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INCH-POUND

MIL-STD-2035A (SH)  
15 MAY 1995  
SUPERSEDING  
MIL-STD-2035 (SH)  
4 JULY 1991

DEPARTMENT OF DEFENSE  
TEST METHOD

NONDESTRUCTIVE TESTING  
ACCEPTANCE CRITERIA



AMSC N/A

AREA NDTI

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## MIL-STD-2035A(SH)

### FOREWORD

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4. MIL-STD-2035(SH) contains acceptance criteria to determine the acceptability of discontinuities revealed by the following nondestructive test methods; visual, radiographic, magnetic particle, liquid penetrant, ultrasonics, and eddy current.

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**1. SCOPE**

**1.1 General.** The acceptance criteria contained herein are for use in determining the acceptability of nondestructive test (NDT) discontinuities in castings, welds, forgings, extrusions, cladding, and other products when specified by the applicable Naval Sea Systems Command (NAVSEA) drawing, specification, contract, order, or directive. Acceptance criteria contained herein are based upon inspection methods performed in accordance with MIL-STD-271. Use of other inspection requirements requires approval by NAVSEA or its authorized representative. Acceptance criteria contained herein are segregated by class representing the degree of severity of the various discontinuities that are acceptable for each class. The applicable class is specified in the NAVSEA drawing, specification, contract, order, or directive. Unless specified otherwise, all welds shall meet the Class 1 criteria of this standard.

**2. APPLICABLE DOCUMENTS****2.1 Government documents.**

**2.1.1 Specifications, standards, and handbooks.** The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 10.2).

## SPECIFICATIONS

## MILITARY

MIL-STD-271 - Requirements for Nondestructive Testing Methods

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, BLDG. 4D, 700 Robbins Avenue, Philadelphia, PA 119111-5094.)

**2.2 Non-government publications.** The following document(s) form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the document which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 10.2).

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

E 1316 - Standard Terminology for Nondestructive Examinations.

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

## AMERICAN WELDING SOCIETY (AWS)

A3.0 - Standard Welding Terms and Definitions.

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(Application for copies should be addressed to the American Welding Society, Inc., 550 NW LeJeune Road, P.O. Box 351040, Miami, FL 33135.)

(Non-Government standards and other publications are normally available from the organizations that prepare or distribute the documents. These documents may also be available in or through libraries or other informational services.)

**2.3 Order of precedence.** In the event of a conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

**3. DEFINITIONS.** The standard terminology for nondestructive testing as described in ASTM E 1316, and the standard terminology for welding as described in AWS 3.0, shall apply to this document, except as noted below.

**3.1 Aligned rounded indication.** Four or more indications in a line, where each is separated from the adjacent indication by less than 1/16 inch or D, whichever is greater, where D is the major diameter of the larger of the adjacent indications.

**3.2 Amplitude Reject Level (ARL).** The established peak amplitude of the signal received from the applicable reflective surface in the calibration standard.

**3.3 Arc strike.** Any localized heat-affected zone or change in the contour of the surface of the finished weld or adjacent base metal resulting from an arc or heat generated by the passage of electrical energy between the surface of the finished weld or base metal and a current source, such as welding electrodes or magnetic particle inspection prods.

**3.4 Burn-through.** A void or open hole that extends through a backing ring, strip, fused root, or adjacent base metal.

**3.5 Cold shut.** The result of pouring molten metal over solidified metal.

**3.6 Design material thickness.** The nominal or average thickness of the material of the strength member, exclusive of reinforcement or backing rings and strips.

**3.7 Disregard level (DRL).** The horizontal level on the instrument display established at a level below the Amplitude Rejection Level (ARL). Spurious and non-relevant noise indications generally appear below this level.

**3.8 Heat checks.** Fissures or tears in the weld heat affected zone of material containing low melting alloying elements.

**3.9 Incomplete fusion.** Lack of complete fusion of some portion of the metal in a weld joint with adjacent metal. The adjacent metal may be either base metal or previously deposited weld metal, or consumable insert.

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**3.10 Incomplete penetration.** Lack of penetration of the weld through the thickness of the joint, or penetration which is less than specified.

**3.11 Lap.** Folding of metal on the surface of the forging, usually when some of the forging metal is squeezed out between the two dies.

**3.12 Linear indication.** An indication in which the length is equal to or greater than three times the width.

**3.13 Non-linear or rounded indication.** Indication whose length is less than three times its width.

**3.14 Oxidation.** A condition resulting from partial or complete lack of inert gas shielding of a surface which is heated during welding resulting in formation of oxide on the surface. This condition may range from slight oxidation evidenced by a multicolored or tightly adhering black film to the extreme of a very rough surface having a crystalline appearance.

**3.15 Root surface concavity.** A depression on the root surface of a weld which may be due to gravity, internal purge, or shrinkage.

**3.16 Root surface convexity.** Reinforcement on the root surface of a weld.

**3.17 Root surface center-line crease or shrinkage.** An intermittent or continuous peripheral center-line concavity formed on the root surface.

**3.18 Tungsten inclusion.** Tungsten entrapped in the weld deposit.

**3.19 Unfused chaplet.** A metal support used in the casting process which has not fused with the casting material.

**3.20 Weld spatter.** Metal particles which deposit on the surface of the weld or adjacent base metal during welding and which do not form a part of the weld.

## 4. VISUAL INSPECTION

**4.1 General.** Visual inspection shall be performed prior to other required nondestructive tests. Welds, castings, and wrought materials shall meet the requirements of the applicable fabrication document or material specification, and, unless otherwise specified, the following standards shall apply.

**4.2 Welds.** Any grinding or other mechanical operation performed on welds shall be performed so that the thickness of the weld and its adjacent base metal are not reduced below the minimum design thickness or the minimum drawing thickness, whichever is greater.

**4.2.1 Shape of the weld face.** Welds shall be free of sharp irregularities between weld beads and shall blend smoothly and gradually into the base metal at the weld edges without

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exceeding the undercut (4.2.16) or re-entrant angle (4.2.19) limits of this specification. Irregularities in contour from localized burring, grinding, and similar mechanical operations are acceptable provided that they comply with the other requirements of this specification.

**4.2.1.1 Fillet contour.** Fillet and fillet reinforced welds with an essentially flat contour are considered as meeting the minimum throat thickness, provided the minimum specified leg sizes have been met.

**4.2.1.2 Root contour.** Full penetration welds made from one side, consumable insert, or nonpermanent backing ring pipe welds shall meet the root contour requirements of table I.

**TABLE I. Root contour limits .<sup>1</sup>**

Condition <sup>3</sup>	Material size (nominal)	Maximum (inch)
Convexity	Pipe less than 2 inches in diameter and other shapes less than 5/32 thick.	1/16 <sup>2</sup>
Convexity	Pipe 2 inches and over in diameter and other shapes 5/32 inch and over in thickness.	3/32 <sup>2</sup>
Concavity	Pipe less than 2 inches in diameter and other shapes less than 5/32 inch thick.	1/32
Concavity	Pipe 2 inches and over in diameter and other shapes 5/32 inch and over in thickness.	1/16

<sup>1</sup>Except for centerline shrinkage or wrinkling, the contour of the root shall have a uniform radius and shall blend smoothly into the base metal. No concavity of contour is permitted unless the resulting thickness of weld metal is not less than the minimum thickness of the adjacent base metal.

<sup>2</sup>For copper-nickel and nickel-copper materials, the root convexity of consumable insert fabricated welds may exceed this amount, provided that: for pipe nominal sizes less than 2 inches, the maximum height of convexity shall not exceed 3/32 inch and the total length of all such areas shall not exceed 1 inch; for pipe nominal sizes 2 inches and greater, the maximum height of convexity shall not exceed 1/8 inch and the total length of all such areas shall not exceed 25 percent of the inside circumference of the pipe.

<sup>3</sup>In the event of joint offset, root surface concavity or convexity shall be measured from a line connecting the two points at which the weld meets the base material.

#### 4.2.2 Weld size.

**4.2.2.1 Fillet weld size, piping only.** Fillet weld size, excluding seal welds, shall be not less than  $T \times 1-3/4T$  unless otherwise specified by drawing (see figure 1).

**4.2.2.2 Fillet weld size, other than piping.** Fillet and fillet reinforced welds shall be not less than the drawing specified size. Weld sizes greater than required by drawing are acceptable provided that they comply with the other requirements of this document.

**4.2.2.3 Seal welds.** Seal weld size shall be as specified by the drawing.

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**4.2.2.4 Butt welds.** Butt weld surfaces shall not be below the adjacent base material surfaces, except for localized weld surface areas and weld toes (unground or corrected by grinding) that do not exceed the limitations for undercut of 4.2.16. Unless otherwise specified in the fabrication document, the final thickness of weld reinforcement on either weld face shall be as shown in table II.

**TABLE II.** *Weld reinforcements.*

Class	Base metal thickness (inch)	Maximum reinforcement (inch)
1	Up to 1/4, inclusive	1/16
	Over 1/4 to 1	3/32
	Over 1 to 2	1/8
	Over 2	5/32
2 and 3	Up to 1/2, inclusive	3/32
	Over 1/2	5/32

**4.2.3 Joint offset.** Unless otherwise specified in the fabrication document or by the applicable specification, the maximum permissible offset for all welded joints shall be as shown in table III.

**TABLE III.** *Maximum permissible offset.*

Base metal thickness	Maximum offset
1/4 inch and less	25 percent of joint thickness
Over 1/4 inch to 3/4 inch	25 percent of joint thickness, but not to exceed 1/8 inch
Over 3/4 inch to 1-1/2 inch	3/16 inch
Over 1-1/2 inch	12-1/2 percent of joint thickness, but not to exceed 1/4 inch.

**4.2.4 Cracks.** Weld joints and base material shall be free of cracks.

**4.2.5 Burn-through.** Weld joints and base material shall be free of burn through.

**4.2.6 Incomplete fusion.** Weld joints and base material shall be free of incomplete fusion.

**4.2.7 Melt-through.** Melt-through and repaired burn-through areas are acceptable provided the areas do not contain cracks, crevices, excessive oxidation, or globules, and provided the root convexity and concavity limits are not exceeded.

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**4.2.8 Crater pits.** Crater pits are considered acceptable provided the area contains no cracks, the root concavity and convexity limits are not exceeded, and the minimum weld thickness requirement is met.

**4.2.9 Oxidation.** Welds and adjacent base metal shall be free of oxide scale accompanied by a wrinkled or crystalline surface appearance. Tightly adhering, iridescent temper films shall be considered acceptable.

**4.2.10 Porosity.** Individual pores cannot exceed 3/32-inch in diameter or length. Pores the sum of whose diameters exceed 1/8-inch in any 2 inch length of weld are unacceptable. (Do not count pores 1/32-inch or less diameter.)

**4.2.11 Edge-melt.** Pipe fitting edge-melt is acceptable provided the scribeline established as a reference for verifying fillet size is evident (see figure 2).

**4.2.12 Arc strikes.** For applications covered by a fabrication document, in which treatment of arc strikes is detailed, arc strikes shall be removed and reinspected as required therein. For other applications, arc strike removal sites within the allowances specified below are acceptable provided minimum thickness requirements (see 4.2) are met and all heat-affected zones are removed.

**4.2.12.1 Class 1.** Welds and adjacent base metal must be free of arc strikes. Where arc strikes are removed, the resulting cavities shall not exceed 1/64-inch in depth or 10 percent of the adjacent base metal thickness, whichever is less, and shall blend smoothly into the base metal.

**4.2.12.2 Class 2 and 3.** Welds and adjacent material must be free of arc strikes. Where arc strikes are removed, the resulting cavities shall not exceed 1/32-inch in depth or 10 percent of the adjacent base metal thickness, whichever is less, and shall blend smoothly into the base metal.

**4.2.13 Gouges, grind marks and surface roughness.** Localized discontinuities within the allowances specified below are acceptable provided that minimum thickness requirements (see 4.2) are met, and the bottom of the depression is visible and rounded or free of notches. The length of the discontinuity shall be limited to 12 inches maximum except for piping and pressure vessels where the maximum length shall be 12 inches or 1/4 of the circumference, whichever is less.

**4.2.13.1 Class 1.** Welds and adjacent base metal shall be free of localized discontinuities which exceed a depth of 1/64 inch or 10 percent of the adjacent base metal thickness, whichever is less.

**4.2.13.2 Class 2 and 3.** Welds and adjacent base metal shall be free of localized discontinuities which exceed a depth of 1/32 inch on materials less than 1/2 inch in thickness and 1/16 inch on materials 1/2 inch and thicker.

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**4.2.14 Weld spatter.**

**4.2.14.1 Class 1.** Welds and adjacent base material shall be free of weld spatter.

**4.2.14.2 Class 2 and 3.** Weld spatter which can be removed with a hand wire brush is rejectable. Tightly adhering spatter 1/8-inch or less in diameter or length is acceptable except for the following circumstances, wherein the inspection area shall be free of spatter: if PT, UT or RT is required; on internal surfaces of closed systems; and on surfaces which are to be wetted.

**4.2.15 Slag.**

**4.2.15.1 Class 1.** Welds and adjacent base material shall be free of slag.

**4.2.15.2 Class 2 and 3.** Tightly adhering slag, that which cannot be removed by a slag pick or hand wire brush, is permissible unless the weld requires MT, PT, RT or UT. If MT, UT or RT is required, slag or scale 1/8-inch or less is allowed provided it does not interfere with test interpretation. If PT is required, the weld shall be free of slag. NOTE: Slag shall not interfere with the evaluation of other visual attributes. Additionally, background surfaces shall be free of slag prior to depositing subsequent passes.

**4.2.16 Undercut.**

**4.2.16.1 Class 1.** The maximum depth of undercut measured from the unground adjacent base metal surface shall not exceed 1/64-inch or 10 percent of the minimum thickness (see 4.2), whichever is less.

**4.2.16.2 Class 2 and 3.** The maximum undercut shall be 1/32-inch, or 10 percent of the minimum thickness (see 4.2), whichever is less. For base metal thickness 1/2-inch or greater, undercut up to 1/16-inch is allowed if the accumulated length of undercut exceeding 1/32-inch does not exceed 15 percent of the joint length or 12 inches in any 36 inch length of weld, whichever is less.

**4.2.17 End-melt.** When undercut exists at the ends of attachment welds (see figure 3), the following undercut requirements apply. Note that the plan requirement for weld size shall be maintained after any grinding or machining.

**4.2.17.1 Class 1.** Maximum depth, measured from the unground adjacent base metal surface, shall not exceed 1/64-inch or 10 percent of the adjacent base metal's nominal thickness, whichever is less.

**4.2.17.2 Class 2 and 3.** For welds across the end of a 1/4-inch thick or less member, the maximum as-welded end-melt is 1/16-inch. If end-melt is greater than 1/16-inch and less than or equal to 3/32-inch, it may be repaired by mechanical means to a maximum depth of 3/32-inch.

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**4.2.18 Corner-melt.** When undercut exists at the corner of attachment welds (see figure 4), the following undercut requirements apply. Note that the plan requirement for weld size shall be maintained after any grinding or machining.

**4.2.18.1 Class 1.** Maximum depth, measured from the unground adjacent base metal surface, shall not exceed 1/64-inch or 10 percent of the adjacent base material's nominal thickness, whichever is less.

**4.2.18.2 Class 2 and 3.** For welds at the corner of attachment welds, the maximum as-welded corner-melt is 1/16-inch. If the corner-melt is greater than 1/16-inch and less than or equal to 3/32-inch, it may be repaired by mechanical means to a maximum depth of 3/32-inch.

**4.2.19 Re-entrant angle.** The angle formed between the base plate and the toe of the weld and the angle formed between adjacent beads of weld must be 90 degrees or greater. Weld rollover near the base material is acceptable provided the weld is completely fused and the final re-entrant angle to the base material is a minimum of 90 degrees. (See figure 5).

**4.2.20 Paint.** Welds shall be essentially free of paint, except that indications of paint 1/8-inch and smaller are acceptable after normal removal operations. If PT is required, the inspection area shall be free of paint.

**4.3 Castings.** Casting surface shall meet the requirements of the applicable material specification.

**4.4 Wrought materials (pipes, bars, plates, forgings, and extrusions).** Wrought material shall be visually inspected in accordance with the applicable material specification.

**4.5 Bronze propellers.** Visual inspection acceptance standards for bronze propellers shall be in accordance with table IV.

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TABLE IV. Acceptance standards for inspection of bronze propellers.<sup>9</sup>

Location of discontinuities	Type of discontinuities <sup>2</sup>	Maximum acceptable discontinuity size (inches) <sup>1,3</sup>	Discontinuity acceptance standards		Allowable areas of concentration
			6 x 6 Area of concentration <sup>6,7</sup> Maximum No. <sup>8,9</sup>	Maximum spacing between aligned discontinuities <sup>4,5</sup>	
<b>CASTINGS</b>					
A band located around the periphery of each blade on both the pressure and suction faces with a width equal to 10 percent of the width of the blade measured at the 0.6 radius, but not to exceed 6-inches; and an area measured from (and including) the hub fillet to 0.4 radius on the pressure face only.	Non-linear	1/8	20	D	5 percent of propeller surface area with distribution limited by a maximum of 5 percent for each blade surface.
	Linear	1/8	6	4D	
The remaining surfaces of the blades.	Non-linear	1/8	20	D	
	Linear	1/4	8	4D	
Hub outside diameter (OD)	Non-linear	1/4	15	D	
	Linear	3/8	6	4D or 1-inch, whichever is less	
<b>WELDMENTS</b>					
All surfaces	Non-linear	1/16	12	4D	5 percent of total weld area.
	Linear	0	0	--	

See footnotes on following page.

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- <sup>1</sup>Liquid penetrant inspection shall be performed as an aid to visual inspection in locating discontinuities. Only discontinuity size shall be used as a basis for rejection.
- <sup>2</sup>A linear discontinuity is one in which the length is greater than or equal to three times the width.
- <sup>3</sup>Any linear discontinuity over 1/16 inch in length located within a peripheral band 1 inch wide; and whose major dimension is oriented normal to the blade edge, shall be repaired.
- <sup>4</sup>Maximum spacing is the distance separating two adjacent discontinuities in terms of the major dimension of the larger discontinuity (D). Aligned non-linear discontinuities shall consist of four or more discontinuities in a line. Aligned linear discontinuities shall consist of two or more discontinuities whose major dimensions are oriented in a line. However, when the total length of the aligned discontinuities does not exceed the maximum length permitted for a single discontinuity, these aligned discontinuities shall be considered as one discontinuity, and shall not be cause for rejection.
- <sup>5</sup>When the major dimension of clustered discontinuities does not exceed the maximum size permitted for a single discontinuity, these clustered discontinuities shall be considered as one discontinuity and shall not be cause for rejection. Scattered discontinuities, separated from the cluster by 1/8 inch or more, shall not be considered as part of the cluster.
- <sup>6</sup>Randomly dispersed casting discontinuities whose major dimensions are 1/16 inch or less shall not be counted in determining total number of discontinuities within an area of concentration.
- <sup>7</sup>More than six discontinuities whose major dimensions are greater than 3/32 inch in any 6 by 6-inch area of the propeller surface constitute an area of concentration. Each area of concentration shall be separated from an adjacent area of concentration by a minimum of 18 inches.
- <sup>8</sup>The total number of non-linear discontinuities may be increased to the combined total, or part thereof, represented by the absence of linear discontinuities.
- <sup>9</sup>For used propellers not originally inspected to the requirements of this standard, the allowable number of discontinuities in each area of concentration may be increased 15 percent for each blade surface, and the minimum spacing between adjacent aligned linear discontinuities may be reduced to 2D provided that: (a) the discontinuities do not exceed the limits of any other requirement of this standard, and (b) the discontinuities have shown no deleterious effects in service.

## 5. RADIOGRAPHIC INSPECTION.

**5.1 General.** Acceptance standards shall be based on the plan or drawing thickness (without application of any allowed tolerance) of the finished part, except that, for structural castings, the acceptance standards may be based on the actual thickness being radiographed. Welds and castings shall meet the requirements of the applicable fabrication documents, and unless otherwise specified, the following acceptance criteria shall apply.

### 5.2 Welds

#### 5.2.1 General.

**5.2.1.1 Cracks.** Any type of crack shall be rejected.

**5.2.1.2 Burn through, melt through and crater pit.** Burn through, melt through, and crater pit are acceptable provided the areas do not contain cracks, crevices, or globules and provided the weld size and contour limits otherwise specified are not exceeded.

**5.2.1.3 Tungsten.** Tungsten inclusions having a maximum dimension greater than 20 percent of the design material thickness or 1/8 inch, whichever is less, shall be rejected; others shall be counted as porosity.

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**5.2.1.4 Questionable indications.** When doubt exists as to whether an indication on the radiograph is the result of surface imperfections or sub-surface defects, the radiograph should be compared with the weld. If the indication in question is the result of an acceptable surface imperfection and does not interfere with the interpretation, that weld may be accepted.

**5.2.1.5 Slag, incomplete fusion and incomplete penetration indications.**

- a. *General.* Indications must meet the limits of the applicable curve (figure) and applicable condition for the class of weld being evaluated. Slag and porosity indications having a maximum size of 1/8 inch may be evaluated as slag or porosity, whichever is less restrictive. A cluster, or an aligned group of indications including both slag and porosity shall be evaluated as either all slag or all porosity.
- b. *Proximate indications.* Two or more individual indications are considered proximate when the separation between adjacent indications is less than L or 1/2 inch (whichever is smaller), where L is the length of the longer of the indications being evaluated. Proximate indications shall be evaluated on the applicable curve for the applicable condition as a single indication whose length is equal to the longest measured overall dimension of the group.
- c. *Aligned indications.* A group of four or more indications shall be considered aligned when a straight line through the geometric center of the two outer indications touches the intervening indications; when said line lies axially with the weld seam within approximately 5 degrees; and when the separation between each two adjacent indications touched by said straight line is less than 4L (where L is the length of the longer of two adjacent indications). Aligned incomplete fusion and incomplete penetration is rejectable. Aligned slag shall be evaluated as a single indication whose length is equal to the sum of the individual lengths of all the indications in the group. Aligned slag that also falls under the proximate criteria above shall be sized by measuring from the extremities of the outer indications, but shall not have their number reduced for evaluation.

**5.2.1.6 Porosity.**

**5.2.1.6.1 General.** For welds 1/8 inch thick and greater, porosity indications 1/64 inch or less in diameter shall not be counted in evaluation of weld quality.

**5.2.1.6.2 Randomly dispersed porosity.** Pictorial presentation of the acceptance criteria for welds of various classes and base metal thicknesses are shown in figures 6 through 23. The porosity patterns shown are not necessarily the patterns that may appear on the radiographs, but are illustrative of a particular combination of number and size of indications permitted. Acceptance criteria for thicknesses not shown may be extrapolated. For weld lengths less than 6 inches, or weld widths less than shown, the acceptance criteria shall be proportionally reduced. Increasing the allowable pores to compensate for weld widths greater than that shown in the porosity charts is not permitted. When it is considered necessary for evaluation, figure 25 may be used to determine the total area of acceptable pores for any applicable thickness. When

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randomly distributed indications occur in a concentrated pattern, but not to such a degree as to be classed as rejectable clusters, these shall be rejectable when the concentration in any 1 inch or more of weld length becomes twice the amount which is shown in the applicable randomly distributed porosity charts.

**5.2.1.6.3 Aligned porosity.** Porosity aligned as specified in 3.1 shall be rejected. However, such linearly aligned pores shall be acceptable when the total length of the stringer of pores does not exceed the length permitted for a single slag indication. The total length of a stringer of pores is the summation of the diameters of the pores and the distances between each two adjacent pores in the stringer.

**5.2.1.6.4 Maximum pore diameter.** Design material thicknesses less than 1/8 inch shall have no more than six pores in any 6-inch length of weld, and no pores shall have a diameter greater than 20 percent of the design material thickness. For design material thicknesses 1/8 inch or greater, the maximum pore diameter shall not exceed the large diameter specified on figures 6 through 23, except that an isolated pore may be 25 percent of T or 3/16 inch, whichever is less, provided that there is not more than one such pore in any 6 inch length. This applies only to porosity; slag, lack of fusion, etc. may be present in acceptable amounts regardless of their proximity to the isolated pore. An isolated pore is defined as a pore separated from any other pore (greater than 1/64 inch) by a distance of at least 1 inch.

**5.2.1.6.5 Clustered porosity.** Porosity shall be classed as clustered when a group of four or more indications are concentrated in a manner as shown on figure 24. Pores separated from the group by 1/8 inch or 3D, (where D is the diameter of the largest pore in that group), whichever is greater, shall not be considered a part of the group.

**5.2.1.6.6 Other indications.** All other indications, including clustered, aligned, and randomly dispersed indications shall be considered in the evaluation and the total indication area shall not exceed the basic requirement of 0.01T inch per inch or 0.015T inch per inch, as applicable (see figure 25 for areas of circle).

**5.2.1.7 Oxidation of root.** Rough oxidized surface, accompanied by a wrinkled or "sugared" appearance on the radiograph shall be rejected.

**5.2.1.8 Multiple indications.** The presence of the various types of indications on the same radiograph section is permitted provided each indication type is within the limits specified herein except that total accumulated slag shall include incomplete fusion and incomplete penetration indications, when permitted.

**5.2.1.9 Undercut.** External undercut or root undercut shall not exceed the limits of 4.2.16. Undercut shall be evaluated by visual inspection wherever possible; where this is not feasible, records of use of workmanship sample or approved measuring system shall accompany the radiographs which exhibit undercut.

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**5.2.1.10 Inadvertent radiography.** Inadvertent radiography is defined as the presentation on a required radiograph of adjacent welds or base material which do not require radiography. Acceptance or rejection of indications so revealed shall be based on the following:

- a. *Base metal.* Any defect revealed by inadvertent radiography shall be evaluated to base metal acceptance criteria; any defect determined to be a crack shall be cause for rejection. For indications other than a crack, if radiography criteria do not exist, an engineering evaluation is required.
- b. *Welds required to be radiographed.* For welds required to be radiographed which are inadvertently radiographed again, any defect revealed by inadvertent radiography shall be evaluated to the original acceptance criteria for that particular weld class.
- c. *Welds not requiring radiography.* For welds which are not required to be radiographed, which are inadvertently radiographed, all defects shall be evaluated. Defects that are determined to be cracks shall cause the weld to be rejected. Other defects shall require an engineering evaluation.

Engineering evaluation, when required, shall confirm that the structural integrity of the weld or base material is maintained. This evaluation shall be based on the following: performance reliability, prescribed inspection methods and acceptance criteria, and the quality of similar parts which meet the designated inspection requirements. Any engineering actions taken in accordance with inadvertently detected defects shall be noted in the radiographic record. Should repairs be required, the repair areas shall be re-inspected as originally specified.

**5.2.1.11 Weld and base metal defect evaluation.** Weld spatter, arc strikes, grinding marks, surface roughness or handling marks which may interfere with inspection shall be removed by wire brushing and/or grinding prior to radiography (see 4.2.12 and 4.2.13). Weld spatter on RT welds that is overlooked during visual inspection and appears on the weld radiographs shall be removed whenever accessible, visually inspected, and the results noted in the radiographic records. Re-RT is not required after removal if the spatter size does not exceed the maximum size porosity pore allowed for that weldment and does not interfere with the interpretation. Base metal surface roughness, grinding marks and handling marks adjacent to radiographed welds are permissible provided their indications on the radiograph do no interfere with interpretation of welds and provided the surface conditions meet the acceptance standards of the applicable base material or component specifications. Surface conditions which violate minimum allowable wall thickness are unacceptable. Indications of cracks in the base material are not permitted. Tool marks or irregular surfaces which are not accessible for removal, such as tool marks on the inside surface of piping adjacent to welds, shall require engineering evaluation, and any technical justification for acceptance shall accompany the radiograph.

## **5.2.2 Class 1 acceptance standard for welds.**

**5.2.2.1 General.** The provisions of 5.2.1 apply.

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**5.2.2.2 Incomplete fusion and incomplete penetration.** Welds shall be free of incomplete fusion and incomplete penetration indications which exceed the limits of figure 26. Acceptable incomplete fusion and incomplete penetration shall be treated as slag when determining the total accumulated length of slag.

**5.2.2.3 Slag.** The maximum single slag length and the maximum accumulation slag lengths shall not exceed that specified on figure 27.

#### 5.2.2.4 Porosity.

**5.2.2.4.1 Maximum area.** The total area of porosity permitted, as determined from the radiographic film, is based on one percent of design material thickness "T" per each inch of weld being inspected. For calculation, the following formula applies:

Total area of pores permitted in 1 inch length of weld =  $0.01T$  inch x 1 inch.

Hence, for any 6 inch length, the total area of pores permitted will be  $0.06T$  square inch.

**5.2.2.4.2 Randomly dispersed porosity.** Randomly dispersed porosity shall not exceed the limits of figures 6 through 15 for weld thicknesses 1/8 to 4 inches.

**5.2.2.4.3 Clustered porosity.** The acceptance standard for clustered porosity as defined in 5.2.1.6.5 shall be as shown in table V.

**TABLE V. Maximum porosity cluster.<sup>2</sup>**

Design material thickness (T)	Maximum cluster size (diameter)	Maximum No. of pores <sup>1</sup>
1/4 inch and less	1/4 inch	4, any size
Greater than 1/4 to 1/2 inch	1/4 inch	No limit, except summation of pore diameters shall not exceed 1/4 inch.
Greater than 1/2 inch	1/2 T or 3/4 inch whichever is less	No limit, except summation of pore diameters shall not exceed 1/2 T or 3/4 inch, whichever is less.

<sup>1</sup>Sizes shall not exceed those shown in 5.2.1.6.4.

<sup>2</sup>The minimum separation between clusters shall be 4T or 3 inches, whichever is less.

#### 5.2.2.5 Other defects.

**5.2.2.5.1 Consumable inserts.** Consumable insert type welds shall be completely fused to the base material. Incomplete insert melting is acceptable if the convexity requirements are met and it can be clearly determined that the insert has been completely fused to the adjacent base metal. The insert shall be considered completely fused to the adjacent base metal if the edges of the insert have flowed, i.e., image of original edge(s) of insert is not present in the radiographic image.

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**5.2.2.5.2 Root surface concavity.** Root surface concavity shall meet the requirements of table I.

**5.2.2.5.3 Root surface convexity.** Root surface convexity shall meet the requirements of table I.

**5.2.2.5.4 Root surface defect length.** Root concavity or convexity may extend for the entire circumference of the weld.

**5.2.2.5.5 Verification.** Verification of questionable dimensional tolerance shall be established by visual inspection. If this is not feasible, records of use of workmanship sample or approved measuring system shall accompany the radiographic records.

### **5.2.3 Class 2 acceptance standard for welds.**

**5.2.3.1 General.** The provisions of 5.2.1 apply.

**5.2.3.2 Incomplete fusion and incomplete penetration.** Welds shall be free of incomplete fusion and incomplete penetration indications which exceed the limits of figure 28. Acceptable incomplete fusion and incomplete penetration shall be treated as slag when determining the total accumulated length of slag.

**5.2.3.3 Slag.** The maximum single slag length and the maximum accumulative slag lengths shall not exceed that specified on figure 29.

**5.2.3.4 Porosity.** See 5.2.2.4.

### **5.2.4 Class 3 acceptance standards for welds.**

**5.2.4.1 General.** The provisions of 5.2.1 apply.

**5.2.4.2 Incomplete fusion and incomplete penetration.** Welds shall be free of incomplete fusion and incomplete penetration indications which exceed the limits of figure 28. Acceptable incomplete fusion and incomplete penetration shall be treated as slag when determining the total accumulated length of slag.

**5.2.4.3 Slag.** The maximum single slag and the maximum accumulated slag shall not exceed that specified on figure 30.

**5.2.4.4 Porosity.** The requirements of 5.2.2.4 apply except that the total area of porosity permitted is based on the area of porosity being 1.5 percent of the material thickness per 1-inch length and the randomly dispersed porosity shall not exceed the limits of figures 16 through 23 for weld thickness 1/4 to 4 inches. Clustered or concentrated porosity is acceptable provided these indications, when evaluated with other porosity indications, do not exceed the maximum number shown in the applicable randomly dispersed porosity chart (or 0.09T square inches) in any 6 inches of weld.

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**5.2.5 Radiographic acceptance criteria for castings and other base metal repair welds.**

**5.2.5.1 General.** The provisions of 5.2.1 apply where applicable.

**5.2.5.2 Post weld repair radiography.** For post weld repair radiography, discontinuities occurring in the weld metal shall be judged for acceptance to the production weld radiographic standards of the applicable class of welds in this section. Discontinuities which are not acceptable to the production weld radiographic standards but are within the base metal standard are acceptable, if previously proven to exist in the base material beyond or beneath the repair weld boundary. A sketch of the acceptable excavated area showing the pertinent dimensions shall be maintained with the radiographs. For repair welds which have been ground flush with the base metal, adequate location markers shall be used to delineate the repaired area.

**5.2.5.3 Repair weld size-determination and acceptance-evaluation.** In applying the production weld standard to base metal weld repair, the surface area of the base metal shall be adjusted to the weld surface area illustrated in the strip porosity charts, with the maximum repair depth determining which chart to use. Interpolation may be employed for thicknesses not shown. Porosity, slag, lack of fusion, or incomplete penetration may be judged in this manner, that is, by considering the repair area as a series of adjacent strips parallel to the longitudinal axis of the weld, if the extent of repair necessitates it, to allow comparison with the porosity illustrations, and the slag, lack of fusion and incomplete penetration charts. The concentration of radiographic indications in any portion of a repair weld shall not exceed that permitted for an equivalent area shown in the strip porosity chart and slag curve for equivalent weld thickness.

**6. MAGNETIC PARTICLE INSPECTION**

**6.1 General.** Welds, castings, and wrought materials shall meet the requirements of the applicable fabrication document, and unless otherwise specified, the following standards shall apply. The size of the indication used for evaluation shall be the size of the particle accumulation and not necessarily the actual size of the discontinuity.

**6.2 Welds.**

**6.2.1 Linear indications.** All welds and at least 1/2 inch of the adjacent base metal on each side shall be free of linear indications (see 3.12) greater than 1/16 inch in length except for undercut indications within the requirements of 4.2.16 and base metal indications within the requirements of 6.4 or the base metal specifications. Indications 1/16 inch and less shall be considered non-linear.

**6.2.2 Non-linear indications.** Rounded indications 1/64 inch and less shall be disregarded for material thickness 3/16 inch and less. Rounded indications 1/32 inch diameter and less shall be disregarded for material thickness greater than 3/16 inch. Non-linear or rounded indications meeting the standards of figures 31 through 48 for 6 inch length of weld are acceptable. The maximum number of indications permissible for weld-length and weld-width different from that shown on figures 31 through 48 shall be prorated. The maximum indication size shall not

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exceed the limits of figure 49. When it is considered necessary for evaluation, figure 25 may be used to determine the total indication area.

**6.2.2.1 Aligned rounded indications.** Aligned rounded indications (see 3.1) shall be cause for rejection if one or more of the aligned indications is greater than 1/32 inch for class 1, greater than 1/16 inch for class 2, or greater than 3/32 inch for class 3.

### 6.3 Castings.

**6.3.1 Linear indications.** Casting surfaces shall be free of tears or crack-like indications longer than 1/16 inch. Other indications, such as shrinkage cavities, cold shuts, unfused chaplets, or internal chills, are acceptable if the maximum number and maximum length of the indications meet the standards of table VI.

**TABLE VI.** *Linear indication acceptance standards for castings, magnetic particle and liquid penetrant inspection (in 36 square inches of area).*

Description	Class	Indication size (inch) maximum	No. of indications maximum
Finished machine surface	1	3/32	6
	2	1/8	10
	3	3/16	10
Rough ground surface	1	1/8	6
	2	3/16	10
	3	1/4	10
As-cast surface	1	3/16	6
	2	1/4	10
	3	5/16	10

NOTES: (All notes apply)

- (1) Casting surfaces shall be free of tears or crack-like indications longer than 1/16 inch. Any area containing a linear indication greater than 1/16 inch shall be cleaned and examined at 5x magnification or ground and reinspected as necessary to assure that it is not a crack or tear. In addition, the length of any indication shall not exceed 1/2 the material thickness at the location where the indication occurs.
- (2) Randomly distributed indications 1/16 and less shall not be counted.
- (3) The distance separating two longitudinally aligned linear indications shall be not less than 4 times D, where D is the length of the longer indication. However, when the total length of the longitudinally aligned indications does not exceed the maximum length permitted for a single indication, these aligned indications shall be considered one indication, and shall not be cause for rejection.
- (4) The distance separating two linear indications not longitudinally aligned shall be not less than D, where D is the length of the longer indication.
- (5) For inspection areas of less than 36 square inches, the maximum number of indications shall be prorated.
- (6) The number of linear indications shall not exceed that permitted above, even if the area does not contain any non-linear indications.

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**6.3.2 Non-linear indications.** Non-linear indications shall be evaluated to the requirements of table VII.

**TABLE VII.** *Non-linear indication acceptance standards for castings, magnetic particle and liquid penetrant inspection (in 36 square inches of area).*

Description	Class	Indication size (inch) maximum	No. of indications maximum
Finished machine surface	1	1/8	8
	2	1/8	12
	3	3/16	16
Rough ground surface	1	1/8	8
	2	1/8	12
	3	1/4	16
As-cast surface	1	1/8	8
	2	1/4	12
	3	5/16	16

NOTES: (All notes apply)

- (1) The maximum individual non-linear indication size shall be the major dimension of an indication. In addition, no indication shall exceed 1/2 the minimum design wall thickness at the location where the indication occurs.
- (2) Indications 1/16 and less shall not be counted.
- (3) For inspection areas of less than 36 square inches, the maximum number of indications shall be prorated.
- (4) Linear and non-linear indications permitted in tables VI and VII may be present in the same 36-square inch inspection area. If an area contains less linear indications than that permitted by table VI, the maximum number of non-linear indications may be increased so that the combined total of linear and non-linear indications equals that of tables VI and VII. For example, class 1 finished machine surface permits six linear indications and eight non-linear indications for each 36 square inches of surface. If there were only two linear indications less than 3/32 inch in length, then the non-linear indications may be increased to 12.
- (5) When the major dimension of a cluster of indications (four or more greater than 1/16 inch) does not exceed the maximum size permitted for a single indication, these clustered indications shall be considered as one indication, and shall not be cause for rejection. Scattered indications, separated from the cluster by 1/8 inch or more, shall not be considered as part of the cluster.

**6.3.3 Repaired surfaces.** Repairs to defective areas shall be made in accordance with the applicable fabrication specification. Areas repaired by welding shall meet the applicable acceptance standard for weld.

**6.4 Forgings and wrought materials (pipes, bars, plates, and extrusions).** Acceptance criteria for forgings and wrought materials shall be in accordance with the applicable material specification. Unless otherwise specified in the material or fabrications specifications, there shall be no indications greater than 1/16 inch.

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**7. LIQUID PENETRANT INSPECTION**

**7.1 General.** Welds, castings, forgings and wrought materials shall meet the requirements of the applicable fabrication document and, unless otherwise specified, the following standards shall apply. The size of the indication used for evaluation shall be the size of the bleed-out and not necessarily the actual size of the discontinuity.

**7.2 Welds (excluding weld overlay and hard surfacing).**

**7.2.1 Linear indications.** Linear indications shall be evaluated in accordance with 6.2.1.

**7.2.2 Non-linear indications.** Non-linear indications shall be evaluated in accordance with 6.2.2.

**7.2.2.1 Aligned rounded indications.** Aligned rounded indications shall be evaluated in accordance with 6.2.2.1.

**7.3 Hard surfacing material.** Unless otherwise approved, nondestructive testing of hard surfacing material of valves and valve seats shall be performed by the liquid penetrant method. The hard surfacing material shall be free of cracks, incomplete fusion, lack of bond to the base metal and other linear indications. Non-linear indications shall meet the following for each 6-inch length of circumferential weld or prorated for welds less than 6 inches. Note that the "D" under minimum spacing in the following paragraphs represents the major dimension of the larger adjacent indications.

**7.3.1 Valve seating surface.**

**7.3.1.1** Area within plus or minus 1/8 inch of contact line shall meet the standard of figure 31. Rounded indications less than 1/32 inch diameter shall be disregarded.

**7.3.1.2** Area outside the above described contact area shall meet the following:

Maximum diameter (D) (inch)	Maximum number	Spacing (min.)
1/16	6	4 x D

NOTE: Rounded indications less than 1/16 inch diameter shall be disregarded.

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**7.3.2 Other sealing surfaces.**

Maximum diameter (D) (inch)	Total number (all indication sizes)	Spacing (min.)
5/64	4	4 x D
3/64	5	4 x D
1/64	6	4 x D

NOTE: Rounded indications less than 1/64 inch diameter shall be disregarded.

**7.3.3 Non-sealing surfaces.**

Maximum diameter (D) (inch)	Total number (all indication sizes)	Spacing (min.)
1/8	2	4 x D
1/16	6	4 x D
1/32	12	4 x D

NOTE: Rounded indications less than 1/32 inch diameter shall be disregarded.

**7.4 Weld overlay.** Unless otherwise approved, nondestructive testing of weld overlay shall be performed by the liquid penetrant method. The weld overlay surfaces and at least 1/2 inch of the adjacent base metal shall be free of cracks and incomplete fusion larger than 1/16 inch. Other indications meeting the requirements of tables VIII and IX are acceptable. Buttering and build-up of localized area shall be considered as welds and inspected by magnetic particle or liquid penetrant test, as applicable. Rounded indications less than 3/32 diameter shall be disregarded.

**7.5 Castings.**

**7.5.1 Linear indications.** Casting surfaces shall be free of tears or crack-like indications longer than 1/16 inch. Other indications, such as shrinkage cavities, cold shuts, unfused chaplets or internal chills, are acceptable if the maximum number and maximum length of the indications meet the standards of table VI.

**7.5.2 Non-linear indications.** Non-linear indications shall be evaluated to the requirements of table VII.

**7.5.3 Heat checks in tin-bronze castings.** For tin-bronze castings of all thicknesses, heat checks shall not exceed 3/16 inch in length or occur more frequently than once per linear inch of weld-base metal fusion line.

**7.5.4 Repaired surfaces.** Repaired surfaces shall be evaluated in accordance with 6.3.3.

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**TABLE VIII.** *Linear indication acceptance standards for liquid penetrant inspection of weld overlay (in 36 square inches of area).*

Description	Class	Indication size (inch) maximum	No. of indications maximum
Finished machine surface	1	3/32	6
	2	1/8	10
	3	3/16	10
Rough ground surface	1	1/8	6
	2	3/16	10
	3	1/4	10

NOTES: (All notes apply)

- (1) The cladded surface shall be free crack-like defects or incomplete fusion longer than 1/16 inch. Any area containing a linear indication greater than 1/16 inch shall be cleaned and examined at 5x magnification or ground and reinspected as necessary to assure that it is not a crack or incomplete fusion. In addition, the length of any indication shall not exceed 1/2 the total material thickness at the location where the indication occurs.
- (2) Randomly distributed indications 1/16 and less shall not be counted.
- (3) The distance separating two longitudinally aligned linear indications shall not be less than 4 times D, where D is the length of the longer indication. However, when the total length of the longitudinally aligned indication does not exceed the maximum length permitted for a single indication, these aligned indications shall be considered one indication, and shall not be cause for rejection.
- (4) The distance separating two linear indications (greater than 1/16 inch) not longitudinally aligned shall not be less than D, where D is the length of the longer indication.
- (5) For inspection areas of less than 36 square inches, the maximum number of indications shall be prorated.
- (6) The number of linear indications shall not exceed that permitted above, even if the area does not contain any non-linear indications.
- (7) All linear indications greater than 1/16 inch shall be counted to determine the maximum number.

**7.6 Forgings and wrought materials (pipes, bars, plates, and extrusions).** Forgings and wrought materials shall be evaluated in accordance with 6.4.

## 8. ULTRASONIC INSPECTION

**8.1 General.** For ultrasonic inspections governed by a fabrication document, material specification, or other referencing document in which the acceptance criteria are specified, acceptance/rejection shall be as specified therein. Unless otherwise specified below any indication producing a response equal to or greater than the calibration reflector shall be rejected.

### 8.2 Full penetration butt welds and corner welds.

#### 8.2.1 Full penetration butt welds and corner welds (class 1).

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**TABLE IX.** *Non-linear indication acceptance standards for liquid penetrant inspection of weld overlay (in 36 square inches of area).*

Description	Class	Indication size (inch) maximum	No. of indications maximum
Finished machine surface	1	1/8	8
	2	3/16	12
	3	1/4	16
Rough ground surface	1	1/8	8
	2	3/16	12
	3	3/8	16

NOTES: (All notes apply)

- (1) The maximum individual non-linear indication size shall be the major dimension of an indication. In addition, no indication shall exceed 1/2 the total material thickness at the location where the indication occurs.
- (2) Indications 1/16 and less shall be disregarded. Aligned indications, as defined (see 3.1), shall be treated as a linear indication in accordance with table VIII if one or more of the aligned indications is greater than 1/16 inch.
- (3) For inspection areas less than 36 square inches, the maximum number of indications shall be prorated.
- (4) Linear and non-linear indications permitted in tables VIII and IX may be present in the same 36-square inch inspection area. If an area contains less linear indications than that permitted by table VIII, the maximum number of non-linear indications may be increased so that the combined total of linear and non-linear indications equals that of tables VIII and IX. For example, class 1 finished machine surface permits 6 linear indications and 8 non-linear indications for each 36 square inches of surface. If there were only 2 linear indications less than 3/32 inch in length, then the non-linear indications may be increased to 12.
- (5) When the major dimensions of a cluster of indications do not exceed the maximum size permitted for a single indication, these clustered indications shall be considered as one indication and shall not be cause for rejection. Scattered indications, separated from the cluster by 1/8 inch or more, shall not be considered as part of the cluster.
- (6) All non-linear indications greater than 1/16 inch shall be counted to determine the maximum number.

**8.2.1.1** Any discontinuity whose reflection exceeds the ARL (see 3.2) with measurable length shall be rejected. Adjacent discontinuities whose reflections exceed the ARL, separated by less than 2L of sound metal (L equals length of longest discontinuity) shall be considered a single discontinuity.

**8.2.1.2** Indications less than the DRL shall be disregarded.

**8.2.1.3** Discontinuities whose reflections are equal to or greater than the DRL shall be evaluated as follows:

**8.2.1.3.1** If the discontinuity length exceeds 1/2T (T equals thickness of the thinner member), it shall be rejected. In no case shall any single discontinuity length exceed 1-1/2 inches.

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**8.2.1.3.2** Adjacent discontinuities separated by less than  $2L$  of sound metal ( $L$  equals length of longest discontinuity) shall be considered as a single discontinuity. The maximum distance between the outer extremities of any two such adjacent discontinuities, or the sum of their lengths, whichever is greater, shall not exceed the length specified in 8.2.1.3.1 (figures 50 through 54).

**8.2.1.3.3** If in any 12 consecutive inches of weld or less, the total accumulative length of individual discontinuities exceeds one  $T$ , they shall be rejected.

**8.2.2 Full penetration butt welds and corner welds (class 2).**

**8.2.2.1** Any discontinuity whose reflection exceeds the ARL and has a length which exceeds  $1/4$  inch shall be rejected. Adjacent discontinuities whose reflections exceed the ARL, separated by less than  $2L$  ( $L$  equals length of longest discontinuity) shall be considered as a single discontinuity.

**8.2.2.2** Indications less than the DRL shall be disregarded.

**8.2.2.3** Discontinuities whose reflections equal or exceed the DRL shall be evaluated as follows:

**8.2.2.3.1** If the discontinuity length exceeds  $T$  ( $T$  equals thickness of the thinner member), it shall be rejected. In no case shall any single discontinuity exceed 2 inches.

**8.2.2.3.2** Adjacent discontinuities separated by less than  $2L$  of sound metal ( $L$  equals length of longest discontinuity) shall be considered as a single discontinuity. The maximum distance between the outer extremities of any two such adjacent discontinuities or the sum of their lengths, whichever is greater, shall not exceed the length specified in 8.2.2.3.1 (figures 50 through 54).

**8.2.2.3.3** If in any 12 consecutive inches or less of weld, the total accumulative length of individual discontinuities exceeds  $2T$ , they shall be rejected.

**8.2.3 Full penetration butt welds and corner welds (class 3).**

**8.2.3.1** Any discontinuity whose reflection exceeds the ARL and has a length which exceeds  $1/2$  inch shall be rejected. Adjacent discontinuities whose reflection exceeds the ARL, separated by less than  $2L$  ( $L$  equals the length of the longest discontinuity), shall be considered as a single discontinuity.

**8.2.3.2** Indications less than the DRL shall be disregarded.

**8.2.3.3** Discontinuities whose reflections equal or exceed the DRL shall be rejected if the discontinuity length exceeds 1 inch or  $1T$ , whichever is greater ( $T$  equals the thickness of the thinner member).

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**8.2.3.4** Adjacent discontinuities separated by less than  $2L$  ( $L$  equals the length of the longest discontinuity) shall be considered as a single discontinuity. The maximum distance between the outer extremities of any two such adjacent discontinuities or the sum of their lengths, whichever is greater, shall not exceed the length specified in 8.2.3.1 for discontinuities having reflections above the ARL, or 8.2.3.3 for discontinuities having reflections equal to or greater than the DRL (figures 50 through 54).

**8.2.3.5** If in any 12 consecutive inches or less of weld, the total accumulative length of individual discontinuities exceeds  $2T$ , they shall be rejected.

**8.3 Full penetration tee welds for incomplete root penetration.**

**8.3.1** Any discontinuity whose reflection exceeds the ARL shall be rejected.

**8.3.2** Any indication less than the DRL shall be disregarded.

**8.3.3** Any discontinuity whose reflection is equal to or greater than the DRL, up to and including the ARL, shall be rejected if its length exceeds 6 inches.

**8.3.4** If in any 12 consecutive inches of weld or less, the total accumulative length of discontinuities exceed 6 inches, they shall be rejected.

**8.4 Tee weld discontinuities into the through member.**

**8.4.1** Any discontinuity whose reflection exceeds the ARL shall be rejected.

**8.4.2** Any indication below the DRL shall be disregarded.

**8.4.3** Discontinuities whose reflections equal or exceed the DRL up to and including the ARL, shall be rejected if the difference between the reported minimum and maximum perpendicular distances from the through member surface is greater than  $1/16$  inch.

**9. EDDY CURRENT INSPECTION**

**9.1 Weld inspection.** All discontinuities detected by eddy current shall be reinspected by the magnetic particle inspection for ferrous materials and by liquid penetrant inspection for nonferrous materials and evaluated in accordance with criteria for that method.

**10. NOTES**

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

**10.1 Intended use.** This standard is a compilation of existing requirements contained in the NAVSEA publications it supersedes and incorporates several changes to the requirements

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which have been introduced in more recent NAVSEA documents. It is intended for use to determine the acceptability of discontinuities revealed by nondestructive test methods.

**10.2 Issue of DODISS.** When this standard is used in acquisition, the applicable issue of the DODISS must be cited in the solicitation (see 2.1.1 and 2.2).

### **10.3 Subject term (key word) listing.**

Discontinuity  
Eddy current inspection  
Liquid penetrant inspection  
Magnetic particle inspection  
Radiographic inspection  
Ultrasonic inspection  
Visual inspection

Preparing activity:  
Navy — SH  
(Project NDTI-N087)

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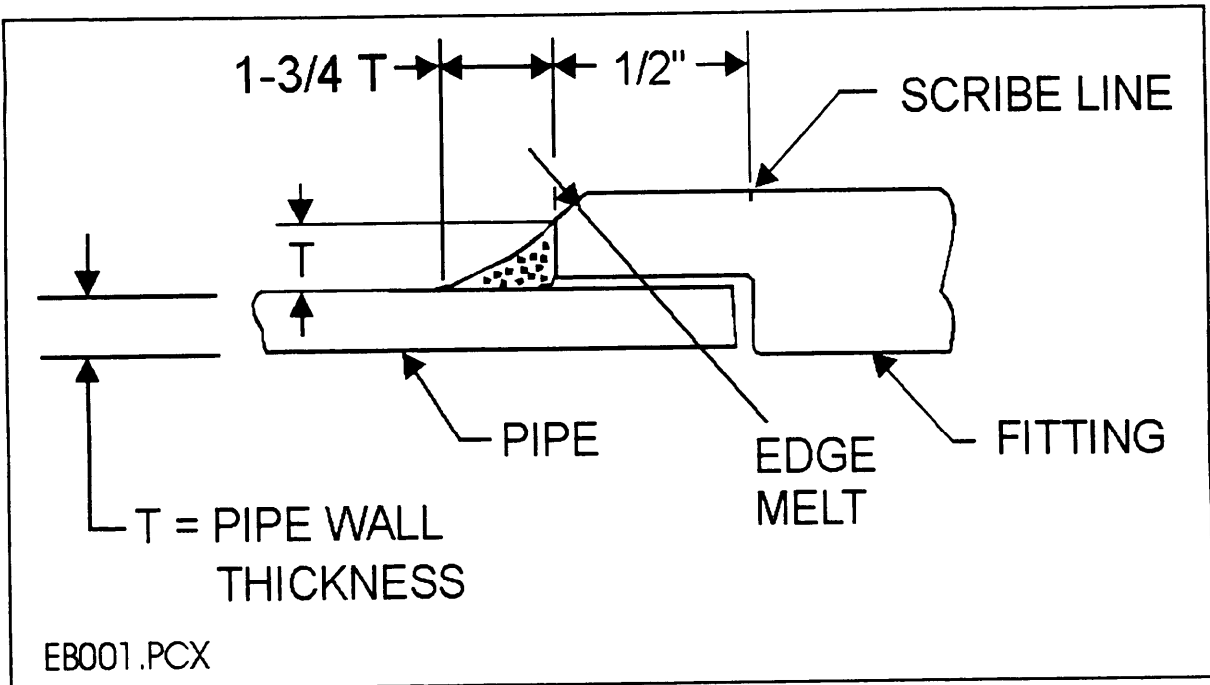


Figure 1. Socket weld fillet size.

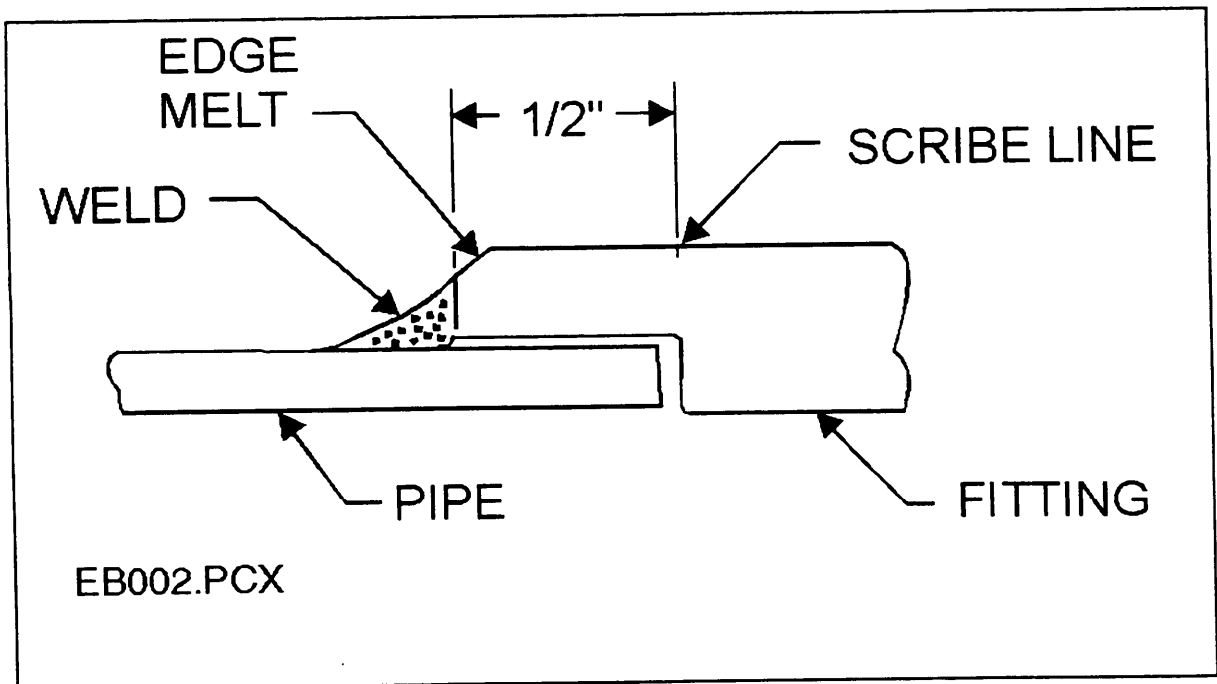
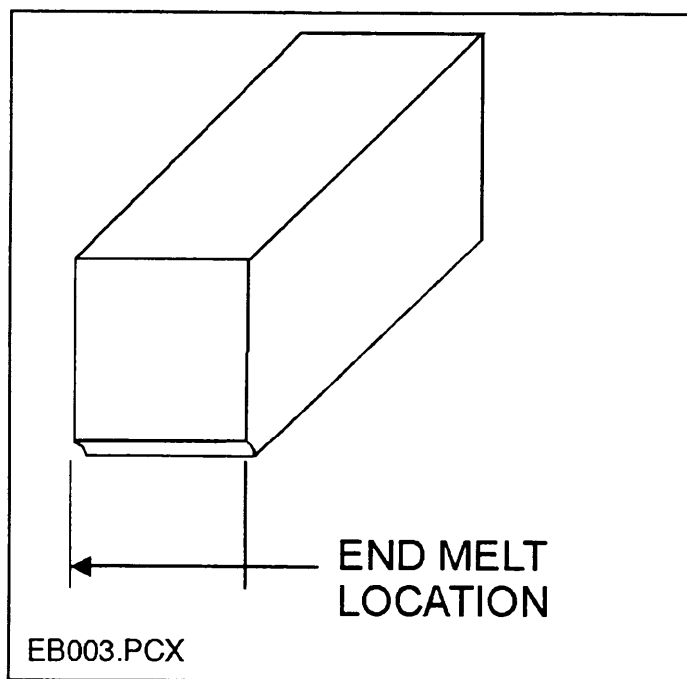
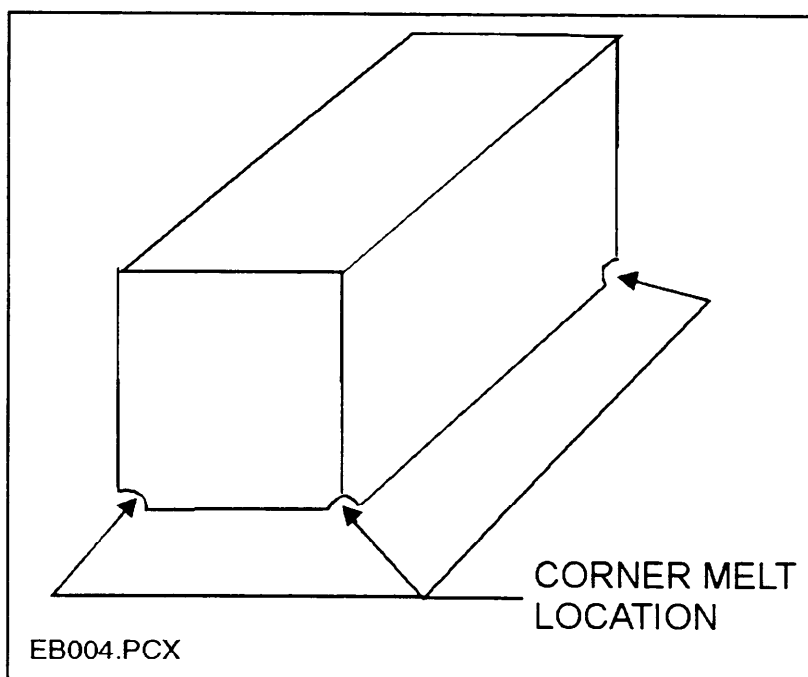


Figure 2. Pipe fitting edge-melt.

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**Figure 3.** *End melt location.*



**Figure 4.** *Corner melt location.*

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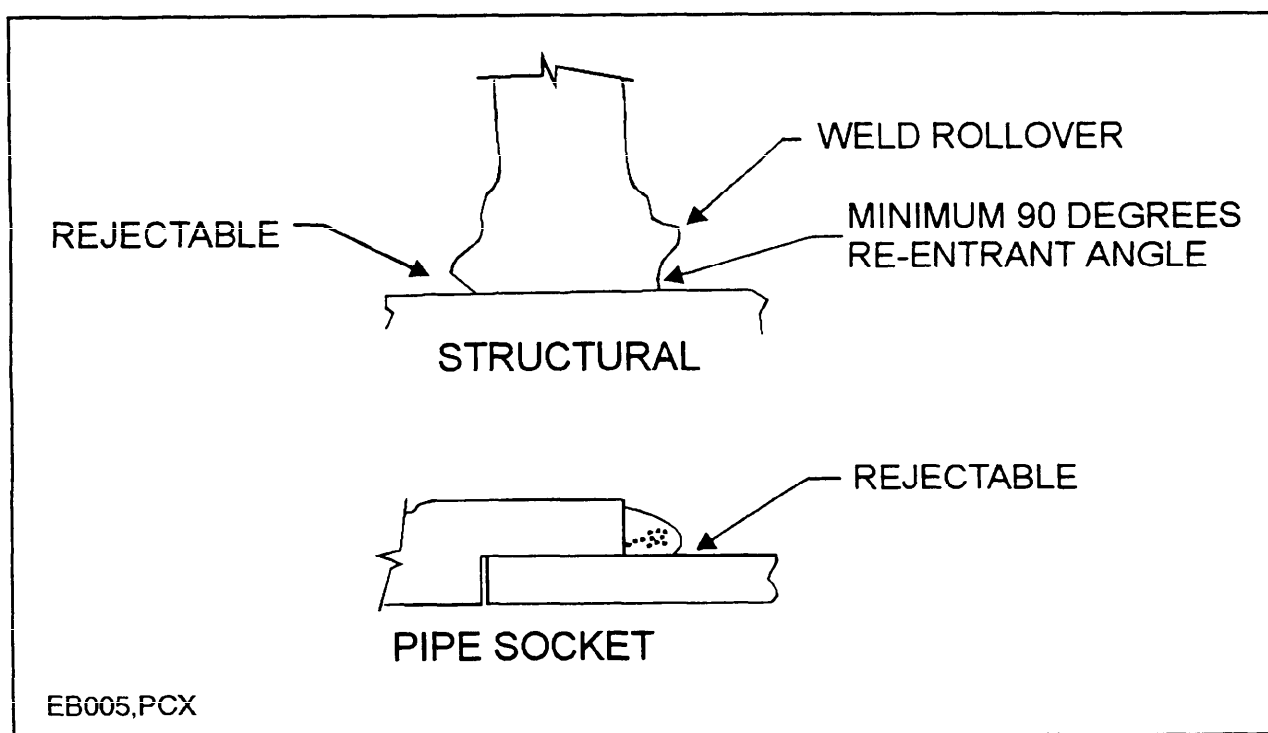
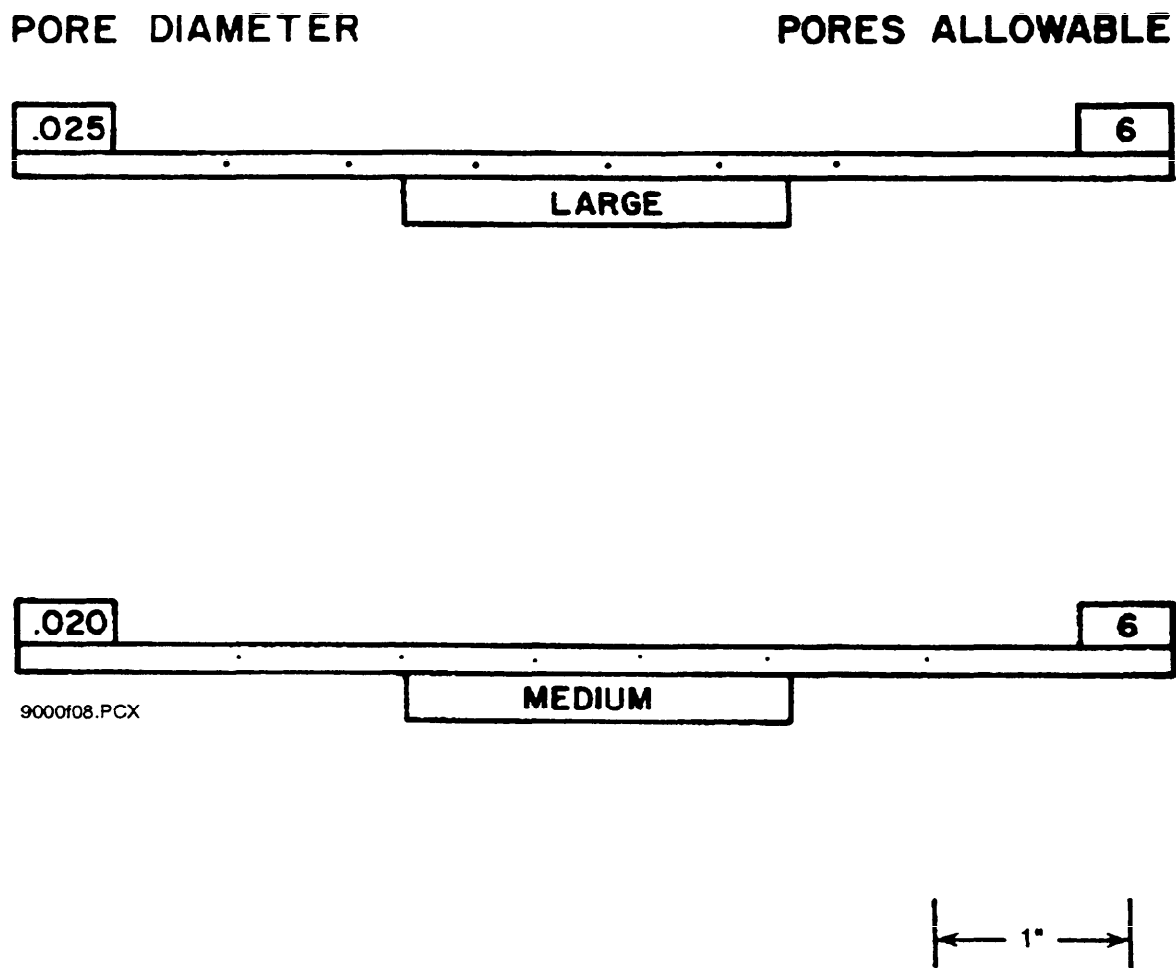


Figure 5. Re-entrant angle illustrations.

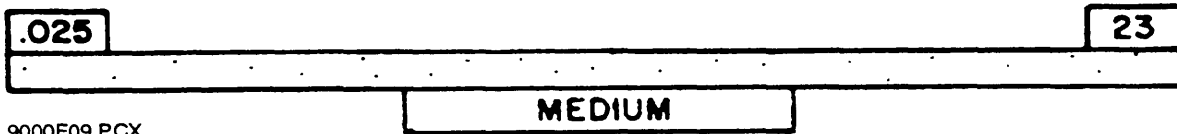
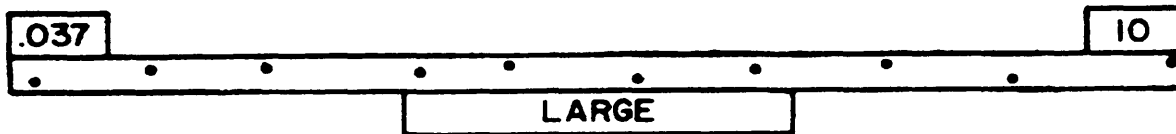
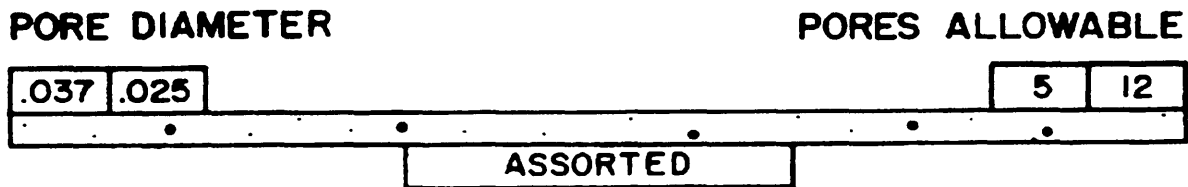
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**FIGURE 6.** Radiographic porosity Class 1 and Class 2 (1 percent  $T$ /inch per 6 inches),  $T$  equals  $1/8$  inch.

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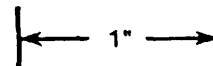
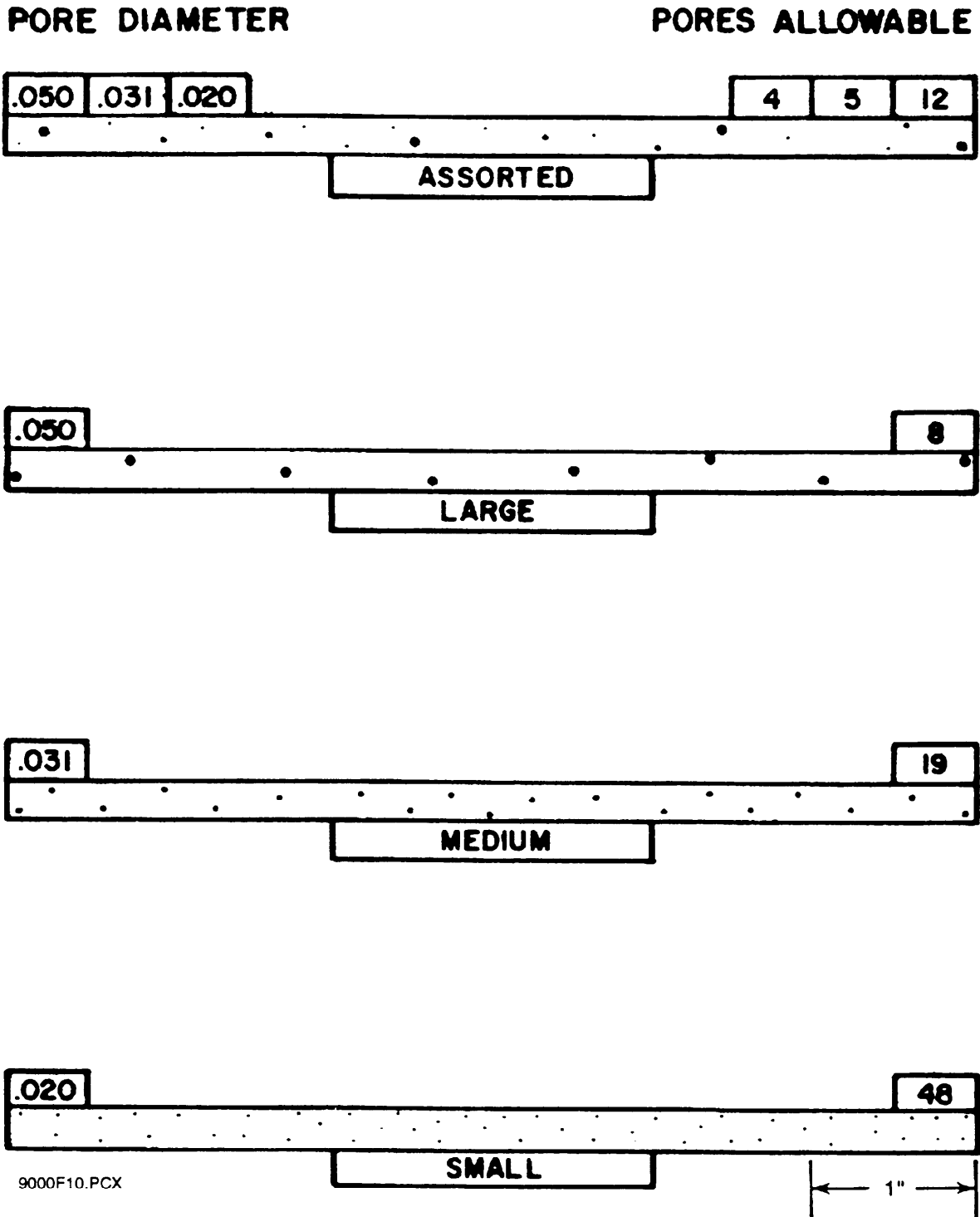


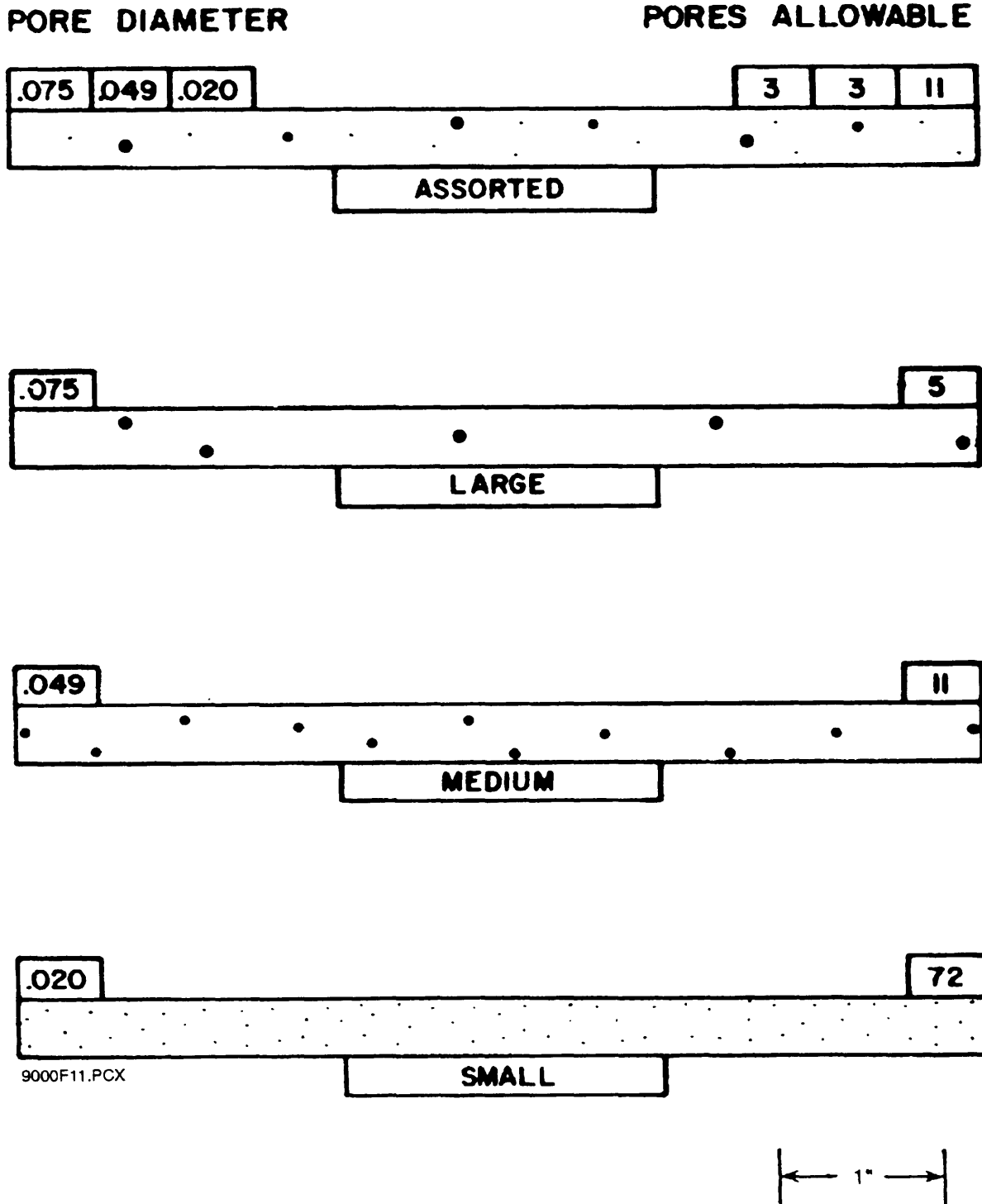
FIGURE 7. Radiographic porosity Class 1 and Class 2 (1 percent  $T$ /inch per 6 inches),  $T$  equals  $3/16$  inch ( $0.0113 \text{ in}^2$  total porosity area).

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**FIGURE 8.** Radiographic porosity Class 1 and Class 2 (1 percent T/inch per 6 inches), T equals 1/4 inch (0.015 in<sup>2</sup> total porosity area).

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**FIGURE 9.** Radiographic porosity Class 1 and Class 2 (1 percent T/inch per 6 inches), T equals 3/8 inch (0.0225 in<sup>2</sup> total porosity area).

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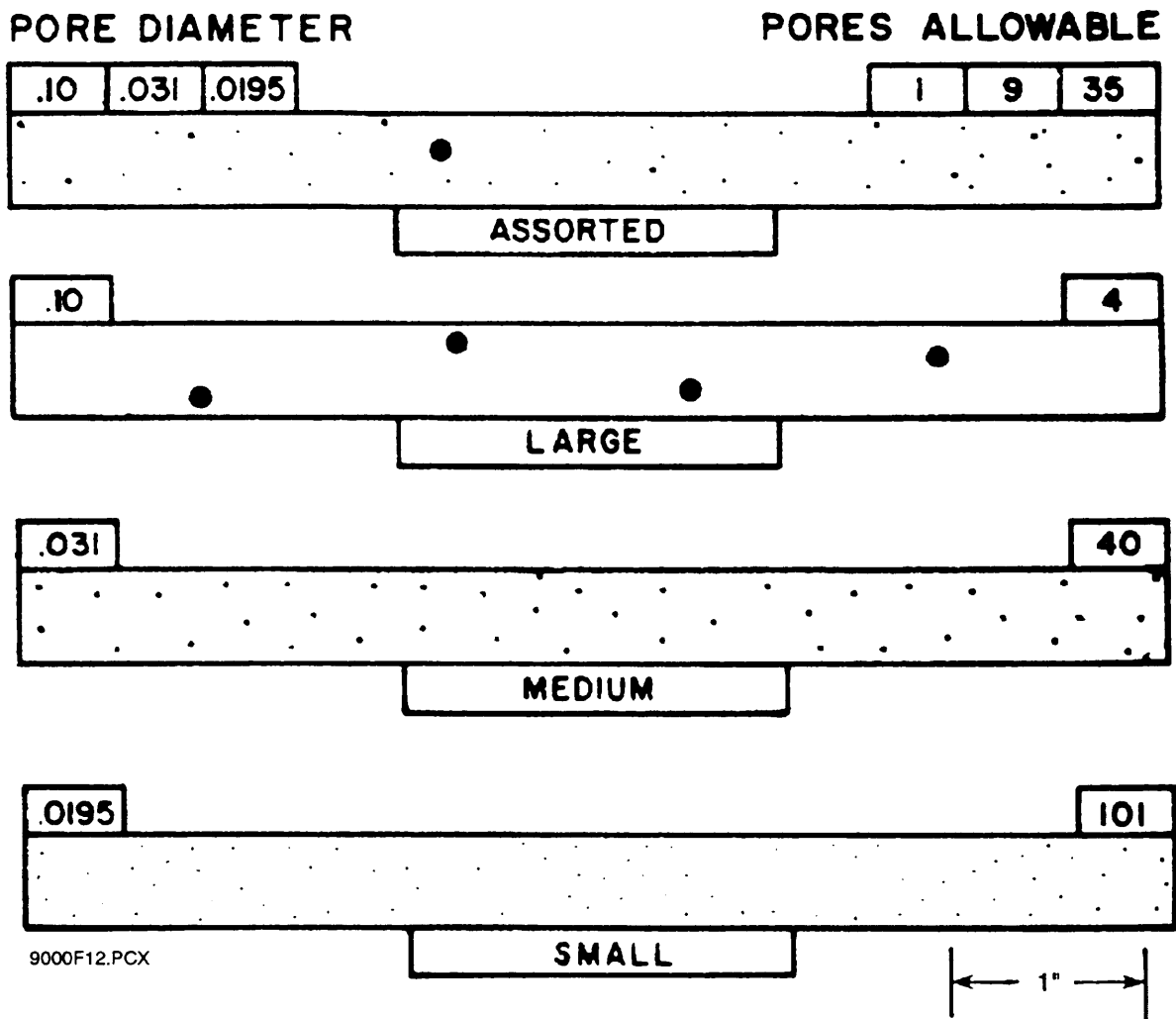


FIGURE 10. Radiographic porosity Class 1 and Class 2 (1 percent T/inch per 6 inches), T equals 1/2 inch (0.030 in<sup>2</sup> total porosity area).

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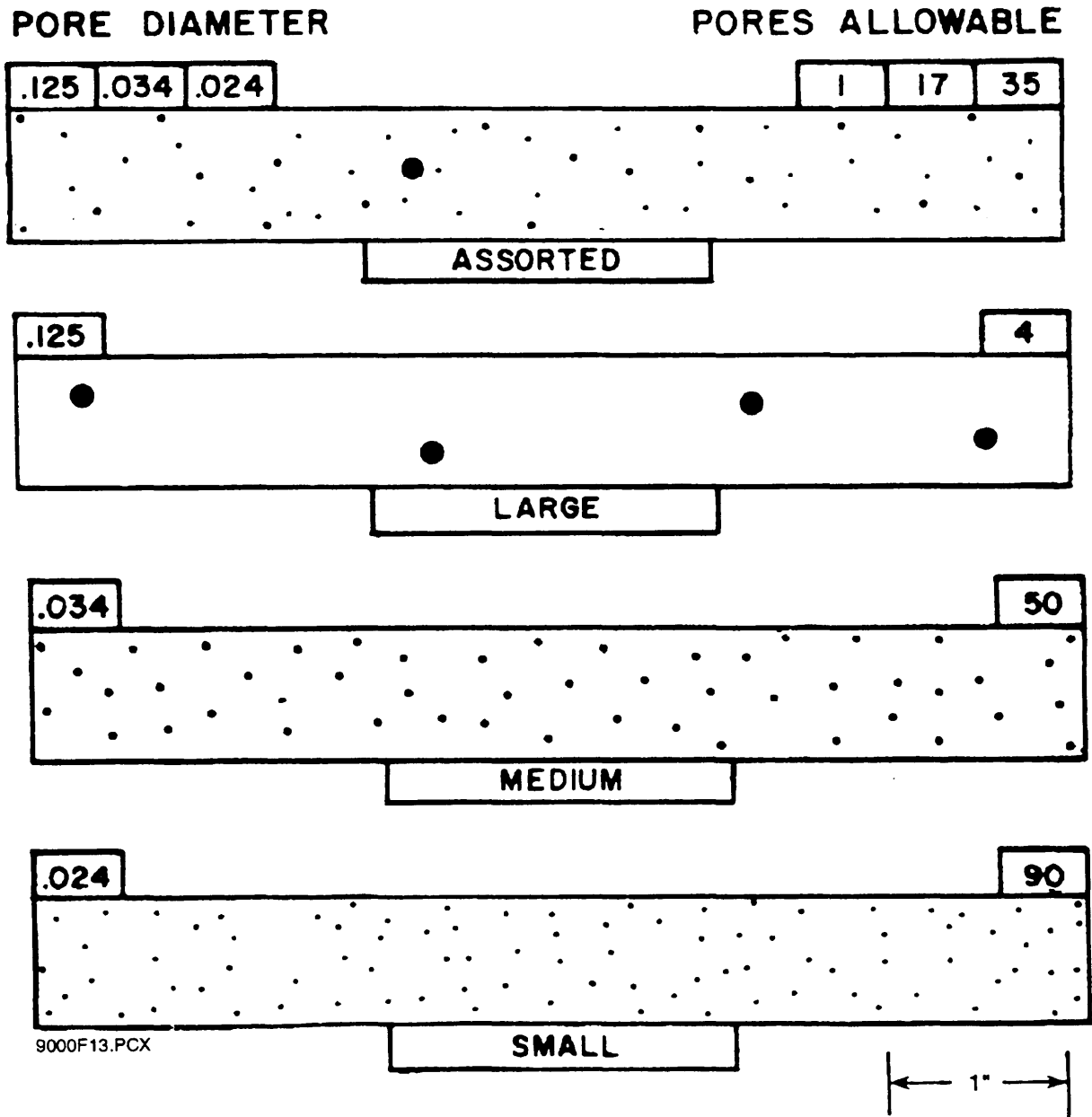


FIGURE 11. Radiographic porosity Class 1 and Class 2 (1 percent T/inch per 6 inches), T equals 3/4 inch (0.045 in<sup>2</sup> total porosity area).

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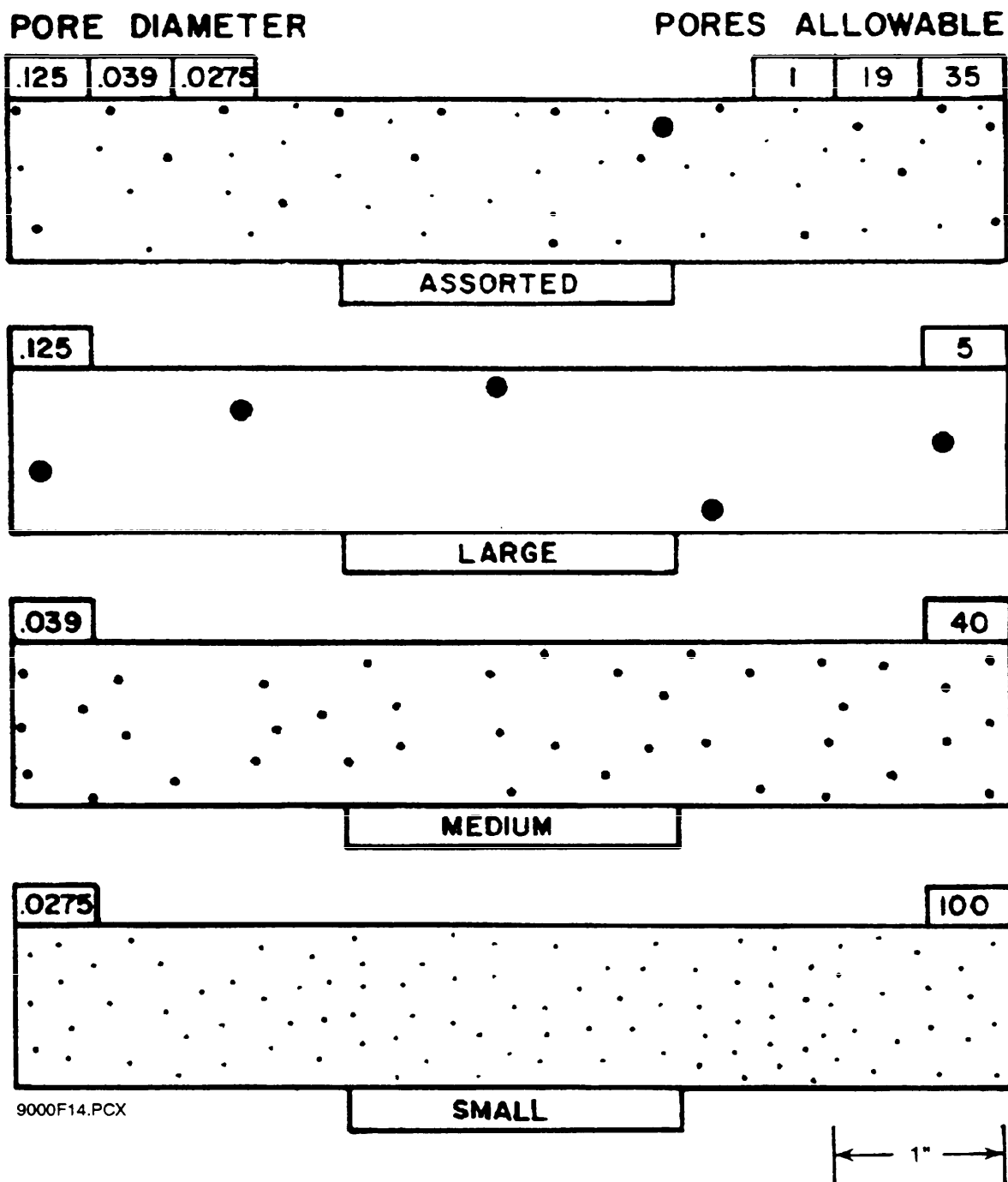


FIGURE 12. Radiographic porosity Class 1 and Class 2 (1 percent T/inch per 6 inches), T equals 1 inch (0.060 in<sup>2</sup> total porosity area).

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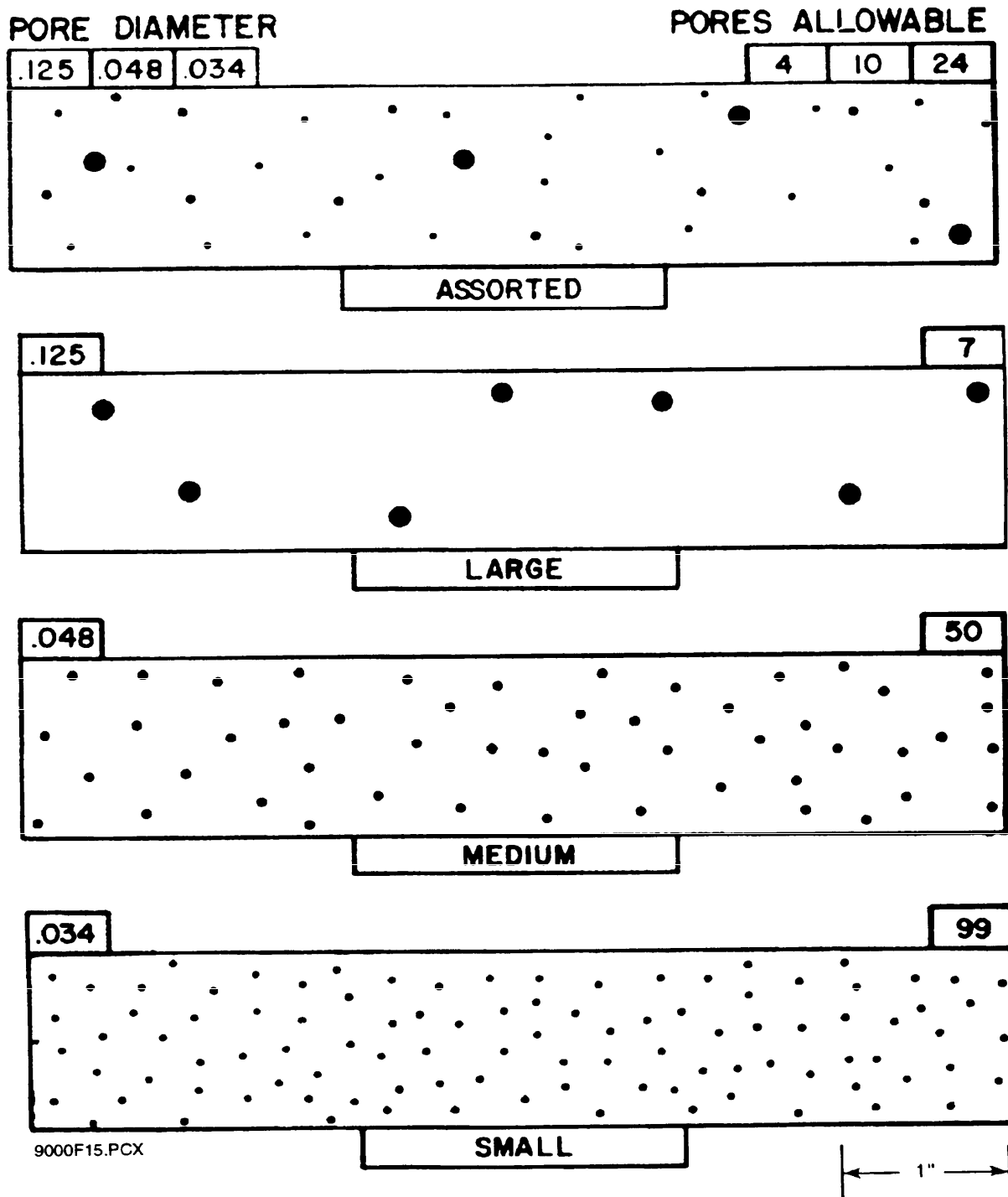


FIGURE 13. Radiographic porosity Class 1 and Class 2 (1 percent T/inch per 6 inches), T equals 1-1/2 inches (0.090 in<sup>2</sup> total porosity area).

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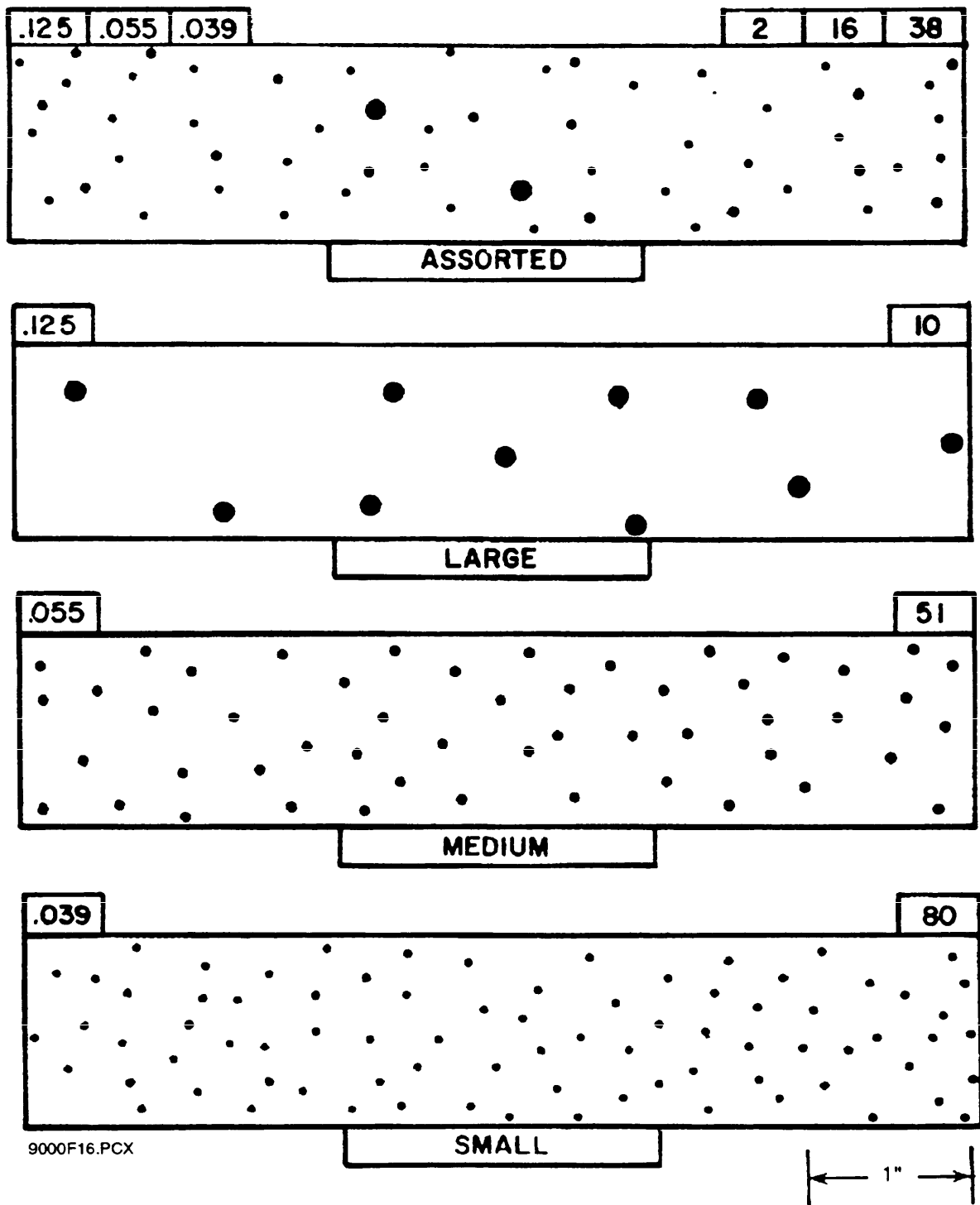


FIGURE 14. Radiographic porosity Class 1 and Class 2 (1 percent T/inch per 6 inches), T equals 2 inches ( $0.120 \text{ in}^2$  total porosity area).

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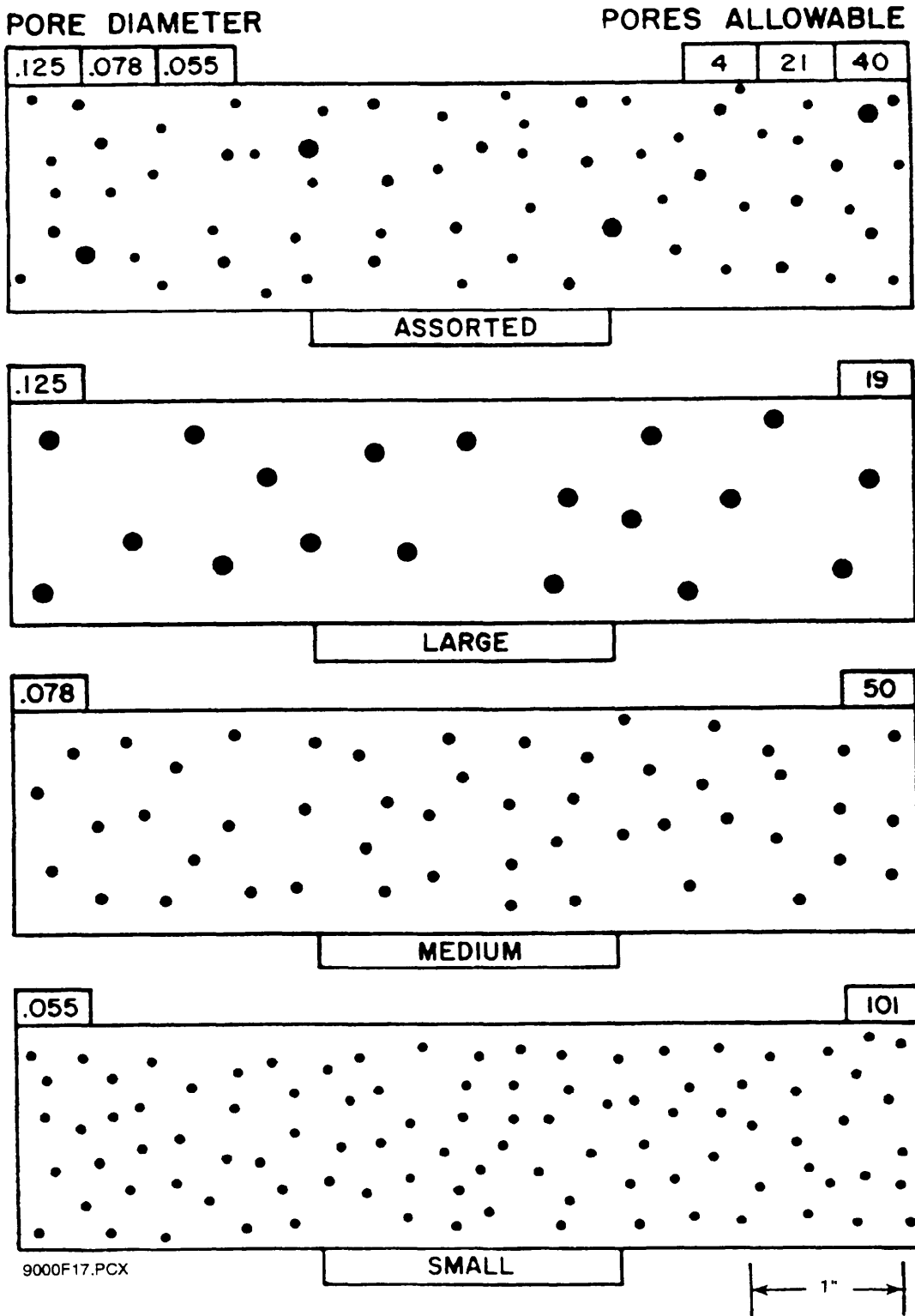


FIGURE 15. Radiographic porosity Class 1 and Class 2 (1 percent T/inch per 6 inches), T equals 4 inches and over ( $0.240 \text{ in}^2$  total porosity area).

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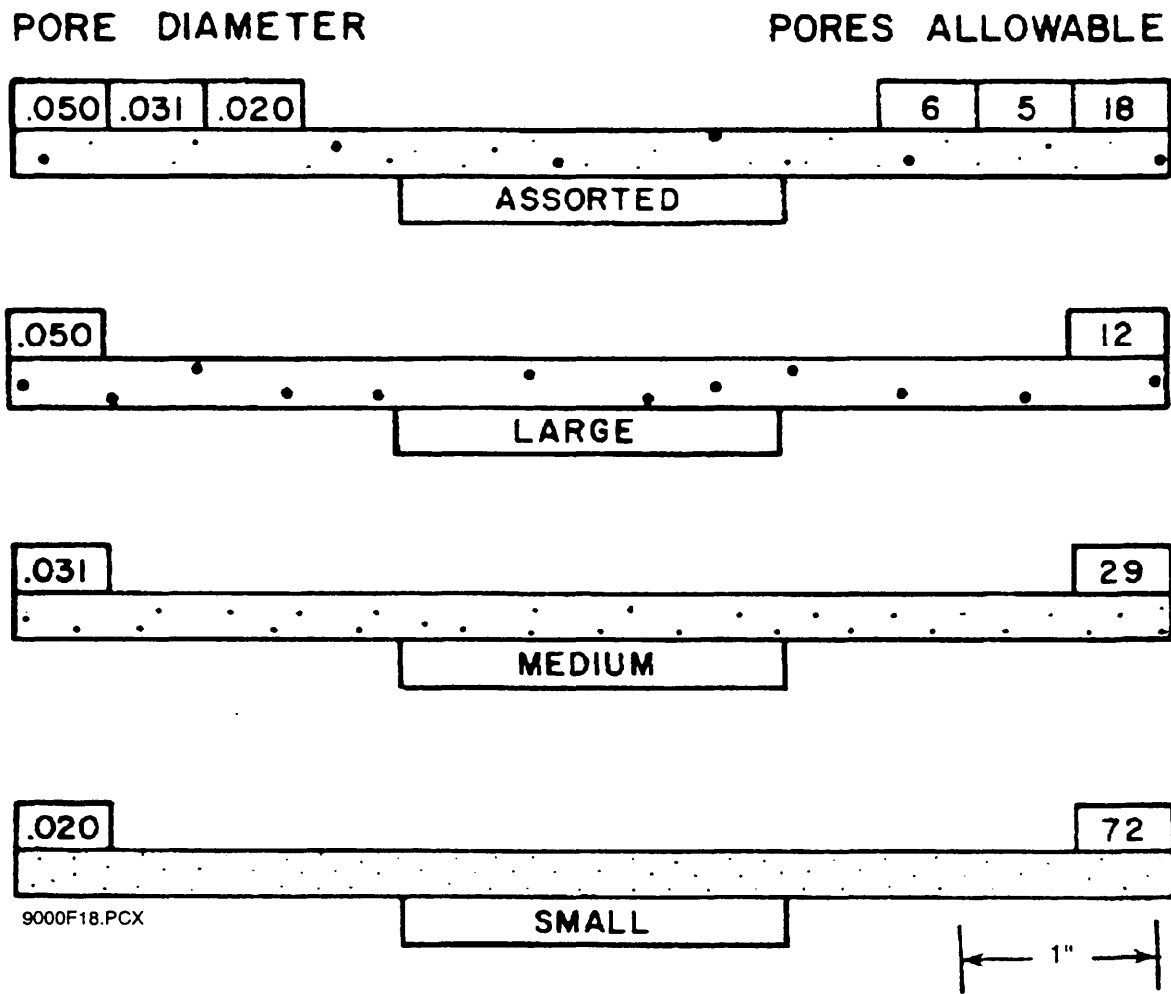
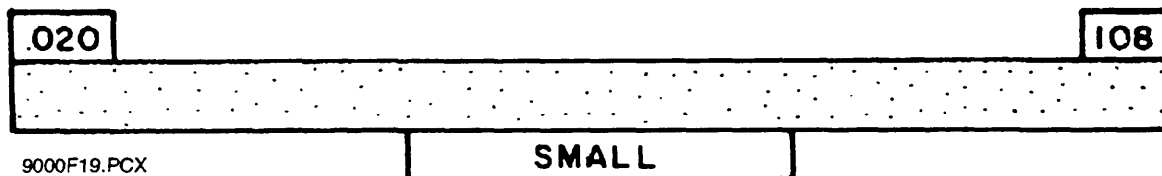
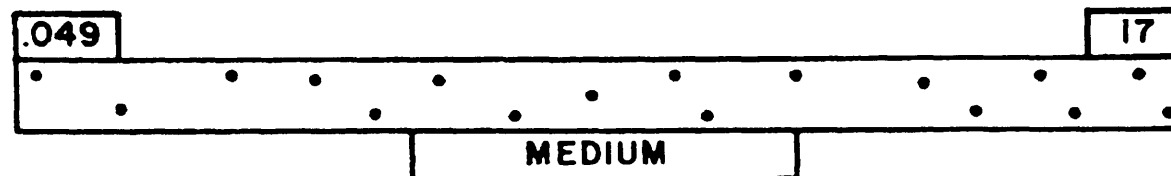
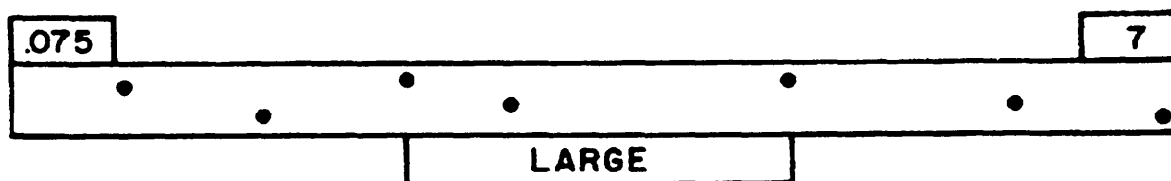
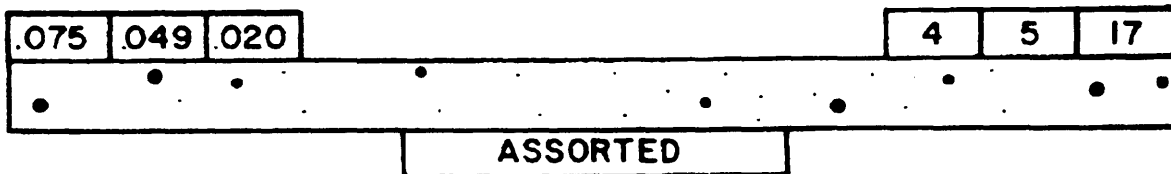


FIGURE 16. Radiographic porosity Class 3 (1.5 percent T/inch per 6 inches), T equals 1/4 inch (0.0225 in<sup>2</sup> total porosity area).

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PORE DIAMETER

PORES ALLOWABLE



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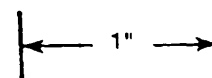
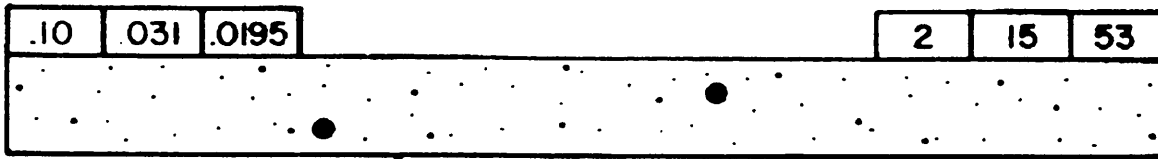


FIGURE 17. Radiographic porosity Class 3 (1.5 percent  $T/inch$  per 6 inches),  $T$  equals  $3/8$  inch ( $0.0337 in^2$  total porosity area).

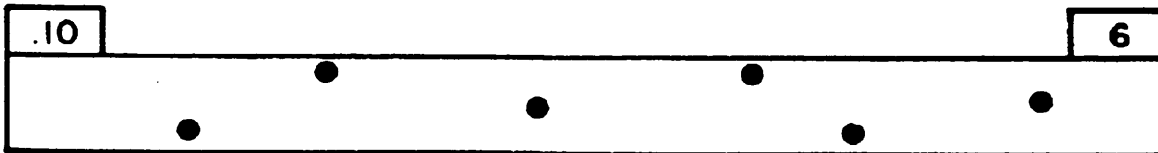
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PORE DIAMETER

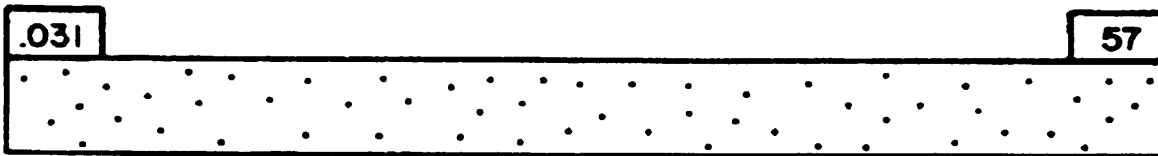
PORES ALLOWABLE



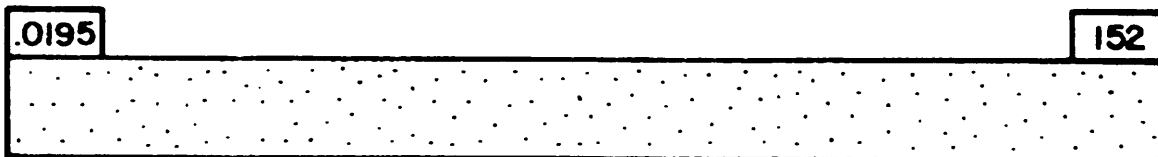
ASSORTED



LARGE



MEDIUM



SMALL

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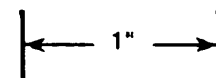
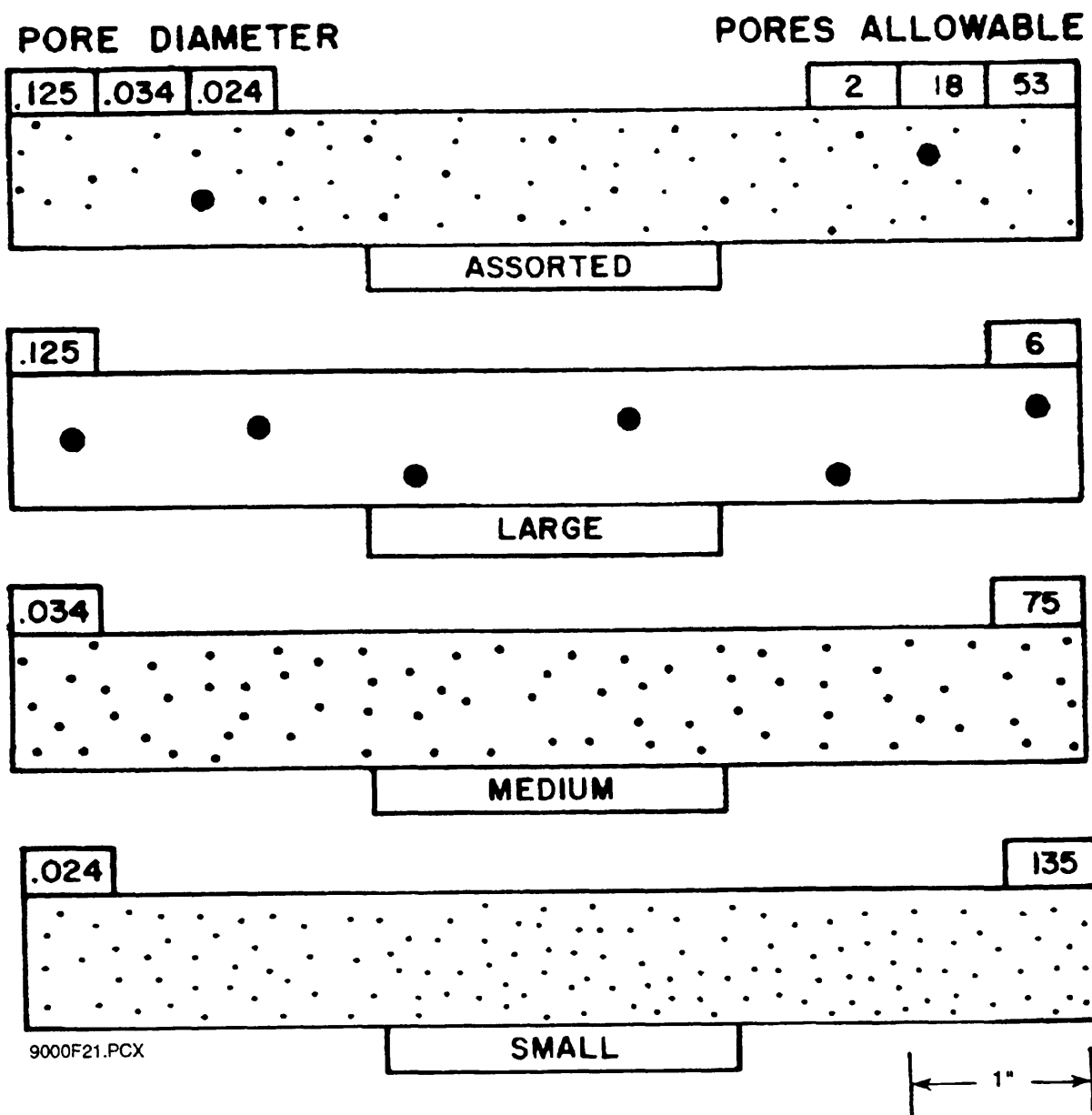


FIGURE 18. Radiographic porosity Class 3 (1.5 percent  $T$ /inch per 6 inches),  $T$  equals 1/2 inch ( $0.045 \text{ in}^2$  total porosity area).

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**FIGURE 19.** Radiographic porosity Class 3 (1.5 percent T/inch per 6 inches), T equals 3/4 inch (0.0675 in<sup>2</sup> total porosity area).

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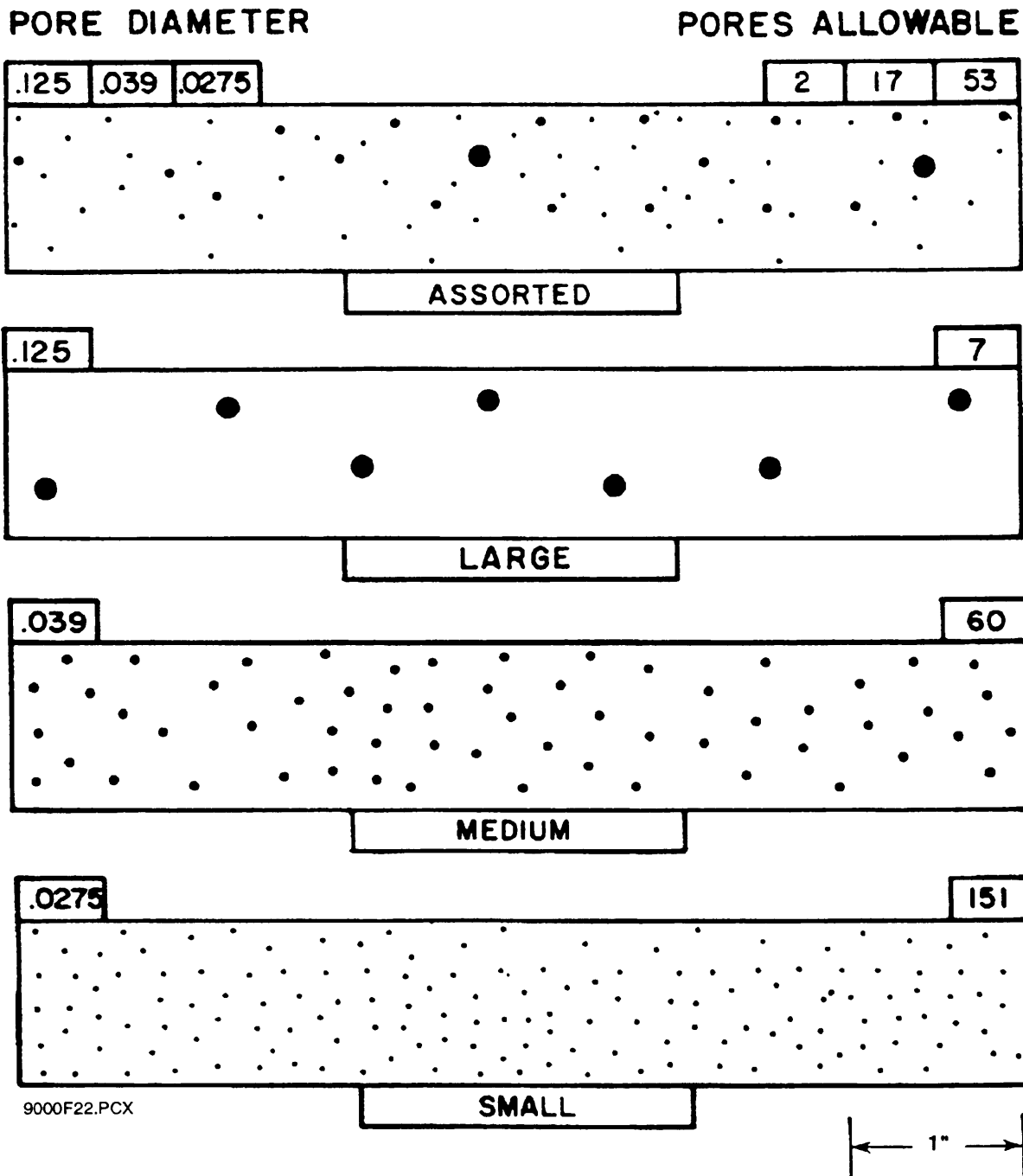


FIGURE 20. Radiographic porosity Class 3 (1.5 percent T/inch per 6 inches), T equals 1 inch (0.090 in<sup>2</sup> total porosity area).

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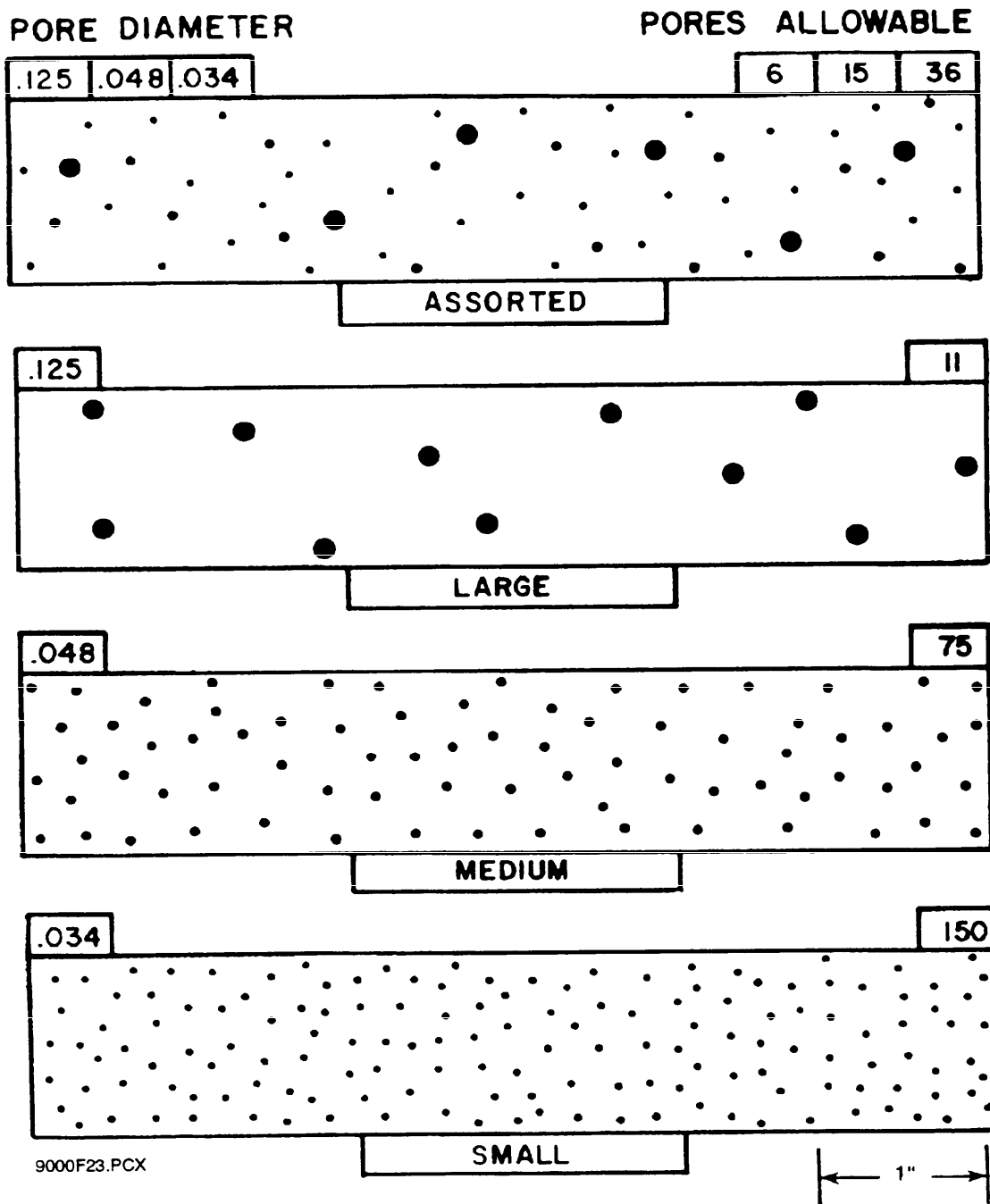


FIGURE 21. Radiographic porosity Class 3 (1.5 percent  $T$ /inch per 6 inches),  $T$  equals 1-1/2 inches ( $0.135 \text{ in}^2$  total porosity area).

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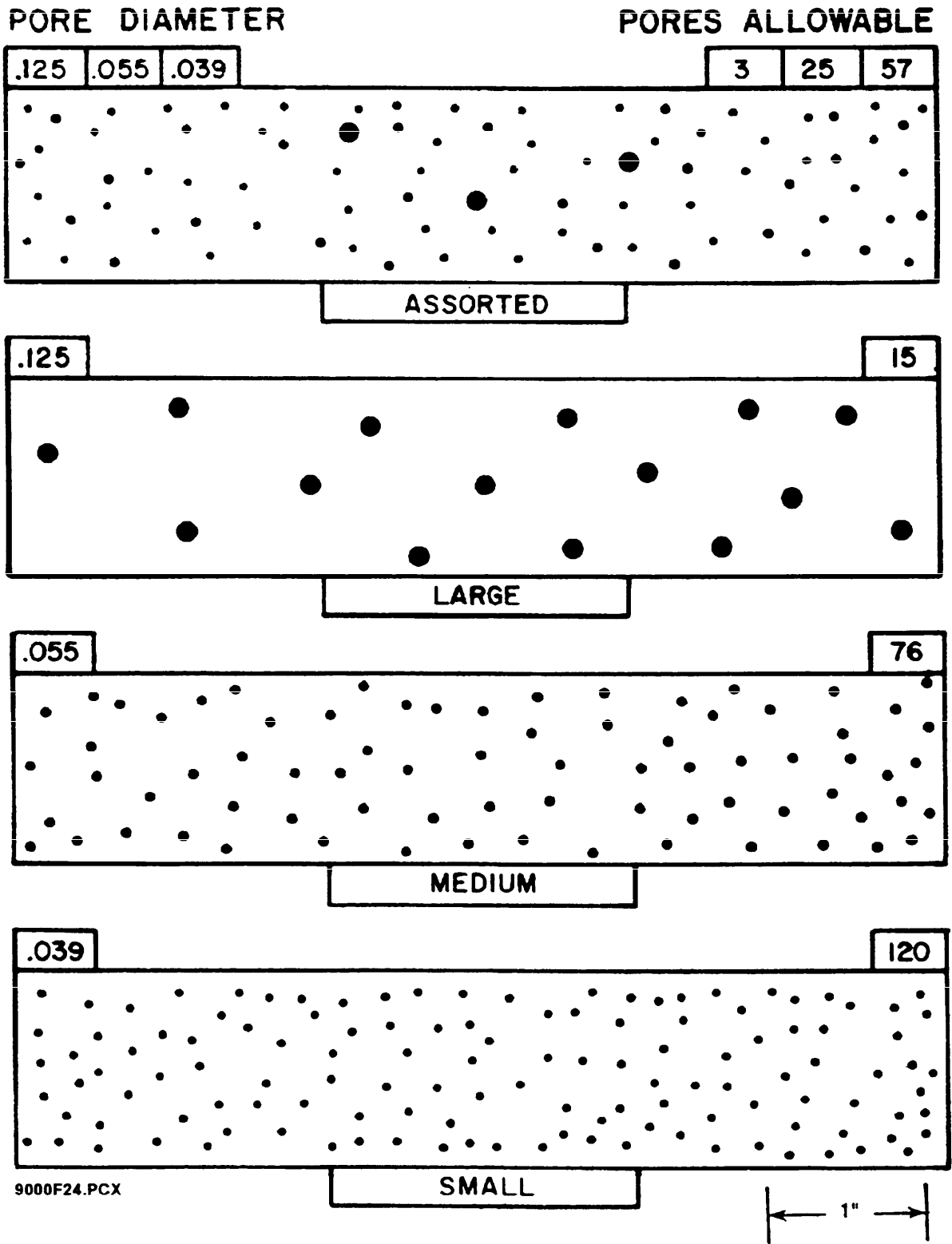


FIGURE 22. Radiographic porosity Class 3 (1.5 percent  $T$ /inch per 6 inches),  $T$  equals 2 inches ( $0.180 \text{ in}^2$  total porosity area).

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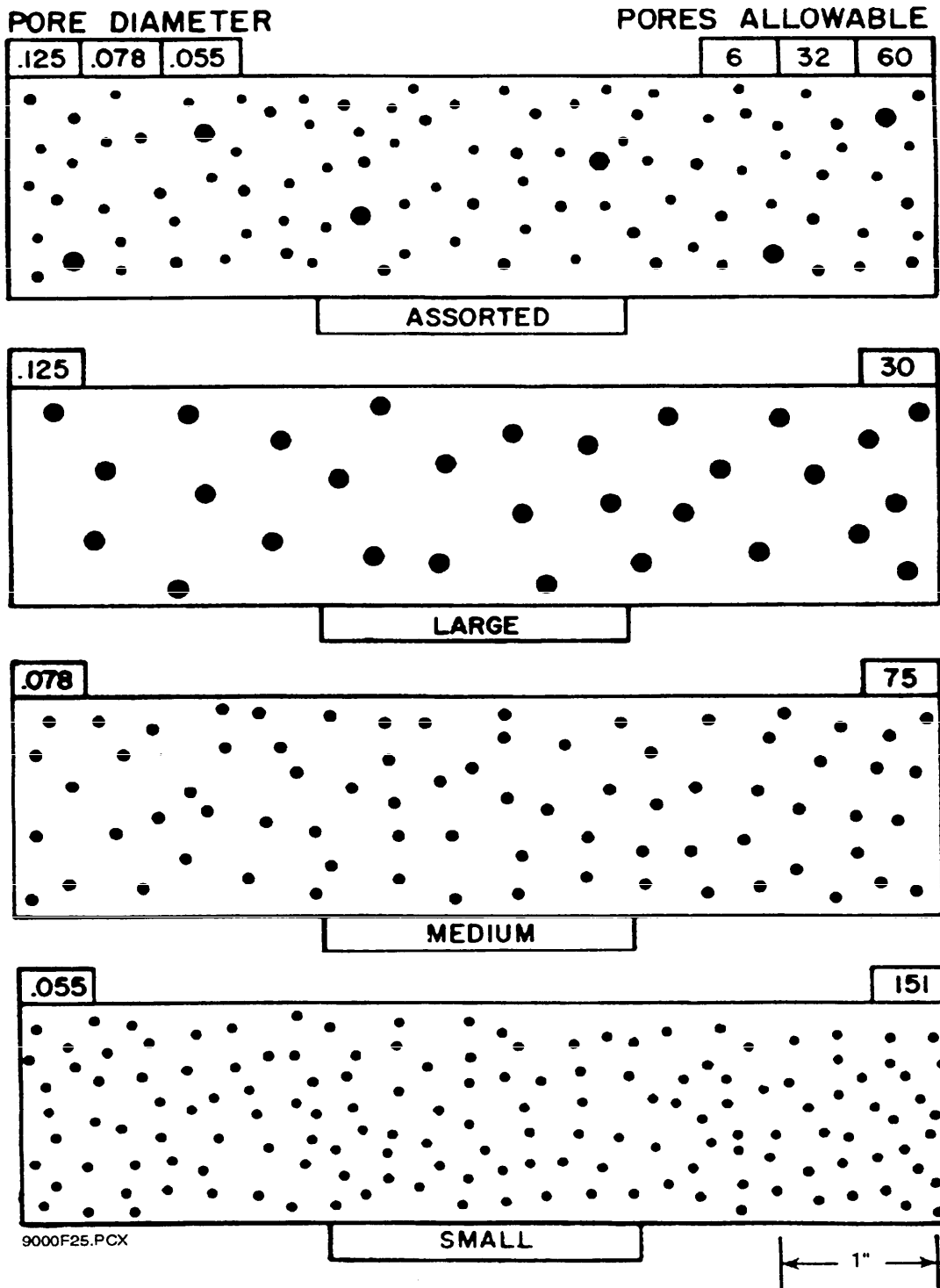


FIGURE 23. Radiographic porosity Class 3 (1.5 percent T/inch per 6 inches), T equals 4 inches and over (0.360 in<sup>2</sup> total porosity area).

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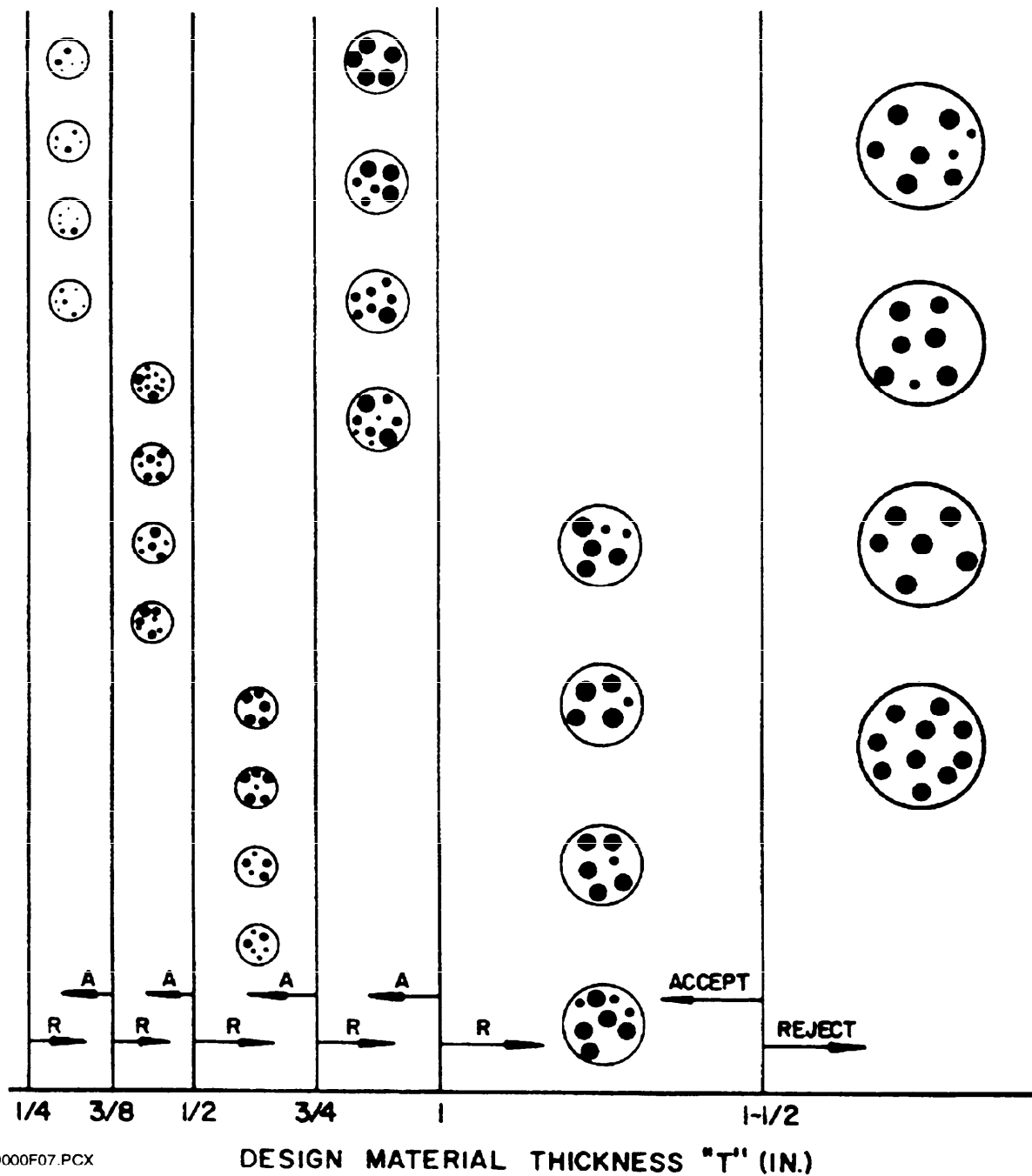


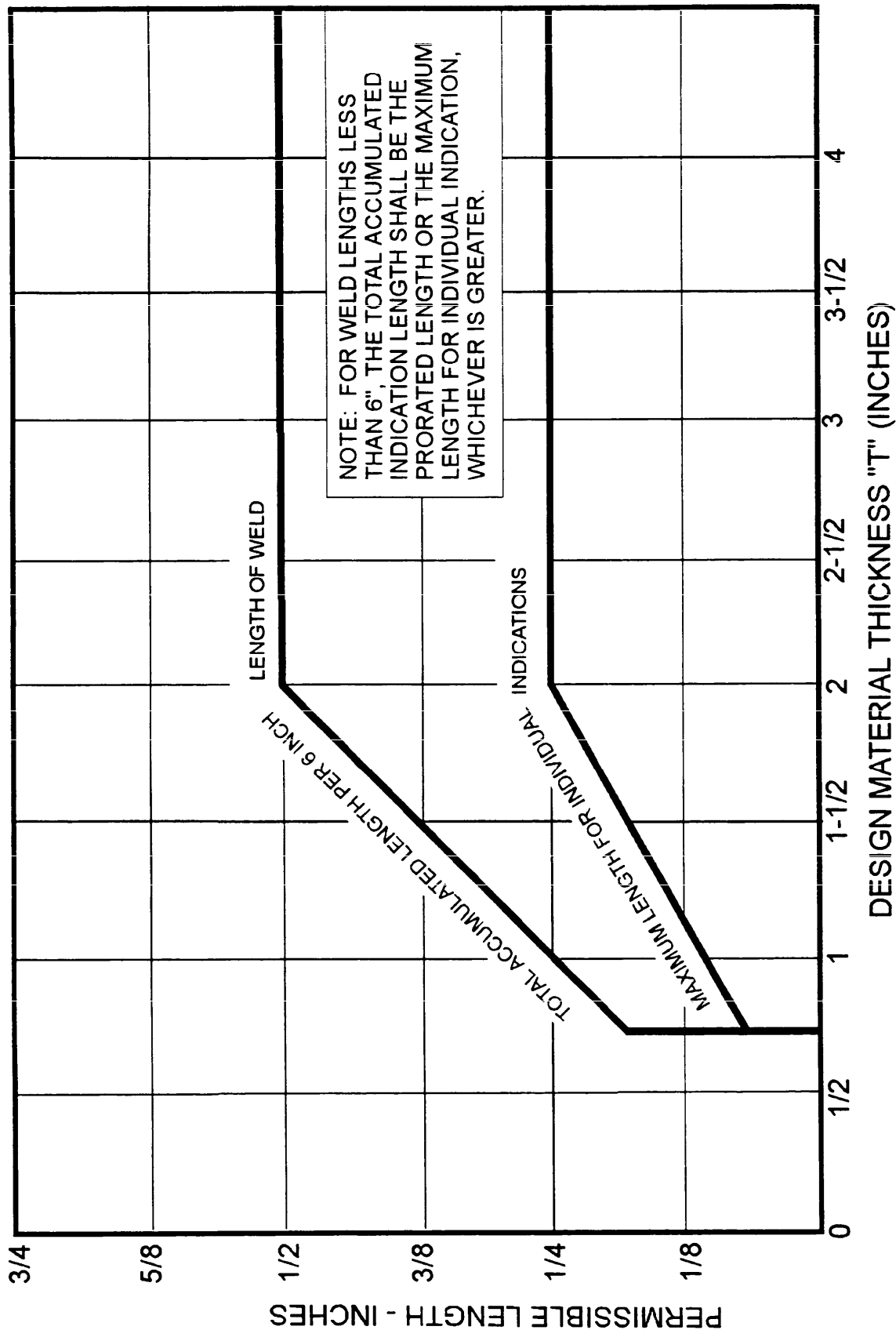
FIGURE 24. Radiographic examples of clustered porosity.

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Diameter (inches)	Area (Square inches)	Diameter (inches)	Area (Square inches)
1/32	.0008	.0195	.0003
3/64	.0017	.020	.0003
1/16	.0031	.024	.0005
5/64	.0048	.025	.0005
3/32	.0069	.0275	.0006
7/64	.0094	.031	.0008
1/8	.0123	.034	.0009
9/64	.0155	.037	.0011
5/32	.0192	.039	.0012
11/64	.0232	.048	.0018
3/16	.0276	.049	.0019
13/64	.0324	.050	.0020
7/32	.0376	.055	.0024
15/64	.0431	.075	.0044
1/4	.0491	.078	.0048
---	---	.100	.0079

FIGURE 25. Area of circles.

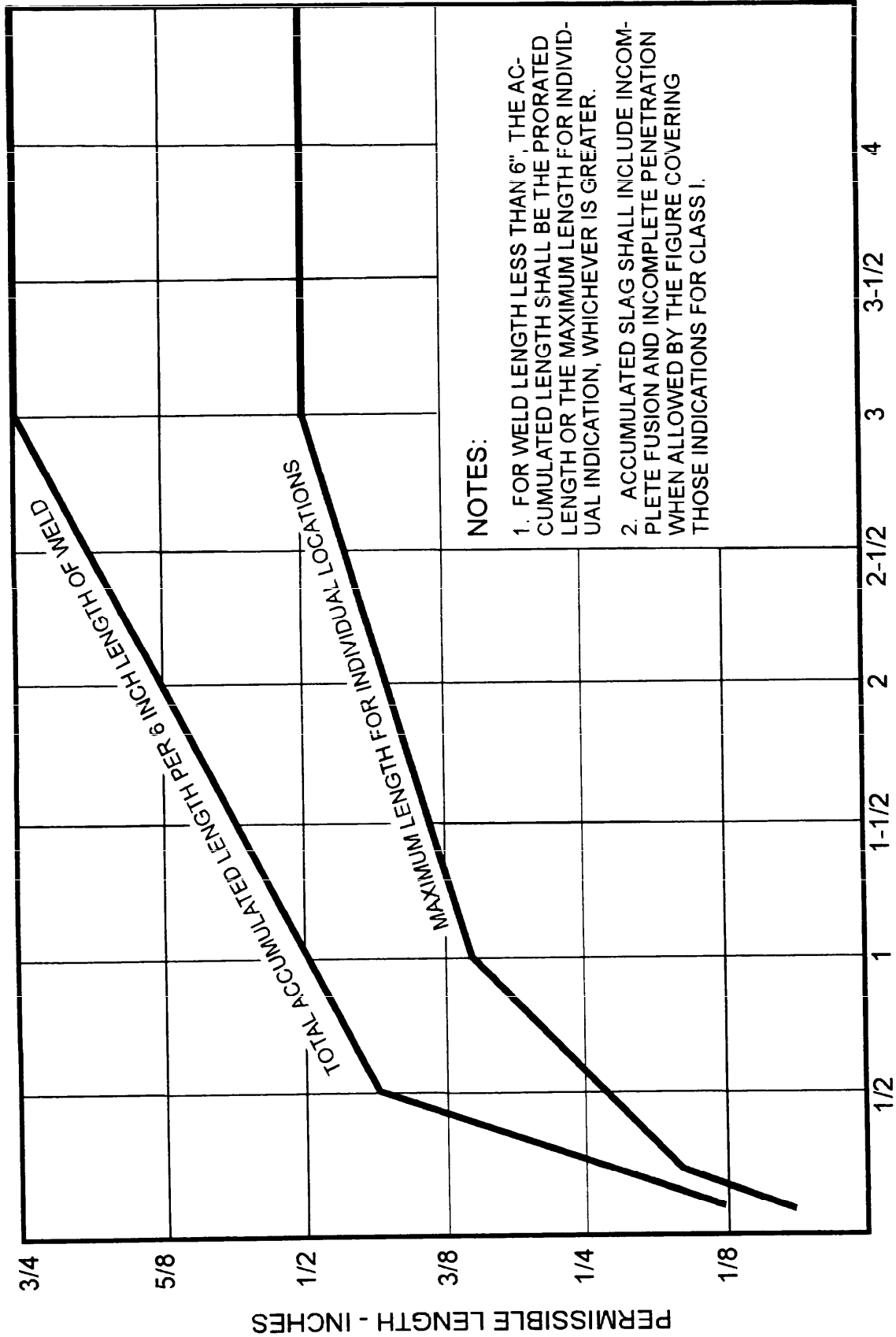
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FIGURE 26. Radiographic Class 1 production weld acceptance standard for incomplete fusion and incomplete penetration indications.

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DESIGN MATERIAL THICKNESS "T" (INCHES)

FIGURE 27. Radiographic Class 1 production weld acceptance standard for slag indications.

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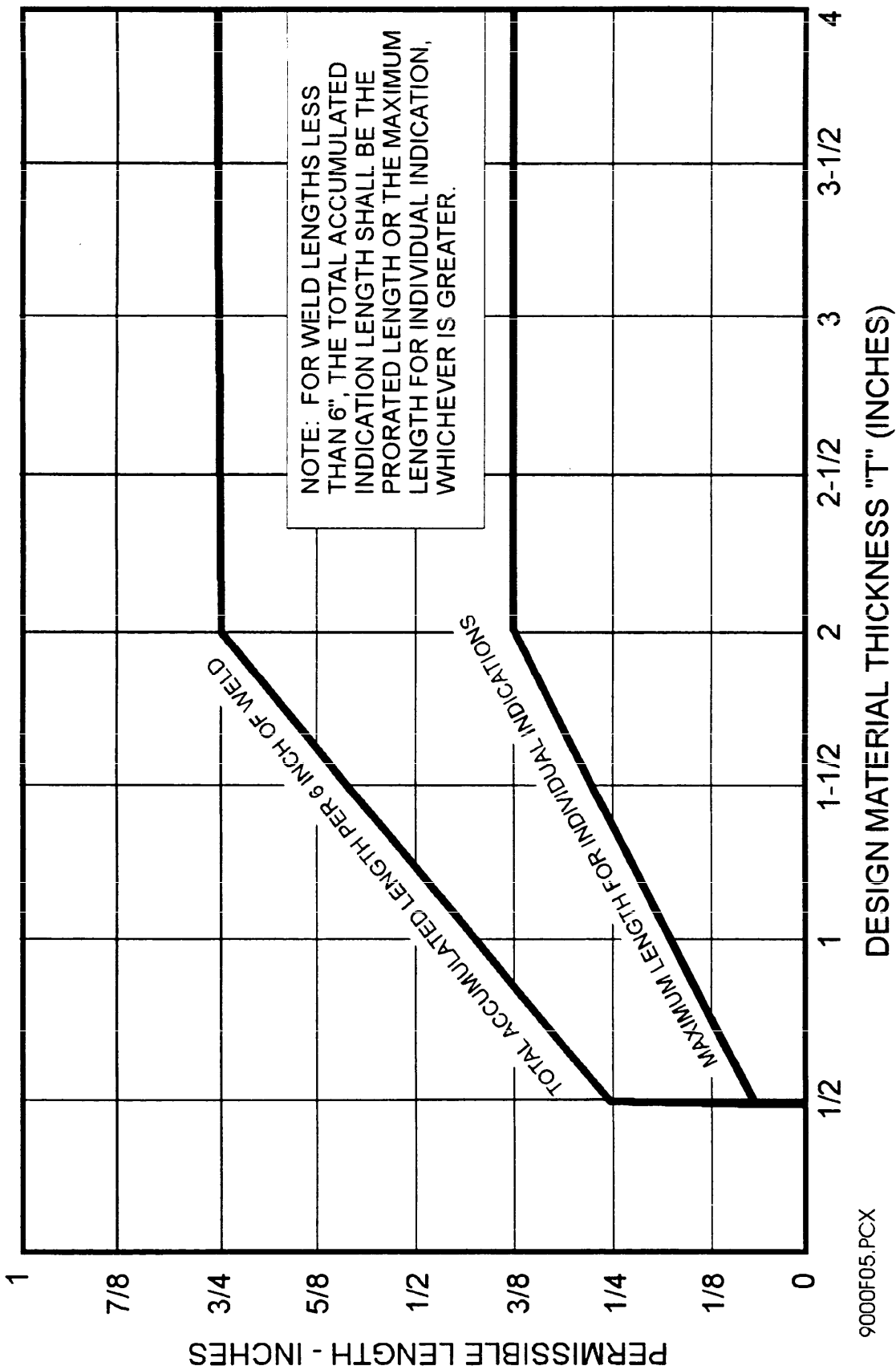
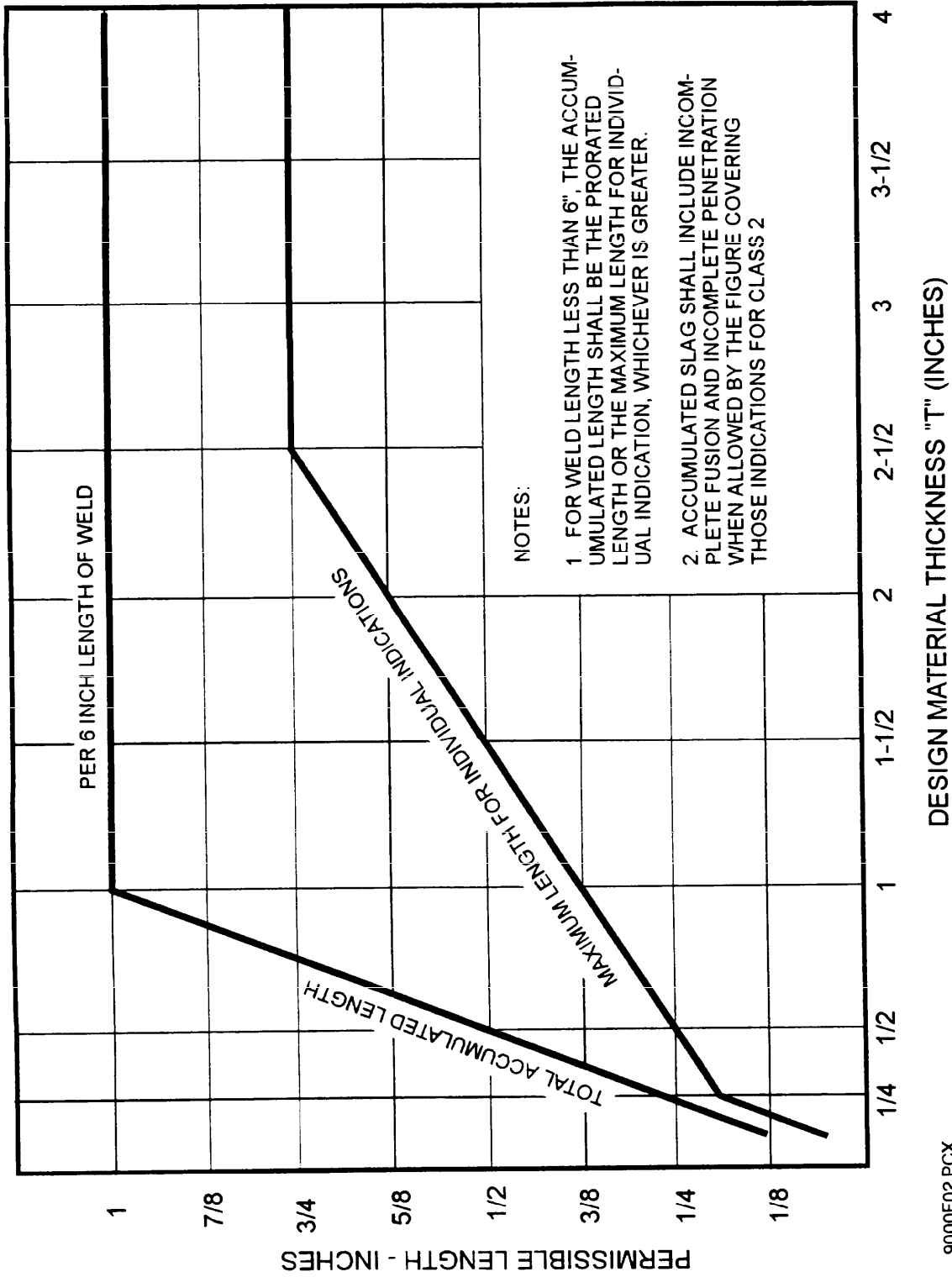


FIGURE 28. Radiographic Class 2 and 3 production weld acceptance standard for incomplete fusion and incomplete penetration indications.

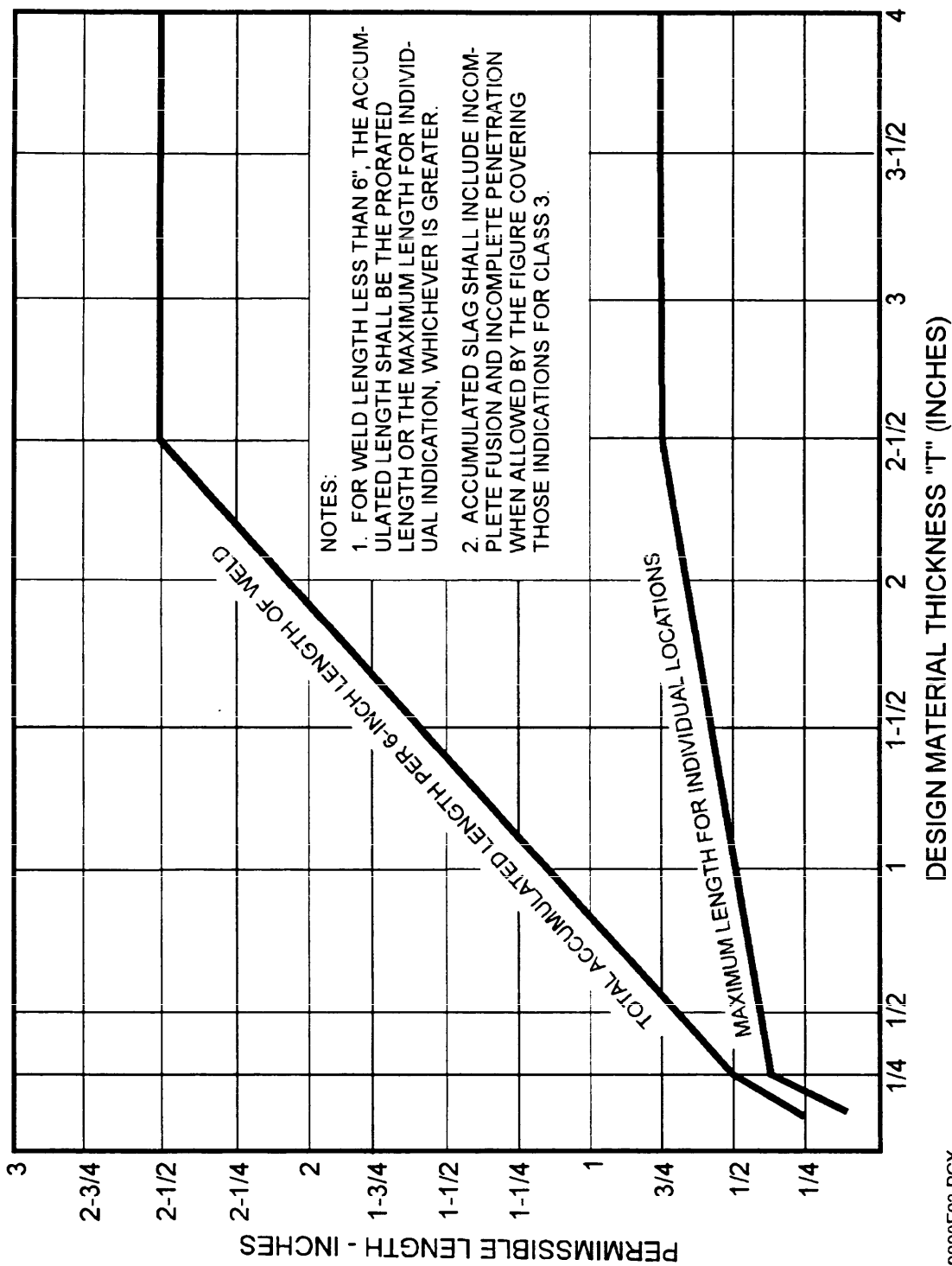
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9000F02.PCX

FIGURE 29. Radiographic Class 2 production weld acceptance standard for slag indications.

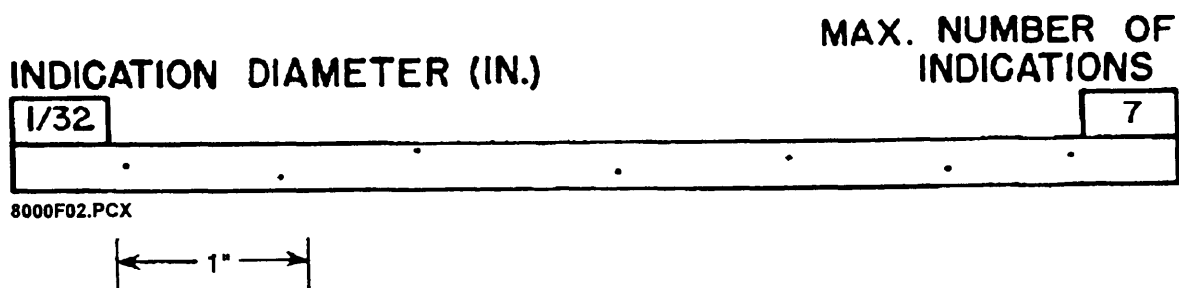
MIL-STD-2035A(SH)



9000F03.PCX

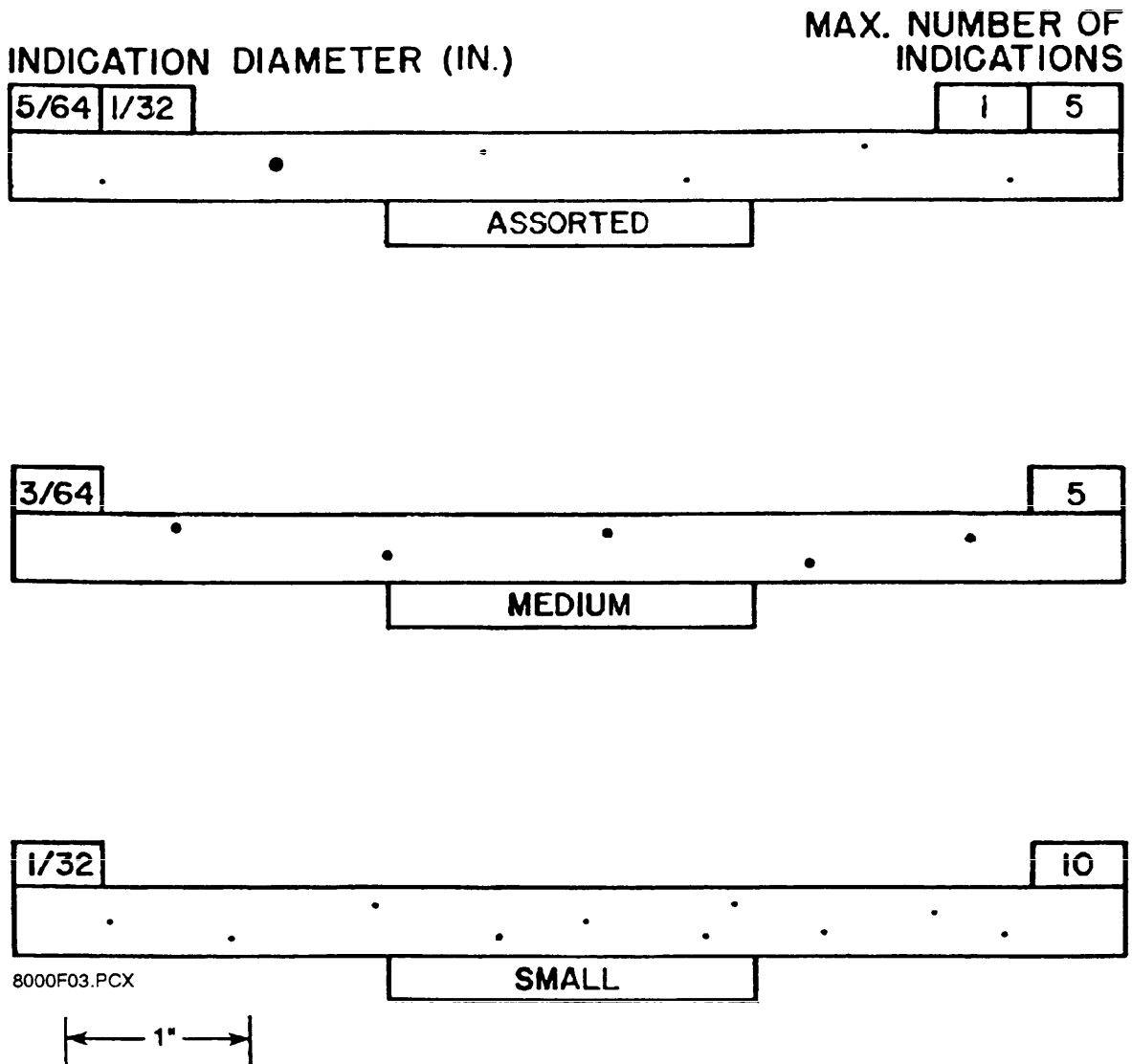
**FIGURE 30. Radiographic Class 3 production weld acceptance standard for slag indications.**

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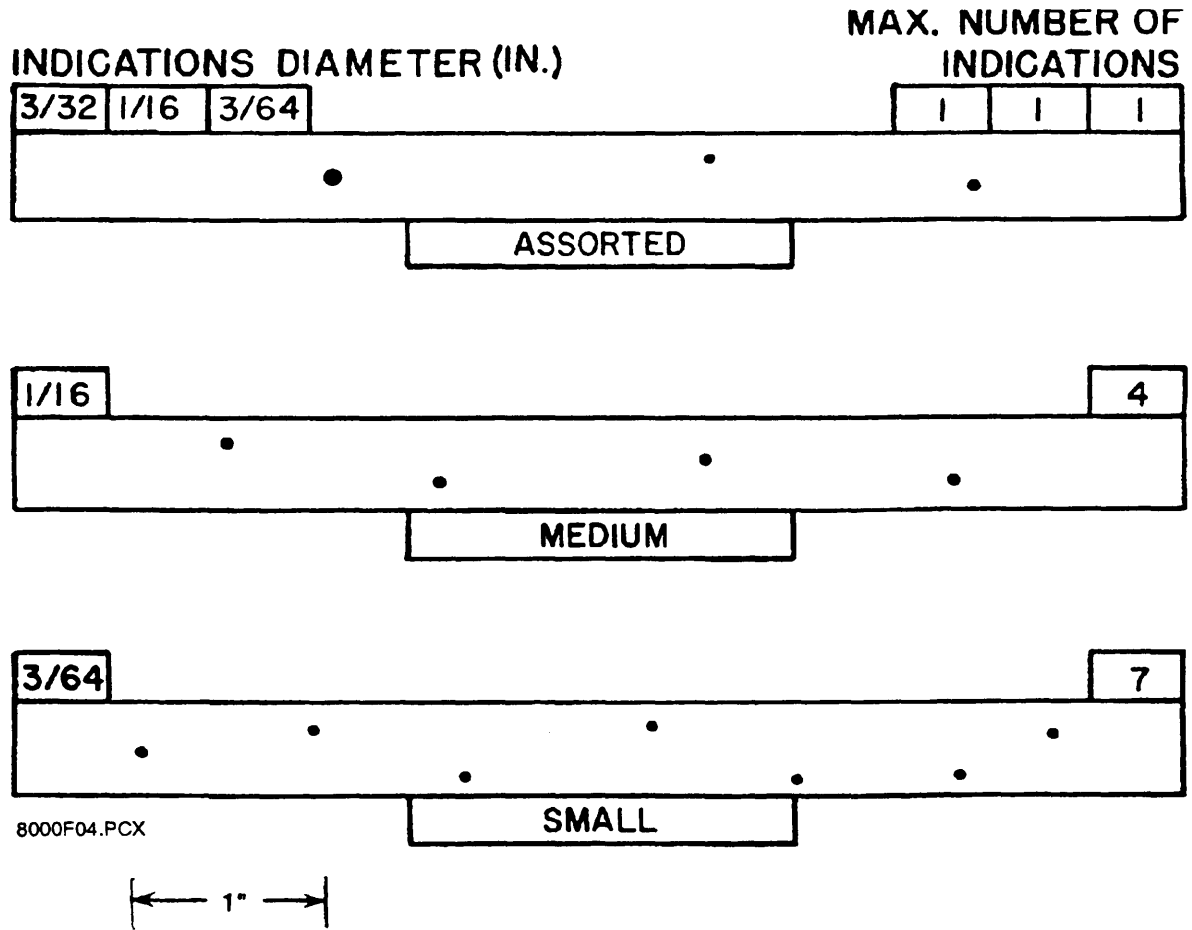
**FIGURE 31.** *Magnetic particle and liquid penetrant Class 1 weld (total indication area equals 0.375 percent of weld surface area) for material thickness equals 1/8 inch and less.*

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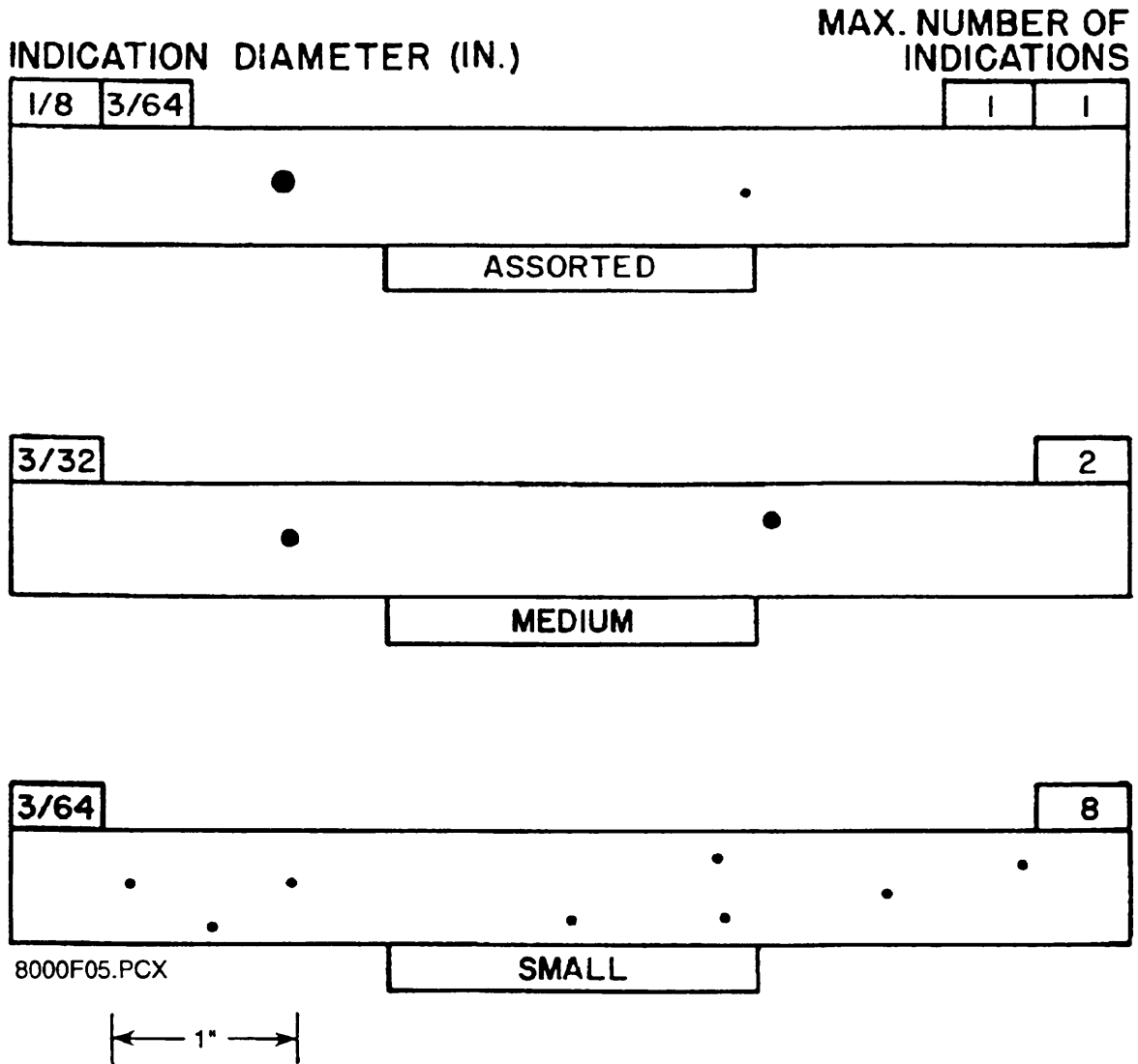
**FIGURE 32.** *Magnetic particle and liquid penetrant Class 1 weld (total indication area equals 0.375 percent of weld surface area) for material thickness equals 3/16 inch.*

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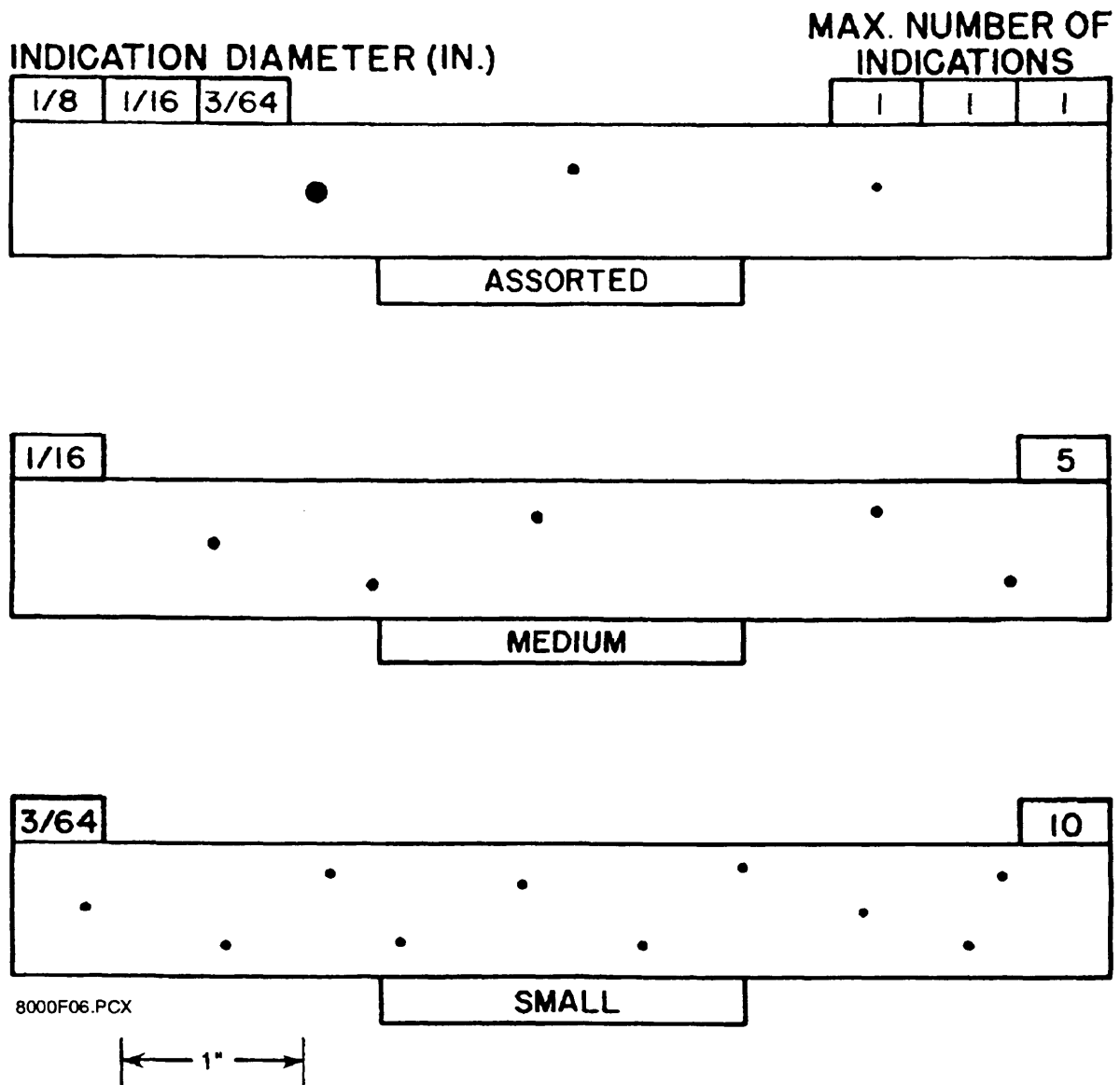
**FIGURE 33.** *Magnetic particle and liquid penetrant Class 1 weld (total indication area equals 0.375 percent of weld surface area) for material thickness equals 1/4 inch.*

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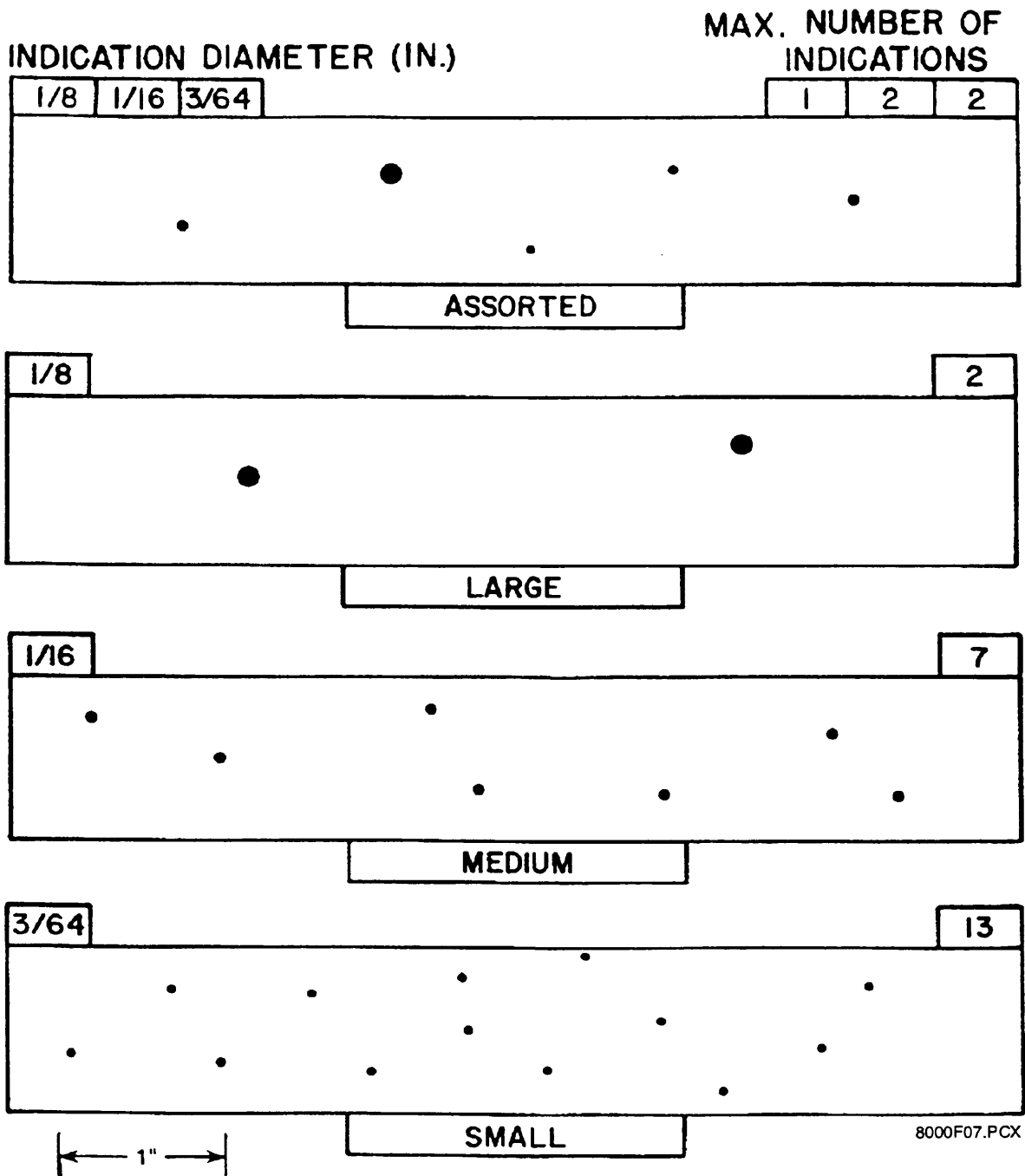
**FIGURE 34.** *Magnetic particle and liquid penetrant Class 1 weld (total indication area equals 0.375 percent of weld surface area) for material thickness equals 3/8 inch.*

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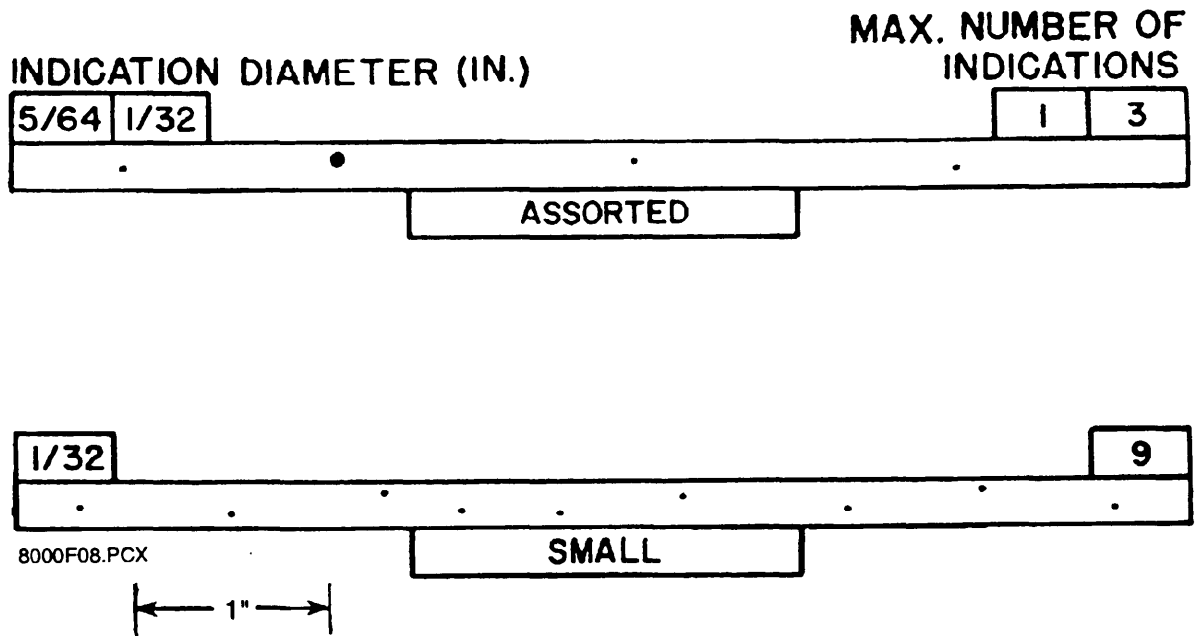
**FIGURE 35.** *Magnetic particle and liquid penetrant Class 1 weld (total indication area equals 0.375 percent of weld surface area) for material thickness equals 1/2 inch.*

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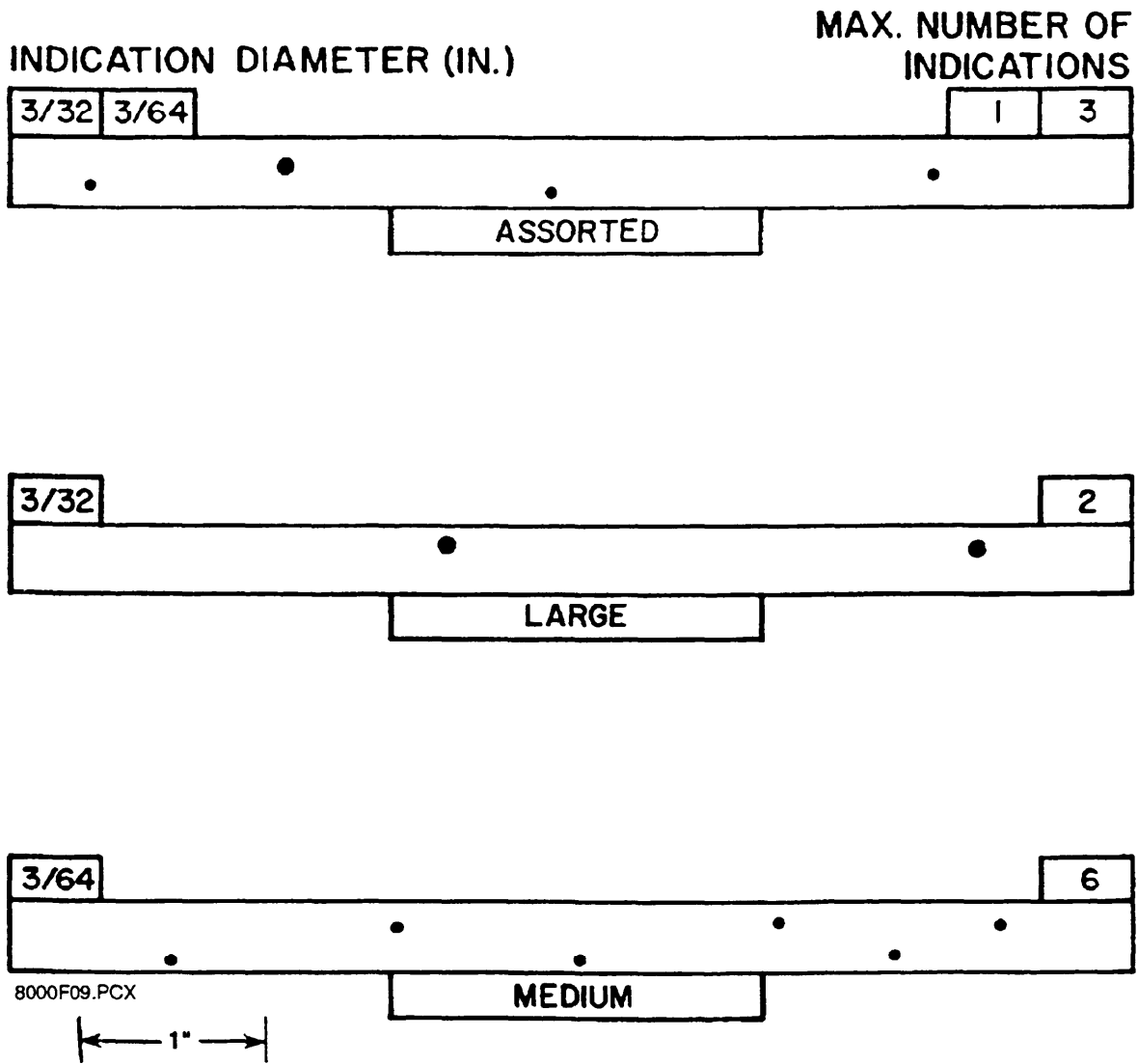
**FIGURE 36.** *Magnetic particle and liquid penetrant Class I weld (total indication area equals 0.375 percent of weld surface area) for material thickness equals 3/4 inch and over.*

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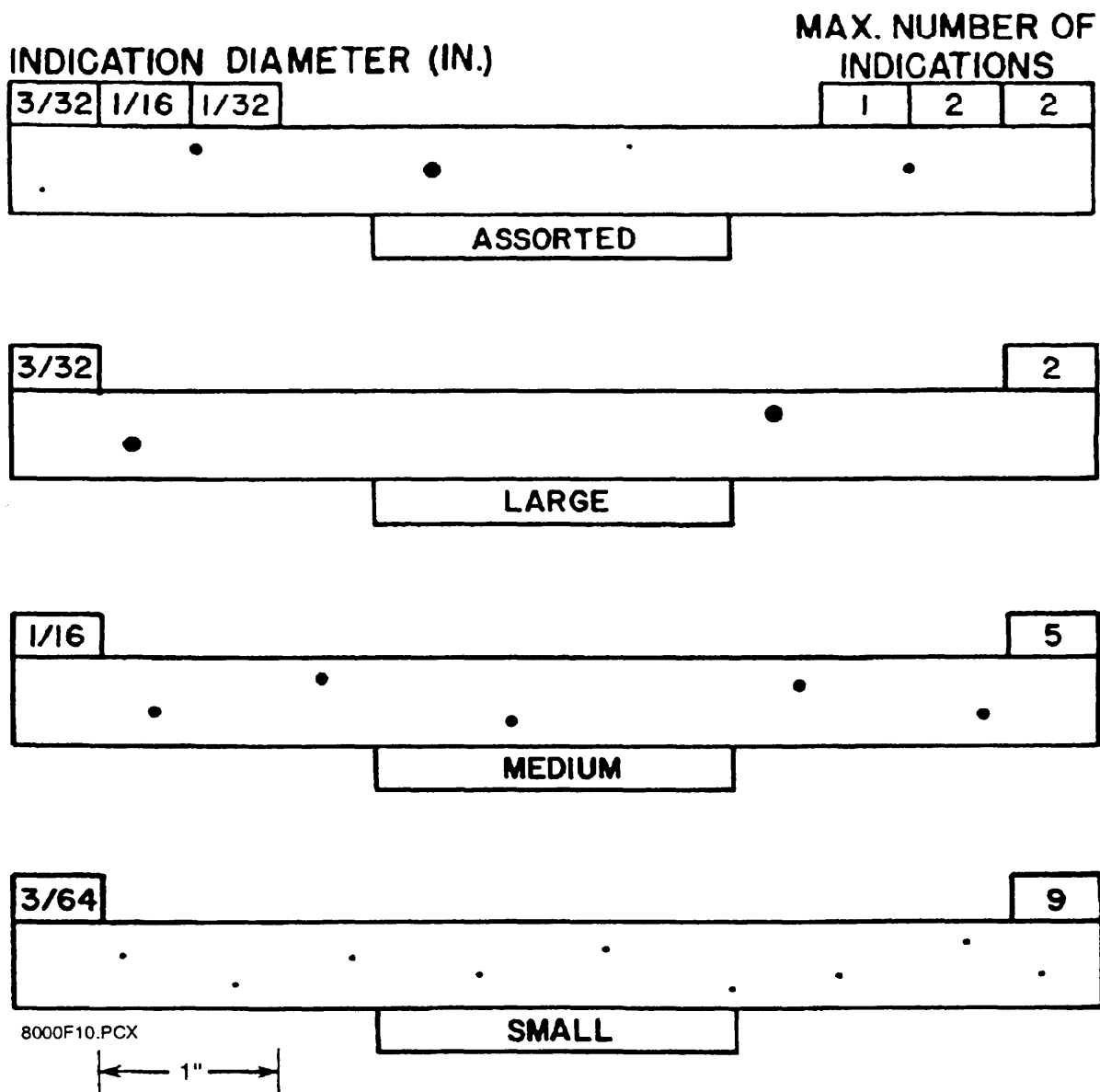
**FIGURE 37.** *Magnetic particle and liquid penetrant Class 2 weld (total indication area equals 0.50 percent of weld surface area) for material thickness equals 1/8 inch and less.*

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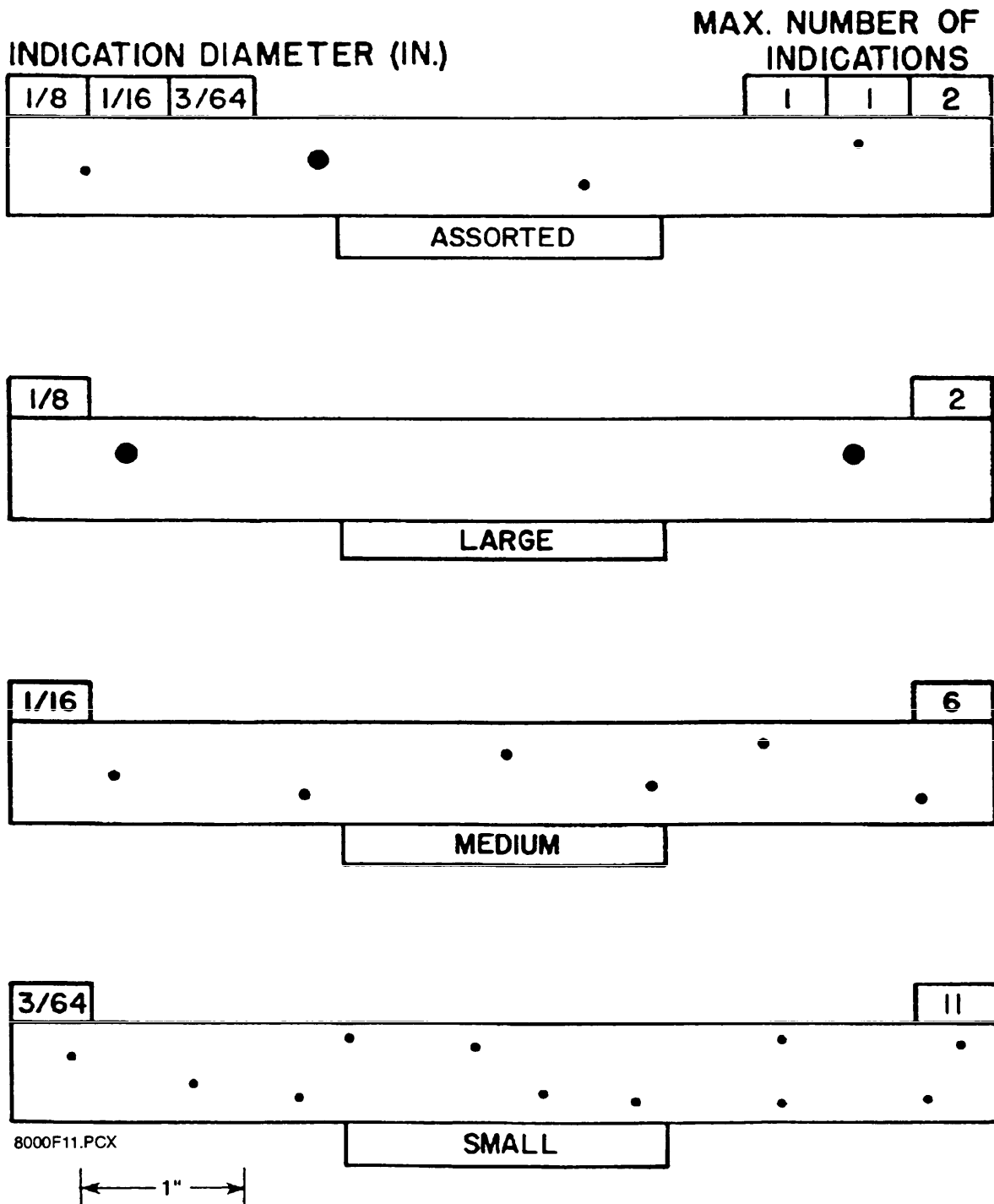
**FIGURE 38.** *Magnetic particle and liquid penetrant Class 2 weld (total indication area equals 0.50 percent of weld surface area) for material thickness equals 3/16 inch.*

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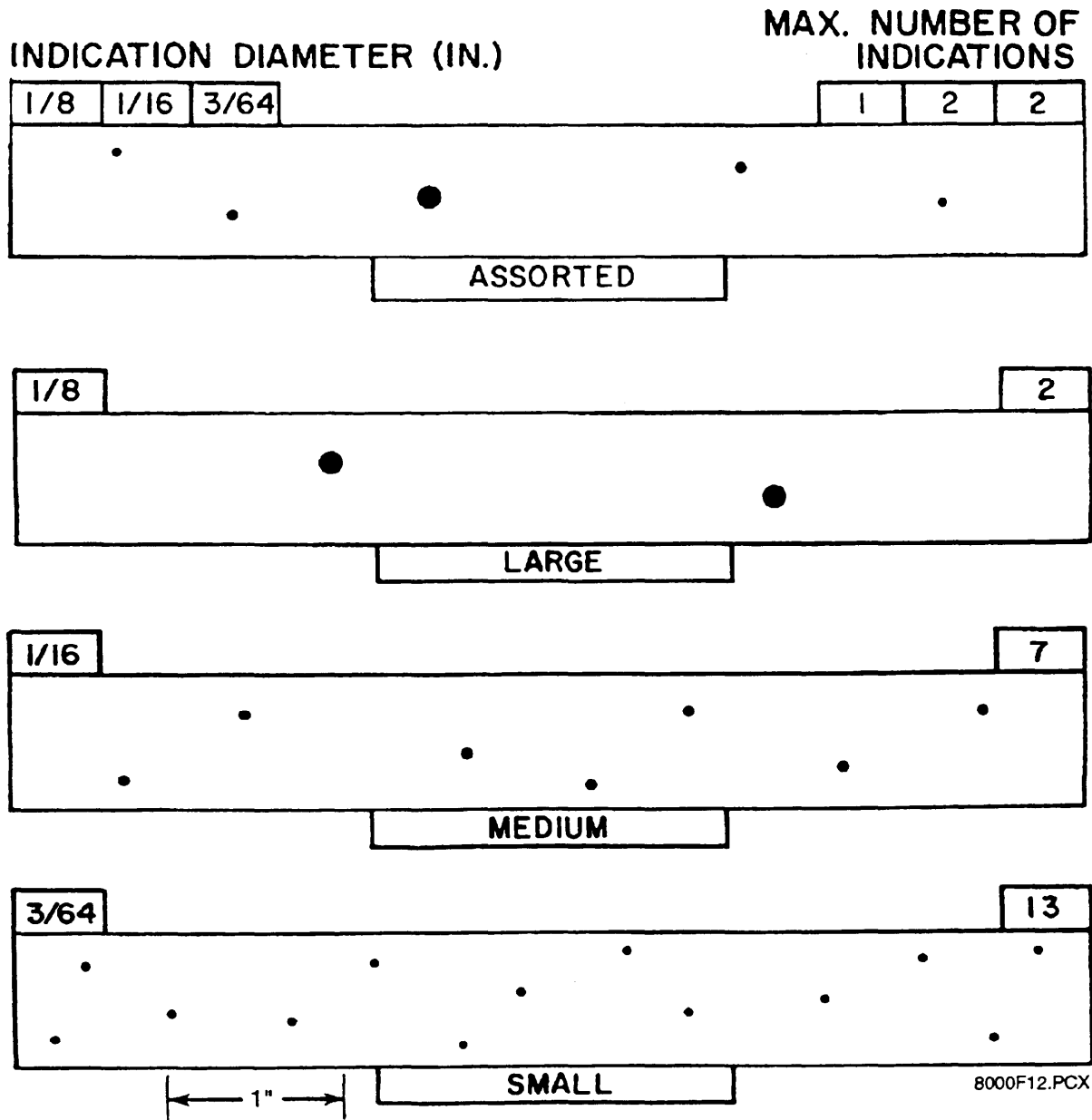
**FIGURE 39.** *Magnetic particle and liquid penetrant Class 2 weld (total indication area equals 0.50 percent of weld surface area) for material thickness equals 1/4 inch.*

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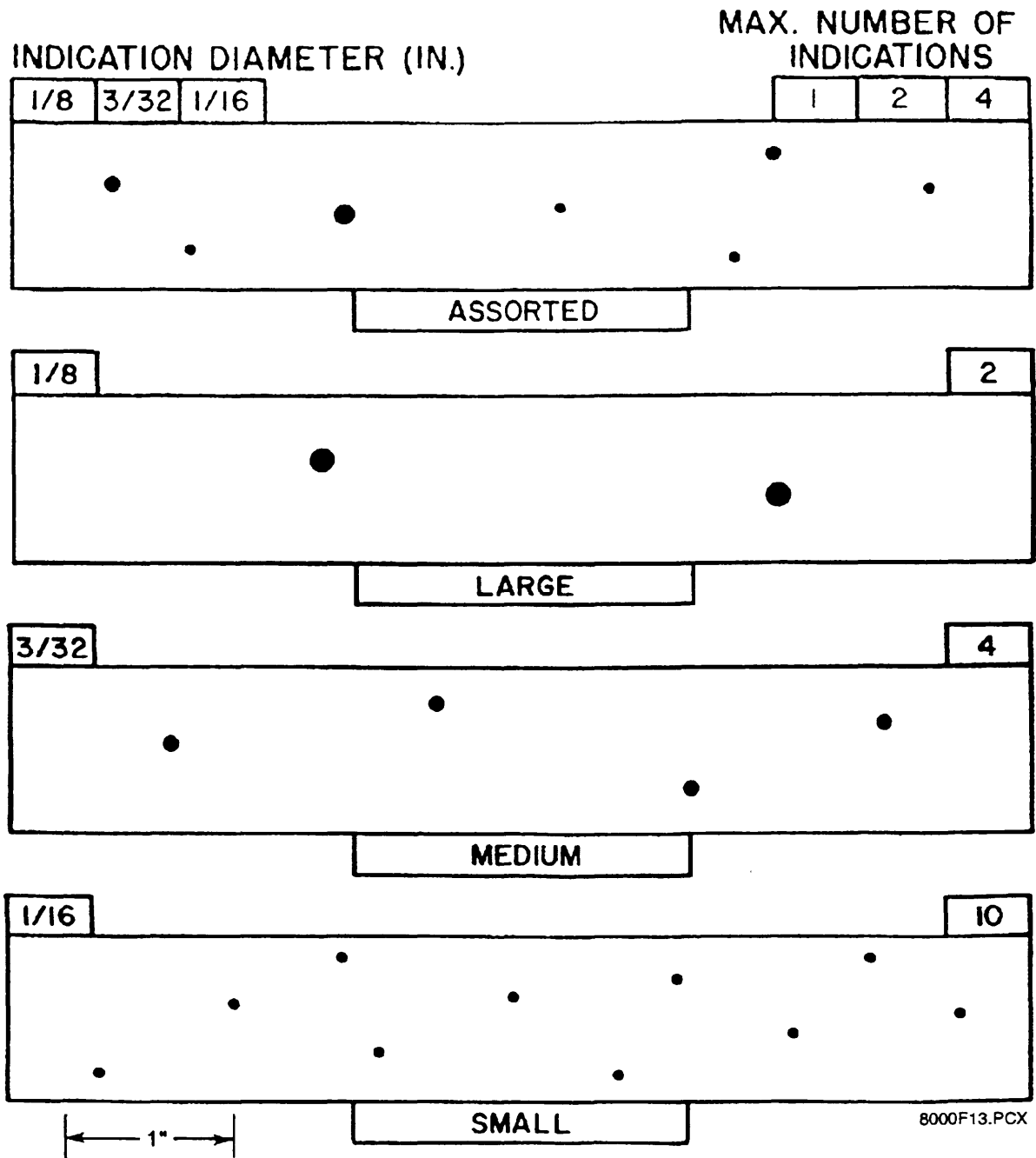
**FIGURE 40.** *Magnetic particle and liquid penetrant Class 2 weld (total indication area equals 0.50 percent of weld surface area) for material thickness equals 3/8 inch.*

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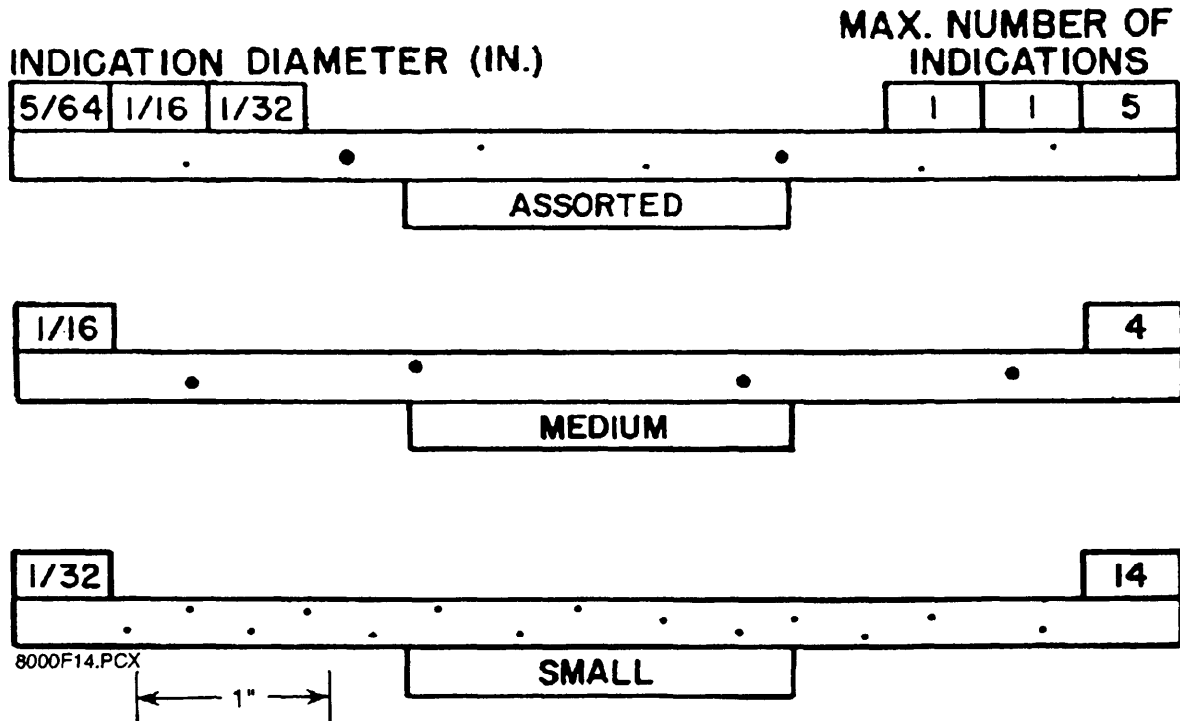
**FIGURE 41.** *Magnetic particle and liquid penetrant Class 2 weld (total indication area equals 0.50 percent of weld surface area) for material thickness equals 1/2 inch.*

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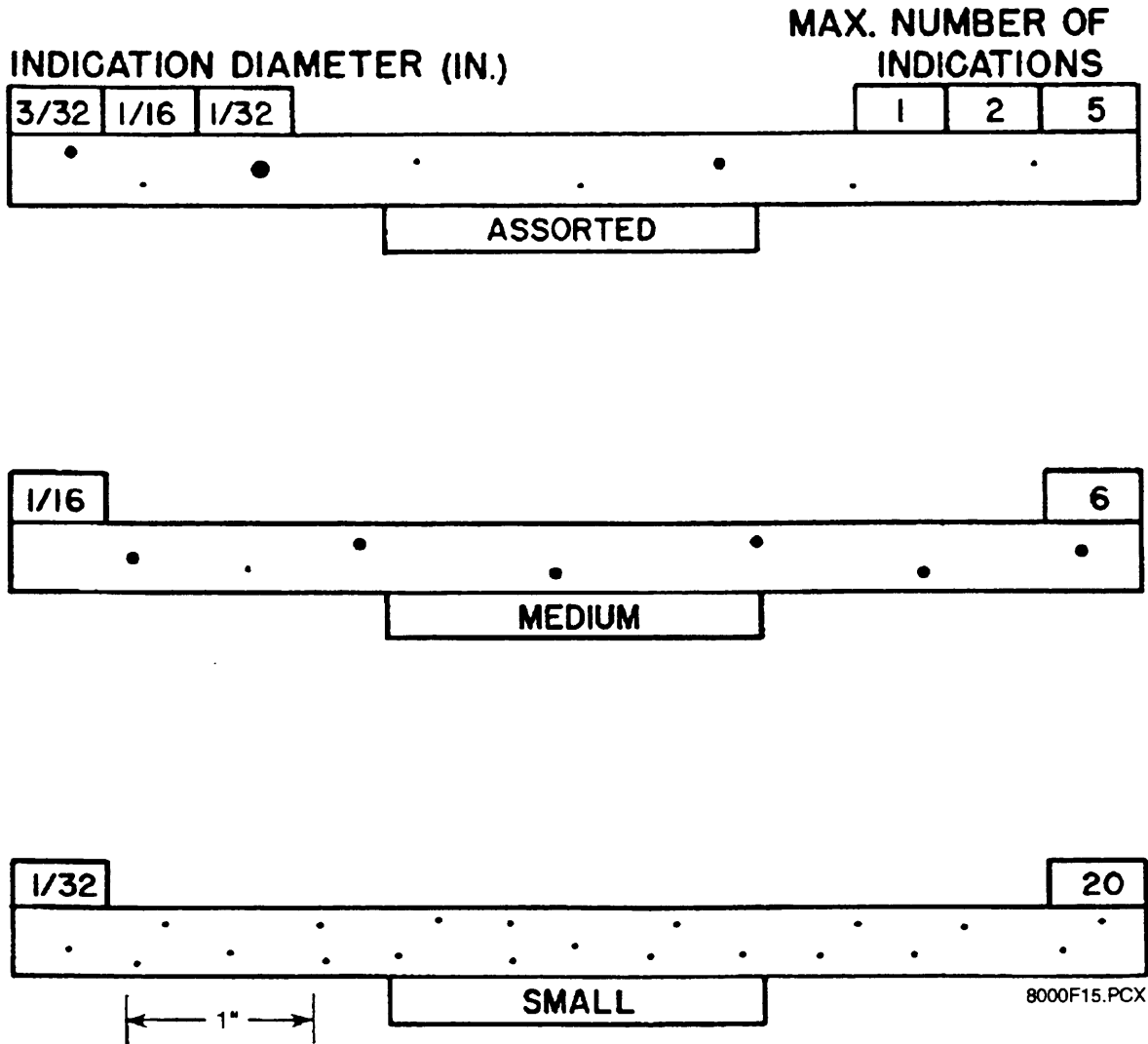
**FIGURE 42.** *Magnetic particle and liquid penetrant Class 2 weld (total indication area equals 0.50 percent of weld surface area) for material thickness equals 3/4 inch and over.*

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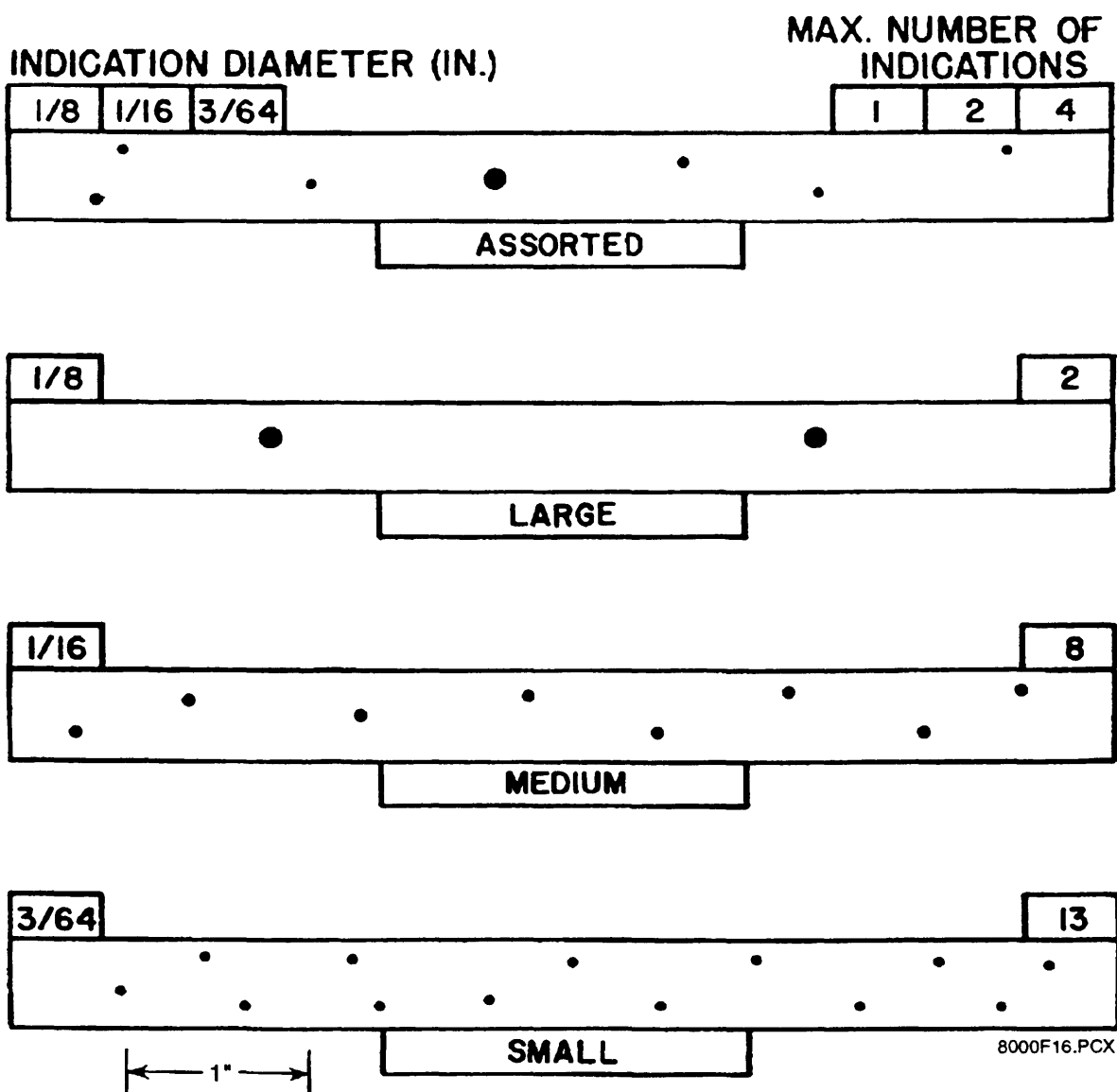
**FIGURE 43.** *Magnetic particle and liquid penetrant Class 3 weld (total indication area equals 0.75 percent of weld surface area) for material thickness equals 1/8 inch and less.*

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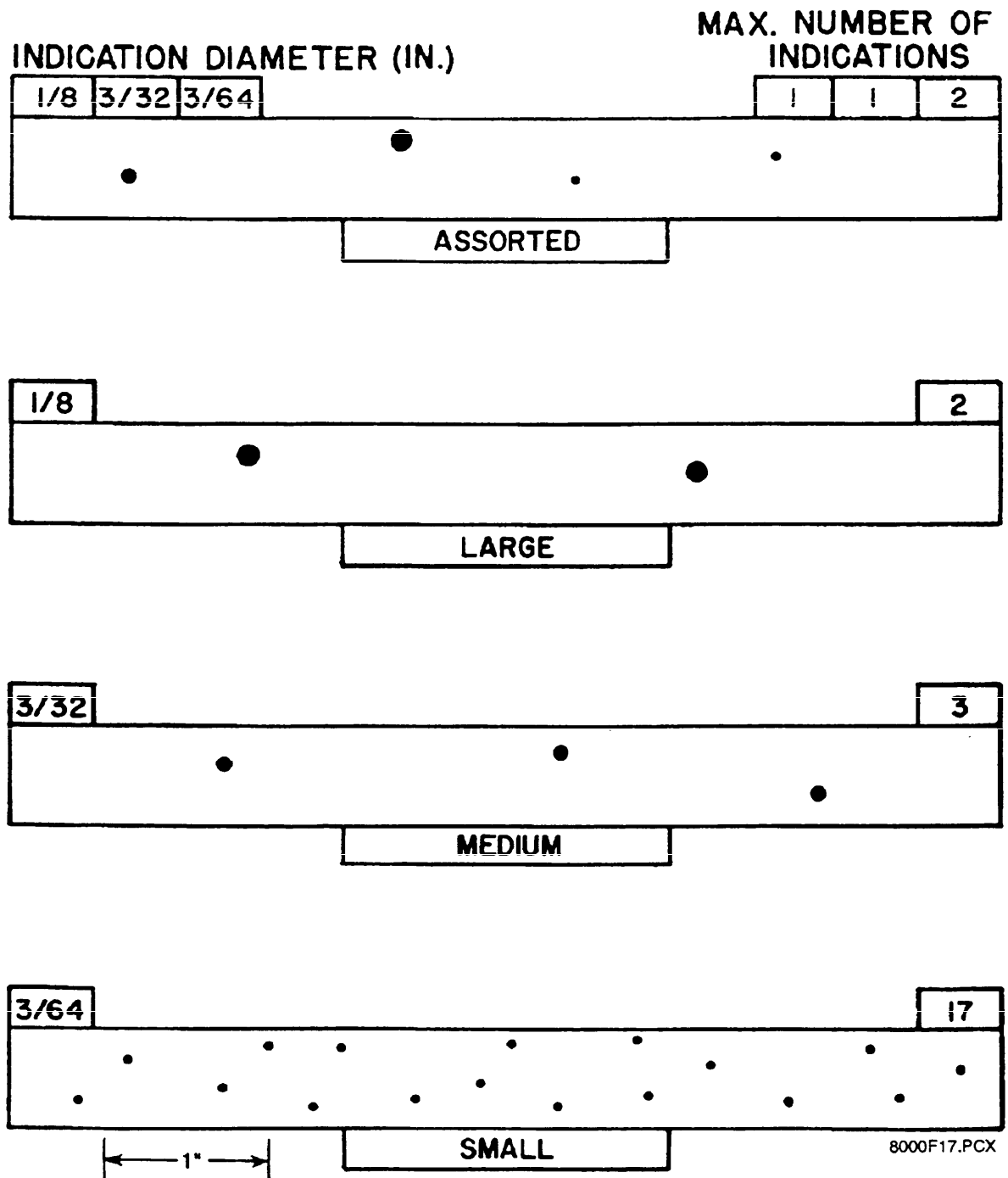
**FIGURE 44.** *Magnetic particle and liquid penetrant Class 3 weld (total indication area equals 0.75 percent of weld surface area) for material thickness equals 3/16 inch.*

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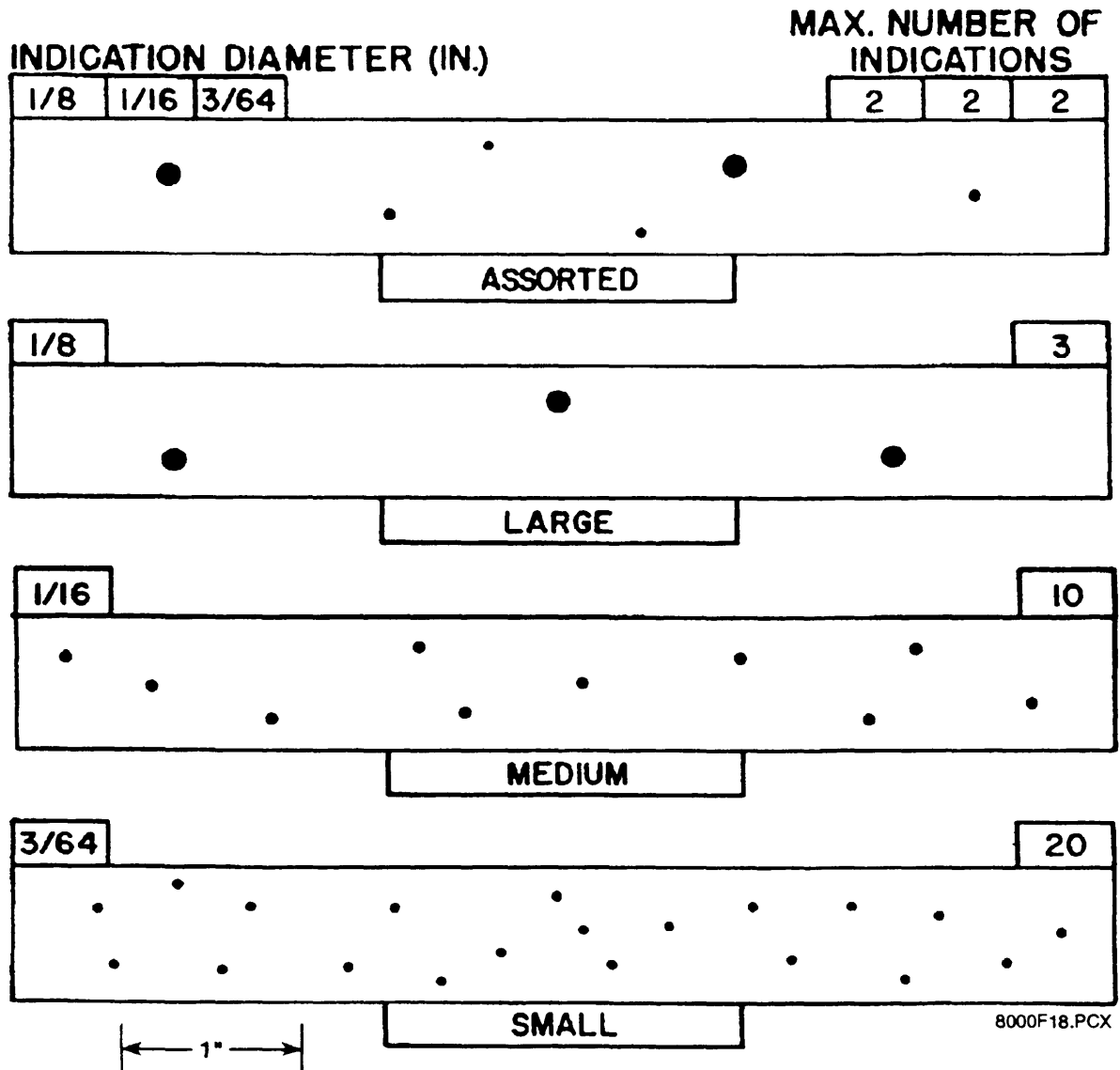
**FIGURE 45.** *Magnetic particle and liquid penetrant Class 3 weld (total indication area equals 0.75 percent of weld surface area) for material thickness equals 1/4 inch.*

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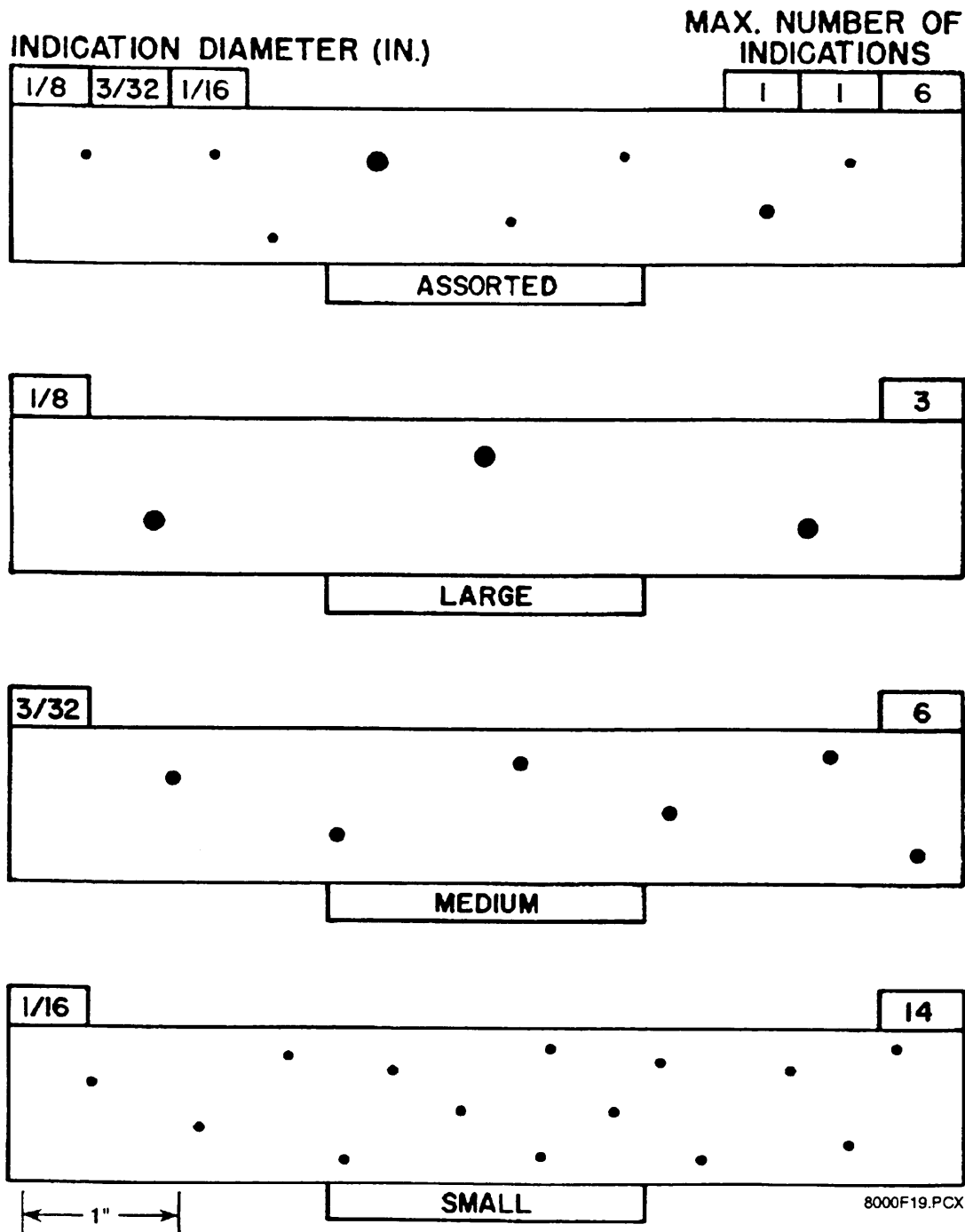
**FIGURE 46.** *Magnetic particle and liquid penetrant Class 3 weld (total indication area equals 0.75 percent of weld surface area) for material thickness equals 3/8 inch.*

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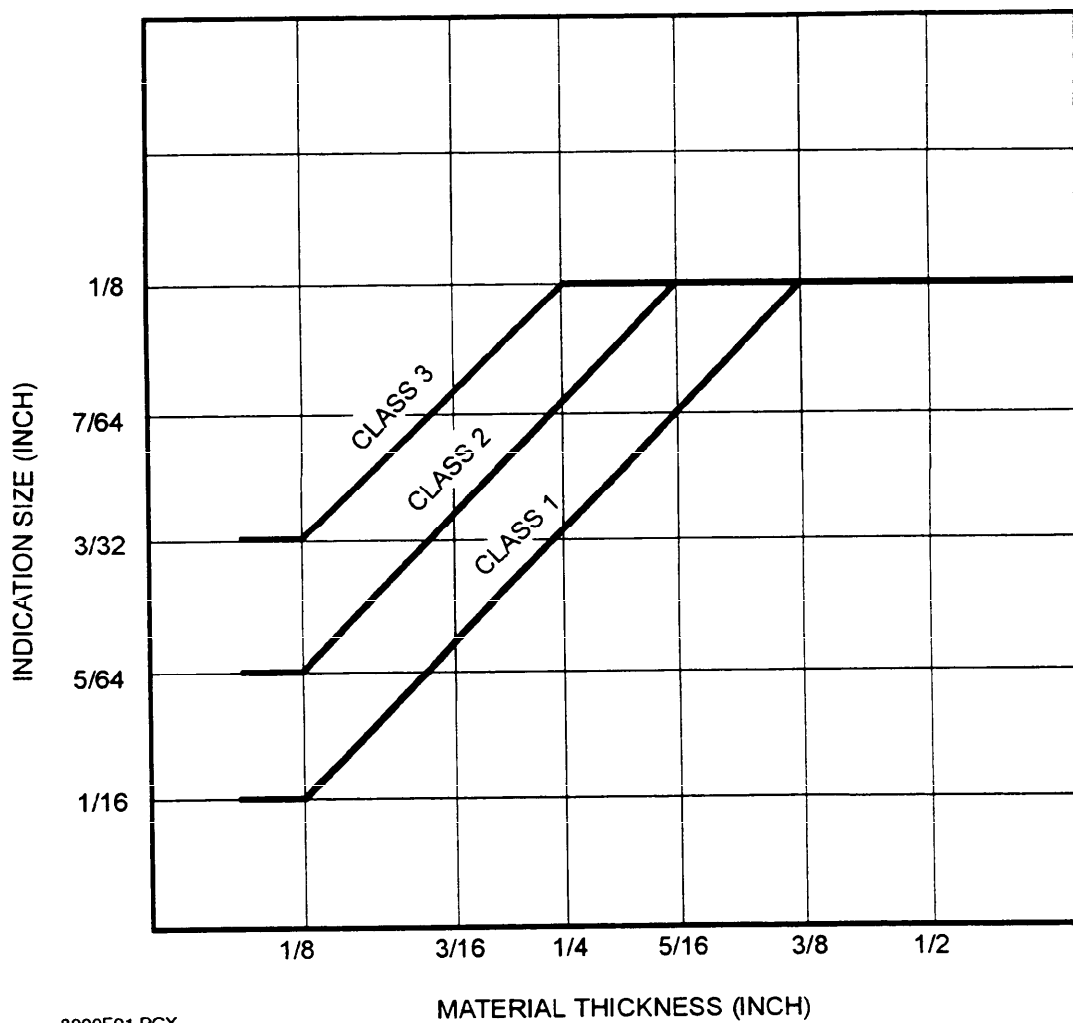
**FIGURE 47.** *Magnetic particle and liquid penetrant Class 3 weld (total indication area equals 0.75 percent of weld surface area) for material thickness equals 1/2 inch.*

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**FIGURE 48.** *Magnetic particle and liquid penetrant Class 3 weld (total indication area equals 0.75 percent of weld surface area) for material thickness equals 3/4 inch and over.*

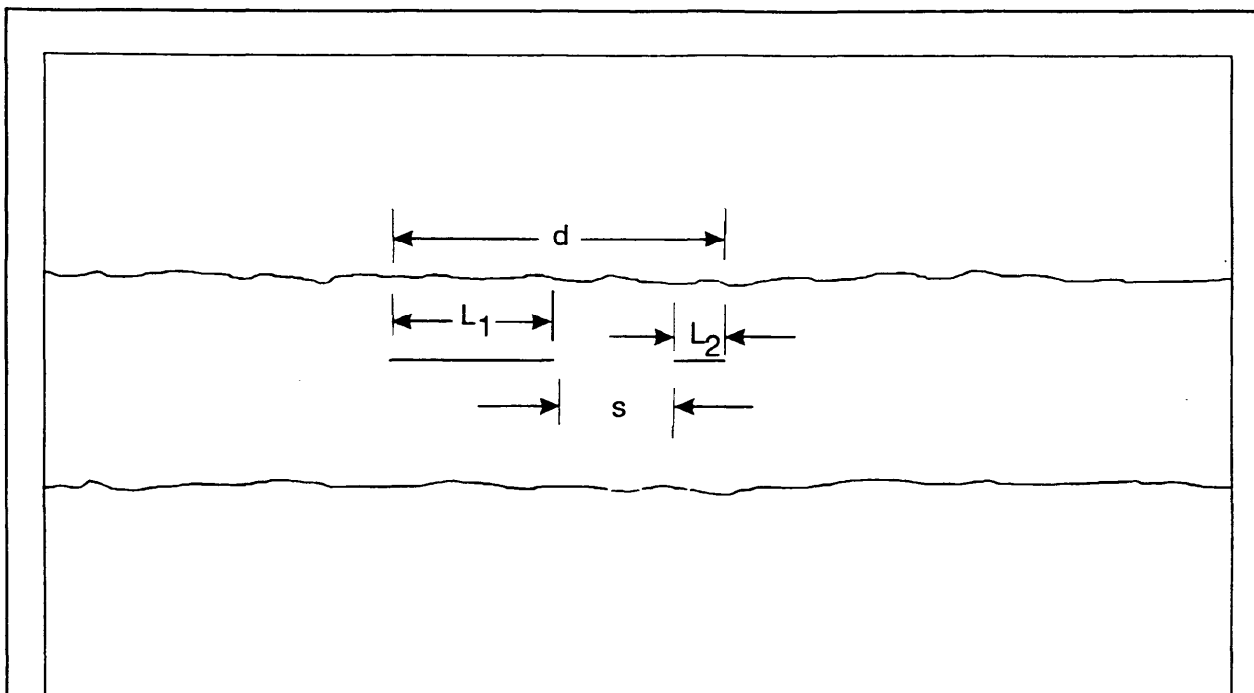
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**FIGURE 49.** *Magnetic particle and liquid penetrant maximum permissible rounded indications size.*

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3010F01.PCX

## TOP VIEW

CODE

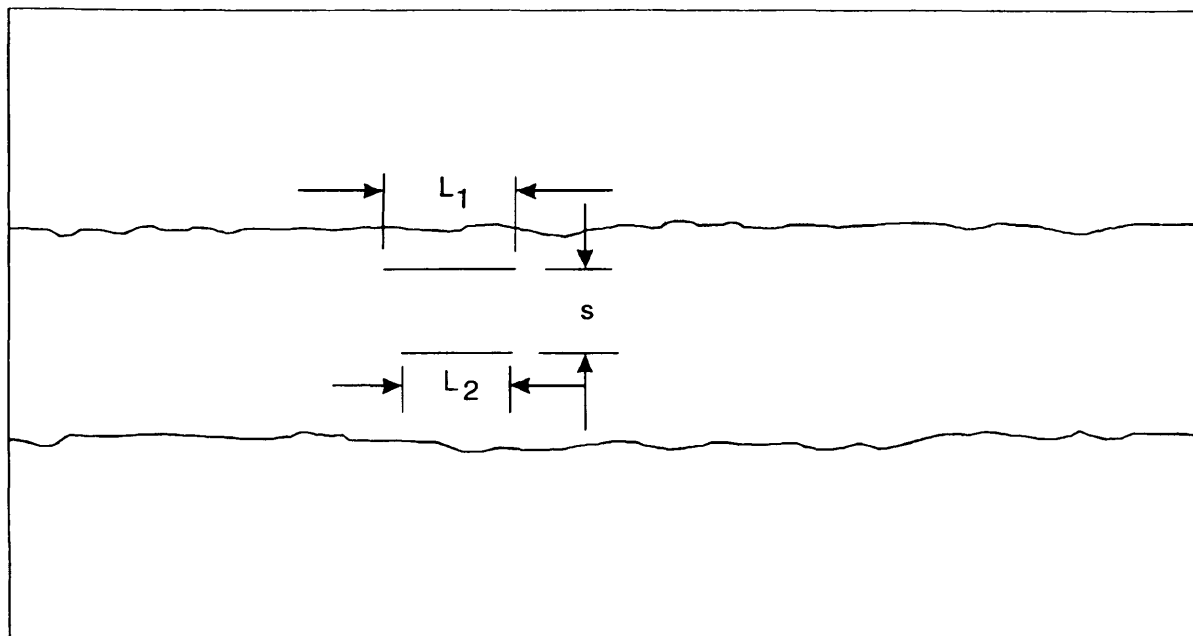
L = LENGTH OF DISCONTINUITY  
s = MAXIMUM SPACING BETWEEN  
ADJACENT DISCONTINUITIES  
d = MAXIMUM DISTANCE BETWEEN  
OUTER EXTREMITIES

DATA

$L_1 = 3/4$  INCH  
 $L_2 = 1/4$  INCH  
 $s = 1/2$ " (LESS THAN  $2L_1$ )  
EVALUATION IS BASED ON  $d$  OR  
 $L_1 + L_2 + s$

**FIGURE 50.** *Ultrasonic evaluation of adjacent discontinuities.*

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301F02.PCX

## TOP VIEW

CODE

L = LENGTH OF DISCONTINUITY  
 s = MAXIMUM SPACING BETWEEN  
 ADJACENT DISCONTINUITIES

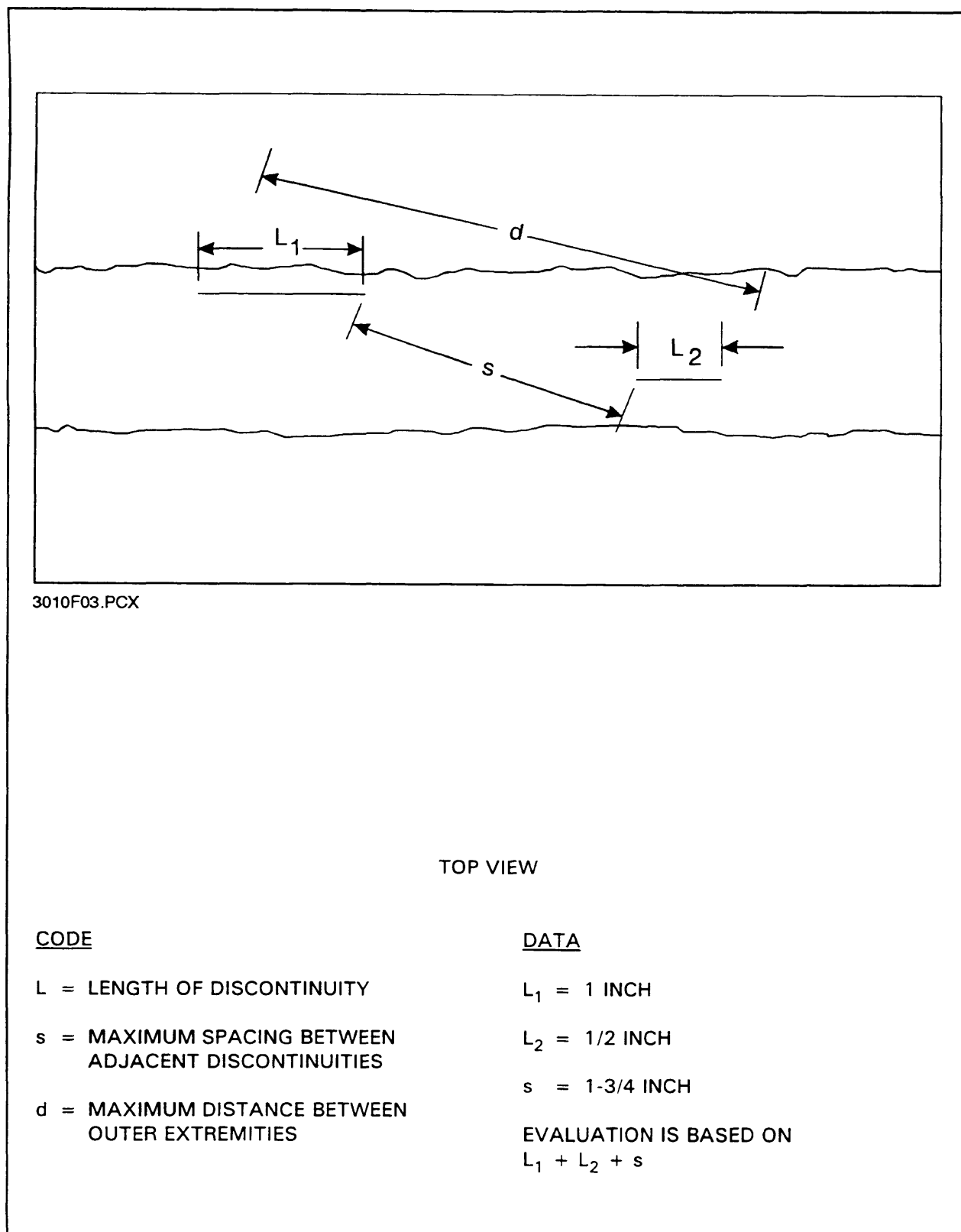
DATA

$L_1 = 5/8$  INCH  
 $L_2 = 1/2$  INCH  
 $s = 3/8$  INCH (LESS THAN  $2L_1$ )

EVALUATION IS BASED ON  
 $L_1 + L_2$

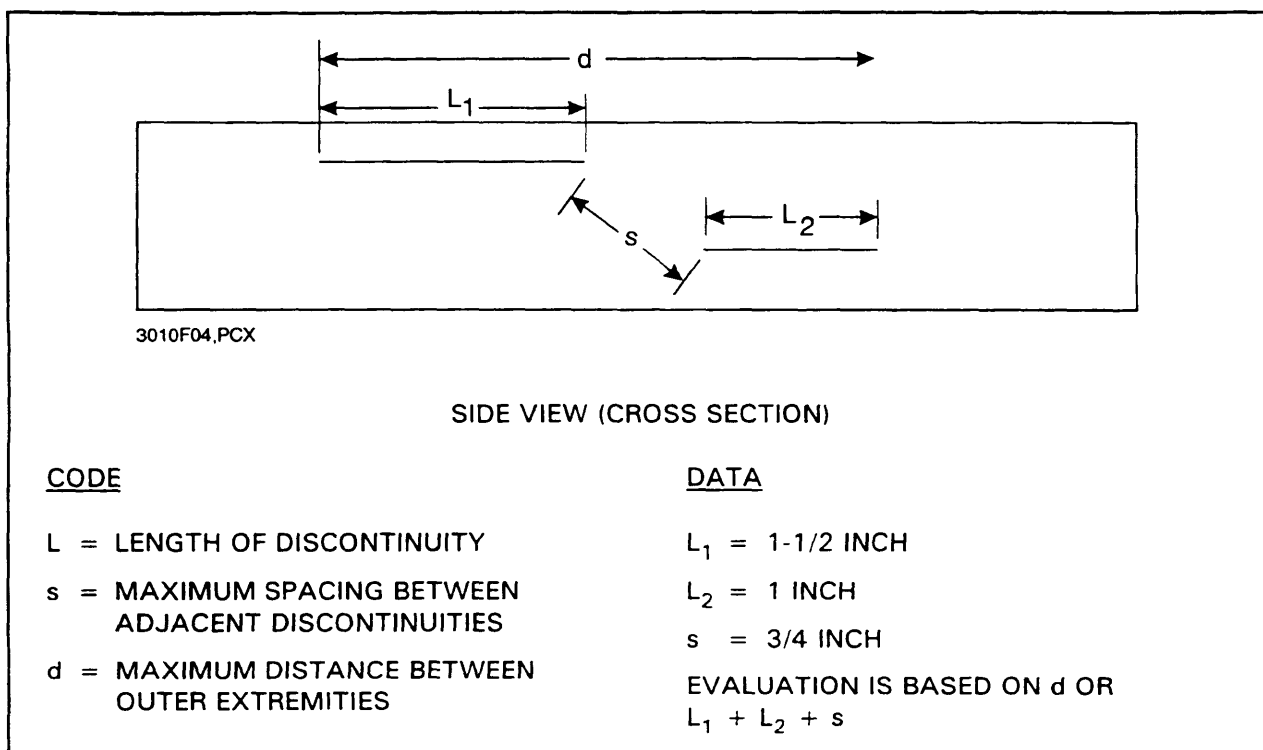
**FIGURE 51.** *Ultrasonic evaluation of parallel discontinuities.*

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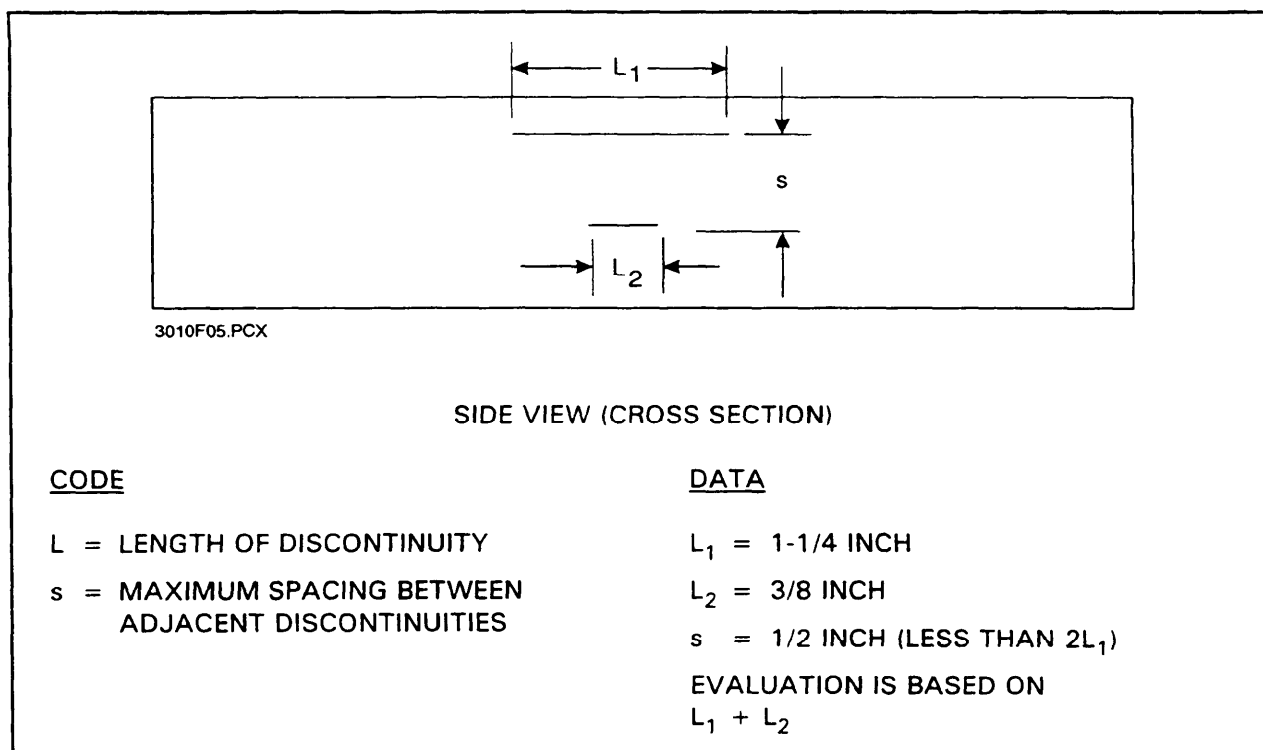


**FIGURE 52.** *Ultrasonic evaluation of offset discontinuities.*

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**FIGURE 53.** *Ultrasonic evaluation of offset depth discontinuities.*



**FIGURE 54.** *Ultrasonic evaluation of parallel depth discontinuities.*

# STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

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3. The preparing activity must provide a reply within 30 days from receipt of the form.

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3. DOCUMENT TITLE NONDESTRUCTIVE TESTING ACCEPTANCE CRITERIA		
4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)		
5. REASON FOR RECOMMENDATION		
<b>6. SUBMITTER</b>		
a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code)	7. DATE SUBMITTED (YYMMDD)
	(1) Commercial (2) AUTOVON (if applicable)	
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a. NAME COMMANDER NAVAL SEA SYSTEMS COMMAND (SEA 03R42)	b. TELEPHONE (Include Area Code) (1) Commercial (703) 602-0347	(2) AUTOVON DSN 332-0347
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