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MIL-STD-1907
7 September 1989
SUPERSEDING
MIL-P-47158(MI)
7 June 1974
MIL-M-47230(MI)
26 July 1974

MILITARY STANDARD

INSPECTION, LIQUID PENETRANT AND MAGNETIC PARTICLE, SOUNDNESS REQUIREMENTS FOR MATERIALS, PARTS AND WELDMENTS

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FOREWORD

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

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, U.S. Army Missile Command, ATTN: AMSMI-RD-SE-TD-ST, Redstone Arsenal, AL 35898-5270, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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1. SCOPE

1.1 Scope. This standard describes the discontinuity limits allowed under four quality level classifications for penetrant inspection and three quality level classifications for magnetic particle inspection. The materials may be forgings, castings, tubes, sheets, bars, etc. Fabrication stages may be machined, unmachined, welded, or unwelded parts/materials.

1.2 Application guidance. This standard provides inspection criteria for determining conformance to soundness requirements for materials, parts and weldments. For purposes of this standard, the term weldment refers to deposited filler material and one-half inch of base metal adjacent to the toe of the weld. For liquid penetrant inspection, brazed joints may also be considered as weldments under this standard.

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2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Standards. The following standards 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 6.2).

STANDARDS

MILITARY

MIL-STD-109	Quality Assurance Terms and Definitions
MIL-STD-1949	Inspection, Magnetic Particle
MIL-STD-6866	Inspection, Liquid Penetrant

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.2 Order of precedence. In the event of a conflict between the text of this document and the 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.

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3. DEFINITIONS

3.1 Cracks. A form of propagating fracture type characterized by a sharp tip and high ratio of length and width to opening displacement, caused by excessive stresses developed during fabrication or service.

3.2 Elongated indications. Elongated indications are those indications whose long axis is three or more times longer than the shorter axis.

3.3 Inclusions. Inclusions are round or elongated particles which may appear internally or on the surface of various products. They are not considered harmful if relatively small and well dispersed and if they do not extend into a fillet, hole, or over an edge. However, if they appear in clusters or stringers or if abnormally large individually (for the quality level specified), they are indicative of materials or practices of questionable quality.

3.4 Microsegregations. Under magnetic particle inspection, metallurgical phenomena, known as microsegregations, may be revealed as extremely narrow lines, usually long and straight, on the surfaces of highly finished parts made of wrought metals. Usually they will have no "feel" when explored with the tip of a sharp object, and a given line will often disappear if a few thousandths of the surface is removed. While microsegregations are not considered harmful, efforts to establish their identity (i.e., to ensure that the indications are not due to cracks, deep laps, long inclusion stringers, etc.) are usually justified, especially when first encountered.

3.5 Laminations. Laminations may appear as inclusion stringers between the rolled surfaces or material such as rectangles or plates; but, in some instances, actual separations may occur. If present, laminations would be indicated on the short transverse section of a unit. Short, intermittent laminations may not be objectionable if the unit is not subjected to high bending stresses. The occurrence of laminations usually can be attributed to faulty rolling mill operations.

3.6 Laps. Laps are surface defects appearing as folds or tangential seams in wrought products and usually are produced during hot working operations.

3.7 Flakes. Also known as shatter cracks, flakes appear as short, discontinuous fissures in forgings and possibly other wrought products. They are attributed to localized stresses which may occur during cooling from hot work.

3.8 Cold shuts. These casting defects are caused by two streams of semi-molten metal coming together inside a mold but failing to fuse. Cold shuts are sometimes referred to as misruns, but the latter term is more correctly used to describe lack of filling of the mold.

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3.9 Shrinks. Casting discontinuities in this category include shrinkage sponge, of which there are a number of manifestations. Shrinkage sponge areas may include small voids in the form of stringers or bunches, or there may be in evidence a "fingerprint" pattern consisting of semi-fused seams. Shrinks are caused by variations in solidification rates in the mold. In castings of substantial size, shrinks usually can be avoided by proper placement of risers, runners, chills, etc.

3.10 Gas hole porosity. Casting discontinuities of this type, usually round or oval shaped, are also known as gas porosity, pin hole porosity, and blow holes. In a relatively common form, cavities may appear on the surfaces of castings and are likely to be caused by the generation of steam when molten metal contacts damp sand, damp chills, inadequately dried mold wash, etc. Porosity may also result from the evolution of absorbed gas during solidification. If the voids are small and well dispersed, they are often harmless, but if relatively large and appear in localized areas, they should be carefully evaluated. Gas holes are probably most insidious when entrapped immediately under thick surface films of castings which are to be machined to exacting finishes, and for which adequate cleanup material has not been allowed.

3.11 Weldment discontinuities. Sketches of typical weldment discontinuities which can be detected by either the magnetic particle or penetrant inspection method are presented in figure 1.

3.12 Cluster. An area of shrinkage appearing on the surface with a highly fluorescent center of microporosity indications.

3.13 Other definitions. Other definitions of inspection terms shall be in accordance with MIL-STD-109.

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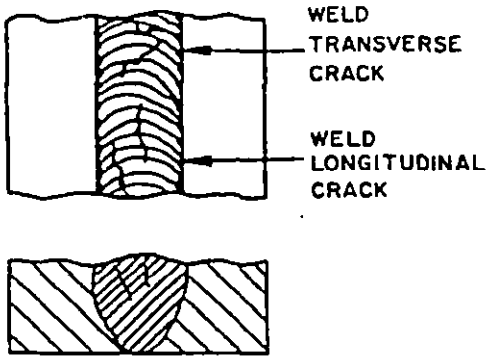

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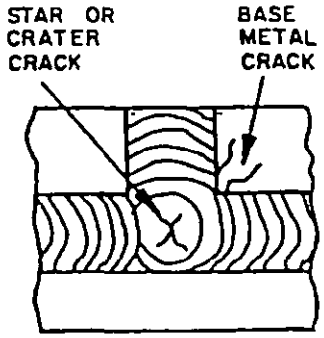

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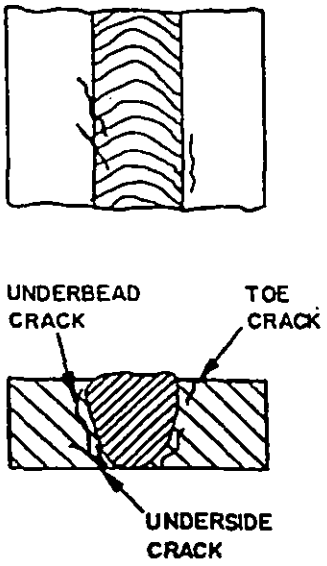

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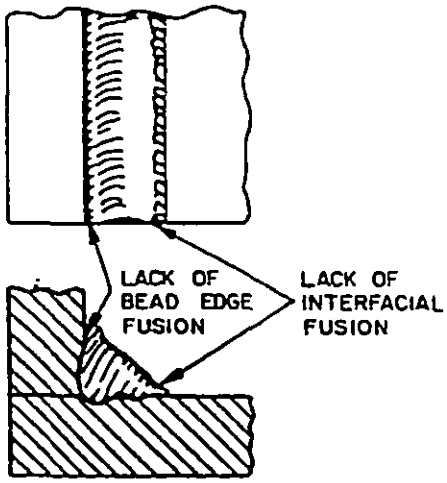

(See Note 2)

FIGURE 1. Weldment discontinuities.

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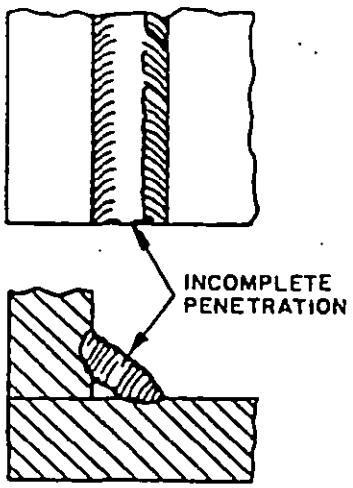

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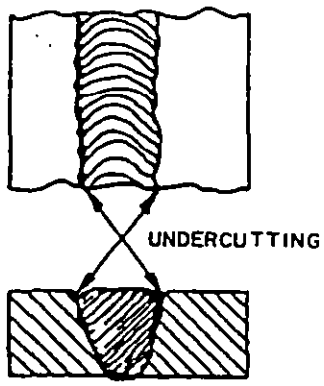

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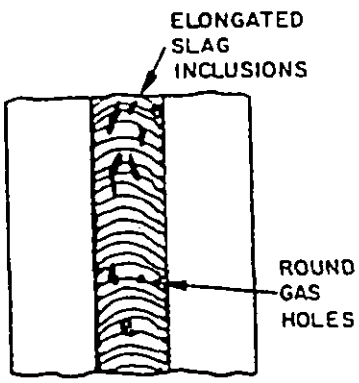

(See Note 2)

NOTES:

1. When cracks are present on weld metal or base metal surfaces, magnetic particle indications are relatively sharp and tend to "Stand Up". Indications of subsurface cracks are wider and less pronounced. All cracks are classed as propagating defects and are subject to rejection. Penetrant inspection will not detect discontinuities that are not open to the surface.

2. Undercutting, lack of bead edge fusion, and inclusions are considered detrimental if they exceed the limits specified herein. Discontinuities of this type are often visible without the use of either the penetrant or magnetic particle inspection process. Magnetic particle indications of lack of penetration (LOP) and lack of subsurface fusion are usually broad and poorly defined. Magnetic particle indications of gas holes and inclusions will vary with their size and location beneath the surface.

FIGURE 1. Weldment discontinuities - Continued.

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4. GENERAL REQUIREMENTS

4.1 Inspection standard classification. At the fabrication stage indicated (see 6.5), weldments, materials, structures, parts, or areas thereof shall be inspected to the quality level classifications of grades A, B, C, or D for penetrant inspection or grades A, B, or C for magnetic particle inspection, as specified in the drawing, purchase order, or other applicable document. If no classification is specified, inspection shall be to the grade C level for both penetrant and magnetic particle inspections.

4.1.1 Grade A. The grade A classification applies to critical parts having mechanical finishes or dynamic stresses that require special materials and/or above normal integrity.

4.1.2 Grade B. The grade B classification is applicable to units subject to high but well-distributed static stresses.

4.1.3 Grade C. The grade C classification is applicable to moderately stressed units.

4.1.4 Grade D. The grade D classification is applicable to castings only and is intended primarily for use in identifying and controlling soundness of low stressed areas adjacent to grade A, B, or C areas. Grade D is rarely applicable as a call out for all sections of a casting.

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5. DETAILED REQUIREMENTS

5.1 Review of indications. All questionable indications shall be carefully examined, preferably under 5X magnification. If dimensional tolerances and other circumstances permit, exploration of magnetic particle indications by lightly filing or grinding surfaces (with reapplication of indicating medium) is recommended. The judicious use of a suitable tool such as a feeler gage or scriber may be helpful in establishing the significance of indications.

5.1.1 Interpretation of indications. Using a marker pencil, circle the indication as close as possible to include the total indication. Use a swab to remove the iron particles or developer from the indication site. Examine the encircled areas with 10X magnification and 100 foot candles of white light. Distinctions can be made between scratches, gouges and tool tears (nonrelevant) or actual cracks, laps, seams, etc., (relevant).

5.1.2 Maximum discontinuity size and distribution for wrought products. For areas other than weldments, allowable size and distribution of surface and subsurface discontinuities are shown in table I.

5.1.3 Maximum discontinuity size and distribution for castings. For castings, allowable size and distribution of surface and subsurface discontinuities are shown in table II.

5.1.4 Maximum discontinuity size and distribution for weldments. For weldments, maximum discontinuity sizes and distribution are shown in table III. When there are indications of incomplete penetration or lack of fusion, the length limits shown in table III for elongated voids or inclusions are applicable. The shape, intensity, location, and arrangement of all subsurface phenomena shall be carefully evaluated since allowable base metal gaps or root openings may also be shown by magnetic particle patterns.

5.1.5 Nonrelevant indications. Parts shall not be rejected because of incidental concentrations of magnetic particles in areas which are not defective. Nonrelevant indications may appear on fillets, weld beads, or other areas, particularly if there is surface roughness.

5.1.6 Microsegregations. The appearance of indications due to microsegregations (see 3.4) shall not be cause for rejection.

5.2 Examination schedule. Unless otherwise specified, 100 percent of the items in an inspection lot shall be examined. Any sampling plan shall be as agreed upon by the contractor and the procuring activity.

5.3 Inspection methods.

5.3.1 Liquid penetrant inspection. Liquid penetrant inspection shall be performed in accordance with the requirements of MIL-STD-6866 as supplemented by a company or local process specification.

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5.3.2 Magnetic particle inspection. Magnetic particle inspection shall be performed in accordance with the requirements of MIL-STD-1949 as supplemented by a company or local process specification.

5.4 Accept/Reject criteria. Within the specified grade, discontinuities exceeding the limits in tables I, II, III shall be rejected. Parts that have indications which are obviously rejectable shall be rejected, tagged, and dispositioned as appropriate. Parts that have questionable indications shall be separated, tagged, and processed for further evaluation. Discontinuities that are defects which will be removed by subsequent processing will not be rejected provided their removal can be verified subsequent to all machining.

TABLE I. Maximum allowable discontinuity sizes (in inches) and distribution; wrought products, areas other than weldments.

Type Discontinuity	Grade A	Grade B	Grade C
Inclusions, rounded:			
Surface	0.031 dia DD-2*	0.047 dia D-3*	0.063 dia D-3*
Subsurface **	0.047 dia DD-2*	0.063 dia D-3*	0.094 dia D-3*
Inclusions, stringers:			
Surface	0.125 long DD-1*	0.375 long DD-1*	0.75 long DD-1*
Subsurface **	0.187 long DD-1*	0.5 long DD-1*	1.125 long DD-1*
Seams or laps (unmachined surfaces)	0.5 long DD-1*	1 long DD-1*	1.5 long DD-1*
Seams or laps (machine surfaces)	0	0	0.25 long DD-1*
Propagating discontinuities (cracks, flakes, laminations, etc.)	0	0	0

*Distribution designations signify the following:

D-3 Discontinuities no closer to each other than three times the maximum size.

DD-1 Discontinuities no closer to each other than 0.5 inch linearly and 0.25 inch in a parallel direction.

DD-2 No more than two indications.

** Magnetic particle inspection only.

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TABLE II. Maximum allowable discontinuity sizes (in inches) and distribution; castings.

Type Discontinuity	Grade A	Grade B	Grade C	Grade D *****
Nonmetallic inclusion, rounded:				
Surface	0.031 dia D-3*	0.047 dia D-3*	0.063 dia D-3*	0.125 dia D-2*
Subsurface ****	0.047 dia D-3*	0.063 dia D-3*	0.094 dia D-3*	N/A
Gas hole porosity/discrete Shrinkage cavities				
Surface	0.031 dia** D-3*	0.047 dia** D-3*	0.063 dia** D-3*	0.125**,*** D-2*
Subsurface ****	0.047 dia** D-3*	0.063 dia** D-3*	0.094 dia** D-3*	N/A
Cracks, hot tears, or cold shuts	0	0	0	0.25 long***
Shrinkage sponge areas (may include small cavities, cavity stringers)	0.250	0.375	0.625	1.25 dia***
Microshrinkage (micro-porosity) Maximum cluster diameter	0.063 D-3*	0.188 D-3*	0.313 D-3*	0.375 D-3*
Alloy or metallic phase segregation				
Surface	0.125	0.375	1.5	1.5
Subsurface	0.25	0.5	1.5	1.5

* Distribution designations signify the following:
- D-2 Discontinuities no closer to each other than two times the maximum size
- D-3 Discontinuities no closer to each other than three times the maximum size

** The limits for gas hole porosity for the individual grades do not apply if the voids are less than one half the maximum sizes specified and are well dispersed.

*** Shrinkage discontinuities are not allowed if within 0.5 inch of an outer edge of a casting section.

**** Magnetic particle inspection only.

***** Penetrant inspection only.

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TABLE III. Maximum allowable discontinuity sizes (in inches) and distribution; weldments.

Type Discontinuity	Grade A	Grade B	Grade C
Cracks, weld, or base metal (longitudinal, transverse, star or crater, underbead, underside, etc.)	0	0	0
Weld undercutting or lack of bead-edge fusion:			
Base metal less than 0.188 inch thick	0.016 deep 0.125 long D-5*	0.016 deep 0.250 long D-5*	0.031 deep 0.250 long D-5*
Base metal 0.188 inch thick and over	0.031 deep 0.125 long D-5*	0.031 deep 0.250 long D-5*	1.047 deep 0.375 long D-5*
Weld metal voids or inclusions, rounded:			
Base metal less than 0.188 inch thick	0.016 dia D-5*	0.031 dia D-5*	0.063 dia D-5*
Base metal 0.188 inch thick and over	0.031 dia D-5*	0.063 dia D-5*	0.125 dia D-5*
Weld metal voids or inclusions, elongated:			
Base metal less than 0.188 inch thick	0.063 long D-5*	0.125 long D-5*	0.188 long D-5*
Base metal 0.188 inch thick and over	0.125 long D-5*	0.250 long D-5*	0.375 long D-5*

*Distribution designations signify the following:

D-5 Discontinuities no closer to each other than five times the maximum dimension.

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6. NOTES

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

6.1 Intended use. This standard is intended to provide requirements for the acceptance of units that are inspected by either the magnetic particle inspection method in accordance with MIL-STD-1949 or the liquid penetrant inspection method in accordance with MIL-STD-6866.

6.2 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).

6.3 Data requirements. This paragraph is not applicable to this standard.

6.4 Critical areas. In terms of quality level classifications shown in section 4, design engineers should indicate on drawings the more critical and the less critical areas of units with regard to stress concentration and mechanical features.

6.5 Fabrication stage. Under ordinary circumstances, it is reasonable for the designer of a finished unit to expect that the quality levels selected will be enforced as a part of the final inspection procedures and to specify that the requirements are applicable after machining, welding, blast cleaning, etc. It does not necessarily follow, however, that the quality levels specified for the finished unit should be included as part of the purchase requirements for bars, plates, unmachined castings, unmachined forgings, or other forms such as partially machined items where the indication will be removed by final machining operations. In specifying raw stock for units subject to severe final inspection requirements, due consideration should be given such factors in relation to the possible cost of rejection of finished parts made of materials of regular quality.

6.6 Subject term (key word) listing.

Analysis, chemical
Casting
Classification
Examinations
Non-destructive testing
Penetrating fluids
Testing
Welding

6.7 Supersession data. This standard combines the requirements of MIL-P-47158(MI) dated 7 June 1974 and MIL-M-47230(MI) dated 26 July 1974 and supersedes both documents.

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6.8 Metrication. Wherever inch/pound dimensions are used in this document, metric equivalents in accordance with FED-STD-376 shall be acceptable.

6.9 Changes from previous issue. This paragraph is not applicable to this standard.

Custodians:
Army - MR
Navy - AS
Air Force - 20

Review activities:
Army - AR, TM, ME
Navy -
Air Force - 24, 70, 80, 82, 84, 99

User activities:
Army - AT, AL, ME, TE, AV
Navy - OS
Air Force - 71, 80
DLA -

Preparing Activity:
Army - MI

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-STD-1907	Inspection, Liquid Penetrant and Magnetic Particle, Soundness Requirements for Materials, Parts and Weldments

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
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	☐ USER
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ MANUFACTURER
	☐ OTHER *(Specify)*: _____

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
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