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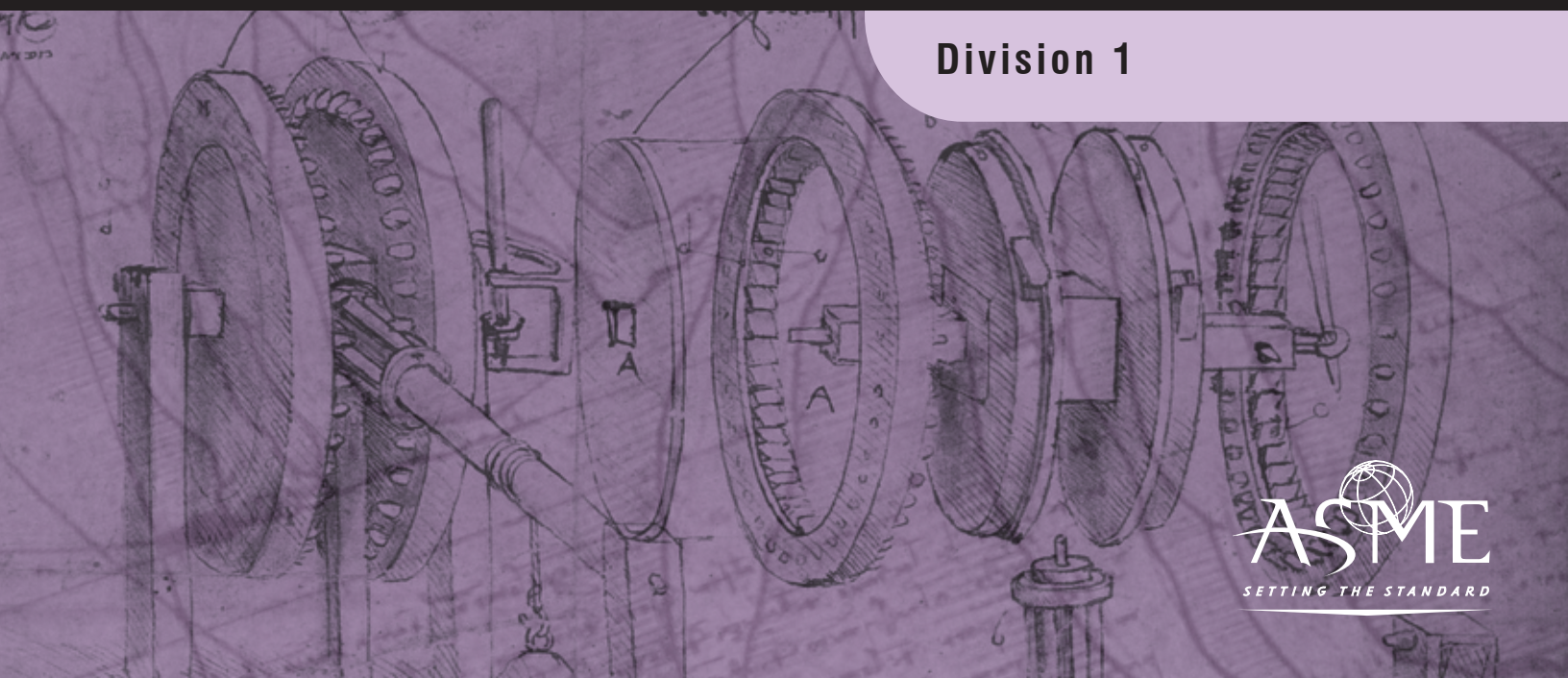
SECTION VIII

Rules for Construction of Pressure Vessels

2023 ASME Boiler and Pressure Vessel Code

An International Code

Division 1



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SETTING THE STANDARD

AN INTERNATIONAL CODE

2023 ASME Boiler & Pressure Vessel Code

2023 Edition July 1, 2023

VIII

RULES FOR CONSTRUCTION OF PRESSURE VESSELS

Division 1

ASME Boiler and Pressure Vessel Committee
on Pressure Vessels

The American Society of Mechanical Engineers

Two Park Avenue • New York, NY • 10016 USA

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MANDATORY APPENDIX 6
METHODS FOR MAGNETIC PARTICLE EXAMINATION (MT)

6-1 SCOPE

(a) This Appendix provides for procedures which shall be followed whenever magnetic particle examination is specified in this Division.

(b) Section V, Article 7 shall be applied for the detail requirements in methods and procedures, and the additional requirements specified within this Appendix.

(c) Magnetic particle examination shall be performed in accordance with a written procedure, certified by the Manufacturer to be in accordance with the requirements of Section V, Article 1, T-150

(d) Documentation showing that the required examinations have been performed and that the results are acceptable shall be made available to the Inspector.

6-2 CERTIFICATION OF COMPETENCY FOR NONDESTRUCTIVE EXAMINATION PERSONNEL

The manufacturer shall certify that each magnetic particle examiner meets the following requirements:

(a) He/she has vision, with correction if necessary, to enable him/her to read a Jaeger Type No. 2 Standard Chart at a distance of not less than 12 in., and is capable of distinguishing and differentiating contrast between colors used. These requirements shall be checked annually.

(b) He/she is competent in the techniques of the magnetic particle examination method for which he/she is certified, including making the examination and interpreting and evaluating the results, except that where the examination method consists of more than one operation, he/she may be certified as being qualified only for one or more of these operations.

6-3 EVALUATION OF INDICATIONS

Indications will be revealed by retention of magnetic particles. All such indications are not necessarily imperfections, however, since excessive surface roughness, magnetic permeability variations (such as at the edge of heat-affected zones), etc., may produce similar indications.

An indication of an imperfection may be larger than the imperfection that causes it; however, the size of the indication is the basis for acceptance evaluation. Only indications which have any dimension greater than $^{1}/_{16}$ in. (1.5 mm) shall be considered relevant.

(a) A linear indication is one having a length greater than three times the width.

(b) A rounded indication is one of circular or elliptical shape with a length equal to or less than three times its width.

(c) Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant.

6-4 ACCEPTANCE STANDARDS

These acceptance standards shall apply unless other more restrictive standards are specified for specific materials or applications within this Division.

All surfaces to be examined shall be free of:

(a) relevant linear indications;

(b) relevant rounded indications greater than $^{3}/_{16}$ in. (5 mm);

(c) four or more relevant rounded indications in a line separated by $^{1}/_{16}$ in. (1.5 mm) or less, edge to edge.

6-5 REPAIR REQUIREMENTS

The defect shall be removed or reduced to an imperfection of acceptable size. Whenever an imperfection is removed by chipping or grinding and subsequent repair by welding is not required, the excavated area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners. Where welding is required after removal of an imperfection, the area shall be cleaned and welding performed in accordance with a qualified welding procedure.

(a) Treatment of Indications Believed Nonrelevant. Any indication which is believed to be nonrelevant shall be regarded as an imperfection unless it is shown by reexamination by the same method or by the use of other nondestructive methods and/or by surface conditioning that no unacceptable imperfection is present.

(b) Examination of Areas From Which Imperfections Have Been Removed. After a defect is thought to have been removed and prior to making weld repairs, the area shall be examined by suitable methods to ensure it has been removed or reduced to an acceptably sized imperfection.

(c) Reexamination of Repair Areas. After repairs have been made, the repaired area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners and reexamined by the magnetic particle method and by all other methods of examination that were originally required for the affected area, except that, when the depth of repair is less than the radiographic sensitivity required, reradiography may be omitted.

MANDATORY APPENDIX 7
EXAMINATION OF STEEL CASTINGS

7-1 SCOPE

This Appendix covers examination requirements that shall be observed for all steel castings to which a 100% quality factor is to be applied in accordance with UG-24(a)(5). Except for applications involving lethal service, steel castings made to an accepted standard, such as ASME B16.5, are not required to comply with the provisions of this Appendix.

7-2 EXAMINATION TECHNIQUES

Examination techniques shall be carried out in accordance with the following:

(a) Magnetic particle examinations shall be per Mandatory Appendix 6 except that acceptance standards shall be as given in 7-3(a)(3) of this Appendix.

(b) Liquid penetrant examinations shall be per Mandatory Appendix 8 except that acceptance standards shall be as given in 7-3(a)(4) of this Appendix.

(c) Radiographic examinations shall be per Section V, Article 2 with acceptance standards as given in 7-3(a)(1) or 7-3(b)(3) of this Appendix.

(1) A written radiographic examination procedure is not required. Demonstration of density and image quality indicator (IQI) image requirements on production or technique radiographs shall be considered satisfactory evidence of compliance with Section V, Article 2.

(2) The requirements of Section V, Article 2, T-285 are to be used only as a guide. Final acceptance of radiographs shall be based on the ability to see the prescribed IQI image and the specified hole or the designated wire or a wire IQI.

(d) Ultrasonic examinations shall be per Section V, Article 5 with acceptance standards as given in 7-3(b)(3) of this Appendix.

7-3 EXAMINATION REQUIREMENTS

All steel castings shall be examined in accordance with (a) or (b) as applicable.

(a) All castings having a maximum body thickness less than 4½ in. (115 mm) shall be examined as follows:

(1) All critical sections[17] shall be radiographed. For castings having radiographed thicknesses up to 2 in. (51 mm), the radiographs shall be compared to those in ASTM E446, Standard Reference Radiographs for Steel Castings up to 2 in. (51 mm) in Thickness. The maximum acceptable severity levels for imperfections shall be as follows:

	Maximum Severity Level	
Imperfection Category	Thicknesses <1 in.	Thicknesses 1 in. to <2 in.
A — Gas porosity	1	2
B — Sand and slag	2	3
C — Shrinkage (four types)	1	3
D — Cracks	0	0
E — Hot tears	0	0
F — Inserts	0	0
G — Mottling	0	0

For castings having radiographed thicknesses from 2 in. to 4½ in. (51 mm to 114 mm), the radiographs shall be compared to those in ASTM E186, Standard Reference Radiographs for Heavy-Walled [2 to 4½ in. (50.8 to 114 mm)] Steel Castings. The maximum acceptable severity levels for imperfections shall be as follows:

Imperfection Category	Maximum Severity Level
A — Gas porosity	2
B — Sand and slag inclusions	2
C — Shrinkage	
Type 1	1
Type 2	2
Type 3	3
D — Cracks	0
E — Hot tear	0
F — Inserts	0

(2) All surfaces including machined gasket seating surfaces shall be examined by the magnetic particle or the liquid penetrant method. When the casting specification requires heat treatment, these examinations shall be conducted after that heat treatment.

(3) Surface indications determined by magnetic particle examination shall be compared with those indicated in ASTM E125, Standard Reference Photographs for Magnetic Particle Indications on Ferrous Castings, and shall be removed if they exceed the following limits:

Type		Degree
I.	Linear discontinuities (hot tears and cracks)	All
II.	Shrinkage	2
III.	Inclusions	3
IV.	Chills and chaplets	1
V.	Porosity	1

(4) Surface indications determined by liquid penetrant examination are unacceptable if they exceed the following limits:

(-a) all cracks and hot tears;

(-b) any group of more than six linear indications other than those in (-a) above in any rectangular area of $1\frac{1}{2}$ in. × 6 in. (38 mm × 150 mm) or less or any circular area having a diameter of $3\frac{1}{2}$ in. (88 mm) or less, these areas being taken in the most unfavorable location relative to the indications being evaluated;

(-c) other linear indications more than $\frac{1}{4}$ in. (6 mm) long for thicknesses up to $\frac{3}{4}$ in. (19 mm) inclusive, more than one-third of the thickness in length for thicknesses from $\frac{3}{4}$ in. to $2\frac{1}{4}$ in. (19 mm to 57 mm), and more than $\frac{3}{4}$ in. (19 mm) long for thicknesses over $2\frac{1}{4}$ in. (57 mm) (aligned acceptable imperfections separated from one another by a distance equal to the length of the longer imperfection are acceptable);

(-d) all indications of nonlinear imperfections which have any dimension exceeding $\frac{3}{16}$ in. (5 mm).

(5) When more than one casting of a particular design is produced, each of the first five shall be examined to the full extent prescribed herein. When more than five castings are being produced, examinations as prescribed shall be performed on the first five and on one additional casting for each additional five castings produced. If any of these additional castings proves to be unacceptable, each of the remaining four castings of that group shall be examined fully.

(b) All castings having maximum body thickness $4\frac{1}{2}$ in. (114 mm) and greater and castings of lesser thickness which are intended for severe service applications[70] shall be examined as follows.

(1) Each casting shall be subjected to 100% visual examination and to complete surface examination by either the magnetic particle or the liquid penetrant method. When the casting specification requires heat treatment, these examinations shall be conducted after that heat treatment. Acceptability limits for surface imperfections shall be as given in (a)(3) and (a)(4) above.

(2) All parts of castings up to 12 in. (300 mm) in thickness shall be subjected to radiographic examination and the radiographs compared to those given in ASTM E280, Standard Reference Radiographs for Heavy-Walled [$4\frac{1}{2}$-in. to 12-in. (114-mm to 305-mm)] Steel Castings. The maximum acceptable severity levels for imperfections shall be as follows:

Imperfection Category	Maximum Severity Level
A — Gas porosity	2
B — Sand and slag inclusions	2
C — Shrinkage	
Type 1	2
Type 2	2
Type 3	2
D — Cracks	0
E — Hot tears	0
F — Inserts	0

(3) For castings having a maximum thickness in excess of 12 in. (300 mm), all thicknesses which are less than 12 in. (300 mm) shall be examined radiographically in accordance with the preceding paragraph. All parts of such castings having thicknesses in excess of 12 in. (300 mm) shall be examined ultrasonically in accordance with Section V, Article 5. Any imperfections which do not produce indications exceeding 20% of the straight beam back reflection or do not reduce the height of the back reflection by more than 30% during a total movement of the transducer of 2 in. (50 mm) in any direction shall be considered acceptable. Imperfections exceeding these limits shall be repaired unless proved to be acceptable by other examination methods.

7-4 REPAIRS

(a) Whenever an imperfection is repaired, the excavated areas shall be examined by the magnetic particle or liquid penetrant method to ensure it has been removed or reduced to an acceptable size.

(b) Whenever a surface imperfection is repaired by removing less than 5% of the intended thickness of metal at that location, welding need not be employed in making repairs. Where this is the case, the excavated area shall be blended into the surrounding surface so as to avoid any sharp contours.

(c) Castings of nonweldable materials which contain imperfections in excess of acceptable limits as given in 7-3 shall be rejected.

(d) For any type of defect, if the repair will entail removal of more than 75% of the thickness or a length in any direction of 6 in. (150 mm) or more, approval of the user or his designated agent responsible for purchasing the casting shall be obtained prior to making repairs.

(e) The finished surface of all repair welds shall be examined by the magnetic particle or liquid penetrant method. When subsequent heat treatment is required, this examination of the repaired area shall be conducted after heat treatment.

(f) See below.

(1) Except as provided in (2) and (3) below, all weld repairs shall be examined by radiography.

(2) Where the depth of repair is less than 1 in. or 20% of the section thickness, whichever is the lesser, and where the repaired section cannot be radiographed effectively, the first layer of each $^{1}/_{4}$ in. (6 mm) thickness of deposited weld metal shall be examined by the magnetic particle or the liquid penetrant method.

(3) Weld repairs which are made as a result of ultrasonic examination shall be reexamined by the same method when completed.

(g) When repair welding is done after the casting has been heat treated and when required by either the rules of this Section or the requirements of the casting specification, the repaired casting shall be postweld heat treated.

(h) All welding shall be performed using procedure qualifications in accordance with Section IX. The procedure qualification shall be performed on a test specimen of the same P-Number and same group as the production casting. The test specimen shall be subjected to the same heat treatment both before and after welding as will be applied to the production casting. All welders and operators performing this welding shall be qualified in accordance with Section IX.

7-5 IDENTIFICATION AND MARKING

Each casting shall be marked with the manufacturer's name and casting identification, including the applicable casting quality factor and material identification. The manufacturer shall furnish reports of the chemical and mechanical properties and certification that each casting conforms to all applicable requirements of this Appendix. The certification for castings for lethal service shall indicate the nature, location, and extent of any repairs.

MANDATORY APPENDIX 8
METHODS FOR LIQUID PENETRANT EXAMINATION (PT)

NOTE: Satisfactory application of this method of examination requires special skills in the techniques involved and in interpreting the results. The requirements specified herein presume application by suitably experienced personnel.

8-1 SCOPE

(a) This Appendix describes methods which shall be employed whenever liquid penetrant examination is specified in this Division.

(b) Section V, Article 6 shall be applied for detail requirements in methods and procedures, unless otherwise specified within this Appendix.

(c) Liquid penetrant examination shall be performed in accordance with a written procedure, certified by the Manufacturer to be in accordance with the requirements of Section V, Article 1, T-150.

(d) Documentation showing that the required examinations have been performed and that the results are acceptable shall be made available to the Inspector.

8-2 CERTIFICATION OF COMPETENCY OF NONDESTRUCTIVE EXAMINATION PERSONNEL

The manufacturer shall certify that each liquid penetrant examiner meets the following requirements.

(a) He has vision, with correction if necessary, to enable him to read a Jaeger Type No. 2 Standard Chart at a distance of not less than 12 in. (300 mm), and is capable of distinguishing and differentiating contrast between colors used. These requirements shall be checked annually.

(b) He is competent in the techniques of the liquid penetrant examination method for which he is certified, including making the examination and interpreting and evaluating the results, except that, where the examination method consists of more than one operation, he may be certified as being qualified only for one or more of these operations.

8-3 EVALUATION OF INDICATIONS

An indication of an imperfection may be larger than the imperfection that causes it; however, the size of the indication is the basis for acceptance evaluation. Only indications with major dimensions greater than $^{1}/_{16}$ in. (1.5 mm) shall be considered relevant.

(a) A linear indication is one having a length greater than three times the width.

(b) A rounded indication is one of circular or elliptical shape with the length equal to or less than three times the width.

(c) Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant.

8-4 ACCEPTANCE STANDARDS

These acceptance standards shall apply unless other more restrictive standards are specified for specific materials or applications within this Division.

All surfaces to be examined shall be free of:

(a) relevant linear indications;

(b) relevant rounded indications greater than $^{3}/_{16}$ in. (5 mm);

(c) four or more relevant rounded indications in a line separated by $^{1}/_{16}$ in. (1.5 mm) or less (edge to edge).

8-5 REPAIR REQUIREMENTS

Unacceptable imperfections shall be repaired and reexamination made to assure removal or reduction to an acceptable size. Whenever an imperfection is repaired by chipping or grinding and subsequent repair by welding is not required, the excavated area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners. Where welding is required after repair of an imperfection, the area shall be cleaned and welding performed in accordance with a qualified welding procedure.

(a) Treatment of Indications Believed Nonrelevant. Any indication which is believed to be nonrelevant shall be regarded as an imperfection unless it is shown by reexamination by the same method or by the use of other nondestructive methods and/or by surface conditioning that no unacceptable imperfection is present.

(b) Examination of Areas From Which Defects Have Been Removed. After a defect is thought to have been removed and prior to making weld repairs, the area shall be examined by suitable methods to ensure it has been removed or reduced to an acceptably sized imperfection.

(c) Reexamination of Repair Areas. After repairs have been made, the repaired area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners and reexamined by the liquid penetrant method and by all other methods of examination that were originally required for the affected area, except that, when the depth of repair is less than the radiographic sensitivity required, reradiography may be omitted.

2023 ASME Boiler and Pressure Vessel Code

AN INTERNATIONAL CODE

The ASME Boiler and Pressure Vessel Code (BPVC) is a globally recognized and trusted source of technical requirements and guidance for the design, construction, and certification of boilers, pressure vessels, and nuclear components. With each new edition, the Code continues to evolve, introducing new technologies and processes to promote safety across pressure equipment applications and disciplines. Developed through a rigorous consensus process and fueled by the foresight of leading industry experts from around the world, the ASME BPVC is an ever-evolving set of standards that meets the needs of a changing world.

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