

THE ARAB REPUBLIC OF EGYPT
REPORT
ON THE REVIEW OF THE ROLLING STOCK SPECIFICATION
FOR
EGYPTIAN RAILWAYS

APPENDIX

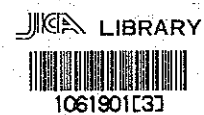
ARAB INTERNATIONAL COOPERATION AGENCY
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DECEMBER, 1979

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

国際協力事業団	
受入 月日 58.9.25	L405
登録No. 09055	63.6 SDF

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APPENDIX 1 General Rules for the Inspection of Diesel Locomotives
on Completion of Construction
(JIS E 4044-1967/1976)

1. SCOPE

This Japanese Industrial Standard specifies general inspection items of diesel locomotives hereinafter referred to as the "locomotives" on completion of construction.

2. DEFINITION OF TERMS

The definitions of terms used in this standard shall be as follows:

- (1) Inspection on Completion of Construction
Type inspection and acceptance inspection carried out by the purchaser and the supplier of locomotives on completion of construction after all manufacturing processes have been finished.
- (2) Type Inspection
Inspection carried out on the first locomotive which represents the same type of locomotives in general.
- (3) Acceptance Inspection
Inspection carried out on all locomotives in usual acceptance.
Applicable Standard: JIS E 4011 - Method of Weight Measurement for Railway Rolling Stock
- (4) Status in Working Order
Status of locomotives equipped with all necessary instruments and materials such as water, fuel oil, lubricating oil, working oil, sand, tools, etc.
- (5) Status of Empty
Status of locomotives are not equipped with such instruments and materials as specified in Term (4) Status in Working Order, however equipped with lubricating oil, etc., which are necessary to out-of-service running.

3. KINDS OF INSPECTION

Kinds of inspection shall be as follows:

- (1) Type inspection
- (2) Acceptance inspection

4. INSPECTION ITEMS

Inspection items shall be as shown in following Table, and type inspection shall be carried out on all items listed, however acceptance inspection shall be carried out on the items listed with mark.

Table

Inspection items		Acceptance inspection	Number of clauses to be complied
Appearance		o	5.1
Construction	Dimensions	o	5.2 (1)
	Rolling stock gauge	o	5.2 (2)
	Weight	-	5.2 (3)
	Relative mutual position of parts	-	5.2 (4)
	Electric circuit	o	5.2 (5)
	Waterproof	o	5.2 (6)
Performance	Engine	o	5.3 (1)
	Cooling apparatus of engine	o	5.3 (2)
	Protective device of engine	o	5.3 (3)
	Changing generating apparatus	o	5.3 (4)
	Diving apparatus	o	5.3 (5)
	Air compressing apparatus	o	5.3 (6)
	Brake equipment	o	5.3 (7)
	Security apparatus	o	5.3 (8)
	Sanding device	o	5.3 (9)
	Heating apparatus	o	5.3 (10)
Running	Starting and accelerating	o	5.4 (1)
	Indicating apparatus	o	5.4 (2)
	Engine and driving apparatus	o	5.4 (3)
	Security apparatus	o	5.4 (4)
	Protective device of engine	o	5.4 (5)
	Air compressing apparatus	o	5.4 (6)
	Brake equipment	o	5.4 (7)
	Riding comfort	o	5.4 (8)
	After the end of test running	o	5.4 (9)

5. INSPECTION

5.1 Appearance Inspection

Appearance inspection shall be carried out in ordinary standing status of locomotives, and shall be carried out on whole portions of locomotives, whole parts, and finished conditions of paintings, etc.

5.2 Construction Inspection

Construction inspection shall be carried out on status in working order of locomotives in general.

(1) Dimensions

When the brake equipment is released on the levelling track, relative dimensions for bodies and trucks of locomotives shall be inspected on the items as follows:

- (a) Height of coupler centre above rail level
- (b) Horizontality of underframe
- (c) Horizontality of truck frame
- (d) Clearance between underframe parts and truck parts, and clearance between underframe parts and wheel rims
- (e) Height of the lowest portions of rail guards, snow - plough apparatus, sander pipes, etc. above rail level.

(2) Rolling Stock Gauge

After running of locomotives beforehand, and at the conditions of spring riggings are stable, inspection shall be carried out by passing locomotives through rolling stock gauge. Furthermore, if necessary, inspection shall be carried out also in status of empty.

(3) Weight

Weight of locomotives shall be measured by the method complying with JIS E 4011, and weight in working order, weight of axle load, weight of wheel and weight of tare shall be inspected.

(4) Relative Mutual Position of Parts

While running through in slow speed on curve of track the curvature of which is equal to minimum curve radius of track locomotives will be operated; connecting parts of bodies and trucks,

body parts, relation of mutual positions of truck parts shall be inspected. However, in case it is impossible to inspect on the minimum curve, inspection shall be carried out on agreement between the purchaser and the supplier.

(5) Electric Circuit

Whole electric circuits shall be inspected on connection, wiring, continuity and dielectric strength.

(6) Waterproofness

Portions having fear that rain-water would intrude such as frames of sash windows, hinged doors, monitor tops, removable roofs, vent holes, etc. shall be inspected on waterproofness.

5.3 Performance Inspection

Performance inspection shall be carried out, in general, in the condition under which whole parts can be operated normally, and locomotives are standing.

(1) Engines

Operating condition of engines shall be inspected on the items as follows:

(a) Engine Bodies

(i) Facility of engine starting and condition of engine stopping.

(ii) Oil pressure oil leakage, etc. of lubricating oil system and fuel oil system.

(iii) Engine speed of no-load minimum revolution and no-load maximum revolution, and fluctuation of engine speed.

(iv) Condition of combustion, especially, colour of exhaust gas, knocking, etc.

(v) Condition of vibration and noise.

(b) Device of Suction and Exhaust Gas

(i) Condition of systems of suction and exhaust gas

(ii) Condition of vibration and noise

(iii) Condition of sound of exhaust gas

- (2) Cooling Apparatus of Engine
Cooling apparatus of engines shall be inspected on the following items:
- (a) Leakage from radiators and piping system
 - (b) Condition of vibration and noise of forced-cooling apparatus and their driving gears
 - (c) Working condition of water temperature controlling system
 - (d) Working condition of pre-heating device of cooling water
- (3) Protective Devices of Engines
Working condition of relays for lubricating oil system, cooling water system, etc. shall be inspected.
- (4) Charging Generating Apparatus
Charging generating apparatus shall be inspected in the condition of engine speed of no-load minimum revolution and no-load maximum revolution on the following items:
- (a) Output voltage of no-load condition
 - (b) Working condition of protective device
 - (c) Terminal voltage of battery and specific gravity of electrolyte
- (5) Driving Apparatus
Driving apparatus shall be inspected on the following items:
- (a) Working condition of speed change gears, containing hydraulic torque converters
 - (b) Facility of operation of reversing gears
 - (c) Revolution speed of main generators and output voltage of no-load condition
- (6) Air Compressing Apparatus
Air compressing apparatus shall be inspected on the following items:
- (a) Air inlet time to reach up to the maximum working pressure
 - (b) Working condition of periodic driving apparatus of air compressor
- (7) Brake Equipment
Brake equipment shall be inspected on the following items:
- (a) Air leakage at the time of the highest working pressure
 - (b) Air pressure of each portion, and working time

- (c) Piston stroke of brake cylinder
 - (d) Working condition of each meter
 - (e) Operation condition of hand brake equipment
 - (8) Security Apparatus
Working condition of emergency alarming apparatus, conductor's valves, automatic train stop device, air whistles, buzzers, head lights, marker lights, safety valves, emergency switches, etc. shall be inspected.
 - (9) Sanding Devices
Sanding devices shall be inspected on the following items:
 - (a) Condition of sanding
 - (b) Interlocking action with the other devices
 - (10) Heating Apparatus
Heating apparatus shall be inspected on the following items:
 - (a) Performance of heating apparatus in driving cabs
 - (b) Working condition of preheating devices of engines
 - (c) Controlling condition of heating apparatus for train
- 5.4 Running Inspection
- Running inspection shall be carried out on the specified track in the running condition of locomotives after the completion of performance inspection.
- (1) Starting and Accelerating
Condition of starting and accelerating of locomotives shall be inspected.
 - (2) Indicating Apparatus
Working condition of pilot lamps and indicating instruments shall be inspected.
 - (3) Engine and Driving Apparatus
Engine and driving apparatus shall be inspected on the following items:
 - (a) Working condition of engine, speed change gears and main generators
 - (b) Condition of noise and heating of engines, speed change gears and main generators

- (4) Security Apparatus
Working condition of automatic train stop device, emergency switches and speedometer shall be inspected.
- (5) Protective Device of Engine
Working condition of relay for cooling water system shall be inspected.
- (6) Air Compressing Apparatus
Supplying condition of compressed air by air compressors shall be inspected.
- (7) Brake Equipment
Brake equipment shall be inspected on the following items:
 - (a) Working condition of service braking and emergency braking
 - (b) Braking distance when emergency braking applied in specified speed
 - (c) In case of rheostatic brake equipment and hydraulic torque converter brake equipment are attached, working condition of them
- (8) Riding Comfort
Condition of vibration, noise, ventilating, etc. shall be inspected.
- (9) After the End of Test Running
After the end of test, running the following items shall be inspected:
 - (a) Heating condition of each journal box
 - (b) Leakage condition of water, oil, air, etc.
 - (c) Condition of contact tips of circuit breakers, contactors, etc.
 - (d) Condition of commutator surface of traction motors and other rotating machines
 - (e) Condition of fastening for each portion of parts

APPENDIX 2 General Rules for the Inspection of Passenger Car
on Completion of Construction

1. SCOPE

This specification stipulates the general rules for the inspection of passenger car on completion of construction.

2. MEANING OF THE TERMS

Meaning of the major terms used in this specification shall be as following:

- (1) Inspection on Completion of Construction
Inspection on completion of construction means the type inspection and delivery inspection to be carried out on the car between the parties after all the manufacturing processes were completed.
- (2) Type Inspection
Type inspection is the inspection to be carried out, as a rule, on the first car representing the type of the passenger car.
- (3) Delivery Inspection
Delivery inspection is the inspection to be carried out on all the cars to be delivered.
- (4) Empty Car Condition
Empty car condition is the condition that nothing but mandatory materials for operation such as lubrication oil are on the car.
- (5) Fully Loaded Condition
Fully loaded condition is the condition under which maximum design load as agreed between the parties are loaded on empty condition passenger car.

3. TYPES OF THE INSPECTION

Types of the Inspection on Completion of Construction are as follows:

- (1) Type Inspection
- (2) Delivery Inspection

4. ITEMS OF INSPECTION

Items of the inspection shall be as shown in the following table, of which all items are applicable, to the type inspection, and those marked with x only is applicable to the delivery inspection.

Inspection Item		Delivery Insp.	No. of Inspection Item
Appearance		x	
Structural	Dimension	x	5.2.1
	Rolling Stock Gauge	x	5.2.2
	Weight	-	5.2.3
	Relative Position of Parts	-	5.2.4
	Electrical Circuit	x	5.2.5
	Watertightness	x	5.2.6
Functional	Braking Device	x	5.3.2
	Hand Braking Device	x	5.3.3
	Room Lighting	x	5.3.4
	Ventilating Device	x	5.3.5
Running	Axle Driven Generating Device	x	5.4.2
	Braking Device	x	5.4.3
	Indication Device	x	5.4.4
	Noise in Passenger Room	-	5.4.5
	Riding Comfortableness	x	5.4.6
	After Running Inspection	x	5.4.7

5. INSPECTION

5.1 Appearance Inspection

Inspect whole passenger car and check followings:

- (1) Inspect structure of portions, painting, marking and circuit, etc., for conformance to the stipulation in the specification and drawings.
- (2) Inspect for the clamping, loosening, and other injurious structural defects of the parts.

5.2 Structural Inspection

Structural inspection shall be performed with empty car condition,

unless otherwise specified.

5.2.1 Dimension of Car Body and Bogie

Dimensional measurement of car body and bogie, and the related parts shall be performed on a level line for the following items:

- (1) Maximum Warping shall be measured at the under side of transom, and the upward camber for the total car body length shall be within the limit determined between the parties.
- (2) Height of Draw and Buffing Gear
The height of the center of draw and buffing gear shall be 1100 to 1110 mm (standard height 1105 mm) from the surface of rail, and the difference of the heights of front and rear draw and buffing gear centers shall be within 10 mm.
- (3) Horizontality of Underframe
Difference of front and rear as well as diagonals of the underframe shall be 25 mm or less, and the difference between left and right of end beam shall be 15 mm or less.
- (4) Horizontality of Bogie
Clearance between journal box and datum plane of the bogie frame, shall be within the dimension shown on the drawing.
- (5) Loading Rate of Bogie Side Bearing
Loading rate of bogie side bearing shall calculately be determined by measuring relative dimensions between car body and bogie, and the result shall be within the specified value.
- (6) Gap between Underframe Parts and Bogie Parts; shall be within the dimension specified on the drawing.
- (7) Gap between Underframe Parts and Outer Periphery of the Wheel shall be within the dimension specified on the drawing.

5.2.2 Rolling Stock Gauge shall be within the limit specified in the specification. The inspection shall be carried out also under maximum loaded condition, when so specified.

5.2.3 Weight

The weight of passenger car shall be inspected by calculating the tare weight by the specification determined between the parties.

5.2.4 Relative Position of Parts

Inspect relative position and condition between connection of car body and bogie, body parts, bogie parts, draw and buffing gear, etc., running the passenger car slowly on a curve equal to the minimum radius of the track on the line where the passenger car shall be used. However, when it is impossible to inspect on the minimum radius, substitution method can be taken by consulting between the parties.

5.2.5 Electrical Circuit

(1) Connection of Electrical Circuits

Check that there is no mistake of connection, and that continuity is good.

(2) Dielectric Strength

The circuit shall bear to the value more than that given by the following table. The test shall be performed with test voltage prepared by separate source which outputs commercial A.C. voltage as near as possible to the sine-wave, applying first the voltage equal or less than 1/2 of the test voltage and raise up to the test voltage as quick as possible within the limit possible to read the spontaneous voltage reading, and keep to the test voltage for one minute for test.

Position of Measurement		Test Voltage
Between High Tension circuit and earth		2E + 1000V
Between Low Tension circuit and earth	24 V circuit and earth	500V
	100V & 200V circuit and earth	2E + 1000V
Between High & Low Tension Circuits		2E + 1000V

Note 1. E is the rated voltage(V) of the circuit.

2. Followings are excluded

Instruments using semiconductor element (call-sign, temperature regulator, loud speaker, telephone, radio receiver, etc.), engine preheating plug, fluorescent lamp, incandescent lamp, germicidal lamp, electric rotating machines of 1 KVA or smaller, or similar to those.

(3) Tail lamps shall light normally.

5.2.6 Watertightness

Watertightness of window sash, ventilator or other places which is conceivable of intrusion of rainwater shall be satisfactory when the body was tested with artificial rain.

5.3 Functional Inspection

Functional inspection shall basically be conducted on empty car formed in least necessary for running condition and under specified electric system on the following items:

5.3.1 Common Test Item

Common test items for various instruments are as following:

- (a) Operation under minimum specified air pressure and voltage,
- (b) Interlocking motion with other equipment,
- (c) Conditions of injurious vibration, noise, or temperature rise.
- (d) Air leakage under specified air pressure.

5.3.2 Air Braking System

Tests shall be performed with separately determined specification, and the followings shall be checked:

- (1) Braking system shall operate smoothly, and the foundation brake gear operates reliably,
- (2) Conductor's valve and release valve operate satisfactorily,
- (3) Instruments indicate normally,
- (4) Emergency alarm device (signal disc) and safety valve shall operate normally.

5.3.3 Hand Brake Equipment

Foundation brake gear shall operate reliably when operated manually.

5.3.4 Room Lighting

Each lighting shall off-or-on satisfactorily.

5.3.5 Open and close operation of ventilating device shall be satisfactory.

5.4 Trial Run on the Main Line

5.4.1 General

After completing functional inspection, main line trial run shall be performed on the main line of ER, under the following conditions:

- (1) Condition of the Car
Test shall be performed under empty car condition, unless otherwise specified.
- (2) Formation of the Train
Formation of the train shall basically be that under actual operation condition.
- (3) Total Running Length
Tests shall be performed on both ways with the total length of about 100 km.
- (4) Running speed
Check basically up to the maximum operating speed determined separately.

5.4.2 Axle Driven Generating Device

The device shall operate satisfactorily, and the output power shall be checked.

5.4.3 Braking System

For service braking and emergency braking, normality of the operation of device shall be checked as in the case of 5.3.2.

5.4.4 Operation conditions of indicating system, indication lamp, indication instruments and the devices operate in relation with speed shall be inspected.

5.4.5 Noise in Passenger Room

Noise in passenger room shall be measured in accordance with the specification agreed upon between the parties.

5.4.6 Riding Comfortableness

Followings shall be checked:

- (1) It shall be free from marked noise and vibration.
- (2) Passenger and crew room shall be free from drafts.
- (3) Ventilation device shall operate satisfactorily.

5.4.7 Conditions of Parts after Running Test;

- (1) Measurement of the temperature at the top of journal box directly after the trial run on the main line shall show no abnormal heat generation.
- (2) Check items specified in para 5.1 (2).
- (3) There shall be no abnormal signs otherwise.

Note: For your reference, forms of inspection result tables for the above test are indicated in follows.

APPENDIX 2-1 Passenger Car Test Results

Date;
Prepared by;

Serial No. of the Car ;
Date and Manufacturer's Name of the Car Body;
Date and Manufacturer's Name of the Bogie ;
Date and Manufacturer's Name of the
Electrical Installation ;

Date and Place of Test

Test and Inspection Items	Date of Inspection	Place of Inspection
Appearance Inspection		
Structural Inspection		
Functional Inspection		
Trial Run on Main Line		

Parts Installed

Description	Type	Ser. No.	Manufacturer	Date Manufd.	Remarks

- (1) Appearance Inspection
- (2) Structural Inspection
- a) Dimension of Car Body and Bogie

Item		in mm.		Remarks
Camber at center of car body				
Height of draw and buffing gear center	Front			
	Rear			
	Diff.			
Horizontality of Underframe (Height of the underside of end beams of underframe)	Position 1			
	Position 2			
	Position 3			
	Position 4			
	Diff. 1 & 2			
	Diff. 3 & 4			
	Diff. 1 & 3			
	Diff. 2 & 4			
	Diff. 1 & 4			
	Diff. 2 & 3			
Distance between datum plane of the bogie frame and the top of journal box				
Loading rate of Bogie Side Brg.				
Gap between Underframe Parts and Bogie Parts				
Gap between Underframe Parts and Outer Periphery of the Wheel				

b) Weight

Items Inspected	Measured Value
Tare Weight	

c) Rolling Stock Gauge

Condition of Car	Conditions

d) Relative Position of Parts (Test passing curves)

Position	Status

e) Electrical Circuit

i) Status of joint

Position	Status

ii) Dielectric Strength

Position	Spec.	Status	Remarks

f) Watertightness

Position	Status

(3) Functional Inspection

Item, Position				Measured value, Condition
Air Braking System	Status of Leakage			
	Braking Test	Service Brake	Apply	
			Release	
	Emerg. Brake	Apply		
		Acting Emerg. Brake Valve		
For all Brake System				
Hand Brake Device				
Room Lighting Equipment				
Ventilating Device				

(4) Trial Run on the Main Line

Condition of Car ;
 Formation of Train ;
 Total Running Dist. ;
 Running Speed ;

Item, Position		Status
Axle Driven Generating Device	Operation	
	Output Power	
Air Braking System	Service Braking	
	Emergency Braking	
Noise in Passenger Room		
Riding Comfortableness		
Conditions of parts after Running Test	Journal Box	
	Clamping, etc.	
	Others	

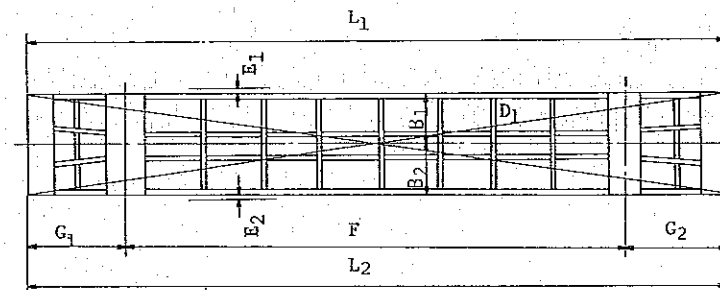
Reference: Weather :
 Temperature:

APPENDIX 3 General Rules for the Stage Inspection of Passenger Car

Measurement items of the stage inspection to be performed at in-process stages of the passenger car are listed below for your reference:

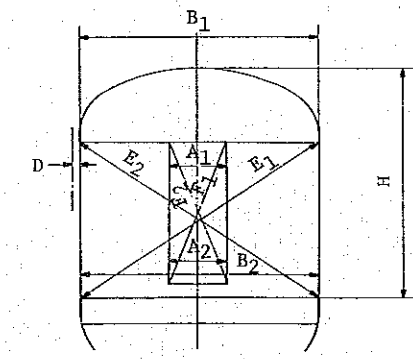
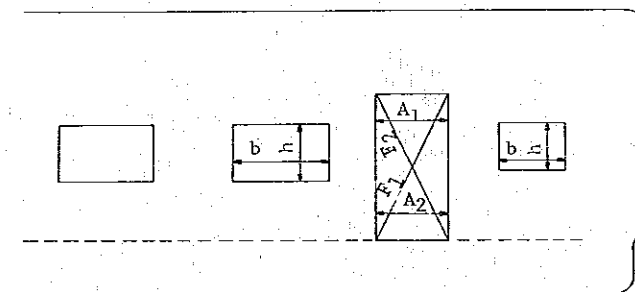
1. UNDERFRAME

No.	Item	Symbols	Allowance or limits	Remarks
1	Overall length	L_1, L_2		
2	Difference of length	$L_1 \sim L_2$		
3	Underframe half width	B_1, B_2		Measure each side from the center
4	Difference of diagonal dimensions	$D_1 \sim D_2$		
5	Bend of solebar in horizontal	E_1, E_2		Small bending unacceptable
6	Distance between bolster centers	F		
7	Difference of length between bolster center and headstock	$G_1 \sim G_2$		
8	Level of top of underframe	H		



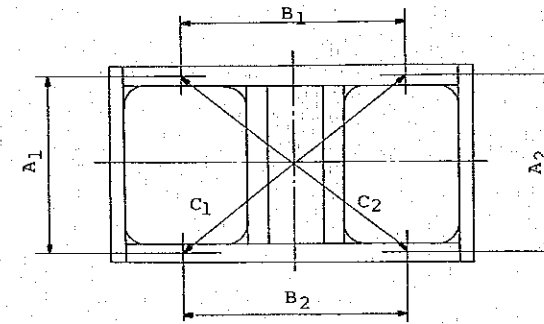
2. CAR BODY

No.	Item	Symbols	Allowance or limits	Remarks
1	Outside width of side framing	B_1, B_2		Measure at both ends and 2 points in between
2	Height of the car body	H		From top of under-frame to top of roof framing
3	Difference of diagonal dimensions	$E_1 \sim E_2$		
4	Bend of cant rail in horizontal			For long post, upper part of the straight part of the post
5	Bend of side exterior plate	D		
6	Width of entrance	A_1, A_2		Measure at upper and lower
7	Difference of width between A1 and A2	$A_1 \sim A_2$		
8	Difference of diagonal dimensions	$F_1 \sim F_2$		
9	Width of side window	b		
10	Height of side window	h		
11	Camber of solebar between bolster centers			



3. BOGIE FRAME

No.	Item	Symbols	Allowance or limits	Remarks
1	Distance between axle guard centers	A_1, A_2		
2	Wheel base	B_1, B_2		
3	Difference of axle guard centers	$A_1 \sim A_2$		
4	Difference of wheel base	$B_1 \sim B_2$		
5	Difference of diagonal dimensions	$C_1 \sim C_2$		



(Note) Reference was made to Japanese National Railway Standard JRS 11300-1F.

COMPARISON TABLE FOR M2-1970 SPECIFICATION FOR STRAIGHT AXLES

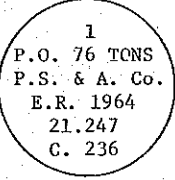
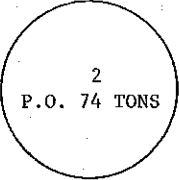
ERS	JRS (JIS)	UIC	BS	AAR																																																																																																																	
<p>1. Quality of material</p> <p>The axles shall be manufactured from the best quality steel made by the open hearth or electric furnace processes.</p> <p>The steel for the axles of locomotives, carriages and wagons shall show on analysis the following chemical composition.</p> <table border="1" data-bbox="326 693 816 924"> <thead> <tr> <th></th> <th>locomotive axles</th> <th>carriage and wagon axles</th> </tr> </thead> <tbody> <tr> <td>Carbon</td> <td>0.45-0.55%</td> <td>0.4-0.5%</td> </tr> <tr> <td>Silicon</td> <td>0.15-0.35%</td> <td>0.15-0.35%</td> </tr> <tr> <td>Manganese</td> <td>0.6-0.9%</td> <td>0.6-0.9%</td> </tr> <tr> <td>Phosphorus</td> <td>0.05% MAX.</td> <td>0.05% MAX.</td> </tr> <tr> <td>Sulphur</td> <td>0.05% MAX.</td> <td>0.05% MAX.</td> </tr> </tbody> </table>		locomotive axles	carriage and wagon axles	Carbon	0.45-0.55%	0.4-0.5%	Silicon	0.15-0.35%	0.15-0.35%	Manganese	0.6-0.9%	0.6-0.9%	Phosphorus	0.05% MAX.	0.05% MAX.	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COMPARISON TABLE FOR M2-1970 SPECIFICATION FOR STRAIGHT AXLES

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<p>2. Workmanship</p> <p>The axles shall be forged perfectly straight and smooth from ingots whose cross sectional area are at least four times the largest section of the rough forged axles.</p>	<p><u>Forging ratio</u></p> <p>Ingot → Axle ≥ 4</p> <p>Ingot → Blooming → Axle ≥ 8 (Average cross-sectional area ratio)</p>	<p><u>Forging ratio</u> (ratio of minimum cross-sectional area of ingot to maximum cross-sectional area of axle)</p> <p>Ingot ≥ 3</p> <p>Ingot $\xrightarrow{\text{(rolled)}} \text{Axle} \geq 5$</p> <p>Ingot $\xrightarrow{\text{Billet}} \text{Axle} \geq 4$ (in total)</p> <p>≥ 2</p>	<p><u>Workmanship</u></p> <p>None</p>	<p><u>Workmanship</u></p> <p>Ingot → Axle Either process permissible.</p> <p>Ingot → Billet → Axle</p> <p>Forging ratio from ingot to axle shall be or more.</p>
<p>3. Freedom from defects</p> <p>The axles shall be free from any defects (such as pipes or blow holes of any kind, undue segregation of phosphorus and sulphur, oxides, silicates, silica grains ... etc.) and accurately finished to the prescribed dimensions.</p>	<p><u>Discard</u></p> <p>Amount of discard is specified.</p> <p>Top of ingot: 20% or more</p> <p>Bottom of ingot: 5% or more</p>	<p><u>Discard</u></p> <p>Detrimental top and bottom portions of ingot shall be discarded.</p> <p>The ingot shall be free from flaws, and all the surface flaws shall be removed.</p>	<p><u>Freedom from defects</u></p> <p>A sufficient discard shall be made from each ingot to ensure freedom from piping and harmful segregation.</p> <p>Axles shall be free from injurious defects.</p>	<p><u>Freedom from defects</u></p> <p>The ingot shall be completely removed or other incomplete portions.</p>
<p>4. Branding</p> <p>The axles shall be stamped clearly when hot in letters and figures about 9mm high, as follows:</p> <p>On one end:</p> <p>(a) End number</p> <p>(b) Manufacturer's name or initials</p> <p>(c) The letters "E.R." and year of manufacture</p> <p>(d) Order number</p> <p>(e) Cast number</p> <p>On the other end:</p> <p>(a) End number</p> <p>In case it is necessary to remove the markings by machining, this may be done only after permission has been obtained from the E.R. Inspecting Engineer. The markings shall be renewed in such case immediately machining is completed.</p>	<p><u>Hot stamping</u></p> <p>The axle shall be stamped with melt No., ingot No., No. indicative of location.</p> <p><u>Cold stamping</u></p> <p>Manufacturer's name, date of manufacture, melt No., ingot number location, classification of heat-treatment (Q, QA, QR).</p>	<p><u>Hot stamping</u> Stamped on the part wheel sheet to such a depth as will permit removal in finishing of axle</p> <p>Heat (melt) number, manufacturer's mark, date of manufacture, state of delivery (classification)</p> <p><u>Cold stamping</u></p> <p>Manufacturer's name, date of manufacture, Heat (melt) number, state of delivery (N: normalized, B: Roughly forged, V: Oil quenched and tempered), Mark indicative of completion of inspection (if requested by inspecting authority).</p>	<p><u>Hot stamping</u></p> <p>Melt No., and other marks as required by the purchaser or its representative shall be stamped on one end of the axle, not on the body of the axle.</p> <p><u>Cold stamping</u></p> <p>After machine-finished, similar stamping shall be performed.</p> <p>Manufacturer's name, date of manufacture, identification mark, order number, melt number, railway name initials, and mark indicative of completion of inspection (if requested by inspecting authority).</p>	<p><u>Hot stamping</u></p> <p>Melt number, serial number</p> <p><u>Cold stamping</u></p> <p>Manufacturer's name, grade of axle, melt number, date of manufacture, serial number, ultrasonic inspection mark.</p>

ERS	JRS (JIS)	UIC	BS	AAR
<p>Forged perfectly straight axles whose cross sectional area is four times the largest section of forged axles.</p>	<p><u>Forging ratio</u></p> <p>Ingot → Axle ≥ 4</p> <p>Ingot → Blooming → Axle ≥ 8</p> <p>(Average cross-sectional area ratio)</p>	<p><u>Forging ratio</u> (ratio of minimum cross-sectional area of ingot to maximum cross-sectional area of axle)</p> <p>Ingot ≥ 3</p> <p>Ingot $\xrightarrow{\text{(rolled)}} \text{Axle} \geq 5$</p> <p>Ingot $\xrightarrow{\text{Billet}} \text{Axle} \geq 4$ (in total)</p> <p>≥ 2</p>	<p><u>Workmanship</u></p> <p>None</p>	<p><u>Workmanship</u></p> <p>Ingot → Axle Either process is permissible.</p> <p>Ingot → Billet → Axle</p> <p>Forging ratio from ingot to axle shall be 3 or more.</p>
<p>Free from any defects (such as blow holes of any kind, phosphorus and sulphur, silica grains ... etc.) in excess of the prescribed limits.</p>	<p><u>Discard</u></p> <p>Amount of discard is specified.</p> <p>Top of ingot: 20% or more</p> <p>Bottom of ingot: 5% or more</p>	<p><u>Discard</u></p> <p>Detrimental top and bottom portions of ingot shall be discarded.</p> <p>The ingot shall be free from flaws, and all the surface flaws shall be removed.</p>	<p><u>Freedom from defects</u></p> <p>A sufficient discard shall be made from each ingot to ensure freedom from piping and harmful segregation.</p> <p>Axles shall be free from injurious defects.</p>	<p><u>Freedom from defects</u></p> <p>The ingot shall be completely removed of pipe or other incomplete portions.</p>
<p>Stamped clearly when hot with characters about 9mm high, as follows:</p> <p>Manufacturer's name or initials</p> <p>"E.R." and year of manufacture</p> <p>It is necessary to remove the markings. This may be done only after the axle has been obtained from the E.R. The markings shall be removed immediately after machining.</p>	<p><u>Hot stamping</u></p> <p>The axle shall be stamped with melt No., ingot No., No. indicative of location.</p> <p><u>Cold stamping</u></p> <p>Manufacturer's name, date of manufacture, melt No., ingot number location, classification of heat-treatment (Q, QA, QR).</p>	<p><u>Hot stamping</u> Stamped on the part wheel sheet to such a depth as will permit removal in finishing of axle</p> <p>Heat (melt) number, manufacturer's mark, date of manufacture, state of delivery (classification)</p> <p><u>Cold stamping</u></p> <p>Manufacturer's name, date of manufacture, Heat (melt) number, state of delivery (N: normalized, B: Roughly forged, V: Oil quenched and tempered), Mark indicative of completion of inspection (if requested by inspecting authority).</p>	<p><u>Hot stamping</u></p> <p>Melt No., and other marks as required by the purchaser or its representative shall be stamped on one end of the axle, not on the body of the axle.</p> <p><u>Cold stamping</u></p> <p>After machine-finished, similar stamping shall be performed.</p> <p>Manufacturer's name, date of manufacture, identification mark, order number, melt number, railway name initials, and mark indicative of completion of inspection (if requested by inspecting authority).</p>	<p><u>Hot stamping</u></p> <p>Melt number, serial number</p> <p><u>Cold stamping</u></p> <p>Manufacturer's name, grade of axle, melt number, date of manufacture, serial number, ultrasonic inspection mark.</p>

ERS	JRS (JIS)	UIC	BS	ARR																			
<p>When axles are ordered completely assembled with wheels, the pressure at which the wheels were forced on the axles is to be stamped on the respective ends of the axle.</p> <p>The arrangement of the markings is shown below:</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>No. 1 End.</p>  </div> <div style="text-align: center;"> <p>No. 2 End.</p>  </div> </div> <p>P.O. = Pressed on P.S. and A. Co. = Manufacturer's initials 21.247 = Order number C. 236 = Cast number E.R. 1964 = Date of E.R. order</p> <p>No markings shall be stamped on the body of the axle.</p>																							
<p>5. Lathe centres</p> <p>Lathe centres, made accurately central to the prescribed dimensions, shall be left in the axles after the ends have been faced exactly square.</p>	<p><u>Lathe centres</u></p> <p>None</p>	<p><u>Lathe centres</u></p> <p>None</p>	<p><u>Lathe centres</u></p> <p>None</p>	<p><u>Lathe centres</u></p> <p>None</p>																			
<p>6. Heat treatment</p> <p>After forging the axles shall be normalised or normalised and tough hardened, and tempered.</p> <p>For normalising, the cold axle shall be uniformly heated to a proper temperature to refine the grain and after having been soaked at this temperature for a sufficient length of time shall be withdrawn from the furnace and allowed to cool under cover to below the critical range in air.</p> <p>The tough hardening shall always be in oil.</p> <p>The tempering temperature must not be less than 500°C.</p>	<p><u>Normalizing, or normalizing and tempering</u> (°C)</p> <table border="1" data-bbox="641 1339 1101 1528"> <thead> <tr> <th></th> <th>Normalizing</th> <th>Normalizing and Tempering</th> </tr> </thead> <tbody> <tr> <td>Class 1 (SFA55)</td> <td>840/890</td> <td>840/890 500/650</td> </tr> <tr> <td>Class 2 (SFA60)</td> <td>830/880</td> <td>830/880</td> </tr> </tbody> </table>		Normalizing	Normalizing and Tempering	Class 1 (SFA55)	840/890	840/890 500/650	Class 2 (SFA60)	830/880	830/880	<p><u>Heat treatment</u></p> <p>Normalized, or oil quenched and tempered.</p>	<p><u>Heat treatment</u></p> <p>Heat treatment shall be either of the following as agreed upon between the manufacturer and purchaser:</p> <p>(a) Cooled in air (normalized)</p> <p>(b) Quenched in oil for suitable time</p> <p>(c) Quenched in oil and subsequently tempered</p>	<p><u>Heat treatment</u></p> <table border="1" data-bbox="2332 1339 2822 1486"> <thead> <tr> <th>Grade</th> <th>U</th> <th>F</th> <th>G</th> <th>H</th> </tr> </thead> <tbody> <tr> <td>Heat treatment</td> <td>None</td> <td>Normalized and Tempered</td> <td>Quenched and Tempered</td> <td>Normalized, Quenched-tempered</td> </tr> </tbody> </table> <p>Heat treatment furnace may be either a batch furnace or a continuous furnace.</p> <p>If directly heat-treated from forging, the temperature for entry to furnace shall be, for grades F, G, and H, 1000°F (538°C) to 500°F (260°C).</p> <p>Stress relief shall be performed before machining or at the temperature of 950°F (510°C). If processed at 950°F or less, stress relieving shall be performed.</p>	Grade	U	F	G	H	Heat treatment	None	Normalized and Tempered	Quenched and Tempered	Normalized, Quenched-tempered
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Class 1 (SFA55)	840/890	840/890 500/650																					
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<p>7. Mechanical tests</p> <p>The manufacturer at his own expense shall provide extra axles for testing as laid down below at the rate of one axle for each 50 axles or part of 50 axles in each cast except that:</p> <p>(1) If there are less than 55 axles in the cast, one axle only shall be selected.</p> <p>(2) If less than 15 axles are ordered, or less than 15 axles made from one cast, the manufacturer may either (a) provide an extra axle for testing or (b) leave a piece on each axle of the cast of the same diameter at the end of the axle so that the E.R. Inspecting Engineer may stamp one of the pieces to be used for the tensile and cold bend tests.</p> <p>The E.R. Inspecting Engineer shall select and test such of the axles as he may think fit up to the total stated above. The axles tested shall be considered to represent the quality of those from which they were selected.</p> <p>All axles, or pieces of axles, tested must comply with the tests specified without further heat treatment of any kind.</p> <p>(a) Falling weight test</p> <p>The axle shall be placed upon bearings resting on a block of metal of not less than 5,000 kgs, weight supported on a rigid concrete or other solid foundation, and must withstand, without fracture, five, blows from a weight of 1,000 kgs, as specified in table.</p> <p>The axle shall be turned 180° after each blow.</p>		<p><u>Tests</u></p> <p>(1) Tensile, falling weight and impact tests(*)</p> <p>Specimens shall be selected:</p> <p>One axle for 50 axles or less per melt and per heat treatment</p> <p>Two axles for 51 axles or more per melt and per heat treatment</p> <p>(2) Macroscopic test(*)</p> <p>To be conducted on both end faces of all the test axles except those subjected to falling weight test.</p> <p>(3) Chemical composition(*)</p> <p>The analysis shall be performed once for every melt.</p> <p><u>Note:</u> Those marked with (*) shall be carried out only if requested by the purchaser.</p> <p>(4) Axles to be subjected to tests shall be selected and marked by the inspector of the purchaser's side from among a lot of axles presented by the manufacturer.</p> <p>(5) Falling weight test</p> <p>Anvil shall be 10 tons or more in weight.</p> <table border="1" data-bbox="1240 1310 1733 1549"> <thead> <tr> <th>Falling weight</th> <th>Roundness of end (radius)</th> <th>Distance between points of support</th> <th>Number of blows</th> <th>Height of fall (H)</th> </tr> </thead> <tbody> <tr> <td>100kg</td> <td>≤ 100</td> <td>1500</td> <td>4</td> <td>$\frac{0.30 \times d^2}{P}$</td> </tr> </tbody> </table> <p>Freedom from defects D ... Diameter at center P ... 1000kg</p> <p>Axle shall be turned through 180° after 2 blows, and then given further 2 blows.</p> <p>This test may be omitted in a lot of less than 15 axles.</p>	Falling weight	Roundness of end (radius)	Distance between points of support	Number of blows	Height of fall (H)	100kg	≤ 100	1500	4	$\frac{0.30 \times d^2}{P}$	<p><u>Tests</u></p> <p>One axle to be sampled as test specimen per unit of 50 axles or its fraction in each melt.</p> <p>One axle to be taken as test specimen for melt of 15 axles or less. Or, test specimen may be obtained by preparing it as an extension of an axle, with its diameter arranged to be same as the end of the axle.</p> <p>The axle for testing and the specimen obtained as an extension of axle shall pass the test without being re-heat-treated.</p> <p><u>Falling weight test</u></p> <p>5 blows (with the axle turned through 180° after first and third blows. Subsequently it shall be nicked and broken.)</p> <p>Falling weight: 1000 kg</p>	<p><u>Tests</u></p> <p>Tensile test, Microscopic structure (heat-treated axle, Grade F, G, H)</p> <p>Number of test specimen:</p> <p>One axle out of 70 axles per melt and heat treatment.</p> <p>Sampling of test specimens:</p> <p>Prepare an extension to each of the axles of 5% or more in number per melt; heat treatment and size of axle. From this extended part of the axle at the position of R/2, a specimen shall be taken in axial direction.</p> <p>Tensile test:</p> <p>Shape of test piece 1/2" φ × 2" GL</p> <p>Microscopic structure:</p> <p>Cross section are to be observed.</p> <p><u>Falling weight test</u> (only for Grade U, non-heat-treated)</p> <p>Selected by Inspector, one/melt, for each size.</p> <p>Distance between points of support: 3 feet (915 mm)</p> <p>Falling weight: 1000 kg</p> <p>Height of fall: $H = d^2$</p> <p>where: H = height of fall (feet) d = diameter at center (in)</p> <p>Number of blows: 5 (Axle shall be turned through 180° after 1st and 3rd blow.)</p>
Falling weight	Roundness of end (radius)	Distance between points of support	Number of blows	Height of fall (H)										
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ERS	JRS (JIS)	UIC	BS	AAR																																																																																																																																																	
<p>(b) Tensile tests</p> <p>The tensile strength and ductility shall be determined from a standard B.S.S. test piece C or D or from a standard continental test piece M or N.</p> <p>The test piece shall be machined cold from one end of each axle tested in the longitudinal direction of the axle. The test piece shall be cut midway between the centre line and the surface of the axle. No test piece may be cut from any axle before all at treatments of same has been completed.</p> <p>The normalised axles shall show a tensile breaking strength of not less than 55 kgs. per mm², with an elongation of not less than 25 per cent on test piece C or D, or of not less than 22 per cent on test piece M or 19 per cent on test piece N.</p> <p>The tough hardened axles shall show a tensile breaking strength of not less than 60 kgs. per mm², with an elongation of not less than 20 per cent on test piece C or D, or of not less than 18 per cent on test piece M or 16 per cent on test piece N.</p> <p>The yield point must not be less than 50 per cent of the ultimate tensile strength.</p> <p>(The yield point is taken to be the load per square inch at which a distinctly visible increase occurs in the distance between gauge points on the test piece, observed by using dividers after the removal of the load, or at which when the load is increased at a moderately fast rate there is a distinct drop of the testing machine lever, or, in hydraulic machines, of the gauge finger).</p>	<p>Mechanical properties</p> <p>Axles shall be subjected to test at the rate of one axle per unit of 50 axles (or its fraction) of the same melt and the same heat treatment.</p> <p>Test specimen shall be prepared by attaching an extension (having a cross section not smaller than the minimum diameter of an axle) to the top of an ingot. Test piece shall be taken, in axial direction, from this specimen (after this is heat-treated) at the location 20 to 30 mm inside from the surface.</p> <p>Test items and shapes of test pieces</p> <p>Tensile test: JIS No.4 test piece (14φ × 50GL)</p> <p>Impact test: JIS No.3 test piece (10 × 55ℓ × 2u)</p> <p>Bending test: JIS No.5 test piece (19 × 25 × 180ℓ or more)</p> <table border="1" data-bbox="652 1396 1172 1564"> <thead> <tr> <th rowspan="2">Type of steel</th> <th colspan="4">Tensile test</th> <th colspan="2">Bending angle</th> <th rowspan="2">Impact test</th> </tr> <tr> <th>Yield point (kg/cm²)</th> <th>Tensile strength (kg/cm²)</th> <th>Elongation (%)</th> <th>Reduction of area (%)</th> <th>Inside radius (mm)</th> <th>Bending angle (°)</th> </tr> </thead> <tbody> <tr> <td>SFA 55</td> <td>≥ 28</td> <td>≥ 55</td> <td>≥ 23</td> <td>≥ 35</td> <td>16</td> <td>180</td> <td>≥ 5</td> </tr> <tr> <td>SFA 60</td> <td>≥ 30</td> <td>≥ 60</td> <td>≥ 20</td> <td>≥ 30</td> <td>22</td> <td>180</td> <td>≥ 4</td> </tr> </tbody> </table>	Type of steel	Tensile test				Bending angle		Impact test	Yield point (kg/cm ²)	Tensile strength (kg/cm ²)	Elongation (%)	Reduction of area (%)	Inside radius (mm)	Bending angle (°)	SFA 55	≥ 28	≥ 55	≥ 23	≥ 35	16	180	≥ 5	SFA 60	≥ 30	≥ 60	≥ 20	≥ 30	22	180	≥ 4	<p>Test pieces shall be taken at R/2 position:</p> <p>one axle in axial direction for tensile test, and two axles in axial and tangential directions for impact test.</p> <table border="1" data-bbox="1216 913 1706 1102"> <thead> <tr> <th rowspan="2">Classification</th> <th colspan="3">Tensile test</th> <th colspan="2">Impact test</th> </tr> <tr> <th>Yield point (kg/cm²)</th> <th>Tensile strength (kg/cm²)</th> <th>Elongation C*</th> <th colspan="2">Charpy SU (kg.m/cm²)</th> </tr> </thead> <tbody> <tr> <td>Normalization</td> <td>-</td> <td>50/65</td> <td>110</td> <td>≥ 5</td> <td>≥ 2</td> </tr> <tr> <td>Oil-quenched, and tempered</td> <td>-</td> <td>55/63</td> <td>113</td> <td>≥ 8</td> <td>≥ 3</td> </tr> </tbody> </table> <table border="1" data-bbox="1216 1144 1706 1333"> <thead> <tr> <th rowspan="2">Standard test piece</th> <th colspan="2">Gauge Length of Test Piece</th> </tr> <tr> <th>L</th> <th>C*</th> </tr> </thead> <tbody> <tr> <td></td> <td>8.16√S</td> <td>R(TS)+2.5A(Eℓ)</td> </tr> <tr> <td></td> <td>5.65√S</td> <td>R +2.2A</td> </tr> <tr> <td></td> <td>4√S</td> <td>R +2A</td> </tr> </tbody> </table> <p>Macrographic test</p> <p>Judgement of test result shall be made in accordance with the samples indicative of limits.</p> <p>Check analysis</p> <p>50 gr. or more shall be taken to get the average chemical composition representing the axles for test.</p> <p>The test method shall be the same practiced in the laboratories of the purchaser's country. The composition shall be within the specified limit.</p>	Classification	Tensile test			Impact test		Yield point (kg/cm ²)	Tensile strength (kg/cm ²)	Elongation C*	Charpy SU (kg.m/cm ²)		Normalization	-	50/65	110	≥ 5	≥ 2	Oil-quenched, and tempered	-	55/63	113	≥ 8	≥ 3	Standard test piece	Gauge Length of Test Piece		L	C*		8.16√S	R(TS)+2.5A(Eℓ)		5.65√S	R +2.2A		4√S	R +2A	<p>Tensile test</p> <p>Position at which the test piece is taken:</p> <p>22 mm inside from surface of wheel seat in axial direction, or the extension of axle in axial direction.</p> <p>Shape of test piece:</p> <p>14φ (0.564") × 20.3 (0.798) GL (4√A)</p> <table border="1" data-bbox="1810 1039 2300 1186"> <thead> <tr> <th>Yield Point (YP) (T/in²)</th> <th>Tensile Strength (TS) (T/in²)</th> <th>Elongation (El) (%)</th> </tr> </thead> <tbody> <tr> <td>TS/2</td> <td>35 - 40 (55 - 63 kg/mm²)</td> <td>TS + El ≥ 60</td> </tr> </tbody> </table> <p>Bending Test (in case of melt of 15 axles or less, and not subjected to falling weight test.)</p> <p>Position at which test piece is taken:</p> <p>Adjacent to the position of tensile test piece</p> <p>Shape of test piece:</p> <p>1 1/4" (32mm) × 9" (230mm) length, 1/16" (1.6mm) (radius at corner)</p> <p>Bend a test piece by means of 1" (25.4mm) radius and 2" wide tool until both ends of the test piece gets in parallel with each other. The test piece shall not be broken even the both ends have come into contact.</p>	Yield Point (YP) (T/in ²)	Tensile Strength (TS) (T/in ²)	Elongation (El) (%)	TS/2	35 - 40 (55 - 63 kg/mm ²)	TS + El ≥ 60	<p>Judgement: Permanent strain caused by 1st blow shall be smaller than the value calculated by the following formula:</p> $\text{Max. permanent strain} = \frac{L}{1.9d} \cdot \frac{d}{2} + \frac{1}{2}$ <p>where L = Length of axle (in) d = Diameter at center (in)</p> <p>Tensile test ... to be carried out after the final heat treatment</p> <table border="1" data-bbox="2374 861 2864 1165"> <thead> <tr> <th rowspan="2">Grade</th> <th colspan="2">Journal diameter (")</th> <th>Yield point (ksi)</th> <th>Tensile strength (ksi)</th> <th>Elongation (%)</th> <th>Reduction of area (%)</th> </tr> <tr> <th>≥</th> <th>≤</th> <th>≥</th> <th>≥</th> <th>≥</th> <th>≥</th> </tr> </thead> <tbody> <tr> <td rowspan="2">F</td> <td>8</td> <td>12</td> <td>50</td> <td>88</td> <td>22</td> <td>37</td> </tr> <tr> <td>12</td> <td>14</td> <td>48</td> <td>86</td> <td>21</td> <td>35</td> </tr> <tr> <td>(N-T)</td> <td></td> <td></td> <td>46</td> <td>84</td> <td>20</td> <td>33</td> </tr> <tr> <td rowspan="3">G</td> <td>4</td> <td>7</td> <td>55*</td> <td>90</td> <td>20</td> <td>39</td> </tr> <tr> <td>7</td> <td>10</td> <td>50*</td> <td>85</td> <td>20</td> <td>39</td> </tr> <tr> <td>-</td> <td>-</td> <td>48*</td> <td>82.5</td> <td>19</td> <td>36</td> </tr> <tr> <td rowspan="2">H</td> <td>7</td> <td>10</td> <td>75*</td> <td>115</td> <td>16</td> <td>35</td> </tr> <tr> <td>7</td> <td>10</td> <td>65</td> <td>105</td> <td>18</td> <td>35</td> </tr> <tr> <td>(N-Q-T)</td> <td>-</td> <td>-</td> <td>60*</td> <td>100</td> <td>18</td> <td>35</td> </tr> </tbody> </table> <p>Yield point values marked with * shall be the values having 0.2% off set indicated by strain gauges.</p> <p>Microscopic structure test:</p> <p>The test shall be conducted on axles of Grades F, G, H, which shall represent uniform microscopic structures as a whole. The judgement shall be made by means of standard samples indicative of limits.</p>	Grade	Journal diameter (")		Yield point (ksi)	Tensile strength (ksi)	Elongation (%)	Reduction of area (%)	≥	≤	≥	≥	≥	≥	F	8	12	50	88	22	37	12	14	48	86	21	35	(N-T)			46	84	20	33	G	4	7	55*	90	20	39	7	10	50*	85	20	39	-	-	48*	82.5	19	36	H	7	10	75*	115	16	35	7	10	65	105	18	35	(N-Q-T)	-	-	60*	100	18	35
Type of steel	Tensile test				Bending angle		Impact test																																																																																																																																														
	Yield point (kg/cm ²)	Tensile strength (kg/cm ²)	Elongation (%)	Reduction of area (%)	Inside radius (mm)	Bending angle (°)																																																																																																																																															
SFA 55	≥ 28	≥ 55	≥ 23	≥ 35	16	180	≥ 5																																																																																																																																														
SFA 60	≥ 30	≥ 60	≥ 20	≥ 30	22	180	≥ 4																																																																																																																																														
Classification	Tensile test			Impact test																																																																																																																																																	
	Yield point (kg/cm ²)	Tensile strength (kg/cm ²)	Elongation C*	Charpy SU (kg.m/cm ²)																																																																																																																																																	
Normalization	-	50/65	110	≥ 5	≥ 2																																																																																																																																																
Oil-quenched, and tempered	-	55/63	113	≥ 8	≥ 3																																																																																																																																																
Standard test piece	Gauge Length of Test Piece																																																																																																																																																				
	L	C*																																																																																																																																																			
	8.16√S	R(TS)+2.5A(Eℓ)																																																																																																																																																			
	5.65√S	R +2.2A																																																																																																																																																			
	4√S	R +2A																																																																																																																																																			
Yield Point (YP) (T/in ²)	Tensile Strength (TS) (T/in ²)	Elongation (El) (%)																																																																																																																																																			
TS/2	35 - 40 (55 - 63 kg/mm ²)	TS + El ≥ 60																																																																																																																																																			
Grade	Journal diameter (")		Yield point (ksi)	Tensile strength (ksi)	Elongation (%)	Reduction of area (%)																																																																																																																																															
	≥	≤	≥	≥	≥	≥																																																																																																																																															
F	8	12	50	88	22	37																																																																																																																																															
	12	14	48	86	21	35																																																																																																																																															
(N-T)			46	84	20	33																																																																																																																																															
G	4	7	55*	90	20	39																																																																																																																																															
	7	10	50*	85	20	39																																																																																																																																															
	-	-	48*	82.5	19	36																																																																																																																																															
H	7	10	75*	115	16	35																																																																																																																																															
	7	10	65	105	18	35																																																																																																																																															
(N-Q-T)	-	-	60*	100	18	35																																																																																																																																															

ERS	JRS (JIS)	UIC	BS	AAR
<p>Should a tensile test piece break outside the middle half of its gauge length (i.e. outside 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. A fresh tests may be made by the manufacturer with a test piece or test pieces taken from the same axle from which the discarded test piece was taken.</p> <p>(c) Cold bend test</p> <p>A test piece 230 mm long and 32 mm. square with 1.5 mm radius at the edges, must withstand being bent cold by direct pressure from a tool 50 mm wide, the end having a radius 25 mm until the side of the test piece are parallel. The ends of the test piece are then to be brought together without fracture, by direct pressure. (This test will be taken only when less than 15 axles are ordered and the falling weight test has not been carried out).</p> <p>(d) Ultrasonic test</p> <p>All axles should be examined by ultrasonic method using a probe of minimum intensity 3 megacycles second, and should give a clear image on the screen of the apparatus showing axle freedom from voids and cracks.</p>	<p><u>Ultrasonic test</u></p> <p>All the products shall be subjected to this test.</p> <p>Frequency: 2 - 2.25 MHz</p> <p>Axial direction ...</p> <p>2MHz 5B sensitivity (for quality of reduction)</p> <p>Criteria for judgement: B1.05 or more</p> <p>2MHz 2B sensitivity (for defect)</p> <p>Criteria for judgement: Absence of defect</p>			<p><u>Ultrasonic flaw detection test</u></p> <p>Ultrasonic flaw detection shall be carried out on all the axles at 2.25 MHz for heat-treated axles and at 1 MHz for non-heat-treated axles. This test shall be performed after the machining of both ends (≤ 250) and the boring of center holes, or at any stage after that.</p> <p>The sensitivity shall be 1/2" indication amplitude for heat-treated axles and 1" indication amplitude for non-heat-treated axles.</p> <p>Judgement: Penetrability ... 1B or more</p> <p>Interior defect ... More than the specified value shall be unacceptable in consideration of DAC.</p>

ERS	JRS (JIS)	UIC	BS	AAR
<p>8. Additional tests</p> <p>In the event of the axle selected for testing not satisfying the requirement of the tensile or bend tests, and the fractured test piece indicating that the result does not fairly represent the bulk of the axles, the E.R. Inspecting Engineer at his discretion, and at the expense of the manufacturer, may take two more test pieces from the same axle for repeating the test under which failure occurred. The axles will be accepted if the results of the repeat tests are satisfactory.</p> <p>Should the axle fail in the falling weight test two more axles shall be taken from the same lot for testing, either before or after the bulk has been subjected to further heat treatment. The axles shall be considered to have passed the test if these two axles fulfil the conditions of the falling weight and tensile tests.</p>	<p><u>Magnetic particle inspection</u></p> <p>All products to be tested. Let current flow through axle.</p>	<p><u>Additional tests</u></p> <p>None</p>	<p><u>Retest</u></p> <p>If the falling weight test at the first blow or any other test fails, twice the number of test pieces shall be taken from the same lot. In this case both axles must pass the test. If both axles fail, they shall be re-heat-treated and be subjected to the test as agreed upon by the purchaser or its representative.</p>	<p><u>Retest</u></p> <p>If the test result fails to meet the requirements, retest will be allowed if the defect is not caused by ruptures, cracks, or flakes in the steel. Re-heat-treatment is permitted in each lot, but shall be limited only up to 3 times.</p> <p><u>Supplementary requirements</u></p> <p>These requirements shall be applied where so specified by the purchaser. The details shall be agreed upon between the manufacturer and the purchaser.</p> <p>(1) Macroscopic inspection to be performed on the longitudinal and transverse cross sections of the extended part, longest, of the axles in the same molten steel.</p> <p>(2) If, with the approval of the purchaser, the manufacturer substitutes Grade F axles for Grade V axles.</p>
<p>9. Independent test</p> <p>If the E.R. Inspecting Engineer desires to make independent tensile or other tests of the material, the broken pieces of any of the axles tested shall be placed at his disposal for the purpose, free of charge.</p>	<p><u>Independent test</u></p> <p>None</p>	<p><u>Independent test</u></p> <p>None</p>	<p><u>Independent test</u></p> <p>Same as ERS.</p>	<p><u>Independent test</u></p> <p>None</p>
<p>10. Metallurgical test</p> <p>At the option of E.R., metallurgical tests according to acknowledged standards may be conducted if so required by E.P. Inspecting Engineer.</p>	<p><u>Metallurgical test</u></p> <p>None</p>	<p><u>Metallurgical test</u></p> <p>None</p>	<p><u>Metallurgical test</u></p> <p>None</p>	<p><u>Metallurgical test</u></p> <p>None</p>

ERS	JRS (JIS)	UIC	BS	AAR
<p>11. Inspection</p> <p>The E.R. Inspecting Engineer shall be allowed unhindered accesses to the manufacturer's works at all times during working hours when axles are in process of manufacture or delivery. He shall be at liberty to inspect the manufacture at any stage and to reject any material which does not conform to this specification. Material so rejected shall be cut up or marked at once in such a way that it cannot be confused subsequently with satisfactory material.</p>	<p><u>Inspection</u></p> <p>None</p>	<p><u>Inspection</u></p> <p>Test specimens shall be taken at the presence of the inspector.</p>	<p><u>Inspection</u></p> <p>Same as ERS</p>	<p><u>Inspection</u></p> <p>(1) The inspector representing the purchaser will have free access to the manufacturer's plants (during the manufacture of the products ordered). The manufacturer shall supply all the conveniences and assistance to the inspector that he may recognize the products are manufactured in accordance with the Specification. The tests and inspections for acceptance of products shall be performed in the premises of the manufacturer.</p>
<p>12. Testing facilities</p> <p>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.</p> <p>All test axles and test pieces shall be selected by the E.R. Inspecting Engineer and the tests shall be carried out in his presence.</p>	<p><u>Testing facilities</u></p> <p>None</p>	<p><u>Testing facilities</u></p> <p>None</p>	<p><u>Testing facilities</u></p> <p>Same as ERS</p>	<p>(2) The purchaser may conduct tests at his laboratory or other places for deciding the acceptance or rejection of the products, provided that in this case the expenses required shall be to the charge of the purchaser.</p> <p>(3) The inspector shall inspect the axles for their workmanship, existence of any flaw, and the conformance with the requirements specified in the order sheet and drawings. If any flaw is found in the inspection, the manufacturer is permitted to cut the flaws.</p> <p>(4) Those which do not comply with the Specification are judged unacceptable (abolished).</p>
<p>13. Guarantee</p> <p>The axles are guaranteed by the manufacturer for, 4 (four) years against any defect imputable to the manufacture and not revealed during acceptance at the mill.</p> <p>The period is calculated from the end of the month stamped on the axle.</p> <p>Axles which during the guarantee period, show defects either making them unfit for service or reducing their period of service are rejected. The rejected axles are placed at the disposal of the supplier.</p> <p>When 2 (two) axles from the same cast are broken in service, or when more than 5% (five per cent) of the axles from the same cast reveal defects within the above conditions, E.R. has the right to refuse the whole of the cast, and to request replacement of the axles without charge.</p>	<p><u>Guarantee</u></p> <p>None</p>	<p><u>Guarantee (Warranty)</u></p> <p>Same as ERS.</p>	<p><u>Guarantee</u></p> <p>Same as ERS.</p>	<p>(5) The documents related to the thus abolished materials shall be kept and stored for 14 days after the submittal of the test report. If the manufacturer is not satisfied with the test result he may request re-test or re-inspection during such period.</p> <p><u>Certificate</u></p> <p>Upon request of the purchaser in the contract or order, a manufacturer's certification that the material or the manufactured and tested in accordance with this specification together with a respect of the test results shall be furnished at the time of shipment.</p>

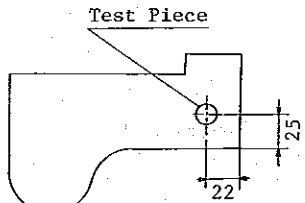
ERS	JRS (JIS)	UIC	BS	AAR
			<u>Inspection</u> Same as ERS <u>Testing facilities</u> Same as ERS <u>Guarantee</u> Same as ERS	<u>Inspection</u>

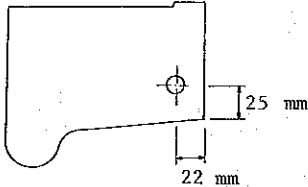

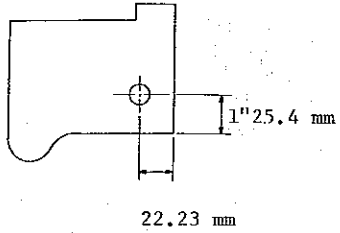
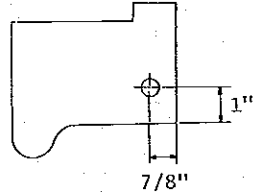
COMPARISON TABLE FOR M4-1964 SPECIFICATION FOR TYRES

ERS	JRS (JIS)	UIC	BS	AAR																																																																																																																																										
<p>1. Scope</p> <p>This specification covers two classes of steel tyres:</p> <p>Class A: for locomotives and rail-cars power bogies.</p> <p>Class B: for carriages and wagons and rail-cars other than power bogies.</p>	<p>Scope</p> <p>Applicable to railway cars.</p> <table border="1" data-bbox="718 592 1101 781"> <thead> <tr> <th>Classification (Width × Thickness)</th> <th>Symbols</th> </tr> </thead> <tbody> <tr> <td>135 × 80</td> <td>STY80T</td> </tr> <tr> <td>125 × 70</td> <td></td> </tr> <tr> <td>125 × 65</td> <td>STY80TW</td> </tr> </tbody> </table>	Classification (Width × Thickness)	Symbols	135 × 80	STY80T	125 × 70		125 × 65	STY80TW	<p>The tyres are for passenger car and freight car use.</p> <p>(Class) BV1, BV2</p>	<p>Scope</p> <p>For locomotive Class C, D, E, HT</p> <p>For carriage and wagon ... Class B, C, D, E, HT</p>	<p>Scope</p> <table border="1" data-bbox="2320 571 2873 724"> <thead> <tr> <th colspan="3">AAR M106-56</th> <th colspan="4">AAR M124-56 (Heat treated tyres)</th> </tr> <tr> <th>A</th> <th>B</th> <th>C</th> <th>A</th> <th>B</th> <th>C</th> <th>D</th> </tr> </thead> <tbody> <tr> <td>Driving tyres for locomotives</td> <td>Driving tyres for freight locomotives, and tyres for locomotive-truck tender-truck, trailer and car wheels and miscellaneous service</td> <td>Driving tyres for switching locomotives</td> <td>Driving tyres for locomotives in passenger service</td> <td>Driving tyres for freight locomotives and tyres for trailer wheels</td> <td>Driving tyres for switching locomotives and tyres for locomotive-truck, tender-truck, trailer and car wheels and miscellaneous service</td> <td>Driving tyres for switching locomotives and heavily loaded trailer tyres without brakes</td> </tr> </tbody> </table>	AAR M106-56			AAR M124-56 (Heat treated tyres)				A	B	C	A	B	C	D	Driving tyres for locomotives	Driving tyres for freight locomotives, and tyres for locomotive-truck tender-truck, trailer and car wheels and miscellaneous service	Driving tyres for switching locomotives	Driving tyres for locomotives in passenger service	Driving tyres for freight locomotives and tyres for trailer wheels	Driving tyres for switching locomotives and tyres for locomotive-truck, tender-truck, trailer and car wheels and miscellaneous service	Driving tyres for switching locomotives and heavily loaded trailer tyres without brakes																																																																																																													
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<p>2. Quality of material</p> <p>The tyres shall be manufactured from the highest quality of steel ingots of a length and weight to produce, after sufficient discard has been taken, two or more type blanks from each ingot.</p> <p>The ingots shall be made from the best selected material by the open hearth or electric furnace processes.</p> <p>Chemical Composition</p> <table border="1" data-bbox="103 1144 534 1407"> <thead> <tr> <th></th> <th>Class A</th> <th>Class B</th> </tr> </thead> <tbody> <tr> <td>C</td> <td>0.72-0.85</td> <td>0.62-0.75</td> </tr> <tr> <td>Si</td> <td>0.15-0.35</td> <td>0.15-0.35</td> </tr> <tr> <td>Mn</td> <td>0.5-0.8</td> <td>0.6-0.9</td> </tr> <tr> <td>P</td> <td>0.05 MAX</td> <td>0.05 MAX</td> </tr> <tr> <td>S</td> <td>0.05 MAX</td> <td>0.05 MAX</td> </tr> <tr> <td>P + S</td> <td>0.09 MAX</td> <td>0.09 MAX</td> </tr> </tbody> </table> <p>The manufacturer shall supply an analysis of each cast when required to do so.</p>		Class A	Class B	C	0.72-0.85	0.62-0.75	Si	0.15-0.35	0.15-0.35	Mn	0.5-0.8	0.6-0.9	P	0.05 MAX	0.05 MAX	S	0.05 MAX	0.05 MAX	P + S	0.09 MAX	0.09 MAX	<p>Quality of material</p> <p>Killed steel by open-hearth furnace, electric furnace or oxygen process.</p> <p>C: 0.60 - 0.75</p> <p>Si: 0.15 - 0.35</p> <p>Mn: 0.50 - 0.90</p> <p>P: ≤0.050 ≤0.045</p> <p>S: ≤0.050 ≤0.045</p> <p>Remarks: Cu content shall not exceed 0.30% as impurities.</p>	<p>Quality of material</p> <p>(1) Open-hearth furnace or electric furnace.</p> <p>(2) Ingot or billet</p> <table border="1" data-bbox="1261 976 1706 1180"> <tbody> <tr> <td>C</td> <td>(Not specified)</td> <td>Ni</td> <td>(≤0.30)</td> </tr> <tr> <td>Si</td> <td>(≤0.50)</td> <td>Cr</td> <td>(≤0.30)</td> </tr> <tr> <td>Mn</td> <td>(≤1.20)</td> <td>Mo</td> <td>(≤0.05)</td> </tr> <tr> <td>P</td> <td>≤0.05</td> <td>V</td> <td>(≤0.05)</td> </tr> <tr> <td>S</td> <td>≤0.05</td> <td>Cu</td> <td>(≤0.30)</td> </tr> <tr> <td>P+S</td> <td>≤0.09</td> <td></td> <td></td> </tr> </tbody> </table> <p>Remarks: If requested in the order sheet, the content of element indicated parentheses can be checked.</p>	C	(Not specified)	Ni	(≤0.30)	Si	(≤0.50)	Cr	(≤0.30)	Mn	(≤1.20)	Mo	(≤0.05)	P	≤0.05	V	(≤0.05)	S	≤0.05	Cu	(≤0.30)	P+S	≤0.09			<p>Quality of material</p> <p>Acid or basic open-hearth furnace, or electric furnace</p> <table border="1" data-bbox="1795 970 2279 1129"> <thead> <tr> <th rowspan="2"></th> <th colspan="4">Locomotive</th> <th colspan="4">Carriage and Wagon</th> </tr> <tr> <th>C</th> <th>D</th> <th>E</th> <th>HT</th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>HT</th> </tr> </thead> <tbody> <tr> <td>P</td> <td>≤0.05</td> <td></td> <td></td> <td></td> <td>≤0.06</td> <td></td> <td>Acid ≤ 0.06 Basic ≤ 0.05</td> <td></td> <td>≤0.05</td> </tr> <tr> <td>S</td> <td>≤0.05</td> <td></td> <td></td> <td></td> <td>≤0.06</td> <td></td> <td>Acid ≤ 0.06 Basic ≤ 0.05</td> <td></td> <td>≤0.05</td> </tr> </tbody> </table>		Locomotive				Carriage and Wagon				C	D	E	HT	B	C	D	E	HT	P	≤0.05				≤0.06		Acid ≤ 0.06 Basic ≤ 0.05		≤0.05	S	≤0.05				≤0.06		Acid ≤ 0.06 Basic ≤ 0.05		≤0.05	<p>Quality of material</p> <p>Open-hearth furnace or electric furnace</p> <table border="1" data-bbox="2338 934 2855 1071"> <thead> <tr> <th rowspan="2"></th> <th colspan="3">AAR M106-56</th> <th colspan="4">AAR M124-56</th> </tr> <tr> <th>A</th> <th>B</th> <th>C</th> <th>A</th> <th>B</th> <th>C</th> <th>D</th> </tr> </thead> <tbody> <tr> <td>C</td> <td>0.50 - 0.65</td> <td>0.50 - 0.75</td> <td>0.70 - 0.85</td> <td>0.52 - 0.62</td> <td>0.62 - 0.72</td> <td></td> <td>0.72 - 0.82</td> </tr> <tr> <td>Si</td> <td></td> <td>0.15 - 0.35</td> <td></td> <td></td> <td></td> <td>0.15 - 0.35</td> <td></td> </tr> <tr> <td>Mn</td> <td></td> <td>0.50 - 0.90</td> <td></td> <td></td> <td></td> <td>0.50 - 0.90</td> <td></td> </tr> <tr> <td>P</td> <td></td> <td>≤ 0.05</td> <td></td> <td></td> <td></td> <td>≤ 0.05</td> <td></td> </tr> <tr> <td>S</td> <td></td> <td>≤ 0.05</td> <td></td> <td></td> <td></td> <td>≤ 0.05</td> <td></td> </tr> </tbody> </table>		AAR M106-56			AAR M124-56				A	B	C	A	B	C	D	C	0.50 - 0.65	0.50 - 0.75	0.70 - 0.85	0.52 - 0.62	0.62 - 0.72		0.72 - 0.82	Si		0.15 - 0.35				0.15 - 0.35		Mn		0.50 - 0.90				0.50 - 0.90		P		≤ 0.05				≤ 0.05		S		≤ 0.05				≤ 0.05	
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<p>3. Freedom from defects: rolling tolerances</p> <p>All surface defects shall be chipped out of the tyre blanks before they are rolled. The tyres shall be free from any defects such as pipes or blow holes of any kind, undue segregation of P. & S., Oxides grains, silicate or silica grains ... etc., and shall be finished accurately to the dimensions specified in the order, and shown on the drawing supplied by the E.R. Mechanical and Electrical Engineering Department. The following tolerances, however, will be permitted:</p> <table border="1" data-bbox="103 829 608 1123"> <thead> <tr> <th></th> <th>Over</th> <th>Under</th> </tr> </thead> <tbody> <tr> <td>Internal diameter as rolled (i.e. machined diameter minus machining allowance</td> <td>Nil</td> <td>3 mm</td> </tr> <tr> <td>External diameter as rolled (i.e. machined diameter plus machining allowance)</td> <td>4.5 mm</td> <td>Nil</td> </tr> <tr> <td>Width</td> <td>1.5 mm</td> <td>Nil</td> </tr> </tbody> </table>		Over	Under	Internal diameter as rolled (i.e. machined diameter minus machining allowance	Nil	3 mm	External diameter as rolled (i.e. machined diameter plus machining allowance)	4.5 mm	Nil	Width	1.5 mm	Nil	<p><u>Freedom from defects</u></p> <p>None</p>	<p><u>Freedom from defects: rolling tolerances</u></p> <p>(1) The tyre shall be sound as a whole and be free from cracking, cavity, and any defects which may deteriorate the quality in the course of usage.</p> <p>(2) Dimensional tolerances</p> <p>Unless otherwise specified, UIC 810-2 shall apply.</p> <p>UIC 810-2 (mm)</p> <p>Tolerance for inside diameter +0 -*</p> <p>Tolerance for outside diameter +* -1</p> <p>Tolerance for width +2 -1</p> <p>(Tolerances marked with * shall be limited on the variation of the maximum variation of 6% of theoretical weight.)</p>	<p><u>Freedom from defects</u></p> <p>(1) Tyres shall be free from any injurious defect.</p> <p>(2) Tyres shall be supplied in specified dimensions and with tolerances agreed upon.</p>	<p><u>Rolling tolerances</u></p> <p>Allowable dimensional tolerances</p> <p>a. Height of flange + 1/16" - 0</p> <p>b. Thickness of flange ± 1/16"</p> <p>c. Radius of throat + 1/8" - 1/16"</p> <p>d. Width of tyre + 3/16" - 0</p> <p>e. Inside diameter + 0 - 1/4"</p> <p>f. Outside diameter</p> <p>against outside diameter + 1/2" of 54 or less - 0</p> <p>against outside diameter + 3/8" of 54 or more - 1/8"</p>
	Over	Under														
Internal diameter as rolled (i.e. machined diameter minus machining allowance	Nil	3 mm														
External diameter as rolled (i.e. machined diameter plus machining allowance)	4.5 mm	Nil														
Width	1.5 mm	Nil														
<p>4. Branding</p> <p>The tyres shall be stamped distinctly when hot on the outside face near the rim of the wheel centre in letters not less than 9.5 mm (3/8") nor more than 12.5 mm (1/2") in size with the following data: cast number, name or initials of manufacturer, order number. The stamping shall not be done in such a manner as to form a possible cause of subsequent failure and shall be so placed as to be still legible when the type has worn down to a minimum thickness at the centre of the tread of 32 mm (1 1/4").</p>	<p><u>Branding</u></p> <p>Subject to Instruction by President of JNR No. 544 "Rules for Stamping on Wheel Sets".</p>	<p><u>Branding</u></p> <p>Hot-stamped on the exterior rim face, after rolled.</p> <p>(1) Stamped depth: 3 or 4 mm</p> <p>(2) Items to be stamped: Cast number, manufacturer's mark, serial number, date of manufacturer, Class of steel (BV1 or BV2), Stamp of inspector.</p>	<p><u>Branding</u></p> <p>(1) Tyres shall be hot-stamped clearly with the marks requested by the purchaser together with cast number.</p> <p>(2) They shall remain legible even when the tyre gets worn.</p>	<p><u>Branding</u></p> <p>Height of letter: 1/2" or more</p> <p>Position: About 1/4" from inside diameter as finished</p> <p>Items: Manufacturer's name or its trade mark, serial number, cast number, indication of class, date of manufacture</p> <p>(1) If hot-stamped mark gets illegible, cold stamping shall of tyres for locomotive use.</p> <p>(2) Set number shall be marked with paint</p>												
<p>5. Heat treatment</p> <p>The tyres shall be heat treated according to the standard specifications of the Country of origin.</p>	<p><u>Heat treatment</u></p> <p>Normalized after controlled cooling.</p>	<p><u>Heat treatment</u></p> <p>Slow cooling after rolling. (Normalization shall be performed if requested in the order sheet or if the manufacturer so specifies.)</p>	<p><u>Heat treatment</u></p> <p>Locomotive Class C: Normalized, or oil-quenched and tempered.</p> <p>Other classes: Oil-quenched and tempered.</p> <p>Carriage and wagon Not specified.</p>	<p><u>Heat treatment</u></p> <p>AAR M106 Not specified.</p> <p>AAR M124 (1) Quenched and tempered (2) Tempered, and then controlled cooling</p>												

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<p>6. Number of tyres to be tested.</p> <p>Extra tyres for testing in the manner described in clauses 7 and 8 shall be provided by the manufacturer, at his own expense, at the rate of one tyre for each 50 tyres or portion thereof in each cast as submitted for testing, with the exception that if there are not more than 55 tyres in the cast one tyre only shall be selected. The E.R. Inspecting Engineer shall select and test such of the tyres as he may think proper to the extent of the number specified above. The tyres tested by deflection shall 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. After selection of tyres for testing each test tyre shall comply with the following tests without further re-heating or any other manipulation whatever, either of the tyres selected for testing or of any portion cut therefrom to furnish the test pieces.</p>	<p><u>Number of tyres to be tested</u></p> <p>Specimen for analysis: to be taken one from each cast.</p> <p>For falling weight and deflection test: One tyre from every cast.</p>	<p><u>Number of tyres to be tested</u></p> <p>Tensile, falling weight and impact* tests.</p> <p>Macroscopic test</p> <p>1 for each cast of 50 tyres 2 for each cast of 50~100 tyres 3 for each cast of 100 tyres or more</p> <p>Brinell hardness test* Each tyre shall be checked.</p> <p>(Note: Tests marked with * shall be carried out only if requested.)</p>	<p><u>Number of tyres to be tested</u></p> <p>(1) Falling weight and tensile tests: One test specimen per unit of 55 tyres or its fraction of each cast (charge).</p> <p>(2) Ladle analysis: If requested, there shall be submitted the analytical table of C, Si, Mn, P, S of each cast of steel.</p>	<p><u>Number of tyres to be tested</u></p> <p>AAR M106 ... One (ingot for test) per one (melt of) molten steel</p> <p>AAR M124 ...</p> <p>(1) Unless otherwise specified, one of the following two shall be selected at the discretion of the manufacturer:</p> <p>(i) Tensile test (ingot for test) shall be conducted on one representative bar taken from a lot of each cast and tempering, and as supplementary the Brinell hardness shall be measured on 10% of tyres of each lot of molten steel.</p> <p>(ii) Brinell hardness shall be measured on all the tyres.</p> <p>(2) If specified in the order sheet, one tyre taken from each molten steel shall be subjected to tensile test, and as supplementary to it Brinell hardness shall be measured on 10% of the tyres of each lot of molten steel.</p>
<p>7. Falling weight test</p> <p>The tyre shall be placed in a running position with the tread resting on a block of metal of not less than 5,000 kgs (5 tons approx.) weight supported on a rigid concrete or other solid foundation, and shall withstand, without fracture, blows from a falling weight of 1,000 kgs (1 ton approx.). The weight shall be allowed to fall freely on to the tread from heights of 3 m (10 feet approx.), 4.5 m (15 feet approx.), 6 m (20 feet approx.) and upwards, until the deflection of the tyre corresponds to that given by the following formula.</p> <p>The following formula shall be used for determining the deflection to be obtained under the falling-weight test:</p>	<p><u>Falling weight test</u></p>	<p><u>Falling weight test</u></p>	<p><u>Falling weight test</u></p>	<p><u>Falling weight test</u></p>

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<p>$D_1 = \frac{0.5}{100} \cdot \frac{d_1}{f_1}$</p> <p>where:</p> <p>$D_1$ = deflection in mms per mm of the internal diameter of the type.</p> <p>d_1 = diameter of tread in mm.</p> <p>f_1 = ultimate tensile stress in kgs/mm²</p> <p>or $D_1 = 0.08 \frac{d}{f}$</p> <p>where:</p> <p>D = deflection in inches per inch of the internal diam. of the tyre.</p> <p>d = diameter of the tread in inches.</p> <p>f = ultimate tensile stress in tons per square inch.</p> <p>In case where the required deflection has been very nearly reached, the height of the final blow may be reduced at the option of the manufacturer so as to provide that the required deflection is reached by that blow.</p>	<p><u>Shrinkage of inside diameter</u></p> <p>(in mm)</p> <table border="1" data-bbox="638 590 1142 737"> <thead> <tr> <th rowspan="2">Item</th> <th colspan="2">Inside diameter (finished)</th> </tr> <tr> <th>less than 1000</th> <th>1000 or more</th> </tr> </thead> <tbody> <tr> <td>Shrinkage of diameter</td> <td>$\frac{1}{3} \left(\frac{D}{T} \right)^2$</td> <td>$\frac{1}{2} \left(\frac{D}{T} \right)^2$</td> </tr> </tbody> </table> <p>where, D = As-rolled inside diameter T = As-rolled thickness</p> <p><u>Height from which the weight is let fall</u></p> <p>(in mm)</p> <table border="1" data-bbox="638 905 1160 1079"> <thead> <tr> <th>Inside dia. of tyre (finished)</th> <th>1st time</th> <th>2nd time & after</th> </tr> </thead> <tbody> <tr> <td>less than 1000</td> <td>2,500</td> <td>Increased by 500 each time</td> </tr> <tr> <td>1000 or more</td> <td>3,000</td> <td>Increased by 750 each time</td> </tr> </tbody> </table>	Item	Inside diameter (finished)		less than 1000	1000 or more	Shrinkage of diameter	$\frac{1}{3} \left(\frac{D}{T} \right)^2$	$\frac{1}{2} \left(\frac{D}{T} \right)^2$	Inside dia. of tyre (finished)	1st time	2nd time & after	less than 1000	2,500	Increased by 500 each time	1000 or more	3,000	Increased by 750 each time	<p><u>Formula for determination of deflection</u></p> <p>$f = 0.56 \frac{D^2}{Re}$</p> <p>where:</p> <p>f: Deflection (mm)</p> <p>D: Mean diameter (mm)</p> <p>$\left(\frac{\text{Outside dia.} + \text{Inside dia.}}{2} \right)$</p> <p>R: Minimum tensile strength (kg/mm²)</p> <p>e: Thickness</p> <p>Falling energy (kg.m) by one blow shall be 15 times the weight of tyre (kg).</p>	<p><u>Formula for determination of deflection</u></p> <p>$D = \frac{(d - 3S)^2}{Nt^2}$</p> <p>where:</p> <p>D: Deflection (in)</p> <p>d: As-rolled inside diameter (in)</p> <p>S: Depth of snip (in)</p> <p>t: As-rolled thickness (in)</p> <p>N: constant</p> <p>Section 1 C = 45 D = 50 E = 55 HT = 60</p> <p>Section 2 B = 45 C = 50 D = 55 E, HT = 60</p> <p>Falling weight = 1 ton</p> <p>Height of fall = 10, 15, 20, (ft)</p>	<p>None</p>																																																																																																																																					
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<p>8. Tensile test</p> <p>A standard B.S.S. test piece C or continental test piece M or N, machined cold from each type tested as above, and taken from the position shown in the sketch, shall show not less than the minimum tensile breaking stress and elongation given in the following table:</p> <table border="1" data-bbox="92 1352 566 1499"> <thead> <tr> <th rowspan="2">Description</th> <th colspan="2">Minimum tensile breaking load</th> <th colspan="3">Minimum elongation Z</th> <th rowspan="2">B.H. 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C</p> <p>Non-annealed ≥ 95</p> <p>Annealed ≥ 109</p> <table border="1" data-bbox="1202 1404 1472 1541"> <thead> <tr> <th>L</th> <th>C</th> </tr> </thead> <tbody> <tr> <td>8.16 √S</td> <td>R + 2.5A</td> </tr> <tr> <td>5.65 √S</td> <td>R + 2.2A</td> </tr> <tr> <td>4 √S</td> <td>R + 2A</td> </tr> </tbody> </table> <p>where, A: Elongation (%)</p> <p>L: Gauge length of test piece</p> <p>S: Cross section within gauge length</p>	L	C	8.16 √S	R + 2.5A	5.65 √S	R + 2.2A	4 √S	R + 2A	<p><u>Mechanical properties</u></p> <table border="1" data-bbox="1792 1205 2309 1514"> <thead> <tr> <th rowspan="2">Usage</th> <th rowspan="2">Class</th> <th colspan="2">Tensile strength</th> <th rowspan="2">Elongation (%)</th> </tr> <tr> <th>(kg/mm²)</th> <th>(t/in²)</th> </tr> </thead> <tbody> <tr> <td rowspan="4">Locomotive</td> <td>C</td> <td>77.2-88.2</td> <td>(49-56)</td> <td>≥18 ~ ≥15</td> </tr> <tr> <td>D</td> <td>88.2-99.2</td> <td>(56-63)</td> <td>≥13 ~ ≥11</td> </tr> <tr> <td>E</td> <td>99.2-110.2</td> <td>(63-70)</td> <td>≥11 ~ ≥9</td> </tr> <tr> <td>HT</td> <td>110.2-121.2</td> <td>(70-77)</td> <td>≥9</td> </tr> <tr> <td rowspan="4">Carriage and Wagon</td> <td>B</td> <td>66.1-77.2</td> <td>(42-49)</td> <td>≥18 ~ ≥14</td> </tr> <tr> <td>C</td> <td>77.2-88.2</td> <td>(49-56)</td> <td>≥14 ~ ≥12</td> </tr> <tr> <td>D</td> <td>88.2-99.2</td> <td>(56-63)</td> <td>≥12 ~ ≥10</td> </tr> <tr> <td>E</td> <td>99.2-110.2</td> <td>(63-70)</td> <td>≥10 ~ ≥8</td> </tr> <tr> <td></td> <td>HT</td> <td>110.2-121.2</td> <td>(70-77)</td> <td>≥8</td> </tr> </tbody> </table>	Usage	Class	Tensile strength		Elongation (%)	(kg/mm ²)	(t/in ²)	Locomotive	C	77.2-88.2	(49-56)	≥18 ~ ≥15	D	88.2-99.2	(56-63)	≥13 ~ ≥11	E	99.2-110.2	(63-70)	≥11 ~ ≥9	HT	110.2-121.2	(70-77)	≥9	Carriage and Wagon	B	66.1-77.2	(42-49)	≥18 ~ ≥14	C	77.2-88.2	(49-56)	≥14 ~ ≥12	D	88.2-99.2	(56-63)	≥12 ~ ≥10	E	99.2-110.2	(63-70)	≥10 ~ ≥8		HT	110.2-121.2	(70-77)	≥8	<p><u>Mechanical properties</u></p> <table border="1" data-bbox="2356 1205 2861 1409"> <thead> <tr> <th rowspan="2">Specification</th> <th rowspan="2">Class</th> <th colspan="2">Tensile strength</th> <th rowspan="2">Elongation (%)</th> <th rowspan="2">Reduction of area (%)</th> <th rowspan="2">Brinell hardness</th> </tr> <tr> <th>(lb/in²)</th> <th>(kg/mm²)</th> </tr> </thead> <tbody> <tr> <td rowspan="3">AAR N106-56</td> <td>A</td> <td>≥105,000</td> <td>(≥73.8)</td> <td>≥12</td> <td>≥16</td> <td></td> </tr> <tr> <td>B</td> <td>≥115,000</td> <td>(≥80.9)</td> <td>≥10</td> <td>≥14</td> <td></td> </tr> <tr> <td>C</td> <td>≥125,000</td> <td>(≥87.9)</td> <td>≥8</td> <td>≥12</td> <td></td> </tr> <tr> <td rowspan="3">AAR N124-56</td> <td>A</td> <td>≥110,000</td> <td>(≥77.4)</td> <td>≥16</td> <td>≥32</td> <td>≥223</td> </tr> <tr> <td>B</td> <td>≥125,000</td> <td>(≥87.9)</td> <td>≥14</td> <td>≥28</td> <td>≥255</td> </tr> <tr> <td>C</td> <td>≥140,000</td> <td>(≥98.4)</td> <td>≥12</td> <td>≥24</td> <td>285 - 331</td> </tr> <tr> <td></td> <td>D</td> <td>≥155,000</td> <td>(≥108.9)</td> <td>≥10</td> <td>≥20</td> <td>321 - 353</td> </tr> </tbody> </table>	Specification	Class	Tensile strength		Elongation (%)	Reduction of area (%)	Brinell hardness	(lb/in ²)	(kg/mm ²)	AAR N106-56	A	≥105,000	(≥73.8)	≥12	≥16		B	≥115,000	(≥80.9)	≥10	≥14		C	≥125,000	(≥87.9)	≥8	≥12		AAR N124-56	A	≥110,000	(≥77.4)	≥16	≥32	≥223	B	≥125,000	(≥87.9)	≥14	≥28	≥255	C	≥140,000	(≥98.4)	≥12	≥24	285 - 331		D	≥155,000	(≥108.9)	≥10	≥20	321 - 353
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ERS	JRS (JIS)	UIC	BS	AAR
 <p>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 tyre from which the discarded test piece was taken.</p>		<p>3. Impact test ... BV₁ > 3 BV₂ > 2</p> <p>4. Brinell hardness test The variation in hardness of the tyres in the same cast shall be within 30.</p> <p>5. The position at which test piece is taken</p> <p>(Tensile test) (Impact test)</p> 	<p>(2) Position at which the test piece is taken.</p> 	<p>(2) The position at which the test piece is taken from the tyre itself.</p> 
<p>9. Additional tests before rejection</p> <p>In the event of the tyre selected for testing not satisfying the requirements of clauses 7 and 8 the E.R. Inspecting Engineer shall make further tests, as specified below, at the expense of the manufacturer, before finally refusing or accepting the tyres represented.</p> <p>(a) Should the tyre fail in the falling weight test, the manufacturer may submit two more tyres from the same lot for testing without subjecting the bulk to heat treatment or re-heat treatment. Should such re-tests not be made, or should either of the re-test tyres fail to fulfil the conditions of the falling weight and tensile tests, the manufacturer may with the concurrence of the E.R. Inspecting Engineer, re-heat treat the bulk and submit for testing either one or two further tyres as may be agreed with the E.R. Inspecting Engineer. Should the results of these repeated tests be satisfactory, the tyres represented shall be accepted. Should either of these tyres fail to fulfil the conditions of the falling weight and tensile tests, the tyres represented shall be rejected.</p>	<p><u>Additional tests before rejection</u></p> <p><u>Falling weight test</u> For re-test, take additional two specimens. If the result of the re-test is not acceptable, all the products of the same cast shall be heat-treated only for once, and thus re-test may be conducted.</p> <p><u>Tensile test</u> For re-test, heat treatment may be performed only for once, provided, however, that those specimens which were heat-treated for falling weight test shall not be re-heat-treated.</p>	<p><u>Additional tests before rejection</u></p> <p>none</p>	<p><u>Additional tests before rejection</u></p> <p><u>Falling weight test and tensile test</u> Retest shall be conducted on additional two tyre of the same lot. Both tyres have to pass the retest. If either of the two fails to pass the retest, the tyres of the lot shall be re-heat-treated, and the test shall be repeated.</p>	<p><u>Additional tests before rejection</u></p> <p>AAR M106-56 ... For retesting, test pieces shall be taken from the tyre itself.</p> <p>AAR M124-56 ... In case of failure in test, the tyres represented by the test piece may be re-tempered, or re-quenced and tempered. This repetition is permitted only up to 3 times.</p>

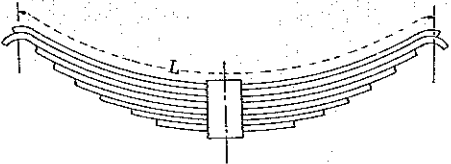
ERS	JRS (JIS)	UIC	BS	AAR
<p>(b) Should the tyre fail in the tensile test, and the fractured test piece indicate that the result does not fairly represent the bulk of the tyres, two more tensile test pieces shall be taken from the same tyre for repeating the test. The tyres shall be accepted if the results of the repeat tests are satisfactory.</p>				
<p>10. Inspection</p> <p>The R.R. Inspecting Engineer shall be allowed unhindered access to the manufacturer's works at all time during working hours when tyres on order are in process of manufacture or delivery. He shall be at liberty to inspect the manufacture at any stage and to reject tyres or material not conforming to this specification. Any tyres 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 confused subsequently with satisfactory tyres or material.</p>	<p><u>Inspection</u></p> <p>None</p>	<p><u>Inspection</u></p> <p>None</p>	<p><u>Inspection</u></p> <p>Same as ERS</p>	<p><u>Inspection</u></p> <p>None</p>
<p>11. Testing facilities</p> <p>The manufacturer shall supply the material required for testing free of charge and shall furnish and prepare the necessary test pieces at his own cost, 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.</p>	<p><u>Testing facilities</u></p> <p>None</p>	<p><u>Testing facilities</u></p> <p>None</p>	<p><u>Testing facilities</u></p> <p>Same as ERS</p>	<p><u>Testing facilities</u></p> <p>None</p>

COMPARISON TABLE FOR M6-1962 SPECIFICATION FOR LAMINATED SPRING STEEL AND LAMINATED SPRINGS

ERS	JIS B2701	JRS17300-2G-15AR4A																																																																																																																		
<p>1. Quality of material</p> <p>The spring plates shall be made from the highest quality of steel made from best selected material by the acid or basic open hearth, crucible or electric furnace processes.</p> <p>The steel is for water hardening and shall conform with one of the following analysis:-</p> <p>(a) Plain carbon steel:</p> <p>Carbon 0.45% to 0.65% Silicon 0.30% max. Manganese.... 0.60% to 0.80% Sulphur..... 0.05% max. Phosphorous.. 0.05% max.</p> <p>(b) Silico-manganese steel:</p> <p>Carbon 0.40% to 0.55% Silicon 1.50% to 1.85% Manganese ... 0.50% to 0.75% Sulphur 0.05% max. Phosphorous.. 0.05% max.</p> <p>The manufacturer shall supply an analysis of each cast when required to do so. The E.R. Inspecting Engineer may take samples at the rate of one per cast for independent analysis if required, such analysis being made at his own cost and not at the charge of the manufacturer.</p>	<p><u>Quality of material</u></p> <p>Steel materials shall be made from killed steel ingots.</p> <table border="1" data-bbox="1418 630 1905 987"> <thead> <tr> <th rowspan="2">Chemical composition</th> <th colspan="2">Plain carbon steel</th> <th colspan="2">Silico-manganese steel</th> </tr> <tr> <th>SUP3</th> <th>SUP4</th> <th>SUP6</th> <th>SUP7</th> </tr> </thead> <tbody> <tr> <td>C</td> <td>0.75 ~ 0.90</td> <td>0.90 ~ 1.10</td> <td>0.55 ~ 0.65</td> <td>0.55 ~ 0.65</td> </tr> <tr> <td>Si</td> <td>0.15 ~ 0.35</td> <td>0.15 ~ 0.35</td> <td>1.50 ~ 1.80</td> <td>1.80 ~ 2.20</td> </tr> <tr> <td>Mn</td> <td>0.30 ~ 0.60</td> <td>0.30 ~ 0.60</td> <td>0.70 ~ 1.00</td> <td>0.65 ~ 0.95</td> </tr> <tr> <td>P</td> <td>≤0.035</td> <td>≤0.035</td> <td>≤0.035</td> <td>≤0.035</td> </tr> <tr> <td>S</td> <td>≤0.035</td> <td>≤0.035</td> <td>≤0.035</td> <td>≤0.035</td> </tr> </tbody> </table> <p>In each type of steel, the content of Cu as impurity shall not exceed 0.30%.</p> <table border="1" data-bbox="1418 1081 1905 1606"> <thead> <tr> <th rowspan="2">Chemical composition</th> <th colspan="2">Manganese chromium steel</th> <th>Vanadium steel</th> <th>Boron steel</th> </tr> <tr> <th>SUP9</th> <th>SUP9A</th> <th>SUP10</th> <th>SUP11A</th> </tr> </thead> <tbody> <tr> <td>C</td> <td>0.50 ~ 0.60</td> <td>0.55 ~ 0.65</td> <td>0.45 ~ 0.55</td> <td>0.55 ~ 0.65</td> </tr> <tr> <td>Si</td> <td>0.15 ~ 0.35</td> <td>0.15 ~ 0.35</td> <td>0.15 ~ 0.35</td> <td>0.15 ~ 0.35</td> </tr> <tr> <td>Mn</td> <td>0.65 ~ 0.95</td> <td>0.70 ~ 1.00</td> <td>0.65 ~ 0.95</td> <td>0.70 ~ 1.00</td> </tr> <tr> <td>P</td> <td>≤0.035</td> <td>≤0.035</td> <td>≤0.035</td> <td>≤0.035</td> </tr> <tr> <td>S</td> <td>≤0.035</td> <td>≤0.035</td> <td>≤0.035</td> <td>≤0.035</td> </tr> <tr> <td>Cr</td> <td>0.65 ~ 0.95</td> <td>0.70 ~ 1.00</td> <td>0.80 ~ 1.10</td> <td>0.70 ~ 1.00</td> </tr> <tr> <td>V</td> <td>-</td> <td>-</td> <td>0.15 ~ 0.25</td> <td>-</td> </tr> <tr> <td>B</td> <td>-</td> <td>-</td> <td>-</td> <td>≥0.0005</td> </tr> </tbody> </table> <p>In each type of steel, the contents of Cu as impurity shall not exceed 0.3%.</p>	Chemical composition	Plain carbon steel		Silico-manganese steel		SUP3	SUP4	SUP6	SUP7	C	0.75 ~ 0.90	0.90 ~ 1.10	0.55 ~ 0.65	0.55 ~ 0.65	Si	0.15 ~ 0.35	0.15 ~ 0.35	1.50 ~ 1.80	1.80 ~ 2.20	Mn	0.30 ~ 0.60	0.30 ~ 0.60	0.70 ~ 1.00	0.65 ~ 0.95	P	≤0.035	≤0.035	≤0.035	≤0.035	S	≤0.035	≤0.035	≤0.035	≤0.035	Chemical composition	Manganese chromium steel		Vanadium steel	Boron steel	SUP9	SUP9A	SUP10	SUP11A	C	0.50 ~ 0.60	0.55 ~ 0.65	0.45 ~ 0.55	0.55 ~ 0.65	Si	0.15 ~ 0.35	0.15 ~ 0.35	0.15 ~ 0.35	0.15 ~ 0.35	Mn	0.65 ~ 0.95	0.70 ~ 1.00	0.65 ~ 0.95	0.70 ~ 1.00	P	≤0.035	≤0.035	≤0.035	≤0.035	S	≤0.035	≤0.035	≤0.035	≤0.035	Cr	0.65 ~ 0.95	0.70 ~ 1.00	0.80 ~ 1.10	0.70 ~ 1.00	V	-	-	0.15 ~ 0.25	-	B	-	-	-	≥0.0005	<p><u>Quality of material</u></p> <table border="1" data-bbox="1964 619 2451 1018"> <thead> <tr> <th rowspan="2">Chemical composition</th> <th>Plain carbon steel</th> <th colspan="2">Manganese chromium steel</th> </tr> <tr> <th>SUP3</th> <th>SUP9</th> <th>SUP9A</th> </tr> </thead> <tbody> <tr> <td>C</td> <td>0.75 ~ 0.90</td> <td>0.50 ~ 0.60</td> <td>0.55 ~ 0.65</td> </tr> <tr> <td>Si</td> <td>0.15 ~ 0.35</td> <td>0.15 ~ 0.35</td> <td>0.15 ~ 0.35</td> </tr> <tr> <td>Mn</td> <td>0.30 ~ 0.60</td> <td>0.65 ~ 0.95</td> <td>0.70 ~ 1.00</td> </tr> <tr> <td>P</td> <td>≤0.035</td> <td>≤0.035</td> <td>≤0.035</td> </tr> <tr> <td>S</td> <td>≤0.035</td> <td>≤0.035</td> <td>≤0.035</td> </tr> <tr> <td>Cr</td> <td>-</td> <td>0.65 ~ 0.95</td> <td>0.70 ~ 1.00</td> </tr> </tbody> </table> <p>In each type of steel, the contents of Cu as impurity shall not exceed 0.30%.</p>	Chemical composition	Plain carbon steel	Manganese chromium steel		SUP3	SUP9	SUP9A	C	0.75 ~ 0.90	0.50 ~ 0.60	0.55 ~ 0.65	Si	0.15 ~ 0.35	0.15 ~ 0.35	0.15 ~ 0.35	Mn	0.30 ~ 0.60	0.65 ~ 0.95	0.70 ~ 1.00	P	≤0.035	≤0.035	≤0.035	S	≤0.035	≤0.035	≤0.035	Cr	-	0.65 ~ 0.95	0.70 ~ 1.00
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<p>2. Freedom from defects</p> <p>The steel when rolled shall be smooth on its surface, free from defects of any kind, and the edges shall be rounded to a suitable radius.</p>	<p><u>Appearance</u></p> <p>Steel materials shall be good in finish, uniform in quality and free from any defect detrimental to use.</p>	<p><u>Appearance</u></p> <p>Same as left column (JIS).</p>
<p>3. Dimensions</p> <p>Rolled plates shall be supplied in the sizes specified in the order. The following tolerances will be allowed:</p> <p>On thickness : Plus 2% minus 1.5% On width : Plus 0.6% minus 0.6%</p> <p>The plates ordered for stock purpose are to be to the commercial lengths 5m to 5.5 m.</p> <p>However 10% of the plates can be accepted with lengths varying from 3 - 5 m.</p> <p>When so specified bars or plates 10 mm thick and above shall be provided with a rib parallel to the edges of the bar and of the dimensions shown on the given sketch.</p> <p>The axis of the ribs and grooves shall be coincident and shall not vary from the axis of the bar by more than 1 mm.</p>	<p><u>Dimensional Tolerance of Flat Steel</u></p> <p>For details, refer to JIS G 4801.</p>	<p><u>Dimensional Tolerance of Flat Steel</u></p> <p>Same as left column (JIS).</p>
<p>4. Branding</p> <p>Each plate shall be stamped with the manufacturer's initials, the date of manufacture, the letter "E.R." and the order number, in such a manner that risk of injury is reduced to a minimum.</p> <p>The plates are then delivered in bundles.</p>	<p><u>Marking</u></p> <p>Steel materials shall be marked on each bundle with the following items by means of suitable method:</p> <p>(1) Symbol indicative of type of steel (2) Molten steel No., and Inspection No. (3) Manufacturer's name or its initials</p> <p>Some of these items may be omitted if approved by purchaser.</p>	<p><u>Marking</u></p> <p>Same as left column (JIS).</p>

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<p>5. Cambering test</p> <p>Up to 3% of the bars or plates comprising each delivery (or each portion of each delivery, if several sizes are included) may be taken from the bulk and a sample from each shall be tested in the presence of the E.R. Inspecting Engineer when they shall comply with the following test.</p> <p>Pieces of the steel of length 60 times the thickness shall be cambered to a radius 80 times their thickness (as shown in table I), hardened and tempered. They shall be pressed straight and the camber noted after release, after which they shall stand being pressed straight again six times in quick succession without showing any permanent set.</p>	<p><u>Cambering test</u></p> <p>None</p>	<p><u>Cambering test</u></p> <p>None</p>
<p>6. Hardening and tempering</p> <p>All plates shall be carefully hardened and tempered.</p>	<p><u>Quenching and tempering</u></p> <p>Spring plates, after formed, shall be heat-treated uniformly. Heat treatment shall be performed ordinarily by quenching and tempering.</p>	<p><u>Quenching and tempering</u></p> <p>After formed, they shall be quenched and tempered.</p>
<p>7. Compression tests (Assembled spring)</p> <p>All springs shall be tested by being deflected by a quick acting scrag before the buckle is put on to an amount equal to $\frac{L}{900t}$ where L is the length of the top plate in mms or inches measured along the arc as shown in the sketch, and t is the thickness of the thickest plate in mms or inches. They shall then stand being deflected again three times in quick succession without showing any permanent set. The required deflections are shown in table II, and shall not be exceeded at any time during manufacture by more than 15 per cent.</p>	<p><u>Scrag Test</u></p> <p>After once applying test load, measure free camber and free height. Then apply the same load repeatedly a few times, and measure free camber and free height. Compare the measures before and after this loading. In case that the test load is not specified, the load to be applied shall be such that will produce surface stress of 70 kg/mm² for plain carbon steel springs and of 90 kg/mm² for steel alloy springs.</p> <p>In this case the following equation shall apply to the calculation of test load:</p>	<p><u>Scrag Test</u></p> <p>After applying test load, measure free camber and free height. Then apply the same load repeatedly a few times, and measure free camber and free height. Compare the measurements before and after this loading. In case the test load is not specified, the load to be applied shall, as a rule, be such that will produce surface stress of 70 kg/mm².</p> <p>Test load shall be calculated by the following formula:</p>

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 <p>All the plates shall be so fitted that the stress when in service is as uniform as possible throughout the spring.</p> <p>When required, springs may be examined by removing the centre bolt or clip after which the plates shall separate so as to touch each other of the extremities, and each plate shall show a regular curvature and spacing. The ends of the plates of all springs shall be in contact with the adjacent plate after the buckle has been fitted.</p> <p>The free camber shall not exceed that specified by more than 3 mm. or 2 per cent of the above deflections, whichever is the greater, and it shall not be less than that specified by more than half of this tolerance.</p> <p>Up to 5 per cent of the springs may also be tested under specified loads to determine the range and deflection per ton. Wherever possible this shall be done after the buckle has been fitted.</p>	$P = \frac{2b\sum t_i^3}{3L_w t_w} \cdot \sigma$ <p>where: P : Load applied on springs (kg) σ : Surface stress of spring (kg/mm²) t_i : Plate thickness (mm) t_w : Maximum plate thickness (mm) b : Plate width (mm) L_w : Span under specified load (mm)</p> <p>Free camber or free height is specified only as approximate dimension.</p>	<p>For $\frac{l}{n} < 80$, $P = \frac{nbt^2}{5.5(l-0.6e)} \cdot \sigma$</p> <p>For $\frac{l}{n} \geq 80$, $P = \frac{nbt^2}{5.3l} \cdot \sigma$</p> <p>where: 2P : Load applied on springs (kg) σ : Surface stress of spring (kg/mm²) t : Plate thickness (mm) b : Plate width (mm) 2l : Span under specified load (mm) 2e : Width of buckle (mm) n : Total number of spring plates</p> <p>Springs shall be given adequate nips. When springs are assembled together, the clearance between plate springs shall conform to the following requirements:</p> <ol style="list-style-type: none"> (1) Clearance between springs shall be 1.2% or less of plate width. (2) Clearance between top plate and 2nd plate shall be 0.4 mm or less at the position situated 5 mm from center of eye toward buckle, under the load of 2 tons.

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<p>8. Buckles</p> <p>The buckles shall be made of good fibrous iron having a tensile breaking strength of not less than 32 nor more than 38 kg. per sq. mm. (20-24 tons per square inch), or of suitable steel having a tensile breaking strength of not less than 38 nor more than 47 kg. per sq. mm. (24-30 tons per square inch). The elongation in each case, measured on a standard test piece A, having a gauge length of 200 mm (8") - (see Appendix), shall be not less than 20 per cent, and in the case of buckles made from the solid the elongation measured on standard test piece C or D, shall be not less than 25 per cent, and the material shall admit of bending, when cold, without showing crack or flaw, as follows:</p> <p>For iron, 19 mm. (3/4") thick through an angle of 120 degrees.</p> <p>For iron 16 mm. (5/8") thick through an angle of 130 degrees.</p> <p>For iron 13 mm. (1/2") thick through an angle of 140 degrees.</p> <p>For steel, all thicknesses, through an angle of 180 degrees.</p> <p>In all cases the inside radius of the bend shall be not greater than 1 1/2 times the thickness of the test piece.</p> <p>The manufacturer shall supply a copy of the tensile test results when required to do so. Tensile tests shall be made at the rate of one per three tons for iron and one per cast for steel.</p> <p>The buckles of carriage springs, and other springs of similar pattern are not to have the bosses welded-on, but they are to be forged from solid wrought iron or suitable steel of the quality specified above, allowance being made for the smith to dress, weld, and finish the buckles to the required dimensions shown on the drawing supplied by the E.R. Inspecting Engineer.</p>	<p><u>Buckles</u></p> <p>None</p>	<p><u>Buckles</u></p> <p>Killed steel S10C or equivalent.</p> <p>Method for manufacturing buckles</p> <table border="1" data-bbox="2033 667 2522 871"> <thead> <tr> <th data-bbox="2033 667 2220 724">For locomotive and tender</th> <th data-bbox="2220 667 2522 724">Seamless</th> </tr> </thead> <tbody> <tr> <td data-bbox="2033 724 2220 871">For other use</td> <td data-bbox="2220 724 2522 871">Weld at one point Welding at two points or less (at upper part of buckle, or its upper and lower parts)</td> </tr> </tbody> </table>	For locomotive and tender	Seamless	For other use	Weld at one point Welding at two points or less (at upper part of buckle, or its upper and lower parts)
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ERS	JIS B2701	JRS17300-2G-15AR4A
<p>Finished forged or welded buckles shall be selected by the E.R. Inspecting Engineer at the rate of one per cent, for testing to destruction in the following manner:</p> <p>Taper blocks shall be forced through the buckles, straining the metal both at the sides and ends. Should the buckle selected part at the weld, or break in an unsatisfactory manner, other buckles up to five per cent shall be taken, and the bulk represented passed for use if the fractures are to the satisfaction of the E.R. Inspecting Engineer.</p>		
<p>9. Rejection</p> <p>Should the material or the finished springs or buckles fail to comply with every particular with the above conditions, the lot from which the samples were selected shall be rejected.</p>	<p><u>Rejection</u></p> <p>None</p>	<p><u>Rejection</u></p> <p>None</p>
<p>10. Inspection</p> <p>The E.R. Inspecting Engineer shall be allowed unhindered access to the works of the manufacturer at all times during working hours when springs 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 material which does not conform to the requirements of this specification. Any material so rejected shall be cut up or marked immediately in the presence of the inspector in such a way that it cannot be confused subsequently with satisfactory materials.</p>	<p><u>Inspection</u></p> <p>The inspection of springs shall conform to (1) to (4) below, provided that the sampling system in case of lot inspection shall be agreed upon between the parties concerned with delivery:</p> <p>(1) Dimensions and hardness of spring plates (2) Appearance and dimensions of spring (3) Permanent set (4) Loading characteristics</p>	<p><u>Test and Inspection</u></p> <p>1. Characteristics tests 2. Scrag test 3. Hardness test 4. Inspection for flaw or cracking on welded buckle.</p>
<p>11. Testing facilities</p> <p>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.</p>	<p><u>Testing facilities</u></p> <p>None</p>	<p><u>Testing facilities</u></p> <p>None</p>

ERS	JIS B2701	JRS17300-2G-15AR4A
<p>12. Painting</p> <p>Each plate shall be given a coat of graphite and oil on the surfaces in contact before final assembly, and the whole spring when finished, shall be given one coat of red lead and one coat of black paint.</p>	<p><u>Painting</u></p> <p>None</p>	<p><u>Painting</u></p> <p>The outer surfaces of spring buckles and top plates shall be applied with one coat each of anti-corrosive paint and, unless specifically indicated, of black paint. The other parts shall be varnished with oil.</p>

ERS	JIS(JRS)	BS	AAR																																																									
<p>1. Quality of material</p> <p>The springs shall be manufactured from the highest quality of steel made from the best selected material by the acid or basic open hearth, crucible, or electric furnace processes.</p> <p>The steel shall conform with one of the following analysis:</p> <p>(a) Plain carbon steel:</p> <p>Carbon : 0.9% min. 1.2% max. Manganese : 0.45% min. 0.75% max. Silicon : 0.30% max. Sulphur : 0.05% max. Phosphorus : 0.05% max.</p> <p>The higher limit of manganese should correspond with the lower carbon content, and vice-versa in any particular cast.</p> <p>(b) Silico-manganese steel:</p> <p>Carbon : 0.50% to 0.60% (1) 0.60% to 0.70% (2) Silicon : 1.40% to 1.90% Manganese : 0.70% to 1.00% Sulphur : 0.05% max. Phosphorus : 0.05% max.</p> <p>(1) for bars up to 10 mm diam. or thickness. (2) for bars over 10 mm diam. or thickness.</p> <p>(c) Manganese-Chrome Steel:</p> <p>Carbon : 0.50% to 0.60% Manganese : 0.65% to 0.95% Chrome : 0.65% to 0.95% Silicon : 0.15% to 0.35% Sulphur : 0.035% max. Phosphorus : 0.035% max.</p> <p>The manufacturer shall supply an analysis of each cast when required to do so. Should independent analysis be required these shall be selected at the rate of one per cast and the cost shall be borne by the Organization.</p>	<p>Quality of material</p> <p>The springs shall be made from killed steel ingots.</p> <p>(a) High-carbon steel materials (SUP4)</p> <p>C 0.9 - 1.1 Mn 0.30 - 0.60 Si 0.15 - 0.35 S 0.035 or less P 0.035 or less</p> <p>(b) Silicon-manganese steel materials</p> <table border="1"> <thead> <tr> <th></th> <th>(SUP6)</th> <th>(SUP7)</th> </tr> </thead> <tbody> <tr> <td>C</td> <td>0.55 - 0.65</td> <td>0.55 - 0.65</td> </tr> <tr> <td>Si</td> <td>1.50 - 1.80</td> <td>1.80 - 2.20</td> </tr> <tr> <td>Mn</td> <td>0.70 - 1.00</td> <td>0.70 - 1.00</td> </tr> <tr> <td>S</td> <td>0.035 or less</td> <td>0.035 or less</td> </tr> <tr> <td>P</td> <td>0.035 or less</td> <td>0.035 or less</td> </tr> </tbody> </table> <p>(c) Manganese-Chromium Steel materials</p> <table border="1"> <thead> <tr> <th></th> <th>(SUP9)</th> <th>(SUP9A)</th> </tr> </thead> <tbody> <tr> <td>C</td> <td>0.50 - 0.60</td> <td>0.55 - 0.65</td> </tr> <tr> <td>Mn</td> <td>0.65 - 0.95</td> <td>0.70 - 1.00</td> </tr> <tr> <td>Cr</td> <td>0.65 - 0.95</td> <td>0.70 - 1.00</td> </tr> <tr> <td>Si</td> <td>0.15 - 0.35</td> <td>0.15 - 0.35</td> </tr> <tr> <td>S</td> <td>0.035 or less</td> <td>0.035 or less</td> </tr> <tr> <td>P</td> <td>0.035 or less</td> <td>0.035 or less</td> </tr> </tbody> </table>		(SUP6)	(SUP7)	C	0.55 - 0.65	0.55 - 0.65	Si	1.50 - 1.80	1.80 - 2.20	Mn	0.70 - 1.00	0.70 - 1.00	S	0.035 or less	0.035 or less	P	0.035 or less	0.035 or less		(SUP9)	(SUP9A)	C	0.50 - 0.60	0.55 - 0.65	Mn	0.65 - 0.95	0.70 - 1.00	Cr	0.65 - 0.95	0.70 - 1.00	Si	0.15 - 0.35	0.15 - 0.35	S	0.035 or less	0.035 or less	P	0.035 or less	0.035 or less	<p>Quality of material</p> <p>The materials shall be produced in acid open-hearth furnace or electric furnace.</p> <p>(a) Carbon steel En 44</p> <p>C 0.90 - 1.20 Mn 0.45 - 0.70 Si 0.30 or less S 0.050 or less P 0.050 or less</p> <p>(b) Silicon-manganese steel</p> <table border="1"> <thead> <tr> <th></th> <th>(En 45)</th> <th>(En 45A)</th> </tr> </thead> <tbody> <tr> <td>C</td> <td>0.50 - 0.60</td> <td>0.55 - 0.65</td> </tr> <tr> <td>Si</td> <td>1.50 - 2.00</td> <td>1.70 - 2.00</td> </tr> <tr> <td>Mn</td> <td>0.70 - 1.00</td> <td>0.70 - 1.00</td> </tr> <tr> <td>S</td> <td>0.050 or less</td> <td>0.050 or less</td> </tr> <tr> <td>P</td> <td>0.050 or less</td> <td>0.050 or less</td> </tr> </tbody> </table> <p>(1) The manufacturer of steel materials, if requested, shall submit the result of analysis.</p> <p>(2) Same as ERS. The sampling rate shall be one of 500 springs and one per cast or more.</p>		(En 45)	(En 45A)	C	0.50 - 0.60	0.55 - 0.65	Si	1.50 - 2.00	1.70 - 2.00	Mn	0.70 - 1.00	0.70 - 1.00	S	0.050 or less	0.050 or less	P	0.050 or less	0.050 or less	<p>Quality of material</p> <p>Steel materials shall be manufactured in open-hearth furnace, crucible, or electric furnace.</p> <p>Chemical composition (%)</p> <p>C 0.90 - 1.05 Mn 0.30 - 0.50 Si 0.15 - 0.30 S 0.05 or less P 0.04 or less</p> <p>(1) Analysis shall be conducted on the sample extracted during melting process, and its record shall be submitted.</p> <p>(2) Sampling ratio shall be 4 samples for 15 tons or less of melted amount, and 6 samples for 15 tons or more of melted amount, and 1/500 springs.</p>
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ERS	JIS(JRS)	BS	AAR																																								
<p>2. Freedom from defects</p> <p>The steel when rolled shall be smooth on its surface, free from defects of any kind, and the edges shall be rounded to a suitable radius.</p>	<p><u>Freedom from defects</u></p> <p>Steel materials shall be good in finish, uniform in quality and free from any defect detrimental to usage.</p> <p>(1) The surface must not have such defect as roughened surface, flaw and decarburization.</p> <p>(2) Ingots or billets shall, before rolled, be removed of flaw on the surface by machining or such other method as will not affect the quality of materials.</p> <p>(3) Hot-rolled materials must be finished by machining or grinding.</p>	<p><u>Freedom from defects</u></p> <p>Rolled materials shall be smooth in surface and free from cracking, surface flaw, laminate or other injurious defect.</p>	<p><u>Freedom from defects</u></p> <p>None</p>																																								
<p>3. Manufacture</p> <p>(a) The steel shall be made by one of the processes named in clause 1.</p> <p>(b) Sufficient metal shall be cropped off the ingots, billets etc., to secure freedom from injurious piping and undue segregation, and all surface defects shall be chipped out of the ingots before rolling or forging.</p> <p>(c) The steel when rolled must be perfectly smooth on its surface, free from defects of any kind and true to section.</p> <p>(d) All bars shall be rolled to within the under-mentioned tolerances:-</p> <table border="1" data-bbox="557 1304 982 1528"> <thead> <tr> <th rowspan="2">Rounds and Squares</th> <th colspan="2">Variation in diameter or thickness, ins.</th> </tr> <tr> <th>Over</th> <th>Under</th> </tr> </thead> <tbody> <tr> <td>Up to 12.5 mm inclusive</td> <td>0.3 mm</td> <td>Nil</td> </tr> <tr> <td>Over 12.5mm to 25.0 mm inclusive</td> <td>0.4 mm</td> <td>Nil</td> </tr> <tr> <td>Over 250.0 mm to 50.0 mm inclusive</td> <td>0.6 mm</td> <td>Nil</td> </tr> </tbody> </table>	Rounds and Squares	Variation in diameter or thickness, ins.		Over	Under	Up to 12.5 mm inclusive	0.3 mm	Nil	Over 12.5mm to 25.0 mm inclusive	0.4 mm	Nil	Over 250.0 mm to 50.0 mm inclusive	0.6 mm	Nil	<p><u>Dimensional tolerance of hot-rolled steel materials</u></p> <table border="1" data-bbox="1023 982 1427 1150"> <thead> <tr> <th>Diameter</th> <th>Tolerance on diameter</th> </tr> </thead> <tbody> <tr> <td>12 - 15 mm</td> <td>± 0.25</td> </tr> <tr> <td>16 - 20</td> <td>± 0.30</td> </tr> <tr> <td>21 - 32</td> <td>± 0.40</td> </tr> <tr> <td>34 - 45</td> <td>± 0.50</td> </tr> <tr> <td>46 - 70</td> <td>± 0.70</td> </tr> <tr> <td>75 - 80</td> <td>± 1.00</td> </tr> </tbody> </table>	Diameter	Tolerance on diameter	12 - 15 mm	± 0.25	16 - 20	± 0.30	21 - 32	± 0.40	34 - 45	± 0.50	46 - 70	± 0.70	75 - 80	± 1.00	<p><u>Tolerance for rolling</u></p> <p>Diameter of round bar +1%, 0.008" (0.2 mm)</p> <p>-0.8%, 0.006" (0.15 mm)</p>	<p><u>Tolerance for round bars</u></p> <p>AAR-M-112 - Clause 7 (c)</p> <p>For example,</p> <table border="1" data-bbox="2041 1024 2457 1192"> <thead> <tr> <th>Size</th> <th>mm</th> <th>mm</th> </tr> </thead> <tbody> <tr> <td>for 7/16" - 5/8"</td> <td>(11.1 - 15.9)</td> <td>±0.007" (±0.11)</td> </tr> <tr> <td>5/8" - 7/8"</td> <td>(15.9 - 22.2)</td> <td>±0.008" (±0.20)</td> </tr> <tr> <td>7/8" - 1"</td> <td>(22.2 - 25.4)</td> <td>±0.009 (±0.23)</td> </tr> </tbody> </table>	Size	mm	mm	for 7/16" - 5/8"	(11.1 - 15.9)	±0.007" (±0.11)	5/8" - 7/8"	(15.9 - 22.2)	±0.008" (±0.20)	7/8" - 1"	(22.2 - 25.4)	±0.009 (±0.23)
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ERS	JIS(JRS)	BS	AAR
<p>4. Branding</p> <p>Each spring shall be stamped with the letters "E.R.", the manufacturer's name or initials, the order number, and the date of manufacture. This shall be done in such a manner that the risk of subsequent failure due to the branding is reduced to a minimum. No branding shall be carried out on springs made from bars less than 9 mm. in diameter, or of equivalent section if of other shapes.</p>	<p><u>Branding</u></p> <p>(JRS) Date of manufacture and manufacturer's name or its initials shall be stamped on the outside face of the end turn.</p> <p>(JIS) Symbol for classification, melt No., or inspection No., manufacturer's name or its initials shall be marked by adequate method.</p> <p>(JRS) Springs made of materials having diameter of less than 16 mm may be marked by tags attached to them instead of stamping.</p>	<p><u>Branding</u></p> <p>(1) The materials shall be clearly marked on each bundle with the manufacturer's number and cast number by some suitable method.</p> <p>(2) Stamping on spring shall not be performed unless requested. Stamping, if performed, must be performed in such a manner as will not give injurious flaw on the material. Materials of 1/2" (12.7 mm) or less in diameter need not be stamped.</p>	<p><u>Branding</u></p> <p>(1) Materials shall be marked with manufacturer's name and cast No.</p> <p>(2) Manufacturer's name or its initials, date of manufacture shall be hot-stamped on the part of the springs which does not give influence on the spring.</p> <p>(3) The mark indicative of the type of the spring shall also be stamped.</p>
<p>5. Compression test</p> <p>Each spring shall be tested by being pressed home three times by a quick-acting scrag. The free height shall then not exceed that specified by more than 3.0 mm. or 1 1/4 per cent, whichever is the greater, and it shall not be less than that specified by more than one half of this tolerance.</p> <p>Up to 5 per cent of the springs may also be tested under varying loads to determine the range and deflection per ton.</p>	<p><u>Measurement of Spring Characteristics</u></p> <p>Measurement of spring characteristics shall be performed after the test load has been applied once.</p> <p><u>Free height</u></p> <p>The tolerance for free height shall be +2% of the free height in case that spring characteristics are specified and that the free height is not treated as mere reference value.</p> <p>(JRS) +1.5% of free height</p>	<p><u>Compression test</u></p> <p>(1) The free height shall not exceed the specified value by 1/8" (3.2 mm) or 1 1/4 (1.25) %.</p> <p>(2) If needed, 5% (in quantity) of springs shall be subjected to load test to obtain the load-deflection characteristics.</p> <p>(Tolerance for load/height is specified: BS 24 Part 3B)</p>	<p><u>Tolerance</u></p> <p>Tolerance for free height (AAR-M-114 - Table III)</p>
<p>6. Workmanship</p> <p>The pitch of the coils shall not be irregular. The ends of compression springs shall be tapered and present a flat bearing of at least two-thirds the circumference at right angles to the axis within a tolerance of 10.0 mm per meter. A plug gauge 1.5 mm less than the specified inside diameter shall pass through the spring.</p>	<p><u>Workmanship</u></p> <p>(1) Equally-pitched compression springs must not have their coils come into contact except at both ends when compressed by 80% of total deflection.</p> <p>(2) A tapered part of coil shall have the length of about 3/4 turn of coil and the thickness at the extreme end equal to about 1/4 of diameter of the material.</p> <p>(3) The taper-processed compression spring does not have its ends finished by grinding in general. If required especially, the grinding may be applied to the length of about 3/4 turn as agreed upon between the purchaser and the manufacturer.</p>	<p><u>Workmanship</u></p> <p>(1) The end surface (both end faces) shall be at least 2/3 time the circumference, and perpendicular to axis, with tolerance of 1/8"/1' (3.2/305)mm.</p> <p>(2) Inside diameter gauge shall be the specified value minus (-) 1/16" (1.6 mm)φ, and the gauge length shall be 1/3" or more of the inside diameter of spring.</p>	<p><u>Workmanship</u></p> <p>(1) The coils of a spring shall be equally pitched and shall not come into contact except on both ends of the spring when compressed 85% of the total deflection.</p> <p>(2) Each end of a bar shall be tapered.</p> <p>(3) End surface shall be 2/3 or more of circumference.</p> <p>(4) Permissible limits of coil diameter (AAR-M-114 Table 1)</p>

ERS	JIS(JRS)	BS	AAR																
<p>If required, the outside diameter may be checked by a ring gauge. When the spring is unloaded, the inside diameter of the gauge shall be 1.5 mm. larger than the specified outside diameter of the spring in the case of helical springs up to 140 mm. diameter, and 3.0 mm. larger in the case of helical springs over 140 mm. diameter and all volute springs.</p> <p>In the case of volute springs the coils must not touch one another even when the springs are compressed right home.</p>	<p><u>Tolerance in coil diameter</u></p> <table border="1" data-bbox="1020 552 1484 772"> <thead> <tr> <th>For free height (mm)</th> <th>Tolerance</th> </tr> </thead> <tbody> <tr> <td>250 or less</td> <td>+1% of mean coil diameter, min. + 1.5 mm</td> </tr> <tr> <td>250 - 500</td> <td>+1.5% of mean coil diameter, min. ±1.5 mm</td> </tr> <tr> <td>500 or more</td> <td>as agreed upon between manufacturer and purchaser.</td> </tr> </tbody> </table> <p><u>Inclination of outside face of coils</u></p> <p>Permissible limit 0.05 Ho → 5/100 (2.9°) If particularly required to specify, 2/100 (1.15°)</p> <p>(JRS) → within 1°</p> <p>(JRS) Both end faces of spring shall be finished by grinding perpendicularly to the axis.</p>	For free height (mm)	Tolerance	250 or less	+1% of mean coil diameter, min. + 1.5 mm	250 - 500	+1.5% of mean coil diameter, min. ±1.5 mm	500 or more	as agreed upon between manufacturer and purchaser.	<p><u>Tolerance in coil diameter</u></p> <p>Coil springs of 4" (102 mm) or less in outside diameter:</p> <p>Specified value + 1/16" (1.6 mm)</p> <p>Coil springs of 4" (102 mm) or more in outside diameter and all volute springs:</p> <p>Specified value + 1/8" (3.2 mm)</p> <p>Gauge length : 3/4" or more</p>	<p><u>Inclination of outside face of coil</u></p> <table border="1" data-bbox="2041 562 2481 695"> <thead> <tr> <th>Diameter of coil</th> <th>Maximum deviation</th> </tr> </thead> <tbody> <tr> <td>2" or less</td> <td>3 1/2°</td> </tr> <tr> <td>2" - 4"</td> <td>3°</td> </tr> <tr> <td>4" or more</td> <td>2 1/2°</td> </tr> </tbody> </table>	Diameter of coil	Maximum deviation	2" or less	3 1/2°	2" - 4"	3°	4" or more	2 1/2°
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<p>7. Heat Treatment</p> <p>All springs shall be correctly hardened and tempered. However the best treatment should be stated.</p>	<p><u>Heat Treatment</u></p> <p>Springs must, after formed to shape, be heat-treated uniformly by means of quenching and tempering.</p> <p>(Hardness of spring after tempered: Carbon steel H_B 352 - 415)</p>	<p><u>Heat Treatment</u></p> <p>All the springs shall be suitably heat-treated.</p>	<p><u>Heat Treatment</u></p> <p>(AAR-M-14 - Clause 4)</p> <p>After formed into coil, the springs shall be quenched and tempered.</p>																
<p>8. Rejection</p> <p>Should the material or the finished springs fail to comply in every particular with the above conditions, the lot from which the samples were selected shall be rejected.</p>	<p><u>Rejection</u></p> <p>none</p>	<p><u>Rejection</u></p> <p>none</p>	<p><u>Rejection</u></p> <p>If 25% or more of the total number of springs of a lot are out of the Standard and unacceptable, the lot shall be wholly rejected.</p>																
<p>9. Inspection</p> <p>The E.R. Inspecting Engineer shall be allowed unhindered access to the manufacturer's works at all times during working hours when springs 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 material or springs not conforming</p>	<p><u>Inspection</u></p> <p>none</p>	<p><u>Inspection</u></p> <p>(1) Defects derivative of manufacture shall be the cause of rejection even after the delivery.</p>	<p><u>Inspection</u></p> <p>Same as ERS</p>																

ERS	JIS(JRS)	BS	AAR
<p>to this specification. Material or springs so rejected shall be cut up immediately or marked at once in the presence of the inspector in such a way that it or they can not be confused subsequently with satisfactory material or springs.</p>			
<p>10. Testing facilities</p> <p>The manufacturer at his own cost shall supply labour and appliances for such testing as may be carried out on his premises. Failing facilities at his own works for making the prescribed tests the manufacturer shall bear the cost of carrying out the tests elsewhere.</p>	<p><u>Testing facilities</u></p> <p>none</p>	<p><u>Testing facilities</u></p> <p>Same as ERS</p>	<p><u>Testing facilities</u></p> <p>Same as ERS.</p>

COMPARISON TABLE FOR M9A-1963 SPECIFICATION FOR ROLLED STEEL DISC WHEEL CENTRES

ERS	JRS(JIS)	UIC	BS																	
<p>1. Quality of material</p> <p>The wheel centres shall be forged and rolled from steel made from selected material by the acid or basic open hearth or acid bessemer process, and shall not show on analysis more than 0.06 per cent of sulphur or of phosphorus. The manufacturer shall supply an analysis when required to do so.</p>	<p><u>Quality</u></p> <p>Wheels shall be manufactured from killed steel ingots produced by open-hearth furnace, electric furnace or 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.</p> <p>The chemical composition shall be: C 0.60 - 0.75, S 0.15 - 0.35, Mn 0.50 - 0.90, and P, S 0.050 or less (for acid furnace process) and 0.045 or less (for basic furnace process).</p>	<p><u>Quality</u></p> <p>The material shall be manufactured in open-hearth furnace or electric furnace (provided that it may be manufactured by other process approved by the government of the purchaser's country).</p> <p>The top and bottom of an ingot shall be discarded. The chemical composition shall be P, S ≤ 0.06, P + S ≤ 0.10, and Mn ≤ 1.20, Si ≤ 0.50, Ni, Cr ≤ 0.30, Mo, V ≤ 0.05, Cu ≤ 0.30.</p>	<p><u>Quality</u></p> <p>Same as ERS</p>																	
<p>2. Freedom from defects</p> <p>The wheel centres shall be free from defects of any kind, and accurately finished to the prescribed dimensions. The disc portion of the centre 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 centre 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.</p>	<p><u>Removal of Flaw</u></p> <p>Tolerances for disc plate</p> <p>(1) +5 0 for 12T axle</p> <p>(2) +4 0 for 10T axle</p>	<p><u>Removal of Flaw</u></p> <p>The wheel center shall be sound over the whole and free from any flaw.</p> <p>Tolerances for disc</p> <table border="1" data-bbox="1516 982 2021 1129"> <thead> <tr> <th rowspan="2">Division</th> <th colspan="2">As rolled</th> <th rowspan="2">Rough finish</th> <th rowspan="2">Finish</th> </tr> <tr> <th>Processed subsequently</th> <th>Not processed subsequently</th> </tr> </thead> <tbody> <tr> <td>Thickness of disc on boss side</td> <td>+8 0</td> <td>+10 0</td> <td>-</td> <td>+2 0</td> </tr> <tr> <td>Thickness of disc on rim side</td> <td>+6 0</td> <td>+8 0</td> <td>-</td> <td>+2 0</td> </tr> </tbody> </table>	Division	As rolled		Rough finish	Finish	Processed subsequently	Not processed subsequently	Thickness of disc on boss side	+8 0	+10 0	-	+2 0	Thickness of disc on rim side	+6 0	+8 0	-	+2 0	<p><u>Freedom from Defects</u></p> <p>Tolerance for plate thickness: +3.2 -1.6</p> <p>Circumferential variation in thickness: within 1.6 mm</p>
Division	As rolled			Rough finish	Finish															
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<p>3. Branding</p> <p>The wheel centres 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 3/8" (9.5 mm. and not more than 1/2" (12.5 mm.) high.</p>	<p><u>Stamping</u></p> <p>Not specified in the Specification. Drawings indicate the stamping of date and charge name, with letters of 10 mm in size.</p>	<p><u>Stamping</u></p> <p>Charge name, manufacturer's name, serial number (if practicable), Date of manufacture</p>	<p><u>Stamping</u></p> <p>Charge name shall be hot-stamped on the plate portion, and the manufacturer's name and the date of manufacture shall be stamped cold on the boss. Stamping letters shall be 9.5 to 12.7 mm in size.</p>																	
<p>4. Heat treatment</p> <p>The wheel centres may be supplied with or without heat treatment at the option of the manufacturer.</p>	<p><u>Heat treatment</u></p> <p>Heat-treated by normalizing.</p>	<p><u>Heat treatment</u></p> <p>To be normalized if requested in the order sheet or by the manufacturer.</p>	<p><u>Heat Treatment</u></p> <p>Execution of heat treatment shall be to the selection of the manufacturer.</p>																	

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<p>5. Number of centres to be tested</p> <p>Extra wheel centres 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 centre for each 100 wheel centres or portion thereof in each cast as submitted for testing, with the exception that if there are not more than 110 wheel centres in the cast one wheel centre only shall be selected. The E.R. Inspecting Engineer shall select and test such of the wheel centres as he may think proper to the extent of the number specified above.</p> <p>The wheel centres tested by deflection shall 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 wheel centres shall comply with the following tests without further re-heating or any other manipulation whatever, either of the wheel centres selected for testing or of any portion cut therefrom to furnish the test pieces.</p>	<p><u>Number of Test Pieces</u></p> <p>The number of test pieces to be taken shall be one per charge.</p>	<p><u>Number of Test Pieces</u></p> <p>The number of test pieces to be taken shall be:</p> <p>1. for a lot of up to 250 wheel centers, 2 for a lot of over 250 wheel centers,</p> <p>where one lot corresponds to the wheel center of the same charge and the same heat treatment.</p>	<p><u>Number of Test Pieces</u></p> <p>The number of test pieces to be taken for falling weight test and tensile test shall be one out of 120/charges.</p>
<p>6. Falling weight or deflection test</p> <p>The wheel centre shall be placed flat with its convex side uppermost upon a circular metal ring having an internal diameter approximately the same as the internal diameter of the wheel centre and resting upon a 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 a height of 10 feet (3.00 m.) and upwards until the boss has been deflected as amount equal to 1/2-inch (12.50 mm) for every 12 inches (300 mm) of the external diameter of the wheel centre. Alternatively the wheel centre, with the convex side uppermost and rigidly supported around the rim only as described above, shall withstand without fracture hydraulic pressure applied on to the boss until the boss has been permanently deflected by an</p>	<p><u>Falling weight or deflection test</u></p> <p>None</p>	<p><u>Deflection Test</u></p> <p>The wheel center shall be placed on a ring in such a way that only the rim comes into contact. In this case the force shall be exerted in such a direction as will cause larger inclination of the disc.</p> <p>The blow shall be given at 3,000 kg.m and until the permanent strain reaches to 10% or more of the length of disc portion.</p>	<p><u>Falling Weight Test</u></p> <p>Same as ERS</p>

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<p>amount equal to 1/2 inch (12.50 mm) for every 12 inches (300 mm) of the external diameter of the wheel centre.</p> <p>The above tests shall not be applied to wheel centres of abnormal design, the tests on which shall be agreed to, between the manufacturer and the E.R. Inspecting Engineer.</p> <p>Note. A wheel centre of abnormal design is defined as one in which the formula $\frac{B \times W}{D}$ gives a result exceeding 0.4.</p> <p>where B = smallest boss diameter. (Where a wheel centre has differing bosses the larger diameter boss shall be taken).</p> <p>W = maximum thickness of web. D = internal diameter of rim.</p>			
<p>7. Tensile test</p> <p>A standard test piece C (see Appendix), machined cold from the rim or web of the wheel centre which has been tested as above, shall show a tensile breaking strength of not less than 33 tons per square inch (52 kg/mm²), with an elongation of not less than 22 per cent, and not more than 40 tons per square inch (63 kg/mm²), with an elongation of not less than 15 per cent. The sum of the tensile breaking strengths and corresponding elongations must not be less than 55.</p> <p>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 centre from which the discarded test piece was taken.</p>	<p><u>Tensile Test</u></p> <p>Tensile strength : 74 - 98 kg/mm²</p> <p>Elongation : 14 or more - 9 or more</p> <p>Reduction of area : 18 or more - 13 or more</p>	<p><u>Tensile Test</u></p> <p>Tensile strength R = 42 to 50 kg/mm²</p> <p>Coefficient proper to material C \geq 105 mm</p> <p>where C = R + 2.5A (for L = 8.16 \sqrt{S}) = R + 2.2A (for L = 5.65 \sqrt{S}) = R + 2A (for L = 4 \sqrt{S})</p>	<p><u>Tensile Test</u></p> <p>Same as ERS</p>

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<p>8. Additional tests before rejection</p> <p>In the event of the wheel centre selected for testing not satisfying the requirements of clauses 6 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 wheel centres represented:</p> <p>(a) Should the wheel centre fail to fulfil the conditions of the falling-weight or deflection test the E.R. Inspecting Engineer shall select two more wheel centres from the same lot, all of which, with his permission, may be heat treated or reheat treated before the selection is made. Should either of the re-tested wheel centres fail to fulfil the conditions of the falling-weight or deflection 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 wheel centres for further tests. Should the results of these repeated tests be satisfactory, the wheel centres represented shall be held to have passed the falling-weight or deflection test. Should either of these wheel centres fail to fulfil the conditions of the falling weight or deflection test, the wheel centres represented shall be rejected.</p> <p>(b) Should the wheel centre or wheel centres which have passed the falling-weight or deflection test fail in the tensile test, two more tensile test pieces shall be taken from the wheel centre which has given the defective test for repeating the test.</p> <p>The wheel centres 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.</p>	<p><u>Additional Test before Rejection</u></p> <p>In case that the tensile test resulted unacceptable, all the products shall be re-heat-treated only for once and be re-tested.</p>	<p><u>Additional Test before Rejection</u></p> <p>If the test result is unacceptable, the products may be rejected, provided, however, that the retest can be arranged between the manufacturer and purchaser.</p>	<p><u>Additional Tests before Rejection</u></p> <p>(1) <u>Falling weight or deflection test</u></p> <p>If the falling weight test has failed, the test shall be performed on additional two wheel centers. In place of two additional tests, or if one of the retests has failed, retest may be performed after re-heat-treatment, subject to agreement by the purchaser or its representative.</p> <p>(2) <u>Tensile Test</u></p> <p>If a test piece fails to satisfy the value given above, or if the purchaser or its representative agrees that this fractured test piece does not represent the lot, two additional retests may be performed.</p> <p>As an alternative to two additional tests or if one of the tests has failed, the falling weight test and the tensile test may be carried out after re-heat-treatment with the agreement of the inspector.</p>

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<p>Inspecting Engineer, may heat treat or re-heat treat the bulk and present them again for the falling-weight or deflection and tensile tests. Should either or these fail, the lot shall be rejected. Should the results of these repeated tests prove satisfactory the wheel centres represented shall be accepted.</p>			
<p>9. Inspection</p> <p>The E.R. Inspecting Engineer shall be allowed unhindered access to the manufacturer's works at all times during working hours when wheel centres 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 this specification. 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.</p>	<p><u>Inspection</u></p> <p>The manufacture of wheel centers shall be subjected to the supervision and inspection by the inspector appointed by the Japanese National Railways.</p>	<p><u>Inspection</u></p> <p>None</p>	<p><u>Inspection</u></p> <p>Same as ERS</p>
<p>10. Testing facilities</p> <p>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. Falling facilities at his own works for making the prescribed tests, the manufacturer shall bear the cost of carrying out the tests elsewhere.</p>	<p><u>Testing Facilities</u></p> <p>None</p>	<p><u>Testing Facilities</u></p> <p>None</p>	<p><u>Testing Facilities</u></p> <p>Same as ERS</p>