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DEPARTMENT OF DEFENSE

HANDBOOK FOR WELDED JOINT DESIGNS, ARMORED-TANK TYPE

This handbook is for guidance only. Do not cite this document as a requirement.

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FOREWORD

1. This handbook is approved for use by all Departments and Agencies of the Department of Defense.

2. This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.

3. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: U.S. Army Tank-automotive and Armaments Command, ATTN: AMSTA-TR-E/BLUE, Warren, MI 48397-5000, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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CONTENTS

1. SCOPE

1.1 Scope. This handbook gives guidelines for particular welded joint designs used in the development of military armored tank type vehicles. This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.

1.2 Purpose. This handbook covers welded joint designs when one or more of the materials being welded is armor. The provisions of this handbook refer entirely to full penetration-weld joints.

1.3 Classification. This handbook covers two basic weld types and variations of each. These weld types are groove type and fillet type.

2. APPLICABLE DOCUMENTS

2.1 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the latest issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplements thereto.

ANSI/AWS	A2.4	Standard Symbols for Welding, Brazing and Non-Destructive Examination.
AWS	A3.0	Welding Terms and Definitions.

(Application for copies should be addressed to the American Welding Society (AWS), 2501 Northwest 7th Street, Miami, Florida 33125.)

3. DEFINITIONS

3.1 Welding terms. Unless otherwise specified herein, terms used in referring to the joints will have the meanings defined in AWS A3.0.

3.2 Welding symbols. Unless otherwise specified herein, the welding symbols in the drawings will have the meanings defined in AWS A2.4.

4. GENERAL WELDING

4.1 Selection of joint types.

4.1.1 Exposed surfaces. Surfaces subjected to ballistic attack, other than external attachments, generally are all designed in accordance with figures 1-7. However, fillet welds may be used for surfaces directly exposed to ballistic attack provided they have mechanical reinforcement inherent in the part design. This reinforcement may be effective from all possible directions of ballistic impact (see figure 10).

4.1.2 Other surfaces. Surfaces not subjected to direct ballistic attack and attachments may be designed using figures 8, 9 and 10.

4.2 Tolerances on design openings. The design opening tolerances shown for various joint types are assembly tolerances and may not be considered as tolerances available for plate size variation but should include all other tolerances that may affect design opening, such as plate flatness, but not weld shrinkage.

4.3 Sample drawing. The isometric drawing (figure 11) is included as a guide only to show typical locations of various joint designs in an armored structure or vehicle. Encircled numbers on the drawing should be taken as referring to the particular type of joint described in this standard. Suffix letters (figures 1-7 inclusive) have been omitted, since they identify plate thicknesses and other details, which will vary with the design of a specific structure of vehicle.

5. WELDED JOINT TYPES

5.1 Groove types. Grooved joints are shown in figures 1 through 7.

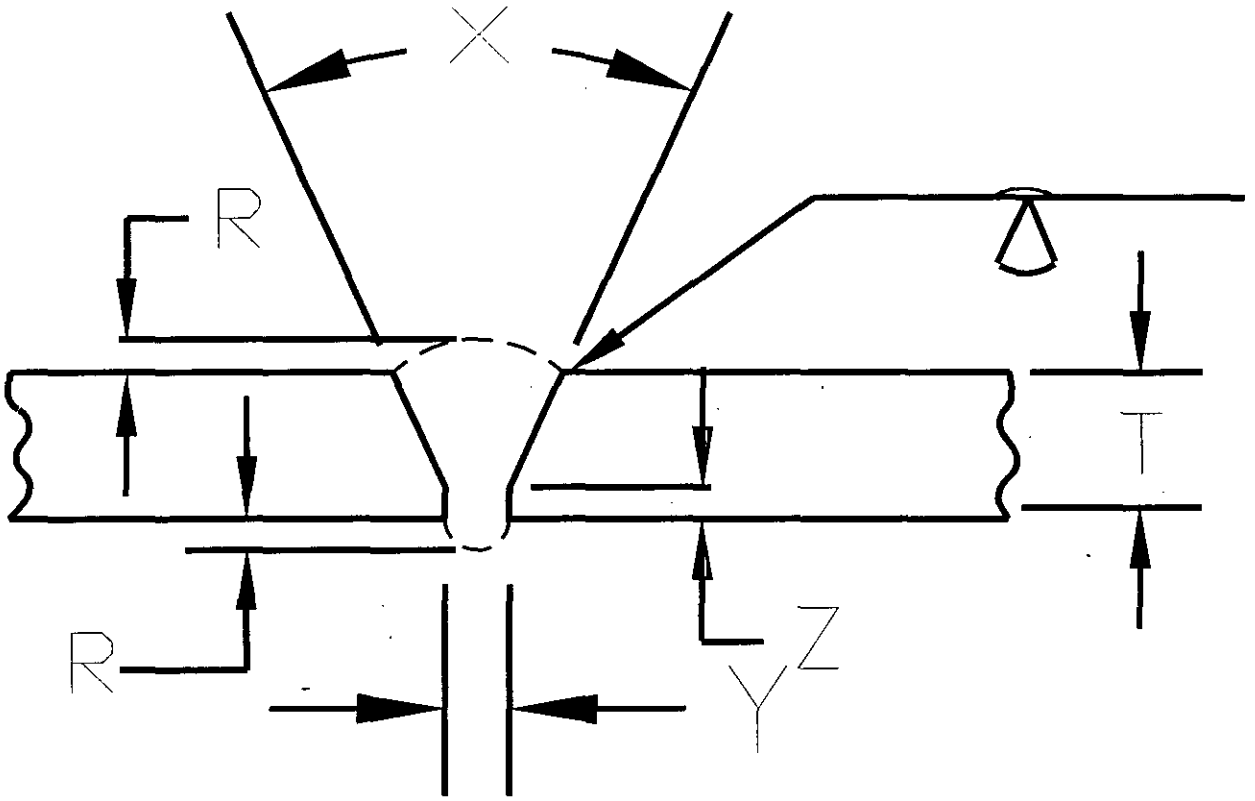
5.2 Fillet types. Fillet joints are shown in figures 8 through 10.

6. NOTES

6.1 Intended use. The joints specified in this handbook are intended for use in military vehicles or other structures that are to be subjected to ballistic attack.

6.2 Subject term (key word) listing.

Armored, tank type
Continuous fillet
Double-bevel-grooved, corner joint
Intermittent-fillet-welded joint
Single-v-grooved, butt joint
Staggered intermittent-fillet
Welded joint designs

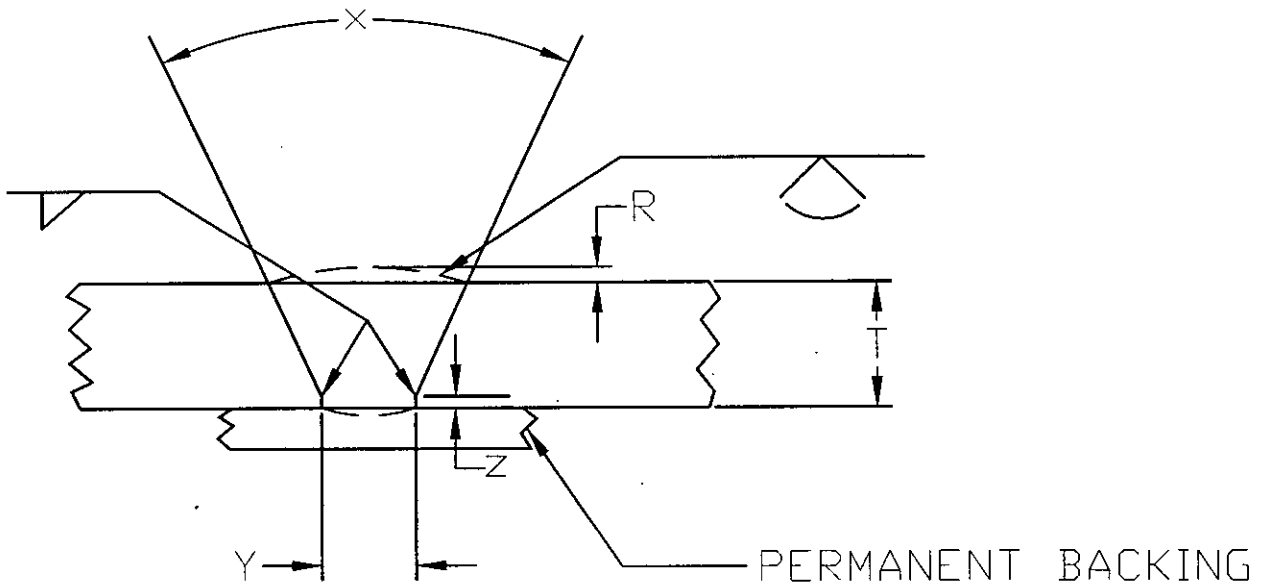


Joint No.	Included Angle (d) X (Degrees)	Design Opening (a) Y (millimeters)	Root Face Z (millimeters)	Max Plate Thickness T (millimeters)	Reinforcement of Weld R (millimeters)	Depth of Bevel (millimeters)
1A	45	(b) 1.6	(c) 0	19.1	2.4	T

NOTES:

(a) Design openings (see "Y" in fig. 1) do not include allowance for shrinkage during welding.
(b) Tolerance, plus 4.8, minus 0 millimeters.
(c) Tolerance, plus 1.6, minus 0 millimeters.
(d) Tolerance, plus 10, minus 0 degrees.

FIGURE 1. Type 1. Single-v-grooved butt joint, welded both sides.

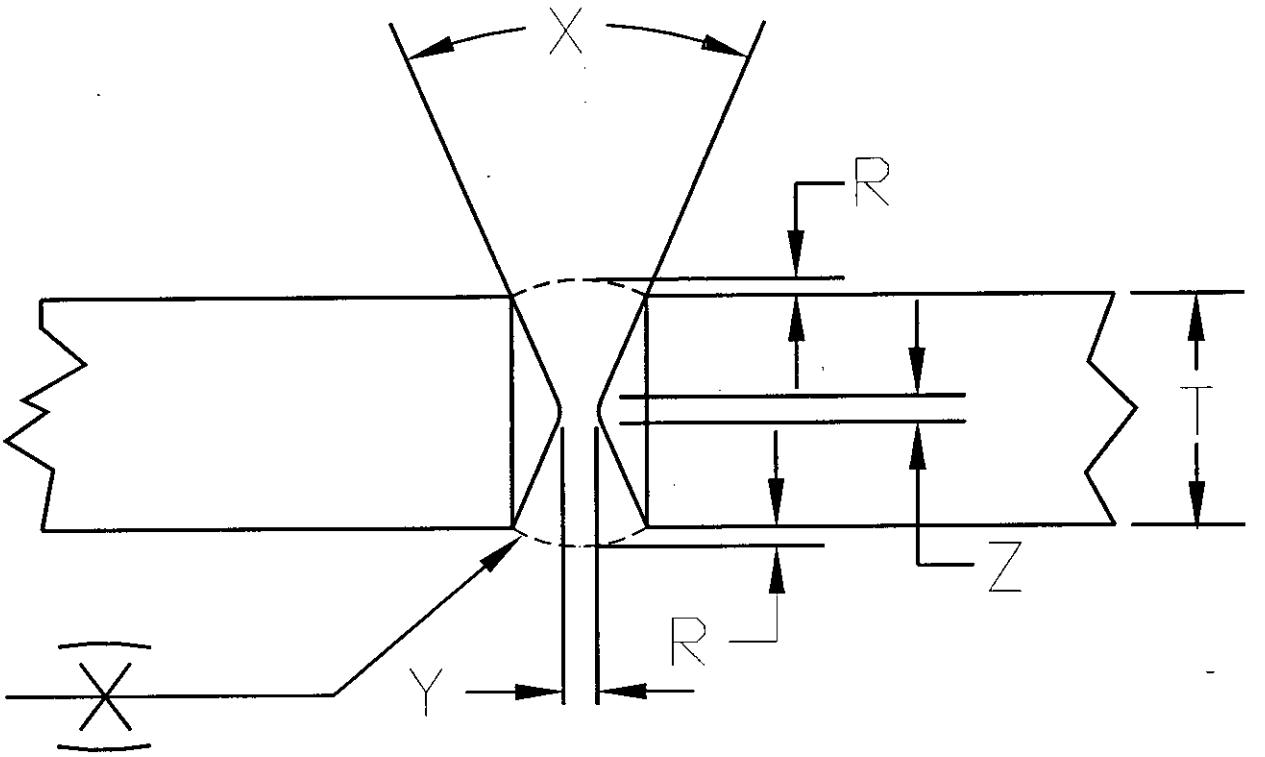


Jint No. (a)	Included Angle (e) X (Degrees)	Design Opening (b) Y (millimeters)	Root Face Z (millimeters)	Max Plate Thickness T (millimeters)	of Weld (millimeters)	Depth of Bevel (millimeters)
2A	45	12.7 (c)	(d) 0	19.1	0 to 2.4	T

NOTES:

(a) To be used only where it is impossible to weld backside of joint.
(b) Design openings (see "Y" in fig. 2) do not include allowance for shrinkage during welding.
(c) Tolerance, plus 4.8 minus 0 millimeters.
(d) Tolerance, plus 1.6 minus 0 millimeters.
(e) Tolerance, plus 10, minus 0 degrees.

FIGURE 2. Type 2. Single-v-grooved butt joint, welding to backing.

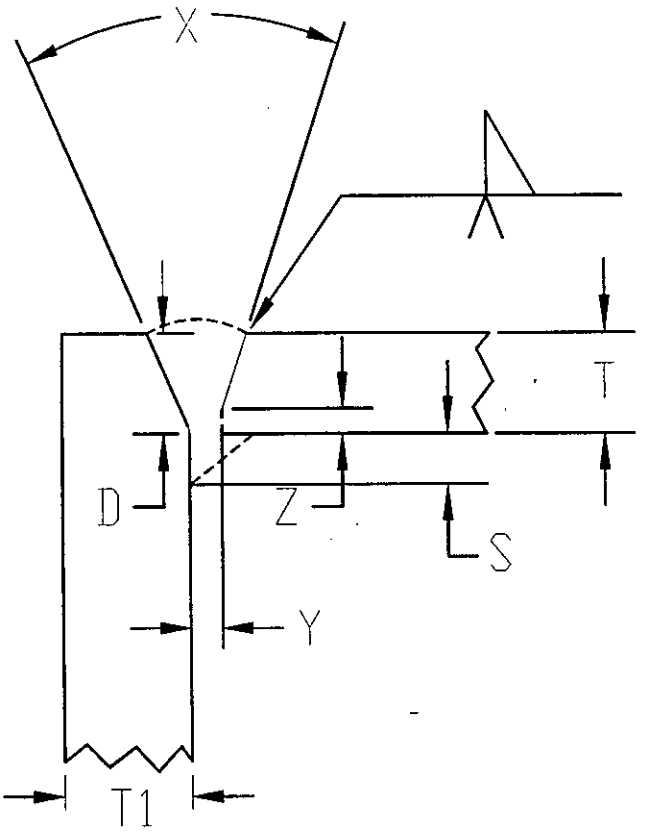


Joint No. (a)	Included Angle (e) X (Degrees)	Design Opening (a) Y (millimeter)	Root Face Z (millimeters)	Reinforcement of Weld R (millimeters)	Depth of Bevel (millimeters)
3A	45	(b) 4.8	(c) 0	0 to 2.4	12.7 T
3B	45	(b) 6.4	(c) 0	0 to 2.4	12.7 T
3C	45	(b) 7.9	(c) 1.6	0 to 2.4	12.7 T

NOTES:

(a) Design openings (see "Y" in fig. 3) do not include allowances for shrinkage during welding.
(b) Tolerance, plus 4.8, minus 0 millimeters.
(c) Tolerance, plus 1.6 minus 0 millimeters.
(d) Tolerance, plus or minus 1.6 millimeters.
(e) Tolerance, plus 10, minus 0 degrees.

FIGURE 3. Type 3. Double-v-grooved butt joint, welded both sides.

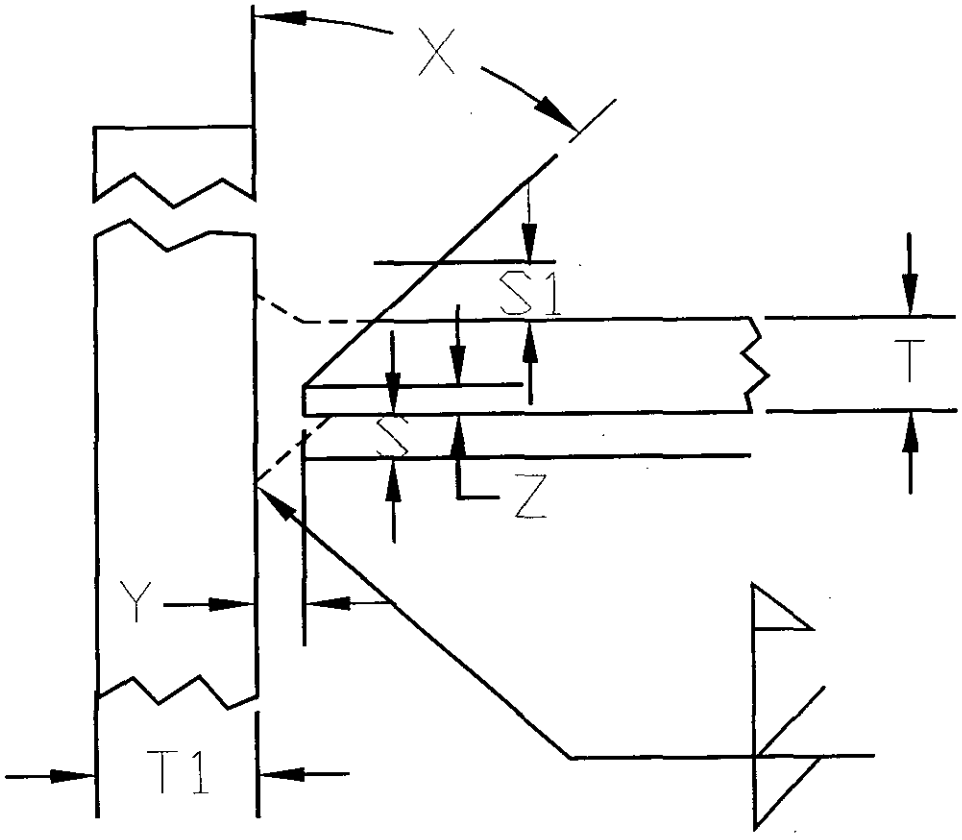


Joint No.	Included Angle (e) X (Degrees)	Design Opening (a) Y (millimeters)	Root Face Z (millimeters)	Plate Thickness T (millimeters)	Plate Thickness T1 (millimeters)	Depth of Bevel D (millimeters)	Min Size of Fillet S (millimeters)
4A	45	(b) 4.8	(c) 0 to	6.4	(d)	T	4.8
4B	45	(b) 4.8	(c) 0 to	9.5 to 12.7	(d)	T	6.4
4C	45	(b) 4.8	(c) 0 to	15.9 to 19.1	(d)	T	7.9

NOTES:

(a) Design openings (see "Y" in fig. 4) do not include allowance for shrinkage during welding.
(b) Tolerance, plus 4.8, minus 0 millimeters.
(c) Tolerance, plus 1.6, minus 0 millimeters.
(d) Values to be equal to or greater than for T-plate thickness.
(e) Tolerance, plus 10, minus 0 degrees.

FIGURE 4. Type 4. Single-v-grooved corner joint, fillet-reinforced.

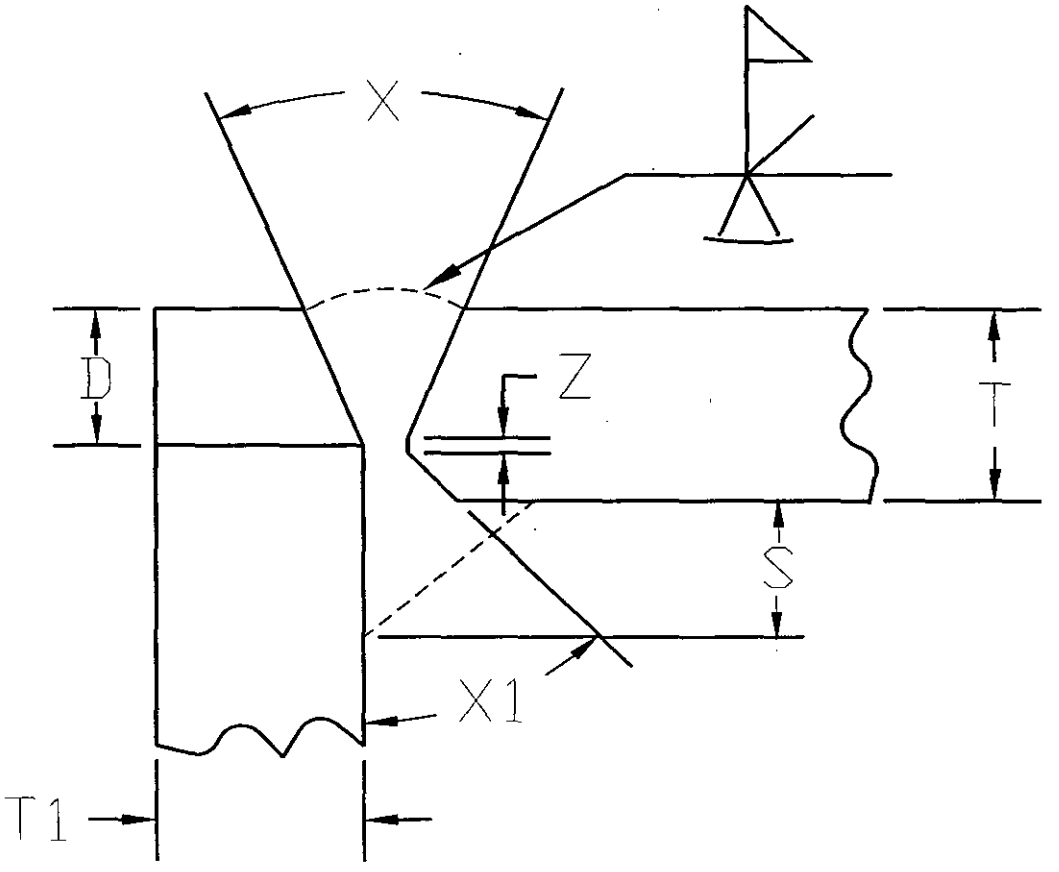


Joint No.	Included Angle (e) X (Degrees)	Design Opening (a) Y (millimeters)	Root Face Z (millimeters)	Plate Thickness T (millimeters)	Plate Thickness T1 (millimeters)	Depth of Bevel (millimeters)	Min Size of Fillet S (millimeters)	Min Size of Fillet S1 (millimeters)
5A	45	(b) 4.8	(c) 0 to 3.2	6.4	(d)	T	4.8	6.4
5B	45	(b) 4.8	(c) 0 to 3.2	9.5	(d)	T	6.4	6.4
5C	45	(b) 4.8	(c) 0 to 3.2	12.7	(d)	T	7.9	6.4
5D	45	(b) 4.8	(c) 0 to 3.2	15.9	(d)	T	9.5	6.4
5E	45	(b) 4.8	(c) 0 to 3.2	19.1	(d)	T	12.7	6.4

NOTES:

(a) Design openings (see "Y" in fig. 5) do not include allowances for shrinkage during welding.
(b) Tolerance, plus 4.8, minus 0 millimeters.
(c) Tolerance, plus 1.6, minus 0 millimeters.
(d) Values to be equal or greater than for T-plate thickness.
(e) Tolerance, plus 10, minus 0 degrees.

FIGURE 5. Type 5. Single-bevel-grooved corner joint, double-fillet reinforced.



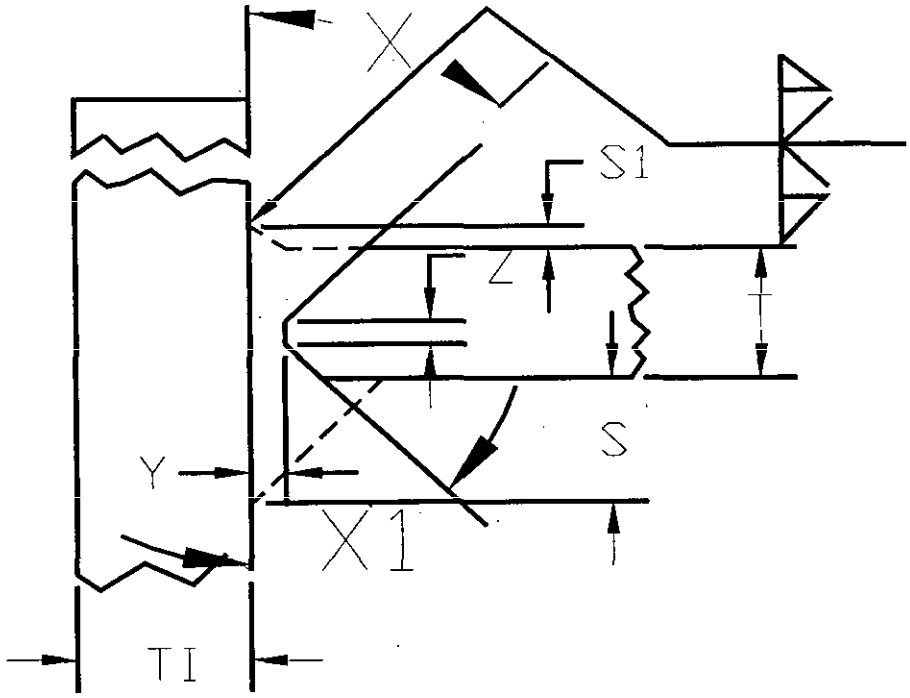
Joint No.	Min Included Angle		Design Opening (a) Y (millimeter)	Root Face Z (millimeter)	Plate Thickness T (millimeter)	Plate Thickness T1 (millimeter)	Depth of Bevel D (millimeter)	Min. Size of Fillet S (millimeter)
	(f) X (Outside) (Degrees)	X1 (Inside) (Degrees)						
6A	45	45	(b) 4.8	(c) 0	9.5 to 12.7	(e)	16.9 to 19.1T	6.4
6B	45	45	(b) 4.8	(c) 0	15.9 to 19.1	(e)	16.9 to 19.1T	7.9
6C	45	45	(b) 6.4	(c) 0	25.4	(e)	16.9 to 19.1T	15.9
6D	45	45	(b) 6.4	(c) 0	6.4	(e)	12.7 to 16.9T	11.1
6E	45	45	(b) 6.4	(c) 0	38.1	(e)	12.7 to 16.9T	12.7
6F	45	45	(b) 9.5	(c) 0	greater than 38.1	(e)	12.7 to 16.9T	12.7

FIGURE 6. Type 6. Double-bevel-grooved corner joint, fillet-reinforced.

NOTES:

(a) Design openings (see "Y" in fig. 6) do not include allowance for shrinkage during welding.
(b) Tolerance, plus 4.8, minus 0 millimeters.
(c) Tolerance, plus 1.6, minus 0 millimeters.
(d) Tolerance, plus 1.6, minus 0 millimeters.
(e) Thickness for each joint to be equal to or greater than its T-plate thickness.
(f) Tolerance, plus 10 minus 0 degrees.

FIGURE 6. Type 6. Double-bevel-grooved corner joint, fillet-reinforced - Continued.

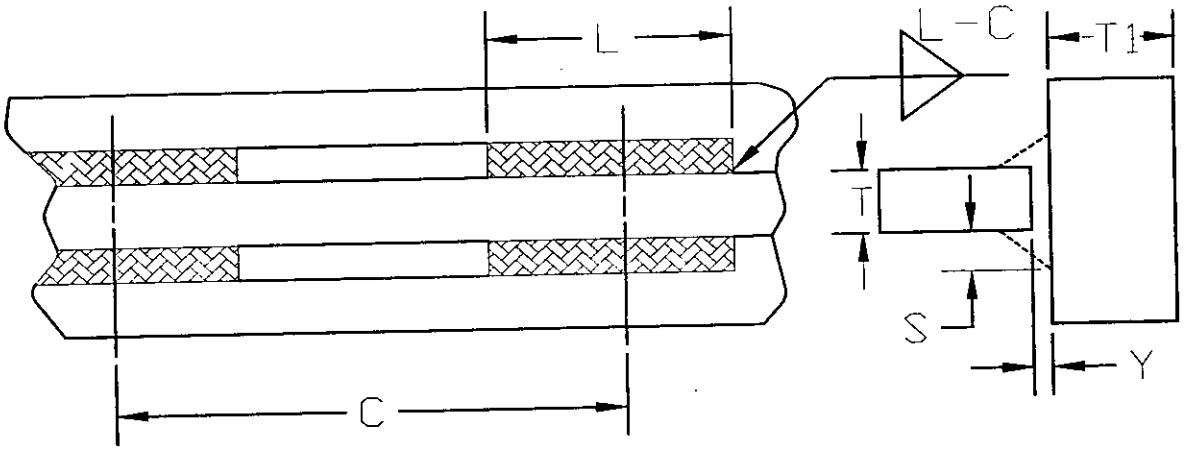


Joint No.	Included Angle		Design Opening (a)	Root Face	Plate Thick-ness	Plate Thick-ness	Depth of Bevel	Min Size of Fillet	Min Size of Fillet
	X (f) (Outside) (Deg)	X1 (Inside) (Deg)	Y (millimeter)	Z (millimeter)	T (millimeter)	T1 (millimeter)	(millimeter)	S (millimeter)	S1 (millimeter)
7A	45	45	(b) 4.8	(c) 0	9.5	(e)	12.7 to 16.9	6.4	6.4
7B	45	45	(b) 4.8	(c) 0	12.7	(e)	12.7 to 16.9	7.9	6.4
7C	45	45	(b) 4.8	(c) 0	15.9	(e)	12.7 to 16.9	9.5	6.4
7D	45	45	(b) 4.8	(c) 0	19.1	(e)	12.7 to 16.9	12.7	6.4
7E	45	45	(b) 6.4	(c) 0	25.4	(e)	12.7 to 16.9	15.9	7.9
7F	45	45	(b) 6.4	(c) 0	31.8	(e)	12.7 to 16.9	19.1	7.9
7G	45	45	(b) 6.4	(c) 0	38.1	(e)	12.7 to 16.9	22.2	7.9
7H	45	45	(b) 7.9	(c) 1.6	Greater than 38.1	(e)	12.7 to 16.9	22.2	7.9

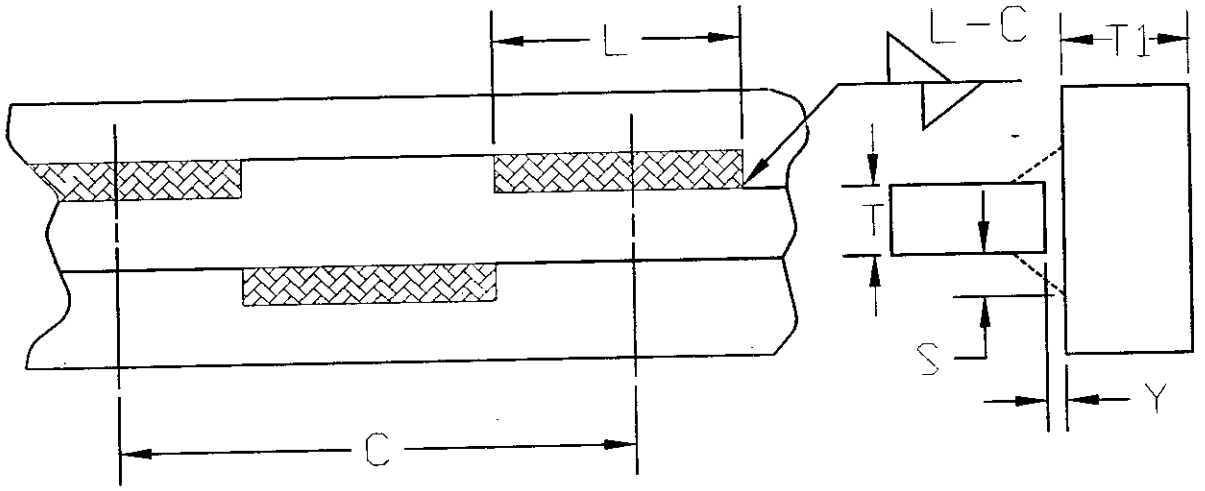
NOTES:

(a) Design openings (see "Y" in fig. 7) do not include allowance for shrinkage during welding.
(b) Tolerance, plus 4.8, minus 0 millimeters.
(c) Tolerance, plus 1.6, minus 0 millimeters.
(d) Tolerance, plus 1.6, minus 0 millimeters.
(e) Thickness for each joint to be equal to or greater than its T-plate thickness.
(f) Tolerance, plus 10 minus 0 degrees.

FIGURE 7. Type 7. Double-bevel-grooved tee or corner joint, double-fillet-reinforced.



Type 8A - Intermittent-fillet-welded joint.



Type 8B - Staggered intermittent fillet-welded joint.

Plate thickness T or T1	Minimum size fillet S (a)
Less than 9.5 mm	4.8 mm
0.5 to 22.2 mm	6.4 mm
More than 22.2 mm	7.9 mm

FIGURE 8. Type 8A. Intermittent and Type 8B staggered intermittent fillet welded joints.

NOTES:

(a) Fillet size "S" to be specified in accordance with design requirements, except that regardless of such requirements, minimum fillet size to be used is:

(b) Normal assembly dimensions will ordinarily give variations in dimensions "Y" of 0 to 2.4. This should be shown as a tolerance on the drawing and will not require any increase in fillet size. When the designer specifies a nominal dimension "Y" greater than 0 (zero) the fillet sizes are increased by this dimension. For joint types 8(A), 8(B), and 9, when the gap exceeds the specified "Y" dimension plus .8 to 2.4 tolerance, a special procedure will be followed as required by the applicable specification covering the welding of armor.

(c) Length ("L") will be not less than 25.4 millimeters.

(d) Pitch ("C") will be not less than 2L, or twice the length.

(e) Type 8A and Type 8B welds will be restricted to single-pass welds.

FIGURE 8. Type 8A. Intermittent and Type 8B staggered intermittent fillet welded joints - Continued.

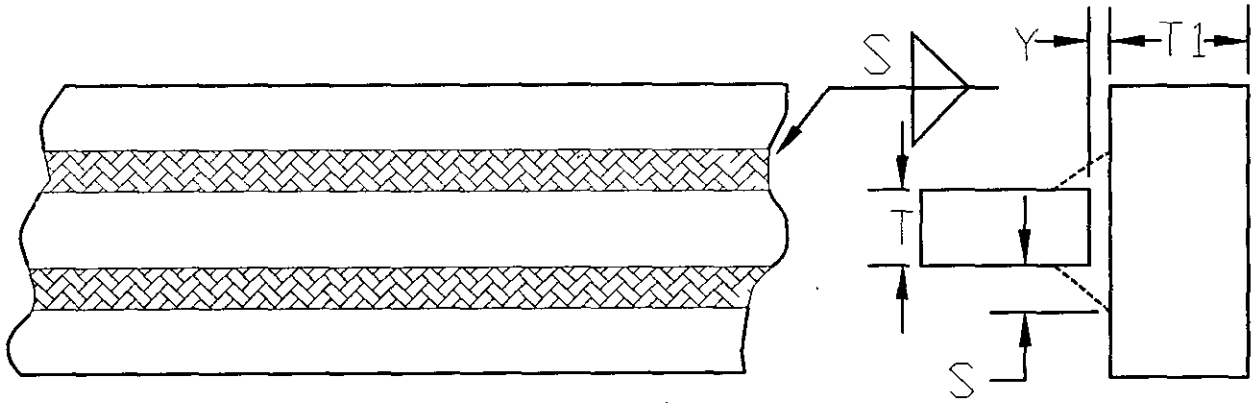
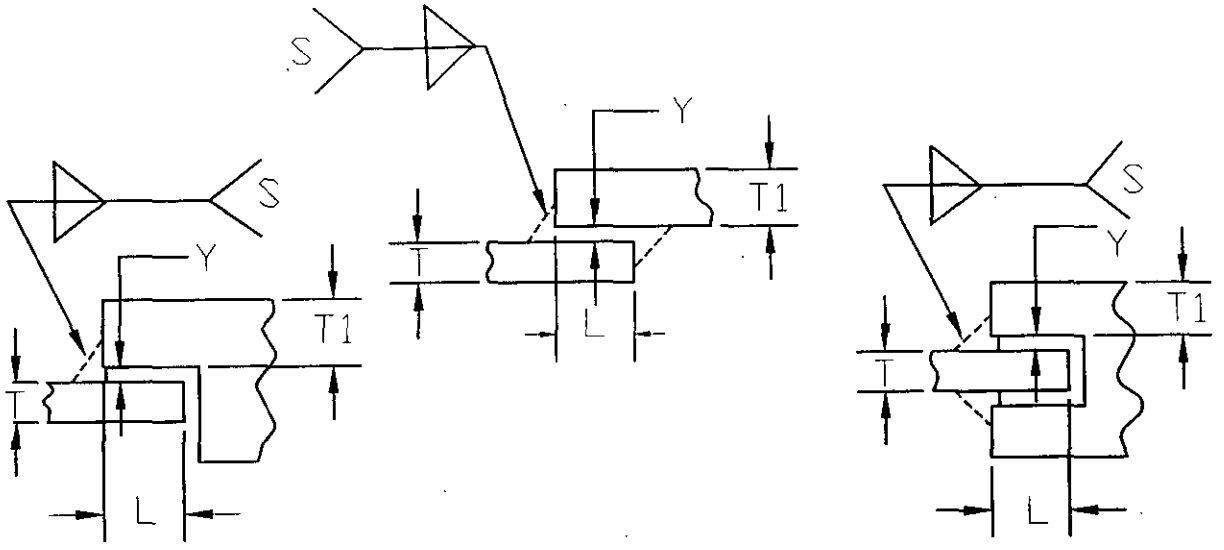


Plate thickness, mm T or T1	Min size fillet, mm S
Less than 9.5	4.8
9.5 to 22.2 incl.	6.4
Greater than 22.2	7.9

NOTES:

1. Fillet size ("S") to be specified in accordance with design requirements, except that regardless of such requirements, minimum fillet size to be used is:
2. Normal assembly dimensions will ordinarily give variations in dimension "Y" of 0 to 2.4. This should be shown as a tolerance on the drawing and will not require any increase in fillet size. When the designer specifies a nominal dimension "Y" greater than 0 (zero), the fillet size is increased by this dimension. For joint types 8 (A), 8(B), and 9, when the gap exceeds the specified "Y" dimension plus the 2.4 tolerance, a special procedure's will be followed as required by the applicable specification covering the welding of armor.

FIGURE 9. Type 9. Continuous-fillet-welded joint.



Joint No.	Plate Thickness T	Minimum Flange Thickness T1	Minimum Flange Lap L	Minimum Fillet Size S
10A	less than 9.5	T	6.4	4.8
10B	9.5 to 15.9 incl	T	7.9	7.9
10C	15.9 to 25.4 incl	T	9.5	12.7
10D	25.4 to 38.1 incl	T	12.7	22.2
10E	greater than 38.1	T	15.9	25.4

NOTE:

(a) Separation. ("Y") when specified shall not exceed 81.3 mm, and furthermore:

When Y = 40.6 mm or less, S = designed fillet size;
When Y = 2.4 to 3.2 mm, S = Y plus designed fillet size.

(b) This joint type is not to be utilized without prior approval from the procuring agency at which time layouts will be reviewed showing the circumstances under which the joint is to be employed. The circumstances under which this joint is to be employed should be analyzed very carefully by the designer to assure that it will not be misused. This joint is not intended to add mechanical strength to the structure nor is it considered a ballistic joint; therefore, should not be utilized in cases where it is depended upon to perform such functions.

FIGURE 10. Type 10. Continuous-fillet-welded joint with mechanical reinforcement.

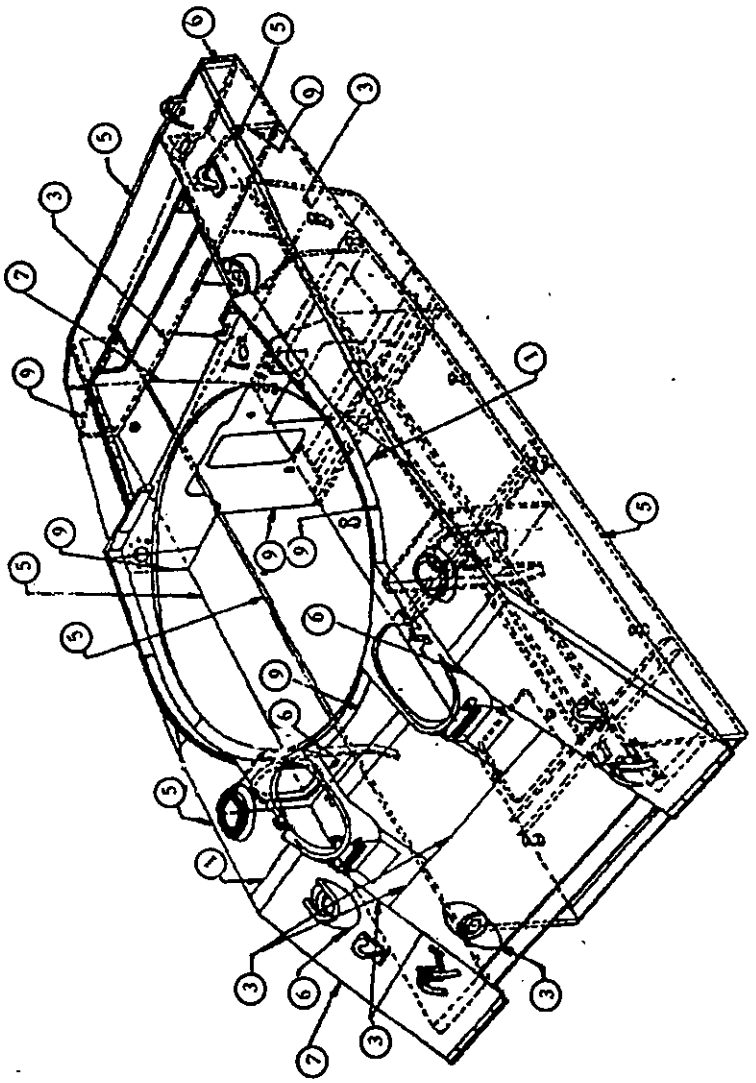


FIGURE 11. Isometric drawing for illustration purposes only.

CONCLUDING MATERIAL

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3. DOCUMENT TITLE
Welded-Joint Designs, Armored-Tank Type

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

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a. NAME	b. TELEPHONE (Include Area Code) (1) Commercial (810) 574-8745	(2) AUTOVON DSN 786-8745
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