Australian Standard™

Railway track material

Part 1: Steel rails

Standards Australia

This Australian Standard was prepared by Committee CE-002, Railway Track Materials. It was approved on behalf of the Council of Standards Australia on 14 June 2002 and published on 1 August 2002.

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The following are represented on Committee CE-002:

Australasian Railway Association

Australian Chamber of Commerce and Industry

Australian Industry Group

Bureau of Steel Manufactures of Australia

Rail Track Association Australia

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Railway track material

Part 1: Steel rails

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PREFACE

This Standard was prepared by the Standards Australia Committee CE-002, Railway Track Materials, to supersede AS 1085.1—2000, *Railway permanent way material*, Part 1: *Steel rails*.

The objective of this Standard is to provide purchasers and suppliers, including owners, operators, designers and manufacturers of railway rail with requirements for as-rolled and hardened steel rails, made from continuously cast blooms for railway purposes.

This Standard is Part 1 of the AS 1085 series (*Railway track material*) comprised of the following parts:

Part 1:   Steel rails

Part 2:   Fishplates

Part 3:   Sleeper plates

Part 4:   Fishbolts and nuts

Part 7:   Spring washers

Part 8:   Dogspikes

Part 10: Rail anchors

Part 12: Insulated joint assemblies

Part 13: Spring fastening spikes for sleeper plates

Part 14: Prestressed concrete sleepers

Part 15: Aluminothermic rail welding

Part 17: Steel sleepers

New parts also under development are Part 18: *Screw spikes and threaded inserts*, Part 19: *Resilient fastening assemblies* and Part 20: *Welding of steel rail*.

Of interest to users of this series are the following:

AS 3818.2, *Timber—Heavy structural products—Visually graded*, Part 2: *Railway track timbers*

AS 2758.7, *Aggregates and rock for engineering purposes*, Part 7: *Railway ballast*

Changes to the previous edition are as follows:

(a)   Change of title of the AS 1085 series (previously *Railway permanent way material*).

(b)   Referenced documents list has been revised.

(c)   Reference to the surface hardness test in Clause 9.1.1.

(d)   Amendments to dimensions in Figures D1 and D4.

(e)   Changes to the tolerances for 68 kg rail.

(f)   Column 6 of Table E3 noted as minimum values.

(g)   The most recent version of the informative Appendix 'Means of demonstrating compliance with this Standard' has been included.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

Statements expressed in mandatory terms in notes to tables and figures are deemed to be requirements of this Standard.

CONTENTS

STANDARDS AUSTRALIA

Australian Standard
Railway track material

Part 1: Steel rails

1 SCOPE

This Standard specifies requirements for as-rolled and hardened steel rails made from continuously cast blooms and profiles for asymmetric switch rails and elevated guardrails for railway purposes.

NOTES:

1 Guidelines for purchasers are given in Appendix A.

2 Guidance on the means for demonstrating compliance with this Standard is given in Appendix B.

3 Information on residual stresses in rail is given in Appendix C.

2 PURPOSE AND CONTEXT OF USE

2.1 Function

Steel rail forms the direct longitudinal support member of the railway permanent way and provides the guiding and running surface for rolling stock. Rail may also be used to conduct current for signalling and traction purposes.

2.2 Action

Steel rail is subjected to—

(a) loads imposed by the passage of rolling stock and during maintenance;

(b) the effects of temperature, fastening systems, joints and welding; and

(c) fatigue, wear, damage and corrosion.

3 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS
1003	Engineers' straightedges (metric units)
1100	Technical drawing
1100.201	Part 201: Mechanical drawing
1199	Sampling procedures and tables for inspection by attributes
1391	Methods for tensile testing of metals
1399	Guide to AS 1199—Sampling procedures and tables for inspection by attributes
1816	Metallic materials—Brinell hardness test
1817	Metallic materials—Vickers hardness test
1929	Non-destructive testing—Glossary of terms

AS
2205	Methods of destructive testing of welds in metal
2205.5.1	Part 5.1: Macro metallographic test for cross-section examination
2706	Numerical values—Rounding and interpretation of limiting values

AS/NZS
1050   Methods for the analysis of iron and steel (all methods)

ISO 9001   Quality management systems—Requirements

ISO 9004   Quality management systems—Guidelines for performance improvements

SAI
HB18   Guidelines for third-party certification and accreditation

HB18.28   Guide 28—General rules for a model third-party certification system for products

ASTM
E 1180   Practice for preparing sulfur prints for macrostructural examination

UIC
860   Technical specification for the supply of rails

861-2   Standard sections for points rails adapted to the UIC 54 and 60 kg/m rail sections

4 DEFINITIONS

For the purpose of this Standard, the definitions given in AS 1929 and those given below apply.

4.1 As-rolled rail

Rail that is cooled off the mill, without accelerated cooling, and is not subsequently heat treated.

4.2 Head-hardened rail

Rolled rail in which the head has a hardened zone extending inwards from its top and side surfaces.

> NOTE: For the purpose of this Standard, head-hardened rail has been treated by accelerated cooling of the head to produce a fine pearlitic structure.

4.3 Hardened rail

Rolled rail that has been head-hardened or full section hardened by in-line or off-line processes.

5 ROUNDING OF NUMBERS

5.1 General

For the purpose of assessing compliance with this Standard, the specified limiting values herein shall be interpreted in accordance with the 'rounding method' described in AS 2706, that is, the observed or calculated value shall be rounded to the same number of figures as in the specified or calculated value and then compared with the specified limiting values. For example, for specified limiting values of 2.5, 2.50 and 2.500, the observed or calculated value would be rounded respectively to the nearest 0.1, 0.01 and 0.001.

5.2 Tensile properties

The determined value of tensile strength shall be rounded off to the nearest 10 MPa, and the determined value of yield stress shall be rounded off to the nearest 5 MPa.

6 DESIGNATION

The nominal rail size shall be designated by the nominal mass, in kilograms, of a 1 m length of rail. For example, 31 kg rail means a rail section having nominally a mass of 31 kg per metre.

The switch rail profiles are matched with 50 kg and 60 kg rails. They shall be referred to as 50 kg asymmetrical switch rails and 60 kg asymmetrical switch rails, respectively. The elevated guardrail profile is for use with either 50 kg or 60 kg rails. It shall be referred to as '50/60 kg elevated guardrail'. The guardrail specified in this Standard, also known as check rail, is for use in points and crossings.

> NOTE: The masses used to refer to asymmetrical switch rails and elevated guardrails refer to the rail profile with which they are commonly used and not the actual mass of the section. This naming convention does not preclude their use with other rail profiles.

7 TRACK SYSTEM COMPATIBILITY

7.1 Profile shape

The dimensions of rails shall conform to the appropriate profile drawing given in Appendix D within the dimensional tolerances given in Table D1. Methods for testing the dimensional tolerances shall be as given in Appendix D.

7.2 Materials

Requirements for materials for track system compatibility shall be deemed to be met when Clause 8.1 is satisfied.

8 SERVICE LIFE

8.1 Materials

When tested in accordance with Appendix E, the chemistry shall conform with the limits given in Table E1 for the basic chemical elements and Table E2 for the residual elements.

8.2 Shape stability and wear resistance

Shape stability and wear resistance requirements shall be deemed to be met when the requirements of Clauses 8.1 and 9 are satisfied.

8.3 Fatigue

Fatigue requirements shall be deemed to be met when the requirements of Clauses 8.1 and 9 are satisfied.

9 MATERIAL INTEGRITY

9.1 Material properties

9.1.1 *As-rolled rail*

When tested in accordance with Paragraph F1.1 (tensile testing) and Paragraph F1.2 (surface hardness test) of Appendix F, the material properties shall conform to the limits given in Table E3 of Appendix E.

9.1.2 *Head-hardened rail*

Head-hardened rail shall comply with the following performance requirements:

(a) *Tensile testing* When tested in accordance with Paragraph F1.1 of Appendix F, the material properties shall conform to the limits given in Table E3 of Appendix E.

(b) *Surface hardness test* When determined in accordance with Paragraph F1.2 of Appendix F, surface hardness shall be within the limits given in Table E3 of Appendix E.

(c) *Test for depth of heat treatment (etch test)* When determined in accordance with Paragraph F1.3 of Appendix F, the dimensions of the heat-affected zone shown in Figure F1(c) shall be in accordance with Table E5 of Appendix E.

(d) *Hardness gradient test* When determined in accordance with Paragraph F1.4 of Appendix F, the hardness results obtained shall vary gradually toward the centre of the rail, with no sharp drop or discontinuity and shall be within the limits given in Table E4 of Appendix E.

(e) *Microstructure test* When examined in accordance with Paragraph F1.5 of Appendix F, the microstructure of the entire cross-section shall be substantially pearlitic and shall not exhibit grain boundary cementite.

NOTE: For rails where additional hardening of the rail section has taken place, the above tests may be specified and additional tests may be necessary to cover further requirements such as the hardness throughout the cross-section.

9.2 Internal soundness

9.2.1 *Bloom reduction*

The cross-section of the rail shall not exceed one-ninth (0.111) that of the bloom from which the rail is rolled.

9.2.2 *Post-rolling operations*

Rails shall be ground or machine-cut to length and drilled, if required, in such a way that the temperature of the rail is not high enough to cause any changes in the microstructure of the steel.

9.2.3 *Sulfur print test*

When tested in accordance with ASTM E1180 (Bauman sulfur print test), the sulfur segregation in the rail shall not exceed the following:

(a) Segregation, which can take the form of a single line, a double line or a cluster of spots, and which occurs within the web region shown in Figure F2 of Appendix F, shall not extend beyond that boundary into the rail head or foot.

(b) Outside the web region, as shown in Figure F2 of Appendix F, the sum of the lengths of other streaks shall not exceed—

   (i)   6 mm in the head; and

   (ii) 6 mm in the foot.

9.2.4 *Ultrasonic test*

When tested in accordance with Paragraph F2.2 of Appendix F, discontinuities shall—

(a) not extend outside the web region shown in Figure F2 of Appendix F; and

(b) not exceed 10 mm in vertical height transverse to the direction of rolling.

NOTE: In view of the significant probability of false rejection, rails that register apparent discontinuities may be retested or cut back and retested. No rail should be accepted until the full length delivered has been confirmed to be satisfactory. Rails containing confirmed discontinuities exceeding the limits given should be rejected or cut back to remove the affected portion.

9.2.5 *Hydrogen-induced cracks*

The rail shall be free of hydrogen-induced cracks.

9.3 External finish

9.3.1 *Visual inspection*

When inspected visually, the depth of surface imperfections such as seams, rolled-in scale and other marks in the zones indicated (see Figure F5, Appendix F) shall be—

(a) less than 0.5 mm in zone A (rail head) and zone C (edge of rail foot);

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(b)   less than 0.75 mm in zone B (rail web and top of foot); and

(c)   less than 1 mm in zone D (underside of rail foot).

Subject to agreement between the supplier and purchaser, discontinuities deeper than the above may be removed by grinding out smoothly. After any such grinding, the rail dimensions shall be not less than specified in Clause 7.1. All grinding shall be conducted in such a way that the temperature of the rail is not high enough to cause any changes in the microstructure and the finished surface is free of sharp edges.

Recurrent or extensive discontinuities in zone A within the limits set in this Clause are unacceptable.

9.3.2 *Eddy current test*

When tested in accordance with Paragraph F3 of Appendix F, discontinuities in 50, 60 and 68 kg rail shall not exceed 1.0 mm in depth on the underside of the foot of the rail.

> NOTE: The eddy current test for 31 and 41 kg rails may be specified at the option of the purchaser (see Appendix A).

10 SUITABILITY FOR CONNECTION

10.1 Profile consistency and end squareness

Requirements for the suitability of rail profile and end squareness for connection purposes shall be deemed to be met when Clause 7.1 is satisfied.

10.2 Suitability for welding and drilling

Requirements for the suitability of rail for welding and drilling for connection purposes shall be deemed to be met when Clause 8.1 is satisfied.

10.3 Holes for fishbolts

Where drilling is required, rails shall be drilled for the fishbolts conforming to the centres and dimensions shown on the appropriate profile drawing in Appendix D. In the process of drilling, the rails shall not be split or damaged, and any resulting burrs or projections shall be removed.

11 SUITABILITY FOR MAINTENANCE

11.1 Suitability for welding, drilling and grinding

Requirements for the suitability of rail for welding, drilling and grinding for maintenance purposes shall be deemed to be met when Clause 8.1 is satisfied.

11.2 Material properties

Requirements for the material properties of rail for maintenance purposes shall be deemed to be met when Clauses 8.1 and 9 are satisfied.

12 HANDLING

Rails shall not be supplied with burrs or sharp edges, which may be a hazard for those handling the rail.

13 MARKING

13.1 General

Rolled-in and stamped brands shall be legible, readily found and shall not compromise the integrity of the rail. These requirements shall be deemed to be met when Clauses 13.2 and 13.3 are satisfied.

> NOTE: Manufacturers making a statement of compliance with this Australian Standard on a product, packaging, or promotional material related to that product are advised to ensure that such compliance is capable of being verified.

13.2 Rolled-in brands

Rolled-in brands shall be applied as follows:

(a) They shall be rolled into the web of each rail at a spacing of not greater than 1.8 m.

(b) The characters shall be a minimum of 20 mm in height.

(c) The characters shall be raised at least 0.5 mm from the plane surface of the web.

(d) The brand shall show the following:

    (i) Nominal rail size.

    (ii) Mill brand.

    (iii) Month and year of rolling.

    (iv) If head-hardened rail, the letter 'H', to indicate 'head-hardened'.

NOTES:

1   For 68 kg rail a stamped 'NH' may be used to indicate 'head-hardened' if agreed between the supplier and the purchaser.

2   The month and year of manufacture is to be used for the purpose of identification only and should not be used as a basis for rejection of the steel rails.

13.3 Stamped brands

Stamped brands shall be applied as follows:

(a) They shall appear at least once on each piece of rail.

(b) They shall be positioned on the opposite side of the web to the rolled-in brand.

(c) One of the stamped brands shall appear at least 500 mm from the end of the piece of rail.

(d) Characters shall be a minimum of 16 mm in height.

(e) Characters shall be sloped 10° off vertical and shall be so designed that they will not initiate cracking (see Figure 1).

> NOTE: Sloping and rounding of marks is intended to reduce the opportunity for initiation of cracking.

(f) They shall include a unique identification code that indicates the production history of the rail (e.g., heat number, bloom number).

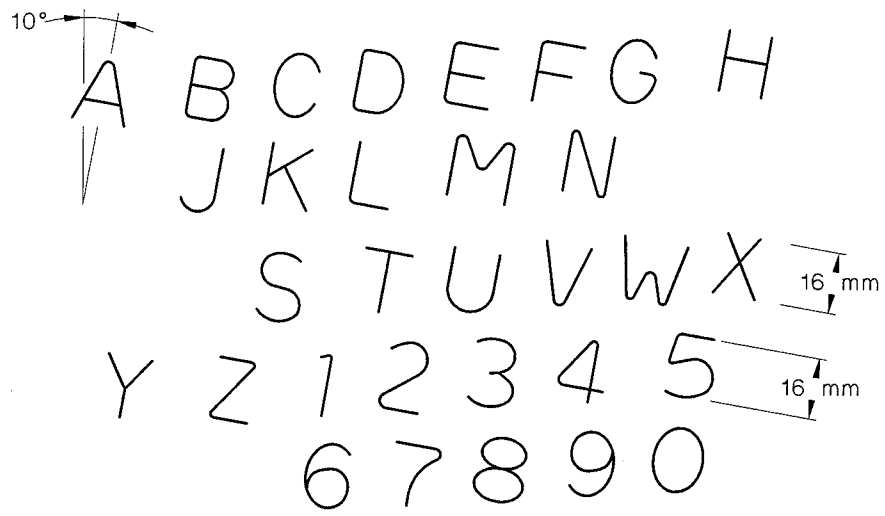(g) The action of applying the brand shall not cause metallurgical changes in the rail.

10°

A B C D E F G H
J K L M N
S T U V W X 16 mm
Y Z 1 2 3 4 5 16 mm
6 7 8 9 0

FIGURE 1   LETTERS FOR STAMPED BRANDS

APPENDIX A

INFORMATION TO BE SUPPLIED BY THE PURCHASER

(Informative)

The following information should be supplied by the purchaser (see also Clause 6):

(a)   Number and part of this Australian Standard, i.e. AS 1085.1.

(b)   Nominal rail size (e.g., 50 kg) where this applies, or the number of the appropriate drawing.

(c)   Quantity (mass or number of pieces).

NOTE: It should be remembered that the actual mass of the profile may be different to the nominal size.

(d)   Lengths of rails, including the supply of short lengths.

(e)   Whether rails are to be drilled or undrilled.

(f)   Any exceptions to the requirements specified in this Standard, and any special or supplementary requirements.

(g)   Information required to be supplied on production quality, such as a quality plan or appropriate acceptable quality levels (see AS 1199).

(h)   Whether inclusion is required of the following tests for all rails in a continuous manner during production:

(i)   Ultrasonic testing (see Clause 9.2.4).

(ii)   Visual surface inspection (see Clause 9.3.1).

(iii)   Eddy current testing (see Clause 9.3.2).

APPENDIX B

MEANS OF DEMONSTRATING COMPLIANCE WITH THIS STANDARD

(Informative)

B1 SCOPE

This Appendix sets out the following different means by which compliance with this Standard can be demonstrated by the manufacturer or supplier:

(a)   Evaluation by means of statistical sampling.

(b)   The use of a product certification scheme.

(c)   Assurance using the acceptability of the supplier's quality system.

(d)   Other such means proposed by the manufacturer or supplier and acceptable to the customer.

B2 STATISTICAL SAMPLING

Statistical sampling is a procedure which enables decisions to be made about the quality of batches of items after inspecting or testing only a portion of those items. This procedure will only be valid if the sampling plan has been determined on a statistical basis and the following requirements are met:

(a)   The sample needs to be drawn randomly from a population of product of known history. The history needs to enable verification that the product was made from known materials at essentially the same time, by essentially the same processes and under essentially the same system of control.

(b)   For each different situation, a suitable sampling plan needs to be defined. A sampling plan for one manufacturer of given capability and product throughput may not be relevant to another manufacturer producing the same items.

In order for statistical sampling to be meaningful to the customer, the manufacturer or supplier needs to demonstrate how the above conditions have been satisfied. Sampling and the establishment of a sampling plan should be carried out in accordance with AS 1199, guidance to which is given in AS 1399.

B3 PRODUCT CERTIFICATION

The purpose of product certification is to provide independent assurance of the claim by the manufacturer that products comply with the stated Standard.

The certification scheme should meet the criteria described in HB 18.28 in that, as well as full type testing from independently sampled production and subsequent verification of conformance, it requires the manufacturer to maintain effective quality planning to control production.

The certification scheme serves to indicate that the products consistently conform to the requirements of the Standard.

B4 SUPPLIER'S QUALITY MANAGEMENT SYSTEM

Where the manufacturer or supplier can demonstrate an audited and registered quality management system complying with the requirements of the appropriate or stipulated Australian or international Standard for a supplier's quality management system or systems, this may provide the necessary confidence that the specified requirements will be met. The

quality assurance requirements need to be agreed between the customer and supplier and should include a quality or inspection and test plan to ensure product conformity.

Information on establishing a quality management system is set out in AS/NZS ISO 9001 and AS/NZS ISO 9004.

B5   OTHER MEANS OF ASSESSMENT

If the above methods are considered inappropriate, determination of compliance with the requirements of this Standard may be assessed from the results of testing coupled with the manufacturer's guarantee of product conformance.

Irrespective of acceptable quality levels (AQLs) or test frequencies, the responsibility remains with the manufacturer or supplier to supply products that conform to the full requirements of the Standard.

APPENDIX C

RESIDUAL STRESSES

(Informative)

C1 GENERAL

Residual stresses in rails are internal stresses that exist independently of externally applied force or thermal gradient, and are induced during the manufacturing process by such operations as cooling after hot rolling, roller straightening and heat treatment during head-hardening. Residual stresses may be either tensile or compressive, and the stress gradient may vary non-linearly across the section in a complex manner. The form and distribution of residual stresses at any cross-section within an individual rail length are such that they are in internal equilibrium.

Residual stresses in rails may be modified from the as-manufactured condition by installation processes such as welding, and by in-service conditions such as normal operating loads.

Residual stresses in rails, and in particular in rails that have been roller straightened during manufacture, may contribute to unacceptable rail performance in terms of either unstable crack growth in the rail web, or fatigue crack initiation from surface imperfections introduced during rail manufacture, transport, handling or installation procedures, or introduced during operational service. Test procedures such as the web saw cut method, strain-gauging or the crack arrest test may be used to obtain quantitative information about the magnitude of residual stresses or their effect on the behaviour of the rail section. Data obtained using such procedures should be considered as indicative only, as rails that are currently in use and have provided satisfactory service performance may fail the proposed acceptance criteria.

Further testing is required to confirm the validity of methods that may be used to determine the magnitude of residual stresses in rails, and any acceptance criteria that relate to rail performance.

In respect of unstable web cracking behaviour examined by means of the web saw cut test, it should also be noted that an additional factor that may influence the probability of this occurring is the presence or otherwise of a suitable initiation site. Typical initiation sites may include a flame-cut end of a rail length.

C2 INFLUENCE OF RESIDUAL STRESSES ON RAIL PERFORMANCE

Failures will not occur solely as a result of residual stresses, but may occur in situations where the combination of residual stresses with discontinuities, railway loadings and thermally induced stresses becomes critical. In other words, high levels of residual stress or any unacceptable distribution of residual stresses within the rail section may increase the probability of fatigue or other cracking modes to initiate at an existing discontinuity.

Failure modes to which residual stresses may contribute are—

(a)   unstable longitudinal cracking of the rail web; and

(b)   fatigue crack initiation in the presence of a suitable discontinuity and most probably from a surface or near surface discontinuity.

References 1, 2, 3, 5, 6, 11 and 17 provide further information on these failure modes.

C3 INFLUENCE OF THE MANUFACTURING PROCESS ON RESIDUAL STRESSES

Rails are straightened during manufacture to meet the requirements outlined in Clause 7.1. For most rail manufacturing, straightening is carried out using a roller straightening process, which may subject the rail section to repeated bending in the vertical and lateral directions. A typical distribution of longitudinal stresses in roller straightened rail is shown by the example given in Figure C1.

This distribution may be present throughout a majority of the rail length, other than near the ends. Longitudinal stresses in a rail length processed by roller straightening decrease to zero towards the end of individual bars, due to the following factors:

(a) The arrangement of rollers in typical roller straightening machines is such that the ends of individual bars (over a distance that is determined by the spacing between the individual rollers of the roller straightening machine and the height of the rail section) are not subjected to the same straightening conditions as apply to the remainder of the length of the rail (Ref. 1).

(b) Longitudinal stresses cannot exist at the free end of a rail length (Ref. 14).

Other rail manufacturing processes (e.g. Ref. 16) may give other residual stress distributions to that shown in Figure C1.
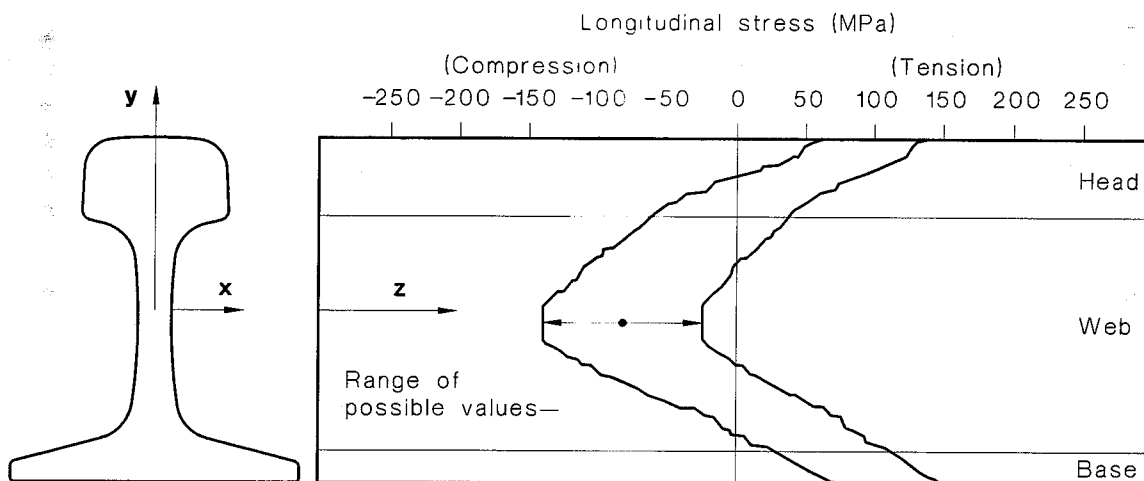

FIGURE C1 TYPICAL DISTRIBUTION OF LONGITUDINAL RESIDUAL STRESSES IN ROLLER-STRAIGHTENED RAIL

C4 MEASUREMENT AND CALCULATION OF RESIDUAL STRESSES

C4.1 General

Measurement procedures, which may be used to determine the level of residual stresses in rail, or the propensity for unstable web cracking in the presence of the residual stress distribution, are as follows:

(a) Web saw cut method.

(b) Strain gauge method.

(c) Crack arrest method.

All of the above methods are destructive. Other, non-destructive methods may be used to provide information on residual stresses in rails. Such techniques may require specialized equipment or additional calibration measurements or both, and hence are not as yet considered either sufficiently accurate or suitable for routine measurement of residual stresses in rails. References 1 and 15 provide information on residual stresses in rails measured using one such method.

NOTES:

1   Values of longitudinal residual stress derived using the strain gauge procedure may not correlate with corresponding data obtained using the web saw cut test.

2   Reference 10 provides detailed information on mechanical methods of stress determination, which may be used for the determination of residual stresses.

3   The contribution of residual stresses to fatigue crack initiation and growth from localized surface defects has been examined previously (Ref. 11), and forms the basis of the surface finish requirements described in Clause 9.3.1 of this Standard.

C4.2   Web saw cut method

C4.2.1   *Purpose*

The purpose of this test is to determine if a sample piece of rail contains a residual stress distribution that has the potential to initiate or promote unstable crack growth in the web of the rail.

C4.2.2   *Procedure*

The web saw cut test involves cutting a length of rail longitudinally along the web, at the neutral axis of the section, to relieve all or part of the residual stress distribution. Changes to the dimensions of the rail section, which arise as a result of the web saw cut, may be used to determine the magnitude of the initial residual stress distribution in the rail web, or the magnitude of the stress intensity value corresponding to the web opening behaviour.

Figure C2 illustrates the general concept of the web saw cut test.

References 7 and 12 provide further details on two such methods. A similar test has been developed and used to examine the probability of unstable crack growth behaviour in railway wheels as a result of changes to the residual stress distribution due to overheating (Ref. 8).

It should be noted that in the method described, the test sample may be prepared such that the saw cut is carried out in a region representative of the roller-straightened portion of the rail length. The action of removing such a test sample from a roller-straightened length of rail modifies the residual stress distribution from that shown in Figure C1. Longitudinal stresses decrease to zero at the free end of the sample, and there is a corresponding increase in the level of vertical residual stresses (Ref. 14). The distribution of residual stresses near the end of such a sample is illustrated in Figure C3. The figure indicates that the redistribution of residual stresses occurs over a distance approximately 1.2 times the height of the rail section, and a region of high vertical residual stresses exists at the end of the sample.

Graeme Barry

Copy of UIC manufacturing Tolerances

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1.6 · Tolerances

1.6.1 · Section and ends

	Dimensions in mm	Tolerances in mm	Observations
1 · Height H of rail	H < 165	+ 0,5 − 0,5	A displacement of the tolerance range of −0.5 mm is acceptable in the sphere of influence of the straightening rollers
	165 ≤ H < 180	+ 0,6 − 0,6	
2 · Width L of rail foot	L < 150	+ 1,0 − 1,0	ditto (with + 0,5 mm)
	150 ≤ L < 160	+ 1,0 − 1,1	
3 · Nominal width C of rail head (1)		± 0,5	ditto (with + 0.1 mm)
4 · Asymmetry of section (2)	L < 150	+ 1,2 − 1,2	(3)
	150 ≤ L < 160	+ 1,5 − 1,5	
5 · Thickness of web (4)		+ 1,0 − 0,5	
6 · Inclination of fishing surfaces (On the basis of 14 mm parallel to the inclined theoretical fishing surface)		+ 0,5 − 0,5	
7 · Height of fishplating		Same tolerance as H	
8 · Squareness of the ends		+ 0,6 − 0,6	
9 · Other dimensions	As H	Same tolerance as H	

(1) Measured 14 mm under the rail running surface i.e. in the areas of the rail shoulder transition and lateral surfaces of the rail head.

(2) Checked by means of the UIC gauge.

(3) Should a customer specifically request it, this tolerance may be ± 1.2 mm for rails of normal grade steel.
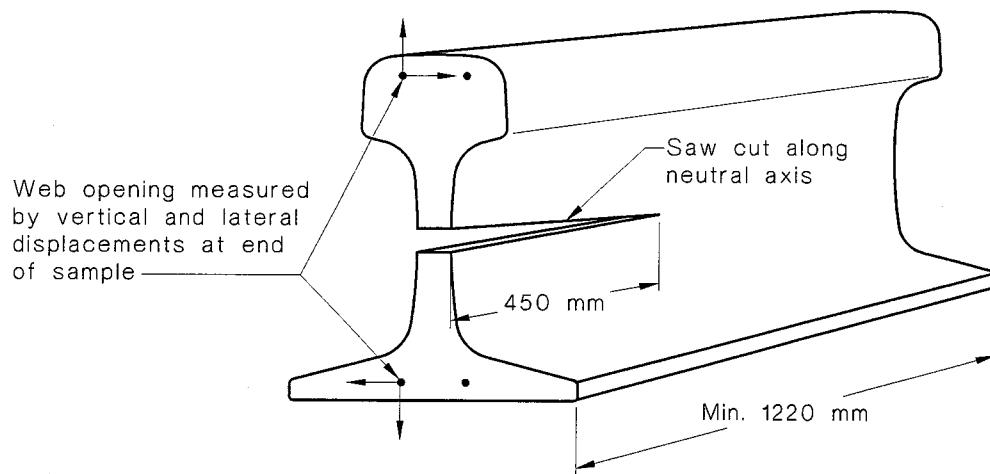
(4) Measured at the point of minimum thickness.
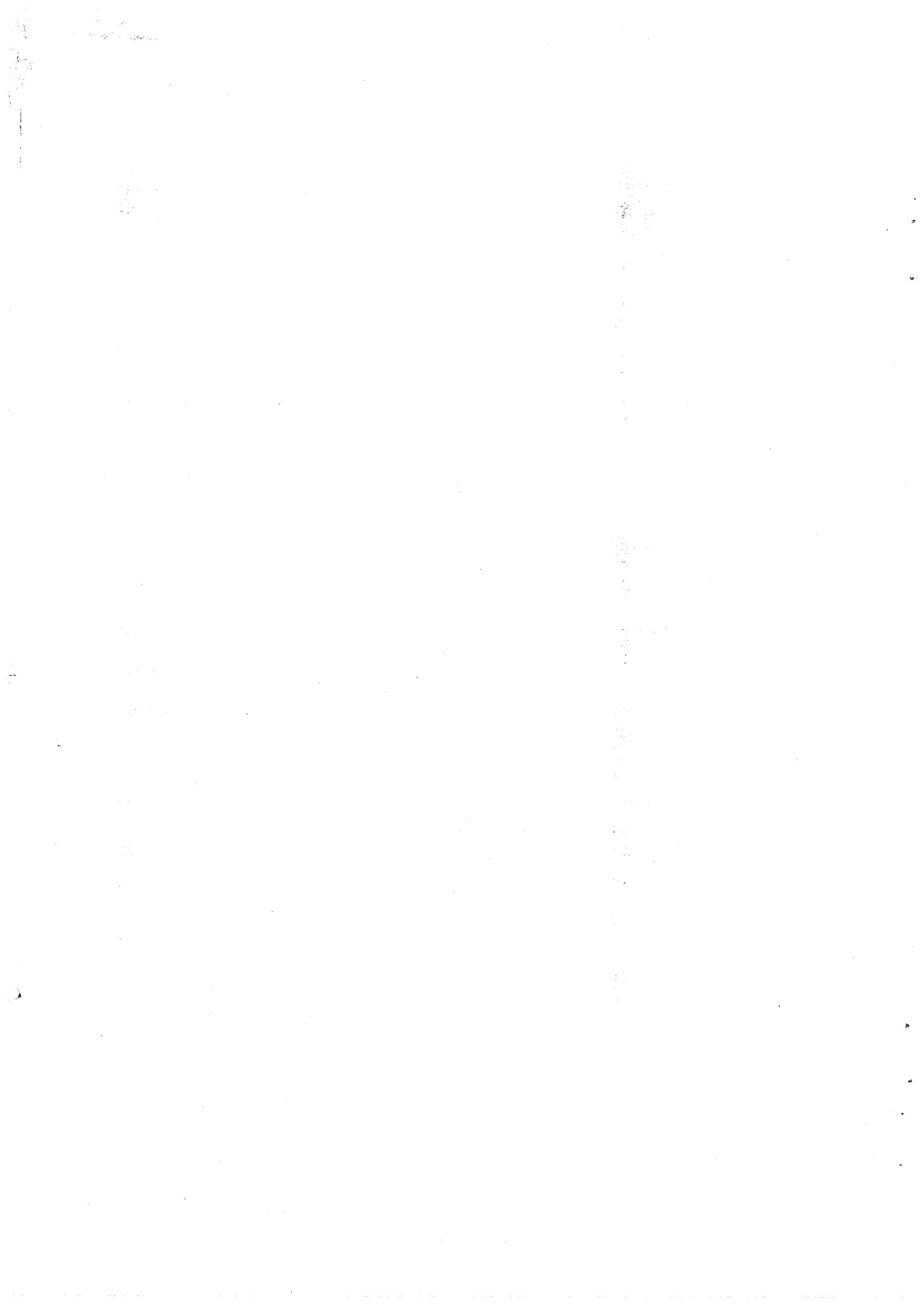
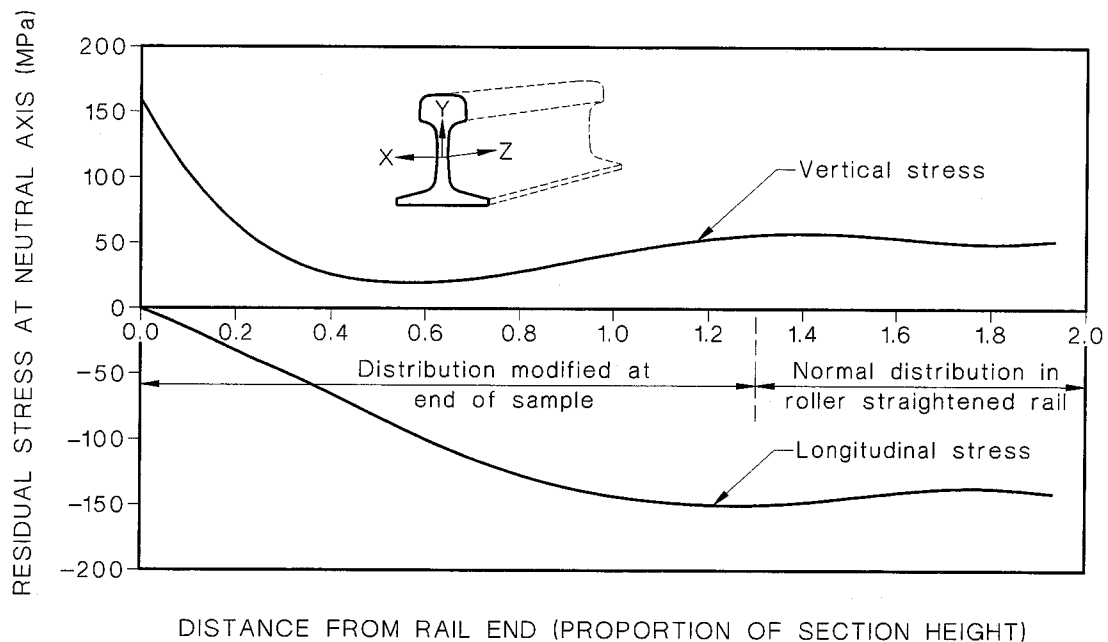**FIGURE C2 GENERAL ARRANGEMENT FOR WEB SAW CUT TEST FOR THE DETERMINATION OF RESIDUAL STRESSES IN THE RAIL WEB**

FIGURE C3 DISTRIBUTION OF LONGITUDINAL AND VERTICAL RESIDUAL STRESSES NEAR END OF SAMPLE REMOVED FROM ROLLER STRAIGHTENED RAIL
(based on strain gauge measurements along the neutral axis at the web surface)

C4.2.3 *Acceptance criteria based on the web saw cut test*

Acceptance criteria that have been proposed for the web saw cut test may be based on either—

(a) the value of the web opening measurement as determined from the vertical and lateral displacements measured at the end of the sample, which should not exceed a nominated value; or

(b) the value of the stress intensity value derived from the web opening measurements, which should not exceed the plane strain fracture toughness for the rail material present in the web (Refs 1, 7 and 12). Such a criterion requires that the fracture toughness of the rail material also be measured. Reference 7 provides further information regarding the location of samples in the rail web for the determination of fracture toughness.

There are several aspects of the procedure involved in the derivation of a stress intensity factor for the web saw cut test in which uncertainty exists; these are as follows:

(i)   The strain conditions in the rail web may not represent plane strain criteria (Ref. 13); the value of fracture toughness that is applicable may be slightly higher than the plane strain fracture toughness; use of the plane strain fracture toughness as an acceptance criteria, therefore, represents a lower bound.

(ii)   A complex residual stress distribution in the web of a rail, for example resulting from straightening in both vertical and lateral planes, may result in some combination of Mode I (in-plane opening) and Mode III (out-of-plane shear) behaviour, in which case the propensity for unstable web cracking may not be adequately described by the Mode I stress intensity factor.

(iii)   The procedure used for derivation of the stress intensity value should make use of the relevant section properties for the rail section being tested.

It should also be noted that information obtained from the web saw cut test may indicate that rails already in use by rail systems, and which have shown satisfactory in-service performance, may fail the test based on the above criteria.

In view of the above issues, it is not possible at this point in time to confirm the validity of the acceptance criteria that have been proposed for the web saw cut test.

C4.3   Strain gauge procedure

C4.3.1   *Purpose*

The purpose of this test is to determine the magnitude of residual stresses at selected locations on the surface of a sample of rail.

Residual stresses at various locations may be determined using techniques that involve the following:

(a)   Attachment of electrical resistance strain gauges to the surface of the rail in accordance with the procedures recommended by the strain gauge manufacturer.

(b)   Measurement of the initial gauge resistance.

(c)   Relieving the surrounding residual stress field by progressive sectioning and isolation of the gauged location.

(d)   Measurement of the final gauge resistance.

(e)   Determination of the change in strain resulting from sectioning.

(f)   Determination of the residual stress by reversing the sign of the strain change (to account for the stress relief effect) and multiplying by the modulus of elasticity for rail steel (2.07×10^5 MPa).

C4.3.2   *Strain gauge types*

For the measurement of longitudinal stresses, single-element strain gauges positioned longitudinally on the rail surface may be used. Such gauges should be of the encapsulated type, with a gauge length of between 2 mm and 5 mm, and with a gauge factor accuracy of less than ±1 percent.

Other gauge orientations may be used for the determination of residual stresses in other directions. In addition, multi-element strain-gauge rosettes may be used for the determination of residual stresses in more than one direction, or for the determination of principal stresses and their orientation. In the latter case, reference should be made to standard engineering procedures for data reduction.

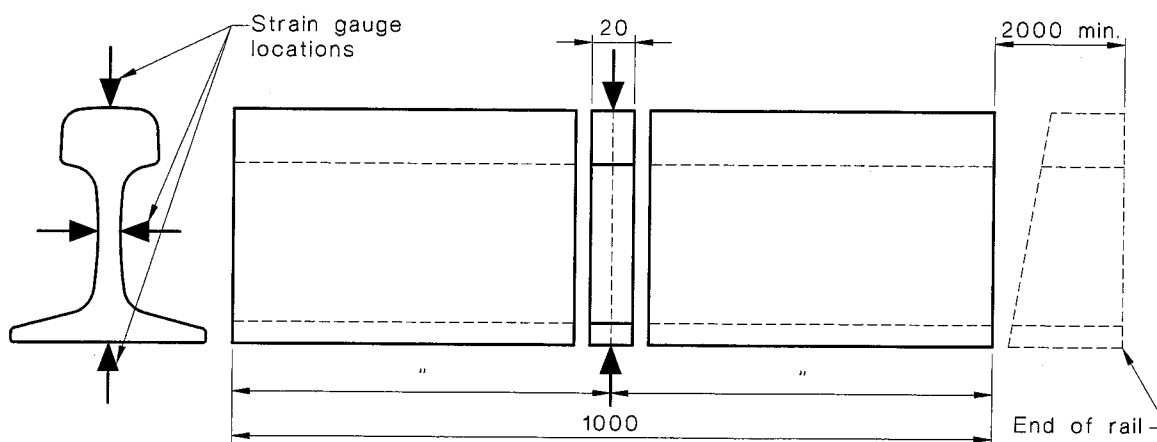**C4.3.3** *Procedure*

The procedure should be as follows:

(a)   The initial and final strain measurements should be carried out with the rail at the same temperature, to avoid any additional component due to thermal effects. In addition, attachment of electrical leads to the strain gauge terminals should be consistent for all measurements.

(b)   Preparation of the rail surface prior to attachment of the strain gauges should be in accordance with the recommendation of the strain-gauge manufacturer and, in any case, consistent with accepted engineering practice, noting that procedures for residual stress measurement may be more rigorous than those for measurement of strains resulting from applied loading. In particular, the surface preparation technique should not in itself modify the residual stresses in the rail.

(c)   Sectioning of the rail to isolate the strain-gauged location should be carried out in a manner that minimizes heat input to the gauged locations, and avoids the possibility of damaging the gauges.

C4.3.4 *Strain gauge locations*

For the determination of residual stresses that may be present in the rail as a result of the manufacturing processes, specifically roller straightening, measurement of longitudinal residual stresses is recommended at the centre of the rail base, on either side of the web at the neutral axis, and at the centre top of the rail head. The strain gauges should be positioned at these locations, at the centre of a 1 m length of rail, which is in turn a minimum of 2 m away from the end of a standard length of rail (typically 25 m). The gauged location is therefore 2.5 m from the end of the original rail length.

Figure C4 illustrates the general arrangement of the strain gauge procedure for determination of residual stresses at the rail surface.

Isolation of the strain-gauged locations for the measurement of residual stresses should be carried out by cutting vertically through the rail section at ±10 mm about the line of the gauges, so as to remove a vertical slice 20 mm in length. Alternative sectioning techniques such as trepanning or hole drilling may be used for the relief of residual stresses. It should be noted that the latter techniques may differ from that illustrated in Figure C4, to the extent to which they relieve the residual stresses, and hence may give rise to different residual stress values.

DIMENSIONS IN MILLIMETRES

FIGURE C4   GENERAL ARRANGEMENT OF STRAIN GAUGE METHODS FOR THE
MEASUREMENT OF RESIDUAL STRESSES AT THE RAIL SURFACE

C4.3.5 *Acceptance criteria based on the strain gauge procedure*

The strain gauge procedure provides information on the magnitude of residual stresses in the immediate vicinity of the gauged locations. Such data are applicable to the analysis of fatigue crack initiation and growth processes from near or near-surface defects. In general, such processes may occur under the influence of additional stresses developed through service loading. In the absence of quantitative information regarding the magnitude of the latter stresses, it is not possible to provide acceptance levels for residual stresses obtained by means of the strain gauge procedure. Acceptance levels that have been proposed include a fixed value (e.g., 250 MPa) or 0.6 times the proof stress of the rail material.

NOTE: Other strain gauge techniques (Ref. 9) may be used for the determination of surface residual stresses in rails. Care should be taken in the interpretation of such results, as the accuracy of strain gauge techniques for the measurement of residual stresses is influenced by factors such as the distribution of residual stresses in the immediate vicinity of the gauge location, and the procedures used for the relief of the surrounding residual stress field.

C4.4 Crack arrest test

C4.4.1 *Purpose*

The purpose of this test is to determine if a sample piece of rail contains a residual stress distribution that has the potential to initiate or promote unstable crack growth in the web of the rail.

C4.5 Procedure

The crack arrest test involves machining a notch in the web at the end of a rail length, insertion of a wedge in the notch and positioning the rail length such that the wedge can be loaded by means of a drop weight impact load. The web cracking behaviour is characterized by interpretation of the length and direction of any crack that propagates from the end of the notch under the action of the impact load.

References 1, 3, 4 and 18 provide further detail on the test method, including notch dimensions, loading conditions and typical results.

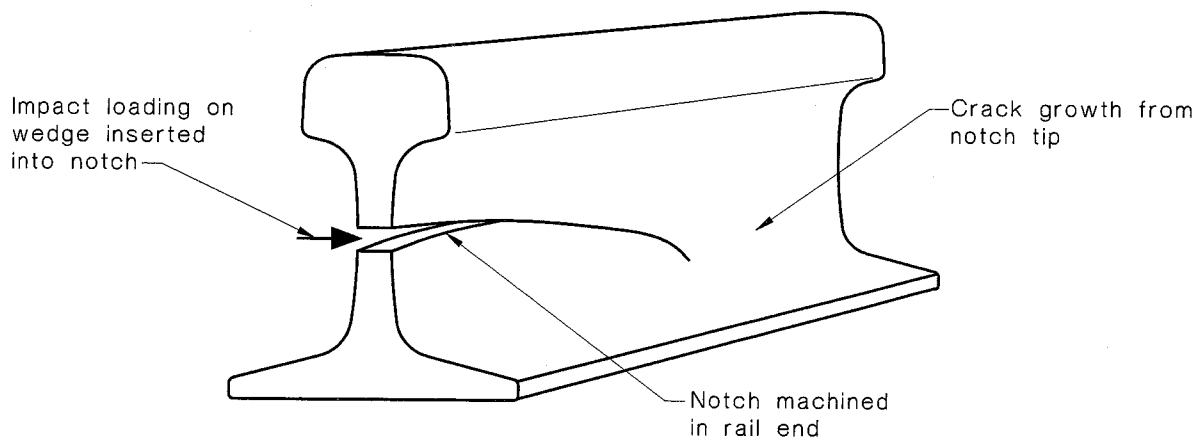Figure C5 illustrates the general concept of the crack arrest test.

FIGURE C5   GENERAL ARRANGEMENT OF CRACK ARREST TEST

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APPENDIX D

TRACK SYSTEM COMPATIBILITY

(Normative)

D1 NOMINAL RAIL PROFILES

This Paragraph provides the following profile and drilling details:

(a) Profile details for 68 kg, 60 kg, 50 kg, 41 kg, and 31 kg rolled steel rails (see Figures D1 to D5).

(b) Drilling details for 31 kg, 41 kg, 50 kg, 60 kg and 68 kg rolled steel rails (see Figures D6 and D7).

(c) Profile details for 50 kg and 60 kg rolled steel asymmetrical switch rails (see Figures D8 and D9).

(d) Profile details for 50 kg and 60 kg rolled steel elevated guardrails (see Figure D10).

The mass values given in this Appendix are rounded to three significant figures and are based on the rail steel density of 7850 kg/m^3.
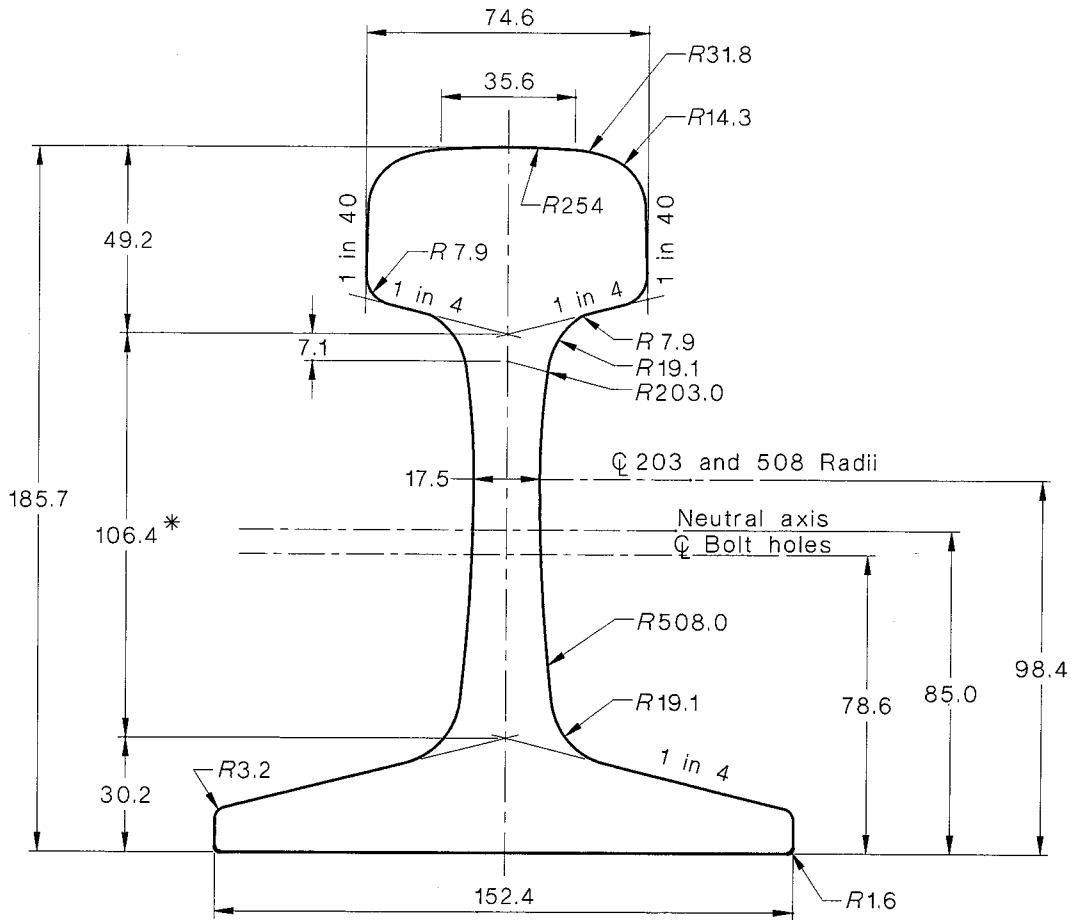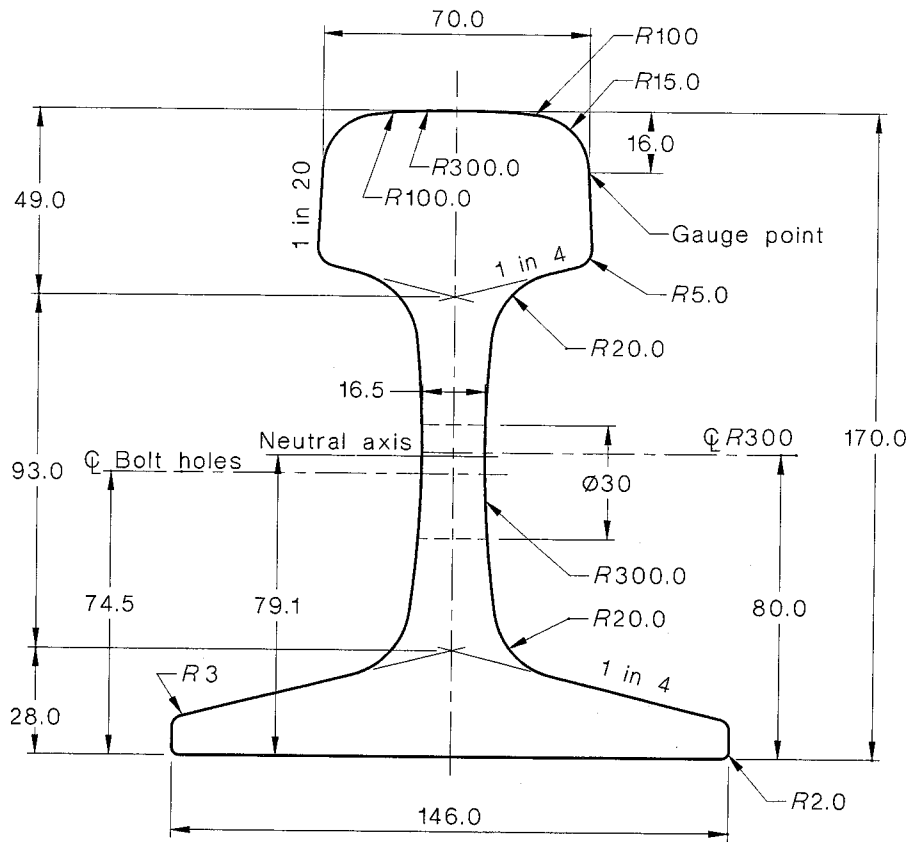
Head area .... 3.125 x 10³ mm²   Second moment of area (I_{x-x}) .... 39.4 x 10⁶ mm⁴
Web area .... 2.335 x 10³ mm²   Second moment of area (I_{y-y}) .... 6.02 x 10⁶ mm⁴
Foot area .... 3.142 x 10³ mm²   Section modulus head .... 391.7 x 10³ mm³
Total area .... 8.602 x 10³ mm²   Section modulus foot .... 463.8 x 10³ mm³
                                          Calculated mass .... 67.5 kg/m

NOTE:The * alongside the dimension 106.4 indicates that the values 49.2, 106.4 and 30.2 do not add up to 185.7. The reason for this is that the dimensions are rounded values.

NOT TO SCALE

DIMENSIONS IN MILLIMETRES, SOME OMITTED FOR CLARITY

FIGURE D1   68 kg RAIL

Head area .... 3.018 x 10^3 mm^2
Web area .... 1.958 x 10^3 mm^2
Foot area .... 2.752 x 10^3 mm^2
Total area .... 7.728 x 10^3 mm^2

Second moment of area (I_{x-x}) .... 29.4 x 10^6 mm^4
Second moment of area (I_{y-y}) .... 4.91 x 10^6 mm^4
Section modulus head .... 323.2 x 10^3 mm^3
Section modulus foot .... 371.4 x 10^3 mm^3
Calculated mass .... 60.7 kg/m

NOT TO SCALE

DIMENSIONS IN MILLIMETRES, SOME OMITTED FOR CLARITY

FIGURE D2 60 kg RAIL
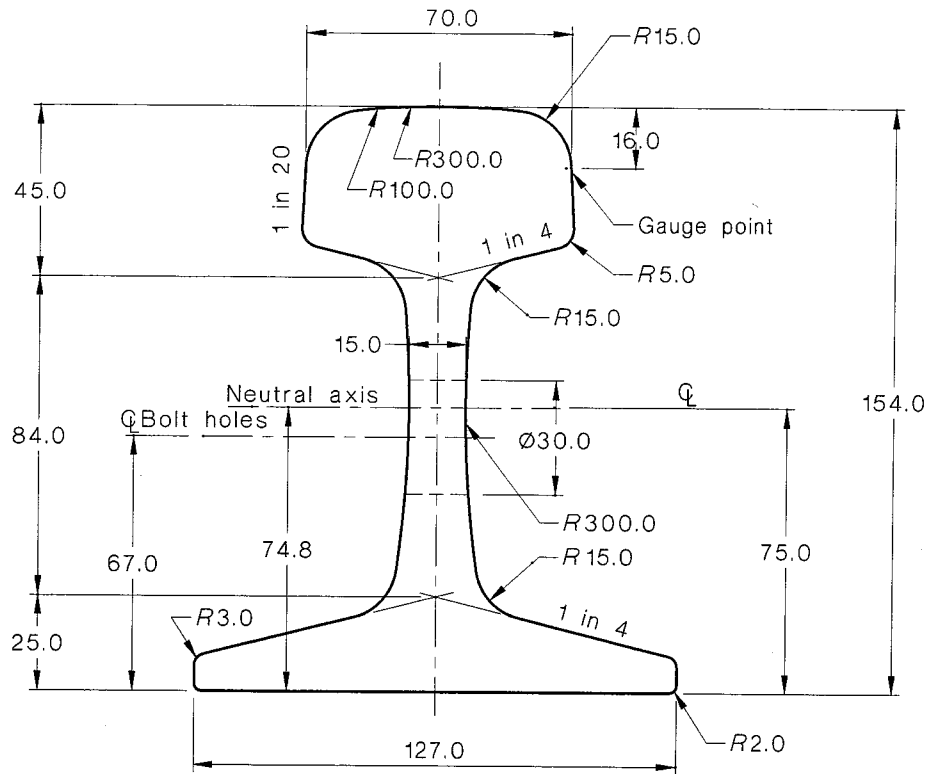
Head area .... 2.729 x 10³ mm²   Second moment of area (I_{x-x}) .... 20.2 x 10⁶ mm⁴
Web area .... 1.565 x 10³ mm²   Second moment of area (I_{y-y}) .... 3.27 x 10⁶ mm⁴
Foot area .... 2.164 x 10³ mm²   Section modulus head .... 254.1 x 10³ mm³
Total area .... 6.457 x 10³ mm²   Section modulus foot .... 269.3 x 10³ mm³
Calculated mass .... 50.7 kg/m

NOT TO SCALE

DIMENSIONS IN MILLIMETRES, SOME OMITTED FOR CLARITY

FIGURE D3 50 kg RAIL
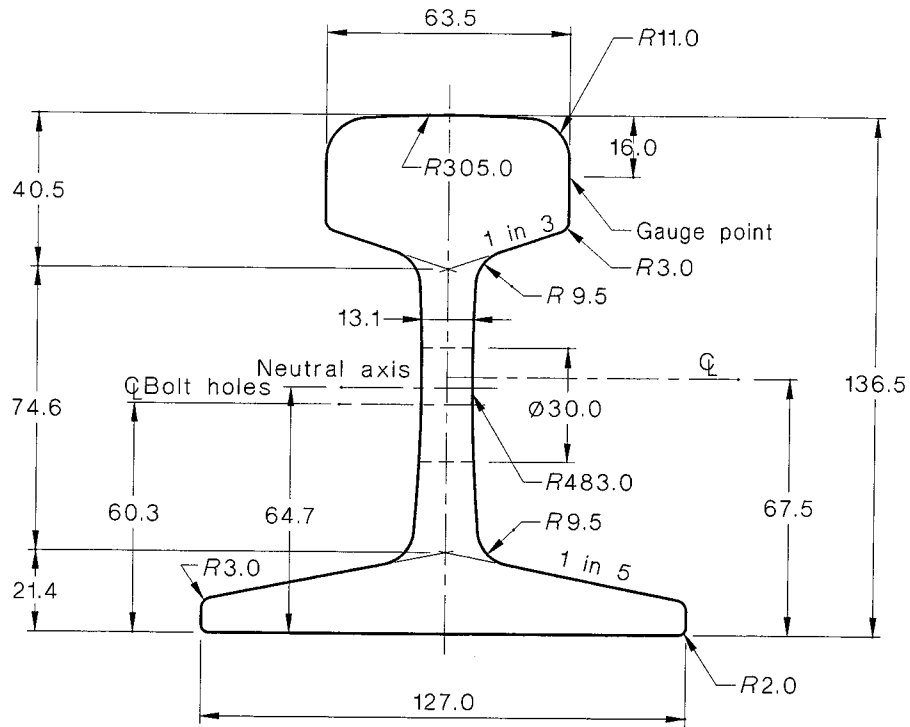
Head area .... 2.162 $\times 10^3$ mm^2 Second moment of area (I_{x-x}) .... 13.27 $\times 10^6$ mm^4
Web area .... 1.122 $\times 10^3$ mm^2 Second moment of area (I_{y-y}) .... 2.67 $\times 10^6$ mm^4
Foot area .... 1.908 $\times 10^3$ mm^2 Section modulus head .... 184.4 $\times 10^3$ mm^3
Total area .... 5.192 $\times 10^3$ mm^2 Section modulus foot .... 204.5 $\times 10^3$ mm^3
    Calculated mass .... 40.8 kg/m

NOT TO SCALE

DIMENSIONS IN MILLIMETRES, SOME OMITTED FOR CLARITY

FIGURE D4   41 kg RAIL

Head area .... 1.832 x 10³ mm²
Web area .... 0.786 x 10³ mm²
Foot area .... 1.391 x 10³ mm²
Total area .... 4.009 x 10³ mm²
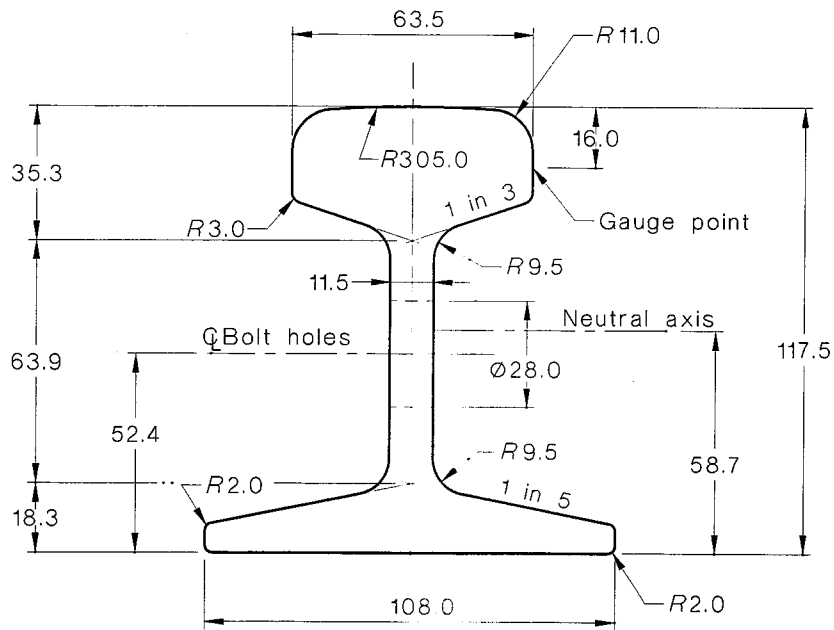
Second moment of area (I_{x-x}) .... 7.68 x 10⁶ mm⁴
Second moment of area (I_{y-y}) .... 1.60 x 10⁶ mm⁴
Section modulus head .... 130.4 x 10³ mm³
Section modulus foot .... 130.4 x 10³ mm³
Calculated mass .... 31.5 kg/m

NOT TO SCALE

DIMENSIONS IN MILLIMETRES, SOME OMITTED FOR CLARITY

FIGURE D5   31 kg RAIL
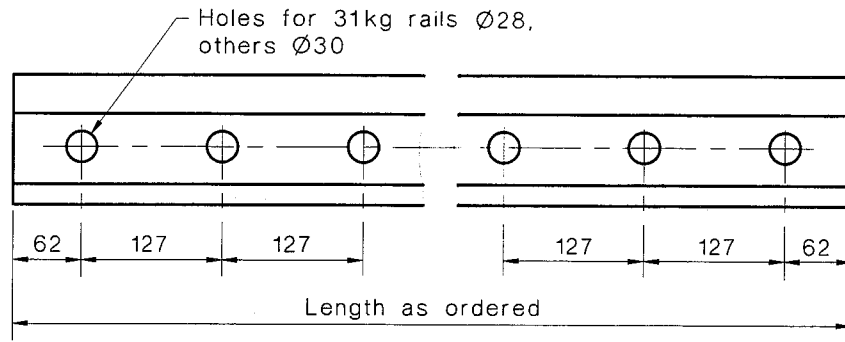
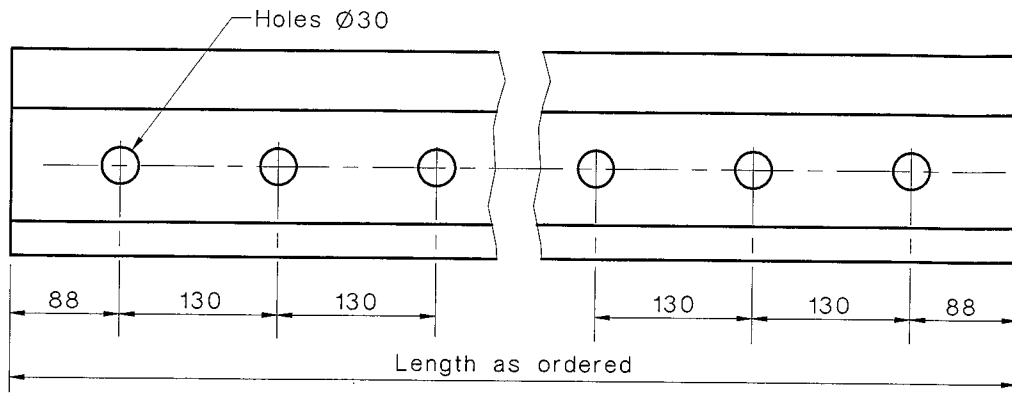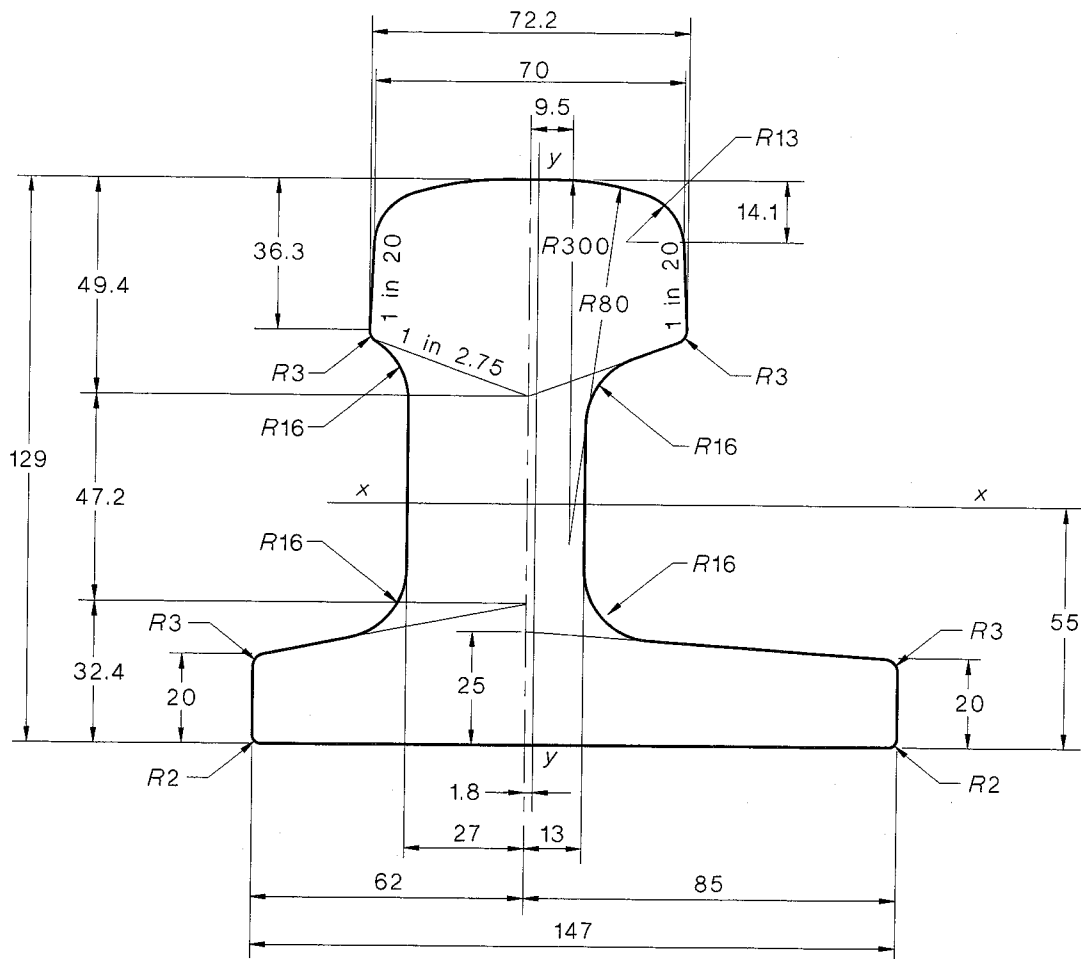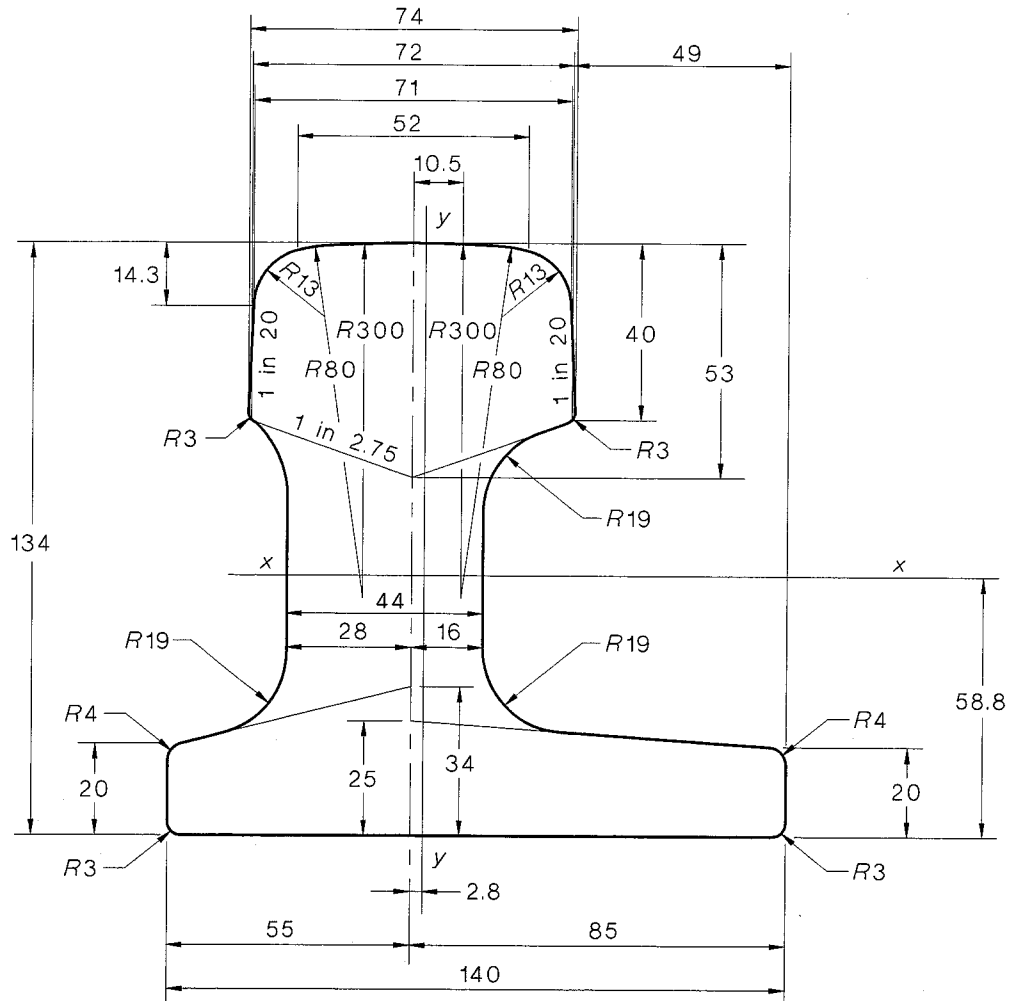**FIGURE D6   DRILLING DETAILS FOR 31 kg AND 41 kg RAILS**

Holes Ø30

| 88 | 130 | 130 | | 130 | 130 | 88 |

Length as ordered

FIGURE D7   DRILLING DETAILS FOR 50 kg, 60 kg AND 68 kg RAILS

72.2

70

9.5

R13

y

14.1

36.3

1 in 20

R300

R80

1 in 20

49.4

1 in 2.75

R3

R3

R16

R16

129

47.2

x   x

R16

R16

55

R3

R3

32.4

20

25

20

R2

y

R2

1.8

27   13

62   85

147

Head area .... 2.90 x 10³ mm²	Second moment of area (I_{x-x}) .... 15.40 x 10⁶ mm⁴
Web area .... 2.35 x 10³ mm²	Second moment of area (I_{y-y}) .... 7.68 x 10⁶ mm⁴
Foot area .... 3.53 x 10³ mm²	Section modulus head .... 207.5 x 10³ mm³
Total area .... 8.78 x 10³ mm²	Section modulus foot .... 281.0 x 10³ mm³
	Calculated mass .... 68.9 kg/m

DIMENSIONS IN MILLIMETRES

FIGURE D8   50 kg ASYMMETRICAL SWITCH RAIL

Head area .... 3.24 x 10^3 mm^2
Web area .... 2.68 x 10^3 mm^2
Foot area .... 3.38 x 10^3 mm^2
Total area .... 9.30 x 10^3 mm^2

Second moment of area $(I_{x\text{-}x})$.......... 17.28 x 10^6 mm^4
Second moment of area $(I_{y\text{-}y})$..........7.44 x 10^6 mm^4
Section modulus head ....229.9 x 10^3 mm^3
Section modulus foot ....293.8 x 10^3 mm^3
Calculated mass ....73.0 kg/m

DIMENSIONS IN MILLIMETRES

FIGURE D9   60 kg ASYMMETRICAL SWITCH RAIL
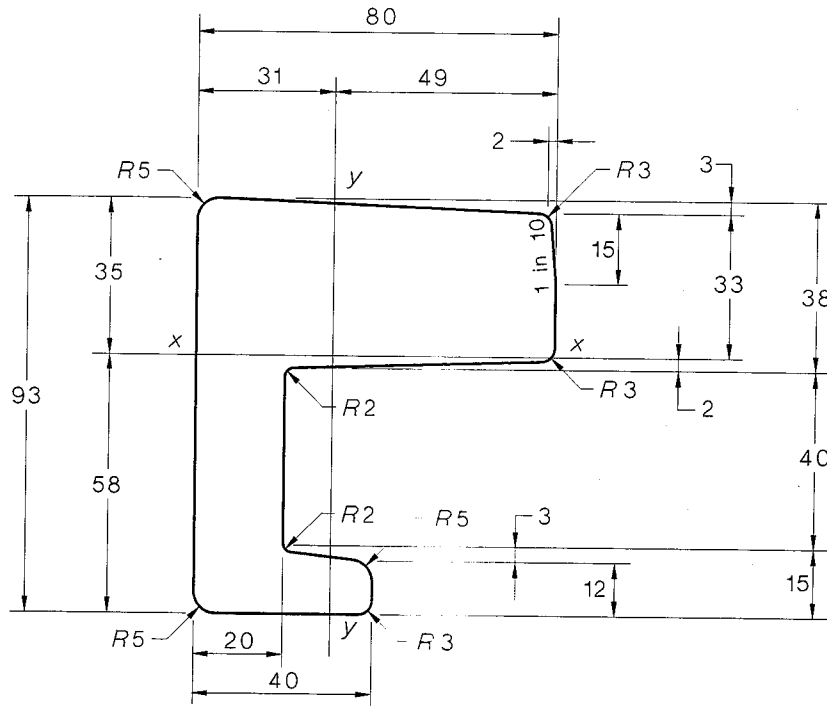
Head area .... 2.85 x 10^3 mm^2 Second moment of area (I_{x-x}) .... 2.98 x 10^6 mm^4
Web area .... 0.76 x 10^3 mm^2 Second moment of area (I_{y-y}) .... 2.19 x 10^6 mm^4
Foot area .... 0.59 x 10^3 mm^2 Section modulus head .... 51.6 x 10^3 mm^3
Total area .... 4.20 x 10^3 mm^2 Section modulus foot .... 84.3 x 10^3 mm^3
                                            Calculated mass .... 32.9 kg/m

DIMENSIONS IN MILLIMETRES

FIGURE D10   50/60 kg ELEVATED GUARDRAIL FOR 50 kg AND 60 kg RAILS

D2 MEASUREMENT OF DIMENSIONS

Dimensions of the rail shall be measured as follows:

(a) *End straightness* End straightness shall be measured by a procedure that is not less accurate than that of placing a 1 m straightedge of Grade A in accordance with AS 1003 at various positions along the end 1.5 m of the rail. The maximum deviation measured as a chordal ordinate of the rail from the straightedge both upwards and sideways shall be measured in millimetres.

NOTE: A Grade A 1 m straight edge has a flatness tolerance of 12 μm.

(b) *Overall straightness* The rail shall be placed head up on a horizontal plane support, with supports at not more than 5 m centres. The maximum ordinate of the upsweep above the level of the horizontal supports shall be measured in millimetres.

Where rail lengths are less than 27 m, the maximum allowable upsweep shall be reduced proportionally.

Rail that is in doubt, contains visible bends, waves or kinks, or is in dispute shall be checked by measuring the maximum deviation from a 1 m straightedge placed on the rail.

(c) *Fishing template standoff* The template shall be shaped to the profile for the designated rail section and shall include the upper fishing surface, the web and the lower fishing surface. With the template in sliding contact with the lower fishing surface, check for stand off from the contour of the web and clearance at the upper fishing surface.

(d) *Eccentricity* Rail eccentricity shall be checked by use of the gauge shown in Figure D11. When using the gauge shown in Figure D11, the gauge point shall not touch the head of the rail and a slip of dimension 2*e* shall not pass between the gauge point and the head of the rail, on either side of the rail (see Figure D12).

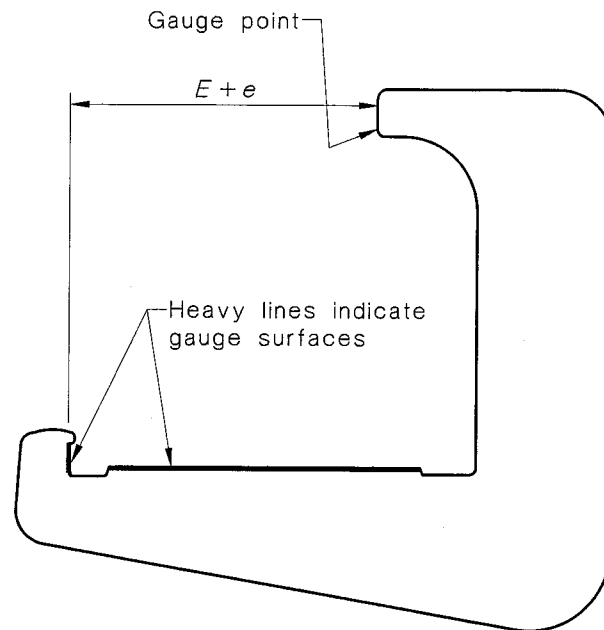(e) *Twist* Rail twist shall be measured as shown in Figure D12.
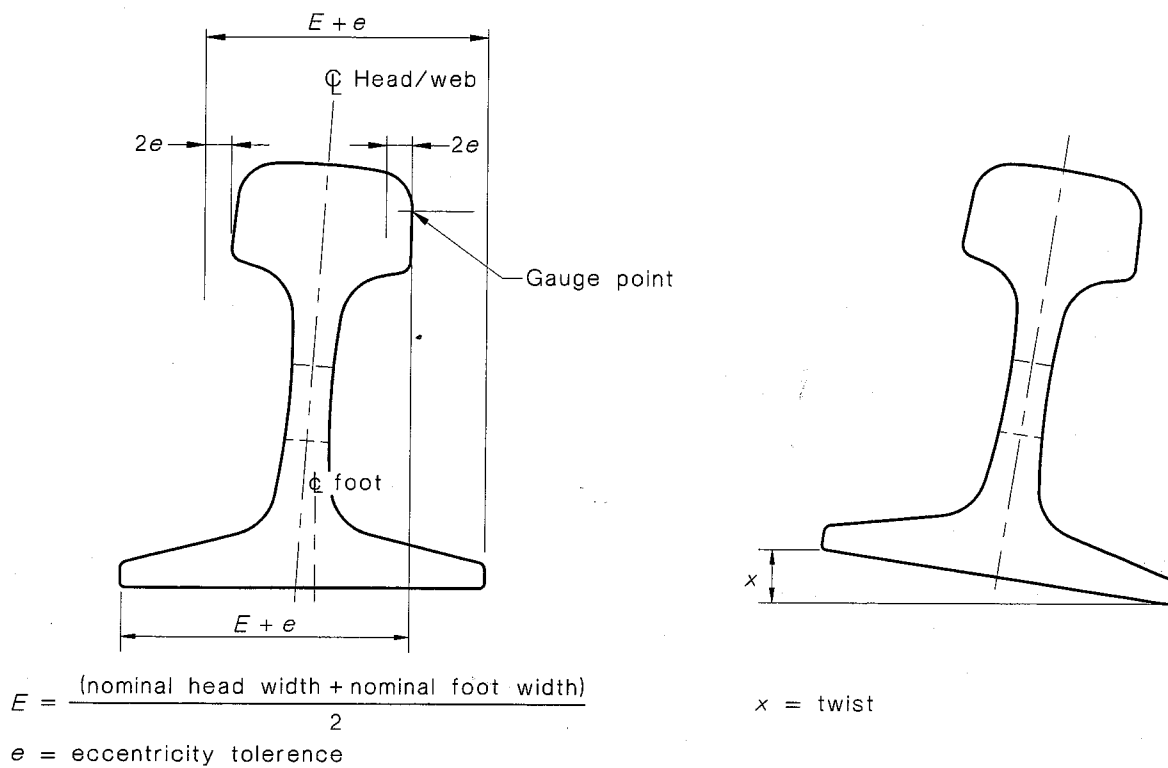

FIGURE D11 ECCENTRICITY GAUGE

$$E = \frac{\text{(nominal head width} + \text{nominal foot width)}}{2}$$

e = eccentricity tolerence

x = twist

FIGURE D12 MEASUREMENT OF ECCENTRICITY AND TWIST

TABLE D1

DIMENSIONAL TOLERANCES (Note 1)

Characteristic	Tolerance mm
Overall height of rail	+1.0 −0.5
Width of head	+1.0 −0.5
Width of foot	±1.0
Thickness of web	+1.0 −0.5
Foot base: flat to maximum concavity (no convexity)	0.5
Fishing surfaces (see Note 2): (a) Maximum standoff of fishing template from web (b) Maximum clearance of template at upper fishing surface	 2 0.2
Eccentricity 'e' of rail section as checked by means of an eccentricity gauge (see Note 2)	±1.5

Overall length measured with a steel tape and adjusted to a rail temperature of 20°C—
   Undrilled rails
   Drilled rails
	
	+150, −0
	±8

End squareness—
   Horizontal
   Vertical
	
	0.7
	0.7

End straightness (see Note 2)—maximum deviation:
Head: sideways
         upwards
         downwards
Foot: sideways
	
	0.5
	0.5
	0
	1.0

Overall straightness (see Note 2): (a) maximum upsweep over 27 m chord (b) over 1 m chord	 20 0.5
Twist (see Note 2)— (a) at either end of the rail with the rail lying naturally (b) at any point along the rail (c) a maximum rate of change	 2 2 1 in 1000
Bolt holes: Diameter Location (measured in accordance with the maximum material principle, see AS 1100.201)— (a) from end of rail to centre of any hole measured at level of bolt (b) from base of rail to centre of hole measured perpendicularly	 ±1 ±1 ±1

NOTES:

1   Tolerances for guardrail and switch rail to be in accordance with UIC 861-2.

2   Appropriate methods for measurement are given in Paragraph D2.

3   Rails shall not contain bends, waves or kinks.

APPENDIX E

MATERIAL PROPERTIES

(Normative)

E1 CHEMICAL COMPOSITION

E1.1 Chemical composition other than oxygen and hydrogen

Chemical composition other than oxygen and hydrogen shall be determined as follows:

(a) Take a sample of liquid steel representing the final product in accordance with AS/NZS 1050.1. Where it is impractical to test a sample taken from the liquid steel or a sample has been contaminated, analysis of test samples from solid metal taken in accordance with AS/NZS 1050.1 may be reported as cast analysis.

(b) Test the sample by procedures that are not less accurate than the methods given in the appropriate parts of AS/NZS 1050.

NOTES:

1   The chemical composition of 50 kg and 60 kg asymmetrical switch rail and elevated guardrail are not specified by this Standard. The use of the 50 kg/60 kg chemical composition given in this Appendix, or the chemistry specified in UIC 861-2 is appropriate.

2   Levels for chromium, molybdenum, niobium and vanadium may be increased subject to agreement between the supplier and the purchaser.

3   Methods available for the removal of hydrogen include diffusion and vacuum degassing.

E1.2 Oxygen

The total oxygen content shall be determined from a sample taken from the head of the rail and tested in accordance with AS/NZS 1050.

NOTE: Total oxygen content includes oxygen present in the form of oxides and is an important indicator of rail cleanliness. Steel cleanliness refers to the presence of non-metalic inclusions, e.g., oxides, sulfides, nitrides.

E1.3 Hydrogen

The requirement for hydrogen content given in Table E2 shall be demonstrated by chemical testing or process control under an appropriate quality system.

E2 MECHANICAL PROPERTIES

The procedures for determining the mechanical properties are given in Appendix F for the limits given in Tables E3, E4 and E5.

TABLE E1

CHEMICAL COMPOSITION

Nominal rail size	Carbon %	Manganese %	Silicon %	Phosphorus %	Sulfur %	Aluminium %	Nitrogen %
31 kg, 41 kg	0.53 to 0.69	0.60 to 0.95	0.15 to 0.58	0.025 max.	0.025 max.	0.005 max.	0.010 max.
50 kg, 60 kg, 68 kg	0.65 to 0.82	0.70 to 1.25					

TABLE E2

MAXIMUM FOR OTHER ELEMENTS

Residual metals									
Cr	Mo	Ni	Cu	Sn	Ti	Nb	V	Cu + 10Sn	Cr + Mo + Ni + Cu + V
0.15	0.02	0.10	0.15	0.04	0.025	0.01	0.03	0.45	0.30

Total oxygen and hydrogen	
O	H
35 ppm (solid)	2.5 ppm (finished rail)

TABLE E3

MECHANICAL PROPERTIES

Nominal rail size		0.2% proof stress MPa, min.	Tensile strength MPa, min.	Elongation %, min.	Surface hardness HB, min.
All rail	31 kg, 41 kg	—	700	8	—
	50 kg, 60 kg, 68 kg	420	880	8	260
Head-hardened rail	50 kg, 60 kg, 68 kg	780	1130	9	340

TABLE E4

HARDNESS IN THE HEAT AFFECTED ZONE FOR HEAD HARDENED RAILS

Location	Hardness HV30
Position C	430 max.
Along traverse 1	430 max. at any point, 360 min. at 10 mm from the rail surface
Along traverse 2	430 max. at any point, 340 min. at 10 mm from the rail surface

TABLE E5

DIMENSIONS OF HEAT-AFFECTED ZONE FOR HEAD-HARDENED RAILS

Nominal rail size	Dimensions (see Figure F1)			
	a		b	
	Min.	Max.	Min.	Max.
50 kg	15	23	20	35
60 kg, 68 kg	15	23	25	40

APPENDIX   F

MATERIAL INTEGRITY

(Normative)

F1   MATERIAL PROPERTIES

F1.1   Tensile testing

Tensile testing shall be carried out in accordance with AS 1391 on a proportional test piece of circular section having a diameter of 10 mm and a gauge length of 50 mm, with other dimensions and tolerances as given in AS 1391. Tensile test pieces shall be machined from the head of the rail at the position given in Table F1 and Figures F1(a) and F1(b) for the particular rail size and type.

TABLE   F1

POSITION OF TENSILE TEST SAMPLE BY RAIL SIZE

| Nominal rail size	As-rolled rail	Head-hardened rail
31 kg	A	N.A.
41 kg	A	N.A.
50 kg	A	B
60 kg	A	B
68 kg	B	B

F1.2   Surface hardness test

After removal of surface decarburization up to a limit of 0.5 mm depth, a Brinell hardness test shall be made on the running surface of the head in a position not more than 20 mm from the centre-line of the rail head. The test should be made with a 10 mm ball with a force of 29.4 kN, in accordance with AS 1816.

F1.3   Test for depth of heat treatment (etch test)

The depth of the heat treatment shall be determined by etching a section of rail. Etching shall be carried out generally in accordance with the requirements of AS 2205.5.1. The shape of the heat-treated zone shall approximate that shown in Figure F1(c) and the dimensions a and b shall be recorded.

F1.4   Hardness gradient test

Check the hardness gradient along traverses 1 and 2, as shown in Figure F1(c) and the hardness at position C as shown in Figure F1(c), at approximately 2 mm from the surface of the rail. Position C and traverse 1 shall be selected such that random testing of both sides of the rail head is achieved. The hardness traverse, with readings taken at a spacing not greater than 2 mm, shall cover the first 12 mm from the beginning of the traverse at the surface of the rail and shall be performed using the Vickers Diamond Pyramid with a 294 N force in accordance with AS 1817.
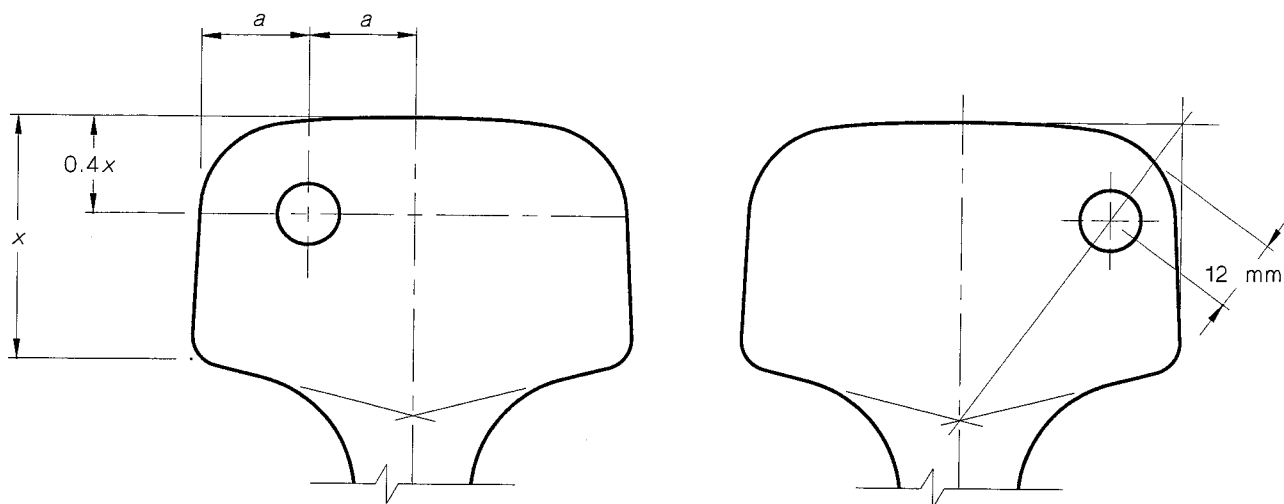
a = 1/4 of the head width at depth 0.4x

(a) Tensile test position A
(Nominal UIC position)

(b) Tensile test position B
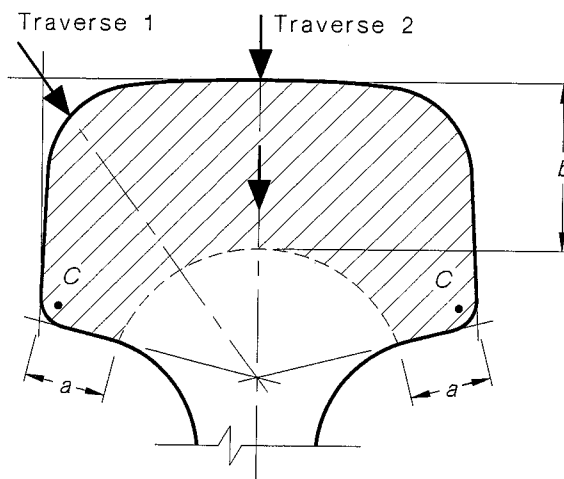
(c) Heat-affected zone

NOTE: The hatched area indicates the heat-affected zone within which the hardened zone will be.

FIGURE F1   RAIL HEAD

F1.5   Microstructure test

A sample shall be taken from the tensile testing position in the rail head (see Figures F1(a) and F1(b)). The sample shall be prepared and examined under a metallurgical microscope at magnifications up to 500X to determine the microstructure of the steel.

F2   INTERNAL SOUNDNESS

F2.1   Sulfur print test

Figure F2 shows the regions of head, web and foot referenced by Clause 9.2.3 for the sulfur print test.
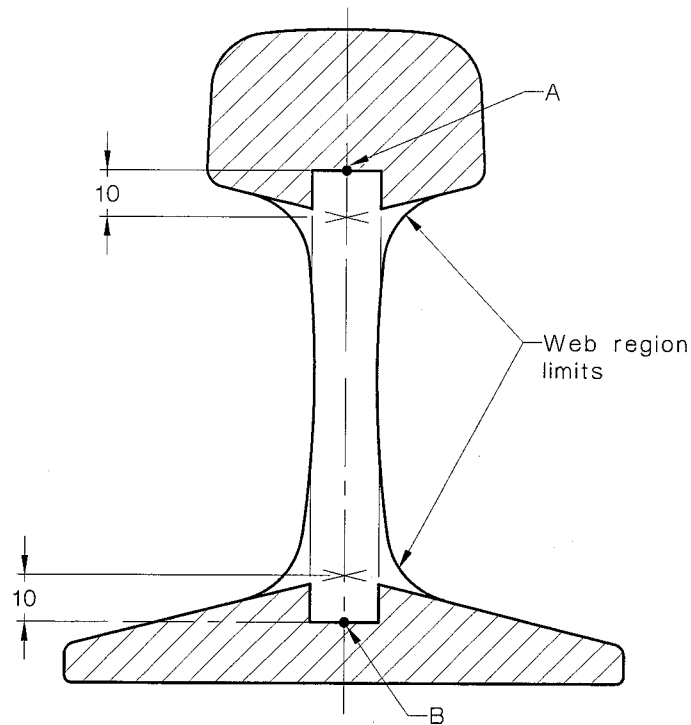
FIGURE F2   RAIL HEAD, WEB AND FOOT REGIONS

F2.2   Ultrasonic test for rolled steel rails

F2.2.1   *General*

Ultrasonic testing of unused rails in the head, web and section of foot (see Figure F3) to determine the presence of discontinuities shall be performed using a technique that ensures that the minimum cross-sectional area that the inspection covers is as follows:

(a)   95 percent or more of the head and web except for 68 kg rail which is 90 percent.

(b)   The region shown in Figure F3 for the foot.

> NOTE: These areas are based on projecting the nominal crystal diameter at the probe.

The location and aiming of the probes shall be chosen by the tester to detect the discontinuities most common to the method of manufacture.

F2.2.2   *Apparatus*

The equipment used shall have sensitivity levels capable of detecting the artificial discontinuities of the size shown in Figure F4.

The equipment shall be tested at intervals appropriate to maintain the required accuracy using a calibration piece with artificial discontinuities in the head, web and foot as shown in Figure F4. The calibration piece shall be of the same nominal rail size as the rails being tested. Other methods of calibration may be used provided that they ensure the same or better level of accuracy.
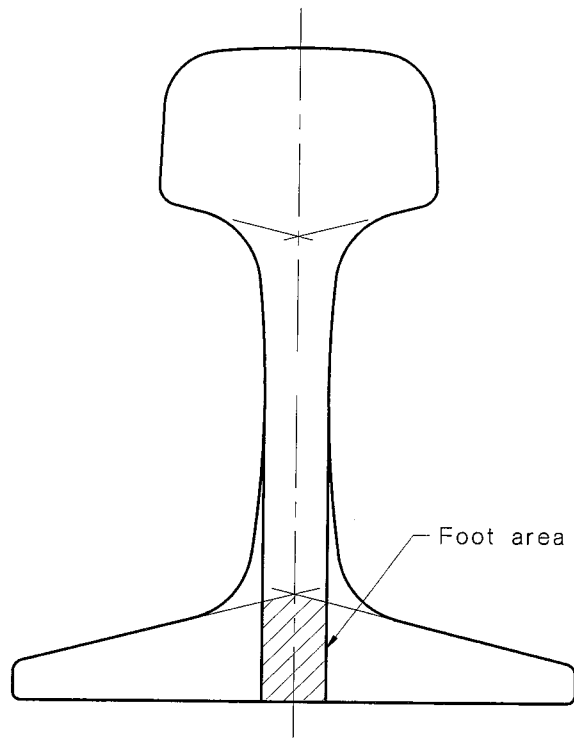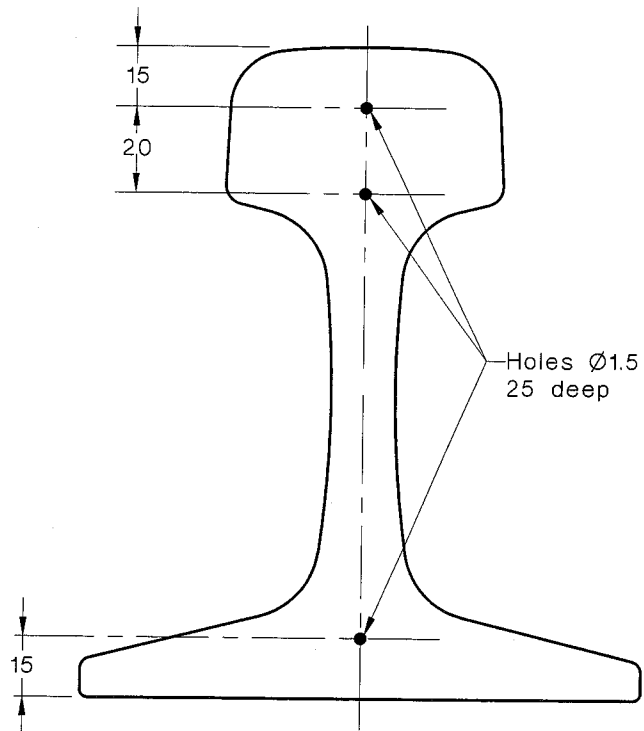
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FIGURE F3 AREA OF FOOT TO BE ULTRASONICALLY TESTED

DIMENSIONS IN MILLIMETRES

FIGURE F4 REFERENCE BLOCK—RAIL HEAD AND FOOT

F3   EXTERNAL FINISH

F3.1   Visual inspection

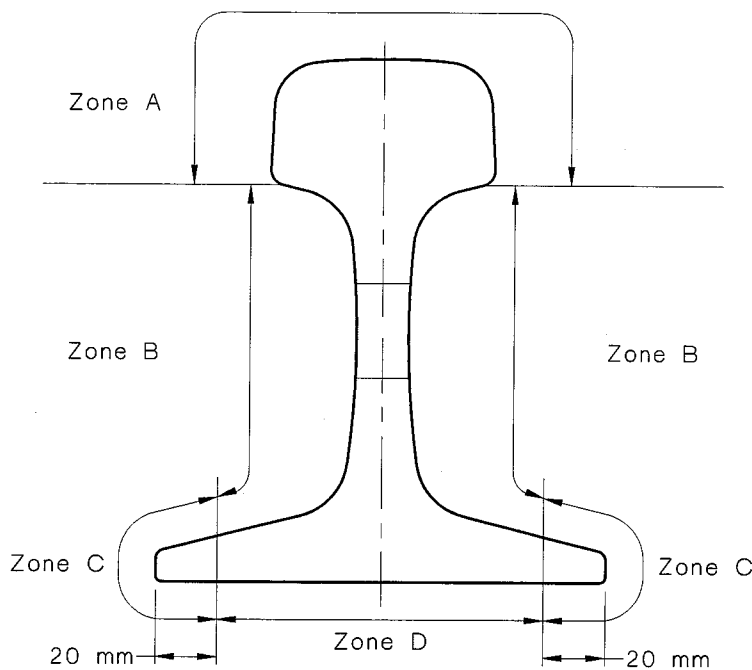Figure F5 shows the limits of the surface zones for visual inspection.

FIGURE F5   ZONES FOR SURFACE DEFECTS

F3.2   Eddy current test for rolled steel rails
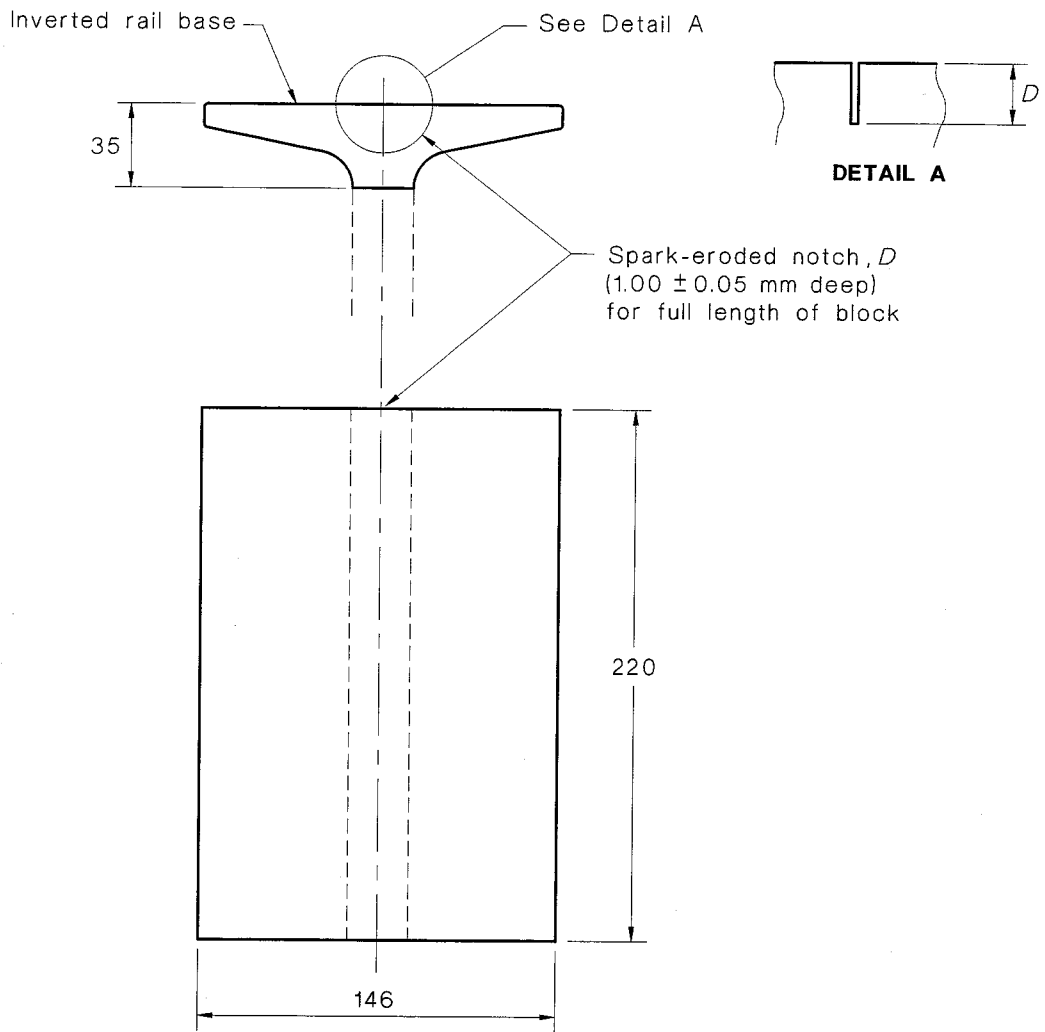
F3.2.1   *General*

Eddy current testing of base sections of 50 kg, 60 kg and 68 kg rails shall be performed using a technique that ensures that a band at least 60 mm wide at the centre of the foot of the rail is sound.

> NOTE: It is intended that this method be primarily applicable to unused rail. More complex methods are necessary for eddy current testing for in-service defects.

F3.2.2   *Apparatus*

The equipment used shall have sensitivity levels capable of detecting the artificial surface opening discontinuities of the size shown in Figure F6.

The equipment shall be tested at intervals appropriate to maintain the required accuracy using a calibration piece with artificial discontinuities as shown in Figure F6. The calibration piece shall be taken from the same nominal rail size as the rails being tested.

Inverted rail base ——⟍   ⌐—— See Detail A

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Spark-eroded notch, D
(1.00 ± 0.05 mm deep)
for full length of block

DETAIL A

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DIMENSIONS IN MILLIMETRES

FIGURE F6   EDDY CURRENT TEST-CALIBRATION BLOCK

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