Gas Industry Standard

GIS/C9:2021

Specification for

Carbon Steel Castings for Pressure Purposes Above 7 Barg (Supplementary to BS EN 10213)

Cadent Your Gas Network
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Foreword

Gas Industry Standards (GIS) are revised, when necessary, by the issue of new editions. Users should ensure that they are in possession of the latest edition. Contractors and other users external to Gas Transporters should direct their requests for copies of a GIS to the department or group responsible for the initial issue of their contract documentation.

Comments and queries regarding the technical content of this document should be directed in the first instance to the contract department of the Gas Transporter responsible for the initial issue of their contract documentation.

This standard calls for the use of procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Compliance with this engineering document does not confer immunity from prosecution for breach of statutory or other legal obligations.

Mandatory and non-mandatory requirements

For the purposes of a GIS the following auxiliary verbs have the meanings indicated:

can indicates a physical possibility;

may indicates an option that is not mandatory;

shall indicates a GIS requirement;

should indicates best practice and is the preferred option. If an alternative method is used then a suitable and sufficient risk assessment needs to be completed to show that the alternative method delivers the same, or better, level of protection.

Disclaimer

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Brief history

First published as BGC/PS/C9	November 1980
Amendment No. 1 published	May 1986
Amended issue published as GBE/C9	April 1993
Editorial update to reflect demerger November 2000	June 2001
Editorial update to reflect merger October 2002	November 2002
Editorial update to comply with GRM	August 2004
Editorial update for National Grid re-branding	October 2005
Editorial update for Cadent re-branding. Technical updates to reflect British Standards changes. Rearranged to reflect new structure of BS EN 10213.	September 2019
Editorial update to convert into a Gas Industry Standard	November 2021

1. Scope

This Gas Industry Standard specifies requirements for the materials, manufacturing, welding, inspection and testing procedures to be used in the production of carbon steel castings for components operating at pressures above 7 barg.

The specified inspection and test requirements have been determined in relation to the service conditions under which the carbon steel castings will have to operate in gas network installations.

This Gas Industry Standard applies to carbon steel castings for use in pressurized equipment such as valves, relief valves, regulators, closures, filter bodies and meter tube carriers, having an inlet connection larger than 50 mm nominal size and designed for operating pressures above 7 barg. Requirements for castings of 50 mm nominal inlet size and below will be given in the relevant equipment specification.

This Gas Industry Standard is based upon carbon steel castings manufactured to BS EN 10213. However, the requirements of this specification may also be applied to steel castings manufactured to equivalent standards as detailed in 6.1.

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

2.1 British and European standards

BS 4570, *Specification for fusion welding of steel castings*

BS 5998, *Specification for quality requirements of steel valve castings*

BS EN 10204, *Metallic products. Types of inspection documents*

BS EN 10213, *Steel castings for pressure purposes*

BS EN 12680-1, *Founding. Ultrasonic examination. Steel castings for general purposes*

BS EN ISO 9934-1, *Non-destructive testing. Magnetic particle testing. General principles*

PD 5500, *Specification for unfired fusion welded pressure vessels*

2.2 American Society for Testing and Materials publications

ASTM A216, *Standard specification for carbon-steel castings suitable for fusion welding for high temperature service*

ASTM A352, *Standard specification for ferritic steel castings for pressure-containing parts suitable for low-temperature service*

2.3 American Society of Mechanical Engineers publication

ASME IX, *Boiler and pressure vessel code Section IX - Welding and brazing qualifications*

3. Terms and Definitions

For the purposes of this document, the following definitions apply.

3.1 Contractor: The person, firm or company with whom the Company enters into a contract to which this specification applies, including the Contractor’s personal representatives, successors and permitted assigns.

3.2 Founder: The firm or company which actually produces the castings to which this

specification applies. The Founder might, therefore, be either the Contractor or the firm or company which supplies the castings to the contractor.

4. Information to be Supplied by the Purchaser

4.1 The following information shall be stated in the order:

a) The heat-treated condition in which the castings are to be supplied.

b) If castings having specific elevated temperature yield or proof stress properties, as specified in Table 6 of BS EN 10213, are required.

c) Whether pressure testing is required.

5. Manufacture

5.1 The steel shall be made by the open-hearth, electric, oxygen blown process or other processes that may be proposed as variants for consideration by the Company.

5.2 The casting shall be delivered in the normalised heat treatment condition. Quenched and tempered steel may be used if agreed with the Company.

5.3 Welding – Fabrication

5.3.1 Where it is necessary for the Founder to fabricate castings from individually cast parts, the requirements of 5.3.2 to 5.3.8 inclusive shall apply.

5.3.2 Detailed welding procedures shall be based upon the requirements of BS 4570 and submitted to the Company in accordance with 5.5.

5.3.3 The procedure documents shall include details of welder qualification tests based upon the recommendations of BS 4570 or ASME Section IX or on current documentary evidence of previous qualification having been acceptable to the Company.

5.3.4 Fabrication of castings shall be carried out only by welders who have successfully completed a qualification test as indicated in 5.3.2 and 5.3.3.

5.3.5 All fabrication welds for both pressure containing parts and non-pressure containing parts shall be examined as follows:

a) Pressure containing parts

Welds between or on pressure containing parts shall be examined and judged according to the requirements of PD 5500 for Category 1 pressure vessels.

The testing shall be by methods specified in BS EN 10213 Table 1 and section 6.3.1.5 in this specification.

b) Non-pressure containing parts

Welds on non-pressure containing parts shall be examined by MPI and visual inspection in accordance with the methods specified in BS EN 10213 Table 1 and section 6.3.1.5 in this specification.

Defects revealed by MPI shall be judged in accordance with BS 5998.

5.3.6 The alignment of sections shall be such that the maximum off-set at surfaces is not greater than 3 mm for nominal wall thickness up to and including 50 mm or the lesser of one sixteenth of nominal wall thickness or 9 mm for thicknesses greater than 50 mm. The alignment at the root face shall be within 1.5 mm. In addition, the alignment of the section centre lines shall be within 1.5 mm for thicknesses up to and including 50 mm or 3 mm for thicknesses greater than 50 mm.

To achieve the above results, the casting wall thickness at the butt weld may be profiled with a taper not greater than 1 in 4, provided that the design wall thickness at the weld is maintained.

5.3.7 Weld profiles shall blend smoothly with the body of the casting. Irregular weld profiles and other surface defects shall be removed by careful hand grinding. The final surface of the weld reinforcement shall be of sufficient standard to allow competent interpretation during NDT.

5.3.8 Undercut, shrinkage grooves, root concavity, excess penetration and overlap are not acceptable and shall be dressed smooth provided that the casting design wall thickness is maintained.

5.4 Welding – Rectification

5.4.1 It is accepted in principle that rectification of castings by welding is sometimes necessary to meet the requirements of the specification. Where it is necessary for the Founder to repair castings by welding, the requirements of 5.4.2, 5.4.3 and 5.4.4 shall apply.

5.4.2 Welding procedures shall be based on the recommendations of BS 4570.

5.4.3 The procedure documents shall include details of welder qualification tests based on the recommendations of BS 4570 or ASME Section IX.

5.4.4 Rectification of castings shall be carried out only by welders who have successfully completed a qualification test as indicated in 5.4.2 and 5.4.3.

5.4.5 All excavations of casting defects prior to rectification shall be subjected to MPI and judged in accordance with BS 5998 before welding.

5.4.6 All major weld rectification, as defined in Table 1, shall be done prior to the final heat treatment process.

5.4.7 Following rectification, all castings subject to major rectification shall be stress relieved.

5.4.8 Following rectification and stress relief where applicable, all castings shall be suitably dressed and shall be subjected to MPI in accordance with the inspection condition stated in BS EN 10213 Table 1 and the method stated in 6.3.1.5 and acceptance criterion specified in BS 5998.

5.4.9 All castings subject to major rectification as detailed in Table 1 shall be subjected to ultrasonic and/or radiographic inspection of the repaired area using the methods specified in BS 5998 and the quality levels specified in Appendix A, B or C, as appropriate. Defects shall be judged in accordance with the acceptance criteria specified in PD 5500.

Original wall thickness mm	Reduction in wall thickness %	
	For areas of cut-out 3,870 mm² and below	For areas of cut-out exceeding 3,870 mm²
Up to 25	75	50
Over 25 Up to and including 50	60	40
Over 50 Up to and including 100	50	30
Over 100 Up to and including 200	40	25
Over 200	30	20
Any thickness	All excavations which penetrate the wall thickness irrespective of the area of breakthrough.	
* A major rectification is one in which the excavation equals or exceeds the limits for reduction in wall thickness in the above table.		

TABLE 1 - Limits for classification of a major rectification*

5.5 Manufacturing procedure

5.5.1 In order to allow the sequence of operations to be varied to suit individual foundry practice, this specification does not outline production procedures. However, a fully detailed manufacturing procedure shall be submitted to the Company prior to commencement of production (see 5.6).

5.5.2 The manufacturing procedure shall include where applicable, but need not be limited to, the following:

- Steel making process,
- Fettling, cleaning and/or acid pickling,
- Initial assessment,
- Heat treatment,
- Methods and scope of analysis and mechanical testing,
- Non-destructive testing (NDT),
- Rectification fabrication,
- Rough machining,
- Pressure testing,
- Final inspection including NDT and dimensional checks.

5.6 Casting inspection procedure

5.6.1 General requirements

The Founder's quality control system shall be capable of implementing this specification and shall maintain close control of quality during all stages of production (see clause 11).

The Founder's proposed manufacturing and inspection procedures shall include stage inspection at appropriate stages to prove foundry technique, to reveal unacceptable defects and to facilitate examination of the castings from the early stages of manufacture through to the end product.

The Company reserves the right to inspect castings at all stages of manufacture but, with proven suppliers, a monitoring surveillance only will normally be operated.

5.6.2 Stage inspection by the Founder

During production, the castings shall be examined for defects by the Founder at appropriate stages of manufacture.

Stage inspection shall include NDT as follows, and as detailed in 6.3.1:

a) Visual examination.

b) Liquid Penetrant.

c) Magnetic particle inspection (MPI).

d) Ultrasonic and/or radiographic examination..

6. Materials

6.1 Chemical composition

Each Founder shall establish for his specific manufacturing procedure the limit on nitrogen allowed and the range of deoxidizers required to ensure the absence of significant porosity, type II sulphides and any susceptibility to intergranular fracture in the castings produced.

The chemical composition as determined by the cast analyses of the steel used in manufacture shall normally comply with the requirements for BS EN 10213 Grade GP280GH. Suitable alternative materials such as those based on ASTM A216 (Grade WCB) or ASTM A352 (Grade LCB) may be considered, depending upon design and service conditions and provided that they meet all the other requirements of this specification.

To permit satisfactory welding conditions, castings subject to welding in the field shall have a chemical composition limited in accordance with Table 2. Residual elements shall not be intentionally added and shall be kept as low as practicable. Elements unspecified shall not be intentionally added without agreement.

Element	Minimum %	Maximum %
Carbon		0.22
Manganese	*	*
Silicon		0.60
Phosphorous		0.040
Sulphur		0.040

* Variations in carbon to manganese ratio are permitted in order to obtain the required low temperature notch ductility properties. However, the manganese/carbon ratio shall be greater than 3:1 and the carbon equivalent shall not exceed 0.46 as derived from the equation:

$$CEV = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15}$$

TABLE 2 - Limits for chemical composition for castings subject to field welding

6.2 Mechanical properties

6.2.1 For all materials, the mechanical properties shall be as specified in Table 3.

Properties	Minimum Values
0.2% proof stress	245 N/mm²*
Elongation (5.65 √A = Gauge length)	20%
Charpy V-notch impact (tested at 0°C)	
- average of three specimens (full size)	27 J
- individual specimens (full size)	20 J

* For certain applications, higher yield strengths may be required and shall be the subject of specific negotiation.

TABLE 3 - Mechanical properties

6.3 Castings

6.3.1 Non-destructive testing requirements

6.3.1.1 The methods and acceptance criteria for the non-destructive inspection of castings shall be based on BS 5998, with the additional testing specified in 6.3.1.4.

6.3.1.2 Appendix A specifies the extent of testing and the acceptance levels for castings produced in large quantities. Appendix C specifies the extent of testing and the acceptance levels for castings produced in small quantities.

6.3.1.3 Where the casting has machined butt-weld ends, radiography shall be carried out on these areas for a distance of 25 mm from the weld end preparation in accordance with the methods defined in BS 5998.

6.3.1.4 Ultrasonic examination may be used as an alternative to radiography. The method shall be based on BS EN 12680-1. Quality levels to be applied when using the ultrasonic alternative are specified in Appendix D. The technique may be accepted as an alternative to radiography in the body of the casting but will only be allowed as a supplement to radiography for weld ends.

6.3.1.5 When MPI is performed, the method used shall be the portable electromagnetic (yoke) method as per section 8.3.3.4 in BS EN ISO 9934-1. The prod method shall not be used on any surfaces.

6.3.1.6 Where there is doubt about the extent or severity of a defect, further investigations shall be undertaken.

6.4 Condition of the casting

6.4.1 Fettling and finishing

All surfaces shall be satisfactorily cleaned for inspection purposes.

6.5 Additional requirements regarding the condition of the casting

When required, pressure testing (proof testing) shall be carried out by the Contractor..

7. Inspection

The manufacturer shall provide a 3.1 inspection certificate in accordance with BS EN 10204..

8. Samples

8.1 Mechanical tests shall be made on samples taken from each cast or heat treatment batch. All tests shall be taken from test bars in the fully heat-treated condition and shall comply with the properties given in Table 3.

8.2 If test bars are cast attached to the castings, they shall not be detached until after completion of heat treatment.

8.3 When separate test bars are used, they shall be cast from the same heat of steel as the castings they represent and shall be subjected to full heat treatment with those

9. Test Procedures

9.1 Tensile tests and impact tests shall be made as specified in BS EN 10213 and section 8 of this specification.

9.2 Impact tests shall be made on full size test pieces.

9.3 Shear area shall be recorded for information.

10. Marking

Castings shall have identification markings containing the following information:

a) Company order and item number.

b) Company specification number - GIS/C9.

c) Manufacturers name or mark.

d) Outside diameter and wall thickness (where applicable).

e) Steel grade and designation.

f) Cast/heat number.

g) Year of manufacture.

The marking shall be by casting-on or by low stress stamping unless otherwise agreed. Small castings may be batched, and the details marked on a label attached to each batch.

11. Variants

A contractor shall only propose variants to this specification where the text indicates that variants would be considered by the purchaser.

12. Records

Records shall be retained for ten years from the date of manufacture of castings. Such records shall include:

a) Heat treatment.

b) Details of chemical analysis and mechanical test results.

c) Sketches indicating the position and extent of any major weld rectification, a major rectification being regarded as one falling outside the limits of classification of Table 1.

d) Records relating to ultrasonic and radiographic examination.

e) Manufacturing and welding procedures.

13. Defects Revealed after Delivery

In the event of castings proving defective during subsequent manufacturing operations, such castings shall be considered not to comply with this specification, notwithstanding any previous certificate of satisfactory testing. Defects that are the result of improper treatment after delivery shall not be grounds for rejection.

Annex - A Non-Destructive Testing Procedures for Castings Produced in Large Quantities

A.1 General

This appendix specifies the extent of testing and acceptable quality levels for castings produced in large quantities. The quality levels are those defined in BS 5998 and specified in Table A.1 below.

<table>
<tr><th rowspan="2">Quality Level</th><th colspan="3">Inspection Requirements</th></tr>
<tr><th>Visual</th><th>MPI</th><th>Radiography</th></tr>
<tr><td>I</td><td rowspan="5">All pressure containing parts</td><td>100% of Pressure containing Parts</td><td>100% of pressure containing parts</td></tr>
<tr><td>II</td><td rowspan="3">Nominated areas</td><td rowspan="2">Nominated areas</td></tr>
<tr><td>III</td></tr>
<tr><td>IV</td><td>-</td></tr>
<tr><td>V</td><td>-</td><td>-</td></tr>
</table>

TABLE A.1 - BS 5998 Table 1: Quality levels and inspection requirements

A.2 Extent of Inspection

A.2.1 Class 300 and below (all sizes) and Class 600 (≤450 mm nominal size)

Individual castings shall be inspected up to the limiting numbers defined in Table A.2

Nominal size mm	Quantity
Up to and including 100	25
Over 100 Up to and including 200	15
Over 200 Up to and including 450	10
Over 450	5
NOTE: The above quantities may be achieved by the summation of identical castings produced for separate orders.	

TABLE A.2 - Numbers of accepted consecutive castings

Following satisfactory inspection of individual castings to the numbers defined in Table A.2, inspection shall be reduced to 10% of castings from each cast.

A.2.2 Class 600 (greater than 450 mm nominal size) and classes above Class 600

Every casting shall be examined.

A.3 Acceptable Quality Levels

A.3.1 The acceptance quality levels for the body of the castings are defined in Table A.3.

A.3.2 For castings with butt weld ends, the quality level for the weld preparation and the adjacent

25 mm shall be I.

Class/size	Position in casting sequence (1)	Quality level		Nominated Area (2)
		Plug	Others	
150	1st batch	IV	IV	All accessible surfaces
	Subsequent 10% samples	IV	IV	Critical areas
300, 400	1st batch	III	I	Critical areas
600 (≤450 mm)	Subsequent 10% samples	III	I	Critical areas
600 (>450 mm) and 600+	All	III	I	Critical areas

NOTES

1. '1st batch' is defined by the quantities in Table A.2.
2. 'Critical areas' includes changes in section, fillet radii and any other areas stipulated to the foundry by the Company

TABLE A.3 - Acceptance quality levels

Annex - B Non-Destructive Testing Procedures for Castings Produced in Small Quantities

B.1 General

This appendix specifies the extent of testing and acceptable quality levels for castings produced in small quantities.

B.2 Extent of Inspection and Acceptance Levels

B.2.1 The extent of inspection and acceptance quality levels for the body of the castings are specified in Table B.1.

B.2.2 For castings with butt weld ends, the quality level for the weld preparation and the adjacent 25 mm shall be I.

Class	**Position in casting sequence**	Quality level		Nominated Area*
		Plug	Others	
≤150	1st off	IV	IV	All accessible surfaces
	All Subsequent castings	IV	IV	Critical areas
>150	1st off	III	I	-
	All Subsequent castings	III	I	Critical areas
* 'Critical areas' includes changes in section, fillet radii and any other areas stipulated to the foundry by the Company				

TABLE C.1 - Extent of inspection and acceptance levels

Annex - C Ultrasonic Inspection

C.1 Ultrasonic inspection shall be in accordance with BS EN 12680-1.

C.2 Table C.1 lists the severity levels from BS EN 12680-1 which shall be considered equivalent to the ASTM radiographic acceptance levels specified in BS 5998.

Discontinuity type	ASTM severity level	BS EN 12680-1 severity level
A	2 3	2 4
B	2 3	1 3
CA	2 3 4	3 3 4
CB	2 3 4	2 3 3
CC	2 4	2 4
CD	2 4	2 3
A = Gas Porosity, B = Sand / Slag Inclusions, CA - CD = Shrinkage Type Indications		
Notes: 1. For severity levels 1 and 2, the maximum indicated discontinuity size shall be a maximum of 10% of the total zone thickness for the core zones. 2. The maximum indicated dimension of a single discontinuity is 320 mm. The area of a single discontinuity is defined as the product of the maximum through wall length and the maximum indicated dimension. 3. There shall be no hot tears, cracks, unfused chaplets, chills or inserts.		

Table D.1 - Severity levels for ultrasonic inspection