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DEPARTMENT OF DEFENSE HANDBOOK

RADIOGRAPHIC INSPECTION, CLASSIFICATION AND SOUNDNESS REQUIREMENTS FOR STEEL CASTINGS

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 Do not cite this document as a requirement.

AMSC N/A AREA NDTI

FOREWORD

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

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

3. MIL-HDBK-1265 prescribes classification and soundness requirements for steel castings. The castings are classified by classes, grades, and criticality levels. Included in the handbook are four tables of maximum permissible radiographic severity levels for discontinuities in various wall thickness for steel castings per ASTM E186, E192, E280 and E446.

4. All information and data contained in this handbook have been coordinated with industry and the U.S. Army, Navy, Air Force and DLA prior to publication.

5. Copies of this document and revisions thereto may be obtained from the Defense Automated Printing Service (DAPS), 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.

6. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, U.S. Army Research Laboratory, Weapons and Materials Research Directorate, ATTN: AMSRL-WM-M, Aberdeen Proving Ground, MD 21005-5069, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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CONTENTS

1. SCOPE

1.1 Scope. This handbook prescribes the requirements for the classification and soundness of steel castings exclusive of weld repair. This handbook supplements detail casting specifications when specified. This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed below are not necessarily all of the documents referenced herein, but are the ones that are needed in order to fully understand the information provided by this handbook.

2.2 Government documents.

2.2.1 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 latest issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto.

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-410 - Nondestructive Testing Personnel Qualification and Certification

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Defense Automated Printing Service (DAPS), 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 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 documents which are DoD adopted are those listed in the latest issue of the DoDISS, and supplement thereto.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E186 - Standard Reference Radiographs for Heavy Walled (2 to 4 1/2-in. (51 to 114-mm)) Steel Castings (DoD adopted)
ASTM E192 - Standard Reference Radiographs for Investment Steel Castings of Aerospace Applications (DoD adopted)
ASTM E280 - Standard Reference Radiographs for Heavy Walled (4 1/2 to 12-in. (114 to 305-mm)) Steel Castings (DoD adopted)
ASTM E446 - Standard Reference Radiographs for Steel Castings Up to 2 in. (51 mm) in Thickness (DoD adopted)
ASTM E1742 Standard Practice for Radiographic Examination (DoD adopted)

(Application for copies should be addressed to the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.)

2.4 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.

3. DEFINITIONS

3.1 Classification. Castings shall be classified by classes, applicable grades and criticality levels.

3.1.1 Classes.

3.1.1.1 Class 1. A casting in which a single failure would cause significant danger to operating personnel or would result in a significant operational penalty. In the case of missiles, aircraft and other vehicles, this includes loss of major components, loss of control, unintentional release or inability to release armament stores, or failure of weapon installation components.

3.1.1.2 Class 2. A casting not included in class 1 but of unknown margin of safety.

3.1.1.3 Class 3. Castings having a margin of safety of 200 percent or less.

3.1.1.4 Class 4. Castings having a margin of safety greater than 200 percent, or for which no stress analysis is required.

3.1.2 Grades Castings shall be of grades A, B, C, D or E as shown in tables I, II, III and IV. Grade A castings would contain the least and/or the smallest size discontinuities. Grades B, C, D and E would contain progressively larger and more numerous discontinuities. Sections of a casting may be of varying grades, depending on the applied stresses to that portion of the castings.

3.1.2.1 Radiographic grade A. A casting that is subject to high stresses when used in critical applications.

3.1.2.2 Radiographic grade B. A casting or specified area of a casting used for critical applications with a small design safety factor.

3.1.2.3 Radiographic grade C. A high quality grade of casting or area of a casting used for general applications with an average safety factor.

3.1.2.4 Radiographic grade D. A casting or area of a casting that is subject to low stresses.

3.1.2.5 Radiographic grade E. A casting used for armor purposes only.

3.1.3 Criticality levels (KL). The criticality level designates the amount of radiographic coverage for each casting. Castings shall be of criticality levels, KL1, KL2, or KL3. Those areas designated KL1 shall have a minimum of 75% radiographic inspection coverage. Areas designated KL2 shall require 50% minimum radiographic coverage. Those areas designated KL3

do not require radiographic inspection but are generally radiographed for information purposes.

3.2 Lot definition.

3.2.1 Inspection lot. Unless otherwise specified, class 1 castings shall be inspected in accordance with table V, and class 2, 3, and 4 castings shall be selected for inspection in accordance with table VI. If class of casting is not identified on drawings, class 2 shall apply.

4. GENERAL REQUIREMENTS

4.1 Inspection.

4.1.1 Responsibility for inspection. The contractor is responsible for furnishing all supplies in conformance to contract or purchase order requirements and, unless otherwise specified in the contract or purchase order, the performance of all inspection requirements contained herein. The inspection provisions contained herein shall become a part of the contractor's overall inspection system or quality program. The absence of inspection requirements does not relieve the supplier of his responsibility for assuring that all supplies submitted to the Government for acceptance conform to all requirements of the contract. The Government reserves the right to perform any of the inspections set forth herein, or otherwise specified in the contract or purchase order, when such inspections are deemed necessary to assure that supplies conform to prescribed requirements.

4.1.2 Qualification for inspection. Personnel performing radiographic inspection shall be qualified in accordance with MIL-STD-410D. Radiographic inspection of production castings shall be conducted in accordance with ASTM E1742.

4.1.3 Final Inspection. Castings shall be inspected as specified herein unless the design activity has information substantiating the suitability of other inspection plans.

4.1.3.1 Documentation for final inspections. For all castings for which radiographic inspection is specified, the contractor shall prepare either photographs, X-ray film, sketches, documents or drawings containing:

(a) Classification of casting.
(b) Alloy and heat treatment.
(c) Grade(s) or defect limits as applicable.

5. DETAILED REQUIREMENTS

5.1 Determination of classes, grades and criticality levels. The design activity shall establish the class, grade and criticality level by critical areas and stress levels for each casting design. The classification(s) and critical area(s) shall be indicated on the applicable drawing. If grade of casting is not indicated on drawing or other contractual document, grade C shall apply.

5.1.1 Class 1 requirements. All areas of class 1 castings shall be of a quality equivalent to or better than grade C, except that all critical

areas of a class 1 casting shall be of a quality equivalent to or better than grade B (see tables I, II, III and IV).

5.1.2 Radiographic grades. The design activity shall specify on the drawing or other document the (quality level) radiographic grade(s) for classes 1, 2 and 3 castings designs. The design activity may specify radiographic grade(s) for class 4 casting designs. Either castings, or section of castings, shall be of grades A, B, C, D or E as shown in tables I, II, III and IV, and shall be in accordance with the reference radiographs specified in the tables, unless the design activity has information substantiating the suitability of castings with more extensive defects.

5.1.3 Criticality levels. The design activity shall specify the criticality level required for each classification of casting. Class 1 castings shall be completely radiographically examined and no criticality level designation is needed. Classes 2, 3 and 4 shall have areas designated by criticality level.

5.2 Standards.

5.2.1 Radiographic standards. Radiographic standard grades shall be established for each casting design for which radiographic inspection is specified. Such standards shall be in terms of ASTM E186, ASTM E192, ASTM E280 and ASTM E446. Maximum acceptable defects shall be in accordance with paragraph 5.1.

5.3 Examination of resubmitted inspection lots.

5.3.1 Rejection. Defects and/or discontinuities which are so aligned as to cause stress concentration are causes for rejection. If more than 25% of any lot of type I Aircraft or type II Guided Missile castings given 100% inspection is rejected because of discontinuities in highly stressed areas, the entire lot shall be submitted to review procedures. Castings not conforming to this specification shall be rejected and submitted to review procedures.

5.3.2 Review. In performing the review of the rejected lot, the cognizant engineering member of the review board may detail a technique for the subjection of a casting to a destructive test, either by loading (as in service use) or by dissection, as practicable. This consideration shall be predicated on the size of the rejected lot, the size of the castings and criticality of the casting application.

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 handbook is to be used as a guide to define the requirements for the classification and soundness of steel castings exclusive of weld repair.

6.2 Producibility warning. The class assigned to the casting should represent a realistic value for the functional requirements. Do not assign a type I casting for a type II function. Casting design coupled with

foundry practice can make overly severe soundness requirements impractical for a manufacturer to satisfy. Caution should be exercised in specifying the grade of maximum permissible radiographic discontinuity level to be met in a casting.

6.3 Table notes. The following notes are an integral part of tables I, II, III and IV:

(1) When two or more types of defects are present to an extent equal to or not significantly better than the acceptance standards for respective defects, the parts should be rejected.

(2) When two or more types of defects are present and the predominating defect is not significantly better than the acceptance standard, the part should be considered borderline.

(3) Borderline castings may be considered acceptable, upon review by competent engineering personnel.

(4) Gas holes or sand spots and inclusions allowed by these tables should be cause for rejection when closer than twice their maximum dimension to an edge or extremity of a casting.

(5) Drawing tolerance (DWG. TOL.) is defined as minimum thickness of material after defect is removed by machining.

(6) Numbers in the tables depict severity. A low number indicates few, small discontinuities while a high number indicates numerous, large discontinuities.

6.4 Subject term (key word) listing.

Coreshift
Criticality levels
Gas holes
Misrun
Mold buckle

TABLE I. Maximum permissible radiographic severity levels for discontinuities in thin wall steel castings (1 in. (25.4 mm) wall or less) per ASTM E192.

DISCONTINUITY	GRADE A INCH			GRADE B INCH			GRADE C INCH			GRADE D INCH		
	1/8	3/8	3/4	1/8	3/8	3/4	1/8	3/8	3/4	1/8	3/8	3/4
GAS HOLES	NONE	NONE	NONE	1	1	1	2	2	2	3	3	3
SHRINKAGE CAVITY	NONE	NONE	NONE	NONE	NONE	1	N/A	N/A	2	N/A	N/A	3
SHRINKAGE SPONGE	NONE	NONE	NONE	1	1	1	2	2	2	3	3	3
SHRINKAGE, DENDRITIC	NONE	NONE	NONE	1	1	1	2	2	2	3	3	3
SHRINKAGE, FILAMENTARY	NONE	NONE	NONE	NA 1/	NA 1/	1	NA 1/	NA 1/	2	NA 1/	NA 1/	3
FOREIGN MATERIAL (LESS DENSE)	NONE	NONE	NONE	1	1	1	2	2	2	3	3	3
COLD SHOT	NONE ALLOWED											
HOT TEAR	NONE ALLOWED											
COLD CRACK	NONE ALLOWED											
MISRUN	NONE ALLOWED											
CORESHIFT	NOT TO EXCEED DRAWING TOLERANCE											
MOLD BUCKLE, POSITIVE	NOT TO EXCEED DRAWING TOLERANCE											
MOLD BUCKLE, NEGATIVE	NOT TO EXCEED DRAWING TOLERANCE											
MOLD RIDGE	NOT TO EXCEED DRAWING TOLERANCE											
EXCESS METAL IN CRACKED CORE	NOT TO EXCEED DRAWING TOLERANCE											

1/ Not available.

TABLE II. Maximum permissible radiographic severity levels for discontinuities in thick wall steel castings (2 to 4 1/2-in. (51 to 114-mm)) per ASTM E186.

CATEGORY	DISCONTINUITIES	GRADE A	GRADE B	GRADE C	GRADE D	GRADE E
A	GAS POROSITY	NONE	1	2	3	3
B	SAND/SLAG INCLUSIONS	NONE	1	2	4	4
C	SHRINKAGE TYPE 1	NONE	2	3	4	5
C	SHRINKAGE TYPE 2	NONE	2	3	4	5
C	SHRINKAGE TYPE 3	NONE	2	3	4	5
D	CRACK	----------NONE ALLOWED----------				
E	HOT TEAR	----------NONE ALLOWED----------				
F	INSERT	----------NONE ALLOWED----------				

TABLE III. Maximum permissible radiographic severity levels for discontinuities in steel castings up to 2 in. (51 mm) in thickness per ASTM E446.

CATEGORY	DISCONTINUITIES	GRADE A	GRADE B	GRADE C	GRADE D	GRADE E
A	GAS POROSITY	NONE	1	2	3	4
B	SAND SPOTS AND INCLUSIONS	NONE	1	2	3	5
CA	SHRINKAGE	NONE	1	2	3	5
CB	SHRINKAGE	NONE	1	2	3	5
CC	SHRINKAGE	NONE	1	2	3	5
CD	SHRINKAGE	NONE	1	2	3	5
D	CRACK	NONE	NONE	DWG. TOL.	DWG. TOL.	NONE
E	HOT TEAR	NONE	NONE	NONE	NONE	NONE
F	INSERT	NONE	NONE	NONE	NONE	NONE

TABLE IV. Maximum permissible radiographic severity levels for discontinuities in heavy walled (4 1/2 to 12-in. (114 to 305-mm)) steel castings per ASTM E280.

CATEGORY	DISCONTINUITIES	GRADE A	GRADE B	GRADE C	GRADE D	GRADE E
A	GAS POROSITY	1	2	3	4	4
B	SAND AND SLAG INCLUSIONS	1	2	3	4	4
C	SHRINKAGE TYPE 1	1	2	3	5	5
C	SHRINKAGE TYPE 2	1	2	3	5	5
C	SHRINKAGE TYPE 3	1	2	3	5	5
D	CRACK	NONE ALLOWED				
E	HOT TEAR	NONE ALLOWED				
F	INSERT	NONE ALLOWED				

TABLE V. Sample size for inspection of class 1 castings.

Lot Size	Sample Size	Lot Size	Sample Size
2-5	All	27-36	10
6-8	5	37-51	11
9-11	6	52-82	12
12-15	7	83-162	13
16-20	8	163-971	14
21-26	9	972 and over	15

Note: Acceptance number is 0

TABLE VI. Sample size for inspection of class 2, 3, and 4 castings.

Lot Size	Sample Size	Lot Size	Sample Size
2-4	All	18-27	7
5-6	4	28-48	8
7-11	5	49 and over	9
12-17	6		

Note: Acceptance number is 0

CONCLUDING MATERIAL

Custodians:
Army - MR
Navy - AS
Air Force - 11

Review activities:
Army - CR, PT
Navy - NP
Air Force - 10. 13
DLA - DH(DCMC-OF, DLSC-LEQ)

Preparing activity:
Army - MR

(Project NDTI-0269)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.

2. The submitter of this form must complete blocks 4, 5, 6, and 7.

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

NOTE: This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	**1. DOCUMENT NUMBER** MIL-HDBK-1265	**2. DOCUMENT DATE (YYMMDD)** 980819

DOCUMENT TITLE RADIOGRAPHIC INSPECTION, CLASSIFICATION AND SOUNDNESS REQUIREMENTS FOR STEEL CASTINGS

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

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON *(if applicable)*	**7.DATE SUBMITTED** (YYMMDD)

8. PREPARING ACTIVITY

a. NAME US ARMY RESEARCH LABORATORY	b. TELEPHONE *Include Area Code)* (1) Commercial (410)306-0725 (2) AUTOVON 458-0725
c. ADDRESS *(Include Zip Code)Commander* WEAPONS & MATERIALS RESEARCH DIRECTORIATE ATTN; AMSRL-WM-M ABERDEEN PROVING GROUND, MD 21005-5069	**IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:** DEFENSE QUALITY AND STANDARDIZATION OFFICE 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22401-3466 Telephone (703) 756-2340 AUTOVON 289-2340