COMPARISON TABLE FOR M9B-1960 SPECIFICATION FOR SOLID ROLLED STEEL WHEELS FOR CARRIAGES AND WAGONS

ERS

1. Quality of material

The wheels shall be forged and rolled from the highest quality of steel ingots of a length and weight to produce, after sufficient discard has been taken, two or more wheels blanks from each ingot. The forging and rolling process shall be performed in such a manner that the central axis of the ingot shall coincide with the axis of the wheel. The ingots shall be made by the acid or basic open hearth or electric process and the wheels shall show on analysis not more than the following limits of sulpher or of phosphorous.

"Steel made by the acid open hearth or electric process: not more than 0.06 per cent of sulpher or of phosphorous for Class C wheels, and not more than 0.05 for Class D & E wheels".

"Steel made by the basic open hearth process: not more than 0.06 per cent of sulpher or of phosphorous for Class C & D wheels, and not more than 0.05 per cent of sulpher or of phosphorous for Class E wheels".

The manufacturers shall supply an analysis of each cast when required to do so.

2. Freedom from defects

The wheels shall be free from defects of any kind, and accurately finished to the prescribed dimensions. The disc portion of the wheel shall be of uniform section and shall not vary more than 1/16 inch (1.5 mm) under or 1/8 inch 3 mm) over the specified dimensions, and in any one wheel the difference between the minimum and maximum thickness at any given radius shall not be more than 1/16 inch (1.5 mm). Measurements for thickness shall not be made, however, at any point where there may be an isolated depression less than 1 inch (25.50 mm) in length.

JRS (JIS)

Quality

Wheels shall be manufactured from killed steel ingots produced by open-hearth furnace, electric furnace or pure-oxygen process. The ingot shall be bottom-poured and have round bottom, and the pipe caused shall be 75 mm or less in diameter at the center of the ingot. The top shall be discarded sufficiently as required.

The chemical composition is: (%)

C : 0.60 ~ 0.75

Si: 0.15 ~ 0.35

Mn: 0.50 ~ 0.90

P, S: 0.050 or less (for acid furnace processing)

0.045 or less (for basic furnace processing)

Freedom from defects

The wheel shall be uniform in quality and free from any defect in service.

Tolerances in plate thickness:

(i) In case that the finish is specified for curved portion at the root of the boss:

+6 ~ 0 mm

(ii) In case that no finish is specified for curved portion at the root of the boss:

+8 ~ 0 mm

UIC

Quality

Wheels shall be manufactured from killed steel ingots produced in open-hearth furnace, electric furnace, or top-blown oxygen converter. Top and bottom of ingot shall be discarded sufficiently as required. Chemical composition shall be as given below.

Non-treated Normarized — Cr + Mo + Ni + Cu ≤ 0.70

Type	C %	Mn ≤	Si ≤	P ≤	S ≤	Cr ≤	Ni ≤	Mo ≤	Cu ≤	V ≤
R-1	~	1.20	0.50	0.04	0.04	0.30	0.30	0.05	0.03	0.05
R-2	~	1.20	0.50	0.04	0.04	0.30	0.30	0.05	0.30	0.05
R-3	0.70	0.90	0.50	0.04	0.04	0.30	0.30	0.05	0.30	0.05

Tread hardened — Cr + Mo + Ni + Cu ≤ 0.60

Type	C %	Mn ≤	Si ≤	P ≤	S ≤	Cr ≤	Ni ≤	Mo ≤	Cu ≤	V ≤
R-6	0.48	0.75	0.40	0.04	0.04	0.30	0.30	0.05	0.30	0.05
R-7	0.52	0.80	0.40	0.04	0.04	0.30	0.30	0.05	0.30	0.05
R-8	0.56	0.80	0.40	0.04	0.04	0.30	0.30	0.05	0.30	0.05
R-9	0.60	0.80	0.40	0.04	0.04	0.30	0.30	0.05	0.30	0.05

Freedom from defects

Surface defects on wheel shall be removed through all the processes.

BS

Quality

Wheels shall be made from steel material produced in acid or basic open-hearth furnace or electric furnace process.

The ingot shall have sufficient amount of discard performed, and two billets or more shall be taken from each ingot. The chemical composition shall be as follows:

Class B (for any type of furnace) (%)
P, S ≤ 0.06

Class C (for any type of furnace)
P, S ≤ 0.06

Class D (for acid open-hearth furnace)
P, S ≤ 0.06

(for basic open-hearth furnace, electric furnace)
P, S ≤ 0.05

Class E (for any type of furnace)
P, S ≤ 0.05

Forging and rolling shall be performed in such a manner that the axis of ingot and the axis of wheel may coincide.

Freedom from defects

Surface flaws shall be completely removed.

Tolerance for plate thickness shall be $^{+3.2}_{-1.6}$.

Circumferential variation in thickness shall be within 1.6 mm.

AAR

Quality

The material shall be produced in open-hearth furnace, electric furnace or converter. The ingot shall have its incomplete portions discarded sufficiently as needed. The chemical composition shall be as follows:

C (%)	Class V	0.65 ~ 0.80
	Class L	0.47 or less
	Class A	0.47 ~ 0.57
	Class B	0.57 ~ 0.67
	Class C	0.67 ~ 0.77
Mn (%)		0.60 ~ 0.85
P (%)		0.05 max.
S (%)		0.05 max.
Si (%)		0.15 max.

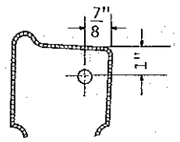
Disc thickness tolerances

Minimum values are specified by types of wheels.

ERS	JRS (JIS)	UIC	BS	AAR
3. Branding The wheels shall be distinctly stamped with the indentifying cast number. The name or initials of the manufacturer, the letters "E.R.", the order number and the date shall be stamped cold on the boss. The letters shall be not less than 8/8" (9.5 mm) and not more than 1/2" (12.5 mm) high.	Stamping Not specified in the Specification. Drawings indicate the stamping of date and charge name, with letters of 10 mm in size.	Stamping Manufacturer's name, charge name, state of execution, date of manufacturer, position and quantity of unbalance (as indicated in the order sheet).	Stamping Charge name shall be stamped hot on the disc portion, and the manufacturer's name and the date of manufacturer shall be stamped cold on the boss. The stamped letters shall be 9.5 to 12.7 mm in size.	Stamping (1) Serial number, date of manufacture, manufacturer's name, class (2) Positions to be stamped: (i) Locomotive ... Hot-stamped on interior rim face (or on exterior end face of boss) (ii) Freight car ...Cold-stamped on interior end face of boss (iii) Passenger car ... Cold-stamped on interior or exterior end face of boss
4. Heat treatment The wheels may be supplied with or without heat treatment at the option of the manufacturer.	Heat treatment The Class 1 wheel shall remain as rolled, and the Class 2 wheel shall have its tread heat-treated. Hs 37 ~ 45 for Class 1 and Hs 46 ~ 52 for Class 2.	Heat treatment R1 ~ R3 Normalizing R6 ~ R9 Hardening and tempering of tread	Heat treatment The execution of heat treatment shall be left to the selection of the manufacturer.	Heat treatment The wheels of Classes L, A, B and C shall be heat-treated. L: HB 197 ~ 277 B: HB 277 ~ 341 A: HB 255 ~ 321 C: HB 321 ~ 363
5. Number of centres to be tested Extra wheels for testing in the manner described in Clauses 6 and 7 shall be provided by the manufacturer, at his own expense, at the rate of one wheel for each 100 wheels or portion thereof in each cast as submitted for testing, with the exception that if there are not more than 110 wheels in the cast one wheel only shall be selected. The E.R. Inspecting Engineer shall select and test such of the wheels as he may think proper to the extent of the number specified above. The wheels tested by the falling weight test sha-l be handed over to the E.R. Inspecting Engineer free of charge if required, and shall be held to represent correctly the average quality of the lot presented from the cast from which they were selected. The selected wheels shall comply with the following tests without further re-heating or any other manipulation whatever, either of the wheels selected for testing or of any portion cut therefrom to furnish the test pieces.	Number of test pieces The number of tensile test pieces shall be one per charge.	Number of test pieces As the number of tensile test specimens, one wheel shall be selected for each charge of up to 250 wheels, and two wheels shall be selected for each charge of more than 250 wheels. Two test pieces shall be taken from one wheel: one at the rim and the other at the disc.	Number of test pieces Falling weight and tensile test pieces shall be sampled one each per 120 charges.	Number of test specimens (No tensile test specified.)

ERS	JRS (JIS)	UIC	BS	AAR
6. Falling weight test The wheels shall be placed flat with its flanged side uppermost upon a circular metal ring having an internal diameter approximately the same as the internal diameter of the wheel and resting upon a block of metal of not less than 5 tons (11,200 lb. = block of metal of not less than 5 tons weight supported on a rigid concrete or other solid foundation and shall withstand without fracture blows from a falling weight of 1 ton. The weight shall be allowed to fall freely on to the boss from the height to 5 feet (1.5 m), 10 feet (3.0 m), 15 feet (4.5 m) and 20 feet (6.00 m) until the striking energy in foot/ton corresponds to that given by the following formula. $E = 2.8 \times R \times T$ Where E = Striking energy in foot/ton. 2.8 = Constant R = Radius in inches, measured from the inside of the rim on the flange face of the wheel, as rolled. T = Thickness of the web in inches as rolled. The thickness of the web shall be measured at the junction of the boss radii and the web. The height of the final blow shall be reduced if necessary, to meet the requirements of the formula.	Falling weight test None	Falling weight test None	Falling weight test Same as ERS	Falling weight test None
7. Tensile test A standard test piece C (see Appendix), machined cold from each wheel tested as above, and taken from the position shown in fig. shall show the tensile breaking strength and minimum elongation given in the table, the intermediate elongations being in proportion.	Tensile test The tensile test piece shall be taken from the position shown below.	Tensile test	Tensile test Tensile test piece shall be taken at the position shown below.	Tensile test

ERS



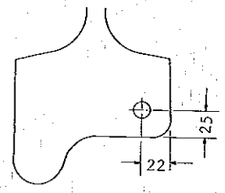
CLASS	TENSILE BREAKING STRESS		Minimum Elongation per cent
	Tons (lb) per square inch	Kg per m/m²	
C	50 (112,000) to 55 (123,200)	78.74 to 86.62	13 to 11
D	56 (125,440) to 62 (138,880)	88.49 to 97.64	10 to 8
E	63 (141,120) to 69 (154,560)	99.22 to 108.67	10 to 8

Should a tensile test piece break outside the middle half of its gauge length (i.e. within the length covered by a quarter of the gauge length measured on either side of the centre point) it may be discarded, and such break shall not be considered as a failure of the test, and a fresh test, or fresh tests, may be made by the manufacturer with a test piece, or test pieces, taken from the same wheel from which the discarded test piece was taken.

8. Additional tests before rejection

In the event of the wheels selected for testing not satisfying the requirements of clauses G and 7 the E.R. Inspecting Engineer, as specified below, shall make further tests at the expense of the manufacturer before finally refusing or accepting the wheels represented:

JRS (JIS)



The mechanical properties shall be as follows:

Tensile strength: 80 ~ 100 kg/mm²

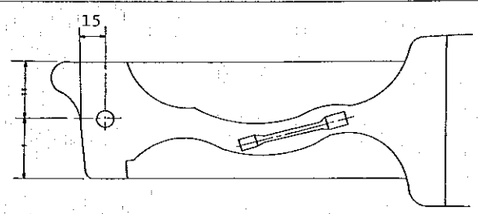
Elongation: 12 or more - 8 or more

Reduction of area: 16 or more - 12 or more

Additional test

In case that the tensile test result was not acceptable, re-test shall be conducted after the wheel is heat-treated (or re-heat-treated), provided, however, such heat treatment shall be limited to only once.

UIC



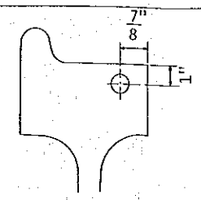
Mechanical properties shall be as follows:

Type	Heat-treated	Yield point N/mm²	Tensile strength N/mm²	Elongation %	at 20°C I.V joules
R1	–	Recorded for reference purposes	600 ~ 720	12	–
	N		"	18	15
R2	–	"	700 ~ 840	9	–
	N		"	14	10
R3	–	"	800 ~ 940	7	–
	N		"	10	10
R6	T	"	780 ~ 900	15	15
R7	T	"	820 ~ 940	14	15
R8	T	"	860 ~ 980	13	15
R9	T	"	900 ~ 1050	12	10

Additional test

If the test piece fails to pass the test, the wheels of the lot represented by it shall be the object of rejection, provided, whoever, that the retest may be arranged between the manufacturer and purchaser.

BS



The values shall be as follows:

Class	Tensile strength (kg/mm²)	Elongation
B	66.1 ~ 77.2	18≦ ~ 14≦
C	77.2 ~ 88.2	14≦ ~ 12≦
D	88.2 ~ 99.2	12≦ ~ 10≦
E	99.2 ~ 110.0	10≦ ~ 8≦

Additional Tests

(1) Falling weight test

If a wheel fails to pass the falling weight test, test shall be conducted on additional two wheels. In place of re-testing on two wheels, or if one of the retested two wheels has failed to pass the falling weight test, the manufacturer may conduct test by re-heat-treatment of the lot subject to the purchaser or its representative's approval.

AAR

None

Additional Tests

None

ERS	JRS (JIS)	UIC	BS	AAR
(a) Should the wheel fail in the falling wheight test the E.R. Inspecting Engineer shall select two more wheels from the same lot, all of which, with his permissiion, may be beat treated or re-heat treated before the selection is made. Should either of the retested wheels fail to fulfil the conditions of the falling-weight test, the manufacturer, with the concurrence of the E.R. Inspecting Engineer may heat treat or re-heat treat the bulk from which the E.R. Inspecting Engineer shall select two more wheels for further test. Should the results of these repeated tests be satisfactory, the wheels represented shall be held to have passed the falling-weight test. Should either of these wheels fail to fulfil the conditions of the falling-weight test, the wheels represented shall be rejected. (b) Should the wheel or wheels which have passed the falling-weight test fail in the tensile test, two more tensile test pieces shall be taken from the wheel has given the defective test, for repeating the test. The wheels shall be accepted if the results of these further tests are satisfactory should the repeated tensile tests not prove satisfactory the manufacturer, with the concurrence of the E.R. Inspecting Engineer, may heat treat or re-heat treat the bulk and present them again for the falling-weight and tensile tests. Should either or these fail, the lot shall be rejected. Should the results of these repeated tests prove satisfactory, the wheels represented shall be accepted.			(2) Tensile test If a tensile test piece has failed to satisfy the value given above, or if the purchaser or its representative agrees that this unfavorable test piece does not represent the lot correctly, the retest may be performed on additional two wheels. In place of conducting this retest, or if one of the test pieces of this retest fails to pass the test, the fa-ling weight test and the tensile test may be performed after re-heat-treatment subject to the approval of the inspector.	

ERS	JRS (JIS)	UIC	BS	AAR
9. Inspection The E.R. Inspecting Engineer shall be allowed unhindered access to the manufacturer's works at all times during working hours when wheels on order are in process of manufacture or delivery. He shall be at liberty to inspect the manufacture at any stage and to reject material which does not conform to his specifications. Material so rejected shall be cut up immediately or marked at once in the presence of the inspector in such a way that it cannot be confused subsequently with satisfactory material.	Inspection The manufacturing of wheels shall be subjected to the supervision and inspection by the inspector appointed by the Japanese National Railways.	Inspection None	Inspection Same as ERS	Inspection The inspector will have free access for inspection in any process of manufacture of wheels. The manufacturer shall supply all conveniences so that the inspector may recognize that the manufacture of the wheels complies with the Specification.
10. Testing facilities The manufacturer shall supply the material required for testing free of charge, and at his own cost shall furnish and prepare the necessary test pieces and supply labour and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.	Testing facilities None	Testing facilities None	Testing facilities Same as ERS	Testing facilities None
		Others The following items are also specified in the UIC Standards: (1) Impact values (2) Microscopic structures (3) Static balance test (4) Hardness distribution in cross section (5) Open area ratio (6) Ultrasonic flaw detection (7) Magnaflux inspection		Others The following items are also specified: (1) Ultrasonic flaw detection (2) Shot peening (3) Magnaflux inspection

APPENDIX 4-7

COMPARISON TABLE FOR M10 STEEL CASTINGS

<table>
<tr><th>ERS</th><th>JIS</th><th>BS</th><th>Remarks</th></tr>
<tr><td>No. M. 10-1959
Specification for Steel Castings</td><td>UDC 669.141.25
JAPANESE INDUSTRIAL STANDARD JIS
Carton Steel Castings G 5101-1975</td><td>BS 3100 : 1967
BS 592
CARBON STEEL CASTINGS FOR GENERAL PURPOSES</td><td></td></tr>
<tr><td>1. Scope
This specification covers carbon steel castings for rolling stock, classified as Grade A and Grade B.
Grade A: covers castings for general service.
Grade B: covers castings for high stresses such as wheel centres, frame stretchers, borgie castings etc.</td><td>1. Scope
This Japanese Industrial Standard specifies carbon steel castings including steel pipes made by centrifugal casting hereinafter referred to as the "steel castings".
2. Type and Symbol
The types and symbols of the steel castings shall be as shown in Table 1.
Table 1. Type and Symbol
<table><tr><th>Type</th><th>Symbol</th><th>Remarks</th></tr><tr><td>1</td><td>SC 37</td><td>For electrical machine parts</td></tr><tr><td>2</td><td>SC 42</td><td>For general structure</td></tr><tr><td>3</td><td>SC 46</td><td>For general structure</td></tr><tr><td>4</td><td>SC 49</td><td>For general structure</td></tr></table></td><td></td><td></td></tr>
<tr><td>2. Quality of material
The castings shall be made from steel produced by the acid or basic open hearth, acid bessemer or electric furnace processes, and shall not show on analysis more than 0.06% of sulphur or of phosphorus.
The manufacturer shall supply an analysis of each cast when required to do so.</td><td>4. Quality
4.2 Chemical Composition
The chemical composition shall be determined by ladle analyses, and shall present less than 0.050% of P and S respectively. Concerning the contents of elements which are not specified, arrangements shall be made for determination between the purchaser and the manufacturer.</td><td>Chemical composition. The steel shall contain:
BS 592: 1967
<table><tr><th>Element</th><th>Grade A
%
max.</th><th>Grade B
%
max.</th><th>Brade C
%
max.</th></tr><tr><td>Carbon</td><td>0.25</td><td>0.35</td><td>0.45</td></tr><tr><td>Silicon</td><td>0.60</td><td>0.60</td><td>0.60</td></tr><tr><td>Manganese</td><td>0.90</td><td>1.0</td><td>1.0</td></tr><tr><td>Sulphur</td><td>0.060</td><td>0.060</td><td>0.060</td></tr><tr><td>Phosphorus</td><td>0.060</td><td>0.060</td><td>0.060</td></tr><tr><td>Nickel</td><td>0.40</td><td>-</td><td>-</td></tr><tr><td>Chromium</td><td>0.25</td><td>-</td><td>-</td></tr><tr><td>Molybdenum</td><td>0.15</td><td>-</td><td>-</td></tr><tr><td>Copper</td><td>0.30</td><td>-</td><td>-</td></tr></table></td><td></td></tr>
</table>

ERS	JIS	BS	Remarks
3. Annealing All castings shall be annealed at a suitable temperature and left to cool in such a way that a fine grain structure is obtained without any detrimental stresses arising in the castings.	3. Method for Manufacture The steel castings shall be heated uniformly in a furnace, and shall be processed by a heat-treatment by annealing, normalizing, tempering after normalizing or tempering after quenching. However, the heat treatment may not be effected if so approved by the purchaser.	14.1 Specified analysis The specified ranges of chemical composition are based on cast analyses and, on request, the manufacturer shall supply a certificate of analysis of each cast of steel. This will not include values for residual elements unless requested by the purchaser or unless there is reason to suspect the presence of such elements in excessive amounts. BS-592 Heat treatment. All castings shall be supplied in the heat-treated condition. The heat treatment shall be carried out at suitable temperatures to give the mechanical properties specified.	
4. Moulding The castings shall be accurately moulded in accordance with the pattern or working drawing supplied by the E.R. Mechanical and Electrical Engineering Department with the addition of such lettering as may be prescribed by the E.R. Inspecting Engineer.	4.5 Shapes, Dimensions, Weights and Tolerances The shapes, dimensions and weights of the steel castings shall conform to the drawings or models. The tolerance shall be defined in accordance with JIS B 0412. However, if agreements have been made regarding this matter between the purchaser and the manufacturer, such arrangements shall overrule JIS B 0412.		
5. Branding The cast number, the manufacturer's name or initials, the order number, the letters "E.R." and the year of manufacture shall be stamped on each casting in letters 9 mm. high, close to the moulded number of the pattern.	9. Marking Each piece of the steel castings which has passed the inspection shall be clearly marked at the place of manufacture with the following particulars. When so approved by the purchaser, a part of the marking may be omitted. (1) Symbols of type (2) Melt number (3) Manufacturer's name of abbreviation thereof	1.8 Identification If requested by the purchaser and by agreement with the manufacturer, each casting shall be legibly marked, where practicable, with a number or identification mark by which it can be traced to the manufacturer and the cast from which it was made. Small castings may, by agreement, be batched, and the identification mark stamped on a tag attached to each batch.	
6. Freedom from defects The steel castings shall not exhibit any pouring defects such as blow holes, pores, sand holes, cracks, hard spots etc. liable to deteriorate the usefulness or the maching properties or general workability of the products.	4.1 The steel castings shall be uniform in quality and free from defects such as flaws or blowholes which are harmful in actual utilization.	1.19 Freedom from defects The castings, as delivered to the purchaser, shall be free from harmful defects (see 1.13).	

ERS	JIS	BS	Remarks
7. Repairs to defective castings Any defects or unsound metal present in a casting from whatever cause arising shall be left bare, and no filling with the object of obliterating such defects shall be permitted unless previously sanctioned by the E.R. Inspecting Engineer. Any castings upon which such work has been done without such sanction having been obtained shall be rejected. When any sanctioned repairs have been completed the casting shall be annealed as provided in Clause 3. When steel castings in the rough are ordered, surfaces which will be machined ultimately must be rough machined by the suppliers to ensure soundness. Sufficient allowance must be made for finish machining to the dimensions shown on the drawing.	5. Repair 5.1 The defects in the steel castings may be repaired by welding or other suitable methods. However, when required by the purchaser, or when there is a danger that the quality of the steel castings may be affected by the repair, discussions shall be held between the purchaser and manufacturer regarding the treat ment of the defects. 7.5 The steel castings shall not receive painting or any other treatment which may interfare with the inspection prior to the inspection.	1.15 Rectification of castings Unless otherwise specified by the purchaser on the enquiry and order, castings may be rectified by welding without the previous sanction of the purchaser. (1) Welding. It is recommended that rectification by welding shall be carried out in accordance with Appendix A. (2) Re-examination. If castings have been subjected to non-destructive testing by agreement between the manufacturer and the purchaser, the castings shall be re-examined in the area of the repair following any rectifying operation performed on the castings.	
8. Testing The steel castings shall be tested at the manufacturer's works. The E.R. Inspector shall receive a list of the castings in lots or melts if they can be reliably separated. The castings are to be divided in lots up to 3000 kgs., or part melts up to 5000 kgs. to be put separately according to the class of material and the method of casting on the test block.	6.1 Analysis 6.1.1 The specimen for analysis shall be extracted from the ladle. When required by the purchaser, however, the product analysis shall be conducted to the steel castings. In this case, the sampling method and the tolerance range for chemical composition shall conform to agreements between the purchaser and the manufacturer. 6.2.1 Unless otherwise specified, the mechanical tests shall be conducted at the manufacturer's work. In this case, the manufacturer shall have the purchaser witness the test when required by the purchaser. 10. Report The manufacturer shall submit to the purchaser the results of specified test as a detailed report stating the melt number.	1.10.1 If a purchaser requires the manufacturer to provide a certificate giving the results of tests, he shall state this on the enquiry and order and the type, location and number of test samples shall be at the discretion of the manufacturer. 1.10.2 If a purchaser requires tests to be carried out in his presence or in the presence of his representative, he shall state this on the enquiry and order (see 1.2(9) and 1.17) and the following procedure shall apply:	

ERS	JIS	BS	Remarks
9. Selection of test pieces (a) For castings over 500 kgs. weight each. A test block for the main and the additional test pieces shall be cast on each casting. (b) For castings between 100 and 500 kgs. weight each. A test block for one tensile test piece is to be cast on each casting. If this will endanger the castings, a special agreement shall be made between the E.R. Inspector and the manufacturer. (c) For castings under 100 kgs. weight each. A test block for one tensile test piece shall be cast on each casting, or, if possible, the test piece shall be cut from the casting, otherwise separate test pieces shall be cast from each melt.	7.3 Test Specimen The test specimen shall be prepared by the following procedures. In the case of the cast steel pipe made by centrifugal casting, however, the test specimens shall be prepared by the agreements between the purchaser and manufacturer. (1) The test specimen shall be cast jointly with the steel castings. The test specimen may be cast separately only when so approved by the purchaser. (2) The dimensions of the test specimen shall conform to either of the following shapes. However, this shall not apply when approved by the purchaser otherwise. (3) Unless otherwise specified, the test specimen shall be cut off after the final heat treatment of the steel castings. When it is difficult to give a heat treatment to the specimen jointly with the steel casting, or when the specimen has been cast separately, the specimen shall be processed by a simultaneous heat treatment together with the steel castings. 7.4 One tension test piece shall be prepared from each specimen which has been taken from the same melt and the same heat treatment. Regarding the steel pipes made by centrifugal castings, the number of the specimens shall be decided by a mutual agreement between the purchaser and the manufacturer.	1.10.2.1 At least one set of tests, as required by the relevant specification, shall be made from each cast or each heat-treatment batch. 1.10.2.3 By agreement between the purchaser and the manufacturer, test bars shall be cast attached to, or separate from the castings. When test bars are attached, the precise location and method of attachment shall be the subject of agreement, since the attachment of test bars may have adverse effects on the quality of the casting. If the purchaser does not make such an agreement with the manufacturer prior to placing the order, the method of providing the test bars shall be decided by the manufacturer. In the case of castings where it is impracticable to provide attached test bars, separate test bars or additional castings from each melt of steel may be provided, as may be agreed between the purchaser and the manufacturer. When separate test bars are used, they shall be cast from the same heat of steel at the castings they represent and shall be heat-treated with those castings except as provided in 1.11.4. 1.10.2.4 If test bars are cast attached to the casting, they shall not be detached until after the heat treatment of the casting has been completed, nor until they have been stamped by the purchaser or his representative. Test bars shall be stamped after the heat treatment process. 1.10.3 For room temperature tensile and impact or bend tests, one test piece for the room temperature tensile test and one test piece for the bend test or one test piece with three notches in accordance with BS 131, Part 1* for the Izod impact test, shall be prepared from each test sample if required by the relevant material specification. Bend test pieces shall be either 1 in (25.4 mm) diameter or of rectangular section 1 in wide by 3/4 in (19.1 mm) thick, or proportionately smaller for smaller castings. The corners of rectangular test pieces may be sightly rounded to a randius not exceeding 1/16 in (1.6 mm). At the manufacturer's option	

ERS	JIS	BS	Remarks
		the test pieces may be unmachined, smooth machined or ground. 1.10.4 For low temperature impact tests, three test pieces shall be taken to represent each cast or heat-treatment batch. The impact test pieces shall be prepared in accordance with BS 131, Part 2*.	
10. Number of tests and additional testing. The E.R. Inspector shall choose two test pieces out of each lot or part melt. In case the test is not satisfactory, the following procedure is to be taken: (a) For castings over 500 kgs. weight each. Additional test piece of the same casting and test pieces from every casting will be tested. Castings, whose additional test pieces fail, shall be rejected. (b) For castings under 500 kgs. weight each. Two additional test pieces from two other castings will be tested, if one of them fails the lot shall be rejected. (c) For castings under 100 kgs. weight each, and without cast on test piece. Two additional test pieces cut from the casting or cast from the same melt, will be tested, if one of them fails the lot shall be rejected. (d) Test pieces rejected for obvious small defects (such as blowholes, slag effect, etc.) shall not be counted.	8. Retests 8.1 When the test piece shows defective finish or flaws which are not likely to be due to the quality of the material, the test piece may be discarded before the test and may be replaced by other test piece newly provided. 8.2 When the test piece is ruptured in a tension test at a point beyond 1/4 of the gauge length from the center of the gauge marks, and if the result does not satisfy the requirements, the test shall be cancelled, and a retest may be conducted on another test piece extracted from the same lot of specimen from which the failed test piece was taken. 8.3 When some portions of the mechanical tests do not satisfy the specified criteria, a retests may be conducted regarding the unsuccessful portion by extracting test pieces, twice as many in number of pieces as the specified test piece number, from the same specimen from which the test pieces were extracted for the original tests. 8.4 If the results of the tests on the heat treated specimens do not satisfy the specified requirements, specimen may be processed again by a heat treatment, and a retest may be conducted. Such a heat treatment shall not be conducted more than twice. The number of the specimens in the retest shall be the same as in the first test, and all the mechanical test shall be conducted again. The obtained test results shall satisfy the specified standards.	1.12 Retests 1.12.1 Should the results of any mechanical test carried out on test pieces fail to conform to the requirements of the specification, the manufacturer may, if he so desires, adopt one of the following procedures. 1.12.2 He may repeat the mechanical test (including the intercrystalline corrosion test) under which failure occurred on two additional test pieces. In the event of either of these duplicate test pieces failing to meet the requirements of the specification, the manufacturer may then follow the procedure given in 1.12.4. 1.12.4 He may submit the castings, together with the test bars, to further heat treatment, after which the test bars shall be submitted to all mechanical tests, including the intercrystalline corrosion test if appropriate, required by the specification. In the case of further failure, the castings, together with the test bars, may be submitted to not more than one further heat treatment, after which the test bars shall be subjected to all mechanical tests required by the specification. In no instance shall the castings and test bars be subjected to more than two additional heat treatment (excluding tempering).	
11. Pressure test The casting may, at the option of the E.R. Inspector, be submitted to a pressure test. The nature of the test and the testing pressure shall not be less than the pressure to which the casting is subjected in service.	Not specified	1.14 Pressure tests If specified on the enquiry and order, castings shall be pressure tested in a manner agreed between the purchaser and the manufacturer, see BS 4080*.	

ERC

12. Tensile test

A standard test piece D, or if a test piece of these dimensions cannot be obtained, a standard test piece C or test piece M or N (see Appendix), without any re-heating or any other manipulation whatever, shall show not less than the minimum tensile breaking strength and elongation given in the following table.

Description	Minimum tensile breaking strength		Minimum elongation %		
	tons/in^2	kg./mm^2 approx.	Test piece		
			C or D	M	N
Grade A	24	38	25	23	21
Grade B	33	52	19	17	15

JIS

6.2.2 Tension Test

(1) The test piece shall be Test Pieces No.4 or No.10 specified in JIS Z 2201.

(2) The test shall be carried out in accordance with JIS Z 2241.

4.3 Mechanical Properties

The mechanical properties of the steel castings shall be in accordance with Table 2.

Table 2. Mechanical Properties

Type	Symbol	Tensile Test			
		Yield point kgf/mm^2 (N/mm^2)	Tensile Strength kgf/mm^2 (N/mm^2)	Elongation %	Reduction %
1	SC 37	18 min. (177 min.)	37 min. (363 min.)	26 min.	35 min.
2	SC 42	21 min. (206 min.)	42 min. (412 min.)	24 min.	35 min.
3	SC 46	23 min. (226 min.)	46 min. (451 min.)	22 min.	30 min.
4	SC 49	25 min. (245 min.)	49 min. (481 min.)	20 min.	25 min.

Remark: The units and figures shown in parentheses are those in accordance with the S1, and have been stipulated for reference.

1 N/mm^2 = 1 MPa

BS

1.11 Mechanical tests

1.11.1 Tensile tests. If tensile tests are required by the relevant material specification, they shall be performed in accordance with BS 18*, including the determination of the yield or proof stress when specified.

Mechanical properties. The mechanical properties to be obtained on test pieces selected, prepared and tested in accordance with the requirements of Section 1 shall be as follows:

Property	Grade A	Grade B	Grade C
Tensile strength, tonf/in^2 min.	28	32	35
kgf/mm^2 min.	44	50.5	55
Yield stress or 0.5% proof stress, tonf/in^2 min.	15	17	19
kgf/mm^2 min.	23.5	27	30
Elongation, % min., on 5.65 $\sqrt{So}$	22	18	14
Angle of bend	120°	90°	–
Radius of bend	1 1/2t	1 1/2t	–
Izod impact value, ft lbf min.	15	15	10

Remarks

ERS	JIS	BS	Remarks
13. Inspection The E.R. Inspecting Engineer shall be allowed unhindered access to the manufacturer's works at all times during working hours when castings on order are in process of manufacture or delivery. He shall be at liberty to inspect the manufacture at any stage and to reject castings or material not conforming to this specification. Any castings or material so rejected shall be cut up immediately or marked at once in the presence of the inspector in such a way that they or it cannot be conused subsequently with satisfactory castings or material.	Not specified	1.17 Inspection The purchaser or his representative shall have access at all reasonable times to those parts of the manufacturer's works engaged on the order; he shall be at liberty to inspect the manufacture at any stage, to witness the required tests and to reject any material that does not comply with the relevant specification. If the castings are to be inspected during manufacture and tested in the presence of the purchaser's representative, it shall be so stated in the enquiry and order.	
14. Testing facilities The manufacturer shall supply the castings required under clauses 9 and 10 for testing free of charge and at his own cost shall furnish and prepare the necessary test pieces, and supply labour and appliances for making all test on his premises in accordance with this specification. Failing facilities at his own works for making the prescribed test, the manufacturer shall bear the cost of carrying out the tests elsewhere. SPECIAL CLAUSES FOR WHEEL CENTRES 15. Balancing test Every wheel, ordered finished (except the coupled wheels of the locomotives) shall be submitted to the balance test. When the wheels are ordered in the rough, one wheel out of every lot of 50 wheels or part thereof shall be tested after being bored and turned. The non-compensated weight measured at the outer circumference of the rim shall not exceed 0.5 kg. (approx. one Pound). The non-compensated weight is to be stamped on the side face of the rim. 16. Guarantee The supplier shall be bound to replace such wheel centre which within two years service become unfit for use. The supplier can take back, at his own expense, the faulty wheel centres.	Not specified	1.16 Testing facilities The manufacturer, in supplying the test bars as required for testing, shall prepare from them the necessary test pieces, and supply the labour and appliances for making all tests on his premises in accordance with the relevant specification. Failing facilities for carrying out the prescribed tests at his own works, the manufacturer may have the tests carried out elsewhere.	

ERS	JIS	BS	Remarks
SPECIAL CLAUSE FOR AXLEBOXES Other tests for cast steel axleboxes are to be according to specification M 250.			

COMPARISON TABLE FOR M13 GREY IRON CASTINGS (ORDINARY GRADE)

<table>
<tr><th>ERS</th><th>JIS</th><th>BS</th><th>Remarks</th></tr>
<tr><td>No. M. 13-1960
Specification for Grey Iron Castings.
(Ordinary Grade)</td><td>UDC 669.131.6:621.74
JAPANESE INDUSTRIAL STANDARD JIS
Grey Iron Castings G 5501-1976</td><td>BS.1452: 1961
BRITISH STANDARD SPECIFICATION FOR
GREY IRON CASTINGS</td><td></td></tr>
<tr><td>1. Scope
This specification covers castings in grey cast iron of ordinary grade quality for general castings.</td><td>1. Scope
This Japanese Industrial Standard specifies the iron castings which show grey in fracture.
2. Class and Symbol
The grey iron casting shall be classified as shown in Table 1.
Table 1 Class and symbol<table><tr><th>Class</th><th>Symbol</th></tr><tr><td>Grey iron casting Class 1</td><td>FC 10</td></tr><tr><td>Grey iron casting Class 2</td><td>FC 15</td></tr><tr><td>Grey iron casting Class 3</td><td>FC 20</td></tr><tr><td>Grey iron casting Class 4</td><td>FC 25</td></tr><tr><td>Grey iron casting Class 5</td><td>FC 30</td></tr><tr><td>Grey iron casting Class 6</td><td>FC 35</td></tr></table></td><td>Scope
1. This British Standard relates to seven grades of grey iron castings, viz. Grades 10, 12, 14, 17, 20, 23 and 26. The grades are numbered in accordance with the minimum tensile strength which can be expected on a 1.2 in (30.5 mm) diameter test bar. Material ordered to Grade 10 will be tested for its mechanical properties only when specifically requested by the purchaser. The grade required should be stated at the time of enquiry and order.
The basis of this standard is the tensile test but data relating to the transverse test are given in Appendix A, so that this may be used as a control test.</td><td></td></tr>
<tr><td>2. Manufacture
The castings shall be made from metal melted in any type of metallurgical plant other than an iron ore smelting furnace.</td><td>3. Manufacture
3.1 The grey iron casting shall be manufactured in cupola furnace, baby cupola, reverberatory furnace, electric furnace, crucible furnace and otherproper melting furnaces.
3.2 The grey iron casting shall be annealed so that the casting stress may be removed, when required by the purchaser.
The grey iron casting may be softened by agreement with the purchaser.</td><td>Quality of metal
2. The metal used for the manufacture of the castings shall be good quality cast iron of the grade specified. The castings shall be cast from metal melted or refined in any suitable metallurgical plant. An iron ore smelting furnace shall not be used unless special permission shall have been obtained from the purchaser.</td><td></td></tr>
<tr><td>3. Chemical composition
The composition of the iron as cast is left to the discretion of the manufacturers.</td><td>4.3 The P and S contents in Class 3 to Class 6 shall be agreed upon between the purchaser and the manufacturer.
6.2 Chemical analysis
6.2.1 The sample for chemical analysis shall, as a rule, be taken from ladle. Check analysis, however, shall be made on the product when required by the purchaser. In this case, the sampling and the allowable deviation of chemical composition shall be agreed upon between the purchaser and the manufacturer.</td><td>2. The composition of the iron as cast shall be left to the discretion of the manufacturer, but a minimum and/or a maximum percentage of phosphorus may be specified by agreement between the purchaser and the supplier.</td><td></td></tr>
</table>

ERS	JIS	BS	Remarks
4. Moulding The castings shall be accurately moulded in accordance with the patterns or drawings supplied by the E.R. Inspecting Engineer. Each casting shall have the letters "E.R." cast on it in letters not less than 1/2" (12.5 mm.) high, together with such other markings (cast or stamped) as may be directed by the E.R. Inspecting Engineer.	5. Shape, Dimension, Weight and Tolerance Thereon The shape, dimension and weight of the iron casting shall be determined by using its drawing or model, and the tolerance thereon shall be agreed upon between the manufacturer and the purchaser. 9. Marking The grey iron casting which have passed the inspection shall be marked on every casting by the workshop with the mark "Inspected", symbol for type, molten number, name of workshop or its abbreviation. In the case these markings are difficult to be done, however, other appropriate way may be adopted. When approved by the purchaser, the above items may be partially omitted.	Moulding 4. The castings shall be accurately moulded in accordance with the pattern or working drawing as supplied by the purchaser with the addition of such lettering as may be specified.	
5. Freedom from defects The casting shall be free from cracks, gas holes, flaws and excessive shrinkage. The surfaces shall be free from burnt-on sand and shall be reasonably smooth. They shall be well dressed or fettled and shall be machinable. Any flaws (blowholes, etc.) on the surface shall be left bare and no attempt shall be made to fill or otherwise obliterate them without the express agreement of the E.R. Inspecting Engineer. Any casting upon which such work has been done prior to such consent having been obtained will be rejected.	4.1 The grey iron casting shall have uniform quality and shall be free from detrimental flaws or cavities. 7.2 The inspection of appearance, dimensions and mass shall be carried out for each grey iron casting. The flaws or cavities that only slightly affect the use may be repaired by welding or other appropriate means, provided that the purchaser approves.	Freedom from defects 3. The castings shall be sound, clean and free from distortion and injurious defects. They shall be well dressed or fettled and shall be free from chill and other indications of free carbides except as specified by the purchaser. They shall be machinable by the normal methods for the grade of iron specified. By agreement between the manufacturer and the purchaser, defects may be rectified. Any casting showing defects during subsequent manufacturing operations does not comply with this British Standard, notwithstanding any previous certificate of satisfactory testing, provided the casting has not been improperly treated after delivery.	

ERS	JIS	BS	Remarks
6. Provision of test bars The E.R. Inspecting Engineer will state at the time the order is placed whether tensile or traverse tests, or both, are required. Test bars shall be cast separately from the casting under the same sand conditions(i.e. green sand or dry sand) as the castings, and from a ladle or ladles of the same metal as that used to pour the castings. The test bars shall receive the same mechanical and thermal treatment, if any, as the castings, and in the case of heat treatment the test bars shall be treated adjacent to the castings they represent. The test bars shall not be cleaned by tumbling unless the castings are so cleaned. Tensile test pieces shall be machined from transverse test bars. Tensile test pieces cast to size are not recognised by this specification.	6. Test 6.1 Mechanical test 6.1.1 The mechanical test shall, as a rule, be carried out in the manufacturing shop. In this case, the manufacturer shall allow the purchaser to attend the test when requested by the purchaser. 7.3.1 Test specimen (2) The test specimen shall be cast separately from the gray iron casting. In this case, the mould for the test specimen shall, as a rule, be of the same type as that for the grey iron casting, and it is required to cast the specimen with the same molten under the same conditions as that for the grey iron casting. By an agreement with the purchaser, however, the test specimen may be cast in monoblock with the gray iron casting. (3) The test specimen shall have 30 mm in diameter as cast. When the test specimen is determined according to principal wall thickness of the grey iron casting, however, the diameter as cast shall follow Table 3. (4) The dimensions as cast of test specimen from the gray iron casting below 4 mm and above 50 mm in principal wall thickness shall be determined by an agreement between the purchaser and the manufacturer.	Provision of test bars 7. Test bars shall normally be cast separately from the castings to which they are related, but shall be poured at the same time and from the same ladle of metal. Sufficient test bar material to meet the requirements of Clauses 10 and 11 shall be provided. When castings are moulded in loam or dry sand the test bars representing the castings shall be cast in dry sand. When castings are moulded in green sand the test bars representing the castings shall be cast in green sand or in dry sand. If the castings are produced in any other mould material, the material to be used for the mould for the test bar shall be agreed between the purchaser and manufacturer. Castings may be ordered where none of the standard test bars in Table 1 would reasonnably represent the material in the casting and in this care provision may be made, by agreement between the purchaser and manufacturer, for an additional piece to be cast on to the casting which can subsequently be removed and used to produce a test piece of suitable size in conformity with Table 2. When castings are subjected to heat treatment the test bars shall be treated under similar conditions. All test bars shall be marked to identify them with the castings they represent.	
7. Dimensions of test bars (A) Transverse test bars. The transverse test bars shall be cast to one of the following dimensions:- (a) 1.2 inches diameter and 21 inches overall length. (b) 30 mm. diameter and 650 mm. overall length. If the diameter of a transverse test bar is found to be more than 0.05 inch (1.2 mm. approx.) greater or less than the dimensions given, it shall be rejected. Transverse tests shall not be carried out on machined bars.	6.1.2 Tension test (1) Test Piece It shall be formed from the test specimen or from the test piece fractured by deflection test to No. 8 specified in JIS Z 2201. (2) Test Method The test method shall follow JIS Z 2241.	Dimensions of test bars 8. Tensile test bars. Tensile test bars from which the appropriate test piece is machined shall be cast as uniform cylindrical bars to the dimensions given in Table 1. It is permissible to use material originally provided for transverse test. If it is not practicable to use a 1.6 in (40.6 mm) or 2.1 in (53.3 mm) nominal size test bar because of limitation of testing facilities, the 1.2 in nominal size bar may be used subject to agreement with the purchaser. In this case, the mechanical properties specified for the 1.2 in bar	

ERS	JIS	BS	Remarks

No. 8 Test piece
This test piece shall be principally used for tension test of general iron castings. It shall be made out of the sample with the dimensions given in the Table, and the parallel portion shall be finished to the diameter D.

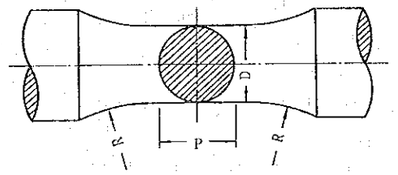


Fig. 8

Unit: mm

Division of test piece	Size of casted sample (dia.)	Length of parallel portion P	Dia. D	Radius of shoulder R
8A	Approx. 13	Approx. 8	8	16 or more
8B	Approx. 20	Approx. 12.5	12,5	25 or more
8C	Approx. 30	Approx. 20	20	40 or more
8D	Approx. 45	Approx. 32	32	64 or more

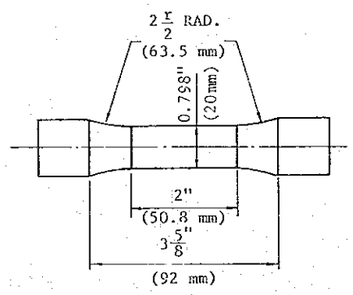
appropriate to the grade of iron shall apply. An alternative procedure is to adopt that given in the third paragraph of Clause 7, and in this case the strengths obtained shall be those for the appropriate larger bar, even if a small test piece was produced from the test portion of the casting.

Table 1 Tensile test bars as cast

Cross-sectional thickness of casting		Diameter as cast	Approximate minimum overall length
Over	Up to and including		
in	in	in	in
-	3/8	0.6	5
3/8	3/4	0.875	7
3/4	1 1/8	1.2	9
1 1/8	1 5/8	1.6	11
1 5/8	-	2.1	13

ERS	JIS	BS	Remarks

(B) Tensile test bars. The tensile test bars shall conform to the following dimensions:



The test pieces shall be machined from the appropriate transverse test bars, as provided above in clause 6.

8. Mechanical tests

The castings must comply with the transverse and tensile tests specified below. The test pieces will be selected by the E.R. Inspecting Engineer or his representative, and the test must be carried out in his presence and to his satisfaction.

(A) Transverse test

A transverse test bar cast to dimensions in clause 7 (A) shall be supported on knife edges or rollers, whose axes are prependicular to that of the test bar, and shall sustain a progressively increasing load vertically applied at its centre.

Table 2 Mechincal property

Class	Symbol	Principal wall thickness of iron casting mm	Diameter on cast of test specimen mm	Tension test Tensile strength kgf/mm² (N/mm²)	Deflection test Maximum load kgf (kN)	Deflection mm	Hardness test Brinell Hg
Grey iron casting Class 1	FC 10	4 to 50 incl.	30	10 min. (98.1 min.)	700 min. (6.860 min.)	3.0 min.	201 max.
Grey iron casting Class 2	FC 15	4 to 8 incl.	13	15 min. (147 min.)	180 min. (1.770 min.)	2.0 min.	241 max.
		Over 8 to 15 incl.	20	17 min. (167 min.)	400 min. (3.920 min.)	2.5 min.	223 max.
		Over 15 to 30 incl.	30	15 min. (147 min.)	800 min. (7.850 min.)	4.0 min.	212 max.
		Over 30 to 50 incl.	45	13 min. (127 min.)	1700 min. (16.670 min.)	6.0 min.	201 max.
Grey iron casting Class 3	FC 20	4 to 8 incl.	13	15 min. (235 min.)	300 min. (1.960 min.)	2.0 min.	255 max.
		Over 8 to 15 incl.	20	22 min. (216 min.)	450 min. (4.410 min.)	3.0 min.	235 max.
		Over 15 to 30 incl.	30	20 min. (196 min.)	900 min. (8.830 min.)	4.5 min.	212 max.
		Over 30 to 50 incl.	45	17 min. (167 min.)	2000 min. (19.610 min.)	6.5 min.	217 max.
Grey iron casting Class 4	FC 25	4 to 8 incl.	13	20 min. (275 min.)	370 min. (7.160 min.)	2.0 min.	269 max.
		Over 8 to 15 incl.	20	26 min. (255 min.)	900 min. (8.900 min.)	3.0 min.	248 max.
		Over 15 to 30 incl.	30	25 min. (245 min.)	1900 min. (9.910 min.)	5.0 min.	241 max.
		Over 30 to 50 incl.	45	23 min. (216 min.)	3320 min. (32.340 min.)	7.0 min.	229 max.
Grey iron casting Class 5	FC 30	8 to 15 incl.	20	31 min. (304 min.)	590 min. (5.394 min.)	3.5 min.	269 max.
		Over 15 to 30 incl.	30	28 min. (294 min.)	1100 min. (10.780 min.)	5.5 min.	262 max.
		Over 30 to 50 incl.	45	27 min. (265 min.)	2600 min. (25.500 min.)	7.5 min.	248 max.
Grey iron casting Class 6	FC 35	15 to 30 incl.	30	35 min. (343 min.)	1300 min. (11.770 min.)	5.5 min.	277 max.
		Over 30 to 50 incl.	45	32 min. (314 min.)	2900 min. (28.440 min.)	7.5 min.	269 max.

6.1.3 Deflection test

(1) Test piece
The test piece specified in JIS Z 2203 shall be used.

(2) Test method
Lay the test piece between two fulcrums, apply a load to the test piece in the middle part until its breakage, and measure the maximum load that the test piece could withstand and the deflection.

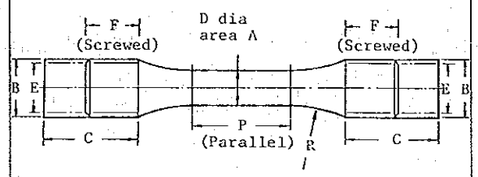


Table 2 Machined tensile pieces

Cross-sectional shape of casting	Nominal diameter of test bar mm	Grade diameter	Area	Min. parallel length	Min. radius	Plain ends		Screwed ends			Approximate minimum overall length
						Min. diameter	Min. length	Size	Min. length		
in	in	D	in²	P	R	b	C	E	F		in
Not exceeding 3/8	0.6	0.389	0.125	1.0	1	0.50	1 1/4	9/16 B.S.F. 9/16 B.S.W.	9/16		4 3/8
Over 3/8 not exceeding 3/4	0.875	0.564	0.25	2.0	1	0.75	1 3/4	3/4 B.S.F. 7/8 B.S.W.	3/4		6 1/8
Over 3/4 not exceeding 1 1/8	1.2	0.798	0.50	3.0	1	1.00	2 1/2	1 1/8 B.S.F. 1 1/8 B.S.W.	1 1/8		8 3/4
Over 1 1/8 not exceeding 1 7/8	1.8	1.128	1.00	3.0	1	1.50	2 3/4	1 1/2 B.S.F.	1 1/2		10 1/2
Over 1 7/8	2.1	1.451	1.75	3.0	1	1.85	3	2 B.S.F.	2		12 7/8

Mechanical tests

9. Tensile tests carried out on a test piece machined to conform to the dimensions shown in Table 2 shall show a tensile strength of not less than that given in Table 3 appropriate to the size of test piece and grade of iron.

Self-aligning grips are recommended to ensure axial loading.

After reaching 50 per cent of the anticipated tensile strength, the rate of increase of stress on the test piece shall not exceed 10 tons/in^2 per minute (15.75 kg/mm^2 per minute).

ERS

The rate of application of the load shall be such that the increase of the bending stress will not exceed 2 tons per square inch (approx. 3 kg/mm^2) per second.

The results of the test shall conform with the following:-

(a) A test bar casted 1.2 inches diameter, when placed on supports set at 18 inches apart, shall show a rupture stress of not less than 21.8 ton per square inch and a deflection before breaking of not less than 0.15 inches.

(b) A test bar casted 30 mm. diameter, when placed on supports set at 600 mm. apart, shall show a rupture stress of not less than 34 kg/mm^2 and a deflection before breaking of not less than 7 mm.

(B) Tensile test

A tensile test bar machined to the dimensions shown in clause 7 (B) above must show a breaking strength not less than 11.5 tons per square inch (approx. 18 kgs per mm^2).

JIS

Flexure Test Piece for Metals JIS-Z 2203-1956
(Reaffirmed: 1971)

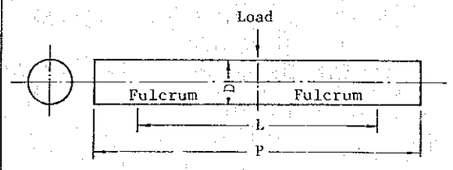
1. Scope

This standard specifies standard test piece (hereinafter referred to as the "test piece") to be used for flexure test of metals.

Whether any test piece is to be used or not shall comply with those specified by the respective standards.

2. Type of test piece

The test piece shall be divided into from A to D in accordance with the shape and size and these reference dimensions shall comply with the following:



Unit: mm

Type of test piece	Diameter D	Diametral tolerance	Fulcrum gauge L	Length P
A	13	±1.0	200	About 300
B	20	±1.0	300	About 350
C	30	±1.5	450	About 500
D	45	±2.0	600	About 650

3. The test piece shall be as-cast. Provided that the surface may be machine-finished on account of the dimensional adjustment within the range of tolerance.

BS

Table 3 Tensile test

Cross-sectional thickness of casting		Nominal diameter of test bar as cast	Grade etc.	Tensile strength, minimum Grade						
Over	Up to and including			10 (see note 2)	12	14	17	20	23	26
in	in	in	in	tons/in^2	tons/in^2	tons/in^2	tons/in^2	tons/in^2	tons/in^2	tons/in^2
-	3/8	0.6	0.370	11.0	13.0	16.0	19.0	22.0	25.0	28.0
3/8	3/4	0.875	0.564	10.5	12.5	15.0	18.0	21.0	24.0	27.0
3/4	1 1/8	1.2	0.798	10.0	12.0	14.0	17.0	20.0	23.0	26.0
1 1/8	1 5/8	1.6	1.110	9.5	11.5	13.5	16.0	19.0	22.0	25.0
1 5/8	-	2.1	1.493	9.0	11.0	12.8	15.0	18.0	21.0	24.0

APPENDIX A

TRANSVERSE TESTS

Test bars

A1. Transverse test bars shall conform to the dimensions shown in Table 4 appropriate to the main cross-sectional thickness of the casting.

Table 4 Transverse test bars

Cross-sectional thickness of casting		Nominal diameter of bar as cast	Limits on diameter (plus and minus)	Overall length
Over	Up to and including			
in	in	in	in	in
-	3/8	0.6	0.045	10
3/8	3/4	0.875	0.065	15
3/4	1 1/8	1.2	0.090	21
1 1/8	1 5/8	1.6	0.10	21
1 1/8	-	2.1	0.10	27

Remarks

ERS	JIS	BS	Remarks
9. Number of tests The number of tests required shall be:- (a) One tensile or/and one transverse test for every 2 tons of castings or part thereof. or (b) One tensile or/and one transverse test for every 30 pieces of castings or part thereof.	(1) One test specimen, besides extra ones, shall be sampled from every molten. When required by the purchaser, however, the quantity of test specimens may be altered. In the case a molten exceeds 10 t, one test specimen shall be sampled from every 10 t or the fraction thereof. One molten of cupola and baby cupola shall be the tapping amount, when composed of same blend, for every three hours. When hot metal from more than two furnaces has been gathered into one ladle, the gathered metal shall be considered one molten.	Tests 10. The test shall be the tensile test and shall be carried out at a frequency not less than that shown below. Grades 10* and 12: one tensile test for up to 10 tons (10.16 tonnes) of castings. Grade 14 and 17: one tensile test for up to 5 tons (5.08 tonners) of castings. Grade 20, 23 and 26: one tensile test for up to 1 ton (1.016 tonne) of castings. In the case of castings weighing over the specified weight for the grades shown above, there shall be one tensile test per casting.	
10. Additional tests before rejection If a faulty or unsound test bar gives a result not in accordance with the specification the result shall be ignored and a fresh test made. If a sound test bar fails a second test shall be made. If this meets the specification the batch or casting represented shall be accepted, but if it fails the batch or casting represented shall be rejected. If a transverse test bar fails to meet the specification a tensile test piece machined from one of the broken ends shall be tested, and if this meets the requirements of the specification, the batch or casting represented shall be accepted.	8. Retest 8.1 When the test piece is found to be badly finished or to have flaws, it may be discarded before the test and replaced by another test piece. When flaws are found out after the tests and are considered to have affected results of the test, the results shall be invalidated. 8.2 When a part of results of the mechanical test can not satisfy the requirements but the results other than that are satisfactory, test pieces of a quantity two times as many as specified shall be taken from the group to which the rejected test pieces belong, to be retested for the test item the original test pieces have failed in satisfying the requirements. In the retest any one of the test pieces shall satisfy the requirements.	Retests 11. a. Tensile test. Should any of the tensile test pieces fail to pass the tests, two further tensile tests shall be made. If both pass, the batch of castings represented complies with the test requirements, but should one fail, the batch does not comply with this British Standard. b. Casting defects. Should any test piece which failed show obvious casting defects, a test piece may be taken from spare test bar material or cut from a casting from the same batch, and the results obtained from this substituted for those obtained from the defective bar. Additional tests 12. If the purchaser desires any tests or special requirements not specified in this standard, he shall state these at the time of enquiry and order.	

ERS	JIS	BS	Remarks
11. Inspection The E.R. Inspecting Engineer shall be allowed unhindered access to the manufacturers' work at all times within working hours when castings on order are in process of manufacture or delivery. He shall be at liberty to inspect the manufacture at any stage and to reject any castings which do not conform to this specification. Any castings so rejected must be broken up at once or marked in the presence of the inspector in such a way they cannot be confused subsequently with satisfactory castings.	7. Inspection 7.1 The results of the inspection for appearance, dimensions and mass, tension test, deflection test, hardness test and chemical analysis shall satisfy the requirements described in 4. and 5. When the correction is applied in accordance with 6.1.3 (3), however, the corrected maximum load shall be used. When approved by the purchaser, the mechanical test may be partially or completely omitted. The inspection of appearance and dimensions, tension test and deflection test shall be generally performed, but the inspection of mass, hardness test and chemical analysis shall be performed only when designated by the purchaser. 10. Report The manufacturer shall submit to the purchaser a record containing the molten number and results of the test.	Inspection 13. The purchaser or his representative shall have access at all reasonable times to those parts of the manufacturer's works engaged on his order; he shall be at liberty to inspect the manufacture at any stage, to witness the required tests and to reject any material that does not comply with the specification. When the castings are to be inspected during manufacture and tested in the presence of the purchaser's representative, it should be so stated in the enquiry and order.	
12. Testing facilities The manufacturer shall supply the material required for testing free of charge, and at his own cost shall furnish and prepare the necessary test pieces and supply labour and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the tests the manufacturer shall bear the cost of carrying them out elsewhere.	Not specified	Testing facilities 14. The manufacturer, in supplying the test samples as required for testing shall prepare from them the necessary test pieces and supply the labour and appliances for making all tests on his premises in accordance with the specification. Failing facilities for carrying out the prescribed tests at his own works, the manufacturer shall carry out the tests elsewhere.	
	6.1.4 Hardness test (1) Test Piece The test piece for the deflection or tension test shall be locally used. (2) Test method The test method shall follow JIS Z 2243.		

COMPARISON TABLE FOR M14 GREY IRON CASTINGS (HIGH GRADE)

<table>
<tr><th>ERS</th><th>JIS</th><th>BS</th><th>Remarks</th></tr>
<tr><td>No. M. 14-1955
Specification for Grey Iron Castings
(High Grade)</td><td>UDC 669.131.6:621.74
JAPANESE INDUSTRIAL STANDARD JIS
Grey Iron Castings G 5501-1976</td><td>BS 1452: 1961
BRITISH STANDARD SPECIFICATION FOR
GREY IRON CASTINGS</td><td></td></tr>
<tr><td>1. Scope
This specification covers castings in grey cast iron of high grade quality for locomotive cylinders, pistons, piston valve heads and liners, piston rings, cylinder and steam chest covers, superheater header, regulator heads, regulator elbows, steam stands, etc.</td><td>1. Scope
This Japanese Industrial Standard specifies the iron castings which show grey in fracture.
2. Class and symbol
The grey iron casting shall be classified as shown in Table 1.
Table 1 Class and symbol
<table><tr><th>Class</th><th>Symbol</th></tr><tr><td>Grey iron casting Class 1</td><td>FC 10</td></tr><tr><td>Grey iron casting Class 2</td><td>FC 15</td></tr><tr><td>Grey iron casting Class 3</td><td>FC 20</td></tr><tr><td>Grey iron casting Class 4</td><td>FC 25</td></tr><tr><td>Grey iron casting Class 5</td><td>FC 30</td></tr><tr><td>Grey iron casting Class 6</td><td>FC 35</td></tr></table></td><td>Scope
1. This British Standard relates to seven grades of grey iron castings, viz. Grades 10, 12, 14, 17, 20, 23 and 26: The grades are numbered in accordance with the minimum tensile strength which can be expected on a 1.2 in (30.5 mm) diameter test bar. Material ordered to Grade 10 will be tested for its mechanical properties only when specifically requested by the purchaser. The grade required should be stated at the time of enquiry and order.
The basis of this standard is the tensile test but data relating to the transverse test are given in Appendix A, so that this may be used as a control test.</td><td></td></tr>
<tr><td>2. Quality of material
The Cast Iron used must be the best close-grained tough quality made from the most suitable mixtures of best selected pig iron. The Cast Iron used for piston rings to be slightly softer than that used for the cylinders, valve chamber lines and piston valves.</td><td>3. Manufacture
3.1 The grey iron casting shall be manufactured in cupola furnace, baby cupola, reverberatory furnace, electric furnace, crucible furnace and other proper melting furnaces.
3.2 The grey iron casting shall be annealed so that the casting stress may be removed, when required by the purchaser.
The grey iron casting may be softened by agreement with the purchaser.</td><td>Quality of metal
2. The metal used for the manufacture of the castings shall be good quality cast iron of the grade specified. The castings shall be cast from metal melted or refined in any suitable metallurgical plant. An iron ore smelting furnace shall not be used unless special permission shall have been obtained from the purchaser.</td><td></td></tr>
<tr><td>3. Chemical composition
The composition of the iron as cast is left to the discretion of the manufacturers.</td><td>6.2 Chemical analysis
6.2.1 The sample for chemical analysis shall, as a rule, be taken from ladle. Check analysis, however, shall be made on the product when required by the purchaser. In this case, the sampling and the allowable deviation of chemical composition shall be agreed upon between the purchaser and the manufacturer.
4.3 The P and S contents in Class 3 to Class 6 shall be agreed upon between the purchaser and the manufacturer.</td><td>2. The composition of the iron as cast shall be left to the discretion of the manufacturer, but a minimum and/or a maximum percentage of phosphorus may be specified by agreement between the purchaser and the supplier.</td><td></td></tr>
</table>

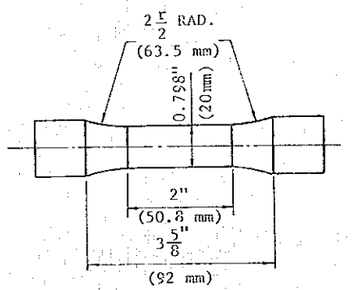
ERS	JIS	BS	Remarks
4. Moulding The castings shall be accurately moulded in accordance with the patterns or drawings supplied by the Chief Inspecting Engineer. Each casting shall have the letters "E.S.R." cast on it in letters not less than 1/2" (12.5 mm high, together with such other markings (cast or stamped) as may be directed by the Chief Inspecting Engineer.	5. Shape, Dimension, Weight and Tolerance Thereon The shape, dimension and weight of the grey iron casting shall be determined by using its drawing or model, and the tolerance thereon shall be agreed upon between the manufacturer and the purchaser. 9. Marking The grey iron casting which have passed the inspection shall be marked on every casting by the workshop with the mark "Inspected", symbol for type, molten number, name of workshop or its abbreviation. In the case these markings are difficult to be done, however, other appropriate way may be adopted. When approved by the purchaser, the above items may be partially omitted.	Moulding 4. The castings shall be accurately moulded in accordance with the pattern or working drawings as supplied by the purchaser with the addition of such lettering as may be specified.	
5. Freedom from defects The casting shall be free from cracks, gas holes, flaws and excessive shrinkage. The surfaces shall be free from burnt-on sand and shall be reasonably smooth. The casting shall be well dressed or fettled and shall have a suitable degree of machinability. Runners, risers, fins and other cast on pieces are to be removed. Any flaws (blowholes, etc.) on the surface shall be left bare and no attempt shall be made to fill or otherwise obliterate them without the express agreement of the E.R. Inspecting Engineer. Any casting upon which such work has been done prior to such consent having been obtained will be rejected.	4. Quality 4.1 The grey iron casting shall have uniform quality and shall be free from detrimental flaws or cavities. 7.2 The inspection of appearance, dimensions and mass shall be carried out for each grey iron casting. The flaws or cavities that only slightly affect the use may be repaired by welding or other appropriate means, provided that the purchaser approves.	Freedom from defects 3. The castings shall be sound, clean and free from distortion and injurious defects. They shall be well dressed or fettled and shall be free from chill and other indications of free carbides except as specified by the purchaser. They shall be machinable by the normal methods for the grade of iron specified. By agreement between the manufacturer and the purchaser, defects may be rectified. Any casting showing defects during subsequent manufacturing operations does not comply with this British Standard, notwithstanding any previous certificate of satisfactory testing, provided the casting has not been improperly treated after delivery.	

ERS	JIS	BS	Remarks
6. Provision of test bars Test bars shall be cast separately from the casting under the same sand conditions (i.e. green sand or dry sand) as the castings, and from a ladle or ladles of the same metal as that used to pour the castings. The test bars shall receive the same mechanical and thermal treatment, if any, as the castings and in the case of heat treatment the test bars shall be treated adjacent to the castings they represent. The test bars shall not be cleaned by tumbling unless the castings are so cleaned. Tensile test pieces shall be machine from transverse test bars. Tensile test pieces cast to size are not recognised by this specification.	7.3.1 Test specimen (2) The test specimen shall be cast separately from the grey iron casting. In this case, the mould for the test specimen shall, as a rule, be of the same type as that for the grey iron casting, and it is required to cast the specimen with the same molten under the same conditions as that for the grey iron casting. By an agreement with the purchaser, however, the test specimen may be cast in monoblock with the grey iron casting. (3) The test specimen shall have 30 mm in diameter as cast. When the test specimen is determined according to principal wall thickness of the grey iron casting, however, the diameter as cast shall follow Table 3. (4) The dimensions as cast of test specimen from the grey iron casting below 4 mm and above 50 mm in principal wall thickness shall be determined by an agreement between the purchaser and the manufacturer.	Provision of test bars 7. Test bars shall normally be cast separately from the castings to which they are related, but shall be poured at the same time and from the same ladle of metal. Sufficient test bar material to meet the requirements of Clauses 10 and 11 shall be provided. When castings are moulded in loam or dry sand the test bars representing the castings shall be cast in dry sand. When castings are moulded in green sand the test bars representing the castings shall be cast in green sand or in dry sand. If the castings are produced in any other mould material, the material to be used for the mould for the test bar shall be agreed between the purchaser and manufacturer. Castings may be ordered where none of the standard test bars in Table 1 would reasonably represent the material in the casting and in this case provision may be made, by agreement between the purchaser and manufacturer, for an additional piece to be cast on to the casting which can subsequently be removed and used to produce a test piece of suitable size in conformity with Table 2. When castings are subjected to heat treatment the test bars shall be treated under similar conditions. All test bars shall be marked to identify them with the castings they represent.	
7. Dimensions of test bars (A) Transverse test bars. The transverse test bars shall be cast to one of the following dimensions: (a) 1.2 inches diameter and 21 inches overall length. (b) 30 mm. diameter and 650 mm. overall length.	6.1.2 Tension test (1) Test piece It shall be formed from the test specimen or from the test piece fractured by deflection test to No. 8 specified in JIS Z 2201. (2) Test method The test method shall follow JIS Z 2241.	Dimensions of test bars 8. Tensile test bars. Tensile test bars from which the appropriate test piece is machined shall be cast as uniform cylindrical bars to the dimensions given in Table 1. It is permissible to use material originally provided for transverse tests. If it is not practicable to use a 1.6 in (40.6 mm) or 2.1 in (53.3 mm) nominal size test bar because of limitation of testing facilities, the 1.2 in nominal size bar may be	

ERS

If the diameter of a transverse test bar is found to be more than 0.05 inch (1.2 mm. approx.) greater or less than the dimensions given it shall be rejected. Transverse tests shall not be carried out on machined bars.

(B) Tensile test bars. The tensile test bars shall conform to the following dimensions:



The test pieces shall be machined from the appropriate transverse test bars, as provided above in clause 6.

8. Mechanical tests.

The castings must comply with the transverse and tensile tests specified below. The test pieces will be selected by the E.R. Inspecting Engineer, and the tests must be carried out in his presence and to his satisfaction.

(A) Transverse test

A transverse test bar cast to dimensions in clause 7 (A) shall be supported on knife edges or rollers, whose axes are perpendicular to that of the test bar, and shall sustain a progressively increasing load applied at its centre.

The rate of application of the load shall be such that the increase of the bending stress will not exceed 2 tons per square inch (approx. 3 kg/mm^2) per second.

The results of the test shall conform with the following:-

JIS

No. 8 Test piece
This test piece shall be principally used for tension test of general iron castings. It shall be made out of the sample with the dimensions given in the Table, and the parallel portion shall be finished to the diameter D.

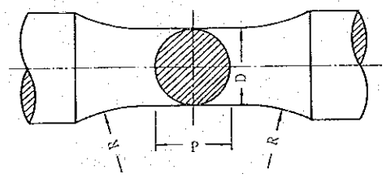


Fig. 8

Unit: mm

Division of test piece	Size of casted sample (dia.)	Length of parallel portion P	Dia. D	Radius of shoulder R
8A	Approx. 13	Approx. 8	8	16 or more
8B	Approx. 20	Approx. 12.5	12.5	25 or more
8C	Approx. 30	Approx. 20	20	40 or more
8D	Approx. 45	Approx. 32	32	64 or more

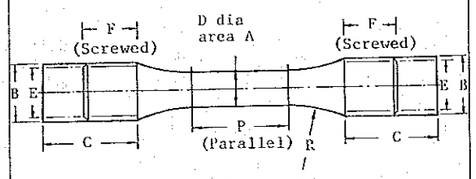
BS

used subject to agreement with the purchaser. In this case, the mechanical properties specified for the 1.2 in bar appropriate to the grade of iron shall apply. An alternative procedure is to adopt that given in the third paragraph of Clause 7, and in this case the strengths obtained shall be those for the appropriate larger bar, even if a small test piece was produced from the test portion of the casting.

Table 1 Tensile test bars as cast

Cross-sectional thickness of casting		Diameter as cast	Approximate minimum overall length
Over	Up to and including		
in	in	in	in
-	3/8	0.6	5
3/8	3/4	0.875	7
3/4	1 1/8	1.2	9
1 1/8	1 5/8	1.6	11
1 5/8	-	2.1	13

Remarks

ERS	JIS	BS	Remarks
(a) A test bar casted 1.2 inches diameter, when placed on supports set at 18 inches apart, shall show a rupture stress of not less than 24.3 ton per square inch and a deflection before breaking of not less than 0.16 inches. (b) A test bar casted 30 mm. diameter, when placed on supports set at 600 mm. apart, shall show a rupture stress of not less than 40 kg/mm^2 and a deflection before breaking of not less than 8 mm. (B) Tensile test A tensile test bar machined to the dimensions shown in clause 7 (B) above must show a breaking strength not less than 14 tons per square inch (approx. 22 kgs. per mm^2).	Table 2 Mechanical Property 6.1.3 Deflection test (1) Test piece The test piece specified in JIS Z 2203 shall be used. (2) Test method Lay the test piece between two fulcrums, apply a load to the test piece in the middle part until its breakage, and measure the maximum load that the test piece could withstand and the deflection.	 Table 2 Machined tensile test pieces Mechanical tests 9. Tensile tests carried out on a test piece machined to conform to the dimensions shown in Table 2 shall show a tensile strength of not less than that given in Table 3 appropriate to the size of test piece and grade of iron. Self-aligning grips are recommended to ensure axial loading. After reaching 50 per cent of the anticipated tensile strength, the rate of increase of stress on the test piece shall not exceed 10 tons/in^2 per minute (15.75 kg/mm^2 per minute).	

ERS	JIS	BS	Remarks

Flexure Test Piece for Metals JIS-Z 2203-1956
(Reaffirmed: 1971)

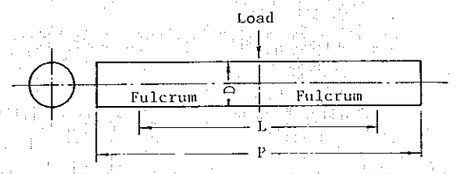
1. Scope

This standard specifies standard test piece (hereinafter referred to as the "test piece") to be used for flexure test of metals.

Whether any test piece is to be used or not shall comply with those specified by the respective standards.

2. Type of test piece

The test piece shall be divided into from A to D in accordance with the shape and size and these reference dimensions shall comply with the following:



Unit: mm

Type of test piece	Diameter D	Diametral tolerance	Fulcrum gauge L	Length P
A	13	±1.0	200	About 300
B	20	±1.0	300	About 350
C	30	±1.5	450	About 500
D	45	±2.0	600	About 650

3. The test piece shall be as-cast. Provided that the surface may be machine-finished on account of the dimensional adjustment within the range of tolerance.

Table 3 Tensile test

Cross-sectional thickness of casting		Nominal diameter of test bar as cast	Grade dia.	Tensile strength, minimum Grade						
Over	Up to and including			10 (see note 3)	12	14	17	20	23	26
in	in	in	in	tons/in²	tons/in²	tons/in²	tons/in²	tons/in²	tons/in²	tons/in²
-	3/8	0.6	0.399	11.0	13.0	16.0	19.0	22.0	25.0	28.0
3/8	3/4	0.875	0.564	10.5	12.5	15.0	18.0	21.0	24.0	27.0
3/4	1 1/8	1.2	0.756	10.0	12.0	14.0	17.0	20.0	23.0	26.0
1 1/8	1 5/8	1.6	1.128	9.3	11.3	13.5	16.0	19.0	22.0	25.0
1 3/8	-	2.1	1.693	9.0	11.0	13.0	15.0	18.0	21.0	24.0

APPENDIX A

TRANSVERSE TESTS

Test bars

A1. Transverse test bars shall conform to the dimensions shown in Table 4 appropriate to the main cross-sectional thickness of the casting.

Table 4 Transverse test bars

Cross-sectional thickness of casting		Nominal diameter of bar as cast	Limits on diameter (plus and minus)	Overall length
Over	Up to and including			
in	in	in	in	in
-	3/8	0.6	0.045	10
3/8	3/4	0.875	0.065	15
3/4	1 1/8	1.2	0.090	21
1 1/8	1 5/8	1.6	0.10	21
1 1/8	-	2.1	0.10	27

ERS	JIS	BS	Remarks
9. Number of mechanical tests The number of tests required shall be:- (a) One tensile and one transverse test for every 2 tons of castings or part thereof. or (b) One tensile and one transverse test for every 30 castings or part thereof. Big and highly stressed castings, such as cylinders and superheater header, shall be tested piece by piece.	(1) One test specimen, besides extra ones, shall be sampled from every molten. When required by the purchaser, however, the quantity of test specimens may be altered. In the case a molten exceeds 10 t, one test specimen shall be sampled from every 10 t or the fraction thereof. One molten of cupola and baby cupola shall be the tapping amount, when composed of same blend, for every three hours. When hot metal from more than two furnaces has been gathered into one ladle, the gathered metal shall be considered one molten.	Tests 10. The test shall be the tensile test and and shall be carried out at a frequency not less than that shown below. Grades 10* and 12: one tensile test for up to 10 tons (10.16 tonnes) of castings. Grades 14 and 17: one tensile test for up to 5 tons (5.08 tonnes) of castings. Grades 20, 23 and 26: one tensile test for up to 1 ton (1.016 tonne) of castings. In the case of castings weighing over the specified weight for the grades shown above, there shall be one tensile test per casting.	
10. Hydraulic tests Castings, which are under internal pressure in service, shall be tested under a hydraulic pressure equal to the working pressure plus 30 lbs. per square inch (approx. 2 kgs/cm^2).	Not specified		
11. Additional tests before rejection If a faulty or unsound test bar gives a result not in accordance with the specification the result shall be ignored and a fresh test made. If a sound test bar fails a second test shall be made. If this meets the specification the batch or casting represented shall be accepted, but if it fails the batch or casting represented shall be rejected.	8. Retest 8.1 When the test piece is found to be badly finished or to have flaws, it may be discarded before the test and replaced by another test piece. When flaws are found out after the test and are considered to have affected results of the test, the results shall be invalidated. 8.2 When a part of results of the mechanical test can not satisfy the requirements but the results other than that are satisfactory, test test pieces of a quantity two times as many as specified shall be taken from the group to which the rejected test pieces belong, to be retested for the test item the original test pieces have failed in satisfying the requirements. In the retest any one of the test pieces shall satisfy the requirements.	Retests 11. a. Tensile test. Should any of the tensile test pieces fail to pass the tests, two further tensile tests shall be made. If both pass, the batch of castings represented complies with the test requirements, but should one fail, the batch does not comply with this British Standard. b. Casting defects. Should any test piece which failed show obvious casting defects, a test piece may be taken from spare test material or cut from a casting from the same batch, and the results obtained from this substituted for those obtained from the defective bar. Additional tests 12. If the purchaser desires any tests or special requirements not specified in this standard, he shall state these at the time of enquiry and order.	

ERS	JIS	BS	Remarks
12. Inspection The E.R. Inspecting Engineer shall be allowed unhindered access to the manufacturers' work at all times within working hours when castings on order are in process of manufacture or delivery. He shall be at liberty to inspect the manufacture at any stage and to reject any castings which do not conform to this specification. Any castings so rejected must be broken up at once or marked in the presence of the inspector in such a way that they can not be confused subsequently with satisfactory castings.	7. Inspection 7.1 The results of the inspection for appearance, dimensions and mass, tension test, deflection test, hardness test and chemical analysis shall satisfy the requirements described in 4. and 5. When the correction is applied in accordance with 6.1.3 (3), however, the corrected maximum load shall be used. When approved by the purchaser, the mechanical test may be partially or completely omitted. The inspection of appearance and dimensions, tension test and deflection test shall be generally performed, but the inspection of mass, hardness test and chemical analysis shall be performed only when designated by the purchaser. 10. Report The manufacturer shall submit to the purchaser a record containing the molten number and results of the test.	Inspection 13. The purchaser or his representative shall have access at all reasonable times to those parts of the manufacturer's works engaged on his order; he shall be at liberty to inspect the manufacture at any stage, to witness the required tests and to reject any material that does not comply with the specification. When the castings are to be inspected during manufacture and tested in the presence of the purchaser's representative, it should be so stated in the enquiry and order.	
13. Testing facilities The manufacturer shall supply the material required for testing free of charge, and at his own cost shall furnish and prepare the necessary test pieces and supply labour and appliances for such testing as may be carried out on his premises in accordance with this specification. Failing facilities at his own works for making the tests the manufacturer shall bear the cost of carrying them out elsewhere.	Not specified	Testing facilities 14. The manufacturer, in supplying the test samples as required for testing shall prepare from them the necessary test pieces and supply the labour and appliances for making all tests on his premises in accordance with the specification. Failing facilities for carrying out the prescribed tests at his own works, the manufacturer shall carry out the tests elsewhere.	
	6.1.4 Hardness test (1) Test piece The test piece for the deflection or tension test shall be locally used. (2) Test method The test method shall follow JIS Z 2243.		

COMPARISON TABLE FOR M106 GLASS PANES FOR ROLLING STOCK

ERS ERS NO. M106-1959	JRS & JIS
A. Plain Glass for General Use Each pane to be of the best glass, free from defects and throughly annealed. The two faces should be ground and polished to give clear and undistorted vision. Glass panes should be so treated as to stand normal shocks without fracture, and if subjected to abnormal shocks, no splinters should follow the consequential breakage.	JIS R3201 Sheet Glass Glass shall be manufactured generally by mechanical drawing method, and have a fire-smoothed surface. Thicknesses shall be 1.9 ± 0.2 (Nominal 2 mm), 3 ± 0.3, 5 ± 0.3 mm. Quality shall be classified into Class A and Class B, which are judged by bubble, inclusion, code/wave, speck/stain/scratch, flow, chip/flare, warp etc. JIS R3202 Float, Polished Plate Glass Manufacture shall be by floating or polishing system. Thicknesses shall be 3, 4, 5, 6, 8, 10, 12, 15, 19 mm. (with tolerance varying by cases) Criteria for judgement of quality for general use, similar to JIS R3201. JRS 63103-1F-15AR7A Sheet Glass for Rolling Stock (Reference Standards: JIS R3201, R3202) Manufacturing method, same as JIS. Thicknesses shall be 1.9, 3, 5 mm for ordinary sheet glass 3, 5, 6 mm for polished sheet glass. Judgement of quality is same with JIS in items, but different in criteria.
B. Plain Glass for Mirrors Each pane to be of the best glass, free from defects and throughly annealed. The two faces should be ground and polished to give clear and undistorted vision before coating.	JRS-67101-1F-15AR6A Mirrors for Rolling Stock Classified into Class A (for general use) and B (for humid environment use). Materials shall conform to JIS R3202. The back shall be silver-plated. Thickness shall be 6 mm. The judgement of quality and the test method are specified.

<table>
<tr><th>ERS
ERS NO. M106-1959</th><th>JRS & JIS</th></tr>
<tr><td>C. Frosted Glass

Each pane to be of the best glass, free from defects or waviness and throughly annealed. The frosting is to be one side only and of such a depth that clear outlines of objects in a lighted room shall not be visible through the glass. Glass Panes should be so treated as to stand normal shocks without fracture, and if subjected to abnormal shocks, no splinters should follow the consequential breakage.</td><td>JIS R3201 Sheet Glass

Ground sheet glass is specified in item 2-1-(2). One of the faces of transparent sheet glass pane shall be processed by means of sand grinding, sand blasting or corrosion.

Thicknesses shall be 1.9, 3, 5 mm.

No grade specified for quality.

Judgement of quality shall be subject to Class B.

JRS-67103-1F-15AR7A Sheet Glass for Rolling Stock

Manufacturing method is the same as JIS.

Thicknesses are 3, 5 mm.

The judgement of quality is same as JIS in items, but different in criteria.</td></tr>
<tr><td>Tolerance:

The panes are to be cut to sizes within the following tolerances. The four sides are to be exactly square. Tolerance on Thickness ± 0.4 m/m., & on Length & Width ± 0.5 m/m.</td><td>JIS R3201 Sheet Glass

in mm
<table><tr><th></th><th>Thickness</th><th>Length/ Width</th></tr><tr><td>2 mm</td><td>± 0.2</td><td>± 1.5</td></tr><tr><td>3 mm</td><td>± 0.3</td><td>± 1.5</td></tr><tr><td>5 mm</td><td>± 0.3</td><td>± 2.0</td></tr></table>
JIS R3202 Float, Polished Plate Glass

in mm
<table><tr><th></th><th>Thickness</th><th>Length/ Width</th></tr><tr><td>3 mm
4
5
6</td><td>+ 0.5
− 0.4</td><td>± 1.5
± 2.0</td></tr><tr><td>8
10
12
15</td><td>+ 1.0
− 0.9</td><td>± 2.5
± 3.0</td></tr><tr><td>19</td><td>± 1.5</td><td>± 5.0</td></tr></table>
JRS-67103-1F-15AR7A Sheet Glass for Rolling Stock

Ordinary sheet glasses shall be 2, 3 and 5 mm in thickness, and the float, polish d sheet glasses, 3, 5 and 6 mm, with tolerances subject to JIS.</td></tr>
<tr><td>Edges:

Each sheet to be supplied with round edges and corners, unless otherwise stipulated.</td><td></td></tr>
</table>

ERS ERS NO. M106-1959	JRS & JIS
Marking: Each pane should be etched by the letters E.R. in Arabic as per drawing. No. M.28838 but to the dimsn. 18 x 25 mms, on the top right hand cornder, and 20 mms apart from sides. Makers trade mark may be etched underneath the E.R. marking and not to exceed 20 x 10 mms in size.	
Packing: Every care is to be taken in packing the sheets. They are to be separated by a sheet of paper and put closely in strong closed cases made of 50 millimeters frame work, 15 millimeters sides, 40 millimeters battens. The frames to be bolted right through and the lids secured with nuts on the bolts. An alternative method of packing, may be proposed by the tenderer in submitting his quotation but should be such as to ensure the safe arrival of the contents at destination with a minimum of breakage.	JIS R3201 Sheet Glass JIS R3202 Float, Polished Plate Glass Packing: Packed, as a rule, by using suitable cushion materials. The package or container shall be marked with: Type of glass, dimensions, number of glasses contained, manufacturer's name. JIS-67103-1F-15AR7A Generally pursuant to the above JIS's.

APPENDIX 4-11

Comparison Table for M170 Gas Oil for Diesel Locomotives and Rail Cars

	Egypt	Japan				U.S.A.		United Kingdom		West Germany	France		U.S.S.R.				China				
Name of Standards	EBS	JIS				ASTM		BS		DIN	NF		GOST				GB				
Standard No.	M170	K2204				D975		2869		51601	M15 -007	M15 -008	305				252				
Date of publishment	1971	1976				1975.3		1970		1975.4	1975		1975				1972.12				
Classification	1055 Cal./gr	No. 1	No. 2	No. 3	No. 3S	No. 1-D	No. 2-D	Class A1	Class A2		Gas Oil	Fuel Oil Domesti-que	L	Z	ZS	A	No. 10	No. 0	No. -10	No. -20	No. -30
Density, 15°C, kg/l	0.820 ~0.850	-	-	-	-	-	-	-	-	0.815 ~0.855	0.810 ~0.890	-	Report 61(General)	Report 40(General)	Report -	Report -	-	-	-	-	-
Flash point, °C (not less than)	65	50	50	50	50	37.8	51.7	55	55	55	55 ~120	55	40 (Specified)	35 (Specified)	35 (Specified)	30 (Specified)	65	65	65	65	50
Distillation temperature, °C, 50% evaporated	-	-	-	-	-	-	-	-	-	-	-	-	280	250	280	240	300	300	300	300	300
65% evaporated	-	-	-	-	-	-	-	-	-	-	250	250	-	-	-	-	-	-	-	-	-
85% evaporated	-	-	-	-	-	-	-	-	-	350	350	-	-	-	-	-	-	-	-	-	-
90% evaporated	-	350 (Not more than)	350 (Not more than)	330 (Not more than)	330 (Not more than)	287.8 (Not more than)	282.2 ~338	357	357	-	-	-	-	-	-	-	355	355	350	350	-
96% evaporated	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	365	365	-	-	350
96% evaporated	-	-	-	-	-	-	-	-	-	-	-	-	360	340	340	330	-	-	-	-	-
Pour point, °C (not more than)	0	-5	-10	-20	-30	-	-				-7(Apr ~Sep) -12(Oct ~Mar)	-3(Apr ~Sep) -6(Oct ~Mar)	-10	-35	-45	-55	+10	0	-10	-20	-30
Cloud point, °C (not more than)	4	-	-	-	-	-	-	0(Mar ~Nov) -7(Dec ~Feb)	0(Mar ~Nov) -7(Dec ~Feb)	-	-	-	-5	-25	-35	-	-	-	-	-	-
Filtration test value, °C (not more than)	-	-	-	-	-	-	-	-	-	0(Summer) -12(Winter)	-	-	Report	Report	Report	Report	-	-	-	-	-
Carbon residue in 10% bottom oil, % (not more than)	-	0.10	0.10	0.10	0.10	0.15	0.15	0.2	0.2	0.1	-	0.35	0.30	0.30	0.30	0.30	0.4	0.4	0.3	0.3	0.3
Cetane number (Cetane index) (not less than)	55	50	45	45	45	40	40	50	45	45	50	40	45	45	45	45	50	50	50	45	43
Kinematic viscosity, 37.8°C, cSt	-	-	-	-	-	1.4 ~2.5	2.0 ~4.3	1.6 ~6.0	1.6 ~6.0	-	-	-	3.5 ~6.0 (General)	2.2 ~5.0 (General)	-	-	-	-	-	-	-
30°C, cSt	-	2.7	2.5	2.0	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20°C, cSt	-	-	-	-	-	-	-	-	-	1.8 ~10	9.5 (Not more than)	9.5 (Not more than)	3.0~6.0 (Specified)	1.8~3.2 (Specified)	1.8~3.2 (Specified)	1.5 (Not more than) (Specified)	3.0 ~8.0	3.0 ~8.0	3.0 ~8.0	2.5 ~8.0	2.5 ~7.0
Sulphur, % (not more than)	1.5	0.50	0.50	0.50	0.50	0.50 or Legal	0.50 or Legal	0.5	1.0	0.55	0.70	0.55	0.2(G-1) 0.2~0.5 (G-2)	0.2(G-1) 0.2~0.5 (G-2)	0.2(G-1) 0.2~0.5 (G-2)	0.2(G-1) 0.2~0.4 (G-2)	0.2	0.2	0.2	0.2	0.2
Water and sediment, v/v % (not more than)	-	-	-	-	-	0.05	0.05	-	-	-	-	0.10	-	-	-	-	-	-	-	-	-
Water, v/v % (not more than)	0.15	-	-	-	-	-	-	0.05	0.05	0.1	Trace	0.10	Not contained	Not contained	Not contained	Not contained	Trace	Trace	Trace	Trace	Not contained
Sediment (Impurities), % (not more than)	0.01	-	-	-	-	-	-	0.01	0.01	-	Not contained	-	Not contained	Not contained	Not contained	Not contained	Not contained	Not contained	Not contained	Not contained	Not contained
Ash, % (not more than)	0.01	-	-	-	-	0.01	0.01	0.01	0.01	0.02	Not contained	-	0.01	0.01	0.01	0.01	0.025	0.025	0.025	0.025	0.025