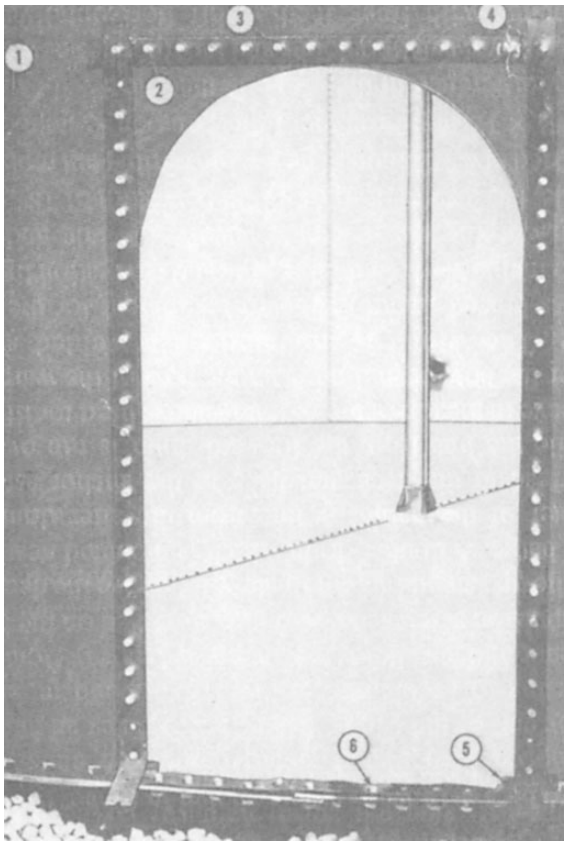


Figure 9-24.—Bolts installed at cleanout opening.

The cleanout cover is a flat, rectangular steel sheet. Two formed, round steel handles are welded the outside face of the sheet.

HORIZONTAL CHANNEL.—Place the bolt channel above the cleanout opening inside the stave (fig. 9-24, #l). Insert 1/2- by 1 l/4-inch bolts through all of the bolt holes. Be sure the bolt heads are square in the channel. Install the gasket along the full length of the top seam outside the stave. Allow a one bolt ho overlap at each end.

VERTICAL CHANNEL.— Each side seam the cleanout opening consists of one vertical row bolt holes. Place a bolt channel inside the tank on each row of bolt holes. Insert the bolts through all of the bolt holes. Be sure the bolt heads are square in the channels. Install the gasket along the full length each row of bolts. Pass the gaskets over the top sea gasket. Allow a one bolt hole overlap at each en Apply a heavy coating of sealing putty at the overlap of the top and vertical seam gaskets. Install the radii gasket under the vertical seam gaskets at the bottom chime of the stave.

CLEANOUT FRAME.—To assist in the installation of the cleanout frame (fig. 9-25, #2), push all of the chime bolts flush with the gasket on the chime of the bottom to provide clearance for sliding

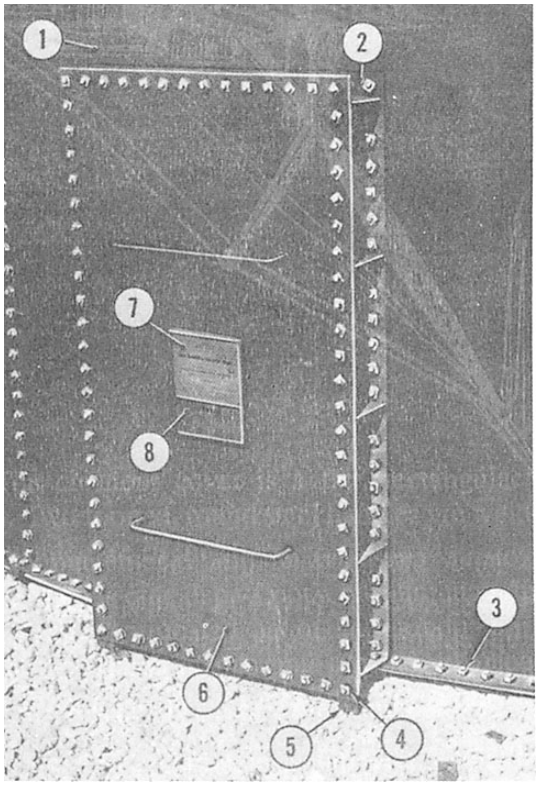


Figure 9-25.—Cleanout cover installed.

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the frame in place. Install the frame with the radiused flanges over the bolts with the flange against the outside of the stave. As the frame straddles a lap seam, make sure a wedge gasket is under the gasket at the seam. Work the bolts through the bottom flange of the frame. Install the nuts temporarily or enough bolts to hold the frame in place.

Install the gasket and the washer with the cup side down over the gasket on all of the seam bolts. Omit the gaskets and the washers on the chime bolts. Apply the nuts with a rounded face down on all of the bolts. Tighten them uniformly around the frame to maintain a leakproof joint.

CLEANOUT COVER— Work from the back and insert 1/2- by 1-inch bolts through the front flanges of the frame. Install the gasket along the full length of each row of bolts in the top and the bottom flanges. Allow a one bolt overlap at each end. Install the gasket along the full length of each row of bolts in the side flanges. Press the gaskets over the top and the bottom flange gaskets. Allow a one bolt hole overlap ate each end.

Apply a heavy coating of sealing compound at the overlap of the top and the side flange gaskets. Stand the cover (fig. 9-25, #6) in position with plates #7 and #8 set for direct reading, and slip the cover over the bolts. Install the gasket and the washer with the cup side down over the gasket on all of the bolts. Apply the nuts with a rounded face down on all of the bolts. Tighten the bolts uniformly around the cover to maintain a leakproof joint.

Cleaning Site

The tank erection crew must clear out all of the debris, paper, and any other matter of an inflammable nature, leaving a clean and neat installation for the pipeline crew or others. All of the tools and other erection equipment must be picked up and returned to the tank erection tool set.

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CHAPTER 10

PONTOONS

When the United States entered World War II, our Navy was faced for the first time with the problem of landing and supplying large forces in areas where traditional harbor facilities were controlled by the enemy. Navy Lightered (N.L.) pontoons were developed in 1942 to meet this difficult situation. They were designed for erection by naval personnel and shipment aboard Navy vessels. These pontoons pro-veal to be an invaluable asset and were used extensively in operations during World War II, the Korean conflict, and again in Vietnam.

P-SERIES PONTOONS

P-series pontoons were used throughout the Republic of Vietnam in combat conditions. Although originally designed to meet the requirements of the Advanced Base Functional Component (ABFC) System, they have been used successfully in many other fields due to their inherent versatility and ease of erection. Large structures are easily and quickly disassembled then made into smaller structures, and then the smaller structures can be quickly and easily reassembled into larger structures. The light draft, structural strength, mobility, and adaptability of pontoon structures made them extremely useful for shallow water passage and tactical deployment in the Mekong Delta. They allowed movement of heavy weapons and shifting of firepower throughout otherwise remote areas. Many structures not discussed in this manual, such as armored barges, helicopter pads, mortar barges, and barracks barges, were constructed in the field for use in special situations throughout the waterways of South Vietnam.

TYPES OF P-SERIES PONTOONS

Five basic types of P-series pontoons are in use today, designated Pl, P2, P3, P4, and P5. These pontoons are specially designed, internally reinforced, welded steel cubes. They are tested to withstand an internal pressure of 20 pounds per square inch (psi). All pontoons have plain deck plates covered with a nonskid coating, and all are, fitted with a 2" plugged hole for air, drain, or siphon connections at the top and bottom of one of the end plates.

The P1 pontoon is cubicle in shape. (See fig. 10-1.) The deck of the P1 is 5'3/8" x 7', and the sides are 5'3/8" high. The side, end, deck, and bottom plating is 3/16" thick. The P1 is the most common and widely used pontoon in the P-series. Its usage is required in every structure of the pontoon system.

The P2 pontoon has the same depth (5'3/8") as the PI, but it has a 7' square deck and a straight-line sloping bow. (See fig. 10-2.) The side, end, and deck plates are 3/16" thick. The sloping bow plate is 3/8" thick. P2 pontoons are used on the bow and stern of various pontoon structures.

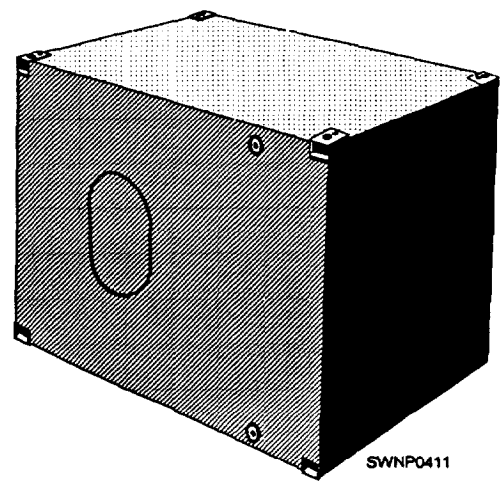


Figure 10-1.—P1 pontoon.

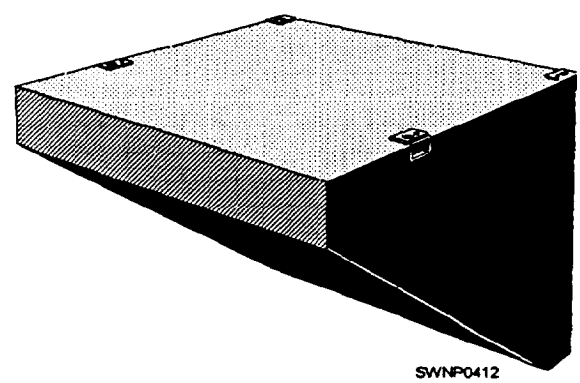


Figure 10-2.—P2 straight-line sloping bow pontoon.

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The P3 pontoon has an inclined deck5'1 3/4" long and 7' wide. (See fig. 103.) The deck slopes from 4' 11 3/8"to3'8 1/4" high. The bottom is horizontal. All plating is 3/16" thick The sloping deck is fitted with five 1" square ribs 5/6" long, evenly spaced and secured by welding, with a covering of nonskid paint applied between the cleats. The P3 is used in conjunction with the P4 to form a gradually sloped ramp for causeway ends and ramp barge bows.

The P4 pontoon has a deck 5'1 3/4" long and 7' wide inclined at the same angle as that of the P3 pontoon. (See fig. 10-4.) The after end is 3'6" high; the forward end, 1'. The bottom is horizontal for 8" on the after end, then slopes upward. The deck, side, and back plates are 3/16" thick; the bottom, or bilge, plate is 3/8" thick. Five evenly spaced, 1" square ribs are welded to the sloped deck, and a coat of nonskid paint is applied between the cleats. Used in conjunction with the P3 pontoon, the P4 forms a continuous ramp for causeway ends and ramp barge bows.

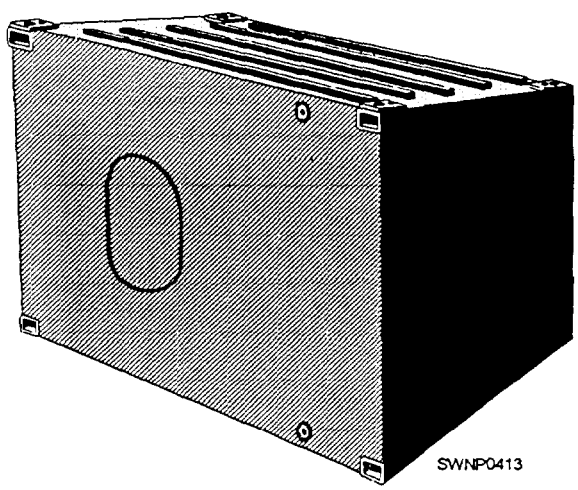


Figure 10-3.—P3 sloped deck pontoon,

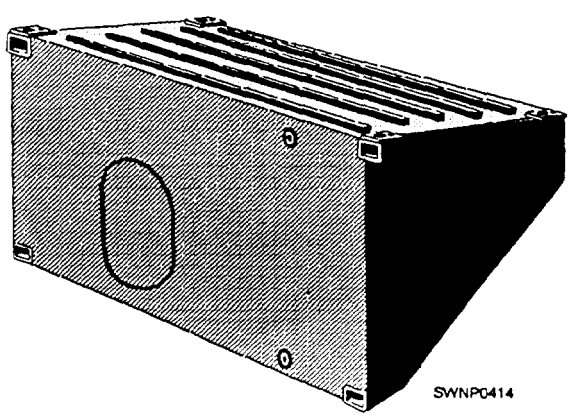


Figure 10-4.—P4 ramp-end pontoon.

P5 pontoons consist of P2 pontoons with quick-lock hinge connectors fixed to the bow. The P5M is a P5 with a male connector; the P5F is a P5 with a female connector. (See fig. 10-5.) P-series 3 x 15 pontoon causeways are connected end-to-end by alternate P5M and P5F pontoons; so are barge sections that are used as wharves where end-to-end connection is required. These pontoons are constructed by welding hinge connectors to P2 pontoons that are then assembled in male and female sequence, forming causeways of any required length. These pontoons are also used for enlarging or extending wharf structures. The center section of the P5F hinge is made from a section of extra strong pipe. When joined, these two parts resist the torsion, compression, and vertical shear forces in the joint.

Making end-to-end connections with P5M and P5F pontoons is not a difficult task (fig. 10-5). When the mating ends of two causeway or wharf sections are brought together, the male pipe connection is simply guided into the female and held in place by pad eyes and links. The resulting pipe joint then prevents vertical movement of either section. A short chain-locking device completes the connection and secures the links in the pad eyes. Each set of hinges is capable of withstanding 300,000 pounds of pull. Closure plates are welded on either side of each connection to bridge open spaces between pontoons.

A wide variety of structures-wharves, barges, causeways, and so on-can be assembled from pontoons. In the assembly of pontoon structures, the pontoons are first joined into strings and the strings are launched; the floating strings are then attached to each other. Structures of not over three strings in width can be entirely assembled on land and then launched as a unit. The number of pontoons in each string and the number of strings attached to each other depends upon the size and type of structure being assembled. The manner of assembly is similar in each case with variations depending largely on the intended use of the completed structure. The size of each pontoon structure is designed by indicating the number of strings in the assembly and the number of pontoons in each string, Thus a 3 x 15 causeway section is three strings wide and fifteen pontoons long. Pontoon gear is usuaIIy shipped with the parts required to complete a specific structure.

PONTOON ATTACHMENTS

Pontoon attachments, used in the basic assembly of pontoon structures, include assembly angles, bolts, nuts, keepers, assembly plates, and closures.

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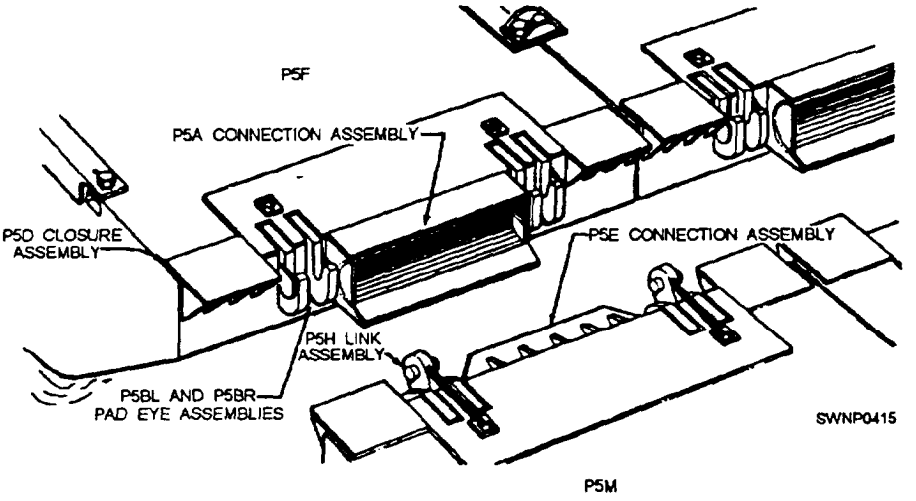


Figure 10-5.—End-to-end connections for P5M and P5F pontoons.

Structural steel ASSEMBLY ANGLES in varying lengths are used to connect the P-series pontoons into stings. Each is suitable for assembling a definite number of pontoons and designated as E-series angles. The angles are positioned to each of the four edges of a row of pontoons. Various types of assembly angles are available. Figure 10-6 shows an ES 16 assembly angle. Figure 10-7 shows assembly angles E 16L and E 26L.

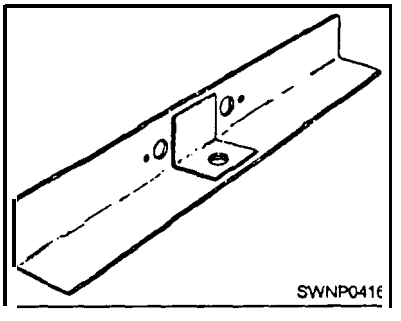


Figure 10-6.—AII E516 assembly angle.

Angles are supplied in several lengths, so strings can be made up with a minimum number of welded joints, and they are designed so these welds fall midway along the edges of each pontoon, rather than between pontoons where stress is greatest. Each angle has one or two cross-sectional sizes, 6" x 6" x 1/2" thick or 8" x 8" x 1/2" thick. Angles with 8" legs are used to replace 6 x6 's at the center of strings 18 to 24 pontoons long, and strings of 30 pontoons have 8" angles throughout to resist the extra stress that their weight imposes. Regardless of dimensions, however, each P-series angle falls into one of two types: basic or end-condition angles. Basic angles are those angles used throughout the body of a structure. Their application is not restricted to top, bottom, left, or right

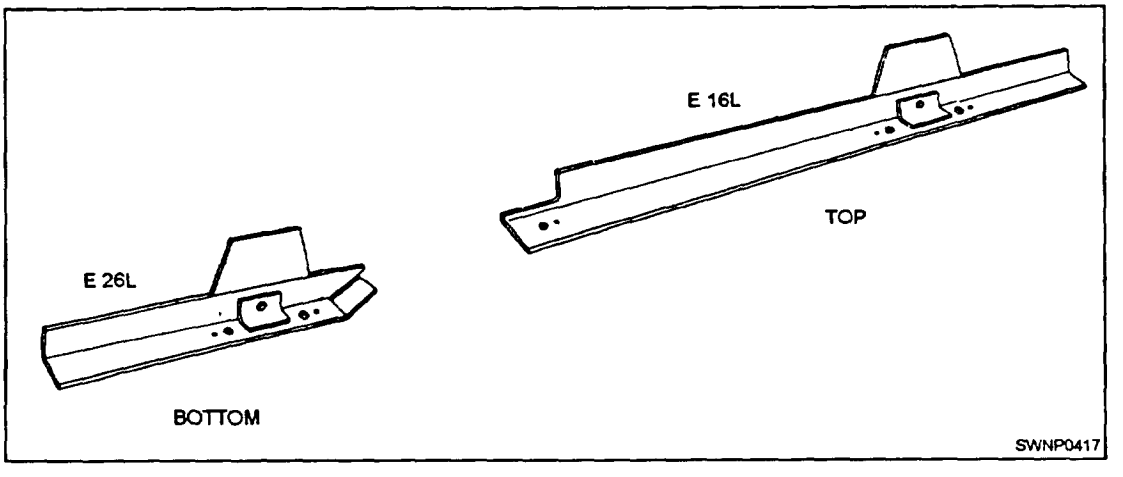


Figure 10-7.—Assembly angles E 16L and E 26L.

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angles of the strings. On the other hand, end-condition angles connect P2, P3, or P4 pontoons to the ends of strings, and each is designed for a specific orientation-top or bottom and right or left. Basic angles can be shortened or lengthened to make up modified configurations, and end-condition angles can be cut and formed from basic angles to meet abnormal operating requirements.

The A6B ASSEMBLY BOLT is a 1 1/2" diameter x 3 3/8" long, hexagonal head, steel bolt (fig. 10-8). Three radial grooves on the head, spaced 120 degrees apart, are the code for grade 5 steel rated at a tensile strength of 105,000 psi. In addition to its use in securing assembly angles to pontoons ate each comer, the A6B bolt is also used to connect strings into structures, to secure deck fittings and accessories, and to pin hinges on dry dock stabilizer towers.

The forged FNl FLANGED NUT (fig. 10-9) is designed to fit into a pontoon pocket with sufficient clearance to allow positioning on the A6B assembly bolt. The flange of the nut is large enough to prevent the nut from turning in the pocket when the bolt is tightened; it is formed near the midline of the nut to clear welds in the pocket and allow positive se sting of the nut boss when the A6B bolt is tight.

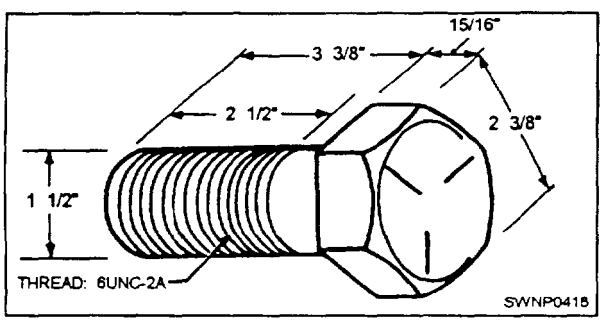


Figure 10-8.—An A6B assembly bolt.

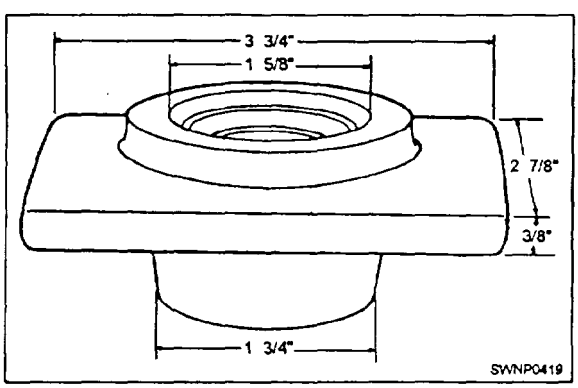


Figure 10-9.—AII FNl flanged nut.

The KPl KEEPER PLATE (fig. 10-10) is made from a plate 3 3/4" long, 2 1/8" wide, and 3/16" thick. The plate is cut out to fit over four of the hexagonal flats on the A6B bolt head. After final tightening of a bolt in a pontoon structure, the keeper plate is positioned around the bolt head and skip-welded to the underlying assembly plate or angle. This prevents the bolt from working loose during operations. To reduce maintenance problems, you should use the keeper plate on the bottom of pontoon structures where daily inspection is impractical. Keeper plates should not be welded to the bolt head.

Steel PLATES of various shapes are used in the assembly of pontoon structures mostly to reinforce those areas that are subjected to maximum stress and shear. A number of different types of assembly plates are shown in figure 10-11. Each of the plates shown is designed for a specific application, as indicated below.

APl CONNECTING PLATE: The AP1 is a steel plate with four drilled holes for A6B assembly bolts. It reinforces the A6B bolts that hold pontoon strings to each other in completed structures that use either 6" or 8" angles.

AP3 LAUNCHING ANGLE PLATE: When pontoon structures are to be side-loaded on an LST, an accessory known as an LA1 launching angle is attached. The AP3 is a steel plate that is used to attach the LA1 to the structure. The AP3 has four drilled holes for A6B bolts, and a curved plate is attached to form a semicylindrical pad. The pad serves as a fender to protect the hull of the LST on which the pontoon structure is side-loaded.

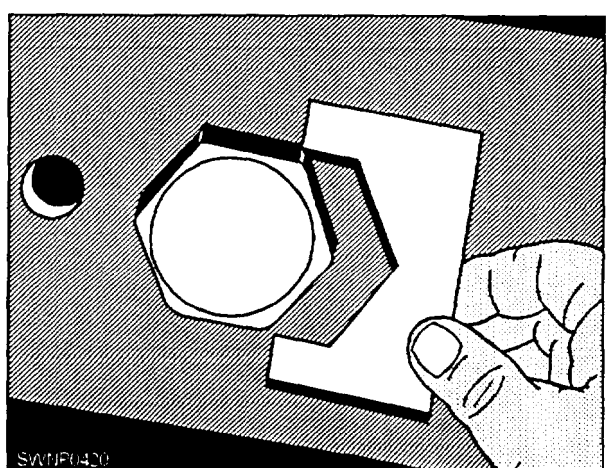


Figure 10-10.—A KPl keeper plate being installed on an A6B bolt.

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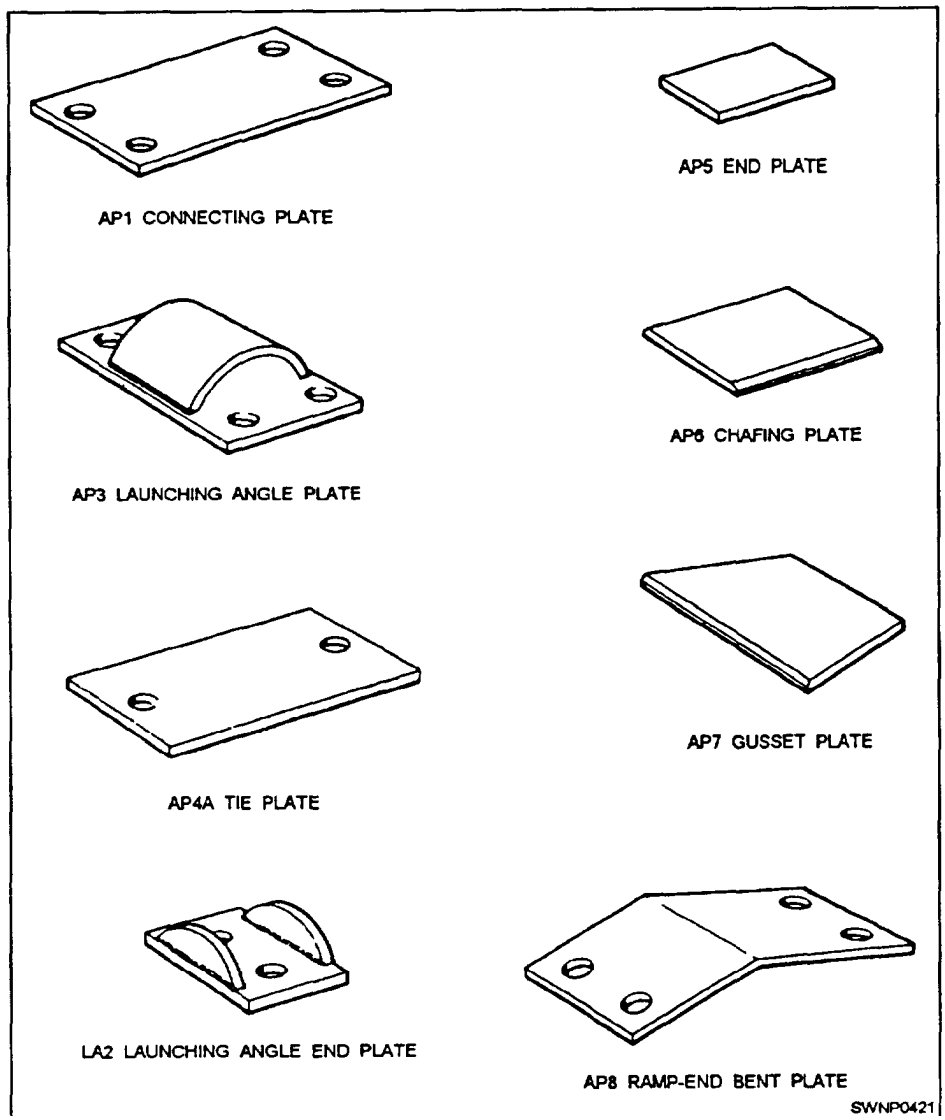


Figure 10-11.—Assembly plates.

NOTE: As of this printing LSTs are being decommissioned and it is undecided what platform will transport causeways. The information on LSTs is given because the Reserve Fleet will retain two and the next platform used could require the same hardware for loading and launching.

AP4A TIE PLATE: The AP4A is a steel plate with two drilled holes for A6B bolts. It is used for connecting pontoon strings to each other at their bow and stem ends. If necessary, an acceptable substitute for the AP4A can be obtained by cutting an API connecting plate in half across the narrower dimension; two plates are produced, both of which can be used.

LA2 LAUNCHING ANGLE END PLATE: The LA1 launching angle used when side-loading a pontoon structure on an LST is attached to the structure at the bow and stem ends with a two-hole assembly plate, just as pontoon strings are connecteed within the structure by the two-holed AP4A at the bow and stem. The two drilled holes in the LA2 are for A6B bolts. Two half-ovals are welded perpendicularly to the upper face of the plate, on either side of the bolt holes. These half+oval lugs serve as fenders to protect the hull of the LST in the same way as the pad on the AP3.

AP5 END PLATE: The AP5 is a steel plate that is welded across the gap between pontoons at the bow and stem of adjacent strings. It is used only in certain special cases where structures require extra reinforcement; for example, where end connectors are used or where the structure will be side-launched. An

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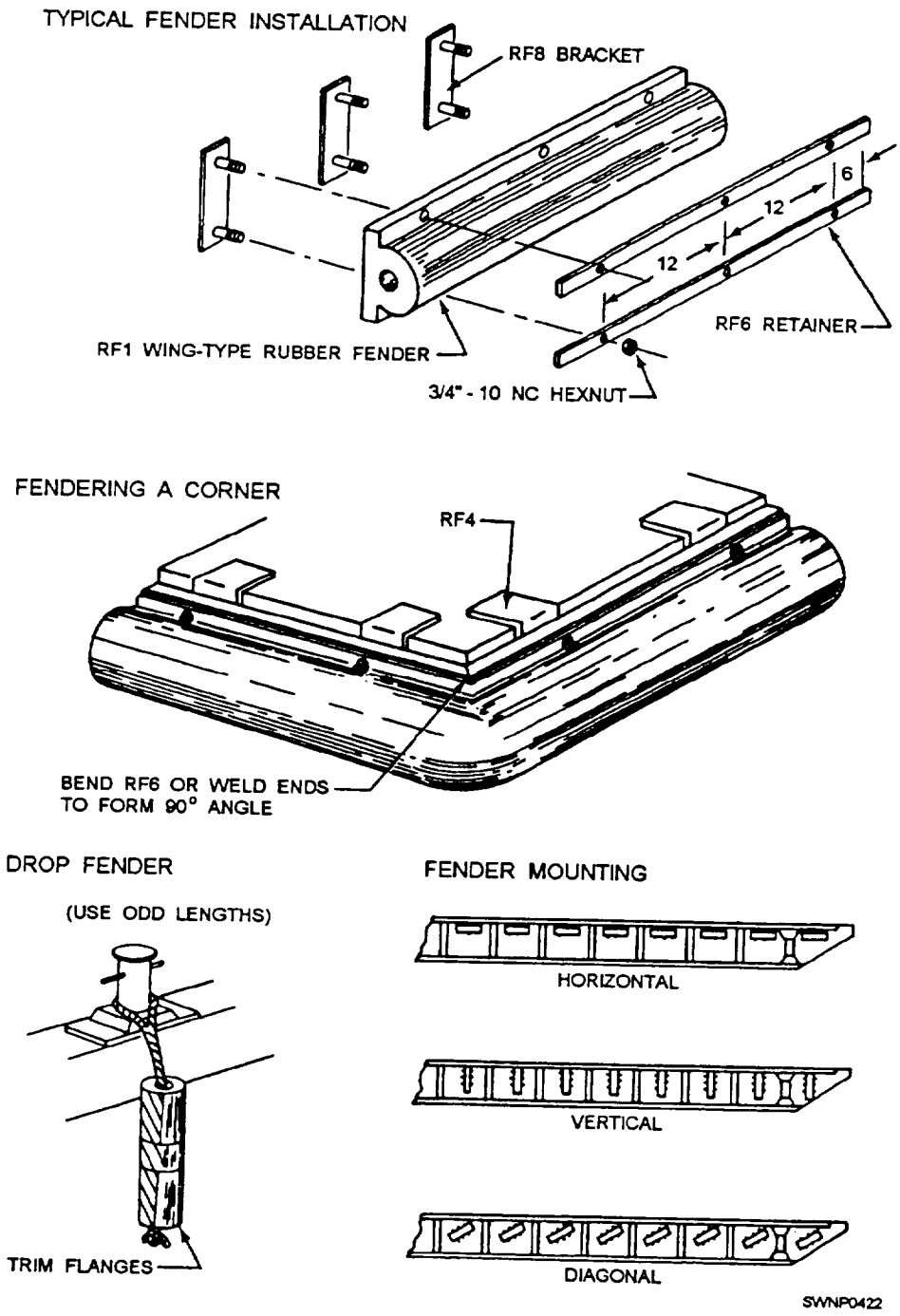


Figure 10-12.—Typical fender installations.

acceptable substitute for the AP5 can be field-fabricated, if necessary, from an API. To do so, remove the holes from the APl by cutting 3“ inside the two edges measuring 18 1/4”, and halve the resulting 18 1/4" x 5" plate to produce two 9 1/8" x 5" plates; both can be used as end plates.

AP6 CHAFING PLATE: The AP6 is a steel plate. 10” square, with two opposite edges beveled. Welded to the sides of causeway sections, the AP6 protects the causeway from damage due to sliding contact. It is frequently used between side-lapped causeway sections. Because the AP6 is a nonstock item, it should be fabricated in the field when it is required. Dimensions are not critical; halves of an APl or an AP7 plate will serve as chafing plates when properly beveled.

AP7 GUSSET PLATE: The AP7 is a steel plate cut in the form of a 9“ high trapezoid. The parallel

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edges are 18" and 12" long, and the 18" edge has a 1/4" bevel. The AP7 reinforces the end-condition angles used at the fore and aft ends of larger structures. The 18“ edge is positioned against a tip or bottom assembly angle so the plate bridges the gap between the pontoons to which the angle is bolted. The 18" edge is welded to the angle, and the two vertical edges are welded to the adjacent pontoons. APl connecting plates can also be used for reinforcing, welded to end-condition angles in the same way as the AP7.

AP8 RAMP-END BENT PLATE: The AP8 is fabricated from steel plate. An 11“ x 20 1/4” rectangle is bent to form two legs, one 8 5/8” and the other 11 5/8” long; each leg has two drilled holes for A6B bolts. The AP8 is used for connecting pontoon strings at the point where each string has a P3 sloped-deck ramp pontoon connected to a P1 pontoon.

RUBBER FENDERS

Anew rubber fendering system for use on pontoon structures has replaced oak timber fenders. Rubber fendering is wing-type, extrusion-shaped, styrene butadiene composition; it is supplied in random lengths to be cut, formed, and fitted in the field for specific structures and operating conditions. For each structure, the fenders, brackets, retainers, and fasteners are furnished in the quantities required. The new fenders absorb enough impact, upon contact with the dock or other structure, to transfer shock from dynamic to static load, thereby protecting both of the impacting structures.

To install rubber fenders, lay out fendering on the deck over the position to be installed. Cut it to the required length, bolt on the retainers and the brackets, and ease it into position, using lines attached. Tack-weld the brackets in place temporarily, remove the lines, and when the entire fender is properly positioned, weld all the brackets as shown on the drawings. Damaged portions can be cut out and repaired with a rubber portion of the same length. Use odd pieces for drop fenders or bumpers. Use a fine-tooth oil-lubricated saw, manually operated or power-operated, for cutting wood or steel bits for drilling holes. Various fendering arrangements and details are shown in figure 10-12. These are subject to change to meet local fendering needs.

H6 HATCH COVER AND FLOOR PANEL ASSEMBLY

Various pontoon structures require a stowage space for tools, chaining, fittings, and miscellaneous gear when not in use. The H6 hatch cover and floor panel assembly (fig. 10- 13) was designed to be installed on any designated pontoon structure and consists of a mounting frame, grating panels, hanger rings, and a 21” diameter, quick-acting, waterproof, flush-mounting, shipboard type of scuttle, together with the parts required to convert a P1 pontoon into a stowage compartment. Making the necessary cutout in the pontoon deck and installing the hatch cover and the other components are done in the field When installed, the hatch cover is a string as the pontoon deck. However, on structures normally traversed by heavy loads, such as causeways and ramp barges, it is advisable to locate the hatch cover away from the regular line of travel-preferably to one side and as far forward or aft as possible—to protect the watertight sealing gasket under the hatch rim.

DECK CLOSURES

Deck closures are used to bridge the openings, or slots, between pontoons while meeting the

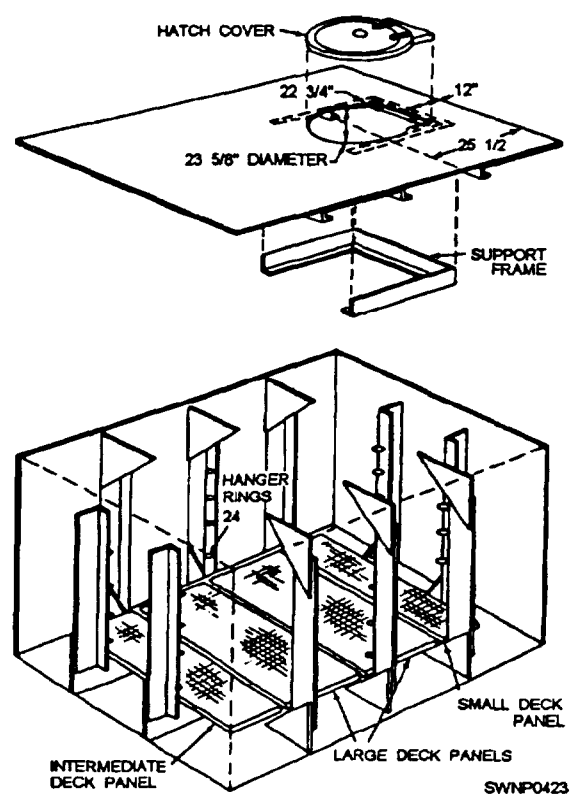


Figure 10-13.—H6 hatch cover and floor panel assembly.

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requirements for fitting around plates and lift pads. They also can be configured to provide access to assembly angles between structures for wrapping chains and wire rope during causeway beaching and LST side-carry operations. Formerly, five types of closures were needed to perform the necessary functions. These were identified as DC1 through DC5. The DC6 deck closure (fig. 10-14), with certain field alterations, was designed to fulfill all closure requirements and will replace the five closures entirely when stocks of these have been depleted.

The H22 and H23 closure plates are used for joining pontoons and for making bridge-to-wharf or barge-to-wharf connections. The H17AF and H17AM heavy-duty hinges are used to close the deck openings formed by the hinges between the pontoon sections. The closures (fig. 10-15), which are 20" wide and 24 1/4" long, are made from 1/2" steel plate and are used in combinations to fit over and enclose the heavy-duty hinges. Nonskid coating is applied on the top of the closures to prevent slippage. The H22 and H23 closures are not included in the heavy-duty hinge set. They are to be fabricated in the field as required.

BITTS AND CLEATS

Bitts and cleats are steel posts, or arms, to which lines are secured. Structures to be side-carried should have bitts and cleats, as well as all other deck fittings, bolted down on the launching angle side. A typical cleat is shown in figure 10-16. The B1 all-purpose bitt (fig. 10-17) consists of a single 4" diameter post that is 13" long with a 6" diameter cap welded to a base that has two drilled holes for A6B assembly bolts. A 1 1/2" diameter crossarm, 16 1/2" long, runs through the post approximately 10" above the deck. The B1 can be used on all structures requiring a single bitt and can be welded to the deck angles opposite the launching angle side.

The B4 bitt (fig. 10-18) is the same as the B1 bitt except for the base that has been designed for quick positioning in the CP1 chain plate.

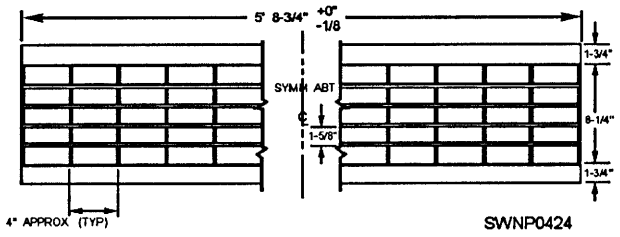


Figure 10-14.—DC6 deck closure.

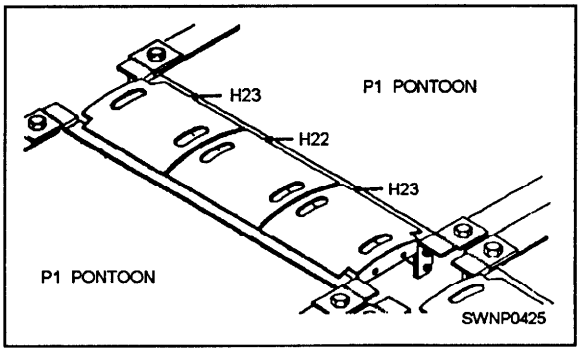


Figure 10-15.—Closure plates H22 and H23.

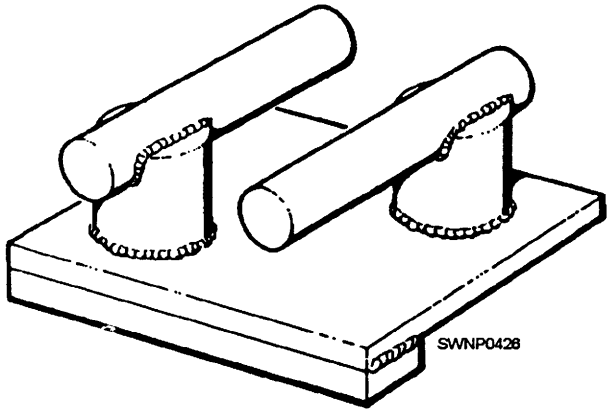


Figure 10-16.—Cleat.

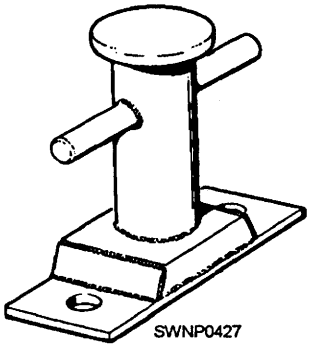


Figure 10-17.—B1 all-purpose bitt.

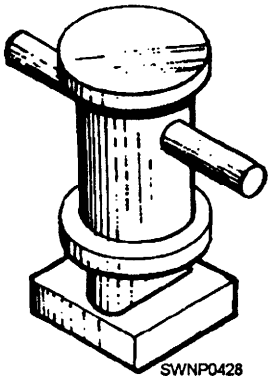


Figure 10-18.—B4 retractile bitt.

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The M147 double bitt (fig. 10-19) consists of two 8" steel pipe posts, 20" long, welded to a 13" x 40" base and capped on the upper ends.

PROPULSION UNITS

Self-propelled pontoon barges and tugs are powered by outboard propulsion units. These units have been specially designed for this purpose and readily installed on tugs or barges of any size. The propulsion unit shown in figure 10-20 is essentially a heavy-duty outboard motor, consisting of a propulsion mechanism and a marine diesel engine mounted on a heavy structural base. Propulsion power is carried from the engine through a right-angle housing and a vertical-drive housing to the propeller. Steering is affected by shifting the propulsion-force direction; the propeller can be turned around a vertical axis in either direction through a complete circle. Each unit has a steering wheel and an indicator that show direction of travel. The tail section, with the propeller, is mounted on the vertical housing assembly that can be elevated outward and backward to raise it out of the water for inspection or repairs. As new equipment and techniques for amphibious operations developed, performance requirements for all components increased accordingly. As a result, propulsion units have increased in power and thrust capability.

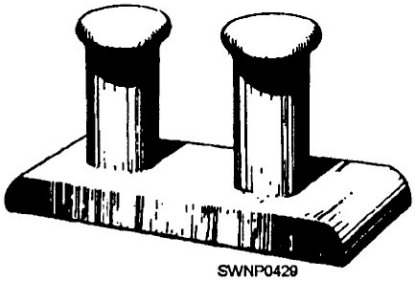


Figure 10-19.—M147 double bitt.

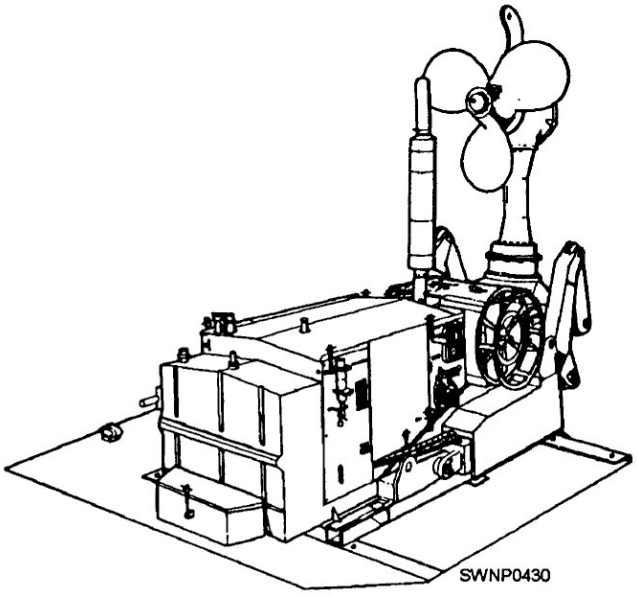


Figure 10-20.—Model L-295 diesel outboard propulsion unit.

PONTOON STRING ASSEMBLY

After the first two assembly angles have been placed on the ways, the pontoons are placed in the angles (figs. 10-21 and 10-22). The pontoons are positioned on their sides with all deck surfaces on the same side. The first pontoon will ordinarily be placed in the center of the angles with the assembly bolt holes aligned; placement of the remaining pontoons from the center toward each end can be accomplished without difficulty.

Bolting Lower Angles

As each pontoon is placed in the assembly angles, the A6B assembly bolt holes in the pontoon nut receptacles are aligned with those in the angles, using spud wrenches or driftpins as necessary. The A6B bolts are then inserted through the assembly angles

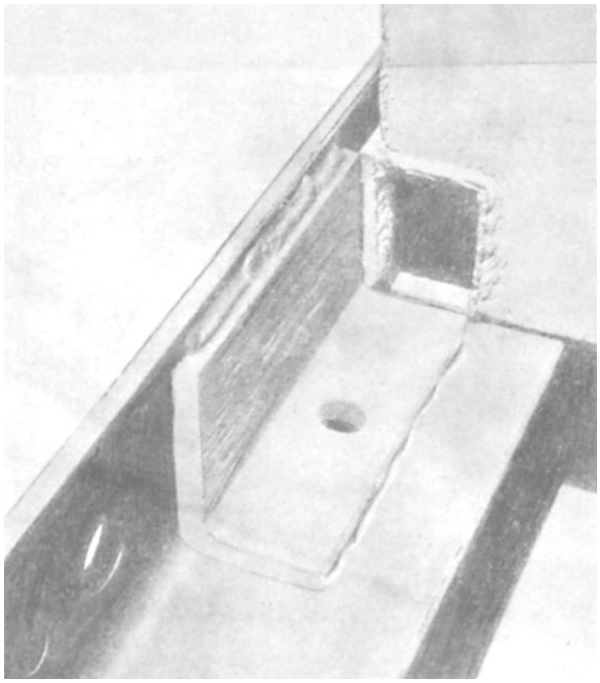


Figure 10-21.—Pontoon positioned on assembly angle.

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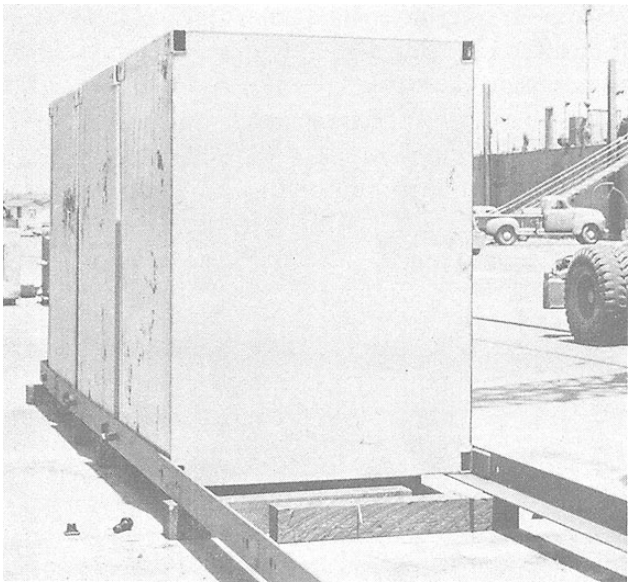


Figure 10-22.—P1 pontoons on assembly angles

and started by hand to thread the FN1 nut (fig. 10-23). The bolts should be snugly tightened, then backed off about one turn.

Positioning Upper Angles

The second pair of assembly angles is placed on the top of the pontoons and positioned and bolted in the same manner as the bottom pair of angles. Spreader jacks, come-alongs, or heavy-duty pinch bars can be used to align holes for the top angles.

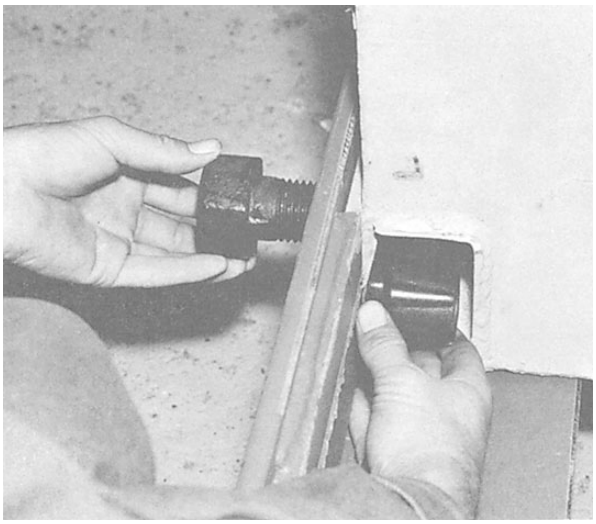


Figure 10-23.—Positioning of A6B bolt and FN1 nut to connect pontoon to assembly angle.

Tightening Bolts

After all of the A6B assembly bolts have been installed, final tightening is accomplished with an impact wrench or 48" ratchet wrench in those locations where accessories or assembly plates are not bolted to the structure.

NOTE: The proper setting of A6B bolts requires tightening to a 2,400-foot-pound torque. (The applicable rule is to draw the bolt or nut up tight and then add another half turn.)

FINAL ASSEMBLY OF STRING

CP1 chain plates, LA1 launching angles, or other accessories that attach to the outer edge of the particular structure under construction can be installed on the string at this time, if desired. Strings, requiring the addition of a launching angle, should be so assembled on the way that the launching angle can be installed on the top of the string. After installation of the chain plates, the A6B assembly bolts that attach the parts are tightened, and the chain plates or other accessory items are welded, as required. KPl keeper plates can be installed at this time in all locations for which they are specified for the one string of the structure being built. After all fittings are in place and the assembly bolts tightened, the assembly should be inspected for security of bolts and fittings. After the first string has been launched, the same assembly procedures are followed for assembly of the second and additional strings, as applicable.

LAUNCHING A STRING

If the pontoon string has been assembled along the edge of a dock, it can be tilted into the water by means of jacks or a crane. If it has been assembled on a way, the anchorage is released and the string is allowed to glide head-on into the water. Note that adequate freeboard will be required for this method of launching. End launchings can be accomplished from flat or nearly flat ways by pushing the string with a bulldozier or pulling it with a tug or M-boats. Strings also have been assembled inland and pulled to the shoreline by a bulldozer. A line, secured to the string before launching, should be made fast ashore to keep the string from drifting away in either side launching

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or end launching and can be used to assure that the string rights itself when launched.

ASSEMBLY OF LAUNCHED STRINGS INTO STRUCTURES

A new method for securing pontoon strings together, referred to as the bolt and nut attachment, has been implemented throughout the pontoon system and completely replaces the heavy tie rod assemblies formerly used. It consists of an A6B bolt and heavy nut connection through holes in the vertical legs of adjoining assembly angles between strings. Special wrenches have been designed to facilitate bilge angle connections while working from the deck, and a two-piece aligning tool is used when hole alignment restricts passage of the bolt. Detailed instructions for using the bolt and nut method of connection to assemble a pontoon structure are presented below.

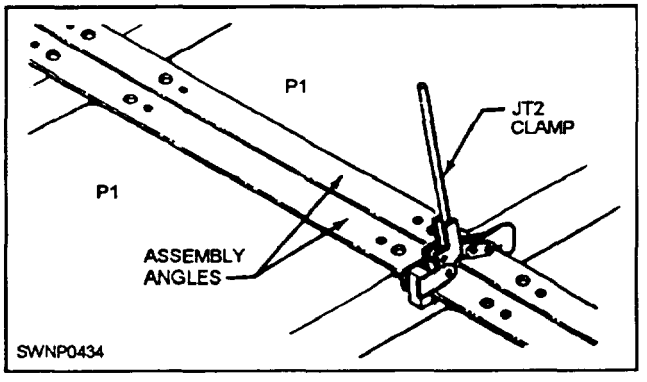


Figure 10-24.—Angle clamp for assembly of pontoon strings

As each pontoon string is launched, it is brought up alongside the other string(s), lined up, and clamped together with JT2 top angle clamps (fig. 10-24). Insert the A6B bolts by hand through the holes in the vertical legs of the top assembly angles located in spaces between the pontoons, and secure them with the heavy nuts. This is done at every space, starting in the middle and working toward each end. Connections are threaded snug only, at this time, to be tightened later.

After the top bolts and nuts are in place, the bottom angle connections are started. The hole locations and bolting pattern are the same as for the top angles, except that here the special wrenches are used for inserting the bolt, holding nut, and tightening, which is accomplished from the deck side.

Using the JT7 drive wrench, insert the A6B bolt in the holes through the adjoining bottom angles and make contact with the nut being held in position with the JT8 backup wrench. When thread contact has been made, draw up snug but do not tighten until all the bottom bolts have been installed. Again, work from the center out to both ends. (If only one special wrench set is used, start in the center and work each side alternately toward the ends.) When all the bolts have been installed, reverse the wrenches so that JT8 holds the bolt while JT7 drives the nut, and tighten all the nuts to the bolts, top and bottom, to the required torque of 2,400 foot-pounds. Note that the applicable rule is to draw the nut up tight, then turn it about another half turn. (See fig. 10-25.)

The JT13, a two-piece aligning tool, should be used when differences in the hole alignment between angles restrict easy passage of the A6B bolts. The

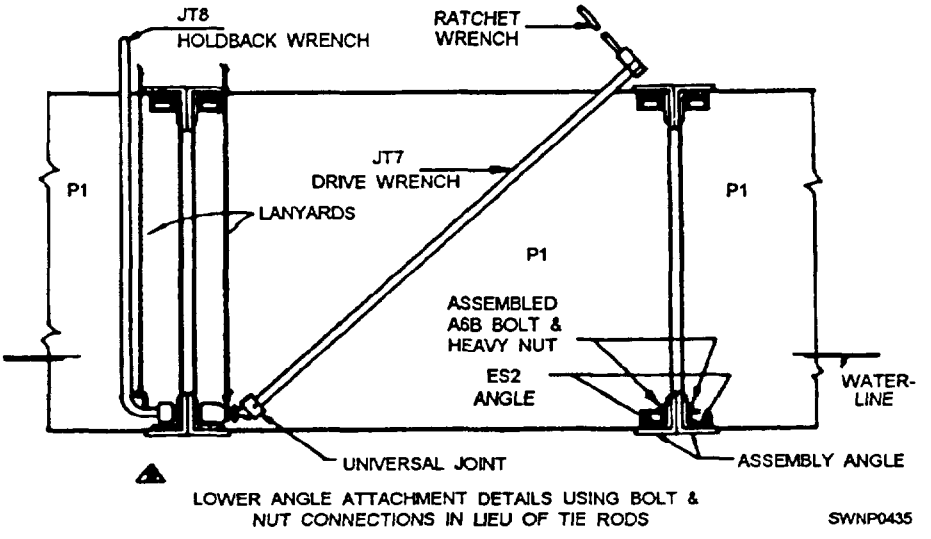


Figure 10-25.—Lower angle attachment details using bolt and nut connections instead of tie rods.

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JT13 is inserted anywhere along the strings (preferably in the center) and drawn together tightly, using the JT7 and JT8 drive and backup wrenches. Leave the aligning tool installed, remove the JT7 and JT8 wrenches, and complete connections of the bolts and the nuts, after which remove the aligning tool and replace it with a bolt and nut. Lanyard rings, provided on wrenches and two-piece aligning tools, must always be used to safeguard against loss.

As each string is secured with the bolt and the nut to the preceding string(s), installation of AP4A plates, pad eyes, chocks, cleats, and other accessories required for the structure and not previously installed on the strings are welded or bolted in position as specified in the detailed drawing. To complete the assembly, skip-weld the deck closures in the slots of the deck.

ASSEMBLY OF COMPLETE STRUCTURE ON LAND

Assembly of a complete structure on land is begun in the same manner as construction of strings, except that the structure is assembled parallel to the shoreline on rails perpendicular to the shoreline. Structures up to three strings wide can be built in this manner by assembling the second and third strings on top of the first. When built this way, the bolt and nut attachment previously described and the assembly plates are installed as the work progresses. KPl keeper plates are welded on the bottom A6B assembly bolts and accessories. They will not interfere with launching and can be attached to the assembly. Portable scaffolding, fabricated in the field and similar to that shown in figure 10-26, is attached to the pontoon assembly angles and can be moved to other locations on the structure to meet construction progress. The completed structure can be side-launched by sliding it out to the ends of the rails and tipping it into the water.

USES OF PONTOON ASSEMBLIES

A barge is any of several pontoon string assemblies connected together to form a complete unit used for transporting cargo, including vehicles and personnel, and used primarily in their transfer from landing craft to amphibious vehicles or for lighterage duties in ship-to-shore movement of cargo. Barges, designed for lighterage operations, either self-propelled or towed, can be built in various sizes and, with modifications as required, can be used as a diving platform for salvage operations, as a tugboat, as a gate vessel, for fuel storage, or for mounting cranes.

The intended use of the barge determines the length of the strings, the number of strings needed, and the pontoon configuration of each string. Seven standard-size barges in the P-series equipment include

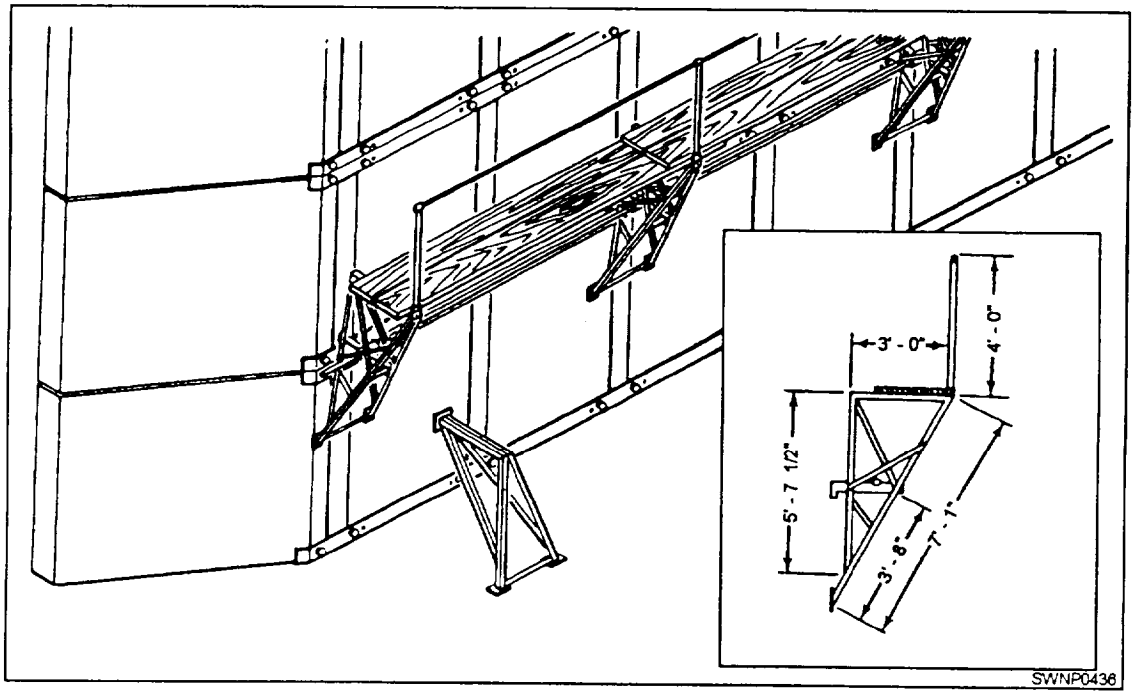


Figure 10-26.—Portable scaffolding used in assembly of structures on a pier.

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the following: 3x7, 3x12, 4x7, 4x12, 5x12, 6x18, and 10x30 barges. The conventional pontoon barge, in sizes up to and including the 6x18 barge, is designed to carry its rated load with 1' of freeboard or a load concentrated at the center point that is heavy enough to bring the deck awash.

The 3x7 pontoon barge is a general-purpose structure that can be used as necessary in lighterage and ferrying operations. Cargo transport can be accomplished by tow, or the barge can be self-propelled by mounting a propulsion unit on the end without fenders. A 3x7 barge with a propulsion unit is shown in figure 10-27.

The 3x12 pontoon ramp barge is ordinarily used for transporting cargo and equipment and has proved suitable for general use in amphibious operation. The sloping bow end with ramps attached permits beaching the barge under its own power. And also it helps to unload tractors and equipment that will be used to assist in forming a causeway pier. Four 3x12 barges can be side-loaded on an LST for side-carry to the assault area, or the barges can be loaded in the well deck of an LSD or deck-loaded on an LST.

The 4x7 pontoon barge is similar in all respects to the 3x7 barge, except it is one string wider. Although this is a general-purpose barge used principally for lighterage operations, it is suitable for any transportation task within its capacity.

The 4x12 pontoon barge is a general-purpose structure that can be used in lighterage operations either by towing or as a self-propelled structure by the addition of propulsion.

The 5x12 pontoon barge is one string wider than the 4x12 barge but similar in all other respects. It is particularly suitable for mounting a crawler crane with a lifting capacity ranging from 20 tons at a 12' radius to 7 tons at 55'. This barge can also be used as a general-purpose structure and can be used in lighterage operations as a self-propelled structure by the addition of propulsion units.

The 6x18 pontoon barge is the second largest barge in the P-series pontoon system. Installation of propulsion units permits its use in lighterage operations for transporting loads (cargo, vehicles, and personnel) up to 250 tons. By the addition of accessories and equipment, the barge can be converted into a 1,500-barrel fuel storage barge (fig. 10-28). Also, by installing heavy-duty hinges, the barge can be converted into a wharf or used for outfitting and repair of smaller structures when placed on its deck.

The 10x30 pontoon barge is the largest barge in the pontoon system. It was developed primarily for mounting a 100-ton derrick (See fig. 10-29.) The barge, however, is adaptable to other uses. With propulsion units attached, it can serve as a lighterage barge in transporting over 800 tons of cargo at one time from ship to shore or dock. The barge can also be



Figure 10-27.—A 3x7 pontoon barge with a propulsion unit.

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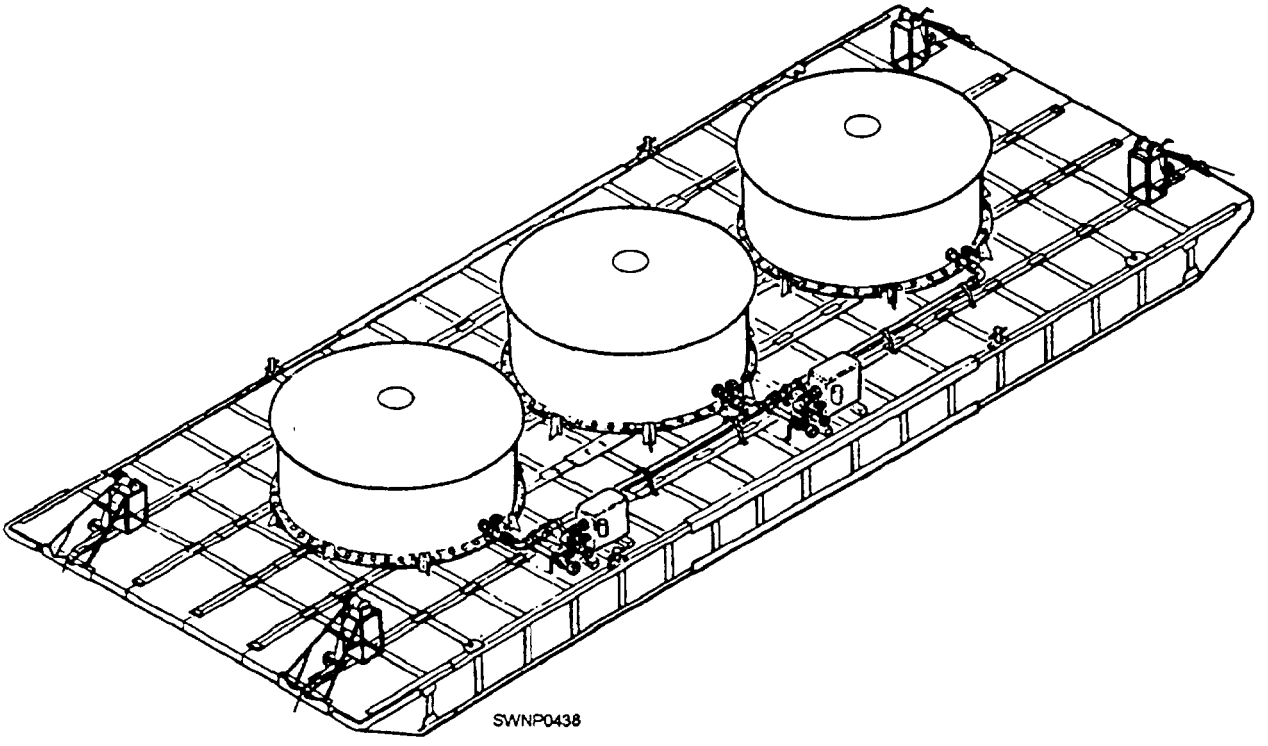


Figure 10-28.—A 1500 barrel , 6x18 fuel storage barge.

used as a pier or wharf or, by installing heavy hinges, could be connected to any existing pontoon wharf to enlarge or extend that structure.

Essentially, tugs are barges equipped with outboard propulsion units and the accessories required for the operations to be performed. The P-series equipment tugs are widely adaptable and can be used for towing, causeway tending, placing and retrieving anchors, salvage operations, assisting in the installation and recovery of fuel systems, and other services.

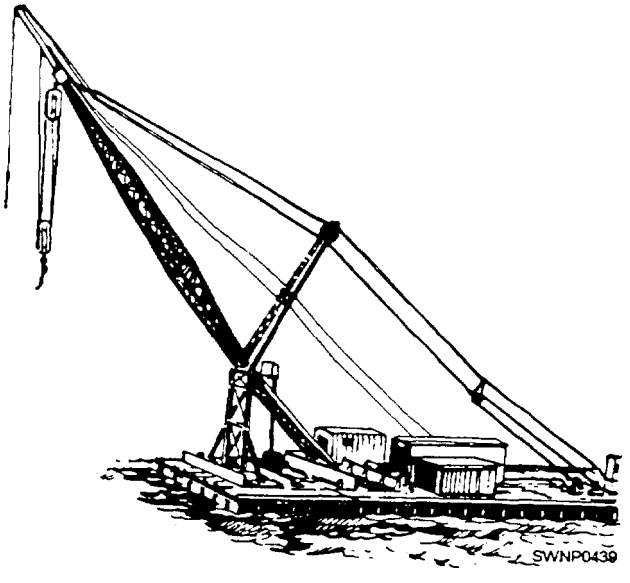


Figure 10-29.—100-ton derrick mounted on a 10 x 30 barge.

The 3x14 warping tug shown in figure 10-30 is equipped with two outboard propulsion units. The after end of the center string incorporates an anchor housing to accommodate the 2,500-pound mooring anchor and also holds the anchor wire away from the propulsion screws. An A-frame, mounted on the bow of the tug, stands approximately 13' above the deck of the barge. A double-drum winch is mounted near the center of the barge. A line from the after drum is fairlead to the deck and back to the anchor astern, while the line from the forward drum is run over a sheave in the top of the A-frame and is used for lifting over the bow or pulling from the bow of the warping tug. The winch is mounted on a welded steel cross-braced frame. Standard equipment for the tug also includes M147 double bitts and navigation lights. The warping tug is approximately 90' long and 21' wide, has a stem draft of 48", a bow draft of 18", and a speed of 6 1/2 knots. The 3x14 warping tug replaces the 3x12 tug throughout the pontoon system. The only difference in these two is that the 3x14 tug is longer by two P1 pontoons and incorporates new style winches with lines feeding off horizontally laid drums.

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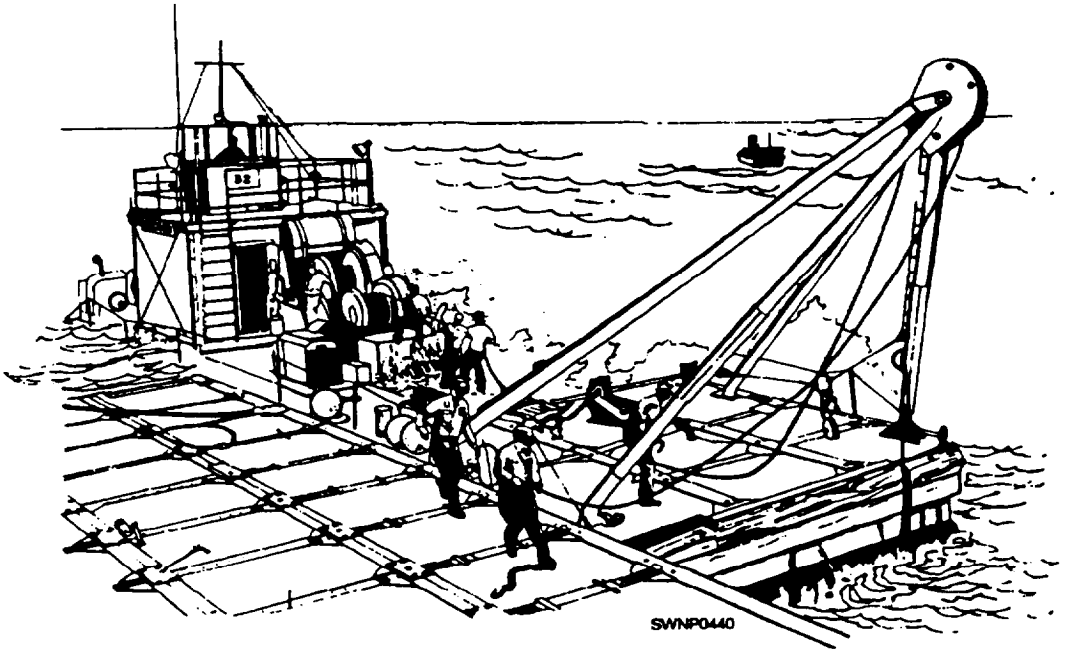


Figure 10-30.—3x14 warping tug.

A PONTOON CAUSEWAY consists of an inshore section, an offshore section, and as many intermediate sections as necessary to make up the desired length. Lengths up to 1 mile are considered possible. Each section is a 3x15 structure designed to support a load of 105 tons with a freeboard of 12".

Each string of the offshore (fig. 10-31) and inshore sections (fig. 10-32) is made up of 12 P1 pontoons with a P3 sloped deck pontoon and a P4 ramp-end pontoon at one end At the other end is an end-to-end connection pontoona—a P5F (female) end connection pontoon on the offshore section and a P5M (male) end connection pontoon on the inshore section. Strings of the intermediate sections (fig. 10-33) are made up of 13 P1 pontoons with a P5F at one end and a P5M at the other.

SIDE-LOADED CAUSEWAYS

Causeways, as well as binges, normally are transported to the combat area side-loaded on an LST. To facilitate this, you should weld a hinge rail or shelf bracket on each side of the LST. An LA1 launching angle is bolted to one of the outboard strings of the barge or causeway (fig. 10-34).

The LST is listed far enough to the side being loaded to permit the hinge bar of the pontoon structure to be hoisted onto the shelf bracket. Then the structure is hoisted upright, either by a crane or by the winch(es) on the LST. The hoisting sequence can vary, depending on the gear used and the LST involved.

Regardless of the method use&personnel from an amphibious construction battalion, usually with a SWC or BMC in charge, bring the required gear aboard and do the job. The ship's company make necessary preparations aboard ship and provide whatever assistance is required of them.

FLOATING DRY DOCKS

Floating pontoon dry docks are structures consisting principally of a main wharf-like deck and vertical side towers constructed of P-series pontoon units. Pontoon dry docks are submerged by admitting a controlled amount of water into the deck pontoons and raised by expelling the water with compressed air. The tower pontoons act as stabilizers to keep the dry dock level when the deck is under waler. Dry docks require 18' of water in which to submerge the decks 12", the maximum safe submergence, and should be moored in sheltered, quiet water 18' to 20' deep, in an area with a smooth bottom, devoid of large rocks or other obstacles. Two sizes of pontoon dry docks are presently in the ABFC System. This is identified as the 4 x 15 (l00-ton capacity) dry dock. Figure 10-35 shows a 6 **x** 30 pontoon dry dock installation.

The assembly method of erecting pontoon strings for the dry docks is the same as those used for other pontoons structures. Only P1 pontoons are used and

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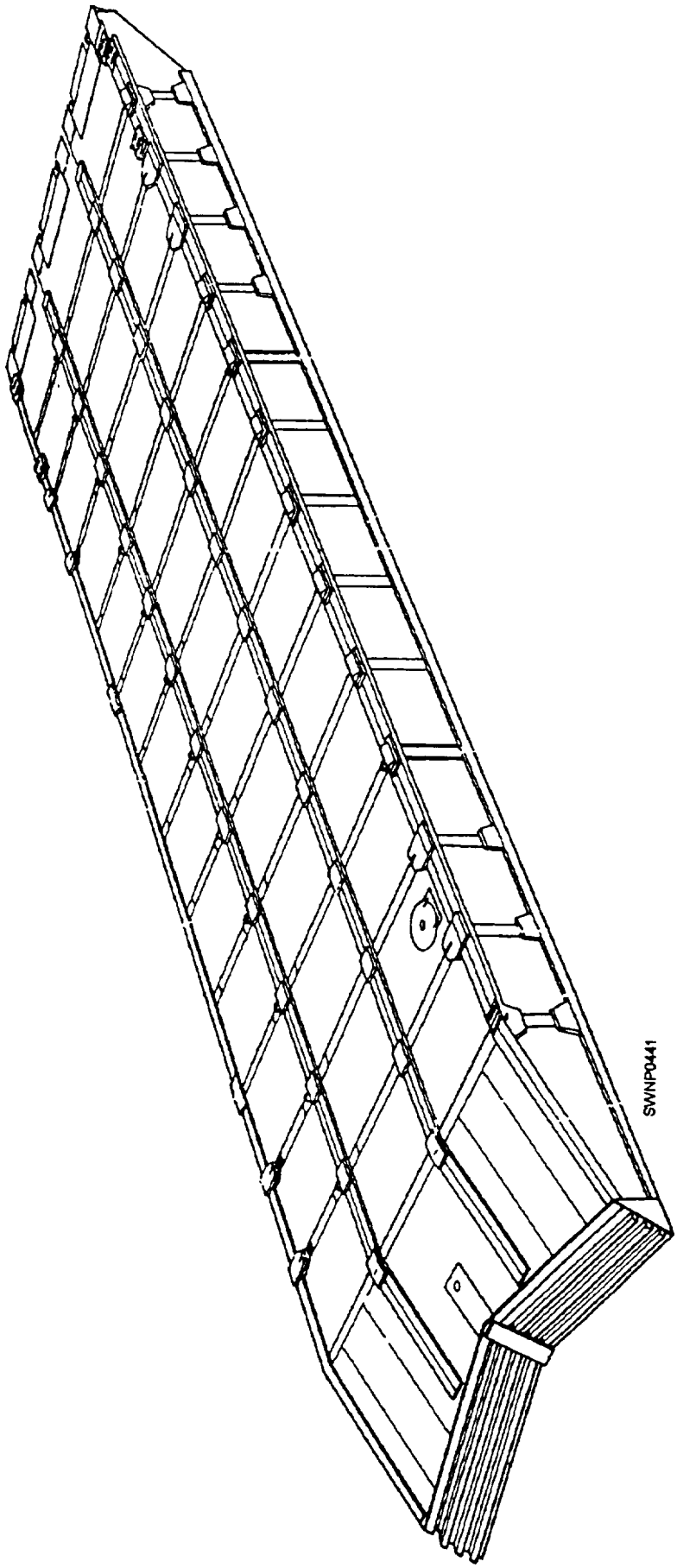


Figure 10-31.—Offshore causeway section.

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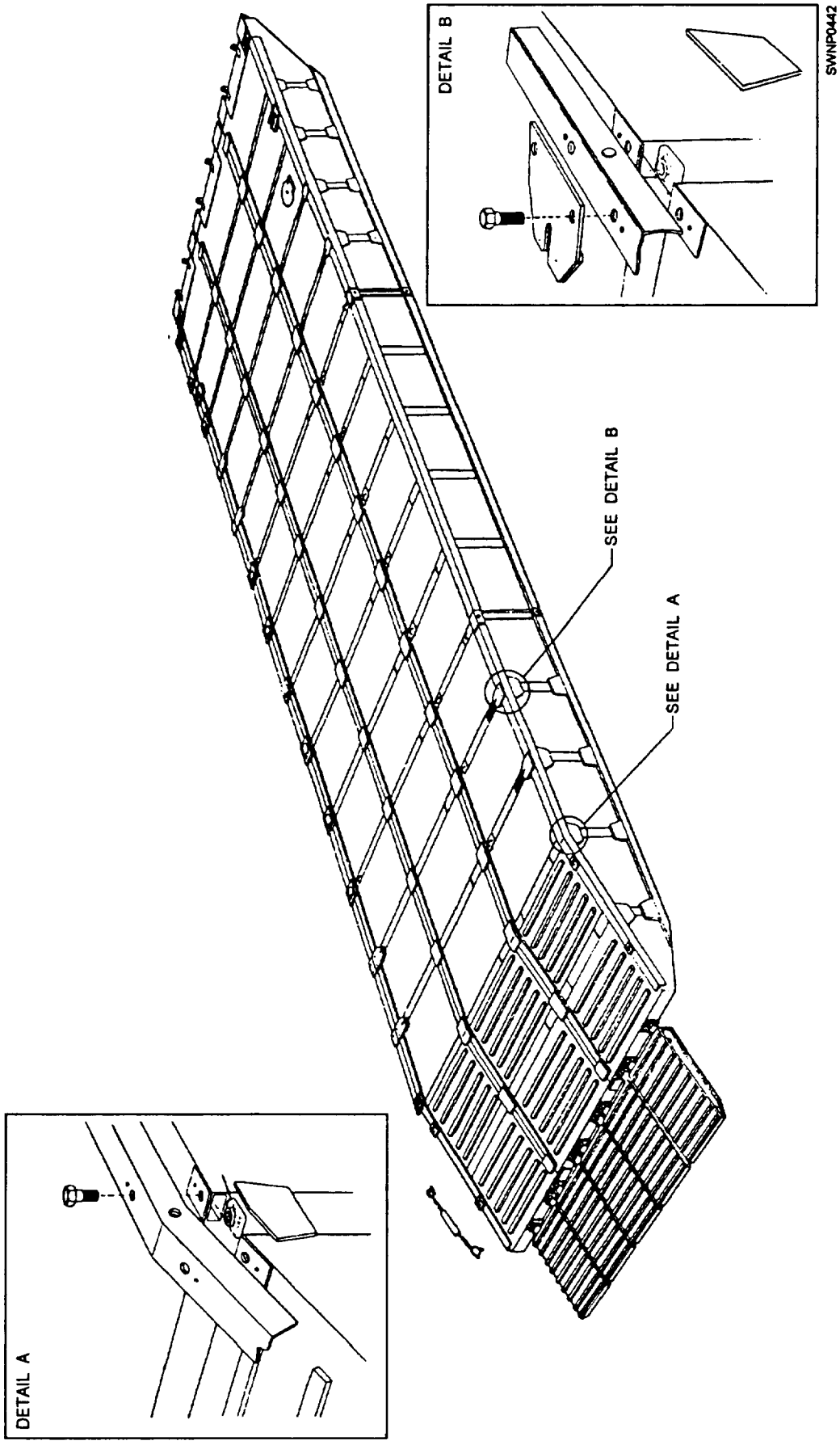
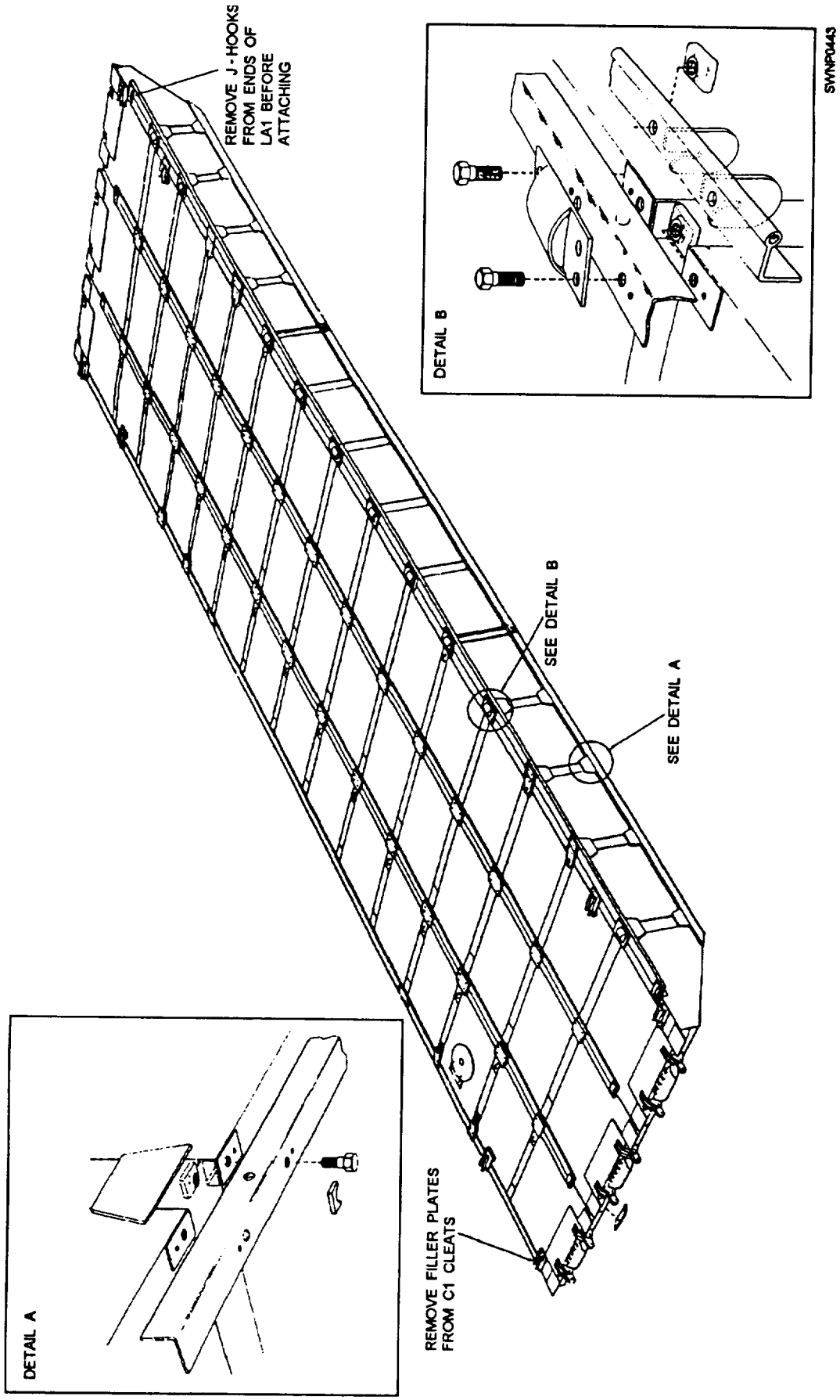


Figure 10-32.—Inshore causeway section.

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FFigure 10-33.—Intermediate causeway section.

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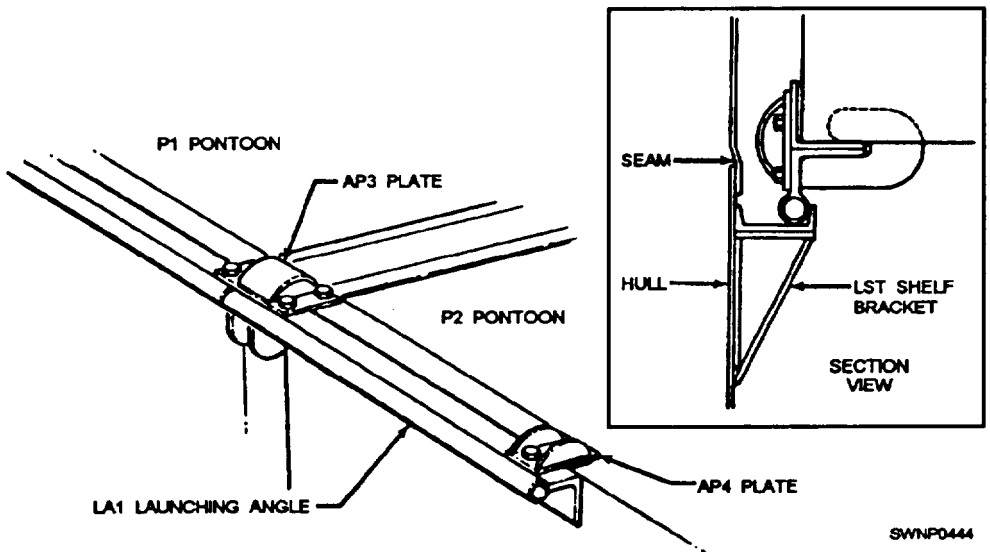


Figure 10-34.—An LA1 launching angle.

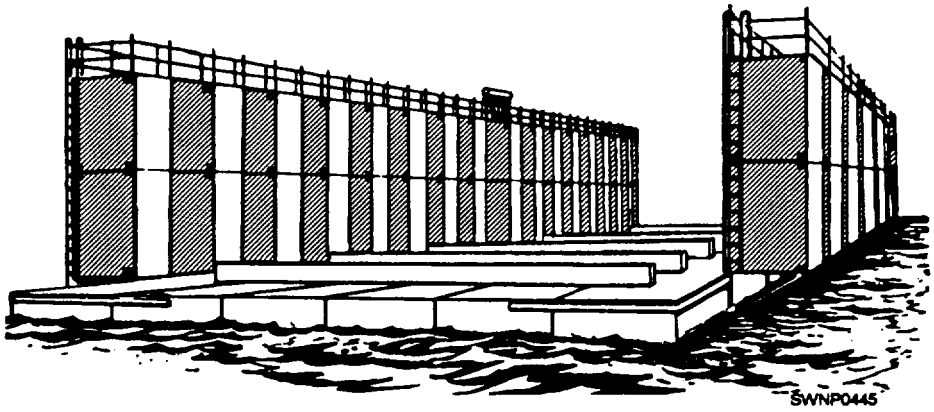


Figure 10-35.—6 x30, 400-ton pontoon dry dock.

are made up into strings, launched, and joined in the water the same as with other structures. However, before pontoon string construction, dry dock drawings should be prepared in detail to show the type and the location of parts, together with field erection information. It is important to make available the applicable drawings of the dry dock to be erected at all times during the initial construction stage. This will ensure that parts are properly located, positioned, and secured and will facilitate erection during the final stage.

ELEVATED CAUSEWAY SECTIONS

The elevated causeway pier facility (ELCAS) provides a link between lighterage and the beach by bridging the surf zone. The standard ELCAS consists of six 3x15 approach or roadway sections and six 3x15 pierhead sections (fig. 10-36). The pierhead is two sections wide by three sections long. Since the facility is modular, it may be expanded by enlarging the pierhead and/or adding approach sections. The basic component of the ELCAS is the 3 x 15 intermediate causeway section that is converted to the elevating mode by the addition of spudwells. Spudwells provide the attachment between the causeway deck and the supporting piling. Internal spudwells (fig. 10-37) are used where the full width of the causeway section is required for traffic and to support the fender piles along the fender side of the pierhead. The internal spudwell incorporates four grooved connection pins that are inserted into four receiver boxes attached to the side of the causeway. Two guillotines are lowered into the pin grooves behind the receiver boxes to secure the spudwell to the section. A steel-angled locking key is used to lock the guillotine into place. External spudwells (fig. 10-38)

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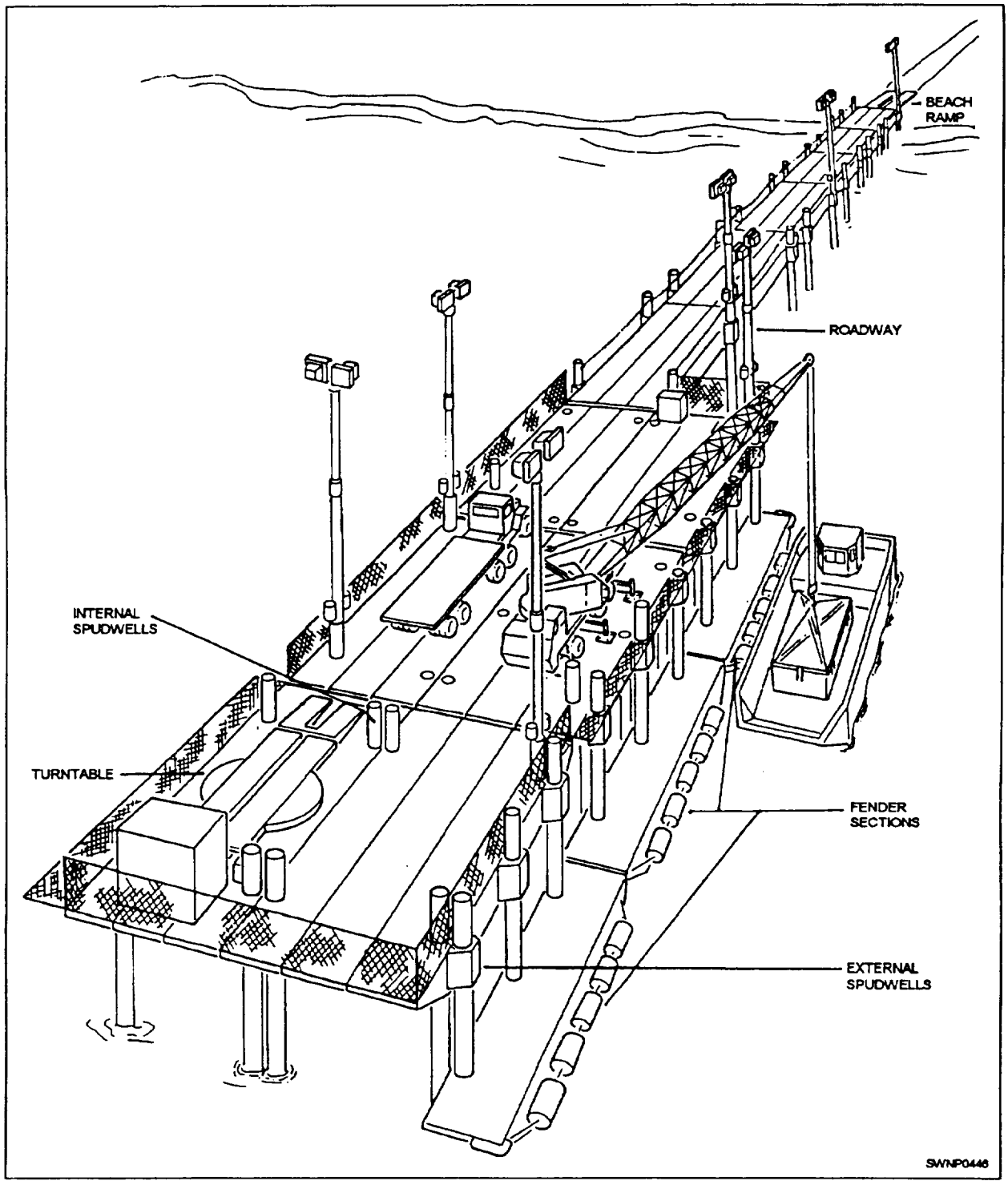


Figure 10-36.—Twelve section elevated causeway.

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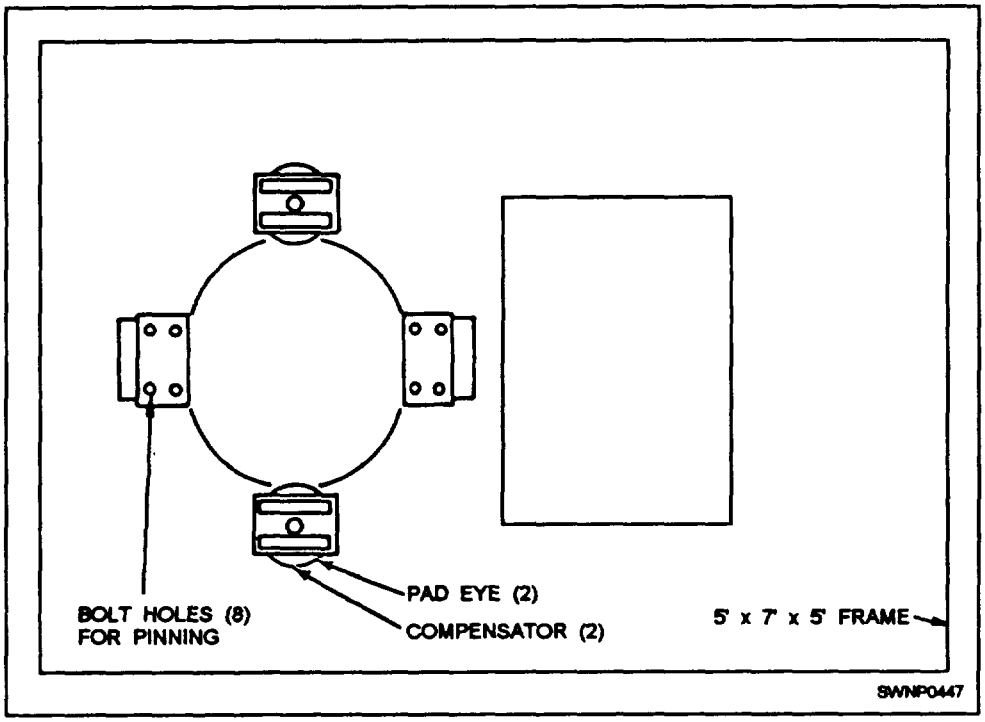


Figure 10-37—Internal spudwell.

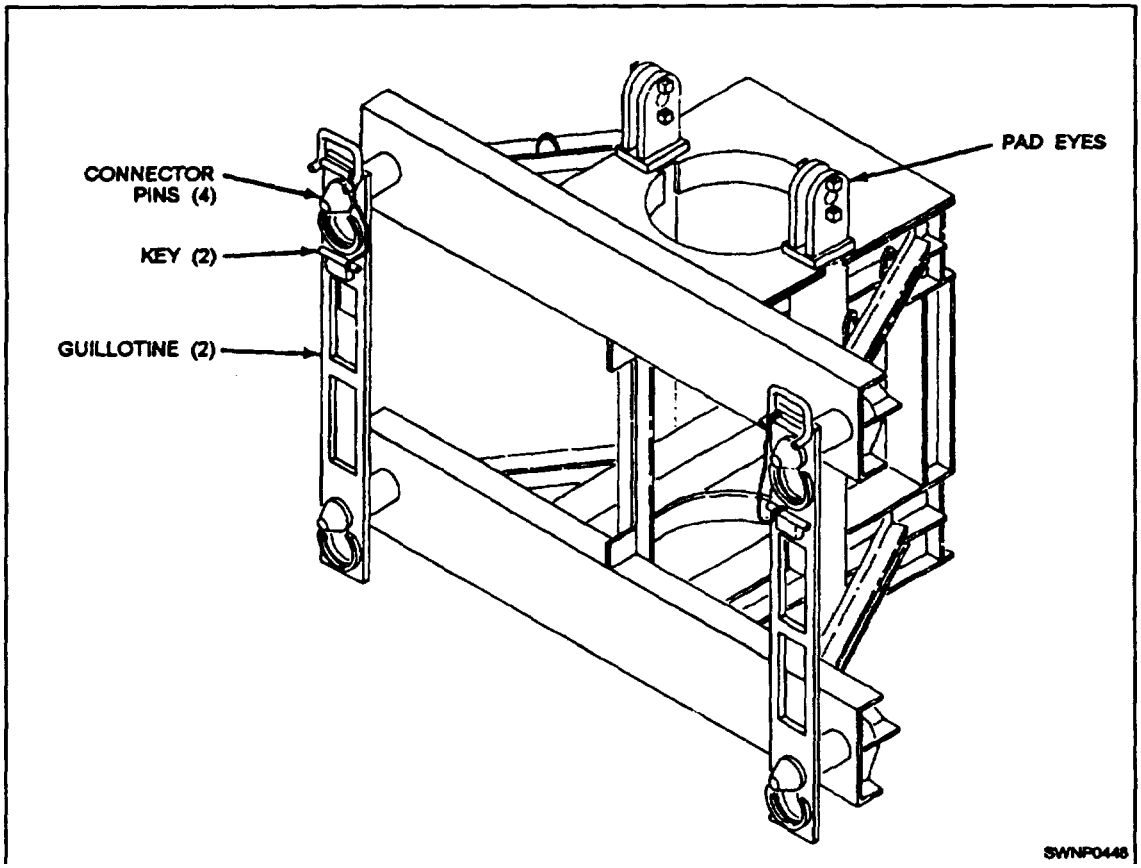


Figure 10-38.—External Spudwell.

are used in the outboard strings of pierhead sections, where side to aide connection with another section is required, and at load-bearing points, such as under the container handling crane. The external spudwell is fabricated into a frame having the same overall dimensions as a PI pontoon. It is interchangeable with

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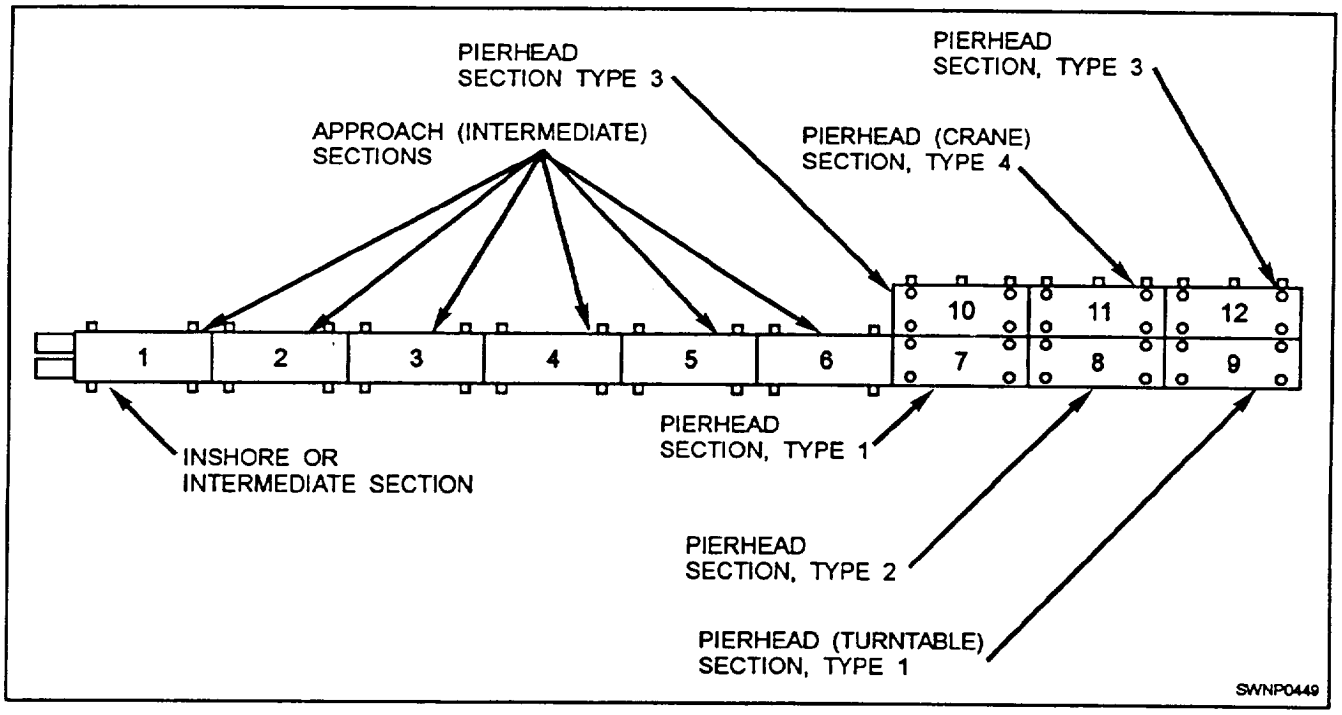


Figure 10-39.—Types and positions of causeway sections in the ELCAS.

the PI pontoon and uses the same attaching hardware. The ELCAS consists of four distinct parts as follows:

Ž **The PIERHEAD** is made up of four types of sections. It is the offshore section of the ELCAS and supports cargo unloading functions. The pierhead includes a crane installation for off-loading lighterage and a turntable for turning trucks around on the causeway.

Ž **The FENDER SECTIONS** provide an interface between the pierhead and the lighterage.

Ž **The ROADWAY** provides for two-way traffic between the pierhead and the beach.

Ž **The BEACH RAMP** provides access from the beach to the ELCAS.

The types of sections used and their locations are shown in figure 10-39.

CONSTRUCTION OF PIERHEAD SECTIONS

The type 1 pierhead section makes use of four internal spudwells. This section is also equipped with support brackets to receive the side connectors used to join these sections side to side with type 3 pierhead sections.

The type 2 pierhead section contains six internal spudwells. Support brackets for side connectors are also used in this type. Additionally, the type 2 section contains six reinforced PI pontoons.

The type 3 pierhead section uses four internal and three external spudwells. Support brackets must be also added to support the side connectors.

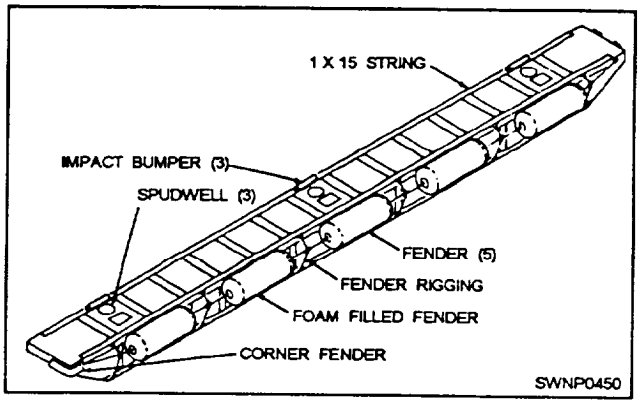


Figure 10-40.—ELCAS fender system details

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The type 4 pierhead section, which supports the container handling crane, contains seven internal and three external spudwells. Six reinforced PI pontoons are also included.

CONSTRUCTION OF FENDER SECTIONS

A fender section is a 1'x15' structure incorporating three fender spudwells (fig. 10-40). Fender piles are driven through the fender spudwells after the causeway is elevated (fig. 10-41). The fender section can then rise and fall on' the piling. A series of foam-filled fenders are strung on the outboard side of the fender system to absorb impact from lighterage. Since it is only one pontoon wide, the fender system uses P5 pontoons as end-to-end connections instead of the P8.

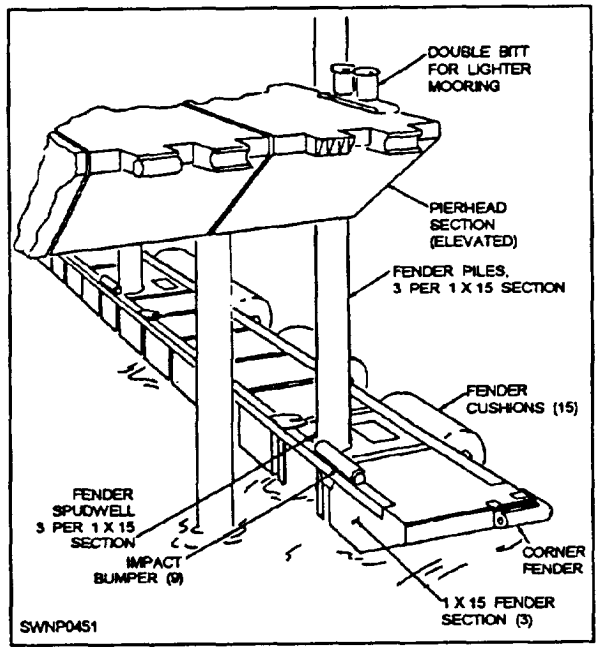


Figure 10-41.—ELCAS fender system.

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CHAPTER 11

PRE-ENGINEERED STRUCTURES: SHORT AIRFIELD FOR TACTICAL SUPPORT

The Short Airfield for Tactical Support (SATS) is a rapidly constructed expeditionary airfield that can be erected near a battle area to provide air support for amphibious Marine forces. In any land-and-sea military/contingency operation, the rapid assembly of a temporary airfield provides ground units with the distinct advantage of continuous air support on foreign soil. Because of this, the Marine Corps has been trying several types of expeditionary airfields since early in World War II. Initial research used wooden planking for the runway surface. Later, during the Korean Conflict, aircraft actually landed on pierced steel mats, known as "Marston matting."

One of the more important breakthroughs in SATS research was the development of Short Expeditionary Landing Field (SELF). SELF, a bulky predecessor of SATS, was a 4,000-foot runway that served as the landing area. In earlier expeditionary arresting operations, the Marine Corps had been successful with the M-2 Mobile Arresting Gear (MOREST). However, the weight of this gear (74,000 pounds) decreased its usefulness as a portable unit.

In 1956, the Commandant of the Marine Corps established exact specifications for the development of a portable expeditionary airfield. This proposed airfield was to be 1,000 feet long, construction completed in 5 days, and capable of accommodating one squadron of aircraft for 30 days. Additionally, the Marine Corps required that the field be designed to allow both launch and recovery (arresting) operations. These standards included the development of a land-based catapult and lighter arresting gear to replace the M-2 MOREST. In 1958, the runway specification was expanded to 2,000 feet and received official SATS designation. However, because the catapult and arresting gear are no longer available in the ABFC (Advanced Base Functional Components) System, they are not discussed in this chapter.

Because Steelworkers can be assigned to crews assigned to place airfield matting, we will discuss the important parts of SATS. Also, the proper placement procedures for AM-2 matting are discussed and information is also provided on the installation and repair and removal of AM-2 mating.

PARTS OF SATS FIELD

A SATS field incorporates numerous parts. We will not attempt to cover all the parts of a SATS installation but will cover enough to make you familiar with the function of each of the major parts that make a SATS field an effective system.

AM-2 MATTING

The AM-2 mat (fig. 1 l-l) is a fabricated aluminum panel, 1 1/2 inches thick that contains a hollow, extruded, one-piece main section with extruded end connectors welded to each end. (AM-2 mats may also be fabricated in two- and three-piece main panel extrusions that, when welded longitudinally, form the same size and shape as the one-piece extrusion.) The AM-2 mat comes in full sheets and half sheets and is painted Marine Corps green. The top surface is coated with a nonskid material of the same color. For runways and taxiways, the mats are installed in a brickwork type of pattern. The staggered joint arrangement provides the required stability across the runway and the necessary flexibility in the direction of aircraft travel.

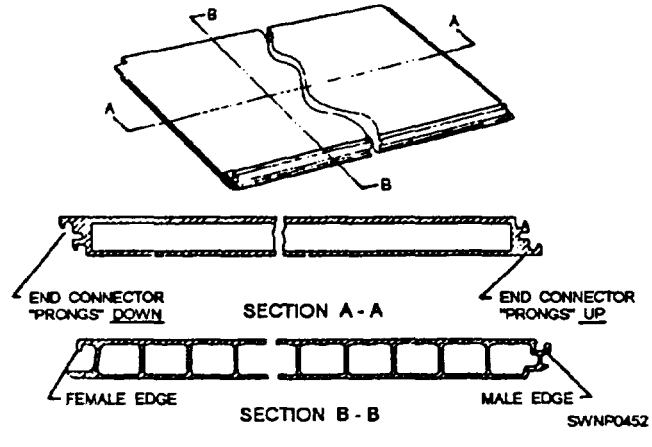


Figure 11-1.—AM-2 mat.

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The sides of the mat panels are constructed to interlock with a rotating motion. The end connectors are arranged with the prongs up on one end and down on the other (fig. 11-1, section A-A). By placing the end connector of one mat properly over the end connector of the previous mat, you can form a continuous layer of matting. A flat-locking bar is then inserted into the slot common to the two mats to form a nonseparable joint.

The physical characteristics of AM-2 matting are shown in table 11-1.

AM-2 mats are packaged in two standard pallet loads for storage and shipment. One pallet assembly, designated F11, consists of 11 full-length mats, 2 half-length mats, and 13 locking bars (fig. 11-2). The other mat pallet, designated F15, contains 16 full-length mats, 4 half-length mats, and 20 locking bars (fig. 11-3). The pallets are fabricated end frames that are held together by tie rods or strapping. The end frames fit around the ends of the mats and become the storage place for the locking bars.

The quantity of mats found in the standard pallet assembly (F11) provides a width of two rows (4 feet) on a runway or taxiway that is 72 feet wide. For widths other than 72 feet, more or less coverage (in terms of strip length) is obtained. Since the parking and storage areas need not have a specific mat pattern, as is required on the runways and taxiways, the "extra" half-length of full-length mats that result from the runway construction may be used in these areas. The use of a guide rail and/or keylocks will not affect the amount of coverage to any great extent.

INSTALLATION

As a Steelworker, you can be assigned to a project placing AM-2 mats for airfield surfaces; therefore, you need to be familiar with the procedures used for installing mats. Primary operations involving site preparation and pallet staging are also discussed. Additionally, information on manpower requirements and the organizational structure of the installation crew is presented.

Site Preparation

'he soil and subbase materials of the site selected as the SATS field must be suitable for use with the AM-2 landing mats. The subbase material must have a minimum compaction of 95 percent, and the engineering staff will provide you further guidance based on their analysis of the soil type and the available base materials.

The operations that are part of the site preparation that must be completed before mats are installed are as follows:

1. The terrain in the area to be used must be cleared, leveled, and rolled to provide the designated compaction for the matting base. Grading must provide adequate drainage of water away from the field area and the soil must be disturbed as little as possible in obtaining the prescribed finish. These operations will provide a soil having a maximum bearing capacity.

2. The soil in any area under the matting, requiring installation of service, drainpipes, or other objects, must be backfilled and thoroughly compacted

Table 11-1.—Physical Characteristics of AM-2 Matting

	ONE-PIECE MAIN EXTRUSION	TWO-PIECE MAT
(1) Weight (full-length mat)	144 lb	148 lb EST
(2) Length (full mat)	12 ft	12 ft
(3) Length (half-mat)	6 ft	6 ft
(4) Width	2 ft	2 ft
(5) Wt/Sq Ft of Coverage	6 lb	6 lb EST
(6) Locking Bars		
Length Width Depth	24 in. 5/8 in. 3/16 in.	

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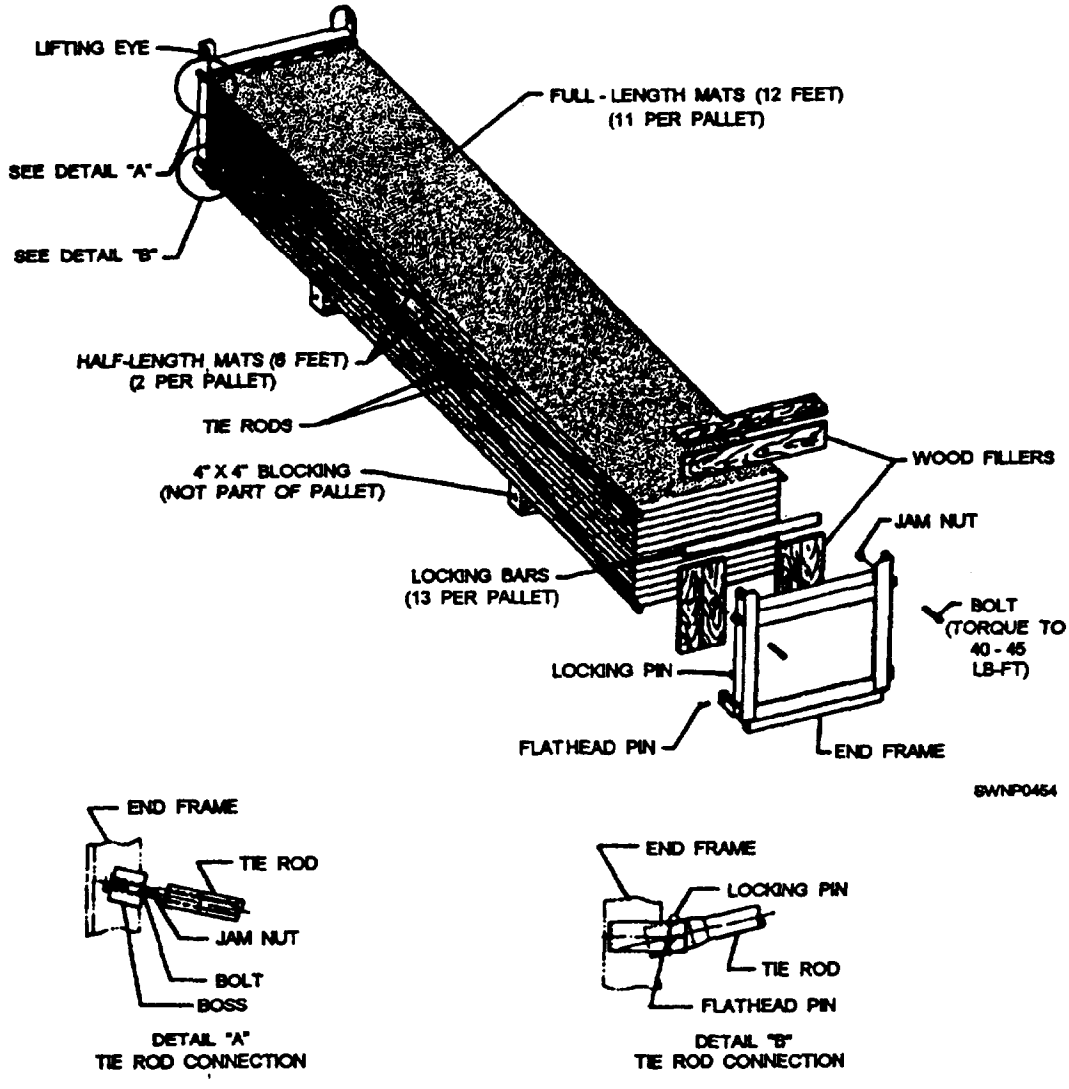


Figure 11-2.—F11 AM-2 full-length pallet.

3. The final grading operation must be adequately level so mats, when laid, do not vary more than l/4inch in height over a 12-foot distance.

4. Hand raking is necessary to remove small rocks and other debris that would hinder this task as well as the connecting of mats.

5. The overall field configuration must be staked out in its entirety. Accurate longitudinal and transverse center lines must be established to ease the staging of the pallets. When no guide rail is used, both lateral runway edges must be accurately marked to ensure smooth linear edges from which to lay the mat field. The line for the edges of the runway is determined by using a transit and marking them clearly with a chalk line or stakes. This type of survey is also required when taxiways and parking areas are installed. When a guide rail installed, only the center line of the guide rail is established by transit.

NOTE: Site preparation may not be required if there is an existing concrete or asphalt runway because matting can be laid over the existing hard surface.

Pallet Staging

Under combat/contingency operations, pallets must be staged in a manner to keep manual handling to a minimum. Additionally, staging should maximize all available equipment and manpower coupled with consideration for the climatic conditions in which the construction is started

Different methods are used for the staging of pallets. The most efficient method is the staging of

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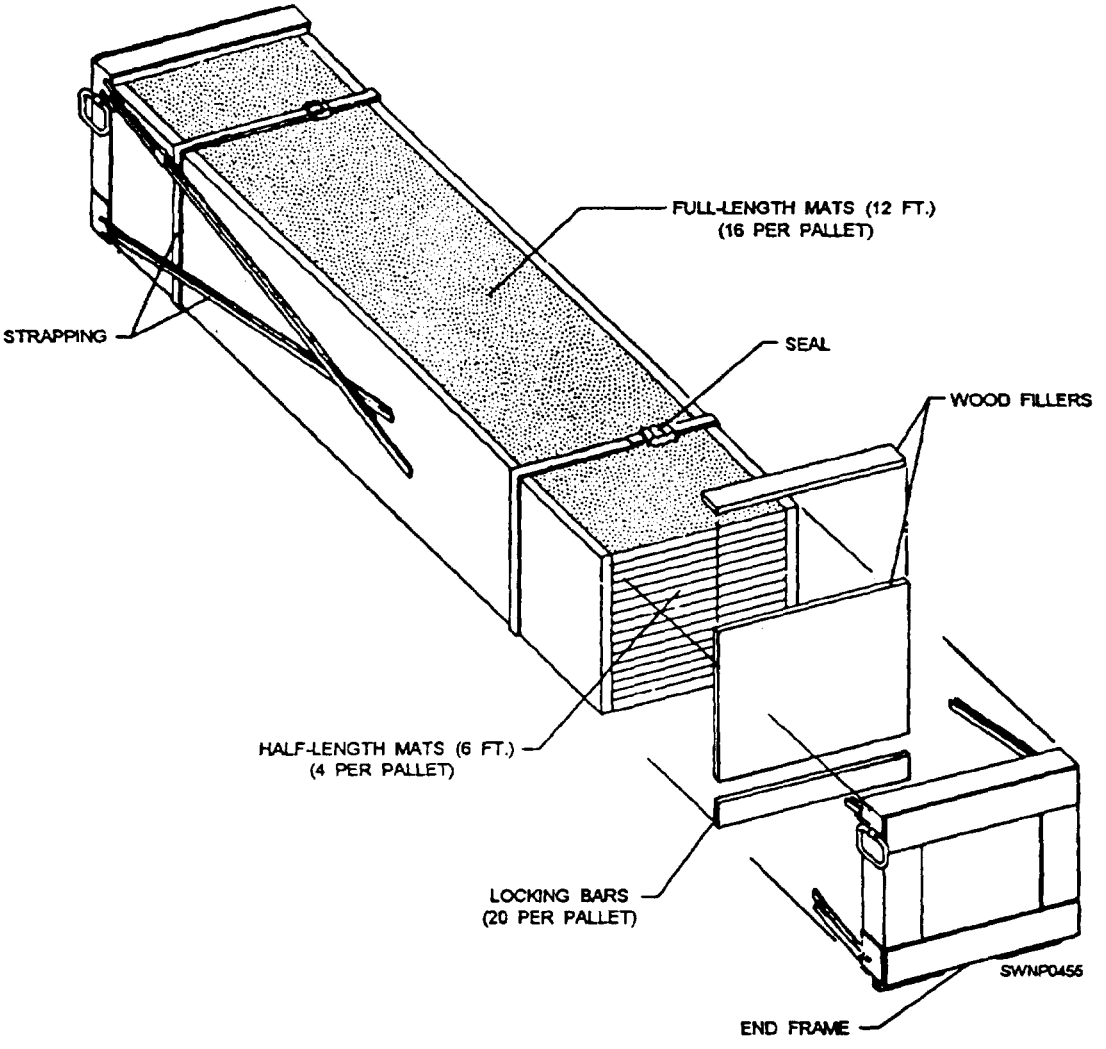


Figure 11-3.—Fl5 AM-2 full-length pallet.

pallets by rough-terrain forklifts. This method is the most eflicient because the forklift can deliver the pallets directly to the mat-laying crews who disassemble the pallets on the forklift. Pallet disassembly is done at the work area, rather than the storage point, because the mats could be dropped and damaged while being moved if they are uncrated and moved in a loose configuration. The forklift remains on site until the pallet load has been installed. This method presumes that an adequate number of forklifts are available to resupply the laying crews continuously. Round-trip time between the work area and the pallet storage area must be considered to keep the work flowing smoothly and completed in a time] y manner.

The primary rough-terrain forklift used in the NCF is the 4K rough-terrain forklift (fig. 11-4). A diesel engine-driven, self-contained, material-handling vehicle, the 4K forklift is designed primarily for the rough-terrain handling and warehousing of materials. The 4K forklift can lift and carry loads up to a maximum of 4,000-pound capacity and is the ideal equipment to use for staging pallets. The hydraulically operated forklift mechanism, mounted on the extreme front of the vehicle, eases the lifting, reaching, tilting, and sliding of loads during material-handling operations.

AM-2 matting in its palletized configuration is vulnerable to damage resulting from improper handling. Lifting eyes are contained in the pallet end frames to receive the sling lifting hooks. Under NO circumstances should “choker” type of slings be used because these damage matting side connectors. Normal cargo-handling precautions must be used during AM-2 pallet assembly handling.

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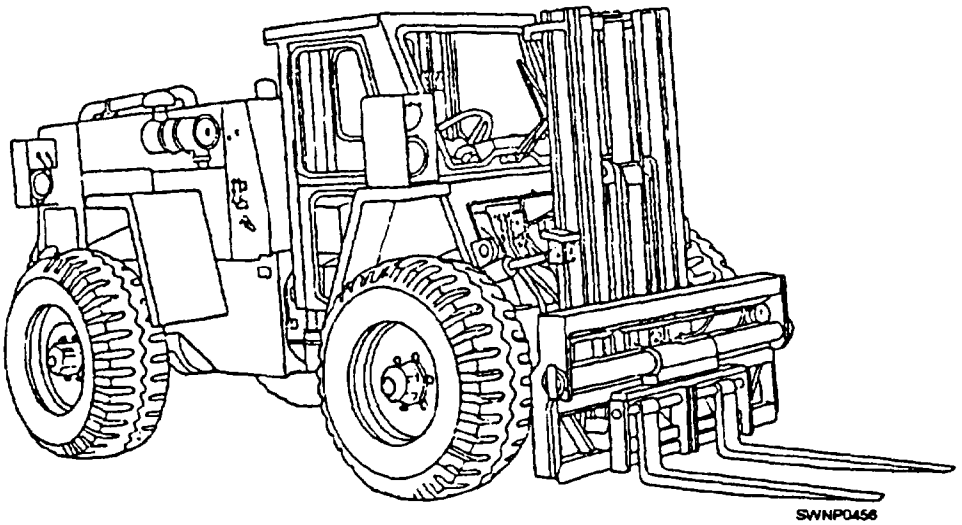


Figure 11-4.—4K rough-terrain forktlift.

PaIlet components are vulnerable to damage by misuse of tools, such as cutting torch, bolt cutters, and sledge hammers. Therefore, extreme care must be used during pallet disassembly. No spare components are packaged in the pallet.

Installation Crew

Field experience dictates that a 16-man crew provide maximum efficiency and flexibility when laying a runway 96 feet in width. Two crews can be used inlaying a runway and additional crews used for laying other areas simultaneously. A typical crew of 16 would include 1 petty officer in charge, 1 alignment person, 2 pry bar crew members, and 12 (six 2-person teams) mat installation personnel.

The alignment person ensures the field is aligned by adjusting the first mat in each transverse row, so it is flush with the presurveyed lateral boundary before the rest of the mats in that row are laid.

The pry bar crew members adjust individual mats, using a pry bar to provide maximum allowance for thermal expansion and insert the mat-locking bars.

The installation pesonnel, working with partners, take a mat from the pallet, carry it to the installation point, and then install the mat in place.

SATS Field Installation Sequence

The sequence of laying matting for a runway where a guide rail for a catapult system is not required is not the same as for a runway where a guide rail is required. Figure 11-5 shows you what a guide rail looks like. When a catapult facility is used with a SATS installation, a guide rail is needed to provide stability to the dolly and the aircraft during the launch. The guide rail is supplied in 9- and 10-foot lengths and has connectors on both sides to mate with the mat end connectors. A l/8-inch rubber seal is installed between each section to provide for thermal expansion and to prevent debris and soil from coming up between the rail sections. Dowel pins are used between two holes in the mats at each end of the guide rails to maintain alignment of the sections. The guide rail is installed concurrently with the mat field, and standard mat-locking bars are used to secure it to the mats.

NOTE: The catapult and arresting system is not available currently in the ABFC System. However, it was originally designed for the ABFC System and could be used in the future; therefore, information on guide rails is provided.

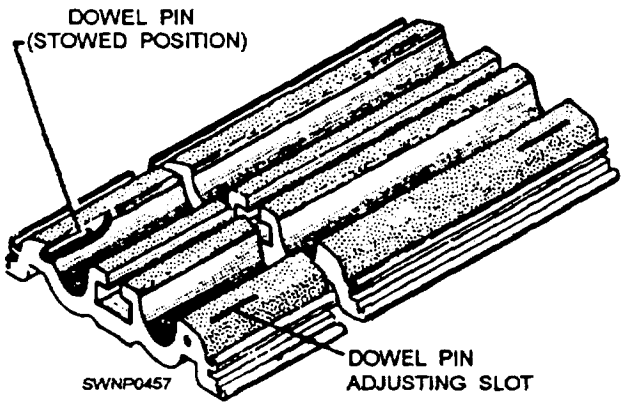


Figure 11-5.—Guide rail.

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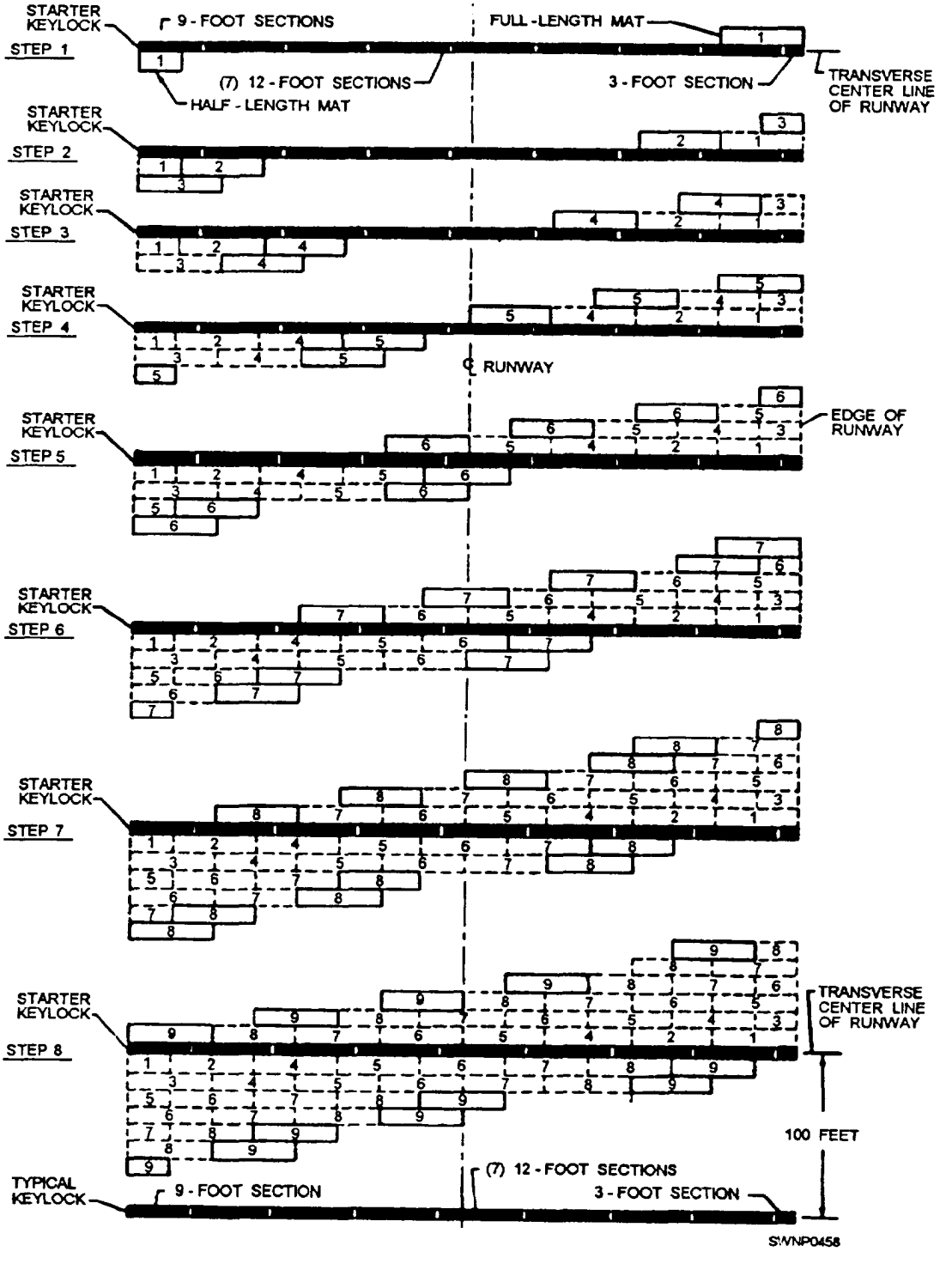


Figure 11-6.—AM-2 mat installation sequence without a guide rail.

The general sequence of laying matting for any length of installation where a guide rail is not required is to start at the transverse centerline and work toward each end simultaneously. The starter keylock section is laid, and then individual mats are laid in a brickwork type of pattern from left to right when facing the working area. The left-to-right sequence is dictated by the mat interlock design which is such that reversing the procedure is difficult and inefficient. The coated side is always "up," and the interlocking prongs on the 2-foot edge are always to the right and up. Survey lines are present to guide at least one edge of the section being laid to maintain proper longitudinal alignment. Other sections of the site maybe laid in

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the same reamer and at the same time if survey lines have been established, pallet staging has been accomplished, and sufficient personnel are available. A typical keylock section is laid every 100 feet, starting with the 100-foot mark on either side of the starter keylock.

The general sequence of laying mating for the runway with the guide rail installed is to start at one end (at the approach apron) and work toward the opposite end. The guide rail divides the runway into two sections, 18 feet and 78 feet (or 18 feet and 30 feet for a 48-foot runway). Individual mats are laid in a brickwork type of pattern from the guide rail to the outer edge in each section when facing the working area. The starter keylock is not used when laying a runway with a guide rail. Instead, typical keylocks are laid at 100-foot intends on the runway, and other sections of the SATS field are laid as explained in the previous paragraph.

Be sure to inspect visually upturned sides and end connectors of AM-2 matting for foreign matter before placing them in position. The presence of dirt, chips, stones, and so on, can prevent proper interlocking of the mats. Brooms or brushes can be used to clean foreign matter from the connectors.

Mat-Laying Procedure without a Guide Rail

The sequence for installing AM-2 mats and related components where a guide rail is not required is shown in figure 11-6. The sequence can be modified, so work proceeds on only one row of mats at any given time; however, SPEED OF INSTALLATION IS IMPORTANT. The sequence, as shown in figure 11-6, allows the use of at least two crews with six 2-man teams on each crew carrying and placing mats and keylocks.

When placing AM-2 mats, you should have three types of keylocks: starter, typical, and female. You should use a step-by-step procedure to place the AM-2 mats.

STARTER KEYLOCK.— The starter keylock is a narrow mat that is used to decrease runway installation time by approximately one half (fig. 11-7). Previous mat installation methods required assembling the runway at one extremity and working to the other end. The starter keylock is installed in the middle of the runway only and enables two mat-laying teams to start together and work simultaneously toward each end of a runway, section. Starter keylocks

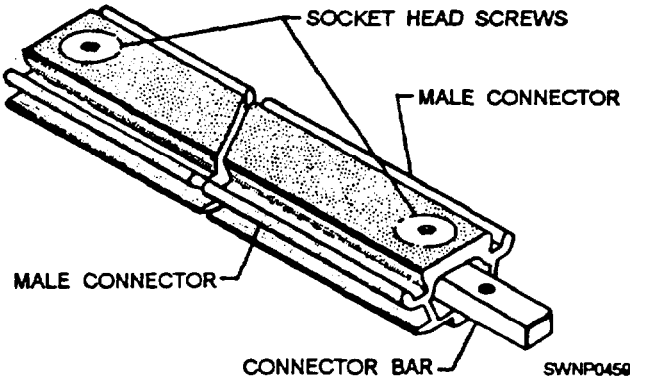


Figure 11-7.—Starter keylock.

are furnished in 3-foot, 9-foot, and 12-foot lengths to allow for the staggering of joints in matting patterns. The starter keylock is coated with a nonskid material. It is not used in installations having a guide rail.

TYPICAL KEYLOCK.— A typical keylock (fig. 11-8) is inserted every 100 feet in the pattern to permit the easy removal of sections of the matting for a multiple-mat replacement. For this reason, only a maximum of 50 feet of any one section needs to be removed to replace mats that could not economically be replaced as individual units by replacement mats. Typical keylocks are furnished in 3-foot, 9-foot, and 12-foot lengths to allow the staggering of joints of matting patterns. The typical keylock is coated with a nonskid material.

FEMALE KEYLOCK.— A female keylock (fig. 11-9) is used to join two adjacent male mats. The female keylock is coated with a nonskid material.

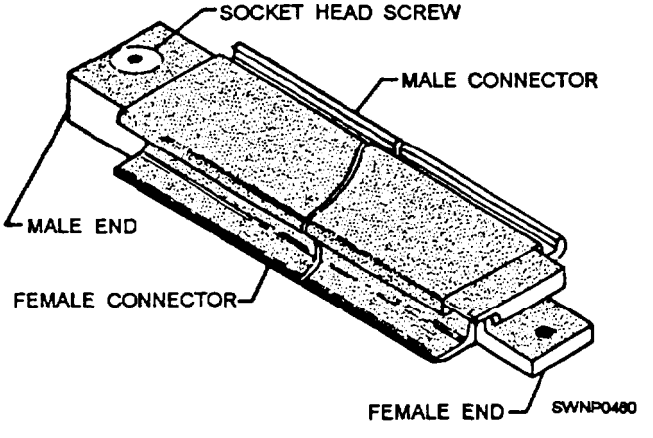


Figure 11-8.—Typical keylock.

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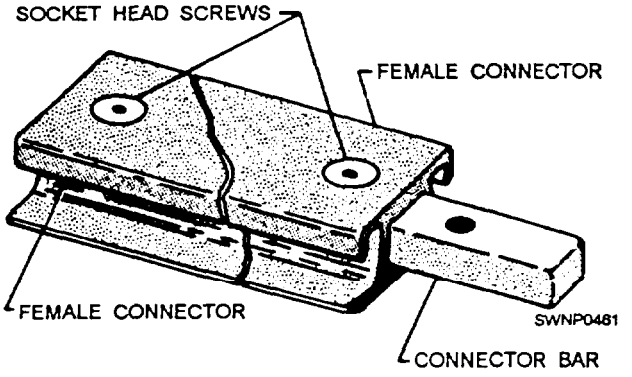


Figure 11-9.—Female keylock.

Steps for Laying AM-2 Mats and Keylocks

The procedure for laying AM-2 mats and keylocks is shown in figures 11-10 through 11-18 and consists of the following steps:

1. Lay starter keylocks on the transverse center line of the runway. (See fig. 11-10.) A 9-foot starter keylock is laid at the outer edge of the runway. Remove the socket head screws from the keylock to allow for extending the locking bars into the next keylock section.

2. Place a 12-foot starter keylock next to, and aligned with, the 9-foot section. Move the 12-foot section against the 9-foot section, and adjust the locking bar so the socket head screws secure the locking bar in each section this procedure secures the 9-foot starter keylock and the 12-foot starter keylock, as shown in detail "A" of figure 11-10.

3. Repeat laying six more 12-foot sections and one 3-foot section of starter keylocks to complete the 96-foot width of the runway.

NOTE: Initially, lay several transverse rows of AM-2 matting in one direction only from the starter keylock row. If matting is started on both sides of the starter keylock, a seesaw force could result, disturbing the alignment of the entire field.

4. With the nonskid side of the mat turned up and the upturned prongs on the right, align the first mat (half mat) on the left side with the starter keylock (fig. 11-11). Align the downturned prongs with the runway edge. Hook the female edge of the mat into the groove on the starter keylock (fig. 11-12) while holding the mat in an angular position. Rotate the mat downward to form the joint. (See fig. 11- 12.)

5. Lay the second and all successive mats the same way as the first mat (fig. 11-11) in relation to the starter keylock. The downturned prongs of the second mat should mate with the upturned prongs of the first mat, as shown in figure 11-13. When the mats are properly engaged, a rectangular slot is formed by the engagement of the end connectors.

6. Lock the first and second mats together, as shown in figure 11-14, by inserting the locking bar (fig. 11-15).

NOTE: The first two mats and all mats in the first row should be aligned accurately before inserting the locking bar. Misalignment of mats will prevent proper installation of the second row. Locking bars may stick

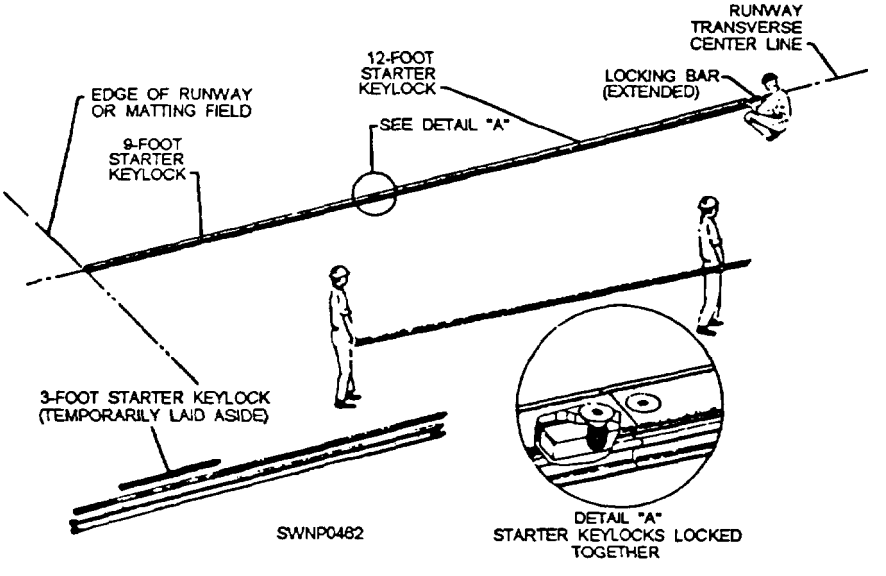


Figure 11-10 —Placing starter keylocks on a transverse center line.

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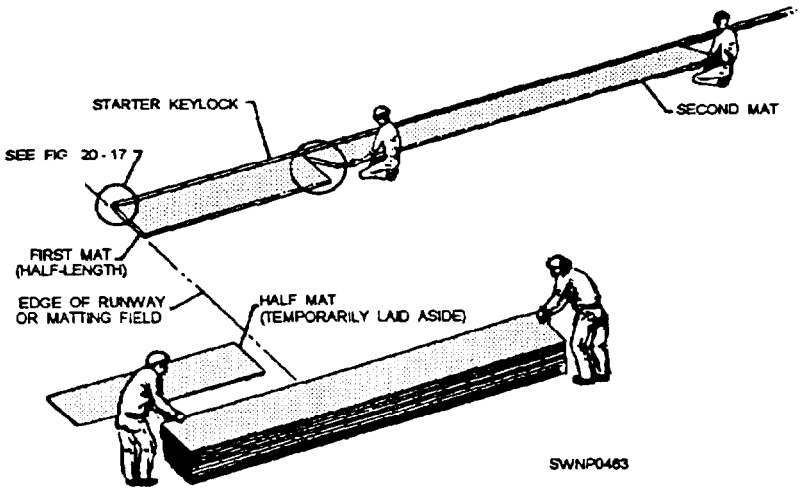


Figure 11-11.—Placing first and second mats

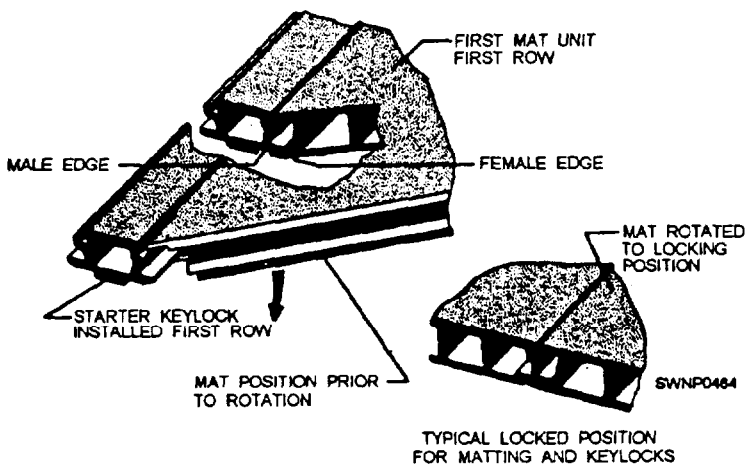


Figure 11-12.—Engaging first half mat (half length) to starter keylock.

because of the natural waviness in the manufacture of the mat end connectors and the locking bars. A few light taps of a hammer should drive the bar into the proper position.

7. Place the third mat at the start of the second row, as shown in figure 11-16. Ensure that the third mat is aligned on the left side with the mat in the preceding row. Refer to figure 11-12 and step 4 for the engagement procedure, which is the same for the engagement of the third mat with the first and second mats.

NOTE: The first row of mats and each alternate row thereafter is laid using half mats at the outer edges of the runway and full mats in between (fig. 11-6). The second row of mats and each alternate row thereafter is laid using full mats only. This method provides a staggered joint for greater matting strength.

8. Complete the first row, installing six more full-length mats and finally a half mat, using the same procedure as described for installation of the second mat. (See step 5.)

NOTE: The first row of mats on the opposite side of the starter keylock row are all full mats (fig. 11-6).

CAUTION

Align the first row accurately with stakes or guidelines delineating the extent of matting. As work progresses, periodically check the alignment of mats already installed. Any misalignment causes a displacement of the runway from the planned position at the far end of the field.

9. Install the second and succeeding rows according to the procedure for the third mat (first mat in the second row) with one notable exception. The second mat in each row must first be hooked to the

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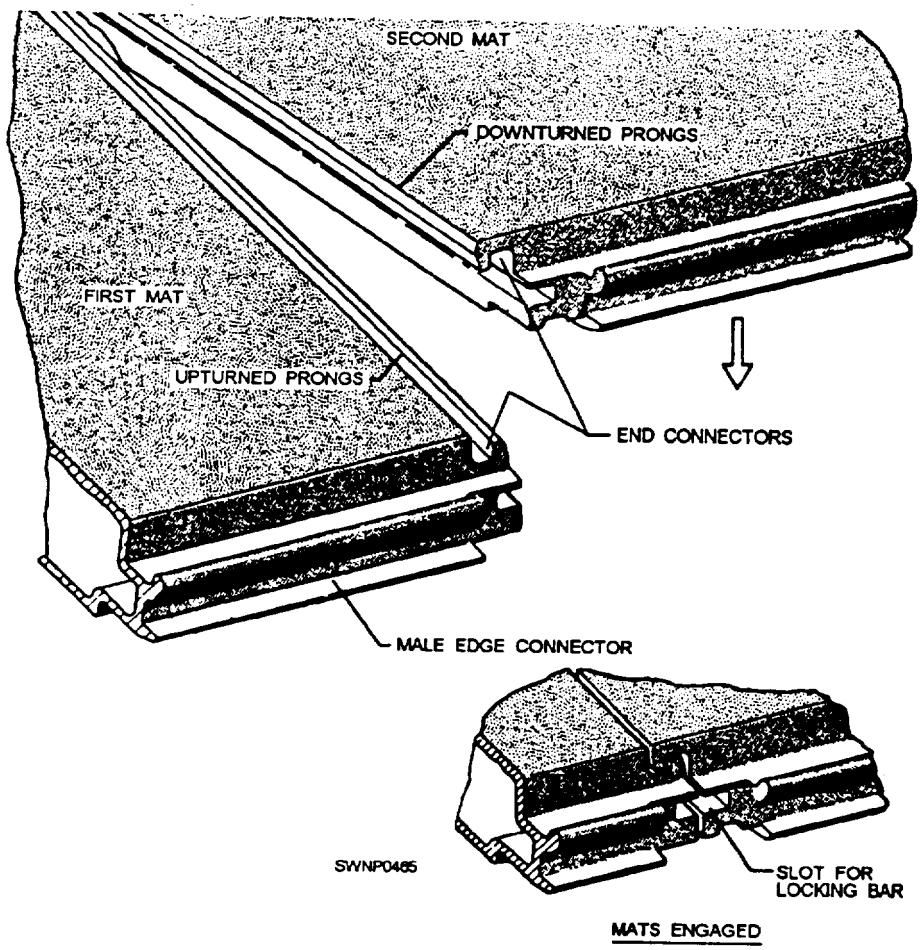


Figure 11-13.—Engagement of the first and second mats.

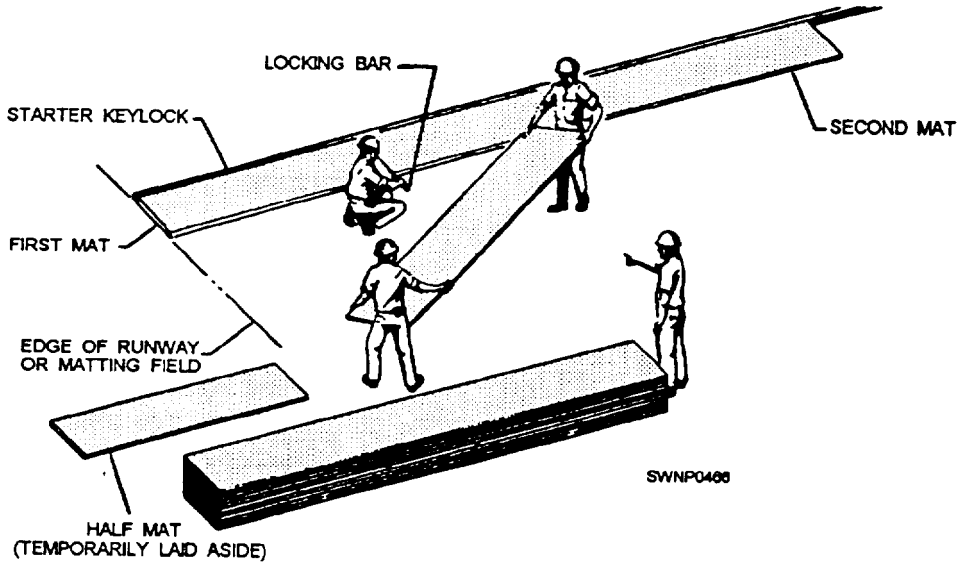


Figure 11-14.—Locking first and second mat, using locking bar.

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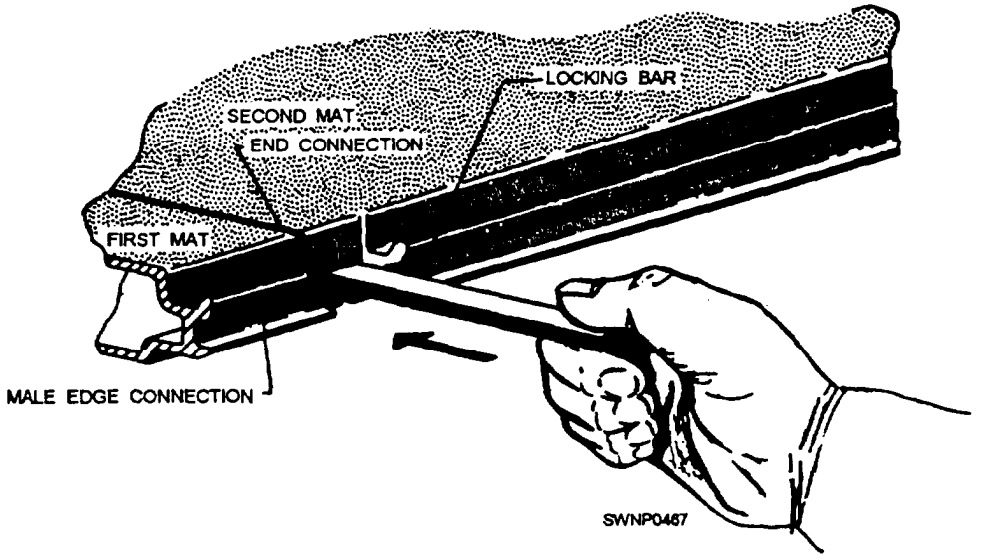


Figure 11-15.—Insertion of the locking bar.

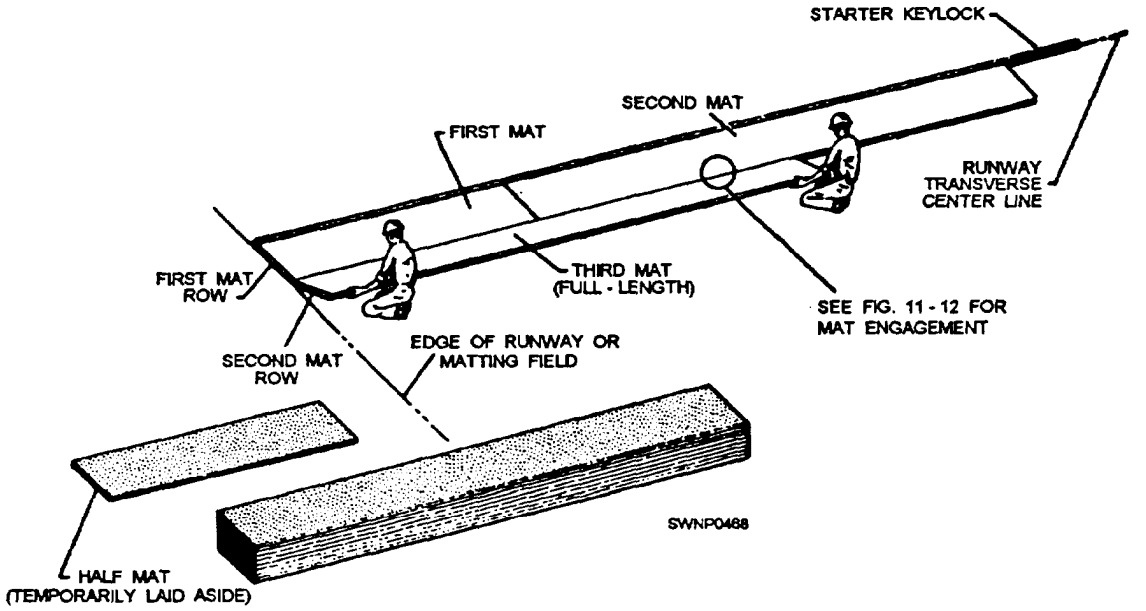


Figure 11-16.—Placing of third mat (full-length).

preceding row while being held at an angle (fig. 11-12). The mat must then be aligned so when it is rotated downward, the end connectors mate properly, as shown in figure 11-13.

NOTE: The mats are designed with an apparent 'loose fit." This is to allow for expansion and also to allow for the natural waviness inherent in the extruded mat sections. Because of this, it is possible to have a row of mats "installed" but misaligned so as to prevent the proper engagement of one or more of the mats in the following row. (Such a condition in exaggerated form, and the method of corrections, is shown is figure 11-17.) Locking bars may be used as temporary spacers between the rows to prevent this. Place a locking bar on edge where the ends of two mats join and as the row ends. After three or four rows have been laid using locking spacers, proceed with the remainder of the runway or taxiway by removing the spacers from the furthest row and using them in the row just laid.

CAUTION

If it becomes necessary to adjust matting with a sledge, always place a wooden block

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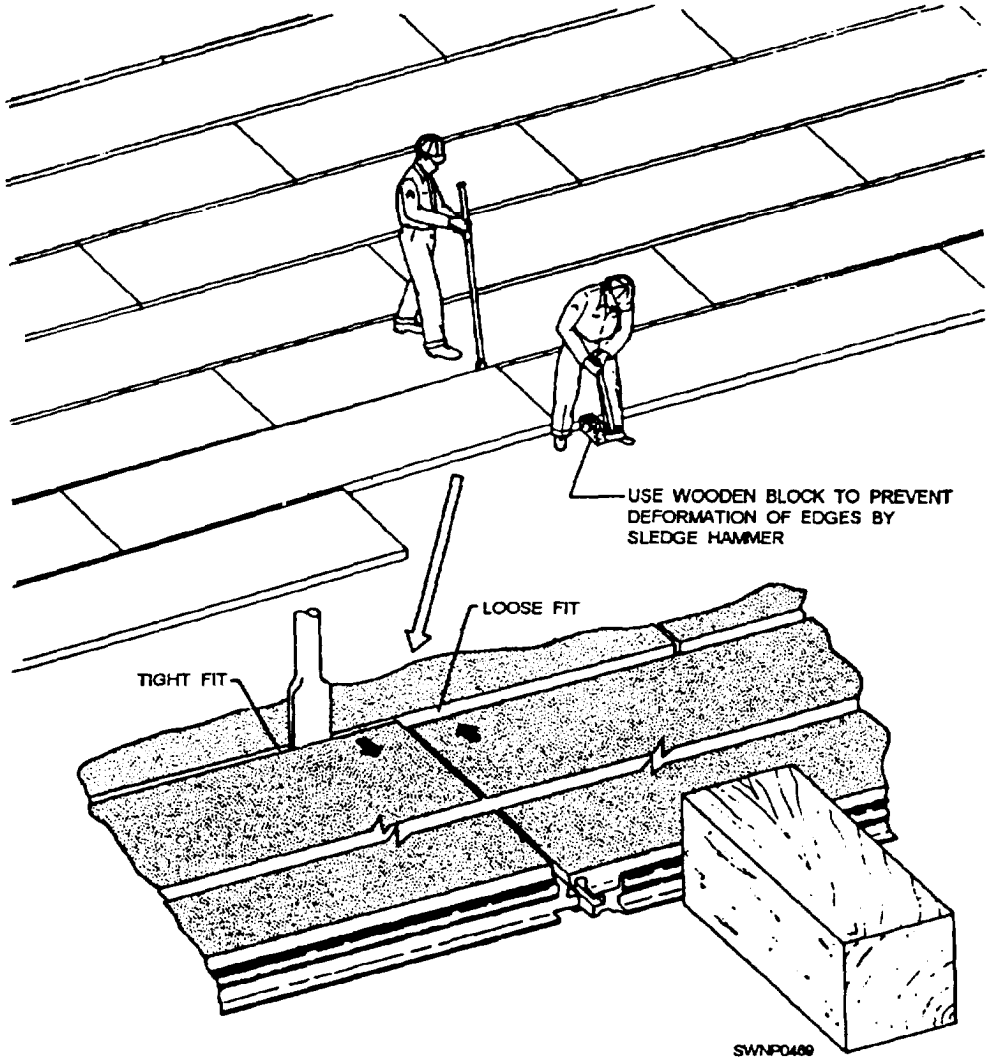


Figure 11-17.—Correction of mat misalignment.

against the mat edge before striking, as shown in figure 11-17.

10. Every 100 feet, install a row of typical keylocks in the matting field (fig. 11-6). Place a 9-foot typical keylock at the outer edge of the runway with the female end of the keylock aligned with the first mat of the preceding row (fig. 11-1 8). Engage the female edge of the typical keylock with the male edge of the mat in the preceding row (similar to fig 11-12 and step 4).

11. Place a 12-foot typical keylock next to the installed 9-foot typical keylock. Move the 12-foot section against the 9-foot section after first engaging the female edge of the keylock with the male edge of the first twoo mats in the preceding row. Raise the socket head screw in the male end of the 9-foot keylock until the threaded hole in the female end of the 12-foot keylock is aligned. Then secure the socket head screw in the 9-foot keylock, using the socket head screw wrench.

See detail "A" of figure 11-18 that shows the typical keylocks secured together. Repeat laying of six more 12-foot sections and one 3-foot section of the typical keylocks to complete the 96-foot width of the runway.

NOTE: After the laying of a row of typical keylocks every 100 feet, continue laying AM-2 matting, according to steps 4 through 9, to the ends of the runway.

Runway APPROACH APRONS are required at each end of the main runway. These aprons are ramps made of mats placed to prevent the tail hook of a low

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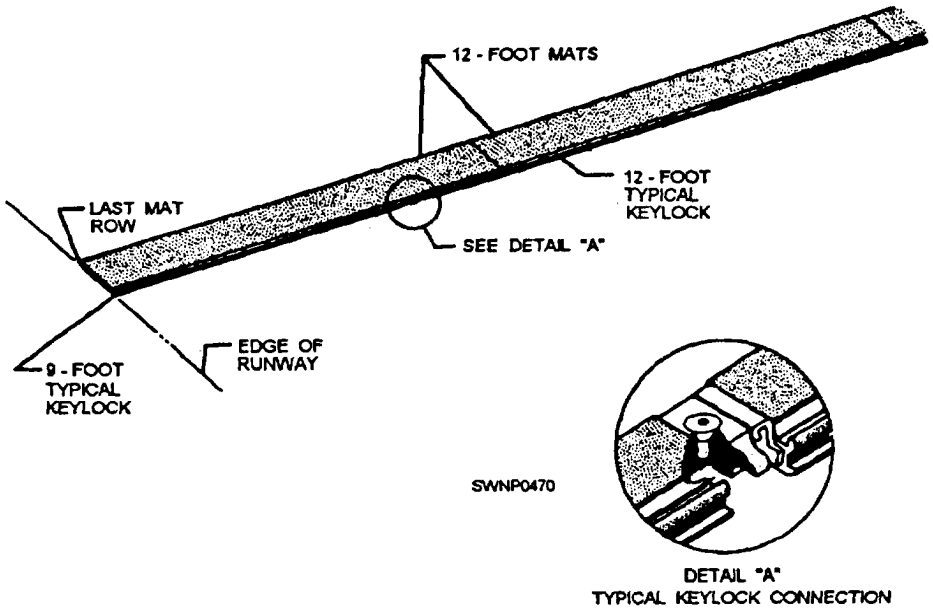


Figure 11-18.–Placing typical keylocks in a matting field.

incoming aircraft from engaging or hooking onto the edge of the runway. (See fig. 11-19.)

The aprons are constructed in a brickwork type of pattern but may be entirely of half-length mat units and extend across the full width of the runway. The free end of the apron should fall a distance of 18 to 24 inches below the normal ground level. The ground surface beneath each mat should be shaped to provide full contact across the bottom of the mat. After installation of the ramp, the excavation should be backfilled (ramp covered to the normal ground level). The backfill should be tamped and compacted.

Installation of the ramp at the starting end of the runway can be readily accomplished although the installation procedure is slightly different. Place the side connector under the overhanging lip of the first row of mats and lift until contact is made. The mat is then rotated downward while keeping the two mats in contact. Locking bars are installed as described previously.

MAT END RAMPS are used at the ends of the runways, laid on a hard surface (concrete), to smooth the passage from one surface to the other. The edge connection between the ramp and mat sections is the same as between two rows of matting. The ramp is fabricated from aluminum extrusions and is provided with welded inserts and extension plates, drilled and tapped to allow the ramp sections to be joined and anchored. (See fig. 11-20,)

When installing mat end ramps, you should use the following procedure:

1. Install the first ramp at the right-hand corner, looking toward the opposite end of the runway. Place the next ramp adjacent to it, ensuring that holes in the overlapping plate on the ramp line up with threaded inserts on the matting ramp. Insert five flathead screws in each ramp, using the Allen wrench provided in the toolbox. Apply antiseize compound to the screw threads.

2. Next, use the locking baron the edge between the ramps and edges of the mats to assure the alignment is straight.

3. As the ramps are placed and screwed together, drill holes in the concrete for lag screw shields, using the holes in each ramp as a template. Drill holes to 5/8-inch diameter and 3 inches deep with the drill bit from the toolbox. Insert an expansion shield in each hole drilled in the concrete. Insert a lag bolt and washer in each counterbored hole. Tighten the lag bolts with the offset, square box-end wrench provided in the toolbox.

4. Complete the end ramp installation, as shown in figure 11-21.

Mat-Laying Procedure with a Guide Rail

The sequence for installing AM-2 mats and related components where a guide rail for a catapult system is required is shown in figure 11-22. The guide rail divides the runway into an 18-foot and a 78-foot

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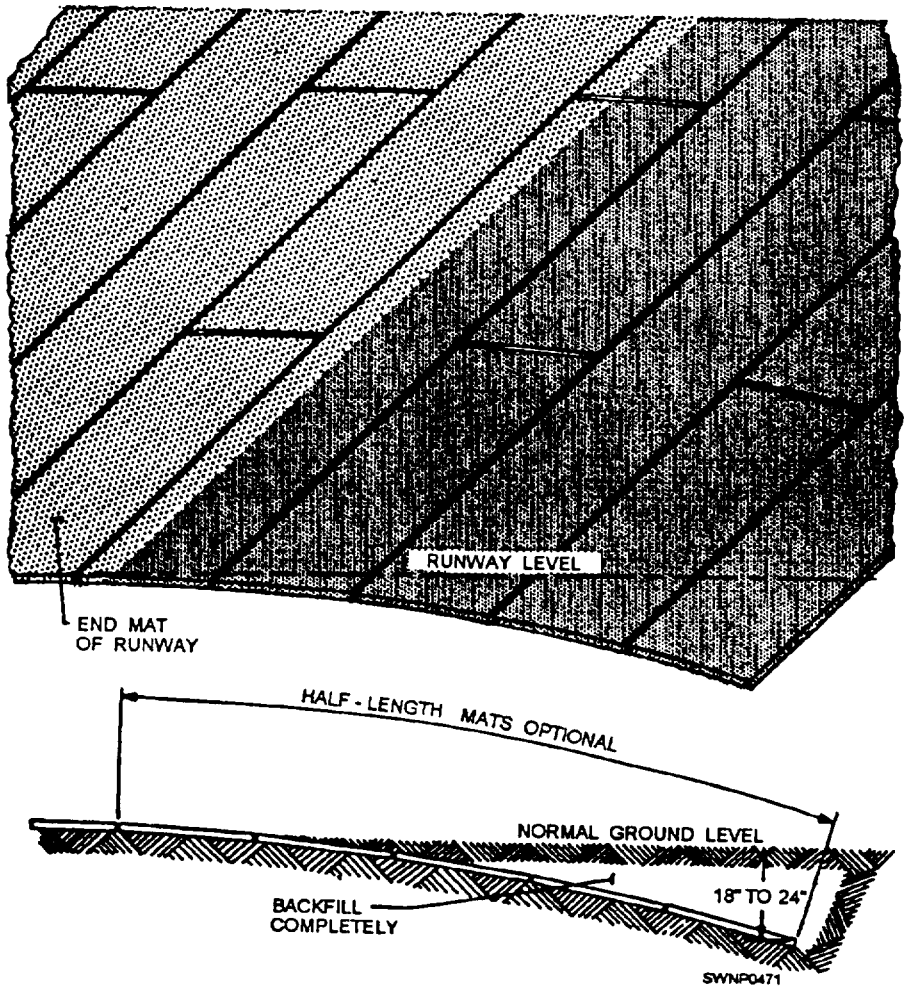


Figure 11-19.—Laying of runway approach apron

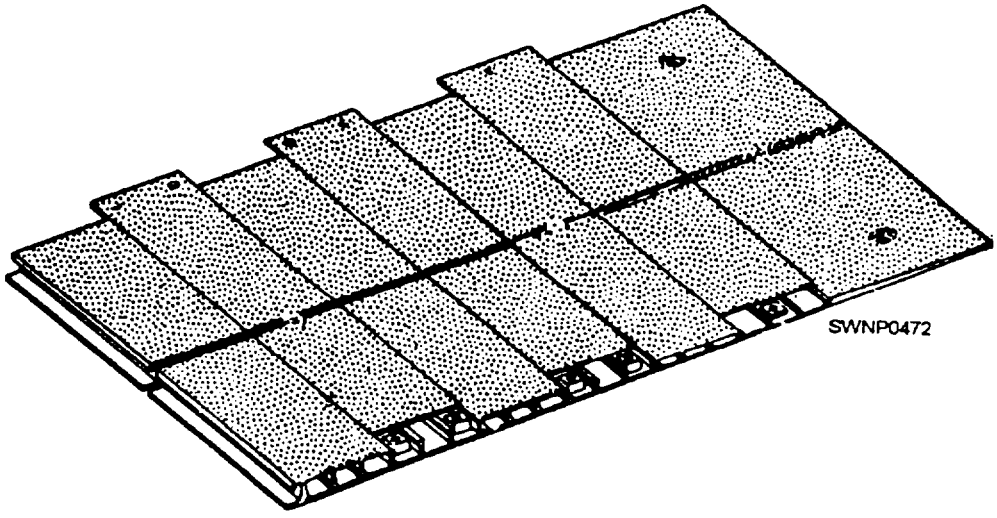


Figure 11-20.—Mat end ramp.

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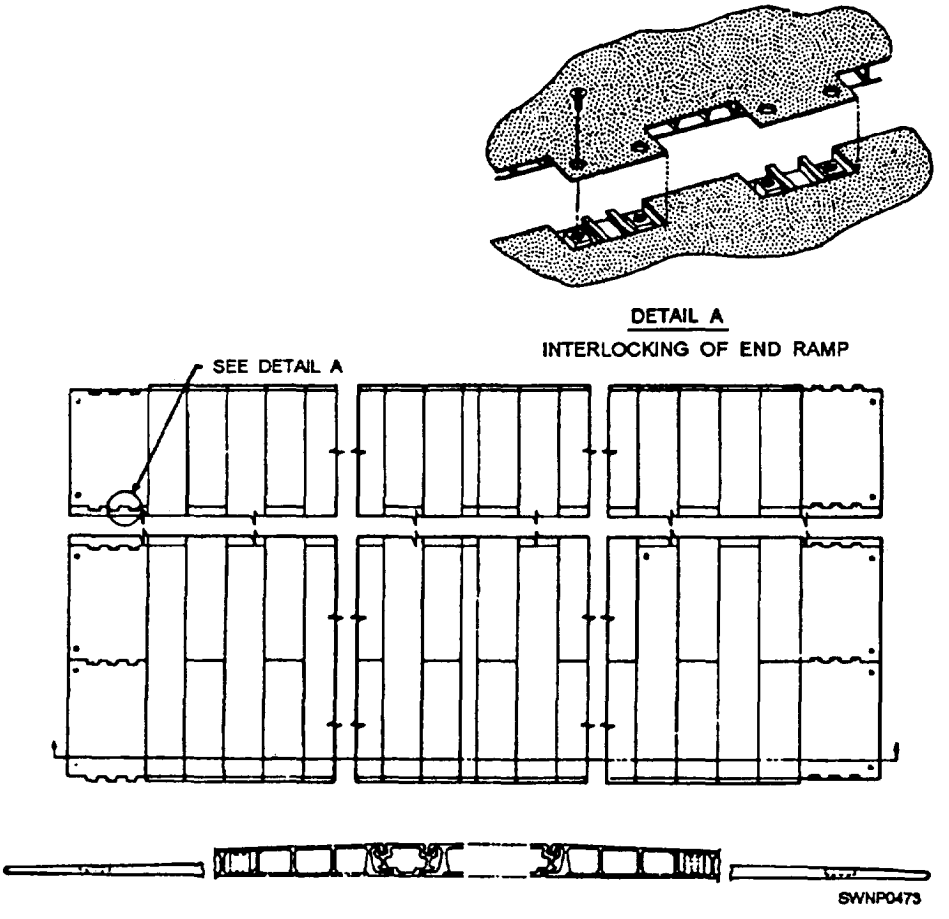


Figure 11-21.—Placememt of mat end ramps.

section. The laying of matting should proceed in one direction only, from one end of the runway. Laying of the guide rail, mats, and related components is as follows:

NOTE: The instructions presented here are for a 96-foot runway, but they are also applicable for a 48-foot runway.

1. Establish the guide rail center line, using a transit.

2. Install the first guide rail with dowel pins facing aft (opposite the direction of laying the guide rails). The first guide rail should be 9 feet in length, NAEC (Naval Air Engineering Center) Part No. 6125354, to prevent alignment of the guide rail joint with the mat joint.

3. Install the next four guide rails (10-foot rail) using spacer seals, NAEC Part No. 414233-1, and gap gauges, NAEC Part No. 414219-1, between the guide rail joints before driving the dowel pins. Check for proper position of the pins in the guide rails, using a pin gauge, NAEC Part No. 414212-1.

NOTE: As the guide rails and mats are being laid, any visible depressions in the grade should be filled in and raked with the applicable hand tools.

4. Insert the transit target, NAEC Part No. 414691-1, in the center slot of the guide rail and preliminary alignment of each rail.

5. Lay the 18-foot section of AM-2 matting, as shown in figure 11-22. Insert the mat-locking bars between the guide rail and the mat. (See fig. 11-23.)

6. Insert the transit target, NAEC Part No. 414691-1, in the center slot of the guide rail and make the final alignment by shifting the five guide rails and attached mats. The guide rails and mats maybe shifted by pounding the edge of the guide rail or mat with a wooden block and a mallet. The guide rail center line should not vary more than 1/4 inch in 50 feet in the horizontal direction nor more than 1/8 inch in 12 feet in the vertical direction as determined by a 12-foot straightedge. The straightedge should be moved in 6-foot increments.

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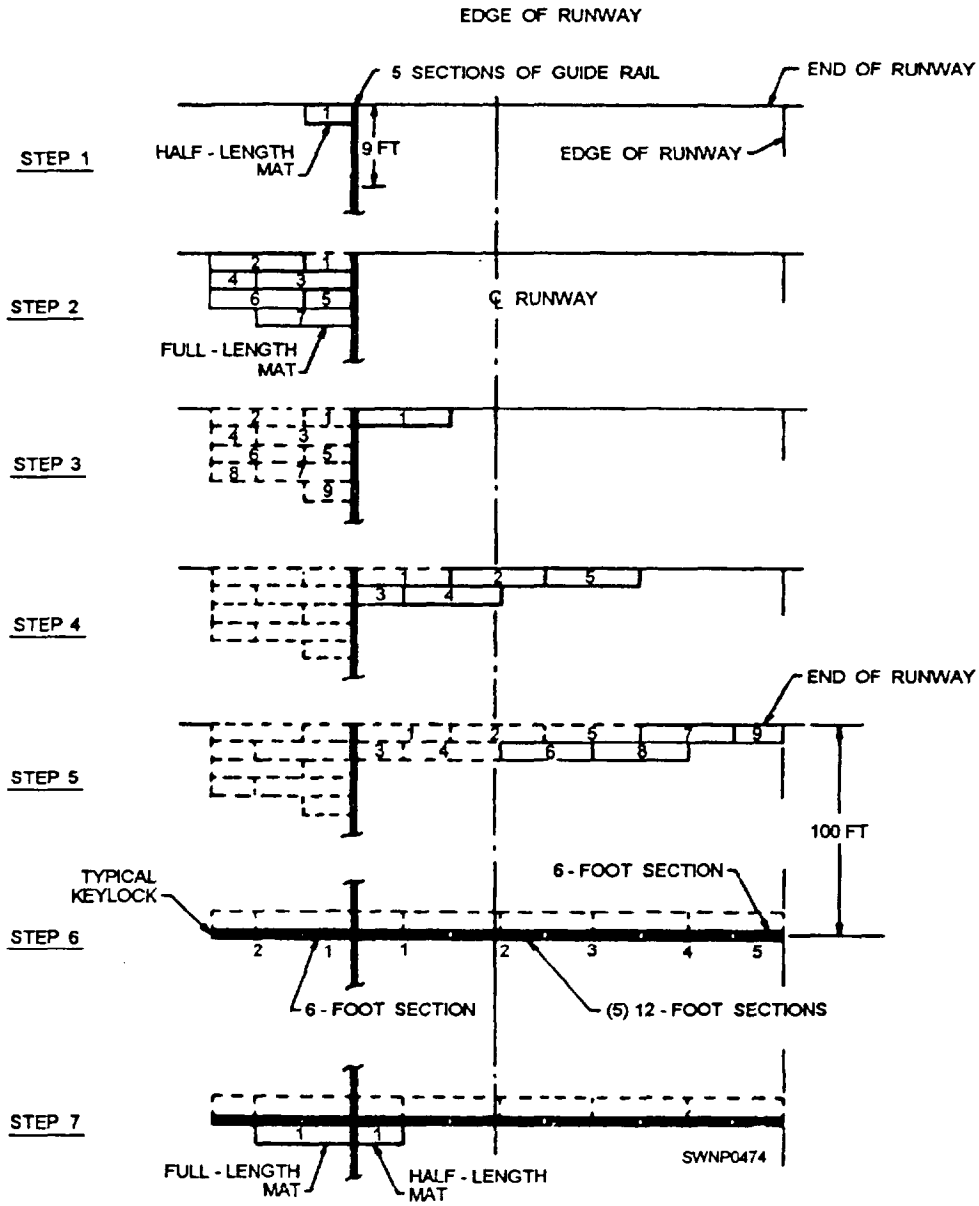


Figure 11-22.—AM-2 mat installation sequence (with guide rails—96-foot-wide runway).

7. Begin laying the 78-foot side of matting for the length of the guide rail and matting as aligned in step 6. Transverse mat joints should not vary more than 3 inches between the 18-foot and 78-foot-wide section of the runway where joints meet the guide rail and the mat. Installation of the 78-foot side may lag behind the guide rail and the 18-foot side but should never be installed beside the guide rails that have not yet been aligned according to step 6.

8. Install the next five guide rails. Guide rail joints should never be closer than 3 inches in reference to the transverse mat joints. (See fig. 11-23.) To ensure the 3-inch distance between the mat and guide rail joints, substitute a 9-foot length of guide rail for a 10-foot guide rail. Lay matting on the 18-foot side and then the 78-feet side. (See steps 5,6, and 7.) Continue installing the runway until 100 feet of the matting has been laid.

NOTE: A minimum of ten gap gauges should remain installed to the rear of the guide rail dowel pins being installed.

9. Every 100 feet, install typical keylocks across the runway. Typical keylocks cannot be secured to the guide rail. Cut keylocks in 6-foot sections, as necessary, to ease installation on the 18-foot and the 78-foot sides of the guide rail. Refer to the section discussed previous] yin this chapter on “Mat-Laying Procedures

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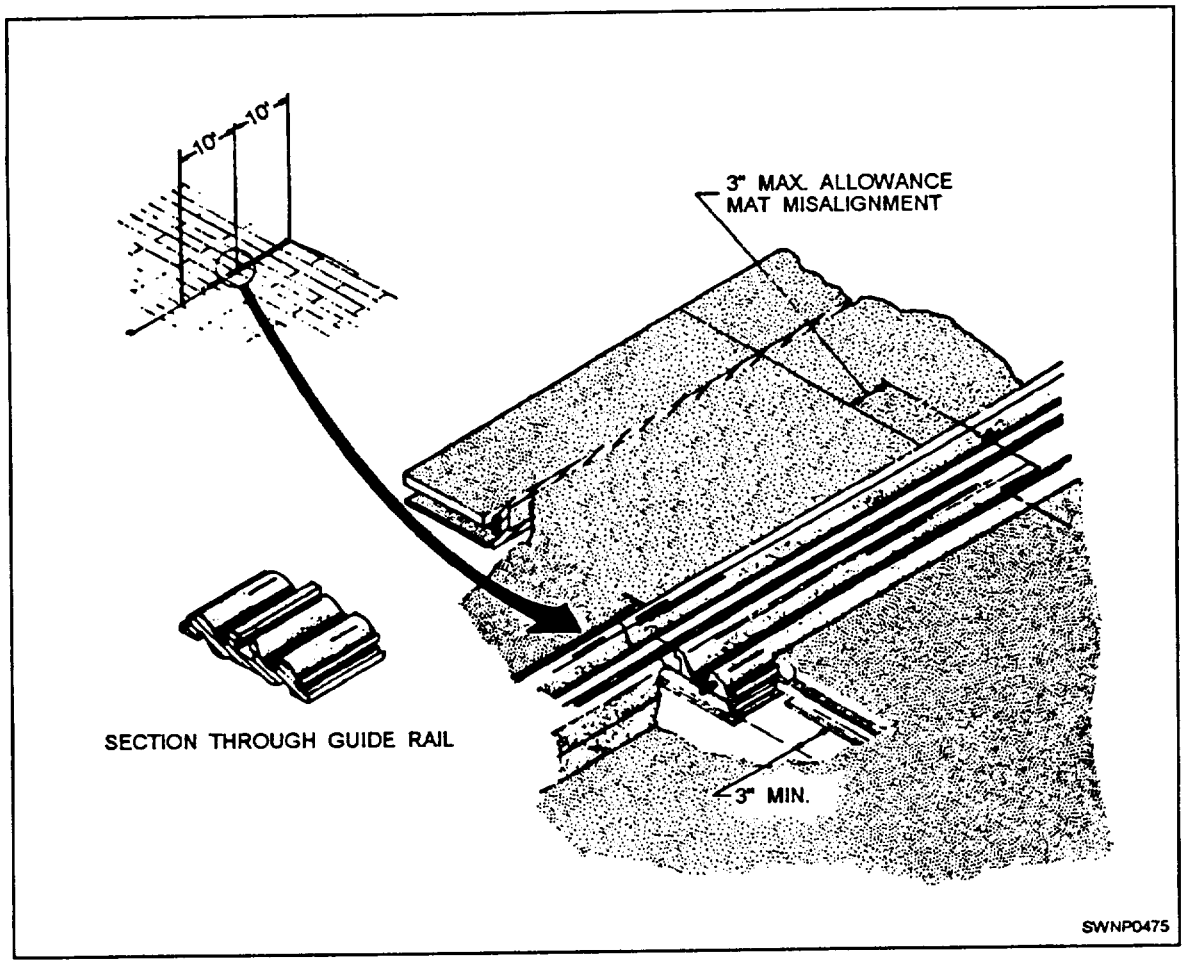


Figure 11-23.—Laying of guide rails and mats.

without a Guide Rail," steps 10 and 11, for typical installation of keylocks in the field

10. Install approach aprons at both ends of the runway. Use 90-degree connectors to join the approach aprons to the field matting. (See fig. 11-24.) Connectors are 12-foot-long aluminum "H" sections that allow relative movement and slight misalignment between the adjoining sections of matting.

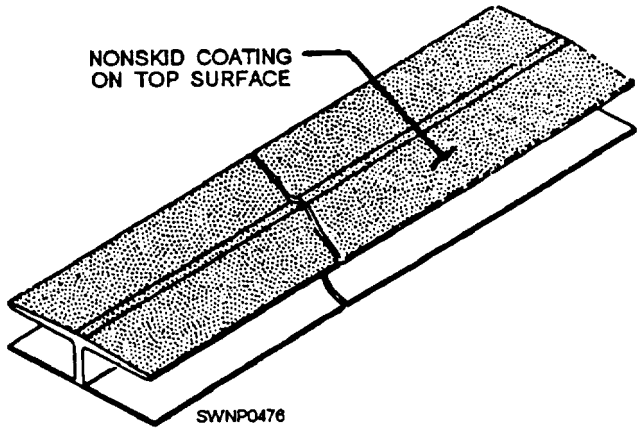


Figure 11-24 .—90-degree connector.

Field-Laying Procedure

The sequence for laying an entire field is as follows:

1. The main runway
2. The lateral taxiways
3. The taxiway that is parallel to the runway
4. The parking stands and storage areas

The above sequence may be modified in the interest of gaining time in the overall installation by laying the main runway and the parallel runway at the same time. Then the lateral taxiways and parking area can be installed.

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CAUTION

If the latter procedure is to be used the distance between the runway and its parallel taxiway must be carefully controlled Since the mat width is 2 feet, a gap of almost 1 foot could occur at each end of the interconnecting lateral taxiway. The gap between the lateral taxi way and the long taxiway and runway should not exceed 2 inches.

RUNWAY-TAXIWAY CONNECTIONS.— Install W-degree connectors on the edge of the runway at the point where the lateral taxiways will connect with the runway. The 90-degree connectors may be used at other points where two mat-laying patterns, at 90 degrees to each other, are to be joined.

NOTE: The 90-degree connectors can be used to connect the end of the lateral taxiway with the long taxiway also.

The two procedures for installing 90-degree connectors are as follows:

PROCEDURE NUMBER 1. Where the adjoining pattern has not been laid, install a sufficient number of 90-degree connectors along the 2-foot edge of matting, such as the edge of the runway, equal to the width of the taxi way or other section to be joined. Lay a half-length mat into the first 90-degree connector, so the end of the mat matches the end of the connector. Engage the prongs of a full-length mat into the prongs of the half-length mat previously laid and push into engagement with the 90-degree connector. Continue to lay mats in the above manner until the first row is completed to the length of the 90-degree connectors. Additional mats may then be laid in the usual manner. (See fig. 11-25.)

PROCEDURE NUMBER 2. Where the adjoining mat pattern has already been laid, adjust the last few rows of matting (of the taxiway), so the space

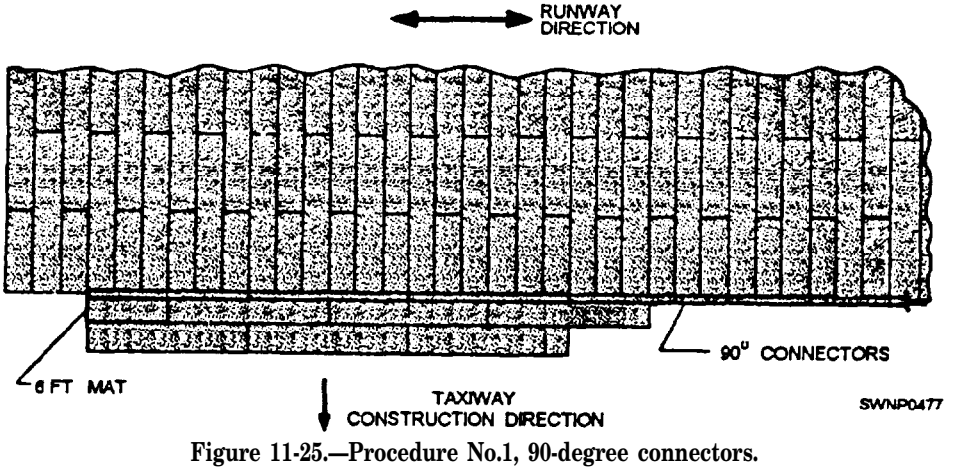


Figure 11-25.—Procedure No.1, 90-degree connectors.

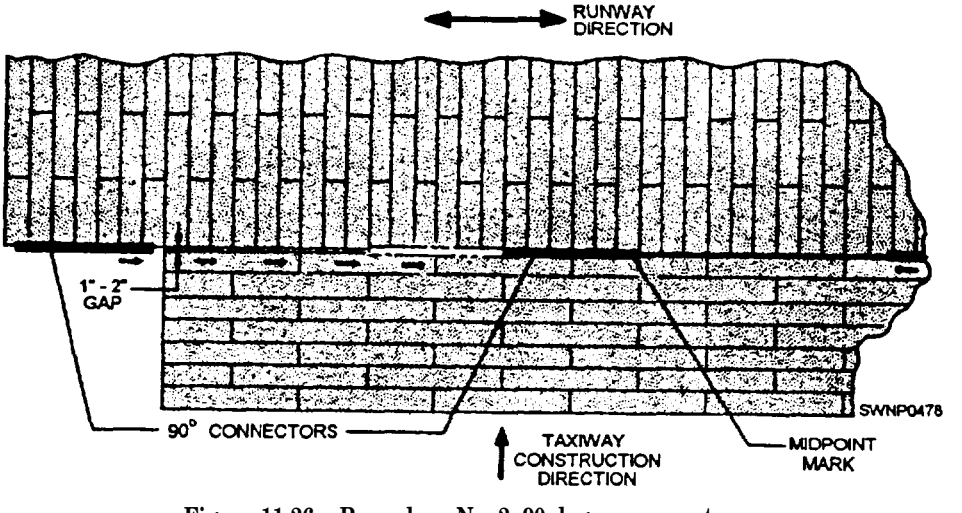


Figure 11-26.—Procedure No. 2, 90-degree connectors.

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between the runway and the taxiway is between 1 and 2 inches. Place a 90-degree connector in position, as shown in figure 11-26. Using a sledge hammer and a wooden block, drive it into position. The most efficient method is to drive the 90-degree connectors from either edge toward the center of the taxiway. Place a mark at or near the midpoint of the 12-foot length of the mat. Drive the first connector to this mark. The positions of the remaining 90-degree connectors are then automatically established. Care must be maintained while driving the connectors not to allow debris to be scooped up by the forward edges of the connectors.

INSTALLATION OF TIE-DOWNS.— The-downs are provided for aircraft anchorage. (See fig. 11-27.) They are shipped in a package or container, as shown in figure 11-28. An individual container contains 120 tie-downs, plus the screws, drilling, and tapping equipment necessary to install the tie-downs.

When tie-downs are to be installed, start by drilling and tapping the AM-2 matting on the prongs-down connector. Drill two holes for each tie-down ring retainer, using tools from the tie-down container. The procedure for drilling is as follows:

1. Secure the sleeve, 412131-1, to the 5/16-inch drill with the setscrew, using the drill fixture, 509044-1, as shown in operation 1, figure 11-29. Orient the sleeve to ensure seating of the setscrew on the body diameter of the drill.

2. Position the drill fixture, as shown in operation 2 (fig. 11-29), and drill one hole, as shown. Proper depth is obtained when the sleeve contacts the bushing.

3. Insert the pilot, 4121301, through the drill bushing into the drilled hole, and drill the second hole, as shown in operation 3 (fig. 11-29).

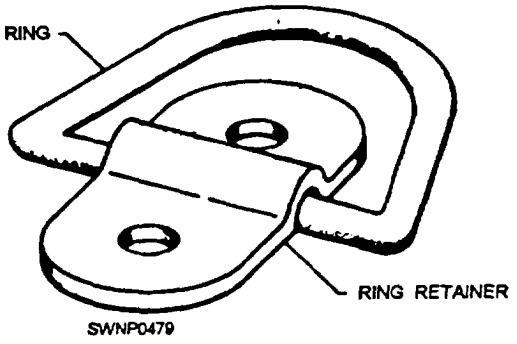


Figure 11-27.—Tiedowu

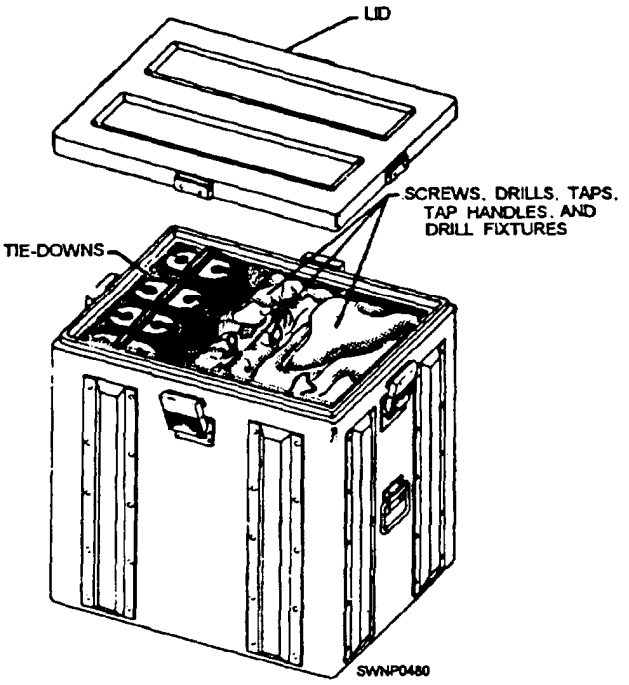


Figure 11-28.—Tie-down container.

4. Tap two holes 3/8 inch, 16 threads per inch, unified national coarse class 3B fit. Finish with the bottom tap to obtain 9/16-inch minimum full-thread length.

5. Store the sleeve and the pilot in the holes provided and secure with setscrews.

After the drilling is completed, secure the ring retainer with two socket head screws.

PARKING AND STORAGE AREAS.— The parking and storage areas should be installed next. Mats and locking bars are installed in the same manner as the runway and taxi ways, except that the staggered joint pattern is not mandatory. This means that the area can be built up in any random pattern and that all leftover half-length or full-length mats can be used. The 90-degree connectors should be installed between these parking and storage areas and taxiways according to the procedure outlined earlier. Install tie-downs on the matting in these areas, as shown in figure 11-30.

BLAST DEFLECTOR INSTALLATION.— To shield the ground area around taxiways and parking areas from the blast effects from aircraft, install blast deflectors as required. Assemble blast deflector adapters to the boundaries of matting that will be

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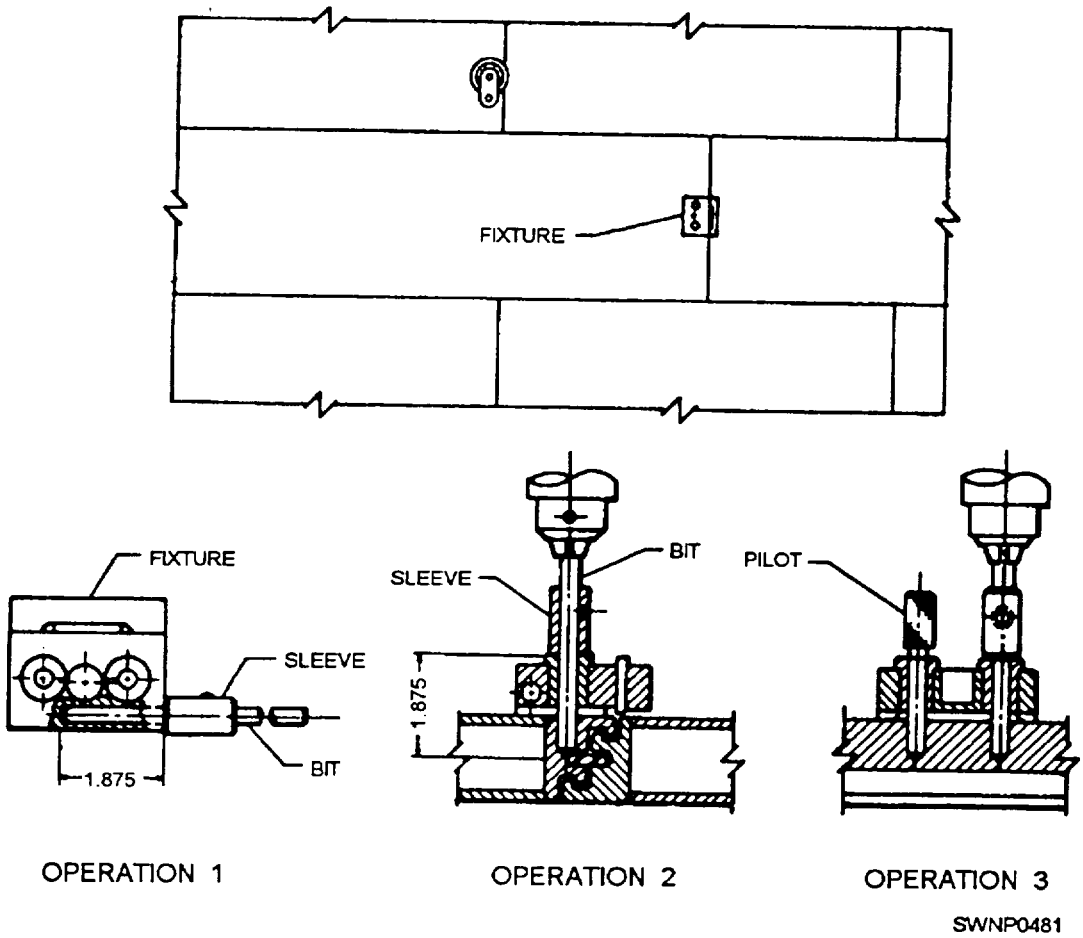


Figure 11-29.—Drilling jig for installing tiedowns

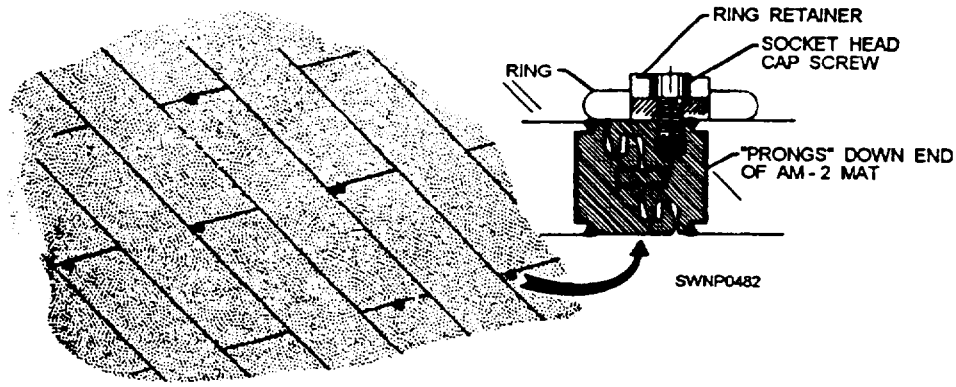


Figure 11-30.—Installing tie-downs in AM-2 matting.

either male edges, female edges, prongs-down ends, or prongs-up ends. Three types of adapters are supplied to fit anyone of the joints. Erect AM-2 mats to the exposed upturned edge of the adapters to provide the blast shield. Use the adapters to support each AM-2 mat. (See fig. 11-31.)

MATTING REPAIR

During use in the field, matting may become damaged and require repair or overhaul. Some of the repairs that may be necessary are covered here. If you are called upon to make repairs other than those

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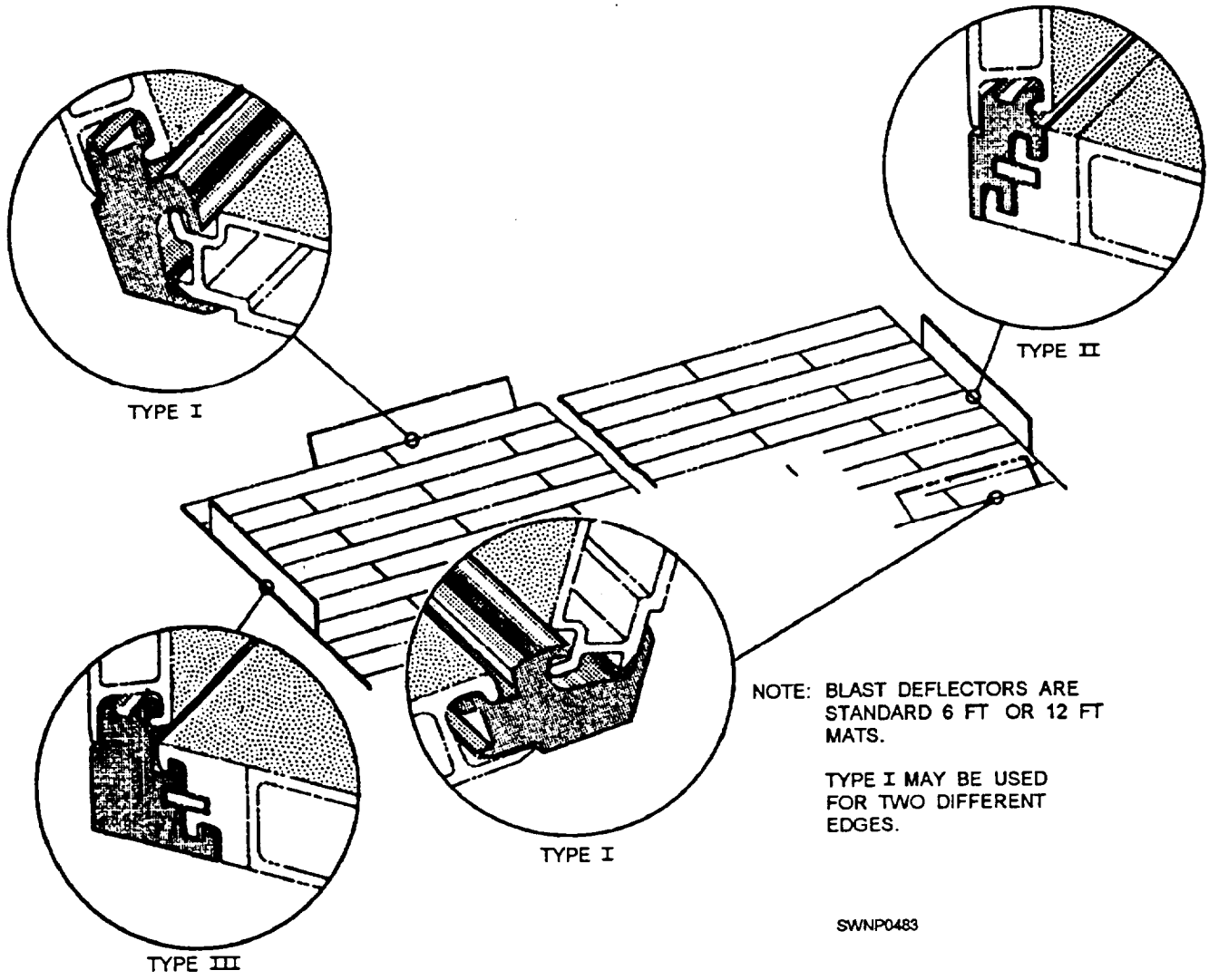


Figure 11-31.—Installation of blast deflector (adapters and mats).

covered below, consult your leading petty officer for instructions.

INDIVIDUAL MAT REPLACEMENT

If an individual mat is damaged and cannot be satisfactorily repaired, damaged AM-2 mats may be cut out of the installation and replaced with a replacement mat assembly. A replacement mat is shown in figure 11-32. Replacement mats allow the replacement of damaged mats with a replacement item that duplicates the original installation. These mats are complete with a nonskid coating. Replacement mats are prepared from AM-2 mats by cutting off the prongs-up edge and the male connector edge and welding on adapters. Additional adapters must be bolted on at the time of installation.

To replace a damaged mat with a replacement mat assembly, follow the procedure below.

1. Cut out the damaged mat so complete removal can be affected without damage to surrounding mats. this can best be accomplished using a portable circular saw, set for a 2-inch depth of cut. The cut should be made along the male edge and prongs-up connector. (See fig. 11-33.)

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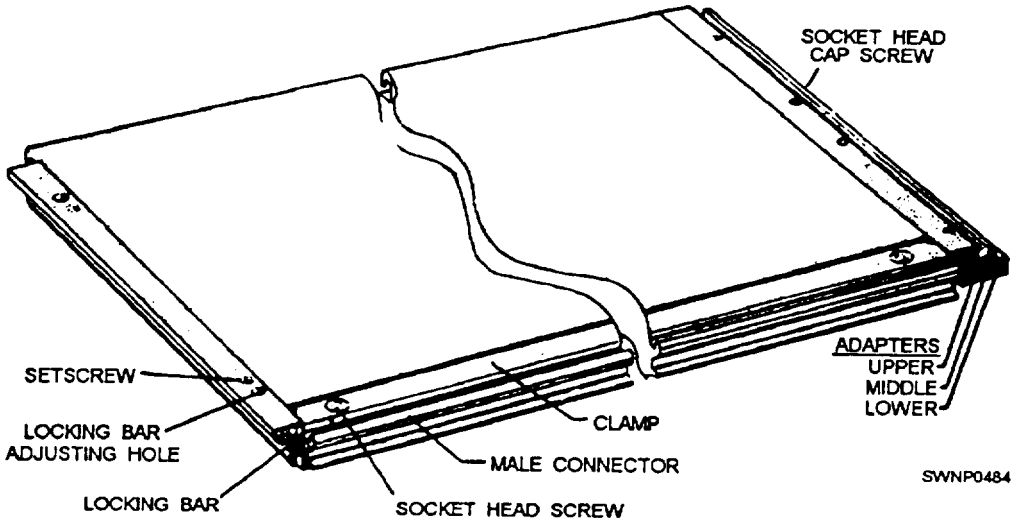


Figure 11-32.—Replacement mat

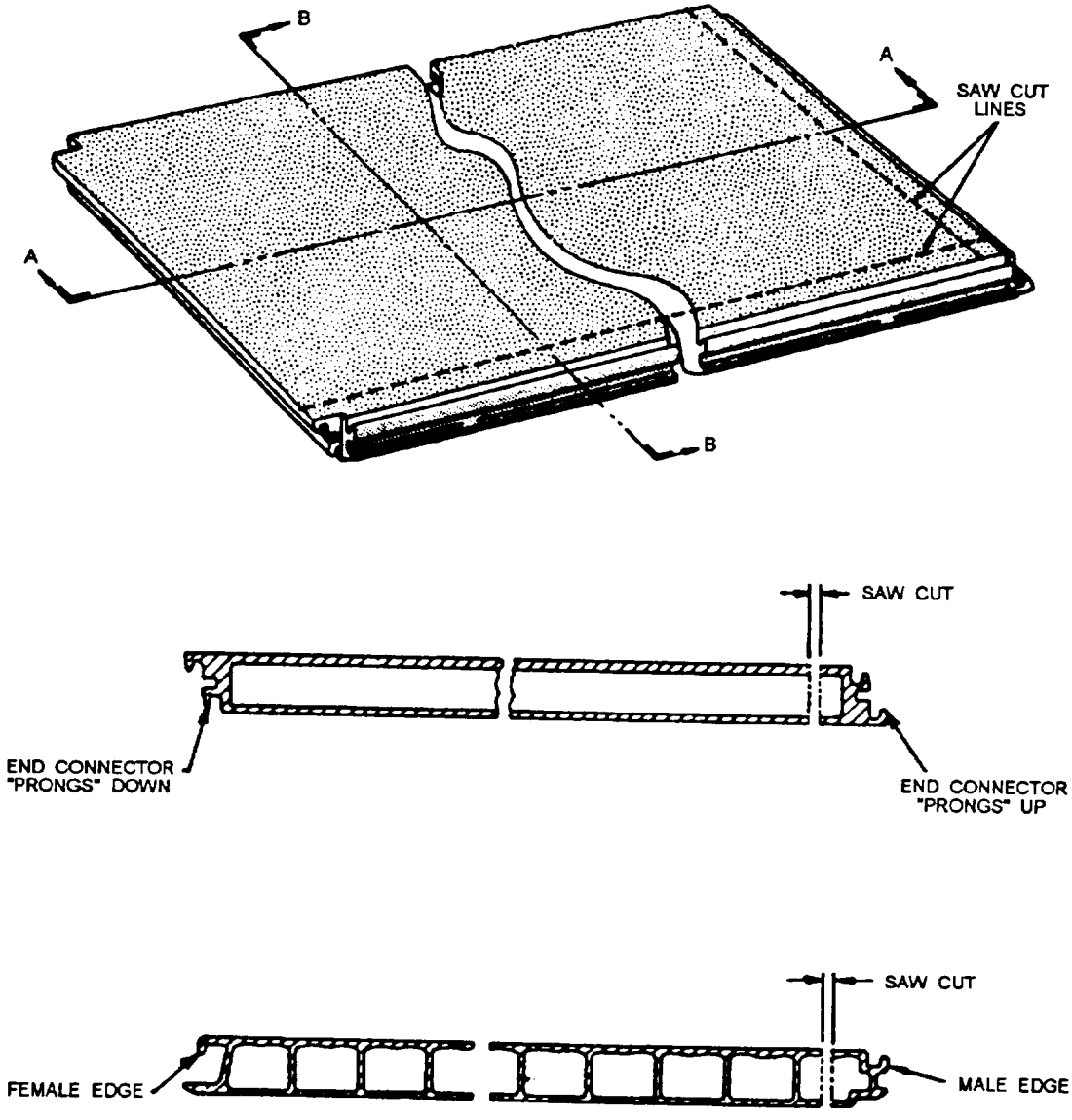


Figure 11-33.—Mat cutting for removing mat.

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2. Ensure that all recesses in the mats surrounding the repair area are clean. Use a broom or brush to remove any debris.

3. Remove the male connector and adapters from the replacement mat, using socket head screw wrenches taped to the pallet. Be careful to retain the dowel pin in the lower adapter. (See view A of fig. 11-34.)

4. Place the lower adapter prong under the lower prong of the prongs-down end of the adjacent mat A, keeping the dowel pin up. (See view A of fig. 11-34.)

5. Place the middle and upper adapters on the lower adapter, using the dowel pin as a locating device. Ensure that the locking bar tongue on the middle adapter is in the locking bar slot of mat A and the upper adapter prong mates with the upper prong of the prongs-down end of the adjacent mat A. (See view B of fig. 11-34.)

6. Place the male connector into the female connector of adjacent mats B and C. (See view C of fig. 11-34.)

7. Place the female connector edge of the replacement mat over the grooves of the male connector edges of adjacent mats E and F (fig. 11-34) in the same manner that AM-2 mats are connected. Gently lower the replacement mat into place, being careful to lift the dowel pin into the hole in the connector adapter and the male connector adapter into the groove in the male connector. (See views A and C of fig. 11-34.)

8. Align the holes between the upper, middle, and lower adapters and the connector adapter. The dowel pin will provide at least approximate alignment, although some minor shifting of the replacement mat with a pry bar maybe necessary. Insert and tighten the four socket head cap screws with the 5/16-inch box wrench provided. (See view B of fig. 11-34.)

9. Place a clamp over the male connector. Alignment of holes can be accomplished by sliding the clamp in the adapter grooves. Insert and tighten the ten socket head screws with the 5/16-inch wrench. (See view C of fig. 11-34.)

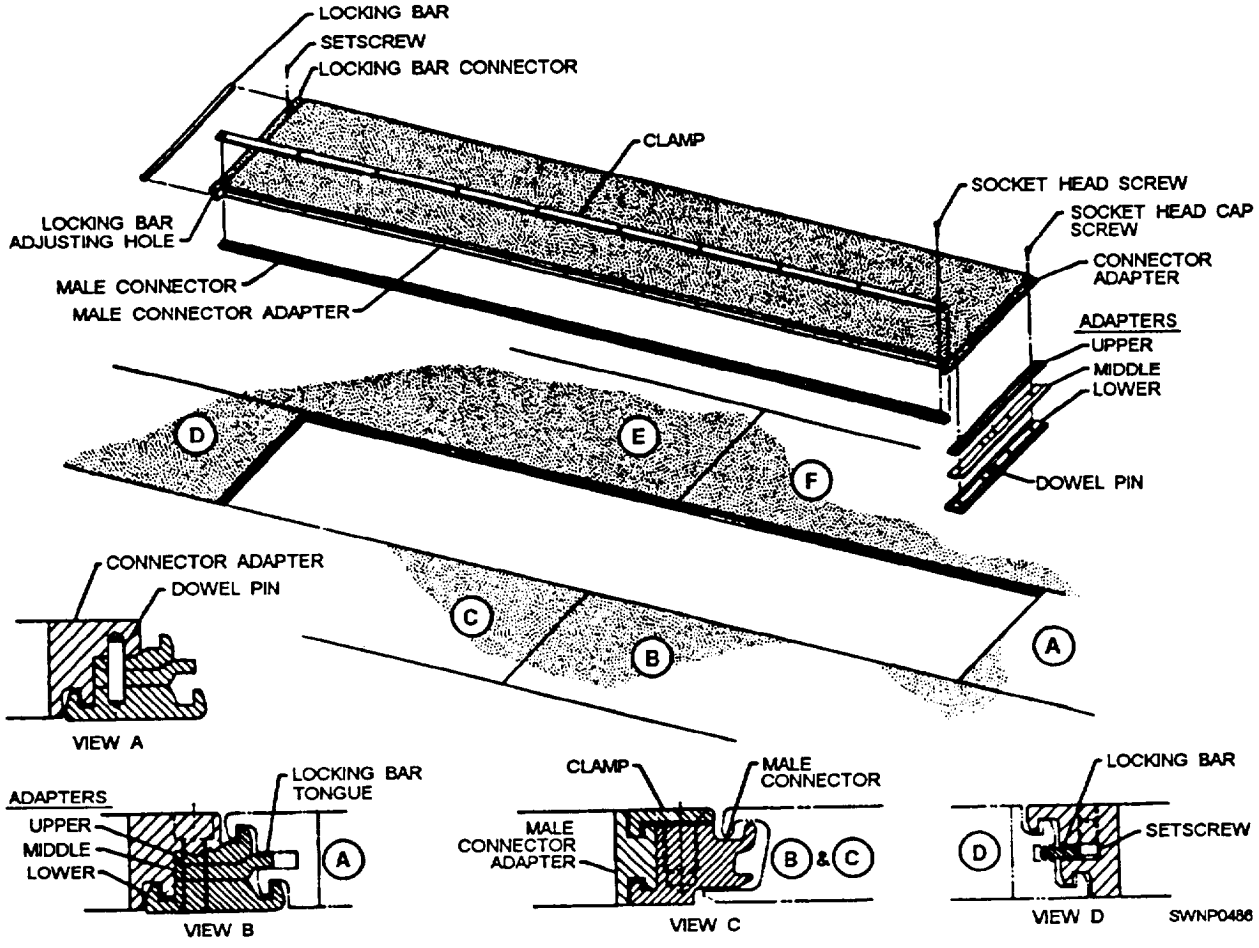


Figure 11-34.—Replacement mat installation.

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10. Using the 5/32-inch socket head screw wrench, loosen the two setscrews retaining the locking bar. Insert a screwdriver or similar instrument in the holes next to the setscrews, and force the locking bar toward mat D as far as possible. This will lock the replacement mat and clear the setscrew holes. Bottom the setscrews so that the locking bar remains in plain. (See view D of fig. 1 1-34.)

SECTION OF RUNWAY REPLACEMENT

A section of runway replacement maybe required when groups of mats are damaged beyond repair or when excessive mat deflection and roughness, due to cavities under the mats, must be corrected.

The procedure for replacing a section of runway is essentially the same with or without a guide rail installation. However, with a guide rail installed, removal of typical keylock sections will proceed from the outer edge of the runway regardless of which side of the guide rail the repair is to take place. Without a guide rail and when starter keylocks are used, typical keylocks must be removed from the right-hand edge of the runway (or taxi way) when facing the end of the runway from the transverse center line. This edge of the runway exposes the female end of the keylock into which the special removal tool must be inserted.

The replacement of a section of the runway is accomplished in the following manner:

1. Remove the first typical keylock action by loosening the socket head screw at the first inboard connection. This screw only needs to be loosened until it is free of the male end of the adjoining keylock (about 7/1 6 inch). The screw should not be removed further since it is designed to be self-retaining and reassembly can be affected from this position.

2. Insert the prong of the removal tool under the turned down lip of the female connector and slide the keylock from its position, as shown in figure 11-35.

NOTE: The initial 3-foot or 6-foot keylock section will have to be pried out since the exposed end is merely an unfinished cross-sectional cut and will not accept the removal tool.

3. Loosen the next and subsequent connectors, as described previously, and remove the remaining keylock sections. If mat distortion is minimal, you may be able to remove more than one keylock section at a time.

4. Use blocking and pry bars to lift the first row of mats high enough to allow the locking bars to clear. Each mat has one pry bar. All pry bars should be operated at the same time for the full width of the runway (or taxi way) to prevent warping of the mats. The mats will readily hinge at the first longitudinal mat joint.

NOTE: If a guide rail has been installed, the adjacent mat maybe cut parallel to the guide rail. 'This cut must be made so it severs the locking bar to allow the locking bar and the end connector to be removed from the guide rail.

5. With the row of mats raised, insert a bent rod or wire in the locking bar hole and remove each locking bar including the bars securing the cut piece of the guide rail. The first row of matting may then be disassembled and removed. (See fig. 11-36.)

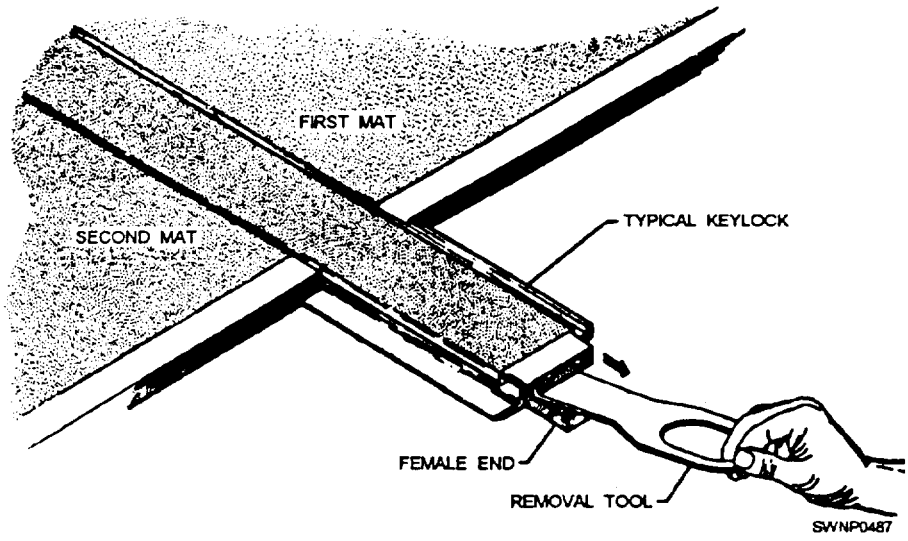


Figure 11-35.—Typical keylock removal tool.

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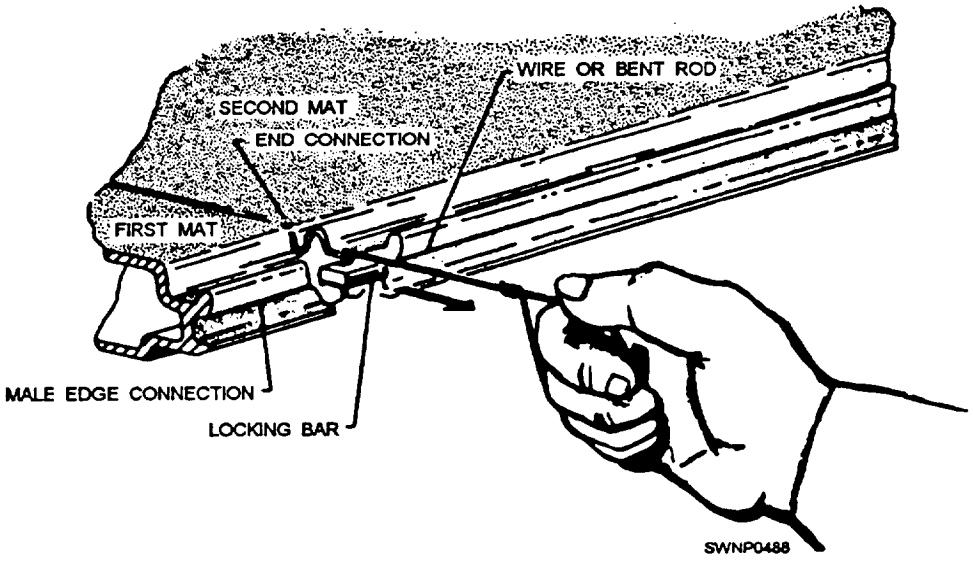


Figure 11-36.—Removal of locking bar.

6. With the clearance now provided, removal of the remainder of the matting and additional guide rail, as necessary to affect the repair, may be readily accomplished Remove the cut piece of guide rail aft of the repair area by removing locking bars and disconnecting the guide rail pins, using a pin remover, NAEC Part No. 414223-1. Slide the guide rail out of the mats.

7. Repair the ground surface, as necessary, before installing the guide rail and new or refurbished matting.

8. The installation procedure must be the same as that for the original installation. Replace the locking bars.

9. Reinstall matting over the repair area until the last row of matting is in place. At this point, this row of matting must be raised in unison with pry bars to permit installation of locking bars.

NOTE: It will not be possible to insert locking bars between the guide rail and adjacent mats for this row. Therefore, a replacement mat should be installed next to the guide rail. A locking bar is built into the replacement mat.

10. Insert the typical keylocks in the reverse order in which they were taken out. Always use wood blocking between the hammer and connector if force is necessary to drive the sections into place.

Excessive mat deflection and roughness, which can be attributed to cavities under the mats, can be repaired in the following manner:

1. Remove all mats that show excessive wear and deformation according to the instructions given earlier.

2. Fill all cavities under the mats and cover cavity areas with old matting. Areas should be reinforced with any available matting: M9M1, M9M2, AM-1, or damaged AM-2 mats. The mats in the bottom layer need not be joined together to save material and manpower. It is advisable to have the reinforcing mats touching, but it is not imperative that the mats in the bottom layer be interlocked. The mats in the bottom layer must be placed with the long dimension of the mats at right angles to the mats in the top layer. A double layer of matting should be considered in all cases where sandy areas can cause excessive mat roughness due to movement of the sand

3. Replace the top layer of matting according to the instructions given earlier.

Before proceeding, note that a heavy-duty mat, as shown in figure 11-37, has been developed

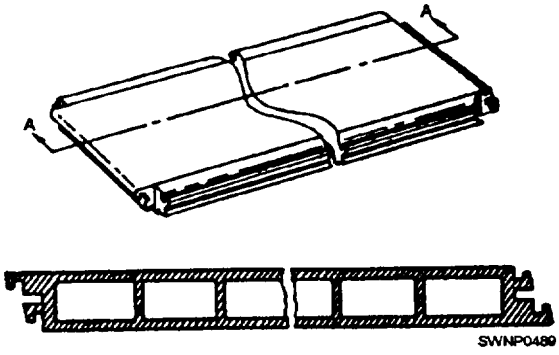


Figure 11-37.—Heavy-duty mat.

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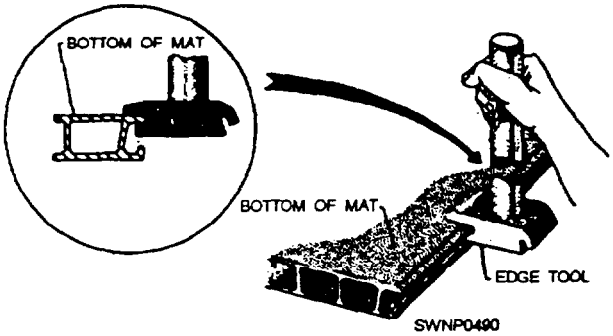


Figure 11-38.—Straightening of lower female edge.

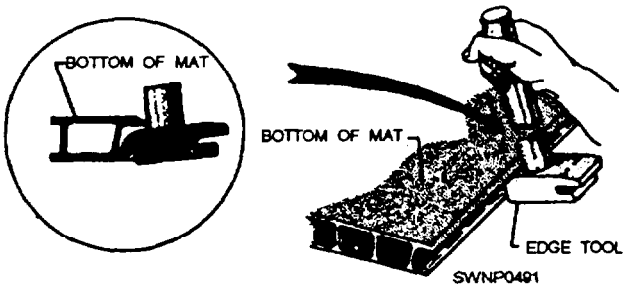


Figure 11-39.—Straightening of upper female edge.

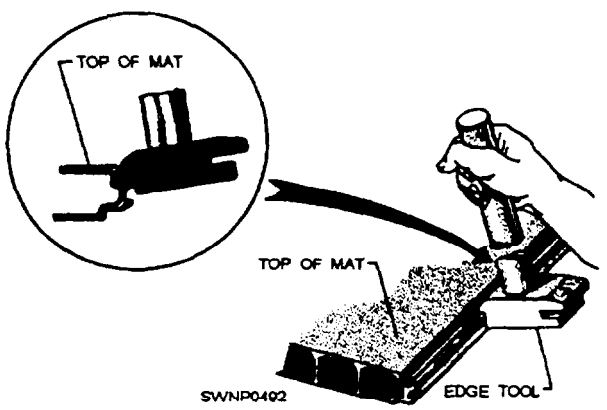


Figure 11-40.—Straightening of male edge.

Heavy-duty mats are used under arresting cables to eliminate excessive dents and other external damage that occurs to regular matting during aircraft arrestment procedures. These mats are only used on the end of the runway where aircraft touch down. Heavy-duty mats are 6 feet in length and 18 inches wide after connectors are attached. They are painted Marine Corps green, color No. 23; the top surface is also coated with a nonskid material of the same color. Locking bars used to secure heavy-duty mats together are approximately 6 feet in length.

EDGE REPAIRS

To straighten male and female integrally extruded edges of AM-2 mats, you use a mat connector repair edge tool, 510827-1. Edges that are slightly damaged during shipping and handling can be straightened with the edge tool to allow the edges to be interlocked during installation.

Figure 11-38 shows the use of the edge tool for the lower female edge of the mat, figure 11-39 shows the use of the edge tool for the upper female edge of the mat, and figure 11-40 shows the use of the edge tool for the male edge of the mat.

The procedure to follow in straightening the edges of AM-2 mats is given below.

1. To straighten the edges of a mat, place it on blocks to raise it off the ground and provide sufficient clearance to use the edge tool.

2. Orient the mat properly; that is, place the top of the mat faceup, as shown in figure 11-40, and place the bottom of the mat faceup, as shown in figures 11-38 and 11-39, as required to allow the edge tool to be used in an upright position.

3. Engage the tool with the mat edge, as shown in figures 11-38, 11-39, or 1140, at the beginning of the bent area,

4. To straighten the edge, apply a lateral form on the tool handle to bend the edge lip toward a straightened position. Be certain that the tool fully engages the mat edge lip by applying a constant force on the tool handle toward the mat.

5. Move the tool into the bent area in small increments and straighten gradually until the entire length of the bent section has been straightened Do not attempt to straighten the bent section in one pass; make several passes with minimum bending per pass until the area has been straightened

CAUTION

Care should be taken during bending to prevent cracking.

REMOVAL PROCEDURES

Disassembled pallets should be distributed in the same pattern that was used for installation of the field mats to facilitate repackaging, as the various components are removed With the use of typical keylock sections, disassembly can be done at several

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points simultaneously consistent with the available personnel and handling equipment. Speed of removal of matting will be considerable y greater if disassemble y takes place in the opposite direction of assembly; that is, the female connector is removed from the male connector.

MATTING REMOVAL WITHOUT A GUIDE RAIL

In a SATS system where a guide rail is not used, matting removal at points other than exposed ends of matting requires removal of typical keylock sections as the initial step.

The procedure for removal is composed of the following steps:

1. Remove typical keylocks by loosening the socket head screw at the first joint until it is free of the lower thread (about 7/1 6 inch). Do not remove further as this screw is self-retaining, and disassembly and future assembly are accomplished from this position. If the exposed end of the typical keylock is a cut end, that particular section must be pried out or pulled out. If the female end is exposed, the section may be removed using the special removal tool. (See fig. 11-35.)

2. The backfill must be removed from the runway approach aprons that may be accomplished as the center portions of the runway are being disassembled.

3. The 90-degree connectors are independently removable by sliding individual connectors lengthwise. However, the mat disassembly procedure should be planned so that the matting engaged on the 12-foot edge is removed first. This cccurs, for example, where the lateral taxiway matting (12-foot edge) meets the runway (fig. 11-26), then 90-degree connectors can be removed more easily than by sliding connectors lengthwise.

4. Tie-downs must be removed before parking area disassembly.

5. Disassembly of a mat row may proceed from the end with the overlapping mat. Remove the locking bar from the adjaent mat by inserting a bent rod or wire into the hole in the locking bar and pulling it straight out. (See fig. 11-35.) The most efficient procedure requires disassemble y in reverse order of assembly. Therefore, starter keylocks will be the last component removed from the runway. Remove the starter keylocks by removing the socket head screws from each adjoining starter keylock Insert the connector bar in the starter keylock just removed to the second hole (the bar will protrude 1 inch), and tighten the screw. Replace and tighten the screw in the adjacent keylock.

MATTING REMOVAL WITH A GUIDE RAIL

In a SATS system where a guide rail is used, portions of the installation, other than the runway, may be disassembled in the same manner as described previously. However, the presence of the guide rail prevents the removal of matting other than from one end. Runway aprons that do not include guide rail sections are an exception. These portions may be removed at any convenient time after the backfill has been removed. Removal of the runway matting and guide rail must start at the same end at which the runway was completed. In addition to the removal of locking bars between the mats, the locking bars connecting the mats to the guide rail must also be removed. Removal of guide rail locking bars is accomplished in the same manner as for mats. (See fig. 11-35.)

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CHAPTER 12

STEELWORKER TOOLS AND EQUIPMENT

In the shop and out on a jobsite, you will be using grinders, portable power drills, compressors, saws, and various other tools. As a Steelworker you need to be thoroughly familiar with the operation and maintenance of these tools as well as all applicable safety precautions.

BENCH AND PEDESTAL GRINDERS

The common bench and pedestal grinders are the simplest and most widely used grinding machines. The grinding work done with them is called OFFHAND GRINDING. Offhand grinding is used for work on pieces that can be held in the hands and controlled until ground to the desired shape or size. This work is done when the piece king ground does not require great precision or accuracy.

The bench grinder (fig. 12-1) is attached to a bench or table. The grinding wheels mount directly onto the motor shaft. One wheel is coarse for rough grinding, and the other is fine for finish grinding.

The pedestal grinder, inmost cases, is larger than the bench grinder and is equipped with a base and pedestal fastened to the floor. The DRY TYPE (fig. 12-2) has no arrangement for cooling the work while grinding other than a water container into which the piece can be dipped to cool it. The WET TYPE (fig. 12-3) is equipped with a built-in coolant system that keeps the wheels constantly drenched with fluid. The coolant washes away particles of loose abrasive material, as well as metal, and keeps the piece cool.

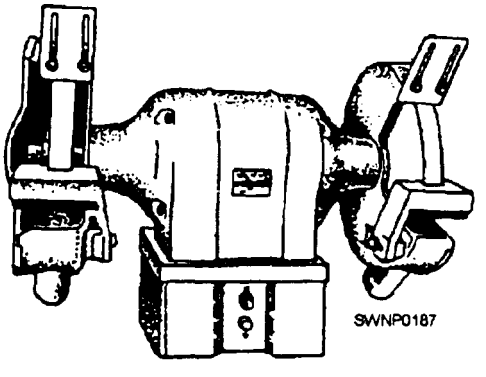


Figure 12-1.—The bencb grinder, Eye shields have not been mounted.

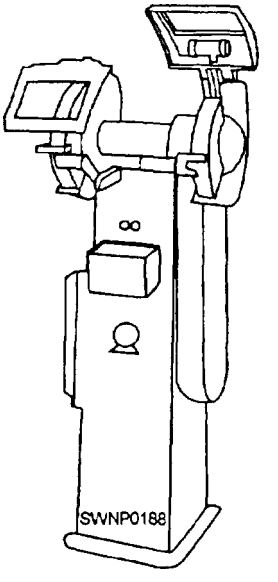


Figure 12-2.—The pedestal grinder (dry type).

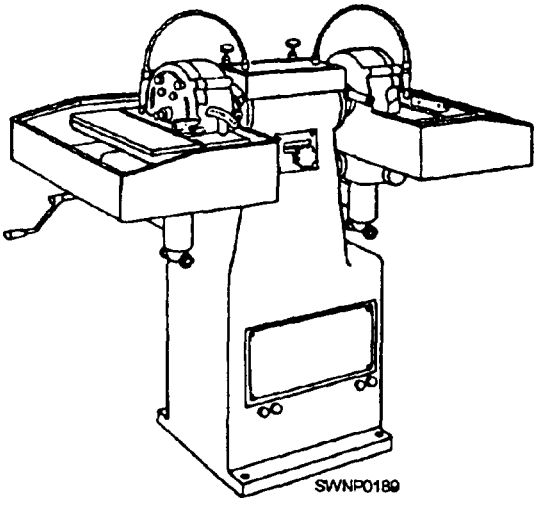


Figure 12-3.—Pedestal grinder (wet type) wttb a built-in coolant system

Bench and pedestal grinders are dangerous if they are not used correctly They must never be used unless fitted with guards and safety glass EYE SHIELDS (fig. 12-4). Even then you must wear goggles or safety glasses. A TOOL REST is furnished to support the work while grinding. It should be adjusted to come within one eighth of an inch from the wheels. This will

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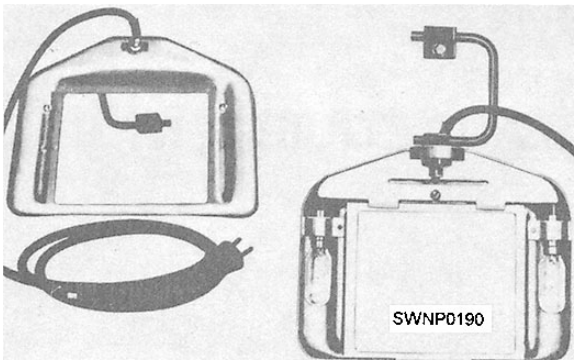


Figure 12-4.—Eye shields for bench and pedestal type of grinders.

prevent work from being wedged between the tool rest and the wheel. Turn the wheel by hand after adjusting the tool rest to ensure there is satisfactory clearance completely around the wheel (fig. 12-5).

The grinding wheels themselves can be sources of danger and should be examined frequently, based upon usage, for irregularities and soundness. You can test a new wheel by suspending it on a string or wire and tapping the side of the wheel with a light metal rod. A solid wheel will give off a distinct ringing sound, A wheel that does not give off such a sound must be assumed to be cracked and should be discarded. Under no circumstances should it be used. Since it is not practical to check the wheels by this manner every time you use the grinder, make it a habit never to stand in front of a grinder when it is first turned on. A cracked wheel can disintegrate and become projectiles quickly.

The wheel must also run true and be balanced on the shaft. A WHEEL DRESSER (fig. 12-6) should be used to bring abrasive wheels back to round and

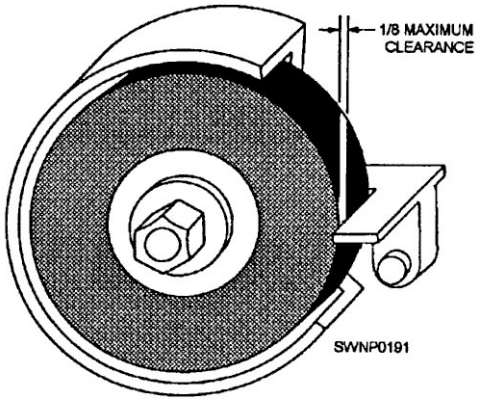


Figure 12-5.—Properly spaced tool rest.

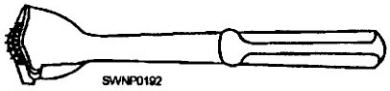


Figure 12-6.—Mechanical wheel dresser.

remove the glaze that occurs after heavy use. This is done by holding the dresser firmly against the wheel with both hands, using the tool rest for support. Then, as the wheel turns, move the dresser back and forth across the surface (fig. 12-7). For maximum efficiency and safety in operating the grinder, you should observe the following rules:

1. Use the face of the wheel, never the sides.

2. Move the work back and forth across the face of the wheel. Even wear results because this action prevents the wheel from becoming grooved.

3. Keep the wheel dressed and the tool rest properly adjusted.

Do not shape soft metals, like aluminum, brass, and copper, that tend to load (clog) the abrasive wheel. These metals should be shaped by other methods, such as tiling, sanding, and chipping.

PNEUMATIC POWER TOOLS

The portable power tools that are available for use are either powered by electric motors or by air (pneumatic) motors. Whether powered by electricity or compressed air, the tools are basically the same and the procedures for using them are the same. This section will deal with pneumatic tools since these require unique maintenance and servicing on the jobsite or in the shop.

NOTE: All low-pressure compressed air systems should have a filter, a regulator, and a lubricator assembly installed at the outlet. This assembly will ensure delivery of clean, regulated mist lubricated compressed air for the operation of pneumatic tools.

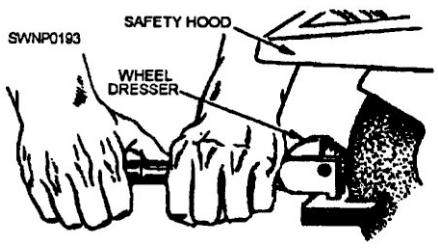


Figure 12-7.—Using a wheel dresser.

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CAUTION

Before operating a pneumatic tool, inspect the air hose and check it for leaks or damage. Blow air through the air hose to free it of foreign material before connecting it to the tool. Keep the air hose clean and free from lubricants. Never point the air hose at another person.

Pneumatic tools must have complete lubrication. The moving parts of pneumatic tools are fitted very closely, and they must be lubricated correctly or they will wear quickly and fail to work.

Valves and pistons on pneumatic hammers require a light machine oil. Since the compressed air comes directly in contact with these parts, it has a tendency to drive the lubricant out through the exhaust.

When working continuously with a pneumatic tool, you should regularly check the lubricator to ensure there is ample lubricant available. Next, empty the filter assembly as needed.

On low-pressure compressed air systems that do not have the filter, the regulator, and the lubricator assembly installed, you should disconnect the air hose every hour or so and squirt a few drops of light oil into the air hose connection. Do NOT use heavy oil because the oil will cause precision parts to either fail or to have operating troubles. If this occurs, you have to clean your tool in cleaning solvent to loosen the gummy substance that results. Blow out the tool with air, lubricate it with light oil, and go back to work.

Keep your pneumatic tools clean and lubricated and you will have few operating problems.

SHOP MACHINERY

Prefabrication of steel parts and assemblies is typically accomplished in a steel shop where heavy steel working machinery is accessible. The steel shop is tasked with manufacturing and fabricating items, such as sheet-metal ducts, pipeline section fittings, plates, and angles. In the following sections, we will discuss some of the common types of machinery found in a well-equipped steel shop.

COMBINATION IRON WORKER

The combination iron worker is likely the most valuable and versatile machine in a shop. The combination punch, shear, and coper (fig. 12-8) is capable of cutting angles, plates, and steel bars, and it can also punch holes. The size of the angles and plates that can be safely handled by the machine depends upon its capacity. It is manufactured in various sizes and capacities, and each machine has a capacity plate either welded or riveted on it. This guide should be strictly adhered to. The pressure and power the machine develops demand extreme caution on the part of the operator.

VERTICAL BAND SAWS

While the vertical band saw is designed primarily for making curved cuts, it can also be used for straight cutting. Unlike the circular saw, the band saw is frequently used for freehand cutting.

The band saw has two large wheels on which a continuous narrow saw blade, or BAND, turns, just as a belt is turned on pulleys. The LOWER WHEEL, located below the WORKING TABLE, is connected to the motor directly or by means of pulleys or gears and serves as the driver pulley. The UPPER WHEEL is the driven pulley.

The saw blade is guided and kept in line by two sets of BLADE GUIDES: one fixed set below the table and one set above with a vertical sliding adjustment. The alignment of the blade is adjusted by a mechanism on the back side of the upper wheel. TENSIONING of the blade—tightening and loosening-is provided by another adjustment located just back of the upper wheel.

Cutoff gauges and ripping fences are sometimes provided for use with band saws. However, you will do most of your work freehand with the table clear because accurate cuts are difficult to make with a band saw when gauges or fences are used.

The size of a band saw is designated by the diameter of the wheels. Thus the 14-inch model (fig. 12-9) has 14-inch wheels. Common sizes are 14-, 16-, 18-, 20-, 30-, 36-, 42-, and 48-inch machines. The 14-inch size is the smallest practical band saw. With the exception of capacity, all band saws are much alike in maintenance, operation, and adjustment.

Blades, or bands, for bandsaws are designated by POINTS (tooth point per inch), THICKNESS (gauge), and WIDTH. The required length of the blade is found by adding the circumference of one wheel to twice the distance between the wheel centers. Length can vary within a limit of twice the tension adjustment range.

Vertical band saws are comparatively simple machines to operate. Each manufacturer publishes a technical manual for their machine. Refer to the

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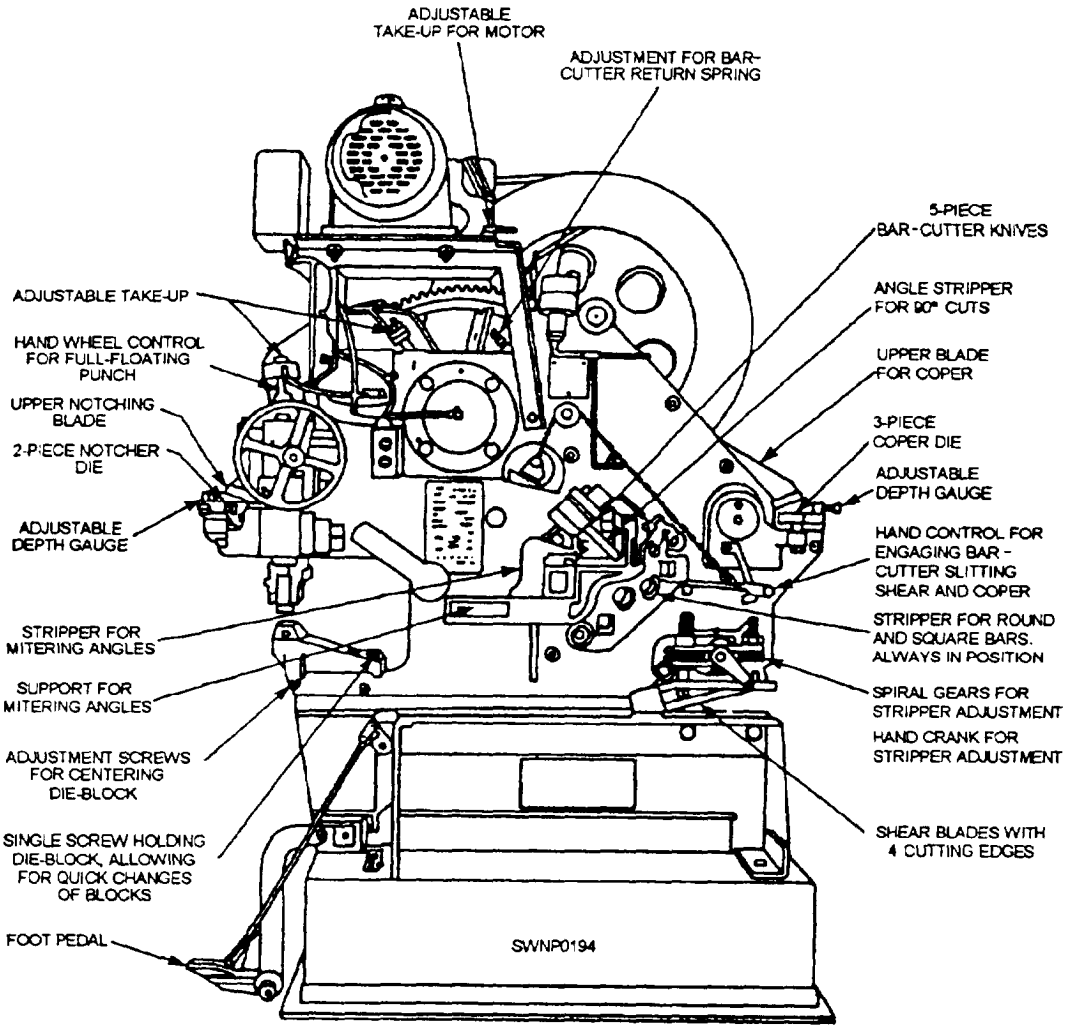


Figure 12-8.—Combination punch, shear, and coper.

manufacturer's manual for detailed information concerning the structure, operation, maintenance, and repair of the individual machine.

One of the key parts of the vertical band saw is its blade that must be sharp and accurately set to cut in a straight line. The radius of the curve, or circle, to be cut determines the size of the saw blade to be used. Use a narrow blade to cut curves of small radii. A 1/8-inch blade will cut a 1-inch curve; a 3/16-inch blade, a 1 1/2-inch curve; a 1/4-inch blade, a 2-inch curve; and a 3/8-inch blade, a 2 1/2-inch curve; provided, in each instance, the teeth have the correct amount of set.

After turning on the power, see that the blade is operating at full speed before you start a cut. It is advisable to true up one face or edge of the stock before taking a cut with the saw. Also, start the cut in the waste stock and do not crowd or cramp the blade.

Keep the top guide down close to the work at all times. When sawing curves or straight lines (outlines), you guide the stock along the lines marked on the face of the stock. When more than one piece is to be sawed, several can be tack-welded together before sawing. Tack-weld from the side on which the outline is marked so the welds will be visible to the saw operator. Be careful not to exceed the rated capacity of the machine.

Do not force the material too hard against the blade. A light contact with the blade permits easier following of the line and prevents undue friction and overheating of the blade.

By keeping the saw blade well sharpened, you need to apply very little forward pressure for average cutting. Move stock steadily against the blade, but no faster than required to give an easy cutting movement.

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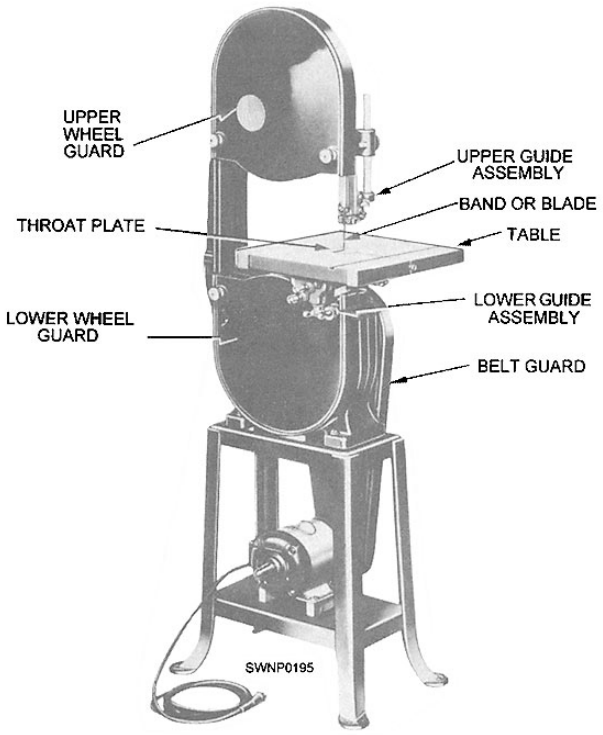


Figure 12-9.—14-inch band saw.

Avoid twisting the blade by trying to turn sharp corners. Remember that you must saw around comers. If you want to saw a very small radius, use a narrow blade.

If you find that a saw cut cannot be completed, it is better to saw out through the waste material to the edge of the stock than to back the blade out of the curved cut. This will prevent accidentally drawing the blade off the wheels.

BAND SAW teeth are shaped like the teeth in a hand ripsaw, which means that their fronts are filed at 90 degrees to the line of the saw. Reconditioning procedures are the same as they are for a hand ripsaw, except that very narrow band saws with very small teeth must usually be set and sharpened by special machines.

A broken band saw blade must be BRAZED when no accessory welder is available. The procedure for brazing is as follows:

1. SCARF the two ends to be joined with a file so that they may be joined in a SCARFJOINT(fig. 12-10).

2. Place the ends in a brazing clamp, or some similar device, that will permit them to be brought together in perfect alignments.

3. Coat the filed surfaces with soldering flux.

4. Cut a strip of silver solder the length of the scarf and the width of the blade. Coat it with flux and insert it between the filed surfaces.

5. Heat a pair of brazing tongs bright red and clamp the joint together. The red-hot tongs wiIl heat the blade and melt the solder. Keep the tongs clamped on the joint until they turn black.

6. Smooth the joint on both sides with a flat file, and finish it with fine emery cloth.

Figure 12-11 shows band ends being joined by using the butt welder-grinder unit. The entire procedure for joining is as follows:

1. Trim both ends of the band square; clean them thoroughly. Butt the ends together in the jaws of the welder-grinder unit; make sure that the ends are aligned and that the seam is centered between the welder jaws. First, set the resistance knob to agree with the dial for the width of band you are going to weld Then press and

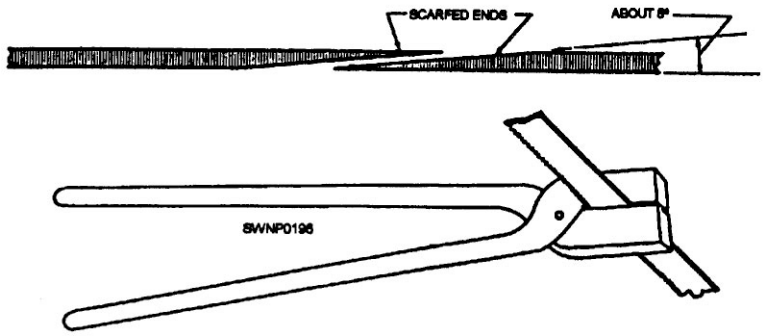


Figure 12-10.—Rejoining a broken band saw blade.

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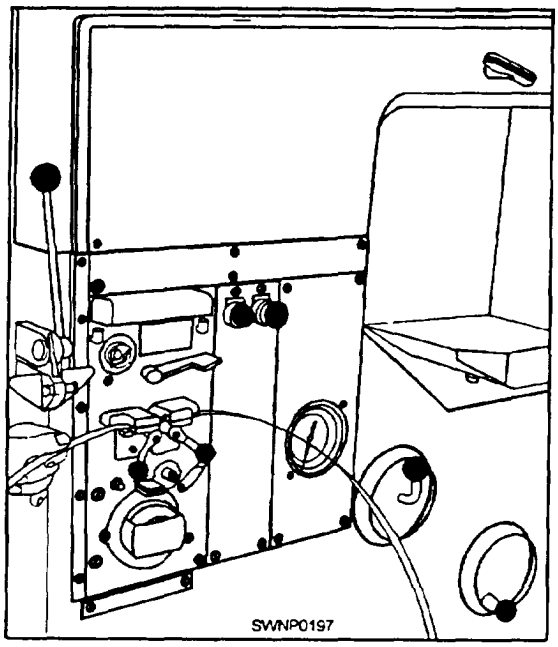


Figure 12-11.—Butt welder-grinder unit.

hold the WELD button until the blade ends fuse together. Let the weld cool for a few seconds and then press the ANNEAL button until the welded area heats to a dull cherry red. Hold the welded area at that temperature momentarily by jogging the button, and then allow the temperature to fall off slowly and gradually by increasing the time between jogs. (Allow about 10 seconds for this last phase.)

2. After the band has been annealed, take it out of the welder jaws and grind the weld bead with the small grinder. Grind the weld area to the same thickness as the rest of the band. Check the back edge of the band for burrs and misalignment; grind off irregularities. After the grinding is completed, place the band in the butt welder-grinder unit and reanneal the welded areas to destroy any hardness that may have developed. See the technical manual furnished with each machine.

Causes of Blade Breakage

A number of conditions may cause a band saw blade to break. Breakage is unavoidable when it is the result of the peculiar stresses to which such saws are subjected. The most common causes of blade breakage that may be avoided by good judgment on the part of the operator are as follows: (1) faulty alignment and adjustment of the guides, (2) forcing or twisting a wide blade around a curve of short radius, (3) feeding too fast, (4) dullness of the teeth or the absence of sufficient set, (5) excessive tension on the blade, (6) top guide set too high above the work being cut, and (7) using a blade with a lumping or improper] **y** finished braze or weld. When a saw blade breaks, shut off the power immediately, and then wait until the wheels stop turning before replacing the blade.

Replacing Saw Blades

To replace a bandsaw blade, open the wheel guard on each wheel. Raise the guide to the top position. Remove the throat plate from the table. Release the tension on the blade by turning the top wheel adjusting screw. Remove the blade and install the replacement.

HORIZONTAL BAND CUTOFF SAW

A relatively new metal-cutting band saw is shown in figure 12-12. This HORIZONTAL BAND CUTOFF SAW is being used in shops to replace the reciprocating type of power hacksaw. The continuous cutting action of the blade provides greater speed, accuracy, and versatility for metal-cutting jobs.

Good results from the use of any metal-cutting band saw depend upon careful choice of blade, speed, rate of feed, and feed pressure. The primary consideration in selecting the blade is the tooth pitch. Tooth pitch should be considered in relation to the hardness and toughness of the material being worked and the thickness of the workpiece. At lease two teeth should be in contact with the work. When cutting thick material, do not select a tooth pitch that will allow too

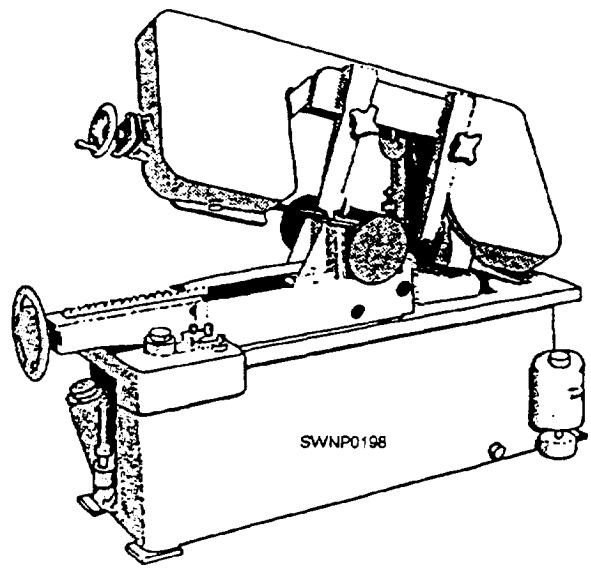


Figure 12-12.—Horizontal band Cutoff saw.

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many teeth to be in contact with the material. The more teeth in contact, the greater the feed pressure required to force them into the material. Excessive feed pressure will cause off-line cutting.

POWER HACKSAWS

The POWER HACKSAW is found in all except the smallest shops. It is used for cutting bar stock, pipe, tubing, or other metal stock. The power hacksaw (fig. 12- 13) consists of a base, a mechanism for causing the saw frame to reciprocate, and a clamping vise for holding the stock while it is being sawed. Two types of power hacksaws are in use today: the direct mechanical drive and the hydraulic drive.

The capacity designation of the power hacksaw shown is 4 inches by 4 inches. This means that it can handle material up to 4 inches in width and 4 inches in height.

Three types of feed mechanisms are in use today. They are as follows:

1. Mechanical feed, which ranges from 0.001 to 0.025 inch per stroke, depending upon the class and type of material being cut.

2. Hydraulic feed, which normally exerts a constant pressure but is so designed that when hard spots are encountered, the feed is automatically stopped or shortened to decrease the pressure on the saw until the hard spot has been cut through.

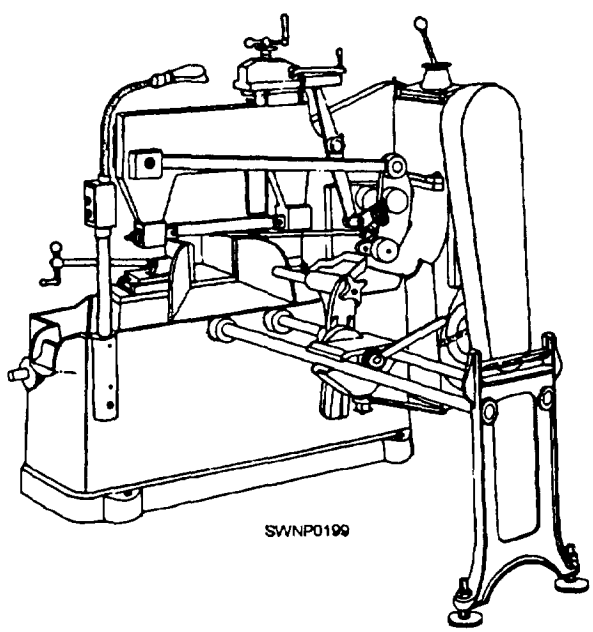


Figure 12-13.—Power hacksaw.

3. Gravity feed, which provides for weights on the saw frame. These weights can be shifted to increase or decrease the pressure of the saw blade on the material being cut.

All three types of feed mechanisms lift the blade clear of the work during the return stroke.

Hacksaw Blades

The blade shown in figure 12-14 is especially designed for use with the power hacksaw. It is made with a tough alloy steel back and high-speed steel teeth-a combination which gives both a strong blade and a cutting edge suitable for high-speed sawing.

These blades vary as to the pitch of the teeth (number of teeth per inch). The correct pitch of teeth for a particular job is determined by the size of the section and the material to be cut. Use coarse pitch teeth for wide, heavy sections to provide ample chip clearance. For thinner sections, use a blade with a pitch that will keep two or more teeth in contact with the work so that the teeth will not straddle the work. Such straddling will strip the teeth. In general, you select blades according to the following information:

1. Coarse (4 teeth per inch—for soft steel, cast iron, and bronze.

2. Regular (6 to 8 teeth per inch)—for annealed high carbon steel and high-speed steel.

3. Medium (10 teeth per inch)—for solid brass stock, iron pipe, and heavy tubing.

4. Fine (14 teeth per inch)—for thin tubing and sheet metals.

Speeds and Coolants

Speeds on hacksaws are stated in strokes per minute—counting, of cm-use, only those strokes that cause the blade to come in contact with the stcck. Speed changing is usually accomplished by means of a gearshift lever. There maybe a card attached to your equipment or near it, stating recommended speeds for

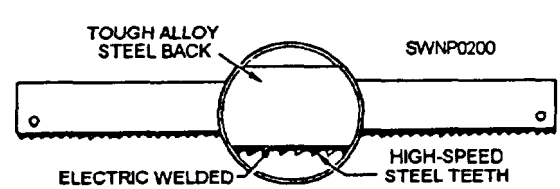


Figure 12-14.—Power hacksaw blade.

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cutting various metals. The following speeds, however, can usually be used:

1. Cold rolled or machine steel, brass, and soft metals—136 strokes per minute.

2. Alloy steel, annealed tool steel, and cast iron-90 strokes per minute.

3. High-speed steel, unannealed tool steel, and stainless steel—60 strokes per minute.

Cast iron should be cut entirely dry, but a coolant should be used for cutting all other materials. A suitable coolant for cutting most metals is a solution of water and enough soluble oil to make the solution white. The coolant not only prevents overheating of the blade and stock but also serves to increase the cutting rate.

Using the Power Hacksaw

Place the workpiece in the clamping device, adjusting it so the cutting-off mark is in line with the blade. Turn the vise lever to clamp on the material in place, being sure that the material is held tightly, and then set the stroke adjustment.

Ensure the blade is not touching the workpiece when you start the machine. Blades are often broken when this rule is not followed. Feed the b] blade slowly into the work, and adjust the coolant nozzle so it directs the fluid over the saw blade.

NOTE: Safety precautions to be observed while operating this tool are posted in the shop. READ and OBSERVE them!

DRILL PRESSES

Many sizes and styles of drilling machines or DRILL PRESSES are in use today-each designed for a particular type of work. Only the drill presses not covered in *Tools and Their Uses,* NAVEDTRA 10085-B2, are discussed here.

One type of upright drill press is the SENSITIVE DRILL PRESS (fig. 12-15). This drill is used for drilling small holes in work under conditions where the operator must "feel" what the cutting tool is doing. The drill bit is fed into the work by a very simple device—a lever. These drill presses are nearly always belt driven because the vibration caused by gearing would be undesirable.

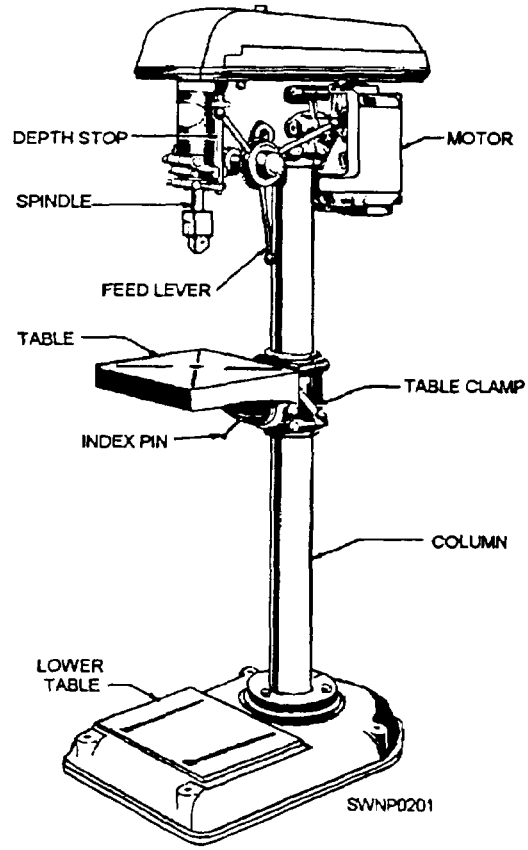


Figure 12-15.—Sensitive drill press.

The RADIAL DRILL PRESS (fig. 12-16) has a movable spindle that can be adjusted to the work. This type of machine is convenient to use on large and heavy work or where many holes are to be drilled since the work does not have to be readjusted for each hole.

Check occasionally to make sure that all locking handles are tight and that the V-belt is not slipping.

Before operating any drill press, visually inspect the drill press to determine if all parts are in the proper place, secure, and in good operating condition. Check all assemblies, such as the motor, the head, the pulleys, and the bench, for loose mountings. Check the adjustment of the V-belt and adjust as necessary according to the manufacturer's manual. Make sure that the electric cord is securely connected and that the insulation is not damaged, chafed, or cracked.

While the drill press is operating, be alert for any sounds that may be signs of trouble, such as squeaks or unusual noises. Report any unusual or unsatisfactory performance to the petty officer in charge of the shop.

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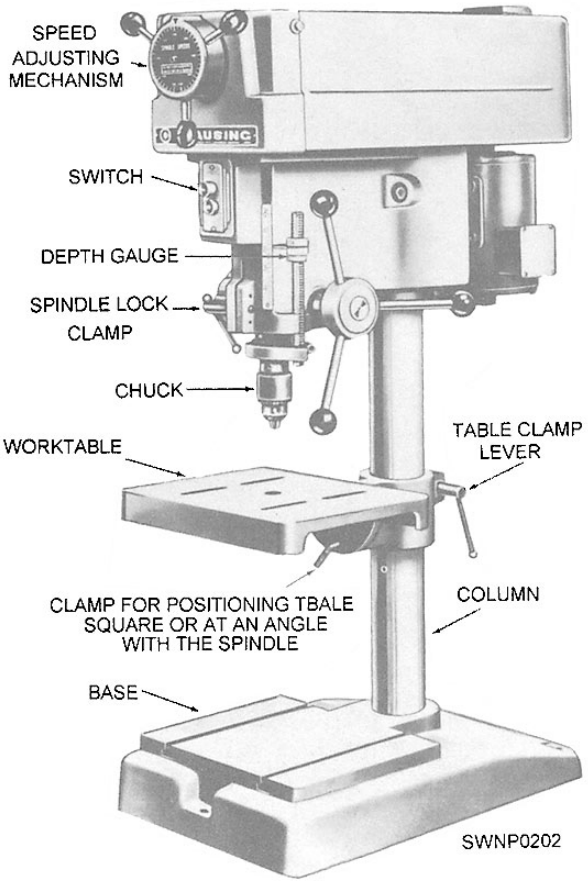


Figure 12-16.—Radial drill press.

After operating a drill press, wipe off all dirt, oil, and metal particles. Inspect the V-belt to make sure no metal chips are embedded in the driving surfaces.

DRILL BITS

Common drill bits are known as TWIST DRILLS because most of them are made by forging or milling rough flutes and then twisting them to a spiral configuration. After twisting, the drill bits are milled to the desired size and heat-treated.

The general-purpose twist drill is made of high-speed steel. Figure 12-17 shows a typical plastic-cutting drill bit and a typical metal-cutting drill bit. Notice the smaller angle on the drill bit used for drilling plastics.

Drill bit sizes are indicated in three ways: by inches, by letter, and by number. The nominal inch sizes run from 1/16 inch to 4 inches or larger. The letter sizes run from "A" to "Z" (0.234 inch to 0.413 inch).

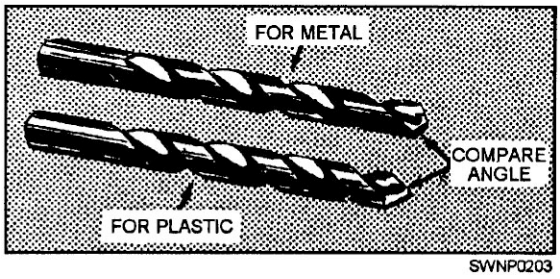


Figure 12-17.—Comparison of a twist drill for plastic and a twist drill for metal.

The number sizes run from No. 80 to No. 1 (0.0135 inch to 0.228 inch).

Before putting a drill bit away, wipe it clean and then give it a light coating of oil. Do not leave drill bits in a place where they maybe dropped or where heavy objects may fall on them. Do not place drill bits where they will rub against each other.

A drill bit should be reground at the first sign of dullness. The increased load that dullness imposes on the cutting edges may cause a drill bit to break.

Cutting Fluids

When drilling steel and wrought iron, use a cutting oil. Cast iron, aluminum brass, and other metals may be drilled dry; therefore, at high-drilling speeds it is advisable to use some medium for cooling these metals to lessen the chances of overheating the drill bit with the resultant loss of the cutting edge. Compressed air may be used for cast iron; kerosene for aluminum; oleic acid for cooper; sulphurized mineral oil for Monel metal; and water, lard, or soluble oil and soda water for ferrous metals. (Soda water reduces heat, overcomes rust, and improves the finish.)

Sharpening Drill Bits

A drill bit becomes dull with use and must be resharpened. Continued use of a dull drill bit may cause it to break or bum up as it is forced into the metal. Improper sharpening will cause the same difficulties.

Remove the entire point if it is badly worn or if the margins are burned or worn off near the point. If, by accident, the drill bit becomes overheated during grinding, do NOT plunge it into the water to cool. Allow it to cool in still air. The shock of sudden cooling may cause it to crack.

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Three factors must be considered when repainting a drill bit:

1. LIP CLEARANCE (fig. 12-18). The two cutting edges or lips are comparable to chisels. To cut effectively, you must relieve the heel or that part of the point back to the cutting edge. Wh.bout this clearance, it would be impossible for the lips to cut. If there is too much clearance, the cutting edges are weakened. Too little clearance results in the drill point merely rubbing without penetration. Gradually increase lip clearance toward the center until the line across dead center stands at an angle of 120 to 135 degrees with the cutting edge (fig. 12-19).

2. LENGTH AND ANGLE OF LIPS. The material to be drilled determines the proper point angle. The angles, in relation to the axis, must be the same. Fifty-nine degrees has been found satisfactory for most metals. If the angles are unequal, only one lip will cut and the hole will be oversize (fig. 12-20).

3. THE PROPER LOCATION OF THE DEAD CENTER (fig. 12-21). Equal angles but lips of different lengths results in oversize holes and the resulting "wobble" places tremendous pressures on the drill press spindle and bearings.

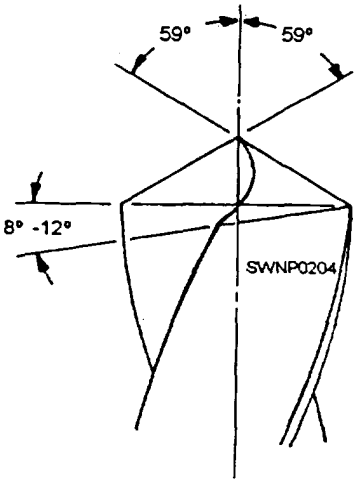


Figure 12-18.—Lip clearance.

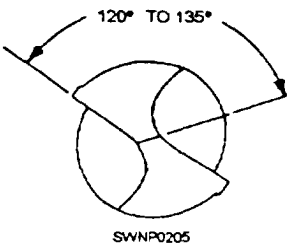


Figure 12-19.—Angle of the dead center.

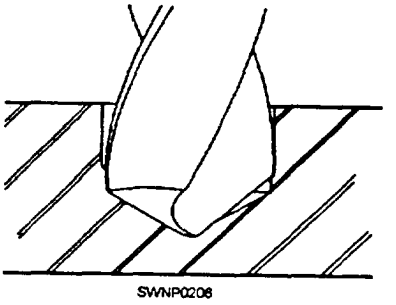


Figure 12-20.—Unequal drill point angles.

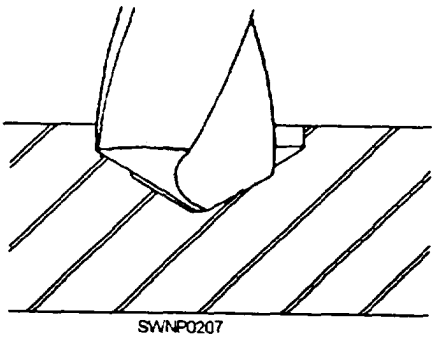


Figure 12-21.—Drill point off center.

A combination of both faults can result in a broken drill bit, and if the drill bit is very large, permanent damage to the drilling machine. The hole produced (fig. 12-22) will be oversize and often out-of-round.

The web of the drill bit increases in thickness toward the shank (fig. 12-23). When the drill bit has been shortened by repeated grindings, the web must

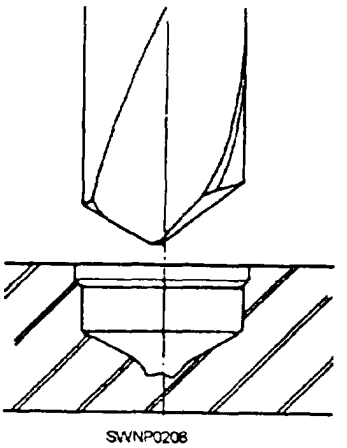


Figure 12-22.—Drill point with unequal point angles and with the drill point sharpened off center.

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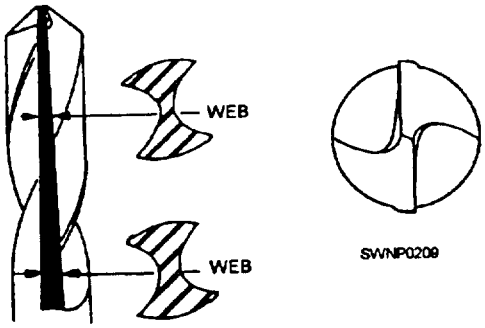


Figure 12-23.—The web of the drill bit and how the drill point is relieved by grinding.

be thinned to minimize the pressures required to make the drill bit penetrate the material. The thinning must be done equally to both sides of the web, and care must be taken to ensure that the web is centered.

The DRILL POINT GAUGE (fig. 12-24) is the tool most frequently used to check the drill point during the sharpening operation.

Use a coarse wheel for roughing out the drill point if much metal must be ground away. Complete the operation on a fine wheel.

Many hand sharpening techniques have been developed. The following are recommended:

1. Grasp the drill shank with the right hand and the rest of the drill bit with the left hand.

2. Place the fingers of the left hand that are supporting the drill bit on the grinder tool rest. The tool rest should be slightly below center (about 1 inch on a 7-inch wheel).

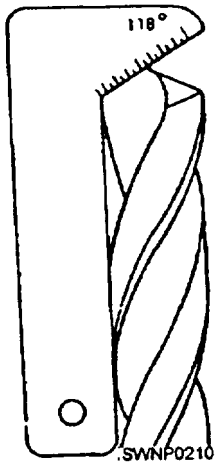


Figure 12-24.—Using a drill point gauge.

3. Stand so the centerline of the drill bit will be at a 59-degree angle with relation to the centerline of the wheel (fig. 12-25), and lightly touch the drill lip to the wheel in approximately a horizontal position.

4. Use the left hand as a pivot point and slowly lower the shank with the right hand. Increase the pressure as the heel is reached to ensure proper clearance.

5. Repeat the operation on each lip until the drill bit is sharpened. DO NOT QUENCH HIGH-SPEED STEEL DRILLS IN WATER TO COOL. LET THEM COOL IN CALM AIR.

6. Check the drill tip frequently with the drill point gauge to assue a correctly sharpened drill bit.

Secure a drill bit that is properly sharpened and run through the motions of sharpening it. When you have acquired sufficient skill, sharpen a dull drill bit. To test, drill a hole in soft metal and observe the chip formation. When proper] y sharpened, the chips will come out of the flutes in curled spirals of equal length. The tightness of the chip spiral is governed by the RAKE ANGLE (fig. 12-26).

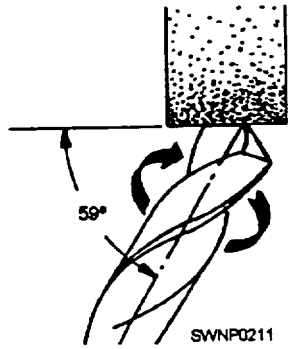


Figure 12-25.—The correct position of the drill bit at the start of the grinding operation. View is looking down on the grinder.

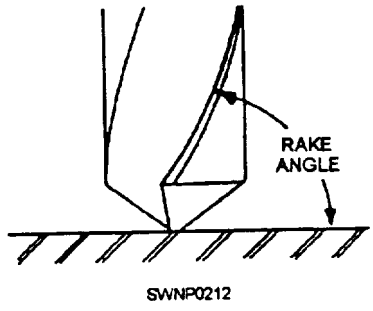


Figure 12-26.—Rake angle of drill bit for ordinary work.

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An attachment for conventional tool grinders is shown in figure 12-27. In a shop where a high degree of hole accuracy is required and a large amount of sharpening is to be done, a machine or attachment is a must.

AIR COMPRESSORS

A compressor is a machine for compressing air from an initial intake pressure to a higher exhaust pressure through reduction in volume. A compressor consists of a driving unit, a compressor unit, and accessory equipment. The driving unit provides power to operate the compressor and may be a gasoline or diesel engine. Compressors are governed by a pressure control system adjusted to compress air to a maximum pressure of 100 psi.

Compressed Air System

A compressed air system consists of one or more compressors, each with the necessary power source, control of regulation, intake air filter, aftercooler, air receiver, and connecting piping, together with a distribution system to carry the air to points of use.

The object of installing a compressed air system is to provide sufficient air at the work area at pressures adequate for efficient operation of pneumatic tools being used.

Many construction projects require more cubic feet of air per minute than any one compressor will produce. Terrain conditions often create problems of distance from the compressor to the operating tool. Since the air line hose issued with the compressor causes considerable line loss at distances farther than 200 feet, a system has been devised for efficient transmission of compressed air over longer distances. This system is called air manifolding (fig. 12-28). An air manifold is a pipe having a large diameter used to transport compressed air from one or more compressors over a distance without detrimental friction line loss. In construction work, air manifolds are usually constructed of 6-inch diameter pipe. A pipe of this size can carry 1,200 cubic feet per minute (cfm) of air (output from two 600 cfm air compressors) at 100 psi with less than .035 pound pressure loss per 100 linear feet. One or more compressors pump air into the manifold and eventually "pressurize" it at 100 psi; then air may be used at any point along the manifold by installing outlet valves and connecting air lines and pneumatic tools.

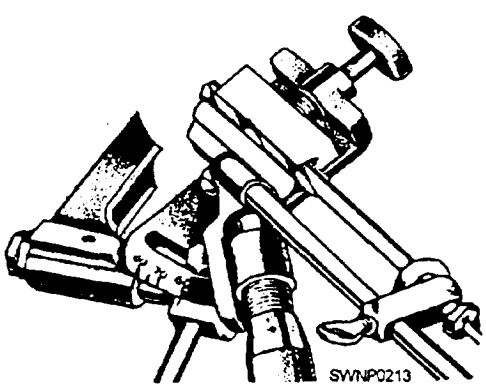


Figure 12-27.—A drill bit sharpening attachment mounted on a conventional bench grinder.

Compressor Operation and Maintenance

The following paragraphs will give generaI instructions on operating and maintaining air compressor units.

A compressor must be located on a reasonably level area. Most compressors permit a 15-degree lengthwise and a 15-degree sidewise limit on out-of-level operation. The limits are placed on the engine, not the actual compressor. When the unit is to be operated out-of-level, it is important to do the following: (1) keep the engine crankcase oil level near the high-level mark (with the unit level) and (2) have the compressor oil gauge show nearly full (with the unit on the level).

An instruction plate, similar to the one shown in figure 12-29, is attached to all compressors. Notice that this plate refers you to the manufacturer's engine and compressor manuals for detailed instructions.

STARTING THE UNIT.— Take the following steps when starting the engine during mild weather:

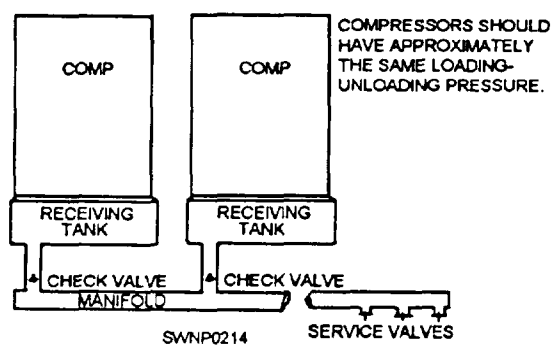


Figure 12-28.—Methods of manifolding compressors.

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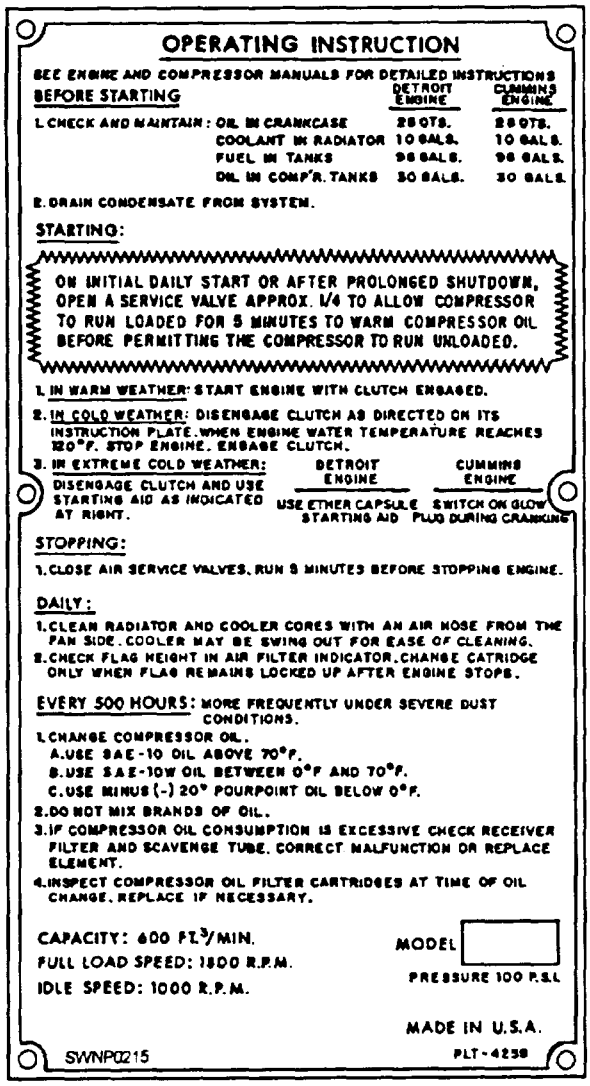


Figure 12-29.—Operating Instruction plate.

1. Open the service valves about one quarter-not wide open.

NOTE: The reason for starting with the service valves partly open is that they aid in quicker warm-up of the compressor oil.

2. Position the low-pressure, engine-oil-system safety knob to ON (fig. 12-30).

3. Turn the ignition switch to the START position. Immediately after the engine starts, release the ignition switch. If the engine fails to fire within 30 seconds, release the ignition switch and allow the starting motor to cool off for a few moments before trying the starter again.

4. With the engine running, check the engine oil pressure gauge. If no pressure is indicated, turn the engine off. When the oil pressure goes above 22 psi, continue to operate the engine and check the low-pressure engine oil switch. The knob on this switch should be in the RUN position.

NOTE: The engine oil pressure gauge indicates erratically until the engine oil warms up.

5. Open the side curtains on both sides of the engine enclosure and leave them open. The flow of air through the oil cooler and engine radiator will be impeded if the side curtains are closed while the engine is running.

6. After the engine has run about 3 minutes, check the engine coolant temperature gauge. The gauge should indicate less than 210°F. If the gauge is showing more than 210°F, SHUT OFF THE ENGINE.

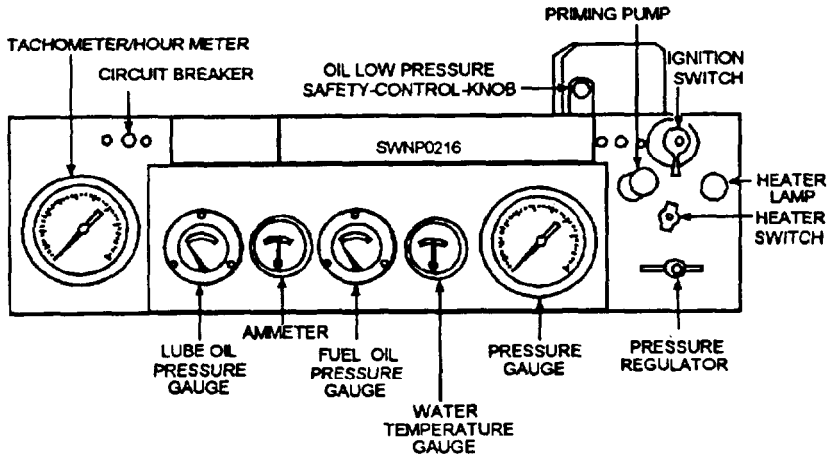


Figure 12-30.—Instrument panel.

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7. After 5 minutes of operation, close the service valve and attach the hose or service line of the tool or device to be operated.

8. Open the service valves fully and start the work. After start-up, the unit automatically provides compressed air at the discharge service valves. Only periodic checking of the gauges on the instrument panel is then required.

9. When the engine is started during the day, after the first daily start-up, the above warm-up steps maybe eliminated,

STOPPING THE UNIT.— When stopping the unit at the end of the day, you should take the following steps:

1. Close the service valves and permit the engine to run at idle for 5 minutes. This will allow the engine coolant temperature to level off and the entire unit to cool down.

2. Turn the ignition switch to the OFF position.

COLD-WEATHER START-UP.— The following steps should be completed during cold-weather Start-up:

1. Start the engine using the heater switch and priming pump according to the engine manual.

2. Warm the engine until the engine coolant temperature reaches 120°F. Leaving the side curtains closed for a few minutes helps the engine to warm up.

3. Turn the ignition switch to OFF.

4. When the engine has stopped, start the engine again with the service valves partly open. Be sure the side curtains are open.

5. When the compressor has run for several minutes and the gauges indicate normal operating conditions, connect up the tools and go to work.

LUBRICATING THE UNIT.— The lubrication chart in the operator's manual for the particular make and model of compressor you are operating will show you where the unit should be lubricated, how often to lubricate, and what lubricant to use. The frequency will vary depending upon operating conditions and usage. Operating under abnormal conditions requires more frequent service.

CAUTION

Before servicing the compressor air system or compressor oil system, open the service valves to the atmosphere to relieve all pressure in the systems.

SERVICING THE AIR CLEANER.— A two-stage, dry type of air cleaner, installed inside the engine enclosure at the right rear, falters the intake air (fig. 12-31). Air is drawn into a first-stage element that causes nearly all the dust in the air to drop into a bin. Air then enters the second-stage element, a paper cartridge, where more dust is trapped and collected.

The dustbin should be removed by hand and emptied daily. Some models have a self-emptying dustbin that is piped into an aspirator in the exhaust pipeline, just beyond the muffler. When the aspirator is used, no alterations are allowed to be made to the engine muffler or exhaust pipe.

A service indicator is mounted on the side of the air cleaner housing. As the paper cartridge clogs with dust, a red indicator flag gradually rises in the window. When the cartridge is completely loaded, the window will show all red, and the flag will be locked in place. It is time to replace the paper cartridge, Discard the old cartridge and reset the red flag so that the window shows clear. Cleaning used paper cartridges is not recommended.

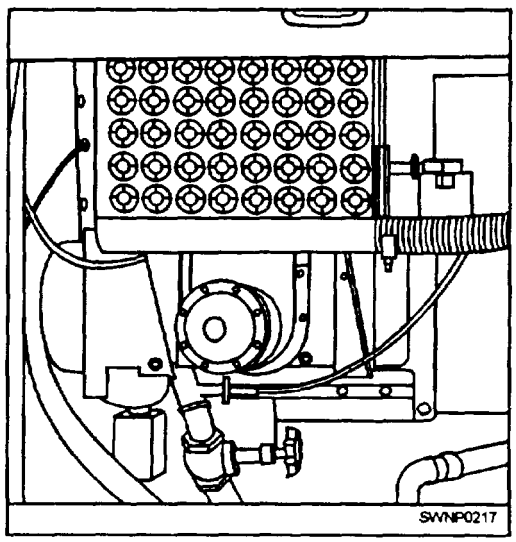


Figure 12-31.—Air cleaner.

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APPENDIX I

GLOSSARY

BLOCK— One or more sheaves fitted in a wood or metal frame supported by a hook or shackle inserted in the strap of the block.

BREECH— The part of the block opposite the swallow.

BURR— The sharp edge remaining on metal after cutting.

CHOKER— A chain or wire rope so fastened that it tightens on its load as it is pulled.

COMPRESSION STRESSES— The stresses developed within a material when forces tend to compress or crush the material.

COPE—The notch or shape to fit or conform to the shape of another member.

DUCTILITY— The property that enables a material to withstand extensive permanent deformation due to tension.

ELASTICITY— The ability of a material to return to its original form after deformation.

FALL— A line reeved through a pair of blocks to form a tackle.

FATIGUE— The tendency of a material to fail after repeated stressing at the same point.

FATIGUE STRENGTH— The ability of a material to resist various kinds of rapidly alternating stresses.

GUY LINE—The fiber line or wire rope used for holding a structure in position.

IMPACT STRENGTH— The ability of a metal to resist suddenly applied loads; measured in foot-pounds of force.

LAY— Refers to the direction in which wires are twisted into strands or strands into rope.

LAYOUT— The process of measuring and marking materials for cutting, bending, drilling, or welding.

MALLEABILITY— The property that enables a material to withstand permanent deformation caused by compression.

MOUSING— technique often used to close the open section of a hook to keep slings, straps, and so on, from slipping off the hook.

OVERHAUL— To Lenghten a tackle by pulling the two blocks apart.

PLASTICITY— The ability of a material to permanently deform without breaking or rupturing.

ROUND IN— To bring the blocks of a tackle toward each other.

SCAFFOLD— A temporary elevated platform used to support personnel and materials in the course of any type of construction work.

SEIZE— To bind securely the end of a wire rope or strand with seizing wire.

SHEARING STRESSES— The stresses developed within a material when external forces are applied along parallel lines in opposite directions.

SNATCH BLOCK— A single sheave block made so the shell on one side opens to permit the line to be placed over the sheave.

SHELTERING— TO attach a socket to wire rope by pouring hot zinc around it.

STRESS— External or internal force applied to an object.

SWALLOW— The opening in the block through which the line passes.

TACKLE— An assembly of blocks and lines used to gain a mechanical advantage in lifting or pulling.

TENSILE STRENGTH— The resistance to being pulled apart.

TENSION STRESSES— The stresses developed when a material is subjected to a pulling load.

TWO-BLOCKED— Both blocks of a tackle are as close together as they wilI go.

ULTIMATE STRENGTH— The maximum strain that a material is capable of withstanding.

WHIPPING— The process of securing the ends of a line to prevent the strands from unlaying or separating.

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APPENDIX II

MATHEMATICS

The purpose of this mathematics section is twofold: first, it is a refresher for the Steelworker who has encountered a time lapse between his or her schooling in mathematics and the use of this subject in sheet metal work; second, and more important, this section applies mathematics to steelworking tasks that can not be accomplished without the correct use of mathematical equations.

The mathematics problems described in this section are examples only and are not converted into the metric system. However, if you so desire, you can convert all of the problems by using the metric conversion tables in appendix 111 of this manual. If you need more information on metrics, order *The Metric System,* NAVEDTRA 475-01-00-79, through your Educational Services Officer (ESO)..

LINEAR MEASUREMENT

Measurements in sheet metal are most often made in feet (ft) and inches (in.). It is necessary that a sheet metal worker know how to make computations involving feet and inches. In addition, it is necessary to become familiar with the symbols and abbreviations used to designate feet and inches, such as the following:

12 inches = 1 foot; 12 in. = 1 ft; 12" = 1'

CHANGING INCHES TO FEET AND INCHES

To change inches to feet and inches, divide inches by 12. The quotient will be the number of feet, and the remainder will be inches.

Example:

Change 30 1/2 inches to feet and inches.

```
    2     ft.     (quotient)
12|30 1/2
  24
   6 1/2 in.     (remainder)
```

CHANGING FEET AND INCHES TO INCHES

To change feet and inches to inches, multiply the number of feet by 12 and add the number of inches. The result will be inches.

Example:

Change 3 feet 6 inches to inches.

3 ft × 12 = 36 inches + 6 inches = 42 inches

CHANGING INCHES TO FEET IN DECIMAL FORM

To change inches to feet in decimal form, divide the number of inches by 12 and carry the result to the required number of places.

Example:

Express 116 inches as feet to 2 places.

```
     9.666
12|116.000
  108
   80
   72
    80
    72
```

Answer: 9.67

CHANGING FEET TO INCHES IN DECIMAL FORM

To change feet in decimal form to inches, multiply the number of feet in decimal form by 12.

Example;

Change 26.5 feet to inches.

```
  26.5
×   12
  530
265
318.0  inches
```

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ADDITION OF FEET AND INCHES

A sheet metal worker often finds it necessary to combine or subtract certain dimensions which are given in feet and inches.

Arrange in columns of feet and inches and add separately. If the answer in the inches column is more than 12, change to feet and inches and combine feet.

Example:

```
12 ft  4 1/2 in.
 5 ft  9 1/4 in.
-------------------
17 ft 13 3/4 in.
```

In the changing inches column, we have

```
 1′ 1 3/4″
17′ 0
---------
18′ 1 3/4″
```

SUBTRACTION OF FEET AND INCHES

Arrange in columns with the number to be subtracted below the other number. If the inches in the lower number is greater, borrow 1 foot (12 in.) from the feet column in the upper number.

Subtract as in any other problem.

Example:

Subtract 2′ 8 1/4″ from 4′ 1″.

```
4′  1″
2′  8 1/4″
```

```
3′ 13″
2′  8 1/4″
----------
1′  4 3/4″
```

MULTIPLICATION OF FEET AND INCHES

A sheet metal worker maybe required to determine the total length of metal required to make eight pieces of duct 1' 8" long. To do this, you should be able to multiply feet and inches by the number of pieces.

Arrange in columns. Multiply each column by the required number. If the inches column is greater than 12, change to feet and inches then add to the number of feet.

Example:

Multiply 1′ 8″ by 8.

```
1′  8″
   8
---------
8′ 64″
```

Change 64″ to feet and inches

```
          5 = 5′ 4″
12 | 64
     60
     --
      4
```

Combine: 8′ and 5′ 4″ = 13′ 4″

NOTE: On occasion it might be necessary to multiply feet and inches by feet and inches. To do this, either change to inches or change to feet using decimals.

DIVISION OF FEET AND INCHES

Two problems may require the sheet metal worker to know how to divide feet and inches. An example of one problem is the division of a piece of metal into an equal number of parts. The other problem is to determine the number of pieces of a certain size which can be made from a piece of metal of a given length.

In dividing feet and inches by a given number, the problem should be reduced to inches unless the number of feet will divide by the number evenly.

Example:

Divide 36 ft 9 in. by 4.

Since 36 is divisible by 4 evenly, you may proceed.

```
          9′  2 1/4″
4 | 36′  9″
```

Example:

Divide 34 ft 9 in. by 4.

Since 34 is not divisible evenly by 4, change the problem to inches.

```
  34
  12
 ---
  68
 34
---
408 in.
```

```
408
 +9
---
417 in.
```

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The answer should then be changed to feet and inches (104 1/4″ = 8′ 8 1/4″).

$$4\overline{)417}\quad 104\ 1/4''$$

To divide feet and inches by feet and inches, change to inches or feet (decimals).

Example:

Divide 10 ft 4 in. by 2 ft 6 in.

Example:

Same problem as above by use of ft (decimals).

$$30\overline{)124}\quad 4$$

120

4 inches remainder

$$2.5\overline{)10.33}\quad 4$$

10.3

.33 ft remainder

It will divide 4 times with .33 ft remainder.

ANGLES

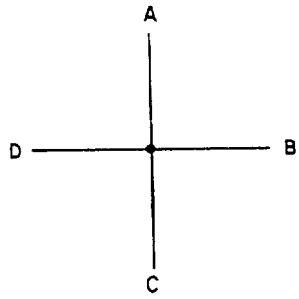
When two lines are drawn in different directions from the same point, as shown below, an angle is formed. /is the symbol for angle, and this angle is described as ∠ABC or simply ∠B. B is the vertex of the angle. AB and CB are the sides of the angle.



Angles are of four types:

1. Right angle-a 90° angle.
2. Acute angle-an angle less than 90°.
3. Obtuse angle-an angle greater than 90°, but less than 180°.
4. Reflex angle—an angle greater than 180°.

MEASUREMENT OF ANGLES

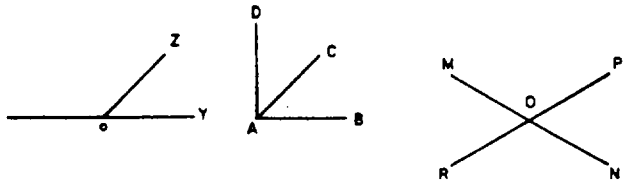


Observe that two straight lines have been drawn to form four right angles.

In order to have a way to measure angles, a system of angle-degrees has been established. Assume that each of the four right angles is divided into 90 equal angles. The measure of each is 1 angle degree; therefore, in the four right angles, there are 4 x 90°, or 360 angle-degrees. For accurate measurement, degrees have been subdivided into minutes and minutes into seconds.

1 degree= 60 minutes (′). 1 minute= 60 seconds (″).

RELATIONSHIP OF ANGLES



1. ∠ZOY and ∠ZOX are *supplementary angles* and their total measure in degrees is equal to 180°. When one straight line meets another, two supplementary angles are formed. One is the supplement of the other.
2. ∠DAC and ∠CAB are *complementary* angles and their total is a right angle or 90°.

Two angles whose sum is 90° are said to be complementary, and one is the complement of the other.

3. ∠ MOP and ∠ RON are a pair of *vertical* angles and are equal.

∠ MOP and ∠ PON are a pair of vertical angles and are equal.

When two straight lines cross, two pairs of vertical angles are formed. Pairs of vertical angles are equal.

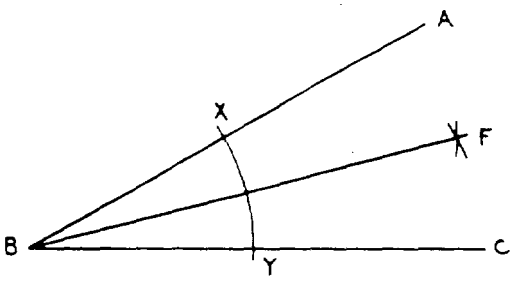
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BISECTING ANGLES

To bisect an angle merely means to divide the angle into two equal angles. his may be done by use of a compass.

Problem:

Bisect ∠ ABC.



Solution:

Step 1. Draw an arc with the radius less than the shorter of AB or BC intersecting AB and BC at points X and Y.

Step *2.* From X and Y using the same radius, draw arcs intersecting at point F.

Step *3.* Draw BF which will bisect ∠ ABC.

Conclusion:

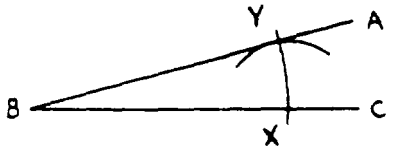
∠ ABF = ∠ CBF

TRANSFERRING ANGLES

It is often necessary in sheet metal layout to construct an angle that equals a given angle.

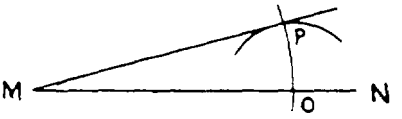
Given:

∠ ABC



Problem:

Construct an angle ∠ PMN equal to ∠ ABC.



Solution:

Step 1. From B, draw an arc with a convenient radius which intersects AB and CB at points X and Y.

Step 2. Using the same radius, draw an arc from M intersecting MN at point O.

Step *3.* With X as center, set the compass to a radius which will pass an arc through Y.

Step **4.** Using this radius (Step 3) and O as center, draw an arc that will intersect the arc drawn from M in Step 2 at point P.

Step *5.* Draw PM completing PMO.

Conclusion:

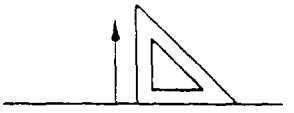
∠ PMO = ∠ ABC

PERPENDICULARS LINES

Lines are said to be perpendicular when they form a right angle (90°).

A perpendicular may be drawn to a line in several ways.

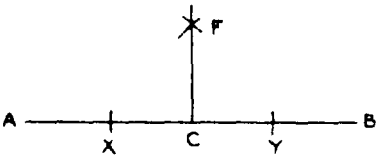
1. Using an object which has a right angle, such as a drawing triangle.



2. Using a compass from a point on a line.

Example:

Construct a perpendicular to AB at point C.



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Solution:

Step 1. Draw an arc from C as a center, using any convenient radius cutting AC and CB at X and Y.

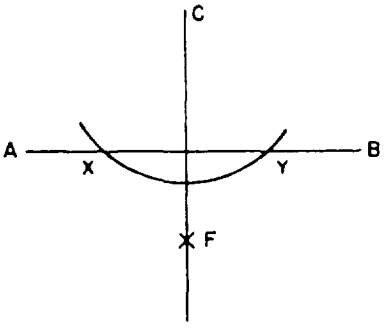
Step 2. Increase the size of the radius and from X and Y, draw arcs which intersect at point F.

Step 3. Draw CF which is perpendicular to AB at point C.

3. Using a compass, from a point outside the line.

Example:

Draw a perpendicular to AB from C.



Step 1. From C, draw an arc using any convenient radius, intersecting AB at X and Y.

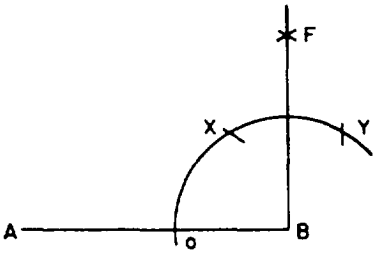
Step 2. Using the same radius, draw arcs from X and Y intersecting at F.

Step 3. Draw CF, which is perpendicular to AB.

4. Using a compass from a point at the end of a line.

Example:

Draw a perpendicular to AB from B.



Solution:

Step 1. From B, swing an arc with any convenient radius intersecting AB at O and continuing in a clockwise direction at least 120°.

Step 2. From O, using the same radius, draw an arc intersecting the arc drawn in Step 1 and X.

Step 3. From point X, draw an arc with the same radius intersecting the arc drawn in Step 1 at Y.

Step 4. From X and Y, draw arcs using the same radius intersecting at F,

Step 5. Draw FB perpendicular to AB at B.

PARALLEL LINES

Two lines are said to be parallel if they are equidistant (equally distant) at all points.

Facts about parallel lines:

Two straight lines lying in the same plane either intersect or are parallel.

Through a point there can be only one parallel drawn to a given line.

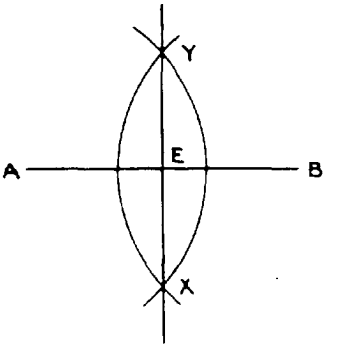
If two lines are perpendicular to the third, and in the same plane, they are parallel.

BISECTING LINES

It is often necessary to find the midpoint of a line. This may be found by measuring, or by using dividers and finding it by trial and error. A much simpler way is by the use of a compass.

Example:

To bisect a line AB by using a compass:



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Solution:

Step 1. Using A as a center and a radius more than 1/2 of AB, but less than AB, draw an arc.

Step 2. Using B as a center and the same radius as Step 1, draw an arc intersecting the arc drawn in Step 1. Mark intersecting points X and Y. Draw XY.

Conclusion:

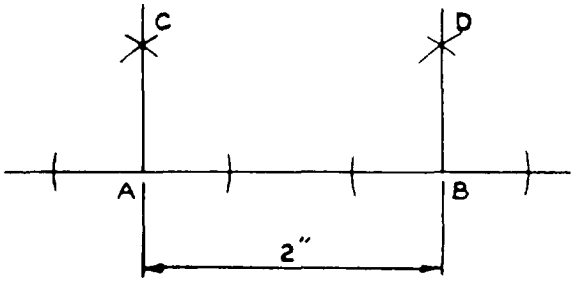
AE = EB

NOTE: That E also represents the midpoint of XY and that XY is perpendicular to AB. XY is termed the perpendicular bisector of AB,

CONSTRUCTION OF PARALLEL LINES USING PERPENDICULARS

Example;

Construct parallel lines 2“ apart.



Solution:

Step 1. Draw a base line and lay out two points A and B 2" apart.

Step 2. Construct perpendiculars AC and BD to AB at A and B.

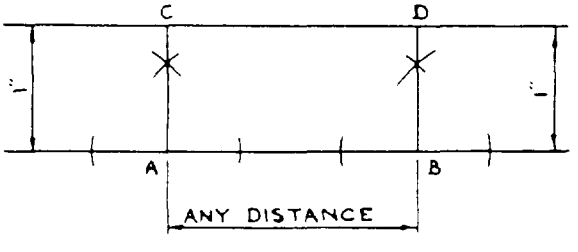
Conclusion;

AC is parallel to BD.

Principle:

Perpendiculars to the same line are parallel.

NOTE: Horizontal parallel lines can be drawn by the same procedures.



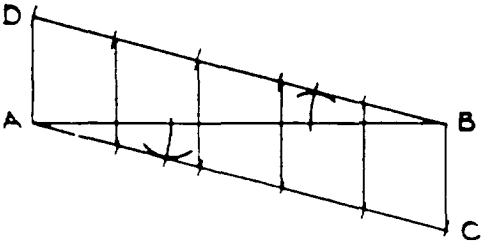
DIVIDING LINES

Lines can be divided into equal parts by a number of methods. Four of these methods are (1) by using parallel lines, (2) by transferring angles, (3) by using equal segments on the side of an angle, and (4) by using a scale.

1. Using parallel lines

Example;

Divide AB into 5 equal parts.



Solution:

Step 1. Assume any angle ABD and draw BD.

Step 2. At A construct ∠ BAC equal to ∠ ABD. Now BD and AC are parallel.

Step 3. Assume a radius so that 5 times the radius will fall within the BD, Swing arcs using this radius on BD and AC.

Step 4. Connect B with the last arc swung from A and connect corresponding points.

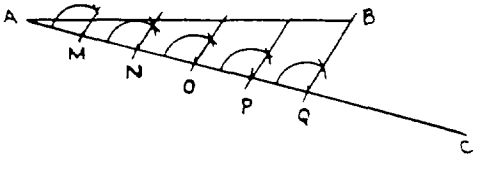
Conclusion:

Lines drawn in Step 3 divide AB into 5 equal parts.

2. Transferring angles

Example:

Divide AB into 5 equal parts.



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Solution:

Step 1. Draw a line AC at any assumed angle to AB.

Step 2. Step off with compass 5 equal parts on AC.

Step 3. At Q (the end of 5 parts), draw line BQ.

Step 4. At points M, N, O, and P, construct angles equal to ∠ BQA.

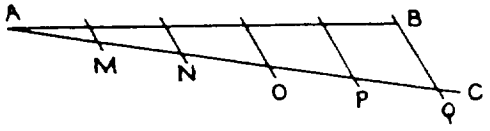
Conclusion:

Where sides of angles constructed in Step 4 meet AB, they will divide AB into equal parts.

3. Equal segments on the side of an angle

Example:

Divide AB into 5 equal parts.



Solution:

Step 1. At any assumed angle draw AC.

Step 2. Step off 5 equal parts on AC.

Step 3. At Q (the end of 5 parts), draw line BQ.

Step 4. Draw lines through P, O, N, and M parallel to BQ.

Conclusion:

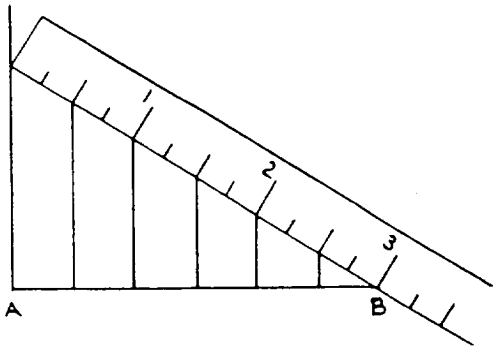
Where parallel lines intersect AB, AB will be divided into 5 equal parts.

Note the similarity of methods 3 and 2.

4. Use of a scale

Example:

Divide line AB, which is 29/16" long, into 6 equal parts.



Solution:

Step 1. At A draw a line perpendicular to AB.

Step 2. Place the scale at an angle so that the distance on the scale will divide easily into 6 parts. In the above, we have selected 3" which will divide into 6 equal parts of 1/2" each.

Step 3. Draw lines from 1/2"; each division is perpendicular to AB.

Conclusion:

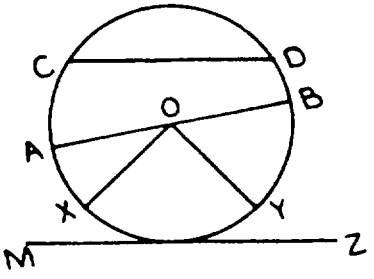
The perpendiculars drawn will divide AB into 6 equal parts.

PLANE SHAPES

A plane shape is a portion of a plane bounded by straight or curved lines or a combination of the two.

The number of different types of plane shapes is infinite, but we are concerned with those which are of importance to you as a sheet metal craftsman. We will cover the circle, triangle, quadrilateral, other polygons, and ellipses.

CIRCLES



Definitions:

A CIRCLE is a closed curved line in which any point on the curved line is equidistant from a point called the center. (Circle O).

A RADIUS is a line drawn from the center of a circle to a point on a circle. (As OA, OB, OX, and OY.)

A DIAMETER is a line drawn through the center of a circle with its ends lying on the circle.

A DIAMETER is twice the length of a radius. (AB is a diameter of circle O.)

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A CHORD is a line joining any two points lying on a circle. (CD is a chord of circle O.)

An ARC is a portion of the closed curved lines which forms the circle. It is designated by CD. An arc is said to be subtended by a chord. Chord CD subtends arc CD.

A TANGENT is a straight line which touches the circle at one and only one point. (Line MZ is a tangent to circle O.)

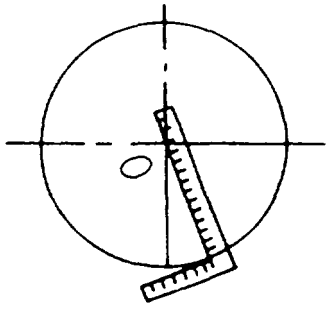
A CENTRAL ANGLE is an angle whose vertex is the center of a circle and whose side are radii of the circle. (As XOY, YOA, and XOB.)

CONCENTRIC CIRCLES are circles having the same center and having different radii.

The CIRCUMFERENCE of a circle is the distance around the circle. It is the distance on the curve from C to A to X to Y to B to D and back to C.

Some examples of problems involving circles applicable to sheet metal work are as follows:

1. Construct a tangent to circle O by use of a square.



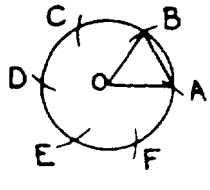
Solution:

Step 1. Place the square in a position so that one side touches the center and the other side touches the circle.

Conclusion:

A line drawn along the second side will be tangent to the circle.

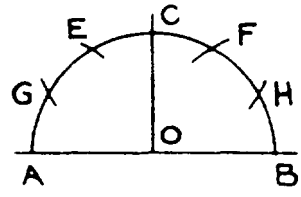
2. Divide a circle into 6 equal parts.



Solution:

Step 1. Using a radius of the circle, begin at any point, and step off chords equal to the radius. If done accurately, this will make 6 divisions of the circle.

3. Divide a semicircle into 6 equal parts.



Solution:

Step 1. At O erect a perpendicular to AB.

Step 2. With point A as the center and radius equal to AO, swing an arc cutting the circle at E.

Step 3. With point B as the center and the same radius as in step 2, swing an arc cutting the circle at F.

Step 4. With the same radius, and point C as the center, swing arcs cutting the circle at points G and H,

Conclusion:

AG = GE = EC = etc.

4. Divide a circle into 8 equal parts.

Problem:

To divide circle O into 8 equal parts.

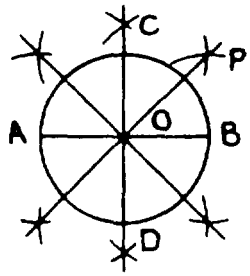
Solution:

Step 1. Draw diameter AB. Draw CD perpendicular to AB, thus dividing the circle into 4 equal parts.

Step 2. Bisect the central angle COB. Mark the point of the intersection of the bisector and circle O.

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Step 3. From B swing an arc equal to BP and from this intersection with the circle, draw the diameter, thus dividing circle O into 8 equal



TRIANGLES

A triangle is a plane shape having 3 sides. Its name is derived from its three (tri) angles.

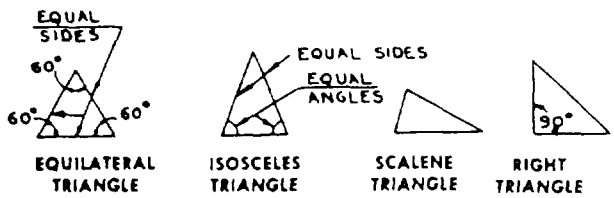
Other facts help define a triangle.

1. The sum of the angles in any triangle equals 180°.
2. A triangle is the only plane shape which maybe defined in terms of its sides only; in all others one or more angles must be stated.

Types of Triangles

There are four kinds of triangles. They are classified according to the size of their sides and angles as follows:

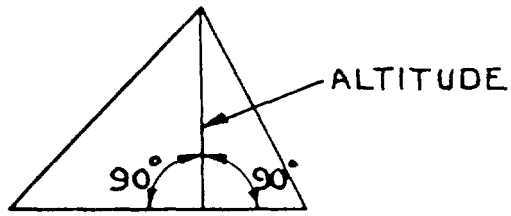
1. Equilateral-all sides are equal-all angles are equal-all angles are 60°
2. Isosceles—two sides equal-two angles equal
3. Scalene—all sides unequal-all angles unequal
4. Right—one right angle



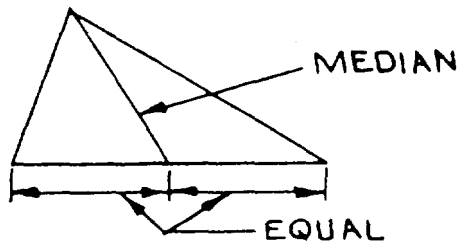
Altitudes and Medians

The altitude and median of a triangle are not the same; the difference is pointed out in the following definitions:

1. The altitude of a triangle is a line drawn from the vertex, perpendicular to the base.



2. The median of a triangle is a line drawn from the vertex to the midpoint of the base.



Construction of Triangles

There are many ways to construct a triangle, depending upon what measurements are known to you. The following examples will assist you. Select the appropriate method according to the information given about the triangle.

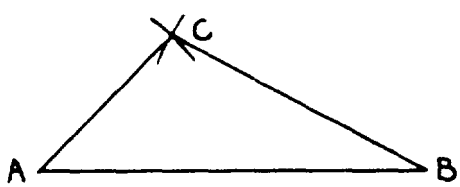
1. A triangle may be constructed if the lengths of three sides are known.

Problem:

Construct a triangle.

Given:

Three sides of a triangle: 2“, 1“, 1 1/2”.



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Solution:

Step 1. Draw a base line equal to one of the sides. Mark the ends of lines A and B.

Step 2. Set the compass equal to the second side (l" in the above) and swing an arc from A.

Step 3. Set the compass equal to the third side (1 1/2" in this case) and swing an arc.

Conclusion:

The intersection of these two arcs will be the vertex C and will complete triangle ABC.

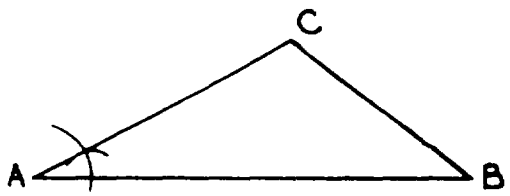
2. A triangle maybe constructed if two sides and the included angle (angle between the sides) are known.

Problem:

To construct a triangle with two sides and the included angle known.

Given:

Two sides 1 1/2" and 2 1/4" and the included angle.



Solution:

Step 1. Draw the base equal to one side.

Step *2.* Construct an angle equal to the given angle.

Step 3. Measure the second side on the side of the angle and connect the ends of the given sides BC.

Conclusion:

Triangle ABC has been constructed with two sides and the included angle given.

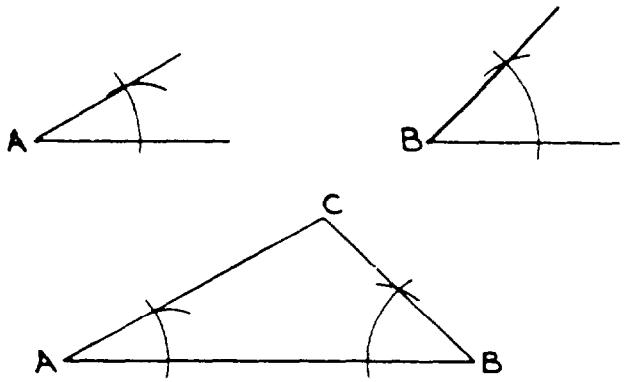
3. A triangle maybe constructed if two angles and the included side are given.

Problem:

Construct a triangle.

Given:

∠ A, ∠ B and line AB 2 1/8" long.



Solution:

Step 1. Draw line AB.

Step 2. At point A, transfer angle A.

Step 3. At point B, transfer angle B.

Step 4. Where sides of ∠ A and ∠ B intersect, mark point C.

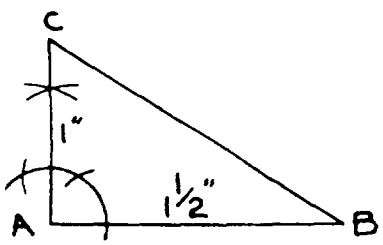
Conclusion:

Triangle ABC has been constructed with two angles and the included side given.

4. A right triangle may be constructed if the two sides adjacent to the right angle are known.

Problem:

Construct a right mangle whose sides adjacent to the right angle are 1 1/2" and l".



Solution:

Step 1. Draw AB 1 1/2" long.

Step *2.* At A, erect a perpendicular to AB.

Step 3. Locate point C 1" from AB and complete the triangle.

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Conclusion:

Triangle ABC is a right triangle,

5. A right triangle maybe constructed by making the sides 3", 4", and 5" or multiples or fractions thereof.

Problem:

Construct a right triangle with sides of 1 1/2", 2", and 2 1/2" (1/2 of 3,4, and 5).

Solution:

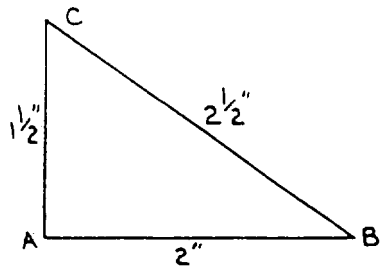
Step 1. Draw line AB = 2".

Step 2. From A, draw an arc equal to 1 1/2".

Step 3. From B, draw an arc equal to 2 1/2".

Conclusion:

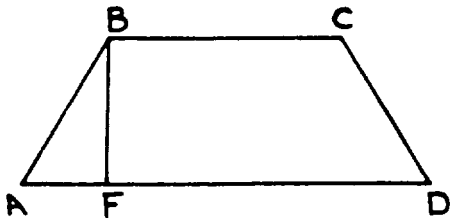
Triangle ABC is a right triangle,



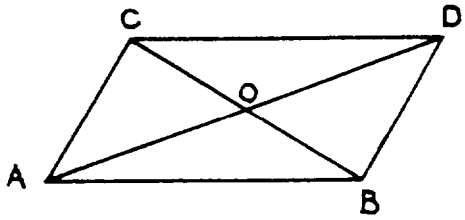
QUADRILATERALS

A quadrilateral is a four-sided plane shape. There are many types, but only the trapezoid, parallelogram, rectangle, and square are described here.

1. A **TRAPEZOID** is a quadrilateral having only two sides parallel. If the other two sides are equal, it is an isosceles trapezoid. BF is the altitude of the trapezoid.



2. A **PARALLELOGRAM** is a quadrilateral having opposite sides parallel.



a. AB is parallel to CD.

b. AC is parallel to BD.

c. AD and CB are diagonals.

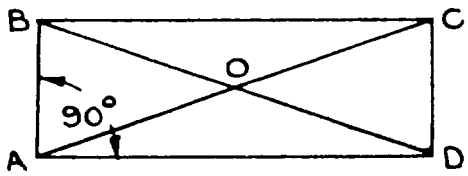
d. Diagonals bisect each other so CO = OB and AO = OD.

e. Opposite angles are equal ACD = DBA and CAB = BDC.

f. If two sides of a quadrilateral are equal and parallel, the figure is a parallelogram.

g. A parallelogram may be constructed if two adjoining sides and one angle are known.

3. A **RECTANGLE** is a parallelogram having one right angle.



a. ABCD is a parallelogram having one right angle. This, of course, makes all angles right angles.

b. AC and BD are diagonals.

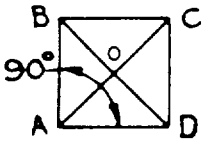
c. O is the midpoint of AC and BD and OB = OC = OD = OA.

d. O is equidistant from BC and AD and is also equidistant from AB and CD.

e. A rectangle may be constructed if two adjoining sides are known.

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4. A **SQUARE** is a rectangle having its adjoining sides equal.



a. ABCD is a square.

b. AC and BD are diagonals.

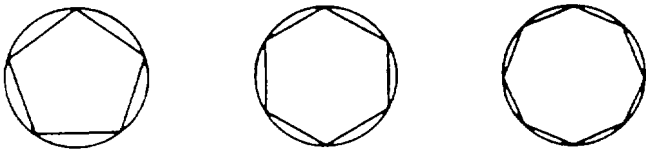
c. O is the geometric center of the square. AO = OC = OB = OD.

d. O is equidistant from all sides.

e. A square may be constructed if one side is known.

POLYGONS

A polygon is a many-sided plane shape. It is said to be regular if all sides are equal and irregular when they are not. Only regular polygons are described here.



Regular Polygons

Triangles and quadrilaterals fit the description of a polygon and have been covered previously. Three other types of regular polygons are shown in the illustration. Each one is inscribed in a circle. This means that all vertices of the polygon lie on the circumference of the circle.

Note that the sides of each of the inscribed polygons are actually equal chords of the circumscribed circle. Since equal chords subtend equal arcs, by dividing the circumference into an equal number of arcs, a regular polygon may be inscribed in a circle. Also note that the central angles are equal because they intercept equal arcs. This gives a basic rule for the construction of regular polygons inscribed in a circle as follows:

To inscribe a regular polygon in a circle, create equal chords of the circle by dividing the circumference into equal arcs or by dividing the circle into equal central angles.

Dividing a circle into a given number of parts has been discussed, so construction should be no problem. Since there are 360 degrees around the center of the circle, you should have no problem in determining the number of degrees to make each equal central angle.

Problem:

What is the central angle used to inscribe a pentagon in a circle?

Solution:

$$\frac{360^\circ}{5\ slides} = 72^\circ\ in\ each\ circle$$

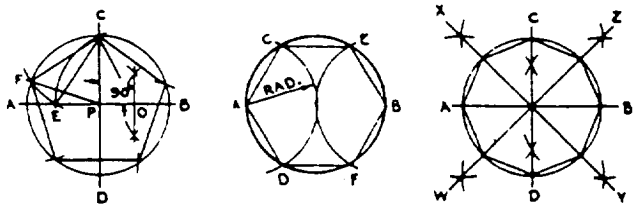
Methods for Constructing Polygons

The three methods for constructing polygons described here are the pentagon, the hexagon, and the octagon.

The **PENTAGON** is a method to develop the length of a side and departs from the rule given. Radius PB has been bisected to locate point O. Radius OC has been used to swing an arc CE from the center O. E is the intersection of arc CE with diameter AB. Chord CE is the length of the side and is transferred to the circle by arc EF using chord CE as radius and C as center.

The **HEXAGON** has been developed by dividing the circumference into 6 equal parts.

The **OCTAGON** method has been developed by creating central angles of 90° to divide a circle into 4 parts and bisecting each arc to divide the circumference into 8 equal parts,

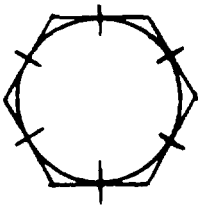


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Circumscribing a Regular Polygon about a Circle

Problem:

Circumscribe a hexagon about a given circle.



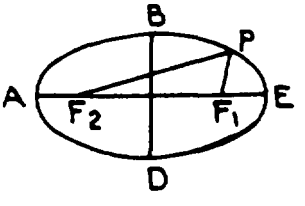
Solution:

Step 1. Divide the circumference into a given number of parts.

Step 2. At each division point draw a tangent to the circle. The intersection of the tangents forms vertices of the circumscribed polygon.

ELLIPSES

An ellipse is a plane shape generated by point P, moving in such a manner that the sum of its distances from two points, F_1 and F_2, is constant.



$BF_1 + PF_2 = C$ = (a constant)

AE is the major axis.

BD is the minor axis.

MATHEMATICAL SYMBOLS

Formulas, which are in effect statements of equality (equations), require the use of symbols to state the relationship between constants in any given set of conditions. To illustrate:

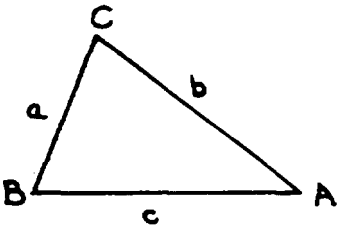
Consider triangle ABC.

Distance (D) around triangle ABC is equal to the sum of a, b, and c.

Expressed as a formula,

$$D = a + b + c$$

This formula would express the distance around a triangle regardless of conditions.



ADDITION AND SUBTRACTION OF MATHEMATICAL SYMBOLS

1. The sum of any two symbols, a and b, is written a+b.
2. The difference of any two symbols, a being the greater and b being the smaller, is written a -b.

MULTIPLICATION OF MATHEMATICAL SYMBOLS

1. The product of any two symbols, a and b, is written as a x b or ab.
2. The sum of any number of like symbols, such as a+ a + a + a, may be combined and written once, preceded by a numeral designating the number of times the symbol occurs, as 4a.

DIVISION OF MATHEMATICAL SYMBOLS

The quotient of any two symbols a and b where a is the dividend and b is the divisor maybe written a/b.

Summary

1. Addition

   a + b = sum

2. Subtraction

   a – b = difference

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3. Multiplication

   a x b = ab = product

   a + a + a + a = 4a

4. Division

   a ÷ b = a/b = quotient

GROUPING—USE OF PARENTHESES

Occasionally a combination of symbols must be treated as a single symbol. When this occurs, the group is set apart by use of parentheses.

In order to symbolize 5 times the sum of a + b, you should write 5(a + b).

The quotient of a + b divided by 2 is written

$$\frac{(a + b)}{2}$$

REMOVAL OF COMMON FACTORS FROM AN EXPRESSION BY USE OF PARENTHESES

In the expression 2a + 2b + 2c: the common factor may be removed and the remainder combined in parentheses: 2(a + b + c) or in the following: 4ab + 2ac + 6ax.

All the terms contain the factor 2a. The expression may be changed to read 2a(2b + c + 3x).

Since the parentheses indicate that each term within is to be multiplied by the factor outside the parentheses, the parentheses may be removed by multiplying each term by the common factor.

Expression: 2x(2y + 3z + m)

Multiply: 4 x y + 6 x z + 2 x m

SUBSTITUTION OF NUMERICAL VALUES FOR GROUPED SYMBOLS

Consider the expression:

$$\frac{5(a + b)}{2}$$

This means to first: add a and b. Second: multiply the sum by 5. Third: divide the product by 2.

Assign numerical values to a and b.

Let a = 4 and b = 2.

Substitute:

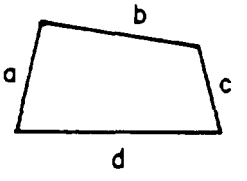
$$\frac{5(4 + 2)}{2} = \frac{5(6)}{2} = \frac{5 \times 6}{2} = \frac{30}{2} = 15$$

PERIMETERS AND CIRCUMFERENCES

Perimeter and circumference have the same meaning; that is, the distance around. Generally, circumference is applied to a circular object and perimeter to an object bounded by straight lines.

PERIMETER OF A POLYGON

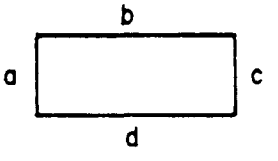
The perimeter of a triangle, quadrilateral, or any other polygon is actually the sum of the sides.



Write an equation for the perimeter(P) of the quadrilateral above.

$P = a + b + c + d$

If this figure were a rectangle,



the formula P= a + b + c + d would still apply, but since opposite sides are equal, we could substitute a for c and b ford and write

$P = 2a + 2b$

If the figure were a square, the formula would become:

$P = 4a$

We may, by the same reasoning, establish that the formula for the perimeter of any regular polygon of n sides having a sides is:

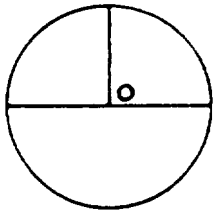
$P = n(s)$

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CIRCUMFERENCE OF A CIRCLE

Definition of Pi: Mathematicians have established that the relationship of the circumference to the diameter of a circle is a constant called Pi and written π. The numerical value of this constant is approximately 3.141592653. For our purpose 3.1416 or simply 3.14 will suffice.

The formula for the circumference of a circle is $C = \pi D$ where C is the circumference and D is the diameter since D = 2R where R is the radius, the formula may be written $C = 2\pi R$.



Given:

Diameter of circle O is 4".

Problem:

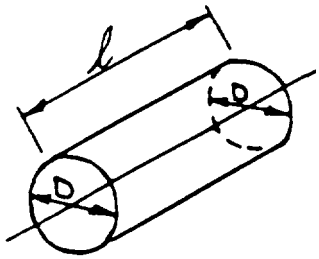
Compute the circumference.

Formula $C = \pi D$

$C = 3.1416 \times 4"$

$C = 12.5664'$

STRETCHOUT OF ROUND OBJECTS



Given:

Diameter of the round pipe= D

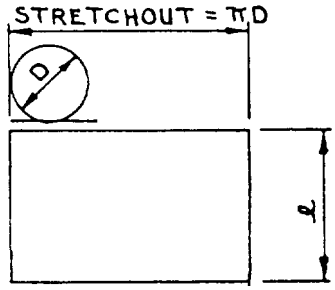
Length of the round pipe= 1

Problem:

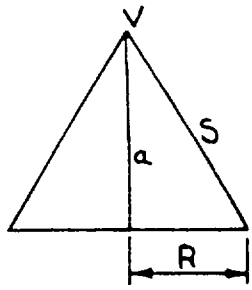
The size of flat sheet necessary to form pipe.

Solution:

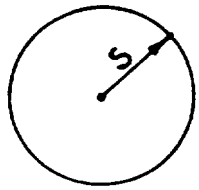
By formula the circumference of the end is πD. If this were rolled out, the stretchout would be πD.



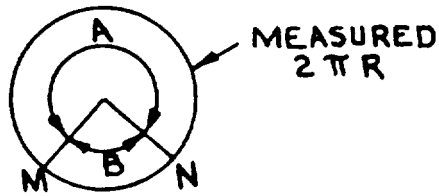
STRETCHOUT OF A RIGHT CIRCULAR CONE



The stretchout of a right circular cone will be a portion of a circle whose radius (S) is equal to the slant height of the cone.



To determine how much of the circle will be required for the cone, you measure on the circumference of this circle the circumference of a circle of radius R.



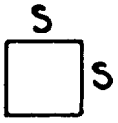
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AREAS

All areas are measured in squares.

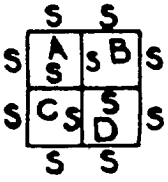
Illustration:

Let one side of a square be s.



This is a square s or s^2.

Ifs equals 1 inch then this would be 1 square inch. Ifs equals 1 foot then this would be 1 square foot, etc.

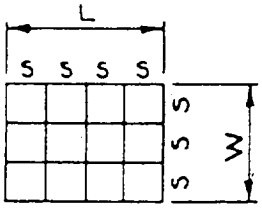


Consider the area of the above. The area of A is one square s or s^2; of B is s^2, etc. The area of the whole is A+ B+ C+ D = s^2+ s^2+ s^2+ s^2= $4s^2$. What is the length of one side? It is obviously 2s, so in the above the area is 2s x 2s = $4s^2$.

The area of a square is the product of two of its sides and since both sides are equal, it may be said to be the square of its side.

NOTE: The area of any plane surface is the measure of the number of squares contained in the object. The unit of measurement is the square of the unit which measures the sides of the square.

AREA OF A RECTANGLE



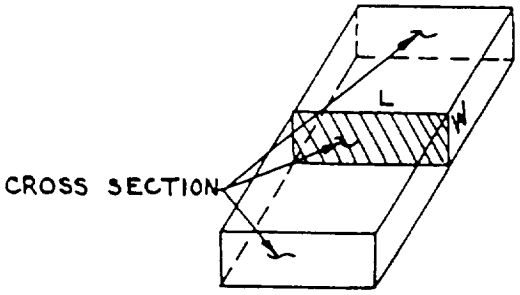
Establish a side of the small square as s and write the formula 3s x 4s = Area. But L = 4s and W = 3s, so our formula becomes

A = L x W

where

A = area of a rectangle
L = length of a rectangle
w = width of a rectangle

AREA OF A CROSS SECTION

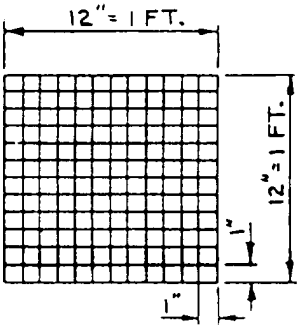


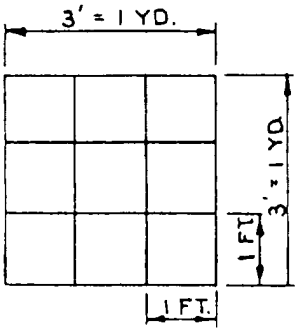
The cross section of an object is a plane figure established by a plane cutting the object at right angles to its axis. The area of this cross section will be the area of the plane figure produced by this cut.

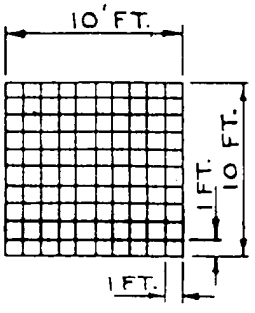
The area of the cross section is L x W.

The most common units are square inches, square feet, square yards and in roofing, "squares."

1 square foot = 144 square inches
1 square yard = 9 square feet
1 square of roofing = 100 square feet







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COMMON CONVERSIONS

1. To convert square inches to square feet, divide square inches by 144.
2. To convert square feet to square inches, multiply by 144.
3. To convert square feet to square yards, divide by 9.
4. To convert square yards to square feet, multiply by 9.
5. To convert square feet to squares, divide by 100.

Example:

1. Convert 1,550 square inches into square feet.

$$144 \text{ sq in.} \overline{)1550 \text{ sq in.}}\ 10.76 \text{ sq ft}$$

2. Convert 15 square feet to square inches.

$$15 \text{ sq ft} \times 144 \text{ sq in.} = 2160 \text{ sq in.}$$

3. Convert 100 square feet to square yards.

$$9 \text{ sq ft} \overline{)100 \text{ sq ft}}\ 11.11 \text{ sq yd}$$

4. Convert 10.3 square yards to square feet.

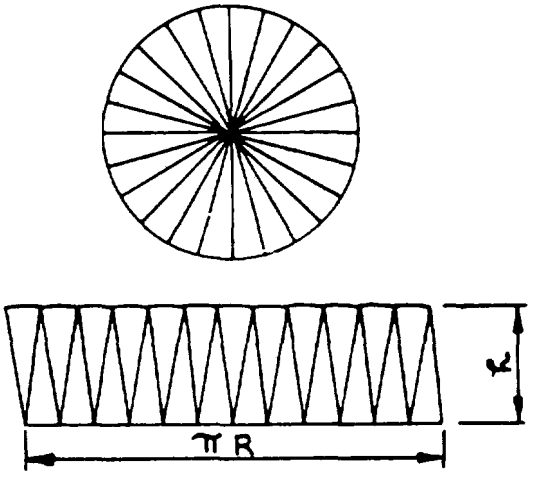
10.3 square yards **x** 9 square feet= 92.7 square feet

5. Convert 17,250 square feet to squares.

$$100 \text{ sq ft} \overline{)17250 \text{ sq ft}}\ 172.5 \text{ squares}$$

AREA OF A CIRCLE

Development of Formula:



The above demonstrates that a circle divided into a number of parts maybe laid out as a parallelogram. As the number of parts is increased, the longer side approaches 1/2 of the circumference; if divided into an indefinite number of parts, it would be equal to 1/2 the circumference. As the number increases, h approaches r and would be equal if the circle was divided into an infinite number of parts.

The areas of the parallelogram is

$$A = bh, \text{ but } b = \pi r$$
$$\text{so } A = \pi rh$$
$$\text{or } A = \pi r \times r$$

The formula for the area of a circle

$$A = \pi r^2$$

where

A = area of circle
r = radius of circle
π = 3.1416

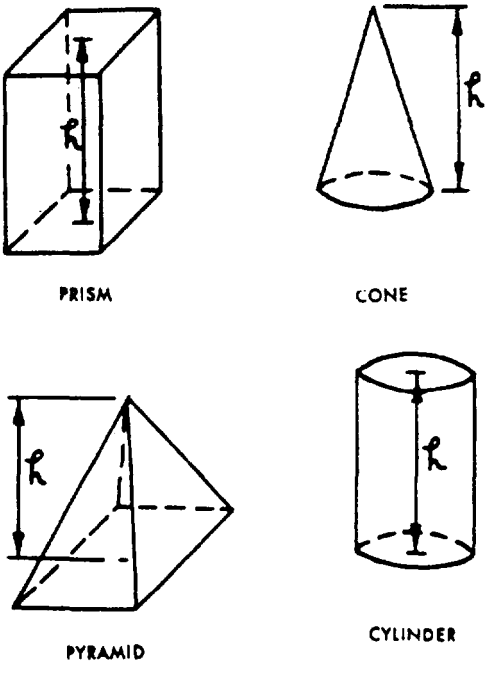
Since r = d/2 where d is the diameter of a circle, the formula for the area of a circle in terms of its diameter is

$$A = \pi \left(\frac{D}{2}\right)^2 = \frac{\pi d^2}{4}$$

GEOMETRIC SOLIDS

In describing plane shapes, you use only two dimensions: width and length; there is no thickness. By adding the third dimension, you describe a solid object.

Consider the solids shown below.



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1. A **PRISM** is a figure whose two bases are polygons, alike in size and shape, lying in parallel planes and whose lateral edges connect corresponding vertices and are parallel and equal in length. A prism is a right prism if the lateral edge is perpendicular the base. The altitude of a prism is the perpendicular distance between the bases.

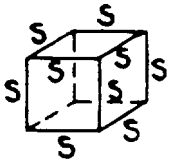
2. A **CONE** is a figure generated by a line moving in such a manner that one end stays fixed at a point called the "vertex." The line constantly touches a plane curve which is the base of the cone. A cone is a circular cone if its base is a circle. A circular cone is a right circular cone if the line generating it is constant in length. The altitude of a cone is the length of a perpendicular to the plane of the base drawn from the vertex.

3. A **PYRAMID** is a figure whose base is a plane shape bounded by straight lines and whose sides are triangular plane shapes connecting the vertex and a line of the base. A regular pyramid is one whose base is a regular polygon and whose vertex lies on a perpendicular to the base at its center. The altitude of a pyramid is the length of a perpendicular to the plane of the base drawn from the vertex.

4. A **CIRCULAR CYLINDER** is a figure whose bases are circles lying in parallel planes connected by a curved lateral surface. A right circular cylinder is one whose lateral surface is perpendicular to the base. (Note: Any reference in this text to a cylinder will mean a circular cylinder.) The altitude of a circular cylinder is the perpendicular distance between the planes of the two bases.

MEASUREMENT OF VOLUME

Volume is measured in terms of cubes,



This represents a cube of sides. The volume of this may be represented by S^3. Ifs equals l", then the volume would be 1 cubic inch, and ifs equals 1', then the volume would be 1 cubic foot, etc.

It can be said that the volume of an object is measured by the number of cubes contained in the object when one side of the cube is equal in length to some unit of linear measure.

COMMON VOLUME FORMULAS

All factors in the formulas must be in the same linear units. As an example, one term could not be expressed in feet while other terms are in inches.

Volume of a Rectangular Prism

$$v = 1 \times w \times h$$

where

v = Volume in cubic inches

w = width of the base in linear units

1 = length of base in linear units

h = altitude of the prism in linear units

Example:

Find the number of cubic inches of water which can be contained by a rectangular can 5" x 6" x 10" high.

$$V = 1 \times w \times h$$

$$V = 5'' \times 6'' \times 10'' = 300 \text{ cubic inches}$$

Volume of a Cone

$$V = \frac{A \times h}{3}$$

or $$V = \frac{\pi r^2 h}{3}$$

or $$V = \frac{\pi d^2 h}{12}$$

where

V = Volume of a cone in cubic units

A = Area of the base in square units

h = Altitude of a cone in linear units

r = Radius of the base

d = Diameter of the base

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Example:

Find the volume of a cone whose altitude is 2'6" and whose base has a radius of 10".

$$V = \frac{\pi r^2 h}{3} = \frac{\pi(10)^2\,(30)}{3} = \pi(1000)$$

$= 3141.6$ cubic inches

Volume of a Pyramid

$$V = \frac{Ah}{3}$$

where

V = Volume in cubic units

A = Area of a base in square units

h = Altitude in linear units

Example:

Find the volume of a rectangular pyramid whose base is 3" x 4" and whose altitude is 6".

Area of the base= 3 x 4 = 12 square inches

$$V = \frac{12 \times 6}{3} = 24 \textit{ cubic inches}$$

Volume of a Cylinder

$$V = Ah$$

or $V = \pi r^2 h$

$$\text{or } V = \frac{\pi d^2 h}{4}$$

where

V = Volume in cubic units

A = Area of the base in square units

h = Altitude in linear units

r = Radius of the base

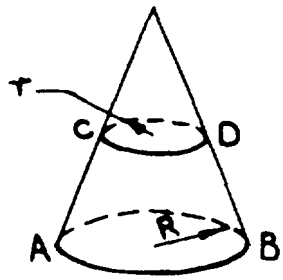
d = Diameter of the base

Example:

Find the volume of a cylindrical tank whose diameter is 9'6" and whose height is 11' 6".

$$V = \frac{3.1416(9.5)^2 \times 11.5}{4} = 815.15 \textit{ cubic feet}$$

Volume of the Frustum of a Right Circular Cone



The frustum of a cone is formed when a plane is passed parallel to the base of the cone. The frustum is the portion below base CD. The altitude of the frustum is the perpendicular distance between the bases.

$$V = 1/3\pi h(r^2 + R^2 + Rr)$$

where

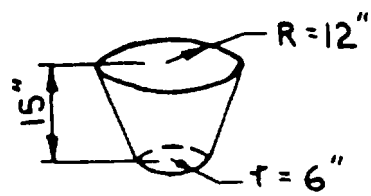
h = Altitude in linear units

r = Radius of the upper base in linear units

R = Radius of the lower base in linear units

Example:

Find the volume of a conical shaped container whose dimensions are indicated in the drawing.



$V = 1/3\pi h(r^2 + R^2 + Rr)$

$V = 1/3\pi 15(6^2 + 12^2 + 6 \times 12)$

$V = 5\pi(36 + 144 + 72)$

$V = 5x(252)$

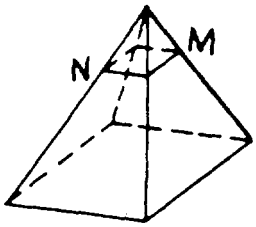
$V = 3956.4$ *cubic inches*

Volume of a Frustum of a Regular Pyramid

A frustum of a pyramid is formed when a plane is passed parallel to the base of the pyramid. The frustum

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is the portion below plane MN. The altitude is the perpendicular distance between the bases.



$$V = 1/3h(B + b + \sqrt{Bb})$$

where

V = Volume of the frustum in cubic units

h = Altitude in linear units

B = Area of the lower base in square units

b = Area of the upper base in square units

Example:

Find the volume of a frustum of a square pyramid if one side of its upper base is 2" and one side of the lower base is 8". The distance between the bases is 10".

The area of the bases will be

$B = (8)^2$

$b = (2)^2$

$V = 1/3 \times 10\,(8^2 + 2^2 + \sqrt{8^2 + 2^2})$

$V = 1/3x10[64+4+(8+2)]$

$V = 1/3x10(64+4+16)$

V = 1/3x10x84

$V = 280$ *cu in.*

Conversion of Units of Cubic Measure

It is often necessary to convert from one cubic measure to another. The conversion factors used are as follows:

1 cubic foot = 1,728 cubic inches

1 cubic yard= 27 cubic feet

1 cubic foot = 7.48 U.S. gallons (liquid measure)

1 U.S. gallon (liquid measure) = 231 cubic inches

1 bushel (dry measure) = 2,150.42 cubic inches

Example:

1. How many cubic feet are there in 4,320 cubic inches?

```
      2.5 cubic feet
1728|4320
    3456
     8640
     8640
```

To convert cubic inches to cubic feet, divide by 1,728.

2. How many cubic inches are there in 3.5 cubic feet?

```
1728
 3.5
8640
5184
6048.0 cubic inches
```

To convert cubic feet to cubic inches, multiply by 1,728.

3. How many cubic yards are there in 35 cubic feet?

```
     1.29
27|35.00
  27
   80
   54
  260
  243
   17
```

To convert cubic feet to cubic yards, divide by 27.

To convert cubic yards to cubic feet, multiply by 27.

4. How many gallons are contained in a tank having a volume of 25 cubic feet?

```
 7.48
  25
3740
1496
187.00 gallons
```

To change cubic feet to,gallons, multiply by 7.48.

To change gallons to cubic feet, divide by 7.48.

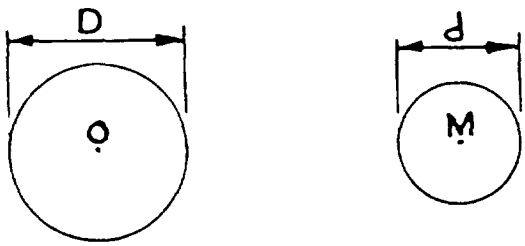
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RATIO

The ratio of one number to another is the quotient of the first, divided by the second. This is often expressed as a:b, which is read the ratio of a to b. More commonly, this is expressed as the fraction a/b.

Ratio has no meaning unless both terms are expressed in the same unit by measurement.

Example:



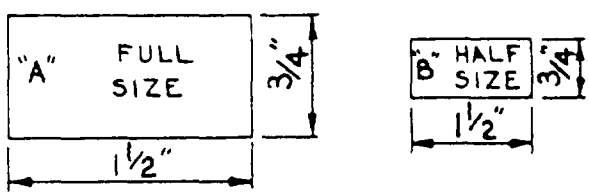
What is the ratio of the diameter of circle O to circle M? This ratio is D:d or D/d. If the diameter of O is 3 inches and the diameter of M is 1.5 inches, then the ratio of the diameters of circle O and circle M would be 3/1.5 or 2/1 (read “ratio of two 1 to one”).

What is the ratio of the diameter of circle M to the diameter of circle O?

RATIO APPLIED TO SCALE DRAWINGS

Since it is not always possible to make a drawing full size, the size of the drawing maybe made in a given ratio to the full size of the object.

Example:



In the above example, A represents the object in its full size and B represents a drawing one-half size. The ratio of the drawing B to object A is one to two. (1/2) (1:2)

Drawings may be commonly “scaled down” by the use of the following ratios:

Let:

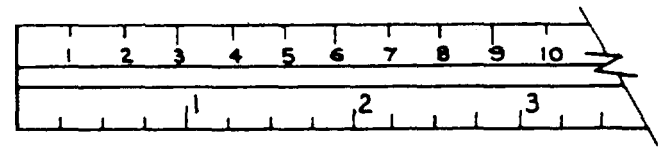
1/4 = 1'0" or a ratio of (1/48) or (1 to 48)

1/8” = 1'0" or a ratio of (1/96) or (1 to 96)

3 = 1'0" or a ratio of (1/4) or (1 to 4)

3/8 = 1'0" or a ratio of (1/32) or (1 to 32)

CIRCUMFERENCE RULE



The above illustration shows a portion of a circumference rule. This is an example of the application of a ratio. The upper edge of the rule is graduated in such a manner that one inch on the upper scale is in the ratio of 3.1416 to 1 on the lower scale. This is in the ratio of the circumference of a circle to its diameter, so that any diameter can be converted to a circumference or vice versa by reading directly across the rule.

In sheet metal pattern development, effective use can be made of the circumference rule. By using the circumference side, you can lay out the development of large objects. After making the layout, you can make the development of the pattern full size.

PERCENTAGE

Percentage (%) is a way of expressing the relationship of one number to another. In reality, percentage is a ratio expressed as a fraction in which the denominator is always one hundred.

Example:

The ratio of 6 to 12, expressed as %:

$$.2\overline{)6.0}\quad .5$$

The ratio of 6 to 12 may be expressed as .5 or 1. To change to %, move the decimal two places to the right.

$$\frac{.5}{1} = \frac{50}{100} = 50\%$$

This means there are 50 parts to 100.

From a galvanized iron sheet weighing 46 1/4 pounds, an "ell" and one section of pipe were produced

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which weighed 30 pounds. Find the percentage of the scrap.

$$\begin{array}{ll} 40\ 1/4 & \text{total weight} \\ -30 & \text{amount used} \\ 16\ 1/4 & \text{weight of scrap} \end{array}$$

$$\frac{16\ 1/4}{46\ 1/4} = .351 = 35.1\%$$

PROPORTION

Proportion is a statement of two ratios which are equal.

Example:

1/3=5/15 or 1:3=5:15

$$\frac{r}{3} = \frac{3r}{9} = r{:}3 = 3r{:}9$$

SOLVING PROPORTIONS

Given the proportion:

$$\frac{a}{b} = \frac{c}{d}$$

by cross multiplying: a x d = b x c

Example:

If 50 sheets of galvanized iron weigh 2,313 pounds, how much will 39 sheets weigh?

Let W = weight of 39 sheets

$$\frac{39}{50} = \frac{W}{2313}$$

CROSS MULTIPLY

$$50 \times W = 39 \times 2313$$

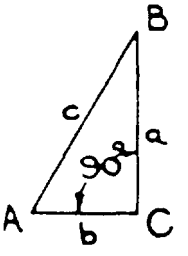
$$W = \frac{39 \times 2313}{50} = 1804.14$$

THE LAW OF PYTHAGORAS

The Law of Pythagoras is the square of the hypotenuse of a right triangle equals the sum of the squares of the two legs. It is expressed by the formula $a^2 + b^2 = c^2$.

1. **RIGHT TRIANGLE—** triangle having one right angle.
2. **HYPOTENUSE—** The hypotenuse of a right triangle is the side opposite the right angle.
3. **LEG—** The leg of a right triangle is a side opposite an acute angle of a right triangle.

Δ ABC is a right triangle.



$\angle$C is a right angle.

c is side opposite $\angle$C and is the hypotenuse.

a is side opposite $\angle$A and is a leg.

b is side opposite $\angle$B and is a leg.

According to the Law of Pythagoras:

$$a^2 + b^2 = c^2$$

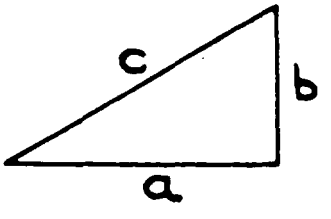
or by subtracting b^2 from both sides

$$a^2 = c^2 - b^2$$

or by subtracting a^2 from both sides

$$b^2 = c^2 - a^2$$

Example:



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1. Given: a = 10; b= 7

Problem: find c.

$$a^2 + b^2 = c^2$$

$$10^2 + 7^2 = c^2$$

$$c^2 = 100 + 49$$

$$c = \sqrt{149} = 12.2$$

2. Given: C = 50; b = 40

Problem: find a

$$a^2 = c^2 - b^2$$

$$a^2 = 2500 - 1600$$

$$a^2 = 900$$

$$a = 30$$

3. Proof of a 3,4,5 triangle.

A right triangle can be constructed by making the sides 3, 4, and 5. We can prove it by the Law of Pythagoras.

$$a^2 + b^2 = c^2$$

$$3^2 + 4^2 = 5^2$$

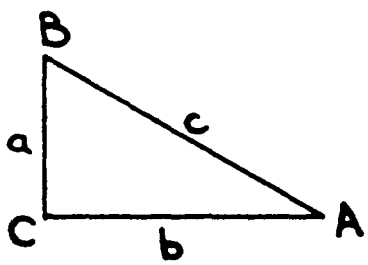
$$9 + 16 = 25$$

$$25 = 25$$

Since values of 3,4, and 5 satisfy the equation, we may conclude that the statement above is correct.

4. Application of the Law of Pythagoras

Given a right triangle ABC:



Prove that the area of a circle of a diameter of side c is equal to the sum of the areas of circles whose diameters are sides a and b.

area circle diameter c = area circle diameter a + area circle diameter b.

$$\text{area circle } c = \frac{\pi c^2}{4}$$

$$\text{area circle } a = \frac{\pi a^2}{4}$$

$$\text{area circle } b = \frac{\pi b^2}{4}$$

Then:

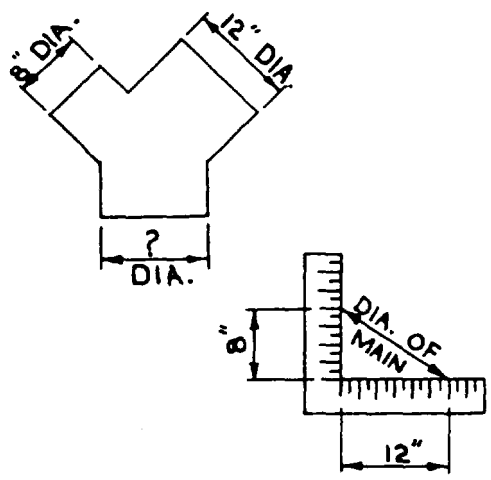
$$\frac{\pi c^2}{4} = \frac{\pi a^2}{4} = \frac{\pi b^2}{4}$$

$$c^2 = a^2 + b^2 \left[\text{multiply both sides by } \left(\frac{4}{\pi}\right)\right]$$

Since this is the rule of the right triangle, the above statement is true.

Example:

In the Y branch shown, the areas of the two branches must equal the area of the main. By the above proof, if the two known diameters are considered to be legs of a right triangle, the hypotenuse will be the diameter of the main.



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APPENDIX III

METRIC CONVERSION TABLE

ENGLISH AND METRIC SYSTEM UNITS OF MEASUREMENT
COMMON EQUIVALENTS AND CONVERSIONS

Approximate Common Equivalents		Conversions Accurate to Parts Per Million (units stated in abbreviated form)	
		Number × Factor	
1 inch	= 25 millimeters	in × 25.4*	= mm
1 foot	= 0.3 meter	ft × 0.3048*	= m
1 yard	= 0.9 meter	yd × 0.9144*	= m
1 mile†	= 1.6 kilometers	mi × 1.60934	= km
1 square inch	= 6.5 square centimeters	in^2 × 6.4516*	= cm^2
1 square foot	= 0.09 square meter	ft^2 × 0.0929030	= m^2
1 square yard	= 0.8 square meter	yd^2 × 0.836127	= m^2
1 acre	= 0.4 hectare	acres × 0.404686	= ha
1 cubic inch	= 16 cubic centimeters	in^3 × 16.3871	= cm^3
1 cubic foot	= 0.03 cubic meter	ft^3 × 0.0283168	= m^3
1 cubic yard	= 0.8 cubic meter	yd^3 × 0.764555	= m^3
1 quart (1q.)	= 1 liter	qt (1q.) × 0.946353	= *l*
1 gallon	= 0.004 cubic meter	gal × 0.00378541	= m^3
1 ounce (avdp)	= 28 grams	oz (avdp) × 28.3495	= g
1 pound (avdp)	= 0.45 kilogram	lb (avdp) × 0.453592	= kg
1 horsepower	= 0.75 kilowatt	hp × 0.745700	= kW
1 pound per square inch	= 0.97 kilogram per square centimeter	psi × 0.0703224	= kg/cm^2
1 millimeter	= 0.04 inch	mm × 0.0393701	= in
1 meter	= 3.3 feet	m × 3.28084	= ft
1 meter	= 1.1 yards	m × 1.09361	= yd
1 kilometer	= 0.6 mile	km × 0.621371	= mi
1 square centimeter	= 0.16 square inch	cm^2 × 0.155000	= in^2
1 square meter	= 11 square feet	m^2 × 10.7639	= ft^2
1 square meter	= 1.2 square yards	m^2 × 1.19599	= yd^2
1 hectare	= 2.5 acres	ha × 2.47105	= acres
1 cubic centimeter	= 0.06 cubic inch	cm^3 × 0.0610237	= in^3
1 cubic meter	= 35 cubic feet	m^3 × 35.3147	= ft^3
1 cubic meter	= 1.3 cubic yards	m^3 × 1.30795	= yd^3
1 liter	= 1 quart (1q.)	*l* × 1.05669	= qt (1q.)
1 cubic meter	= 250 gallons	m^3 × 264.172	= gal
1 gram	= 0.035 ounces (avdp)	g × 0.0352740	= oz (avdp)
1 kilogram	= 2.2 pounds (avdp)	kg × 2.20462	= lb (avdp)
1 kilowatt	= 1.3 horsepower	kW × 1.34102	= hp
1 kilogram per square centimeter	= 14.2 pounds per square inch	kg/cm^2 × 14.223226	= psi

†nautical mile = 1.852 kilometers

* exact

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APPENDIX IV

HAND SIGNALS

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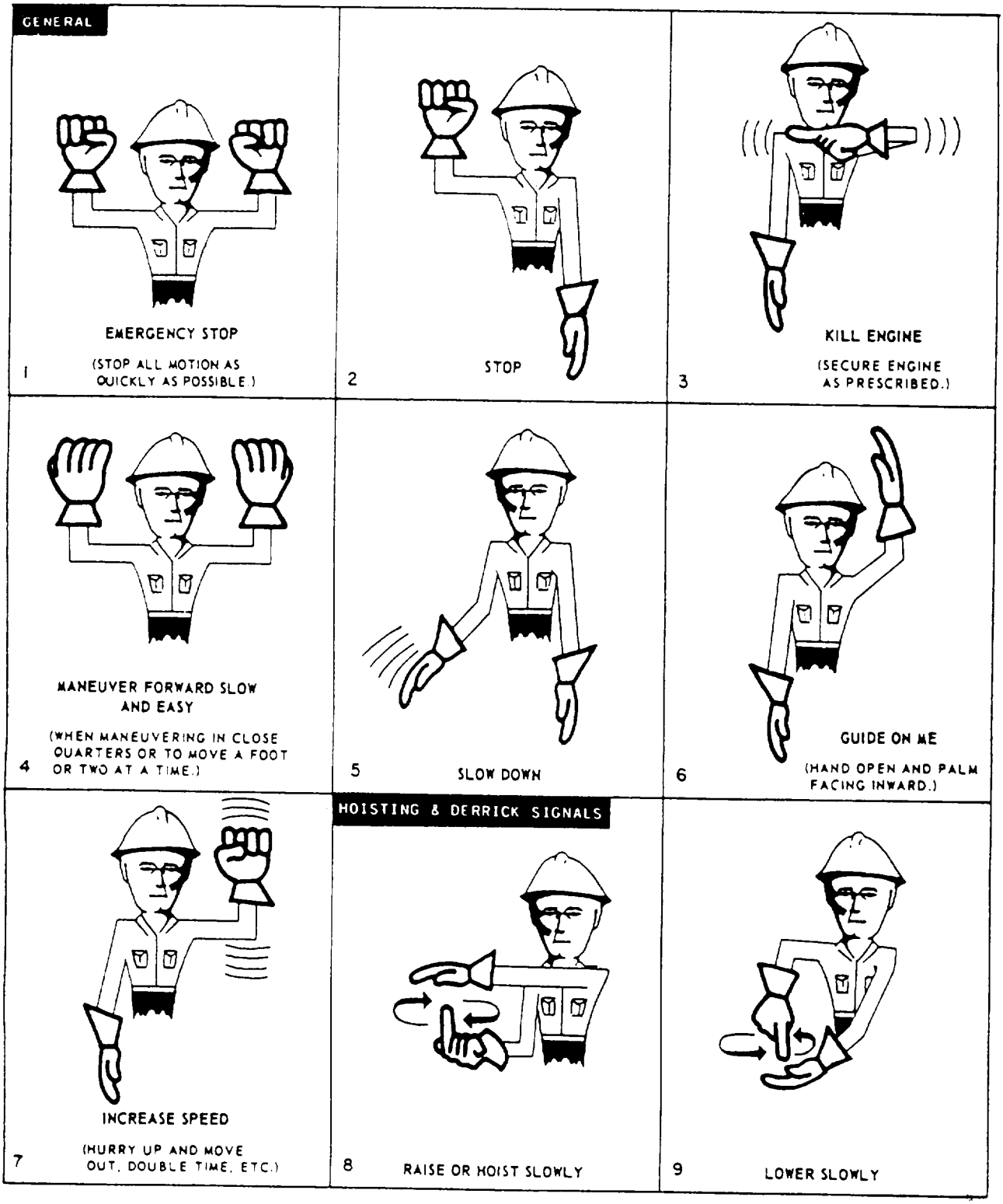


Figure AIV-l.—Hand signals.

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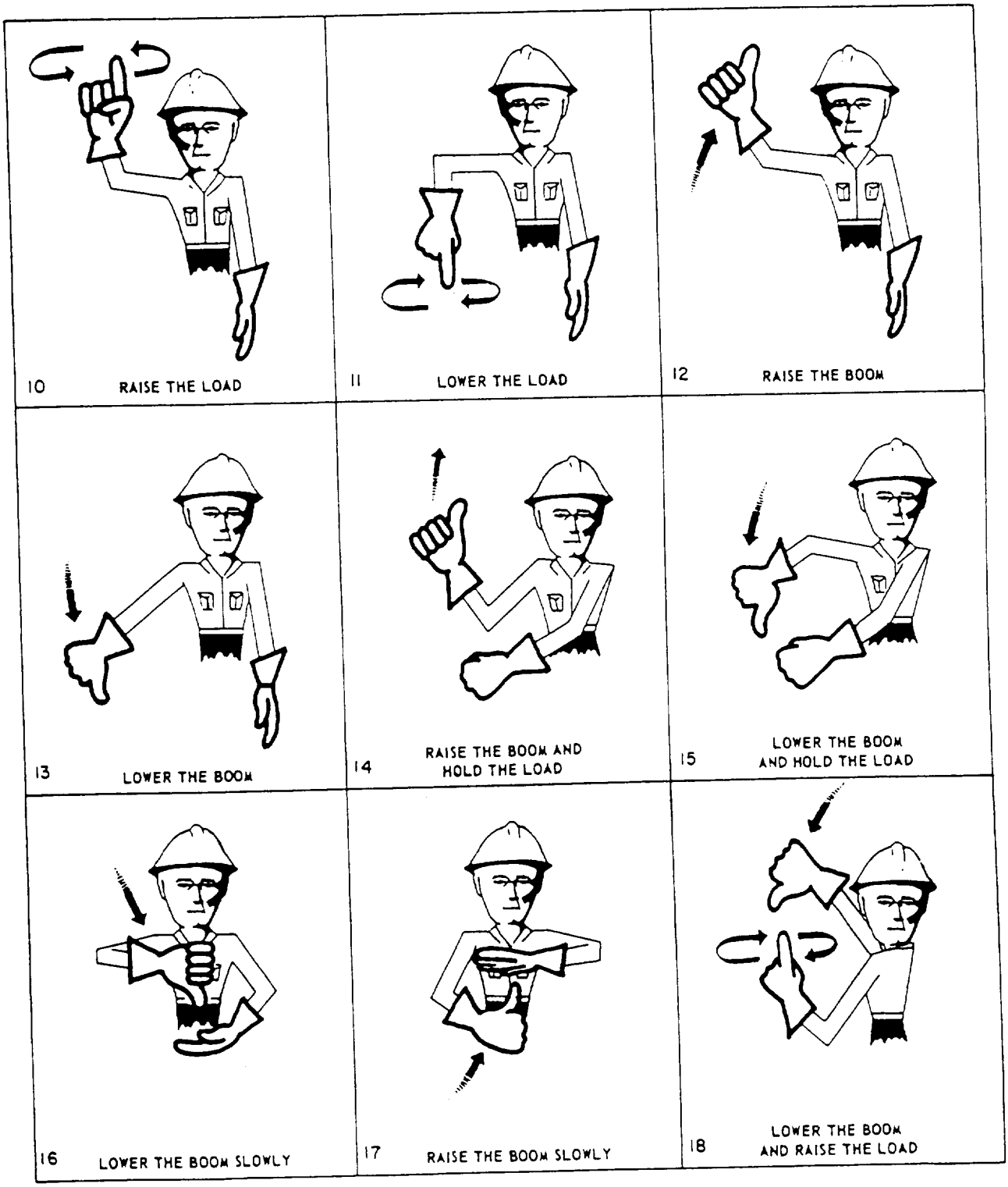
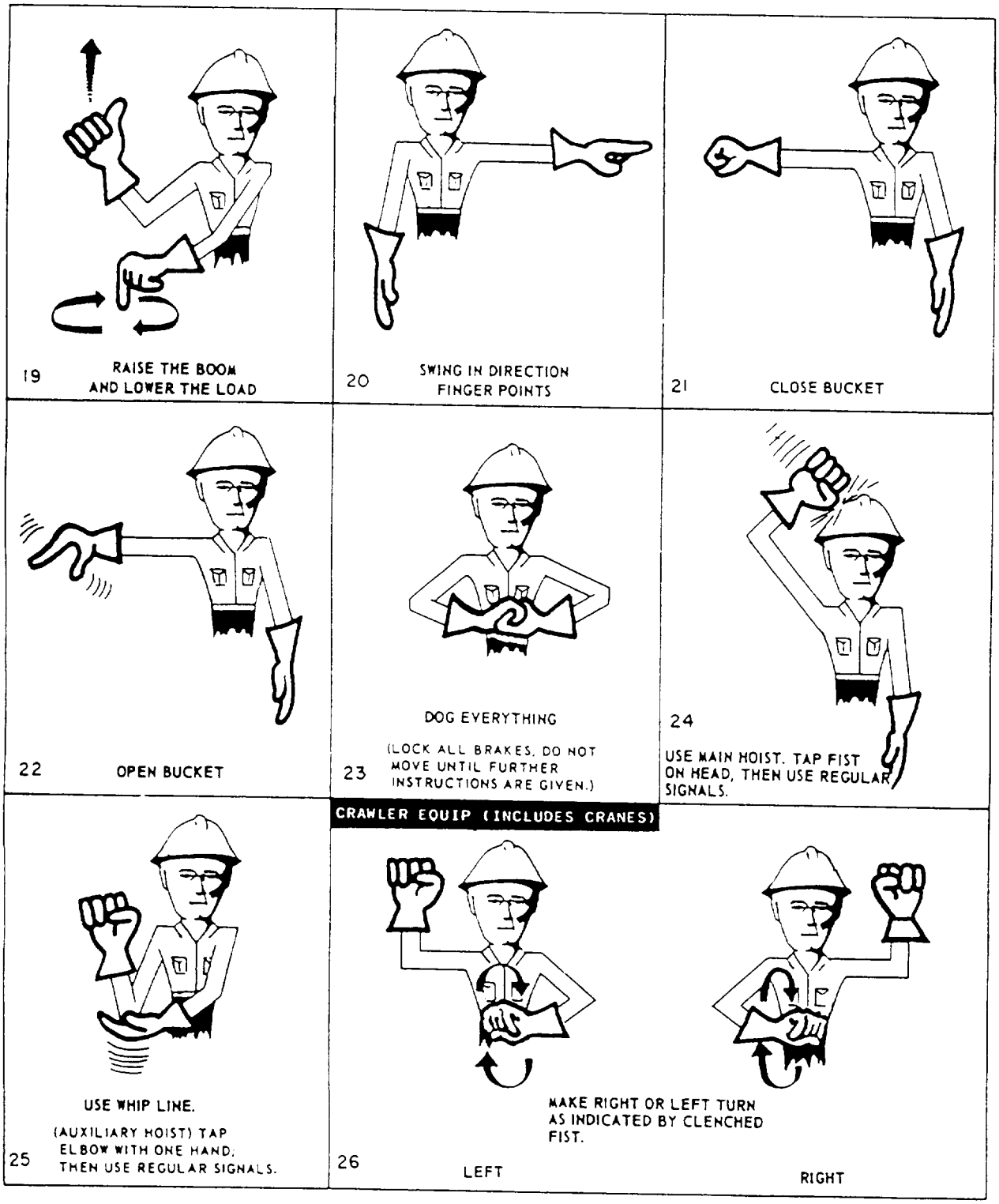


Figure AIV-1.—Hand signals—Continued.

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F]gure AIV-1.—Hand signals.—Continued.

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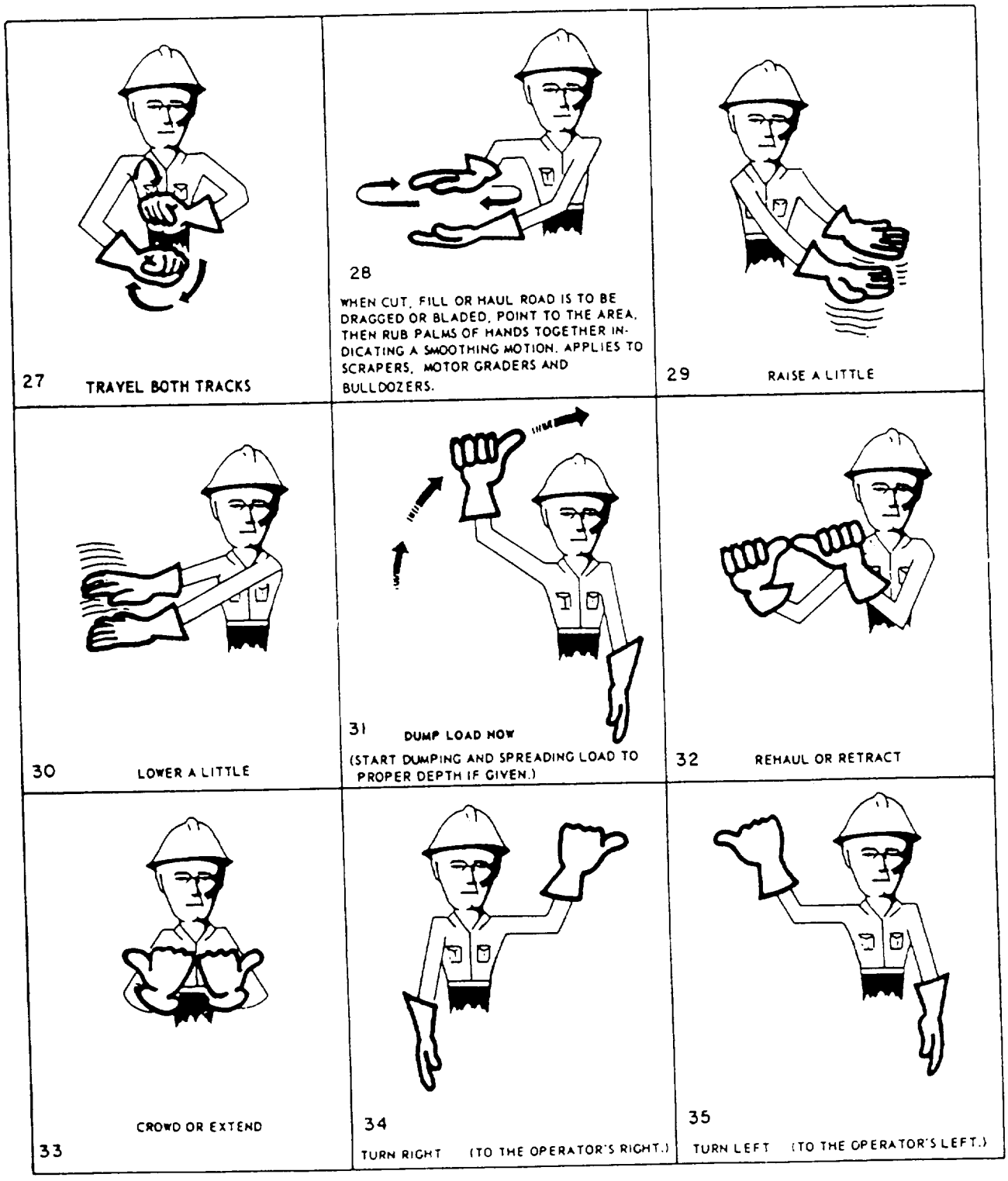


Figure AIV-l.—Hand signals—Continued.

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APPENDIX V

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Chapter 12

Steelworker 3 &2, NAVEDTRA 10652-F, Naval Education and Training Program Management Support Activity, Pensacola FL, 1977.

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Assignment Questions

Information: The text pages that you are to study are provided at the beginning of the assignment questions.

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ASSIGNMENT 1

Textbook Assignment: "Technical Administration," pages 1-1 through 1-30.

Learning Objective: Identify the principles and techniques a crew leader applies in job planning, supervision, and production.

1-1. When you become a petty officer, you take on which of the following responsibilities?

1. Company clerk
2. Project manager
3. Project estimator
4. Crew leader

1-2. Administration is the mechanical means petty officers use to accomplish which of the following functions?

1. To plan, organize, supervise, manage, and document activities
2. To apply their technical knowledge in directing personnel
3. To ensure their subordinates work as efficiently as possible
4. To set training goals for newly assigned supervisors

1-3. You are assigned duty as a petty officer in charge of a crew. What is your first responsibility before you make any work assignments?

1. To pass on to the operations officer the details of getting the job done
2. To ensure your crew understands what is expected of them
3. To establish daily work goals for your crews
4. To determine whether equipment for the job is appropriate

1-4. To ensure a job is completed on schedule, you should take which of the following actions?

1. Order extra equipment
2. Conduct training
3. Demand quality work
4. Encourage teamwork and establish goals

1-5. To ensure a job is completed on on schedule, you should take which of the following actions?

1. Order extra equipment
2. Conduct training
3. Demand quality work
4. Encourage teamwork and establish goals

1-6. Many young Seabees ignore danger or think a particular regulation is unnecessary. You, as a crew leader, can correct this problem by taking which of the following actions?

1. Rotating work assignments
2. Giving proper instruction and training
3. Criticizing them openly
4. Scheduling projects appropriately

Learning Objective: Identify the procedures for tool kit maintenance, inspection, and material requisitioning.

1-7. A tool kit contains the hand tools required for a crew of what size?

1. Five
2. Two
3. Three
4. Four

1-8. As a crew leader, you must schedule tool kit inventories at what time intervals?

1. Daily
2. Weekly
3. Monthly
4. Bimonthly

1-9. Which of the following forms is a crew leader most likely to use when ordering materials?

1. DD Form 1148
2. DD Form 1250
3. NAVSUP Form 1149
4. NAVSUP Form 1250

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1-10. Of the following rate training manuals, which one offers information on the National Stock Number System?

1. Military Requirements for Petty Officer Third Class
2. Blueprint Reading and Sketching
3. Tools and Their Uses
4. Constructionman

Learning Objective: Identify the purpose of reporting labor hours used on given projects, the categories of labor, and the type of information that is entered on the daily labor distribution report.

1-11. A labor accounting system is required to measure the man-hours that a unit spends on various functions.

1. True
2. False

A.	Direct
B.	Indirect
C.	Overhead
D.	Military

Figure 1A

IN ANSWERING QUESTIONS 1-12 THROUGH 1-14, REFER TO FIGURE 1A.

1-12. Labor that contributes to the product but does not produce an end product itself.

1. A
2. B
3. c
4. D

1-13 Labor that does not contribute directly or indirectly to the end product, but includes all labor that must be performed regardless of the assigned mission.

1. A
2. B
3. c
4. D

1-14 Labor that contributes directly to the completion of the end product.

1. A
2. B
3. c
4. D

1-15. What is the labor code for an embarkation?

1. D02
2. M03
3. M08
4. X05

1-16. When you attend a leadership school at Port Hueneme, your time is reported on the daily time card under what labor code?

1. X08
2. XOl
3. T04
4. MO5

1-17. Refer to textbook figure 1-4. The 2 hours shown for Aaron represent time spent in what labor category?

1. Training
2. Overhead
3. Indirect
4. Disaster control operations

1-18. After a daily labor distribution report form is filled out, it should be initialed by what person?

1. The company chief
2. The platoon commander
3. The assistant company commander
4. The company commander

1-19. The daily labor distribution reports from each company are compiled and tabulated by what organizational unit?

1. The Supply Department
2. The Management Department of the Operations Department
3. The Training Department
4. The Engineering and P&E Division

1-20. Information from the daily labor distribution report serves as a feeder report to the operations officer, as well as a construction management analysis source document, for which of the following personnel?

1. Crew leaders
2. Platoon leaders
3. The company chief
4. Each of the above

Learning Objective: Recognize the principles of the Personnel Readiness Capabilities Program (PRCP), the Safety Program, and the responsibilities of key personnel.

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1-21. PRCP provides for collecting information on which of the following subjects?

1. Predeployment planning
2. Readiness of an NCF unit
3. Training publications available to the NCF
4. Prior military service education

1-22. Newly acquired skills are reported to which of the following personnel?

1. The company commander
2. The educational services officer
3. The PRCP coordinator
4. The company clerk

1-23. What person directs the safety policy committee?

1. The safety chief
2. The company chief
3. The administration officer
4. The executive officer

1-24. What is the primary objective of the safety policy committee?

1. To develop a safety doctrine and policy for a battalion
2. To discipline personnel involved in an accident
3. To elect a battalion safety chief and members of the committee
4. To review all vehicle accident reports and determine the causes of accidents

1-25. The safety supervisors' committee serves what primary purpose?

1. It maintains safety programs for each project
2. It collects and exchanges safety information and policies between projects
3. It advises the safety division on safety procedures
4. It investigates accidents that occur on the job

1-26. Recommendations for improving safety on the job should be forwarded to the safety policy committee via the safety supervisors' committee.

1. True
2. False

1-27. What safety group should you, as a crew leader, contact when recommending changes in safety matters?

1. Safety division
2. Supervisors' safety committee
3. Safety policy committee
4. Crew safety committee

1-28. As a leader of a crew working on a construction project, you are responsible for which of the following duties?

1. Training your crew members conditions
2. Correcting unsafe practices and conditions
3. Executing certain procedures when a crew member is involved in an accident
4. All of the above

1-29. What person is responsible for conducting short stand-up safety meetings?

1. Safety chief
2. Safety officer
3. Crew leader
4. Company chief

1-30. In addition to discussing project safety during stand-up safety meetings, which of the following topics of concern should be included?

1. Vehicle safety
2. Prestart checks
3. Equipment maintenance
4. All of the above

1-31. What is one of the most practical safety techniques that you, as a crew leader, can apply?

1. Stand-up meetings
2. Reprimanding violators in front of their peers
3. Designating a crew member as a safety representative
4. Leadership by example

Learning Objective: Recognize the procedures and documentation for hazardous material warnings, handling, and turn-in procedures.

1-32. A material safety data sheet (MSDS) is required to be on site for all hazardous material.

1. True
2. False

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1-33. A material safety data sheet does NOT contain which of the following information?

1. All hazards associated with exposure to the material
2. Applicable laws governing use
3. Personnel protective equipment/safety precautions
4. First-aid/medical treatment for exposure

1.	Health hazard
2.	Fire hazard
3.	Reactivity
4.	Specific hazard

Figure 1B

IN ANSWERING QUESTIONS 1-34 THROUGH 1-37, REFER TO FIGURE 1B.

1-34. In a hazardous code chart, what does the top diamond indicate?

1. 1
2. 2
3. 3
4. 4

1-35. In the hazardous code chart, what does the bottom diamond indicate?

1. 1
2. 2
3. 3
4. 4

1-36. In the hazardous code chart, what does the right diamond indicate?

1. 1
2. 2
3. 3
4. 4

1-37. In the hazardous code chart, what does the left diamond indicate?

1. 1
2. 2
3. 3
4. 4

1-38. The degree of hazard is indicated on the code chart numerically from O through 4. As the number increases, the threat decreases.

1. True
2. False

1-39. Concerning the use of hazardous material, you should practice what safety rule?

1. Draw all material needed for an entire project
2. Draw material between each phase of a project
3. Draw only daily requirements
4. Draw weekly requirements

1-40. Hazardous material must be stored in approved containers and stored what distance from an ignitable source?

1. 15 feet
2. 25 feet
3. 35 feet
4. 50 feet

1-41. When turning in hazardous materials, you must submit a legible MSDS with the material.

1. True
2. False

Learning Objective: Identify principles and techniques for planning and estimating projects.

1-42. In planning a construction project, you should be concerned with which of the following estimates?

1. Equipment
2. Material
3. Manpower
4. All of the above

1-43. Activity quantities provide the basis for preparing the material, equipment, and manpower estimates.

1. True
2. False

1-44. According to NAVFAC P-405, Seabee Planner's and Estimator's Handbook, a man-day is based upon how many hours?

1. 8
2. 9
3. 10
4. 12

1-45. According to NAVFAC P-437, Facilities Planning Guide, a man-day consists of how many hours?

1. 8
2. 9
3. 10
4. 12

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1-46. A “material takeoff” is also known by what other term?

1. A material estimate
2. An equipment summary
3. A work element
4. A takeoff

1-47. Equipment estimates do NOT contain which of the following information?

1. Types of equipment
2. Number of equipment required
3. Fuel required
4. Time required on site

1-48. As an estimator for a construction project, manpower estimates must contain sufficient detail to list man-days for all ratings assigned to each activity.

1. True
2. False

Learning Objective: Identify the different types of construction drawings and their uses.

1-49. What type of drawings contains size, quantity, location, and relationship of building components?

1. Master plan drawings
2. Project drawings
3. Red-lined drawings
4. As-built drawings

1-50. What type of drawings consists of boundary lines, acreage, locations, and descriptions of existing and proposed structures, existing utilities, north point indicator (arrow), and contour lines?

1. Master plan drawings
2. Project drawings
3. Red-lined drawings
4. As-built drawings

1-51. During construction, you should mark up what type of drawing to indicate a minor change or a field adjustment?

1. Master plan drawings
2. Project drawings
3. Red-lined drawings
4. As-built drawings

1-52. What type of drawing is made to indicate changes to a completed project?

1. Master plan drawings
2. Project drawings
3. Red-lined drawings
4. As-built drawings

1-53. The order of project drawings is always the same.

1. True
2. False

1-54. Title blocks may vary in format but contain the same information.

1. True
2. False

1-55. The revision block is at what location on the drawing?

1. Top left corner
2. Bottom left corner
3. Top right corner
4. Bottom right corner

1-56. A revision block contains what type of revisions?

1. Environmental
2. Structural
3. Supplementary
4. Site

1-57. Graphic scales must be shown prominently on each drawing, because when drawings are reduced in size, the reductions are often not scaled to proportion.

1. True
2. False

1-58. What is the purpose of “specific notes” on a project?

1. To give dimensional information
2. To be explanatory
3. To save space
4. Each of the above

1-59. Working drawings do NOT serve which of the-following functions?

1. Provide a basis for making material, labor, and equipment estimates
2. Complement the specifications; one is complete without the other
3. Provide a means of coordination between ratings
4. Provide extensive environmental and pollution control information

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1-60. Civil working drawings do NOT include which of the following plans and information?

1. Site prep and site development
2. Fencing
3. Comprehensive instructions for construction
4. Water supply units

Learning Objective: Identify the BASIC concepts and principles of project management (project packages) .

1-61. A project package consists of a total of how many files.

1. 7
2. 8
3. 9
4. 10

1-62. In a project package, the safety plan is kept in what file?

1. File 1
2. File 5
3. File 3
4. File 7

1-63. At what location in a project package should you find the master activity sheets and the level II?

1. File 1, left side
2. File 3, left side
3. File 3, right side
4. File 1, right side

1-64. What file contains all authorizing and coordinating information about a project?

1. File 1
2. File 2
3. File 3
4. File 4

1-65. The construction activity summary sheets are contained in what file?

1. File 2, right side
2. File 2, left side
3. File 3, right side
4. File 3, left side

1-66. Project level IIIs are located in what file?

1. General information
2. Correspondence
3. Activity
4. Network

1-67. In what file are field adjustment requests filed?

1. Quality control
2. Correspondence
3. Activity
4. Plans

1-68. The project specifications are found in what file?

1. File 5
2. File 3
3. File 7
4. File 9

1-69. A list of long lead items is filed in the left side of what file?

1. File 1
2. File 2
3. File 3
4. File 5

1-70. The right side of the Safety/Environmental file contains which of the following information?

1. Safety plan
2. Highlighted EM 385
3. Environmental plan
4. Each of the above

1-71. The left side of the specifications file contains technical data for the project.

1. True
2. False

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ASSIGNMENT 2

Textbook Assignment: "Layout and Fabrication of Sheet Metal and Fiber-glass Duct," pages 2-1 through 2-39.

Learning Objective: Identify the tools and equipment needed for measuring and fabricating sheet metal and recognize their uses.

2-1. The procedure for measuring and marking material for the cutting, drilling, and/or welding of metal is known by the term "layout."

1. True
2. False

2-2. What type of tool is most frequently used to scribe lines on sheet metal?

1. Prick punches
2. Trammel points
3. Scratch awls
4. Dividers

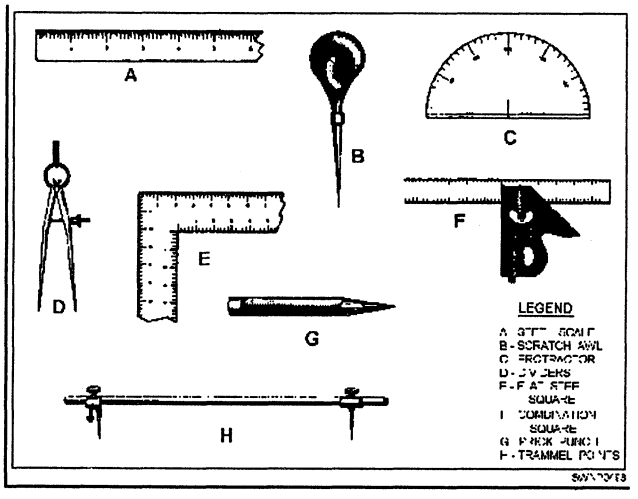


Figure 2A

IN ANSWERING QUESTIONS 2-3 THROUGH 2-6, REFER TO FIGURE 2A.

2-3. To construct parallel lines in layout work, you should first clamp tool A to the base line of your work. What other tools in figure 2A do you need to complete the job?

1. D and C
2. C and G
3. B and E
4. A and D

2-4. You need to draw a line that cuts the base line of your layout work at an angle of 45 degrees. Of the tools in the figure, which one is quickest and easiest to use in constructing this angle?

1. C
2. D
3. E
4. F

2-5. What layout tool should you use to mark a point on your work?

1. B
2. D
3. G
4. H

2-6. Which of the tools is required to scribe a circle having a radius of 22 inches?

1. B
2. C
3. D
4. H

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2-7. To construct a right angle by bisecting a base line, you must set the dividers for what distance?

1. To exactly one half of the length of the base line
2. To less than one half of the length of the base line
3. To more than one half of the length of the base line
4. Equal to the length of the base line

2-8. In a simple drip pan layout, the radius of a corner arc is equal to what dimension of the pan?

1. Its depth
2. Its length
3. Its width
4. Its diagonal cross section

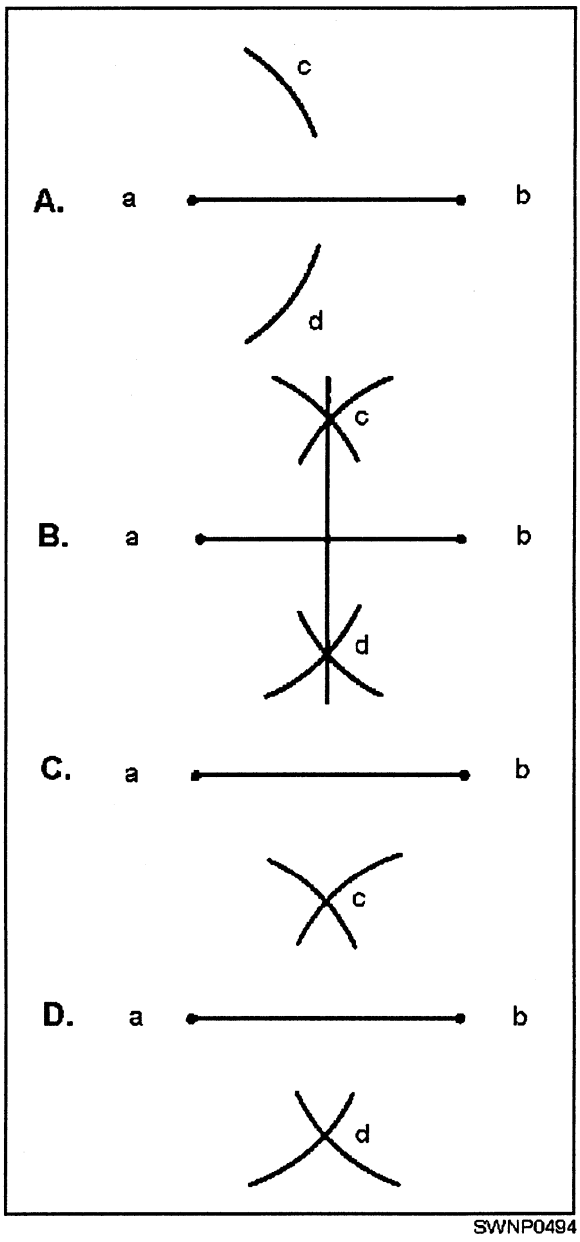


Figure 2B

IN ANSWERING QUESTION 2-9, REFER TO FIGURE TO FIGURE 2B.

2-9. To construct a 90 degree or right angle using steps A through D shown in the figure, you should perform the steps in what sequence?

1. A, B, C, D
2. B, C, A, D
3. C, A, D, B
4. D, B, C, A

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2-10. Refer to figure 2-11 in the textbook. To find point F in bisecting angle ABC, you must set the dividers for what distance?

1. To less than one half of the line BD
2. To twice the length of EB
3. To greater than the total length of arc DE
4. To greater than one half of the length of arc DE

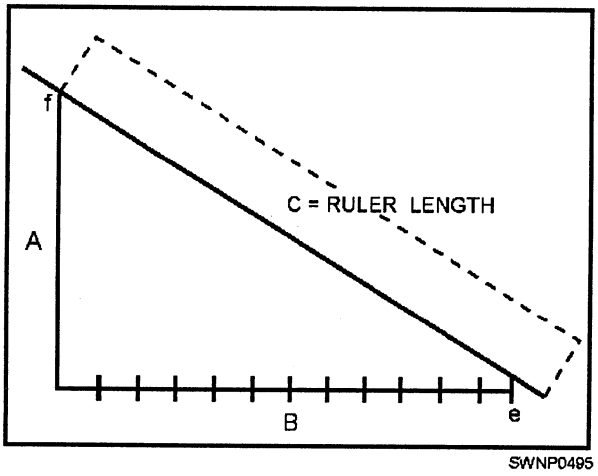


Figure 2C

IN ANSWERING QUESTIONS 2-11 THROUGH 2-13, REFER TO FIGURE 2C.

2-11. Base line B is 10 inches long and you want to divide it into 12 equal parts. Using a rule after drawing line A perpendicular to the base line, you should orient the ruler in which of the following ways?

1. Set the 12-inch mark at (e) and the 0-inch mark at (f)
2. Set the 12-inch mark at (e) and the 1-inch mark at a point 4 1/2 inches above (d)
3. Set the 9-inch mark at the midpoint of base line B and the 3-inch mark at the midpoint of line A
4. Set the 9-inch mark at the midpoint of line A

2-12. Your next step in dividing base line B into equal parts is to drop perpendiculars to B from what mark on the ruler?

1. 1 inch
2. 3/4 inch
3. 1/2 inch
4. 1/4 inch

2-13. After line B is divided into 12 equal parts, what is the approximate length of each part?

1. 5/16 inch
2. 7/16 inch
3. 13/16 inch
4. 15/16 inch

2-14. You set dividers for the radius of a circle and strike off this distance on the entire circumference. Into how many equal arcs have you divided the circumference?

1. Six
2. Two
3. Three
4. Nine

2-15. Into how many equal parts is the circumference of a circle divided if the lines intersecting at the center of the circle form angles of 30 degrees?

1. 4
2. 6
3. 12
4. 18

2-16. What is the approximate circumference of a circle that has a diameter of 18 inches?

1. 45.5 inches
2. 56.5 inches
3. 133.0 inches
4. 365.0 inches

2-17. What is the mathematical formula for determining the area of the stretchout of a cylinder?

1. $A = \pi r$
2. $A = \pi rd$
3. $A = 2\pi r$
4. $A = (\pi d)h$

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Learning Objective: Identify uses and operation of tools and equipment used in fabricating sheet metal.

IN ANSWERING QUESTIONS 2-18 THROUGH 2-20, SELECT FROM COLUMN B THE TYPE OF SNIPS THAT SHOULD BE USED TO MAKE THE CUTS IN COLUMN A.

	A. CUTS	B. TYPES OF SNIPS
2-18.	Outside circles	1. Circular
	1. 1	2. Aviation
	2. 2	
	3. 3	3. Hawkbill
	4. 4	
		4. Beakhorn
2-19.	Compound curves and intricate designs	
	1. 1	
	2. 2	
	3. 3	
	4. 4	
2-20.	Internal openings, such as rings or holes	
	1. 1	
	2. 2	
	3. 3	
	4. 4	

2-21. Squaring shears are designed to cut which of the following materials?

1. Wire rope
2. Steel rods
3. Sheet metal
4. Fiber line

2-22. Metal stakes are used to make an assortment of bends by hand and to finish many types of work.

1. True
2. False

IN ANSWERING QUESTIONS 2-23 THROUGH 2-25, SELECT FROM COLUMN B THE TYPE OF STAKE THAT SHOULD BE USED TO FORM THE SHAPES IN COLUMN A.

	A. SHAPES	B. STAKES
2-23.	Forming, seaming, and riveting pieces and parts of pipe mandrel	1. Conductor
		2. Hollow pipe
		3. Blowhorn
	1. 1	
	2. 2	4. Beakhorn
	3. 3	
	4. 4	
2-24.	Blunt and slender tapered jobs	
	1. 1	
	2. 2	
	3. 3	
	4. 4	
2-25.	Riveting and shaping round and square work	
	1. 1	
	2. 2	
	3. 3	
	4. 4	

2-26. What part of the bar-folding machine is used to make right angles and 45-degree bends?

1. The depth gauge
2. The bar handle
3. The wing
4. The angle stop

2-27. A total of how many adjustments must be made on a cornice brake before you can use the machine to bend sheet metal?

1. One
2. Two
3. Three
4. Four

2-28. What feature on the cornice brake enables you to make as many duplicate bends as required?

1. The clamping device
2. The balancing weight
3. The stop gauge
4. The mold clamps

2-29. The box and pan brake is often referred to as a finger brake.

1. True
2. False

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2-30. When forming a curved shape, you can fabricate the most accurate bend by using what piece of equipment?

1. A stake
2. A mandrel
3. A pipe
4. A slip-roll forming machine

2-31. The slip-roll forming machine is designed to allow one end of the top front roll to be released quickly so you can perform what task easily?

1. Removal of the work
2. Cleaning operations
3. Repairs on the machine
4. Adjustments to the machine

2-32. What operation of the combination rotary machine is used to reduce the size of the end of a cylinder?

1. The beading
2. The burring
3. The crimping
4. The clamping

Learning Objective: Recognize the methods of pattern development and identify types of edges, seams, and notches used in fabricating sheet metal.

2-33. Instead of scribing directly on the metal when a single piece is being made in quantity, you can make a pattern or template and transfer it to the metal.

1. True
2. False

2-34. Assume that the cylinder shown in textbook figure 2-51 has a diameter of 8 1/2 inches. Excluding the seam, what is the length of the stretchout?

1. 26 5/8 inches
2. 38 3/4 inches
3. 51 7/8 inches
4. 61 5/8 inches

2-35. A patternmaker decides to divide a half plan or top view into 12 equal parts. What number of divisions will be required for the stretch-out line?

1. 6
2. 12
3. 24
4. 48

2-36. What method of pattern development should you use to develop a pattern for an object that has a tapering form with lines converging at a common center?

1. Radial line
2. Parallel line
3. Triangulation
4. Scratching

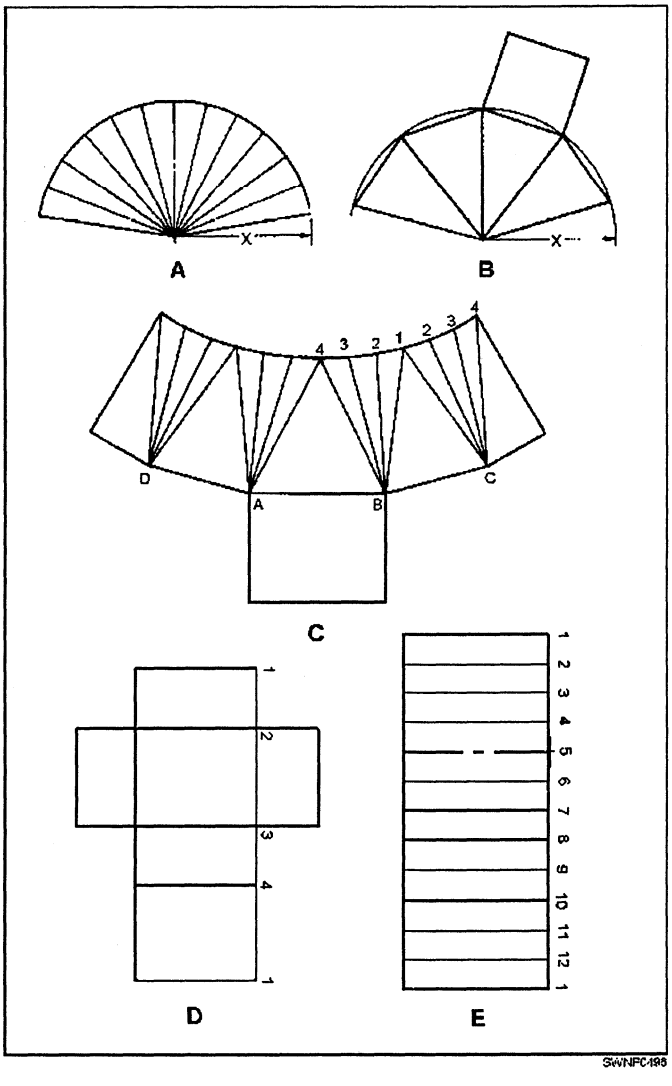


Figure 2D

IN ANSWERING QUESTIONS 2-37 THROUGH 2-39, REFER TO FIGURE 2D.

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2-37. What stretchouts are developed by the radial-line method?

1. A and B
2. A and C
3. C and D
4. C and E

2-38. Triangulation is used to develop what pattern?

1. A
2. C
3. D
4. E

2-39. What pattern will ultimately fold or roll into a cylinder?

1. A
2. C
3. D
4. E

IN ANSWERING QUESTIONS 2-40 THROUGH 2-42, REFER TO FIGURE 2-52 IN THE TEXTBOOK.

2-40. The radial line method is used to develop a frustrum of a right cone.

1. True
2. False

2-41. The stretchout pattern of the frustrum has been stepped off into how many spaces?

1. 6
2. 7
3. 12
4. 14

2-42. The length of the numbered line on the stretchout from 1 to 1 is equal to what measurement?

1. Height of the frustrum
2. Circumference of the base of the cone
3. Radius of the top of the frustrum
4. Slant height of the frustrum

IN ANSWERING QUESTIONS 2-43 THROUGH 2-45, ASSUME THAT YOU ARE TO DRAW A PATTERN OF A TRANSITION PIECE FOR A SQUARE DUCT AND A SMALLER ROUND DUCT, AS SHOWN IN TEXTBOOK FIGURE 2-53.

2-43. What view of the transition piece should you draw first?

1. A
2. B
3. C
4. D

2-44. What triangle should you develop first in E?

1. B3 and 4
2. B4 and 5 or C7 and 8
3. D7 and 6
4. A2 and 1 or B2 and 1

2-45. You have constructed perpendicular bisectors of AB, BC, CD, and DA in E and have established the location of point 0_0. What step should you perform next in order to check the overall symmetry of your transition piece?

1. Swing length D5 from point 5
2. Swing an arc of radius A2 from point A
3. Swing arcs A and B from point O
4. Swing arcs from point G that will intersect at point O

Learning Objective: Identify the various sheet-metal joints and locking methods used in the fabrication of sheet-metal sections.

2-46. When fabricating a wired edge to a cylinder, you must add how much edging to a pattern?

1. 1 1/2 times the thickness of the metal
2. 2 1/2 times the diameter of the wire to be used
3. Twice the diameter of the upper burring roller
4. One half of the diameter of the wire to be used

2-47. In the fabrication of rectangular duct, what seam is used most often?

1. Grooved
2. Pittsburgh lock
3. Lap
4. Standing

2-48. When laying out a pattern, you consider what feature last?

1. Seams
2. Laps
3. Notches
4. Edges

2-49. What type of notch is used on a corner when a single-hemmed edge is to meet a 90-degree angle?

1. Square
2. Slant
3. V
4. Wire

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2-50. What type of connection is used to join a flat sheet and a round pipe/fitting?

1. Dovetail seam
2. Drive slip
3. Pocket slip
4. Standing seam

Learning Objective: Identify the various joints, installation procedures, metal requirements, and connections used in sheet-metal duct systems.

2-51. What type of screw is most often used in sheet-metal work?

1. Self-tapping
2. Machine
3. Thread-cutting
4. Drive

2-52. Drive screws are simply driven into sheet metal.

1. True
2. False

2-53. Tinners are designated by their weight per 1,000 rivets.

1. True
2. False

2-54. The distance from the center of the rivet to the edge of the sheet must equal how many rivet diameters?

1. 1
2. 1 1/2
3. 2
4. 2 1/2

2-55. The correct method for riveting using tinner rivets is to draw, upset, and head the rivet.

1. True
2. False

2-56. What gauge of aluminum sheet metal is required to construct a duct 62 inches wide at the top and 28 inches high on the sides?

1. 26
2. 24
3. 18
4. 16

2-57. You are to construct a duct of 24 gauge sheet metal. Each section is 7 feet 10 inches long. If the total system length is 60 feet, you should place the bracing angles at what location?

1. 2 feet on center along the length of the duct
2. 4 feet on center along the length of the duct
3. 2 feet from each joint
4. 4 feet from each joint

2-58. The cross breaking of a duct having a flat side of 18 inches or greater can be omitted under which of the following conditions?

1. The duct is installed in the vertical position
2. The material used is at least reinforced at the edges of each duct segment
3. The duct is insulated with approved materials
4. The duct is insulated with rigid insulation and the sheet metal used is 2 gauges heavier

2-59. When securing duct systems to heating and cooling units, you should use what material to fabricate the flexible connections?

1. Light-gauge sheet metal
2. Asbestos
3. Heavy canvas
4. Aluminum

2-60. When “S” slips and drive slips are used on a duct system, you lock the joint into position in what way?

1. By bending the “S” slip over the drive slip
2. By bending the drive slip over “S” slip
3. By cutting off the drive slip even with the “S” slip and welding each corner
4. By center punching the “S” slip

Learning Objective: Identify material requirements, fabrication, and installation procedures used in fiber-glass duct systems.

2-61. Fiber-glass duct has which of the following advantages?

1. Added insulating value
2. Ease of fabrication and handling
3. Ease of installation
4. Each of the above

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2-62. In all applications, the inside diameter is the determining factor of the duct size.

1. True
2. False

2-63. Fiber-glass duct must not be used in a heating system in which the heat generated exceeds what temperature?

1. 150°F
2. 200°F
3. 250°F
4. 300°F

2-64. What are the dimensions of the galvanized steel straps used to support fiber-glass duct?

1. 3/4-inch diameter by l/8-inch thick
2. l-inch diameter by l/8-inch thick
3. l-inch diameter by l/16-inch thick
4. 1 l/8-inch diameter by 1 l/16-inch thick

2-65. You have fabricated a fiber-glass duct system that has a 30-inch diameter. At what distance should the supports be placed?

1. 6-foot centers
2. 2-foot centers
3. 8-foot centers
4. 4-foot centers

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ASSIGNMENT 3

Textbook Assignment: "Structural Steel Terms/Layout and Fabrication of Steel and Pipe," pages 3-1 through 3-29.

Learning Objective: Identify structural steel members by appropriate terminology and recognize steel structural erection rocedures.

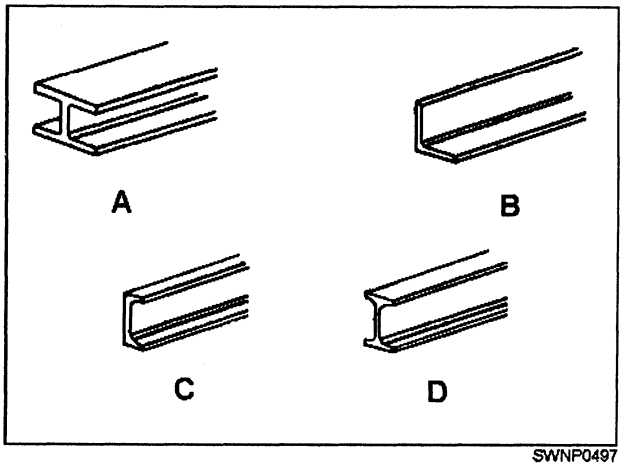


Figure 3A

IN ANSWERING QUESTIONS 3-1 AND 3-2, REFER TO FIGURE 3A.

3-1, What structural shape does the designation W6 x 13 fit best?

1. A
2. B
3. C
4. D

3-2. What structural shape does the classification S15 x 42.9 indicate?

1. A
2. B
3. C
4. D

3-3. A piece of steel plate 3 feet square weighs 180 pounds. What is the classification of this plate?

1. 10-pound plate
2. 20-pound plate
3. 30-pound plate
4. 40-pound plate

3-4. A 10-foot piece of steel that is 3/8-inch thick and 2 inches wide is classified as a

1. bar
2. strip
3. sheet
4. plate

3-5. What sequence is the proper order you should follow for the erection of structural members?

1. Girders, bearing plates, anchor bolts, columns, beams
2. Anchor bolts, column plates, girders, bearing plates, beams
3. Anchor bolts, bearing plates, columns, girders, beams
4. Bearing plates, anchor bolts, columns, girders, beams

3-6. When cutting the holes in bearing plates to receive anchor bolts, you cut the holes larger than the bolts for what reason?

1. To allow for height adjustment
2. To permit lateral adjustment
3. To compensate for angle connections
4. To allow space for welding of columns

3-7. Bearing plates are brought to their proper levels by

1. installing shim packs
2. welding the plates to the bearing plates
3. forcing the grout under the bearing plates
4. using locknuts

3-8. What structural shapes are most often used in columns?

1. Standard beam
2. Tee shapes
3. Pipes
4. Wide flange beam

3-9. What structural steel member is used primarily to span from column to column horizontally?

1. Beam
2. Truss
3. Girder
4. Column splices

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3-10. Which of the following members form a lightweight, long-span system used as floor supports and built-up roofing supports?

1. Bar joist
2. Truss
3. Beam
4. Girder

3-11. Workers have installed diagonal braces between bays of a truss system. Their next step is to secure the roof system with what structural members?

1. Angle ties
2. Sway frame
3. Diagonal locking bars
4. Bottom chord extensions

3-12. When using purlins to span roof trusses, you should ensure the legs face in what direction?

1. Up toward the center or apex of the roof
2. Flat with the face of the channel face directly toward the truss
3. Downward with both legs welded to the truss
4. Outward or down toward the slope of the truss system

3-13. What structural members are used to frame the sides of a building which are attached to the outside perimeter columns?

1. Eave struts
2. Purlins
3. Girts
4. Ridge plates

Learning Objective: Identify methods of fabricating plate and structural shapes and the procedures for cutting, forming, and joining plate steel and structural steel shapes.

3-14. When laying out a plate with many parts, you must consider which of the following factors?

1. Time required
2. Economic use of material
3. Accuracy of measurements
4. All of the above

3-15. A job has been laid out and is determined to be accurate. At this time, what modification should be made to all cutting lines?

1. Cut them with a torch on the inside of the kerf
2. Center punch, then cut them with the kerf on the outside edge of the reference lines
3. Transfer to patterns before cutting them so the work can be checked after cutting
4. Lightly paint them to preserve the layout lines

3-16. When a 10-inch beam is connected to a 10-inch girder with the web of one end butted to the side of the other, the required layout is indicated by what letter?

1. A
2. B
3. E
4. H

3-17. The beam S 12 x 35 encloses the girder W 10 x 39, and it extends above the girder 2 inches. The beam butts the girder together at the center line of the girder. The bottom flange is flush with the bottom of the girder flange. What layout is required?

1. C
2. F
3. G
4. H

3-18. As the webs of the girder W 10 x 39 and beam S 8 x 23 are connected and welded, what beam connection layout must be used for the beam S 8 x 23? (The top flange is flush.)

1. A
2. B
3. D
4. E

Learning Objective: Identify the procedures for laying out structural members.

3-19. Which of the following conditions must exist before you lay out steel members ?

1. Adequate lighting
2. All required tools are on hand
3. An accurate field drawing or sketch
4. All of the above

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3-20. Structural shapes are more difficult to lay out than plate because the reference lines are not always visible.

1. True
2. False

3-21. When two beams of equal dimensions are fitted together, coping is required so one will butt up against the web of the other. You can determine the size of cope needed

1. by dividing the flange width by 1/8, then adding 1/16 inch
2. by dividing the flange width by 1/2, then subtracting 1/2 of the thickness of the web and adding 1/16 inch
3. by dividing the flange width by 1/4, then adding 1/8 inch
4. by dividing the flange width by 1/2, then adding 1/2 of the thickness of the web and subtracting 1/16 inch

3-22. The legs used to attach to intersecting steel to make a connection are referred to as

1. connection legs
2. web legs
3. fit-up legs
4. gauges

3-23. Outstanding legs are the legs of the angles that attach the supporting angle or intersected steel beam.

1. True
2. False

3-24. The lines in which holes in the angle legs are drilled are known as what type of lines?

1. Dimension
2. Layout
3. Gauge
4. Drill

3-25. On what part of a connection angle does the distance from the heel of the angle to the first gauge line remain constant?

1. Web leg gauge
2. Outstanding leg
3. Gauge line
4. Top flange

3-26. The standard 3-inch distance between the holes on any gauge line is known as

1. leg gauge
2. pitch
3. web leg gauge
4. dimension angle

3-27. When a beam is joined to the flange of a vertical member, you should use what type of connection?

1. Cap plate
2. Direct insert
3. Seated
4. Slotted angle

Learning Objective: Identify procedures for laying out proposed metalwork.

3-28. A template is to be used as the pattern for the construction of a large number of precision metal parts. This template should be made of what material?

1. Graph paper
2. Plain white paper
3. Template paper
4. Metal

3-29. When using templates to help lay out a steel member, you should make sure the identifying marks on the templates and the member correspond to which of the following plans or drawings?

1. Erection
2. Detail
3. Flat
4. Field

3-30. What information does the erection mark on a member provide?

1. The location of the member during erection
2. Date of fabrication
3. The sequence of erection
4. The erection completion date

Learning Objective: Identify pipe layout operations, procedures in constructing design patterns for pipe, and methods of joining pipe into different arrangements.

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3-31. To fabricate 25 pieces of pipe of the same diameter and layout dimensions, you should use the shop method of making templates.

1. True
2. False

3-32. When quartering a pipe before proceeding to lay out a joint, you should place the inside angle of the framing square against the pipe after taking what action?

1. Leveling one leg of the framing square
2. Blocking one leg of the framing square
3. Blocking the pipe
4. Leveling the pipe

3-33. What is the first step in developing a template layout for pipe?

1. Drawing a circle equal to the outside diameter of the pipe
2. Constructing the template angle equal to twice the angle of the turn
3. Dividing the circumference of the projected view by one half
4. Bisecting the template angle

3-34. The curve in view C of textbook figure 3-45 is determined

1. by spacing the perpendicular line in view C to equal the outside dimension of view A
2. by extending the line a-i in view C
3. by basing the length of the perpendicular lines in view C on 1/2 of the length of the outside diameter of view A
4* by joining in a smooth curve the set of points formed by the intersection of perpendicular lines drawn from the base line with parallel lines drawn from the point on a-i

3-35. In making a simple miter turn, you perform what step after determining the cutback measurement?

1. Measure one half of the distance to the cutback on the vertical plane
2. Mark one half off the cutback measurement along the center line on top of the pipe
3. Lock the protractor blade
4. Determine the outside radius of the pipe

3-36. Assume you are making a full-sized drawing to determine the cut necessary for a two-piece welded turn where the angle of turn of the pipe is 60 degrees. First, you should draw the center lines to intersect as shown in textbook figure 3-46. Then you should

1. lay the pipe over the drawing so its center line will intersect point b
2. lay the pipe over the drawing so its edges will intersect points d and e
3. draw lines a-b-c-d
4. draw the outlines of the pipes

3-37. In view A of textbook figure 3-49, the distance 1-P is equal to

1. the diameter of the pipe
2. the radius of the pipe
3. the thickness of the pipe wall
4. double the thickness of the pipe wall

3-38. In what position should the protractor be locked to show the number of degrees of turnaway from the header to fabricate a branch-to-header connection of equal diameter pipe?

1. At an angle equal to the degree of turnaway
2. At half of the angle of turnaway
3. At one third of the angle of turnaway
4. At one fourth of the angle of turnaway

3-39. In textbook figure 3-50, the cutback measurements for laying out the end of the branch are the distances represented by what letters?

1. EC and AB
2. AB and BC
3. DA and EC
4. BC and DA

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3-40. Refer to textbook figure 3-51. Where a branch is welded to a large header, what should be the distance on each side of the branch between points A and B?

1. Same as or a little more than the thickness of the branch wall
2. Same as or a little less than the thickness of the branch wall
3. Same as or a little more than the thickness of the header wall
4. Same as or a little less than the thickness of the header wall

3-41. In fabricating a three-piece connection of equal diameter pipe, you must decide upon the size of the open angle between each pair of center lines for what reason?

1. To determine the position of the center lines
2. To determine the angle of the adjoining sides of adjacent branches
3. To quarter the ends of the three pieces of pipe
4. To apply circumferential lines to each piece of pipe

IN ANSWERING QUESTION 3-42, REFER TO TEXTBOOK FIGURE 3-54 AND TABLE 3-2.

3-42. Of the following paired cutback measurements, which belongs to angle ACG?

1. AB = 1/16 inch and FE = 6 inches
2. AB = 1 1/16 inches and FE = 4 1/8 inches
3. FE = 6 inches and ED = 4 1/8 inches
4. FE = 1/16 inches and CD = 6 inches

3-43. Refer to textbook figure 3-54. Without the use of templates or tables, how do you locate point B of the true Y?

1. By determining the vertex of the triangle ABC
2. By constructing a perpendicular line from point D to bisect line AC
3. By intersecting the center lines of the three pipes
4. By intersecting lines AB and BC

3-44. In the preparation of an orange peel template, such as the one shown in textbook figure 3-57, which of the following projection lines are taken from view A?

1. B-C and A1-B1
2. A-B and B-B1
3. B-B1 and X-X1
4. A1-B1 and X-X2

3-45. When cutting a pipe with a hand torch, you use what type of cutting process to hold the cutting torch perpendicular to the interior center line of the pipe at every point?

1. Miter
2. Radial
3. Reverse
4. Concentric

Learning Objective: Identify procedures for pipe bending, including heat bending and wrinkle bending.

3-46. What are the flange spiders of a center line template made of wire used for in pipe bending?

1. To clamp the ends of the wire
2. To maintain a constant clearance around the pipe
3. To indicate pipe clearance
4. To indicate the center line of the pipe

3-47. Before heating a pipe, what action, if any, should you take to prevent a reduction in the cross-section area of a hot-bend pipe?

1. Pack it with wet sand
2. Pack it with dry sand
3. Pack it with wet packing
4. None

3-48. What is the technique for applying heat to the bend area of the pipe shown in textbook figure 3-62?

1. First, heat ends A and B, then the part in between
2. First, heat the area midway between A and B, then the ends
3. First, heat the outside (heel) of the bend, then the inside (throat)
4. First, heat the inside (throat) of the bend, then the outside (heel)

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3-49. Flat spots in hot-bent copper pipe are caused by which of the following factors?

1. Improper heating
2. Not enough support for the pipe wall
3. Stretch in the outside (heel) of the bend
4. All of the above

3-50. The use of which of the following bending techniques should prevent wrinkles and flat spots in properly packed and heated copper pipe?

1. Bending so all the stretch takes place at the center of the bend area, none on the ends
2. Bending so all the stretch takes place at the ends of the bend area, none at the center
3. Bending so more of the stretch takes place at the center of the bend area than at the other end
4. Dividing the bend area into segments, then bending one segment at a time so stretching is evenly spread over the entire area

3-51. In bending steel pipe, you can control wrinkles and flat spots at the throat of a bend by over-bending, then pulling the end back to round out the flat spot.

1. True
2. False

3-52. Pipe made of what material is likely to break if overbent and then pulled back?

1. Steel
2. Brass
3. Copper
4. Aluminum

3-53. In hot bending aluminum pipe with a torch, you should use which of the following techniques?

1. Keep the flame on the throat while the pipe is being bent
2. Heat only the throat of the bend and avoid overheating
3. Notice changes in heat color to determine the proper bending temperature
4. Overheat then remove heat when bending starts

3-54. When using the wrinkle-bending technique to make a 60-degree bend in a pipe, you should make a total of how many wrinkles to keep from buckling the pipe?

1. One or two
2. Two or three
3. Three or four
4. Five or more

3-55. What technique should you use to wrinkle-bend a 12-inch-diameter pipe?

1. With one torch, heat a strip about 2 feet long and 2 to 3 inches wide along the throat of the planned bend
2. With one torch, heat a strip about 2 feet long and 2 to 3 inches wide along the heel of the planned bend
3. With more than one torch, heat a strip about 2 feet long and 2 to 3 inches wide along the throat of the planned bend
4. With more than one torch, heat a strip about 2/3 of the circumference of the pipe, and 2 to 3 inches wide along the throat of the planned bend

3-56. When bending a heated pipe, you should use what technique, if any?

1. While holding one end of the pipe firmly in position, lift the other end
2. While holding the midpoint of the pipe on the ground, lift both ends at the same time
3. While holding the midpoint of the pipe on the ground, lift one end then the other
4. None

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ASSIGNMENT 4

Textbook Assignment: "Fiber Line" and "Wire Rope," pages 4-1 through 5-15.

Learning Objective: Identify types, fabrication of, size designations, and proper handling and care of fiber line.

4-1. What is the primary reason manila line is preferred for use as standard issue line?

1. Its resistance to wear
2. It is waterproof
3. Its quality and relative strength
4. It is easy to handle

4-2. The primary reason for the use of nylon line is that it

1. is waterproof
2. is resistant to abrasion
3. resumes normal length after being stretched
4. has a breaking strength that is nearly 3 times greater than that of manila line

4-3. Fiber line is fabricated in three twisting operations.

1. True
2. False

4-4. Which, if any, of the following types of line is formed from three twisting operations in a right-hand direction?

1. Hawser laid
2. Shroud laid
3. Cable laid
4. None of the above

4-5. The circumference of a 1 1/4-inch manila line is equal to about how many millimeters?

1. 29
2. 32
3. 38
4. 44

4-6. What is the maximum size of fiber line normally carried in stock?

1. 12 inches
2. 14 inches
3. 16 inches
4. 18 inches

4-7. You may have to order line by diameter, rather than circumference, and refer to it as rope.

1. True
2. False

4-8. Soap is not used to clean fiber line because

1. it shrinks the line
2. it creates abrasion
3. it causes deterioration of fibers
4. it takes the oil out of the line

4-9. When nylon line becomes slippery with grease or oil, it should be cleaned with what solvent(s)?

1. Acetone only
2. Either kerosene or diesel fuel
3. Alcohol or gasoline
4. Gasoline only

4-10. Which of the following fabrics should you use to apply whippings to a line?

1. Rope yarn
2. Marline
3. Houseline
4. Twine

4-11. When nylon line is properly handled and maintained, it should last five times longer than manila line subjected to the same use.

1. True
2. False

4-12. Which of the following agents can cause damage to a line that is hard to detect by visual examination?

1. Storage room containing chemicals
2. Lime
3. Direct sunlight
4. Each of the above

4-13. When stowing wet line, you should always select a heated well-ventilated space to promote rapid drying.

1. True
2. False

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4-14. A line that is kinked from excessive turns should be given a thorough footing by

1. coiling the line down clockwise and then pulling the bottom end of the coil up and out of the middle of the coil
2. coiling the line down counterclockwise and then pulling the bottom end of the coil up and out of the middle of the coil
3. taking an end at the inside bottom of the coil and after pulling it free, coiling the line down clockwise
4. taking an end at the inside bottom of the coil and after pulling it free, coiling the line down counterclockwise

4-15. Which of the following methods of inspecting fiber line for safety is approved?

1. Visual inspection
2. Smell test
3. Fiber break test
4. Each of the above

4-16. The breaking strength of a line is considerably higher than its safe working load to account for what factor?

1. The different applications of pressure due to load sizes
2. The strain imposed by bending over sheaves in a block
3. Excessive vibration
4* Exposure to moisture

4-17. You are going to use a new 2-inch manila line to hoist a load, and you do not have tables to use to determine the safe working load (SWL) of the line. This situation requires you to use the “rule of thumb” formula to calculate the SWL for the 2-inch line. By doing so, you determine the SWL for the line is

1. 400 pounds
2. 600 pounds
3. 800 pounds
4. 900 pounds

4-18. What is the breaking strength of a 2 l/2-inch fiber line?

1. 4,625 pounds
2. 4,825 pounds
3. 5,225 pounds
4. 5,625 pounds

4-19. The safety factor of a line is the ratio between the breaking strength and the safe working load.

1. True
2. False

4-20. Nylon has a breaking strength approximately three times greater than that of manila line. What is the breaking strength of a 2-inch nylon line?

1. 7,600 pounds
2. 8,6oo pounds
3. 9,600 pounds
4. 10,600 pounds

4-21. Nylon line can be stretched what percentage of its length before it will part?

1. 20%
2. 30%
3. 40%
4. 50%

4-22. Although nylon line is superior in many ways to manila line, what characteristic can cause it to be hazardous?

1. It is very smooth and slips through the hands easily
2. It may part when stretched more than 30%
3. The snapback is severe when a heavy strain is released
4. Freezing produces a slight loss of stretch

Learning Objective: Recognize the fundamentals of making knots, bends, and hitches.

4-23. The free or working end of a line is known as the

1. bight
2. running end
3. tag end
4. open end

4-24. What type of knot is best used to tie two lines of the same size together so they will not slip?

1. Reef
2. Figure eight
3. Overhand
4. Sheepshank

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4-25. Which of the following types of knots is used to take a load off a weak section out of line and can also be used to shorten a line?

1. Reef
2. Figure eight
3. Overhand
4. Sheepshank

4-26. When tying lines together that are unequal in size, you should use what type of knot?

1. Becket bend
2. Bowline
3. Running bowline
4. Half hitch

4-27. A free-running lasso that will not tighten up on the standing part of the line is provided by what knot?

1. Bowline
2. Running bowline
3. Spanish bowline
4. French bowline

4-28. When tying up timber or anything that is round or nearly round, you should use what type of hitch?

1. Barrel
2. Clove
3. Half
4. Scaffold

Learning Objective: Recognize the fundamentals of splicing fiber line.

4-29. A properly made short splice will retain up to 50% of the strength of the line, while a properly tied knot will retain 100% of its strength.

1. True
2. False

4-30. What type of tape is used for whipping the strands and lines in nylon line instead of seizing stuff as in manila line?

1. Duct
2. Aluminum
3. Friction
4. Strapping

4-31. Because nylon line is smooth and elastic, at least how many extra tucks are required when splicing it?

1. One
2. Two
3. Three
4. Four

4-32. What type of splice should be used to run freely through a block?

1. Back
2. Long
3. Short
4. Eye

4-33. When there is not much overlap for splicing, you should use what type of splice?

1. Back
2. Long
3. Short
4. Eye

4-34. A back splice should be used to prevent a line from unlaying or unraveling at the end of a line.

1. True
2. False

Learning Objective: Recognize how wire rope is fabricated and identify the different grades, lays, and types of wire rope.

4-35. What type of rope should you select for a job that requires wire rope of great flexibility while maintaining adequate strength?

1. 6 by 7 fiber core
2. 6 by 19 wire strand core
3. 6 by 24 wire rope core
4. 6 by 37 fiber core

4-36. What type of wire rope should you select for use on a permanent hoist in which the rope runs through several sheaves and onto a small-diameter drum?

1. Hot-dipped galvanized wire rope with a fiber core
2. Electroplated wire rope with an independent wire rope core
3. Plain wire rope with a fiber core
4. Hot-dipped galvanized wire rope with a wire strand core

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4-37. Wire rope that withstands crushing the best has which of the following properties?

1. Wires that are uncoated
2. Is made of improved plow steel
3. An independent core
4. A galvanized wire core

4-38. How does preformed wire rope compare to nonpreformed wire rope?

1. It is harder to splice
2. It is more flexible
3. It is likely to fly apart when cut or broken
4. It is less flexible

4-39. The three grades of plow steels used in manufacturing wire rope can have a variation in tensile strength of

1. 10,000 psi
2. 20,000 psi
3. 30,000 psi
4. 40,000 psi

4-40. When looking at a wire rope, you observe that the wires in the strands are laid to the right and the strands are laid to the left. This wire rope has what type of lay?

1. Regular right lay
2. Lang right lay
3. Lang left lay
4. Left regular lay

4-41. What type of wire rope is most often used by the Construction Battalions (Seabees) of the Naval Construction Force?

1. 8 strand, consisting of 6, 7, 12, 19, 24, or 37 wires in each strand
2. 6 strand, consisting of 4, 8, 16, 24, or 36 wires in each stand
3. 6 strand, consisting of 6, 7, 12, 19, 24, or 37 wires in each strand
4. 8 strand, consisting of 4, 8, 16, 24, or 36 wires in each strand

---

Learning Objective: Identify various factors to consider in selecting a method of measuring wire rope and for computing safe working loads.

4-42. The ability of a wire rope to withstand the compressive and squeezing forces that can distort its cross section when running over sheaves, rollers, and drums is known by what term?

1. Abrasion resistance
2. Fatigue resistance
3. Crushing strength
4. Tensile strength

4-43. The outer wires of each strand of wire rope contribute to the fatigue resistance or abrasion resistance of the wire. This factor makes which of the following service applications correct?

1. Use large wires when high abrasion resistance only is required
2. Use small wires when high abrasion resistance only is required
3. Use large wires when high fatigue resistance only is required
4. Use small wires when both high fatigue and abrasion resistance are required

4-44. The correct way to measure wire is to measure from the top of one strand to the top of the strand directly opposite it.

1. True
2. False

4-45. Compute the safe working (SWL) of a 2-inch wire rope.

1. 6,000 pounds
2. 7,000 pounds
3. 8,000 pounds
4. 9,000 pounds

4-46. Which of the following actions does NOT help to prevent wire rope failure?

1. Checking for overriding or crosswinding of drums
2. Lubricating with heavy-duty grease
3. Inspecting fitting attachments
4. Ensuring correct size, construction, and grade are utilized

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Learning Objective: Recognize the fundamentals of wire rope handling.

4-47. In what manner should right and left lay wire rope be coiled down?

1. Both clockwise
2. Both counterclockwise
3. Left lay, clockwise; right lay, counterclockwise
4. Right lay, clockwise; left lay, counterclockwise

4-48. When wire rope or fiber line is received from the manufacturer on a reel, it should be unwound instead of pulled off in bights in order to keep the rope or line from

1. chafing
2. kinking
3. breaking
4. unraveling

4-49. When a loop forms in wire rope and it is pulled into a kink, you should take what action?

1. Uncross the ends and push them apart
2. Cut out the kinked portion
3. Pull it out by stretching one end of the rope
4. Pound it out with a wooden mallet

4-50. In those cases where reverse bends cannot be avoided, you should take what action to help decrease wear and fatigue in wires and strands?

1. Use smaller diameter rope than is ordinarily used
2. Lubricate the rope at more frequent intervals than usual
3. Reduce the space between the blocks and drums being used
4. Use larger blocks and drums than are ordinarily used and space them as far apart as possible

4-51. Sheave diameter should not be less than 20 times the diameter of the wire rope, EXCEPT in the case where wire rope has which of the following properties?

1. An independent core
2. Electroplated wire strands
3. 6 by 37 with a fiber core
4. 6 by 24 with a steel core

4-52. Before cutting wire rope, you should apply a total of how many seizings to each side of the area being cut?

1. One
2. Two
3. Three
4. Four

4-53. When putting on the turns of seizing wire, you use a serving bar or iron to increase the tension on the seizing wire when what conditions exist?

1. The seizing is only temporary, or the diameter of the wire rope is 1/2 inch
2. The seizing is only temporary, or the diameter of the wire rope is 1 inch
3. The seizing is to be permanent, or the diameter of the wire rope is 1 1/2 inches or more
4. The seizing is permanent, or the diameter of the wire rope is 1 5/8 inches or more

4-54. Seizing is placed at intervals from each other that equal what distance?

1. The diameter of the wire rope
2. Twice the diameter of the wire rope
3. Three times the diameter of the wire rope
4. Four times the diameter of the wire rope

4-55. What advantage is gained by cutting back or reversing ends of wire rope connections?

1. The exposure of worn parts
2. The prevention of corrosion on exposed ends
3. An increase in the service life of the rope
4. A change in the tension direction of the rope core

4-56. While inspecting a wire rope, you come across individual wires that are broken and bent back (fishhooks). What situation caused this condition to develop?

1. Damaged drum
2. Incorrect sheave size
3. Reverse and sharp bends
4. Improper fleet angle

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4-57. Overloading a rope will decrease its diameter. A rope should be removed from service when its diameter is reduced to what percentage of its original size?

1. 50%
2. 75%
3. 80%
4. 85%

4-58. Of all the protective actions you should take when storing wire rope, which one is of prime importance?

1. Wrap securely in waterproof material
2. Rotate to prevent damage to bottom coils
3. Always place out of direct sunlight
4. Clean and lubricate well

4-59. Fishhooks, kinks, abrasion, and corrosion in wire rope are causes to remove it from service. Wire rope is unsafe when what percentage of the total number of wires within the length of one lay of the rope is broken?

1. 8%
2. 6%
3. 5%
4. 4%

Learning Objective: Identify the techniques used for special attachments for wire rope.

4-60. To make a temporary eye splice with a 1 1/2-inch rope, you need a total of how many wire rope clips?

1. Five
2. Six
3. Three
4. Four

4-61. You have to change the fitting on the end of a wire rope several times during a job and the fitting must bear a heavy load without slipping or failing. What type of fitting meets your needs best?

1. A poured socket
2. A wedge socket
3. A wrapped and mule-tailed socket
4. A spliced fitting

4-62. When making an eye in wire rope with the Nicopress, you are primarily saving what resource?

1. cost
2. Time
3. Labor
4. Material

4-63. A basket socket, fabricated by the dry method, has one sixth of the strength of a poured zinc connection.

1. True
2. False

4-64. Molten lead is used vice zinc for a basket socket. This socket has approximately what fraction of the strength of a zinc connection?

1. One fourth
2. One half
3. Three fourths
4. Seven eighths

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ASSIGNMENT 5

Textbook Assignment: "Rigging" and "Reinforcing Steel," pages 5-1 through 6-37.

Learning Objective: Recognize block-and-tackle arrangements used by Steelworkers.

5-1. The most important operation in rigging is safety.

1. True
2. False

5-2. The mechanical advantage of a machine is the amount a machine can multiply the force used to lift or move a load.

1. True
2. False

5-3. What term is used when blocks of a tackle are as close together as they can go?

1. Two-blocked
2. Fall
3. Running block
4. Standing block

5-4. What is a block called when it is attached to an object to be moved?

1. A two-block
2. A fall
3. A running block
4. A standing block

5-5. The "becket" holds the block together and supports the pins.

1. True
2. False

5-6. The "cheeks" are the solid sides of the frame or shell.

1. True
2. False

5-7. A "sheave" is a round grooved wheel over which the line runs.

1. True
2. False

5-8. The "breech" is the opening through which the line passes.

1. True
2. False

5-9. If you wish to rig a tackle using 1/2-inch wire rope, you should select blocks that have a sheave that are of what size, in diameter?

1. 10 inches
2. 14 inches
3. 18 inches
4. 20 inches

5-10. When it is necessary to change the direction of pull on a line, you should use what type of block?

1. Snatch
2. Standard
3. Leading
4. Double

5-11. Adding a snatch block does NOT increase the mechanical advantage, of a tackle system.

1. True
2. False

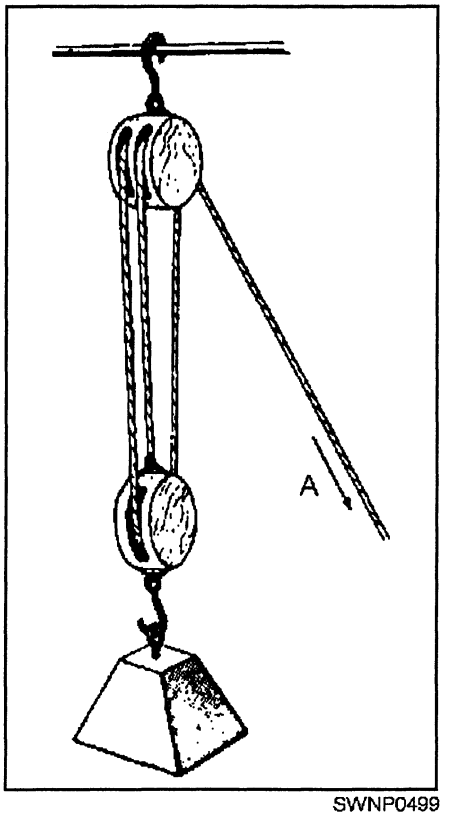


Figure 5A

IN ANSWERING QUESTIONS 5-12 THROUGH 5-14, REFER TO FIGURE 5A.

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5-12. In reeving a tackle with the blocks shown in figure 5A, you should first insert the standing end of the fall as shown by what arrow?

1. A
2. B
3. C
4. D

5-13. If the load on the tackle weighs 150 pounds, what force must be applied at arrow A to hoist the load if the effects of friction are not considered?

1. 50 pounds
2. 100 pounds
3. 300 pounds
4. 450 pounds

5-14. If the load is 900 pounds, what total pull must be applied at arrow A to overcome the friction in the blocks and lift the load?

1. 300 pounds
2. 330 pounds
3. 390 pounds
4. 570 pounds

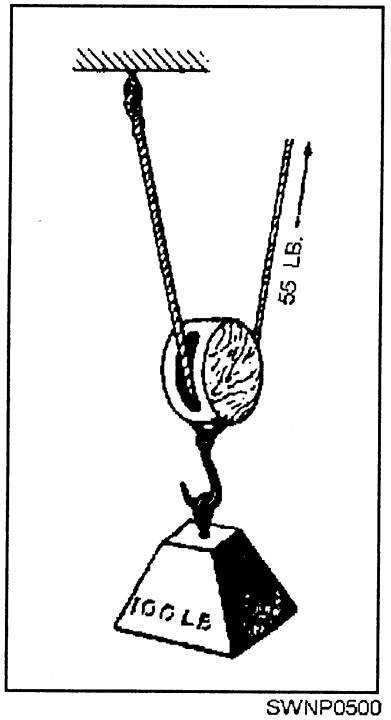


Figure 5B

IN ANSWERING QUESTION 5-15, REFER TO FIGURE 5B.

5-15. What type of tackle is used to lift the weight shown in figure 5B?

1. Single luff tackle
2. Gun tackle
3. Runner
4. Single whip tackle

5-16. In what type of tackle is the running block usually rigged with its sheaves at a right angle to the sheaves of the standing block?

1. A twofold purchase
2. A single luff
3. A double luff
4. A gun

5-17. What is the mechanical advantage of gun tackle when it is inverted?

1. 1
2. 2
3. 3
4. 4

5-18. A threefold purchase is made of two triple sheave blocks and provides a mechanical advantaqe of what value?

1. 4
2. 6
3. 8
4. 10

5-19. Determine the mechanical advantage of a compound tackle using two inverted luff tackles.

1. 8
2. 12
3. 16
4. 20

5-20. When the necessary allowance for friction is made, what is the safe working load (SWL) of a double-luff tackle reeved a with line that has a SWL of 3 tons?

1. 5 tons
2. 10 tons
3. 15 tons
4. 20 tons

Learning Objective: Identify the various means used to lift, move, or support heavy loads.

5-21. What are the primary advantages of wire rope slings?

1. Resiliency and strength
2. Strength and hardness
3. Flexibility and weight
4. Flexibility and strength

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5-22. When compared to wire rope slings, fiber line slings offer the advantage of protecting the finished material; however, they are not as strong as wire rope and are easily damaged by sharp edges on material.

1. True
2. False

5-23. Chain slings offer which of the following advantages?

1. Resistance to abrasion
2. Best for slinging hot loads
3. Best for handling loads with sharp edges
4. All of the above

5-24. "Strap" is the term commonly used when referring to what type of sling?

1. Single leg
2. Endless
3. Fiber line
4. Wire rope

5-25. When the weight is evenly distributed among the slings, how many 1/2-inch chain slings will you need to hoist a 5-ton load safely?

1. One
2. Two
3. Three
4. Four

5-26. Why are chain slings less reliable than fiber line or wire rope slings?

1. They have less resistance to stress and strain
2. They have welded links
3. Their links may crystallize and snap without warning
4. They cannot be protected from rust

5-27. When using rope yarn or wire to mouse a hook, you should make how many wraps?

1. 10 to 14
2. 8 to 10
3. 5 t0 7
4. 3 t0 5

5-28. What is the safe working load (SWL) of a 3/4-inch-diameter hook?

1. 500 pounds
2. 750 pounds
3. 1,000 pounds
4. 1,250 pounds

5-29. What is the SWL of a 1/2-inch-diameter shackle?

1. 1,000 pounds
2. 1,250 pounds
3. 1,500 pounds
4. 1,750 pounds

5-30. What is the small platform called that is used to store small lot items that can then be moved as one large item instead of piece by piece?

1. A sling
2. A spreader bar
3. A bridle
4. A pallet

5-31. What jack is used for tightening lines and bracing parts on bridge construction?

1. A ratchet
2. A screw
3. A steamboat
4. A hydraulic

5-32. When making a turn with a load on rollers, you should point the front and rear rollers in what direction?

1. Slightly opposite the direction of the turn
2. The front rollers slightly opposite to the direction of the turn with the rear rollers pointing slightly in the direction of the turn
3. Both slightly in the direction of the turn
4. The front rollers must be slightly, inclined in the direction of the turn with the rear of the rollers in the opposite direction

5-33. Blocking and cribbing are often necessary as a safety measure to keep an object stationary in position. This action can prevent accidental injury to personnel who must work near these heavy objects.

1. True
2. False

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Learning Objective: Identify the procedures for the construction, placement, and application of various types of scaffolding.

5-34. What is the maximum length of a swinging platform equipped with reinforcing under rails?

1. 14 feet
2. 18 feet 6 inches
3. 22 feet
4. 24 feet 6 inches

5-35. On a swinging platform, at what distance from the ends of each beam are the stops located?

1. 12 inches
2. 14 inches
3. 16 inches
4. 18 inches

5-36. A boatswain's chair should be used only if no other scaffolding means are not available.

1. True
2. False

5-37. If secured properly, the material used by a crew working on a scaffold can be stored on another scaffold.

1. True
2. False

5-38. Handlines should be used to raise and lower objects from scaffolding when they cannot be reached easily by hand.

1. True
2. False

Learning Objective: Describe the various types of field-erected hoisting devices.

5-39. What is the maximum height limit for an 8-inch-diameter gin pole?

1. 20 feet
2. 30 feet
3. 40 feet
4. 50 feet

5-40. What is the safe capacity of a 40-foot spruce timber gin pole that has a 10-inch diameter?

1. 6,000 pounds
2. 7,000 pounds
3. 8,000 pounds
4. 9,000 pounds

5-41. How long should the guy ropes be for a 15-foot gin pole?

1. 30 feet
2. 45 feet
3. 60 feet
4. 75 feet

5-42. To what depth should the hole be dug for the base of a gin pole?

1. 6 feet
2. 2 feet
3. 3 feet
4. 4 feet

5-43. When a gin pole is being erected, the rear guy line must be kept under tension to prevent the pole from swinging and throwing all of its weight on one of the side guys.

1. True
2. False

5-44. What are the primary advantages of using the tripod over other rigging installations?

1. Load capacity and stability
2. Load capacity and cost
3. No guy lines required and load capacity
4. Stability and no guy lines required

5-45. The strength of a tripod is directly affected by the strength of the rope and the lashings used.

1. True
2. False

5-46. When shears are used to lift heavy loads, the length to diameter (L/D) ratio should not exceed what number?

1. 40
2. 50
3. 60
4. 70

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5-47. What is the maximum allowable drift (inclination), in degrees, for shears?

1. 30
2. 35
3. 40
4. 45

5-48. When shears are erected, the spread of the legs should equal what length?

1. One fifth of the length of the legs
2. One fourth of the length of the legs
3. One third of the length of the legs
4. One half of the length of the legs

Learning Objective: Identify the purpose, types, and uses of reinforcing steel in concrete.

5-49. What is the primary factor that determines the strength of concrete?

i. Dryness
2. Water-to-cement ratio
3. Age
4. Type of steel reinforcement

5-50. Concrete is strong in tension but weak in compression.

1. True
2. False

5-51. Which of the following factors make steel the best material for reinforcing concrete?

1. Steel adds compressive strength
2. The expansion properties of both steel and concrete are approximately the same
3. Steel is easily bent to fit all shapes of forms
4. Steel adheres well to concrete

5-52. What type of surface condition on rebar provides the best adherence with concrete?

1. Clean and smooth
2. Loose or scaly rust
3. Painted
4. Light firm layer of rust

5-53. On what part of rebar are diameter measurements taken?

1. The round/square where there are no deformations
2. Across the deformations where the diameter is greatest
3. The diagonal of its widest section
4. The diameter of the deformation plus the height of the deformation

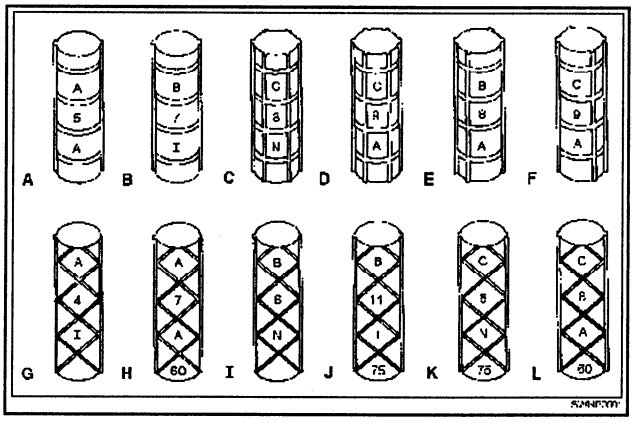


Figure 5C

IN ANSWERING QUESTIONS 5-54 THROUGH 5-56, REFER TO FIGURE 5C.

5-54. The identifying marks of bar D indicate what grade of rebar?

1. 40,000 psi
2. 50,000 psi
3. 60,000 psi
4. 75,000 psi

5-55. What types of rebar are equal in size, type, and grade in both bar-branding systems?

1. E and L
2. D and F
3. B and J
4. A and F

5-56. What types of rebar are rolled axle steel?

1. A, D, F, L
2. B, C, G, K
3. C, E, N, A
4. H, I, J, K

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5-57. When the number designation 8x8x10x10 is used, what do these numbers indicate about a roll of wire mesh?

1. The wire gauge is 8 and the crosswise spacing is 10 inches
2. The wire gauge is 10 and crosswise and lengthwise spacing is 8 inches
3. The wire gauge is 8 and the length spacing is 8 inches
4. The crosswise spacing is 10 inches and the wire gauge is 10

Learning Objective: Identify the fundamentals of bending, tying, and placing reinforcing bars.

5-58. What size pin diameter is required when a bend is made on a #9 bar?

1. 8 1/2 inches
2. 9 inches
3. 11 1/4 inches
4. 18 inches

QUESTIONS 5-59 THROUGH 5-62 CONCERN THE HYDRAULIC IRONMASTER ROD BENDER.

5-59. What is the maximum capacity for cold working rebar?

1. #7
2. #9
3. #10
4. #11

5-60. The bend angle which is set on the control rod is graduated into (a) what range of degrees at (b) what intervals?

1. (a) 10° to 360° (b) 10°
2. (a) 5° to 180° (b) 10°
3. (a) 5° to 190° (b) 5°
4. (a) 5° to 180° (b) 5°

5-61. What is the purpose of the shearing support?

1. To prevent the bars from kicking up during shearing operations
2. To prevent the breaking of bars after bending past 190 degrees
3. To allow the table to back off slightly after bending
4. To disengage the bending cylinder and return the rack to neutral

5-62. A bar marked 1 B0409 is to be bent into a 180-degree S-shape that is considered a standard bend. What is the minimum diameter of the pin around which the bar can be bent?

1. 8 inches
2. 2 inches
3. 3 inches
4. 4 inches

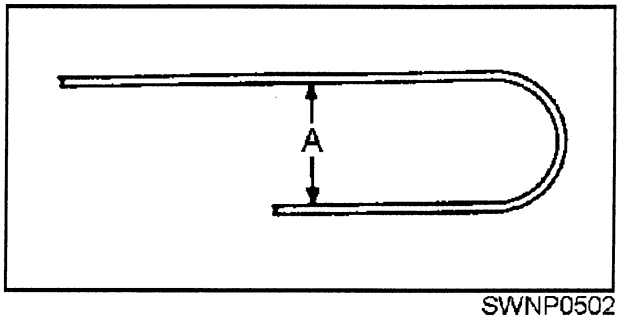


FIGURE 5D

IN ANSWERING QUESTION 5-63, REFER TO FIGURE 5D.

5-63. In checking the building plans, you notice that six rebars marked 3C0205 are to be bent with standard 180-degree hooks at one end. Distance A should equal

1. 1 1/2 inches
2. 2 1/2 inches
3. 3 1/2 inches
4. 4 inches

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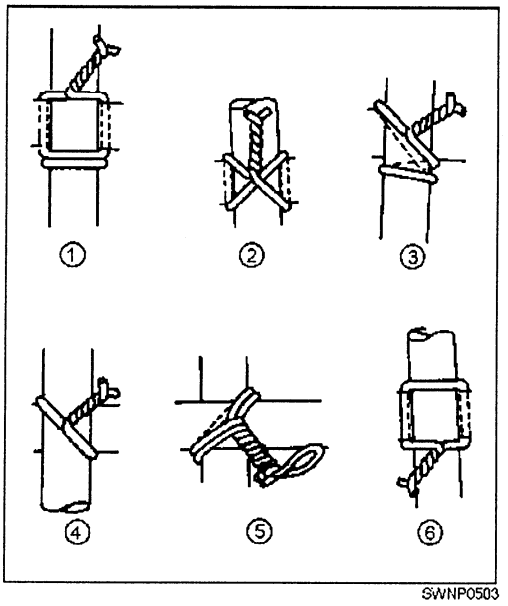


Figure 5E

IN ANSWERING QUESTIONS 5-64 THROUGH 5-66, REFER TO FIGURE 5E.

5-64. What tie is most often used in floor slabs?

1. 6
2. 2
3. 3
4. 4

5-65. What type is tie #l?

1. Double-strand single strand
2. Saddle tie with a twist
3. Figure eight tie
4. Saddle tie

5-66. What tie will cause the LEAST amount of twisting action on rebar?

1. 5
2. 2
3. 3
4. 4

5-67. In concrete, proper coverage of the bars is required to prevent what condition(s) from developing?

1. Fire, weather, and corrosion damage
2. Bars expanding and breaking through the concrete
3. Rust seeping to the surface of the concrete
4. Loss of tensile strength in the bars

5-68. In footings between the ground and steel, what minimum thickness of concrete should be provided?

1. 6 inches
2. 8 inches
3. 3 inches
4. 4 inches

5-69. When splicing 1/2-inch-thick rebar of reinforcing steel without the benefit of drawing specifications, what is the minimum distance that you should lap the bar?

1. 12 inches
2. 15 inches
3. 20 inches
4. 25 inches

5-70. When a column assembly of rebar is raised into place, the reinforcing steel is tied to the column form at intervals of what distance?

1. 5 feet
2. 2 feet
3. 3 feet
4. 4 feet

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ASSIGNMENT 6

Textbook Assignment: "Pre-engineered Buildings, K-spans, Towers, and Antennas" and "Pre-engineered Storage Tanks," pages 8-1 through 9-13.

Learning Objective: Identify the construction characteristics of pre-engineered metal structures and procedures for erection and disassembly.

6-1. What is the true length of a pre-engineered building (P.E.B.) that consists of four bays?

1. 40 feet 6 inches
2. 60 feet 6 inches
3. 80 feet 6 inches
4. 90 feet 6 inches

6-2. There are a total of how many intermediate frames in a P.E.B. that is 100 feet long?

1. Nine
2. Eight
3. Six
4. Four

6-3. What is the most important step in pre-erection work that increases the ease of erecting a P.E.B.?

1. Earthwork placement
2. Forms placement
3. Concrete placement
4. Anchor bolt placement

6-4. At what location is the erection manual and a set of drawings for a P.E.B. to be erected and maintained?

1. With the plans and specifications
2. In the battalion tech library
3. In the small parts box (Box 1)
4. At the quality control office

6-5. You are ready to begin the erection of a P.E.B. at a selected site. At what location(s) should the girts, purlins, cave struts, and brace rods be staged?

1. In the center of the site
2. At each end of the site
3. At the designated locations around the site where they will be used
4. Only at one end of the site

6-6. After all foundation work is completed and cleaned off, the base shoes are bolted in place. What component(s) is/are laid out next?

1. The doors only
2. The assembled columns and roof beams
3. The girts only
4. The purlins and struts

6-7. When a gin pole is being used to raise the end frame of a P.E.B., what action should you take to prevent distortion of the frame as it is being raised into place?

1. A driftpin should be dropped into the frame
2. A block should be mounted to the top of the gin pole
3. A tag line should be attached to the frame
4. A bridle should be attached securely on each side of the frame below the splice connection and to the ridge of the roof beam

6-8. A gin pole is being used to raise an end frame of a P.E.B. What action can the tagman take to maintain control of the frame if it moves beyond the vertical position?

1. Keep the line taut
2. Allow some slack in the line
3. Keep the frame in balance just beyond the vertical position
4. Take a few turns of the tag line around the bumper of a truck previously positioned for this purpose

6-9. How do you determine whether the erected columns of the frame for a P.E.B. are plumb and square?

1. By checking each corner with a carpenter's level
2. By checking each corner with a carpenter's square
3. By checking the horizontal distance from the upper corner of one frame to the upper corner of the adjacent frame
4. By checking the diagonal distance from the upper corner of one frame to the lower corner of the adjacent frame

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6-10. When should a construction team install the cave struts, girts, and purlins in the bays of a P.E.B.?

1. After the building is completed
2. After all the frames are erected
3. As soon as each frame is erected
4. As soon as the diagonal brace rods are installed

6-11. When the base angles are installed, you can take what action that will permit adjustments after the wall sheeting has been applied?

1. Bolt the base angles in place
2. Sweep the concrete foundation
3. Place a flat steel washer under each nut
4. Leave the nuts loose

6-12. Helix nails or sheet-metal screws are recommended for attaching what type of P.E.B. insulation material to the building?

1. Hardboard insulation that is applied directly to the inside surface of the structural
2. Blanket-type insulation installed between the sheets and structural
3. Hardboard secured to wood framing
4. Sheet board to the outside frame

6-13. When disassembling a P.E.B., you remove what structural member first?

1. Windows
2. Doors
3. Sheeting
4. Purl ins

6-14. After the sheeting has been removed from a P.E.B., you can proceed to disassemble the building by removing what parts first?

1. Frames
2. Girts and purlins
3. Windows, doors, and end walls
4. Diagonal brace angles and sag rods

Learning Objective: Identify erecting procedures for K-span buildings (ABM 120).

6-15. The K-span building machine turns coils of steel into structural strength arched panels which are machine seamed together. This process eliminates the need for nuts, bolts, or other types of fasteners.

1. True
2. False

6-16. The machine operator does NOT control which of the following functions?

1. The running of the stock through to form the panel shape
2. The cutting of the stock to the correct length
3. The selection of the site location
4. Putting the arch in the panel

6-17. Concrete forms and accessories are provided for a K-span building of what size?

1. 100 feet long by 50 feet wide
2. 100 feet long by 40 feet wide
3. 80 feet long by 50 feet wide
4. 80 feet long by 40 feet wide

6-18. All material for the forms is provided for with the exception of

1. stakes
2. side form panels
3. end wall caps
4. cross pipes

6-19. Why is attaching the spreader bar a critical step in erecting panels?

1. A loose clamp can cause panels to slip and fall, resulting in injury to personnel and damage to the panel
2. A loose clamp can cause damage to the crane
3. Guide ropes are not required with a spreader bar
4. It allows panels to be placed in high winds

6-20. It is not necessary to seam each set of standing panels before detaching the spreader bar.

1. True
2. False

6-21. How many inches “on center” do you weld the panels to the attaching angle?

1. 8
2. 10
3. 12
4. 14

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6-22. Which of the following building characteristics determine the foundation design of a K-span?

1. Wind load only
2. Building size only
3. Soil conditions only
4. Each of the above

6-23. Where are the actual footing details for a K-span building located?

1. In the erection manual
2. In the plans and specifications
3. In the blueprints
4. In the construction drawings

6-24. When do you install the end wall attaching angle?

1. After the first three panels are set
2. When the exact building length has been determined
3. After the first set of panels is set
4. After all panels are set

6-25. How many inches is the top exterior portion of the concrete sloped after all of the panels are welded to the attaching angle?

1. 6
2. 5
3. 3
4. 4

6-26. The Super Span (ABM 240) uses heavier coil stock, has a larger minimum and maximum span, and has a panel profile than that used for the K-span building (ABM 120) .

1. True
2. False

6-27. Although there are some differences between the ABM 120 and the ABM 240, the actual construction steps are the same for both buildings.

1. True
2. False

Learning Objective: Identify erecting and dismantling procedures for prefabricated steel towers.

6-28. What is the correct method for assembling a side of the first section of a tower?

1. Each leg is connected to the foundation stub
2. Two legs are connected to the foundation stub, then the angle and cross braces are joined
3. Two legs are connected to the foundation stubs, the angle and braces are joined, and the side is then erected as a unit
4. The whole section is assembled and fitted to the foundation stubs , and then connected

6-29. How are the bolts used in assembling a steel tower locked in place after the tower has been completed?

1. They are tightened with locknuts
2. They are center punched
3. They are countersunk
4. They are fitted with lock washers

6-30. When dismantling a tower, you should insert the fiber line in the snatch block after what steps have been accomplished?

1. The securing of one end of the tag line to one end of the bowline
2. The securing of the snatch block to the base of the tower
3. The lining up of the snatch block with the power source
4. The attaching of a shackle to the gusset plate and hanging a snatch block in the shackle

6-31. To remove the legs of a tower section, you remove the first gusset plate to accomplish what action?

1. The securing of the tag line with a clove hitch
2. The cutting out of all of the rivets that hold the leg
3. The taking up of the slack in the hoist line
4. The tightening of the two inserted machine bolts

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6-32. You are dismantling the leg of a tower structure section that has served as a gin pole in the dismantling operation. You should remove the top machine bolt and loosen the other machine bolt one-quarter turn before taking what action?

1. Cutting the remaining rivets from the leg
2. Signaling the vehicle operator to back up slowly
3. Removing the gusset plate from one side of the splice
4. Signaling the crew to remove the hoist line from the base snatch block

6-33. How is an untapered antenna tower made structurally stable?

1. By guy wires attached to ground anchors
2. By external braces fastened to the base of the tower
3. By use of oversized base supports
4. By use of a composite base or foundation

6-34. What type of antenna tower requires a composite base?

1. Heavy construction
2. Guyed, light construction
3. Pivot type, light construction
4. Tapered, light construction

6-35. When level, the supports for an antenna tower can help keep sections of the tower from twisting.

1. True
2. False

6-36. You are fastening parts of an antenna tower with high strength steel bolts that are 3/4 inch by 10 inches in size. What is the maximum torque that you should apply to tighten the bolts?

1. 105 foot-pounds
2. 205 foot-pounds
3. 370 foot-pounds
4. 490 foot-pounds

6-37. Refer to textbook figure 8-33 which shows a davit hoist used for erecting a lightweight guyed tower. Why is a snatch block attached to the tower base?

1. To maintain a fixed distance between the hoisting line and the upper end of the davit
2. To help tower sections being hoisted from touching sections already in place
3. To direct the hoisting line to a winch
4. To fasten the tower base to the concrete foundation

6-38. How is a lightweight, pivoted 120-foot tower raised with a gin pole?

1. By a hoisting line attached to a single point near the tower top
2. By a snatch block and hoisting sling attached to the tower at two points
3. By a snatch block and tag line attached to the tower base
4. By a snatch block attached at the top of the tower

6-39. At least how many sections of a tower are erected before temporary guying becomes necessary?

1. One
2. Two
3. Three
4. Four

6-40. For a 200-foot tower with two guy layers, cable attachments should be positioned at approximately what levels?

1. The 60- and 100-foot levels
2. The 60- and 160-foot levels
3. The 160- and 200-foot levels
4. The 100- and 200-foot levels

6-41. When the guy tension is not specified in the tower installation plans, the tension is adjusted at first to what percentage of the breaking strength of the guy strand?

1. 10%
2. 20%
3. 30%
4. 40%

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6-42. After an antenna tower is erected and plumbed, you should test the tension of how many of its guy lines with a dynamometer?

1. One guy in each direction of pull
2. One guy only at each level to which guys are clamped
3. The uppermost guys only
4. All of the guys

Learning Objective: Identify the principles and methods of assembling and erecting pre-fabricated bolted steel tanks.

6-43. What size bolted steel tank will you need to store 10,000 gallons of water?

1. A 1.00 barrel tank
2. A 250 barrel tank
3. A 500 barrel tank
4. A 900 barrel tank

6-44. What size earth pad is required for a tank with an outside diameter of 15 feet 5 inches?

1. 15 feet 5 inches
2. 16 feet 5 inches
3. 17 feet 5 inches
4. 18 feet 5 inches

6-45. What advantage is gained from the spreading of a layer of clean sand or gravel over the foundation for a tank ?

1. Good drainage is ensured
2. Corrosion is prevented
3. Oxidation is increased
4. Erosion is prevented

6-46. The two bottom plates of a 100 barrel tank are what shape?

1. Wedge
2. Semicircular
3. Circular
4. Square

6-47. What part of the tank erection kit do you use to make the tank deck slope properly?

1. A bolt retainer angle
2. A flanged manhole
3. A top chime
4. The center ladder

6-48. What part of the deck section acts as a supporting rafter for the top of the tank?

1. The center ladder support
2. The flanged side
3. The radial seam joint
4. The bolt retainer angle

6-49. What is the total capacity, in gallons, of a 250 barrel tank?

1. 4,500
2. 5,350
3. 10,500
4. 21,000

6-50. The bottom of what size tank consists of 14 wedge-shaped plates that connect to a one-piece center-ring section?

1. 100 barrel
2. 250 barrel
3. 500 barrel
4. 900 barrel

6-51. After the bottom plates of a 250 or 500 barrel tank have been installed, their pattern should resemble what shape?

1. A triangle
2. A rectangle
3. A wheel
4. A trapezoid

6-52. What characteristic should the ends of gasket material that you have broken or cut exhibit to ensure a leakproof joint?

1. They should overlap at least two bolt holes and be squarely across the second hole
2. They should be cut squarely and bolted close together over two bolt holes
3. They should be laid over each other in a crosswise fashion
4. They should extend at least one bolt hole and be folded back under the cutoff piece

6-53. After the first intermediate plate has been installed on the bottom of a 500 barrel tank, the remaining plates are installed in a counterclockwise direction.

1. True
2. False

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6-54. What is the reason that all catch nuts for the bolts on the bottom plates of a tank should be finger-tightened only?

1. So each plate can be adjusted to allow the last plate to fit
2. So the wedge gussets fit under
3. So caulking can be applied under all gaskets
4. So the gaskets are not damaged during assembly

6-55. At what point during construction should the center support ladder components and manhole dome be placed inside the tank?

1. Just before the bottom bolts are tightened
2. Just before the last stave is installed
3. Just after the deck has been installed
4. Just after sealing compound has been applied to all bottom seams

6-56. To determine which end of a stave is the top, you look at the stave from the outside while it is in the vertical position. If the stave is in the proper position, offsets are at what corners?

1. Upper right and lower left
2. Lower right and upper left
3. Lower left and upper left
4. Upper right and upper left

6-57. The special stave, fitted with a pipe coupling of the same size as the tank supply pipe, must be the first stave to be installed.

1. True
2. False

6-58. Of the 14 deck plates used for the 500 barrel tank, 2 are fitted with what components?

1. Liquid level indicators
2. A tank thief and vent
3. Cross-braced flanges
4. Left-side lap seams

6-59. As the deck plates are being installed, you find that the ends of some of them will not align with the bolt holes on the manhole or the top chime bolts. What action should you take to eliminate this problem?

1. Cut the short end around the manhole with a torch
2. Raise or lower the center support ladder until all deck section bolt holes are aligned
3. Raise the outside or top chime section and pull the vertical staves out or in as required
4. Increase the size of the holes by drilling

6-60. If a tank is to used for other than water storage, the emergency vent valve can be omitted.

1. True
2. False

6-61. The outside ladder assembly of a 500 barrel tank has how many steps?

1. Five
2. Seven
3. Eight
4. Nine

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ASSIGNMENT 7

Textbook Assignment: "Pontoons" and "Pre-engineered Structures: Short Airfield for Tactical Support," pages 10-2 through 11-27.

Learning Objective: Identify the design and construction features of P-series pontoons and attachments.

7-1. What types of pontoons are used to form a continuous ramp for causeway ends and barge bows?

1. P1 and P2
2. P3 and P4
3. P1 and P3
4. P2 and P4

7-2. What pontoon number does a P2 become when quick-lock connectors are fixed to-its bow?

1. P5
2. P2
3. P3
4. P4

7-3. A 4 by 12 pontoon assembly consists of

1. 4 pontoons, each 12 feet square
2. several 4-foot by 12-foot pontoons
3. 4 pontoon strings in width and 12 pontoons long
4. 4 pontoon strings, each 12 feet long

7-4. Assembly angles E16L and E26R are designed to be used

1. as basic condition angles on the edges of the pontoon strings
2. as basic condition angles anywhere on the pontoon strings
3. as end condition angles on left and right edges, respectively, of the pontoon strings
4. as basic condition angles only to be used on topside of the continuous angles

7-5. What device is used to prevent an A6 assembly bolt from working out of assembly angles?

1. A cotter pin
2. Keeper plates
3. Flanged nuts
4. Links

7-6. What accessory is used for connecting pontoon strings at the point where each string has a P3 sloped-deck ramp pontoon connected to a P1 pontoon?

1. AP8 ramp-end bent plate
2. AP7 gusset plate
3. AP6 chafing plate
4. AP5 end plate

7-7. When installing RF1 rubber fenders, you use the RF4 fender bracket for what purpose?

1. Horizontal fender connections
2. Corner installations
3. Drop fender installations
4. Diagonal fender installations

7-8. The H6 hatch cover and floor panel assembly are primarily used to convert what type of pontoon into a storage compartment?

1. P1
2. P2
3. P5M
4. P4

7-9. The DC6 deck closure is used

1. to bridge openings or slots between pontoons
2. to bridge the space between adjacent causeway sections being set up
3. to make a bridge to wharf connection
4. to make a barge to wharf connection

7-10. What bitt is desiqned for quick positioning in the chain plate of a causeway section?

1. The B1 all-purpose bitt
2. The MI147 double bitt
3. The B4 retractable bitt
4. The LK12 utility bitt

Learning Objective: Identify the fundamentals of assembling pontoons to form a string, launching the string, and joining launched strings to form barges and causeways.

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7-11. At what location should you position the first and succeeding pontoons after the first two assembly angles are installed in a causeway section?

1. The first pontoon is placed in the center of the angle and succeeding pontoons on each side of the first one
2. The first pontoon is placed on the bow and succeeding pontoons on the stern, working forward
3. The first pontoon is placed on the bow, the second on the stern, the third on the bow, and the fourth on the stern
4. The first pontoon is placed on the stern then succeeding pontoons work outward and forward

7-12. In which of the following ways are A6B bolts used in the construction of pontoon systems?

1. To connect strings into structures
2. To secure assembly angles to pontoons at each corner
3. To secure deck fittings and accessories
4. All of the above

7-13. After being launched, what special tool is used to clamp together a series of pontoon strings?

1. JT7 drive wrench
2. JT8 backup wrench
3. JT13 two-piece aligning tool
4. JT2 top angle clamp

7-14. The JT13 aligning tool should be used when the differences in the hole alignment between angles restrict easy passage of A6B bolts.

1. True
2. False

7-15. What pontoon barge was designed for mounting a crawler crane?

1. The 3 by 12
2. The 4 by 12
3. The 5 by 12
4. The 6 by 18

7-16. What is the primary use of the 10 by 30 barge?

1. As a 1,500 barrel fuel storage tank
2. As a mount for a 100-ton derrick
3. As a heavy-duty wharf structure
4. As a warping tug

7-17. A pontoon causeway consists of what sections?

1. One inshore and one offshore with as many intermediate sections as required for length
2. One inshore, one intermediate, and two offshore
3. Two inshore, two offshore, and two intermediate
4. One inshore and two offshore

7-18. What types of pontoons make up an inshore section of a causeway?

1. P1, P5M, and P4
2. P1, P2, P3, and P4
3. P1, P5F, and P5M
4. P1, P3, P4, and P5M

7-19. Causeway sections are normally deployed on what type of ship?

1. LSD
2. LCM
3. LST
4. LPD

7-20. To submerge the decks of a dry dock to its maximum depth of 12 feet, you need a sheltered area with a smooth bottom with how many feet of quiet water?

1. 12 to 14
2. 18 to 20
3. 22 to 24
4. 24 to 26

7-21. What type(s) of pontoons are used to form dry docks?

1. P1 and P5M
2. P1, P2, and P3
3. P1 only
4. P4 only

Learning Objective: Identify the design, use, and features of the Elevated Causeway Sections (ELCAS).

7-22. The ELCAS is used to bridge the surf zone.

1. True
2. False

7-23. A standard ELCAS consists of three 3 by 15 approach/roadway sections and

1. nine 3 by 15 pierhead sections
2. six 3 by 15 pierhead sections
3. three 3 by 15 pierhead sections
4. four 3 by 15 pierhead sections

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7-24. What unique component of the ELCAS system gives it the ability to elevate?

1. P1 pontoons
2. Supporting pilings
3. Spudwells
4. 3 by 15 intermediate causeway sections

7-25. Internal spudwells are used in the inboard string of pierhead sections.

1. True
2. False

7-26. The ELCAS consists of a total of how many parts?

1. Eight
2. Six
3. Three
4. Four

7-27. How many spudwells are required to construct a type 3 pierhead section?

1. Three internal and four external
2. Four internal and four external
3. Four internal and three external
4. Three internal and three external

7-28. The fender system uses P8 pontoons as end-to-end connections instead of P5 pontoons since it is only one pontoon wide.

1. True
2. False

Learning Objective: Identify the construction features and functions of the major components of the Short Airfield for Tactical Support (SATS).

7-29. AM-2 matting is manufactured from what type of metal?

1. Steel
2. Aluminum
3. Iron
4. Copper

7-30. Why are AM-2 mats installed with their joints staggered in a brickwork fashion?

1. To stabilize the runway across its width and in the direction of aircraft travel
2. To stabilize the runway across its width and to make it flexible in the direction of aircraft travel
3. To make the runway flexible across its width and to stabilize it in the direction of aircraft travel
4. To make the runway flexible across its width and in the direction of aircraft travel

7-31. What are the contents of one full pallet assembly of AM-2 matting?

1. 11 half mats, 2 full mats, and 2 locking bars
2. 2 half mats, 11 full mats, and 2 locking bars
3. 4 half mats, 8 full mats, and 12 locking bars
4. 2 half mats, 11 full mats, and 13 locking bars

7-32. What does one F15 pallet assembly of AM-2 matting contain?

1. 2 half mats, 4 full mats, and 10 locking bars
2. 2 half mats, 8 full mats, and 20 locking bars
3. 4 half mats, 20 full mats, and 24 locking bars
4. 4 half mats, 16 full mats, and 20 locking bars

7-33. The standard pallet assembly (F11) provides a width of two rows (4 feet) on a runway or taxiway that is how many feet wide?

1. 54
2. 72
3. 69
4. 99

Learning Objective: Recognize the general principles and procedures for installing AM-2 runway mats.

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7-34. When a SATS site for placement of AM-2 mats is being prepared, the surface must be leveled and graded so that over a span of 12 feet, the maximum variation in height of the mats is

1. 1 inch
2. 3/4 inch
3. 1/2 inch
4. 1/4 inch

7-35. For which of the following reasons should accurate longitudinal and transverse center lines be established before a SATS installation?

1. To ensure there is enough room for the airfield
2. To ensure that the site meets CBR requirements
3. To make the deployment of pallets easier
4. All of the above

7-36. What equipment is best suited for handling pallets of AM-2 airfield matting?

1. A motorized rough-terrain crane
2. A helicopter
3. A 4K forklift
4. A 6,000-pound rough-terrain forklift

7-37. In addition to the POIC, the typical installation crew assigned to lay a 96-foot-wide runway consists of what personnel?

1. 1 alignment man, 12 mat installation men, and 2 pry bar men
2. 2 alignment men, 12 mat installation men, and 2 pry bar men
3. 2 alignment men, 24 mat installation men, and 2 pry bar men
4. 2 alignment men, 12 mat installation men, and 4 pry bar men

7-38. The pry bar men of the installation crew are responsible for which of the following tasks?

1. Adjusting the first mat in each transverse row
2. Spacing the mats to allow for thermal installation and insertion of the mat-locking bars
3. Taking the mats from a pallet and installing them in place
4. All of the above

7-39. What is used as the starting point for laying runway mats in an installation not requiring a guide rail system?

1. The approach apron
2. The transverse center line
3. The longitudinal center line
4. The end opposite the approach apron

7-40. In an installation requiring a guide rail system, starter keylocks are used for laying runway mats.

1. True
2. False

7-41. To guide the crew in the installation of the AM-2 matting, you should install keylocks every 100 feet.

1. True
2. False

7-42. What action, if any, is recommended to prevent a seesaw force from disturbing the alignment of the matting when a keylock section is placed and aligned at the center line?

1. Lay several transverse rows of matting initially in opposite directions
2. Initially lay several transverse rows of matting in one direction only
3. Lay several longitudinal rows of matting in one direction
4. None

7-43. When AM-2 mats are being installed, the installers can prevent misalignment due to the "loose fit" design by taking what action?

1. Using locking bars as temporary spacers between the rows
2. Installing rubber spacers between the longitudinal rows
3. Installing rubber spacers between the transverse rows
4. Installing gap gauges between the transverse rows

7-44. What devices are used to secure typical 9-foot and 12-foot keylocks together?

1. Male-female edges
2. Locking bars
3. Socket head screws
4. Binding straps

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7-45. On what type of surface should mat ends be laid?

1. Crushed rock
2. Concrete
3. Packed dirt
4. Sand

7-46. At what depth should the free end of the approach apron be buried?

1. Between 12 to 16 inches
2. Between 16 to 18 inches
3. Between 18 to 24 inches
4. Between 24 to 26 inches

7-47. When guide rails and mats are being laid, any depression in the grade that is not within specifications can be disregarded.

1. True
2. False

7-48. What total number of gap gauges should remain installed after the guide rail pins have been installed?

1. 10
2. 2
3. 5
4. 4

7-49. To speed up the installation of AM-2 mats, you should assume that no two parts are laid at the same time. For the field-laying procedure, what is the order of sequence of installation, first to last?

1. Lateral taxiway, main runway, parallel taxiway, and parking areas
2. Main runway, parallel taxiway, parking areas, and lateral taxiways
3. Main runway, lateral taxiways, parallel taxiways, and parking and storage areas
4. Lateral taxiway, parallel taxiway, main runway, and parking and storage areas

7-50. As described in the text for taxiway procedure #2, the space between the taxiway and the runway should fall within what size range, in inches?

1. 1 to 2
2. 2 to 3
3. 3 to 4
4. 4 to 5

7-51. Parking and storage areas may be laid with leftover mats in any random pattern.

1. True
2. False

Learning Objective: Identify the procedures for repairing damaged matting and for disassembling and removing the matting from the runway.

7-52. When cutting out a damaged AM-2 mat, you should make a cut along (a) what edge and (b) what connector?

1. (a) Female (b) prongs-up
2. (a) Male (b) prongs-down
3. (a) Female (b) prongs-down
4. (a) Male (b) prongs-up

7-53. In the lower adapter, the dowel pin functions as (1) a locating device in the placement of the upper and middle adapters on the lower adapter, and (2) a means of keeping the holes in the upper, middle, lower, and connector adapters in approximate alignment.

1. True
2. False

7-54. What action is taken to lock in place the locking bar of the replacement mat shown in figure 11-34 of the textbook?

1. The attachment of a clamp over the male connector
2. The bottoming of the setscrew
3. The tightening of the socket head screws
4. The insertion of the dowel pins

7-55. A section of SATS runway must be replaced. To remove the typical keylock section, you should ensure what step is taken first?

1. Pry the keylock out halfway
2. Insert the keylock removal tool
3. Remove the socket head screw
4. Loosen the socket

7-56. When replacing a SATS runway section, you remove the initial 3-foot and 6-foot keylock section by

1. hammering it out with a sledge
2. prying it with a bar
3. pulling it with a keylock removal tool
4. cutting it with a portable saw

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7-57. The first row of runway mats can be disassembled and removed by lifting the entire row evenly with lifting blocks and pry bars and by pulling out the locking bars.

1. True
2. False

7-58. In the procedure for replacing damaged mats with new or refurbished mats, the last row of matting is raised in unison for what purpose?

1. To level the ground surface
2. To attach end connectors
3. To insert locking bars
4. To install the guard rail

7-59. What material should be used to reinforce filled cavities under AM-2 matting?

1. Dry sand
2. Crushed rock
3. Damaged AM-2 mats
4. Restored AM-2 mats

7-60. In which of the following ways should you position mats-so their edges can be straightened with the edge repair tool?

1. To give the tool clearance, place them on blocks that have the height to do this
2. When straightening male edges, place the tops of the mats face up
3. When straightening lower and upper female edges, place the bottoms of the mats face up
4. All of the above

7-61. What components do you remove last when using the most efficient procedure for disassembling a SATS runway (no guide rail)?

1. Typical keylocks
2. Female keylocks
3. Starter keylocks
4. Starter locking bars

7-62. When disassembling a guide rail equipped SATS runway, you should start removing mats from the end of the runway that was assembled last.

1. True
2. False

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ASSIGNMENT 8

Textbook Assignment: "Steelworker Tools and Equipment," pages 12-1 through 12-15.

Learning Objective: Describe the principles and techniques for operating and maintaining tools used by Steelworkers in the shop and field.

8-1. Work that does not require great accuracy and is accomplished on a bench or pedestal grinder is known as what type of grinding?

1. Free hand
2. Precision
3. Off hand
4. Offset

8-2. What advantage is gained by flooding the wheel on a wet type of grinder?

1. The wheel will not become brittle
2. The chips and cracks are made easy to find
3. Fire hazards are totally eliminated
4. The wheel and work are kept cool and clean

8-3. Tool rests on a grinder must always be used and properly adjusted to prevent what problem from occurring?

1. Work becoming wedged between the rest and the wheel
2. Fingers being caught in the wheel
3. Clothing getting caught in the wheel
4. Sparks and dust obscuring the view of the work

8-4. Grinding wheels can be sources of danger and must be checked periodically for irregularities and soundness. To test the wheel, you suspend it on a string or wire and tap it with a metal rod. A solid wheel gives off a clear ringing sound.

1. True
2. False

8-5. When using a wheel dresser, you should never take which of the following actions?

1. Remove the glaze from the wheel
2. True the wheel
3. Put the flat surfaces on the sides of the wheel
4. Bring the wheel back to round

8-6. Because doing so will clog the wheel, you should never shape which of the following metals on an abrasive wheel?

1. Gray cast iron
2. High carbon steel
3. Aluminum
4. Tungsten

8-7. Which of the following actions should you take before using a pneumatic tool?

1. Inspect the air hose for leaks or damage
2. Blow air through the air hose to free it of foreign material before connecting it to the tool
3. Keep the air hose clean and free of lubricants
4. All of the above

8-8. Compressed air comes directly in contact with valves and pistons in pneumatic hammers and causes which of the following conditions to occur?

1. Rust formations in the valves
2. Lubricants evaporate from the system
3* Lubricants are driven out of the exhaust
4. Lubricants become contaminated with moisture

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8-9. Which of the following steps must be taken when working continuously with a pneumatic tool on a compressed air system not equipped with a filter, a regulator, and a lubricator assembly?

1. Stop hourly, disconnect the hose, and squirt a few drops of heavy oil into the hose connection
2. Stop twice daily, disconnect the hose, and squirt a few drops of light oil into the hose connection
3. Every morning before starting, squirt as much oil as you can into the hose connection
4. Disconnect the hose every hour or so and squirt a few drops of light oil into the hose connection

8-10. What lubricant must be used to clean a pneumatic tool that has become gummed up and dirty from heavy oil?

1. Kerosene
2. Cleaning solvent
3. Gasoline
4. Diesel fuel

8-11. What other task does the combination iron worker perform in addition to shearing, coping, notching, and mitering?

1. Straightening bends
2. Punching holes
3. Cutting circles
4. Bending rebar

8-12. The maximum capacity of a material that can be safely handled by a combination iron worker is found at what location?

1. On the supervisor's checklist
2. At designated sites
3. On the capacity plate
4. On the material handling cards

8-13. The vertical band saw is primarily used to make curved cuts; however, it is frequently used for what other type of cutting?

1. Design
2. Off hand
3. Machine
4. Straight

8-14. On a band saw, the mechanism that adjusts and controls the alignment and tensioning of the blade is at what location?

1. On the blade guides
2. On the lower wheels
3. On the upper wheels
4. On the worktable

8-15. What is the smallest size band saw manufactured?

1. 12 inches
2. 14 inches
3. 16 inches
4. 18 inches

8-16. Which of the following values do you add to the circumference of one wheel to determine the required length of a vertical band saw blade?

1. Twice the distance between the wheel centers
2. The distance between the wheel centers
3. Twice the tension adjustment range
4. Tooth points per inch by thickness by gauge

8-17. What factor determines the size of the radius of the curves and circles you can cut with a vertical band saw?

1. The number of teeth per inch of blade
2. The thickness of the material being cut
3. The speed of the blade
4. The width of the blade

8-18. When making identical cuts on multiple pieces at the same time on a band saw, you must follow what procedure?

1. Put them in a jig
2. Clamp them together
3. Tack-weld them together
4. Increase the blade speed

8-19. Which of the following blades can be reconditioned by the same procedures that are used for a band saw blade?

1. A hacksaw
2. A circular saw
3. A hand ripsaw
4. A chain saw

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8-20. Which of the following processes do you use to repair a broken band saw blade when there is no accessory welder available?

1. The soldering
2. The riveting
3. The overlapping
4. The brazing

8-21. Why must you anneal a band saw blade again after grinding the weld bead off a butt-welded blade?

1. To achieve uniform thickness alignment
2. To remove burrs and correct alignment
3. To remove any hardness that has developed while grinding
4. To retemper the band saw blade

8-22. When working on a band saw and the blade breaks, you should take what action first?

1. Step clear of the machine
2. Pull the piece clear you are working on
3. Attempt to guide the broken piece out of the machine
4. Immediately shut off the power

8-23. What shop tool is gradually being replaced by the horizontal band cutoff saw due to its increased speed, accuracy, and versatility?

1. The vertical band saw
2. The reciprocating power hacksaw
3. The power shear
4. The unishear

8-24. What is the minimum number of teeth that should be in contact with the work when band sawing metals?

1. One
2. Two
3. Three
4. Four

8-25. Which of the following materials can be cut with a power hacksaw?

1. Bar stock
2. Tubing
3. Pipe
4. All of the above

8-26. What are the two types of power hacksaws?

1. High speed and low speed
2. Forward and reverse action
3. Mechanical and hydraulic drive
4. Vertical and horizontal feed

8-27. What does "the pitch of the teeth" mean in relation to the selection of band saw blades or hack saw blades?

1. The forward and reverse angle of the teeth
2. The number of teeth per inch
3. The width of the cutting area
4. The distance the blade can twist without affecting the cut

8-28. You are using a reciprocating power hacksaw. What feed on the hacksaw will shut off automatically if a hard spot is hit?

1. The hydraulic
2. The gravity
3. The mechanical
4. The pneumatic

8-29. How can you determine the speed of a power hacksaw?

1. Count the forward strokes
2. Count the reverse strokes
3. Count the strokes per minute
4. Count the strokes per minute that contact the material

8-30. Which of the following materials can be cut without using a coolant?

1. Solid brass
2. Rolled aluminum
3. Cast iron
4. Cold rolled steel

8-31. Why are belts almost always used instead of gears on a sensitive drill press?

1. Gears cause excessive vibration which eliminates the "feel"
2. Belts are stronger than gears
3. Belts require little maintenance
4. Gears are too heavy

8-32. Which of the following factors makes a radial drill press convenient to use on work where many holes must be drilled?

1. The ease the chuck can be swung out of the way
2. The work does not have to be readjusted for each hole
3. Adjust the drill base easily to drill all holes
4. Drill holes horizontally

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8-33. You have completed a preoperational safety inspection of a drill press; however, after it is started, you still should be alert for

1. frayed v-belts
2. loose locking handles
3. frayed electric cords
4. squeaks or unusual noises

8-34. The size of a drill bit can be indicated by which of the following designators?

1. Letters
2. Inches in diameter
3. Numbers
4. Each of the above

8-35. Which of the following cutting oils/cooling fluids reduces heat, overcomes rust, and improves the finish on ferrous metals?

1. Mineral oil
2. Kerosene
3. Soda water
4. Motor oil

8-36. When reshaping a badly worn drill bit that has become overheated by accident, you should take which of the following actions?

1. Dip it in cool water
2. Cool it with compressed air
3. Dip it in oil
4. Cool it in still air

8-37. What results when you use a drill bit you repointed but allowed too little lip clearance on it?

1. It will rub without penetration
2. It will gouge material
3. Its cutting action is increased
4. It will break easily

8-38. What results when you bore holes with a drill bit whose lip length and lip angles are improper?

1. Tapered holes
2. Angled holes
3. Oversized holes
4. Undersized holes

8-39. What shape are the chips that come from a hole that has been drilled in soft metal with a drill bit that was sharpened properly?

1. Long curled chips of unequal size
2. Long straight chips of equal size
3. Short tightly curled spirals
4. Curled spirals of equal length

8-40. Air compressors have a system for taking in air and exhausting it at a much higher pressure. This is accomplished by compressing the air through a process known by what term?

1. Reduction in volume
2. Pumping action
3. Compaction
4. Flow reduction

8-41. Air compressors in the field have a pressure control system that is governed to allow how many pounds of pressure?

1. 200 psi
2. 150 psi
3. 100 psi
4. 50 psi

8-42. The terrain or activity on a construction site may not allow a compressor to be placed near the actual work. For this reason, you should remember that air line hoses suffer a considerable loss in pressure beyond what distance?

1. 150 feet
2. 200 feet
3. 250 feet
4. 300 feet

8-43. A manifold compressor system that has a pipe 6 inches in diameter and 100 feet long can carry a total of how many cubic feet of air per minute?

1. 900 cfm
2. 1,000 cfm
3. 1,100 cfm
4. 1,200 cfm

8-44. When operating an air compressor, you must keep it within the 15-degree out-of-level limits for what reason?

1. To prevent stress on the compressor drive shaft
2. To prevent it from rolling without blocking
3. To prevent the starting torque from turning over the compressor
4. To maintain the proper engine crankcase and compressor oil levels

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8-45. When starting the engine of an air compressor, you should open the service valves to what position to hasten the warm-up of the compressor oil?

1. The one-quarter OPEN position
2. The half-OPEN position
3. The three-quarters OPEN position
4. The fully OPEN position

8-46. For what reason are both side curtains of the engine enclosure of an air compressor kept in the OPEN position when the engine is running?

1. To help detect engine malfunctions
2. To maintain an air flow through the oil cooler and radiator
3. To place the engine preheat switch within easy reach
4. To simplify mechanical adjustments

8-47. For how many minutes should the engine and compressor operate before you close the service valve and connect the tool hoses?

1. 10
2. 8
3. 6
4. 5

8-48. In cold weather conditions, what should you do to aid the warm-up of an air compressor?

1. Run it wide open for a couple of minutes
2. Open the service valves wide open
3. Leave the side curtains closed for a few minutes
4. Close all valves for 5 minutes

8-49. You must lubricate an air compressor according to the instructions maintained in what location(s)?

1. The crew leader’s instruction or SOP book
2. On the instruction plate or in the operator’s manual
3. Notices and instructions maintained by the mechanic
4. Your own notes from past inspections

8-50. The drain cocks on all air compressor field units must be opened for what reason?

1. To drain excess oil
2. To relieve air pressure
3. To drain condensation
4. To expel dust

8-51. In addition to shortening construction time, what is another advantage of using a blind rivet on pre-engineered metal buildings?

1. Eliminates the need for a bolting crew
2. Eliminates the need for scaffolding
3. Eliminates the need for tag lines
4. Eliminates the need for a drilling crew

8-52. What type of action does the blind rivet installation tool produce to compress the blind rivets after they are inserted into their holes?

1. A combined holding and hammering action
2. A combined clamping and crimping action
3. A combined vibrating and crushing action
4. A combined reciprocating and pulling action