BS EN 15689:2009

Railway applications — Track — Switches and crossings — Crossing components made of cast austenitic manganese steel

ICS 93.100

BSI
British Standards

National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Railway applications - Track - Switches and crossings - Crossing components made of cast austenitic manganese steel

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Bahnanwendungen - Oberbau - Weichen und Kreuzungen - Gegossener austenitischer Manganstahl für Herzstückbauteile

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Foreword

This document (EN 15689:2009) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2010, and conflicting national standards shall be withdrawn at the latest by May 2010.

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This European Standard is complementary to the series of standards EN 13232 “*Railway applications — Track — Switches and crossings*”, which covers the design and quality of switches and crossings in flat bottomed rail.

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1 Scope

The scope of this European Standard is:

— to establish material requirements for cast austenitic manganese steel for fixed crossings and cradles for crossings with moveable parts designed to be welded or bolted to rails;

— to formulate codes of practice for inspection, testing of un-machined and machined heat-treated castings;

— to list the methods by which crossings should be identified and traced;

— to define limits of weld rectification by the supplier;

— special requirements for pre-hardened crossings.

Geometrical aspects, as machining tolerances and inspection of finished crossings are covered in EN 13232-6 and EN 13232-7 and therefore not in this European Standard.

This European Standard specifies the minimum requirements for cast manganese crossing components. Special applications (for instance tram systems) can require different demands in certain paragraphs and need to be agreed between customer and supplier.

2 Normative references

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

EN 444:1994, *Non-destructive testing — General principles for the radiographic examination of metallic materials using X- and gamma-rays*

EN 462-3:1996, *Non-destructive testing — Image quality of radiographs — Part 3: Image quality classes for ferrous metals*

EN 473:2008, *Non destructive testing — Qualification and certification of NDT personnel — General principles*

EN 571-1, *Non destructive testing — Penetrant testing — Part 1: General principles*

EN 1370, *Founding — Surface roughness inspection by visual/tactile comparators*

EN 1371-1, *Founding — Liquid penetrant inspection — Part 1: Sand, gravity die and low pressure die castings*

EN 10204, *Metallic products — Types of inspection documents*

EN 13232-1:2003, *Railway applications — Track — Switches and crossings — Part 1: Definitions*

EN 13232-6:2005, *Railway applications — Track — Switches and crossings — Part 6: Fixed common and obtuse crossings*

EN 13232-7:2006, *Railway applications — Track — Switches and crossings — Part 7: Crossings with moveable parts*

EN ISO 11970, *Specification and approval of welding procedures for production welding of steel castings (ISO 11970:2001)*

ISO 8062, *Castings — System of dimensional tolerances and machining allowances*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in 7.4 and 7.5 of EN 13232-1:2003, 3.1 of EN 13232-6:2005, Clause 4 of EN 13232-7:2006 and the following apply.

3.1
weldable crossing
crossing with rail ends suitable for welding into track

3.2
fishplated crossing
crossing with rail ends suitable for mechanical joints

3.3
pre hardened
contact area and running table which is intentionally hardened prior to installation in track

3.4
chaplet
metallic core support that remains in finished part

3.5
customer
operator or user of the equipment, or the purchaser of the equipment on the user's behalf

3.6
supplier
body responsible for the use of the EN in response to the customer's requirements

4 Quality systems

The supplier responsible for the manufacture of the crossing shall be certified by an accredited third party and have an audited quality system or shall have a quality system approved by the customer.

5 Sample approval

The suitability of the pattern design, mould preparation procedures, casting conditions and heat treatment procedures shall be demonstrated by producing prototype casting for every new pattern.

Sample approval by the supplier is necessary for every new pattern. Any subsequent modifications in the manufacturing process, which may influence the quality of the components, shall be the responsibility of the cast foundry to test and record. The customer shall have the right to have access to these records.

All tests according to Clause 7 shall be performed for sample approval. However, radiography may be dispensed with by the customer, in which case this shall be specified in the tender documents.

6 General requirements

6.1 Materials (liquid chemistry)

Table 1 — Materials (liquid chemistry)

Element	Percentage weight components Weight %
Carbon	0,95 to 1,3 [a]
Silicon	0,65 max.
Manganese	11,5 to 14,0 [a]
Phosphorus	0,050 max.
Sulphur	0,030 max.
Nickel	1,75 max.
Molybdenum	0,75 max.
Chromium	0,50 max.
Copper	0,30 max.
Aluminium	0,045 max.
[a] Manganese shall not be less than 10 times the carbon content.	

Other alloying elements shall not be added.

6.2 Microstructure

Crossing shall have an austenitic microstructure and be free of detrimental carbide precipitation. To prove the as-cast carbidic structure has changed to an acceptable austenitic structure this shall be demonstrated by metallographic examination or mechanical testing (see Clause 7).

6.3 Surface conditions

6.3.1 Un-machined and heat treated surfaces

The minimum level of surface finish shall be as specified in Table 2 with the relevant SCRATA comparators (refer to EN 1370).

Table 2 — Inspection zones

Inspection zone	Ai	Aii	Aiii	Bi	Bii	Biii
Surface finish	A2	A2	A3	A2	A2	A4
Surface inclusions	B2	B2	B4	B2	B2	B5
Gas porosity	C2	C2	C3	C2	C1	C4
Laps and cold shuts	D1	D1	D2	D2	D1	D5
Scabs	E3	E3	E5	E3	E3	E5
Welds	J1	J1	J1	J1	J1	J1

6.3.2 Definition of surface zones

The definition of surface zones is as shown in Figure 1.

Dimensions in millimetres

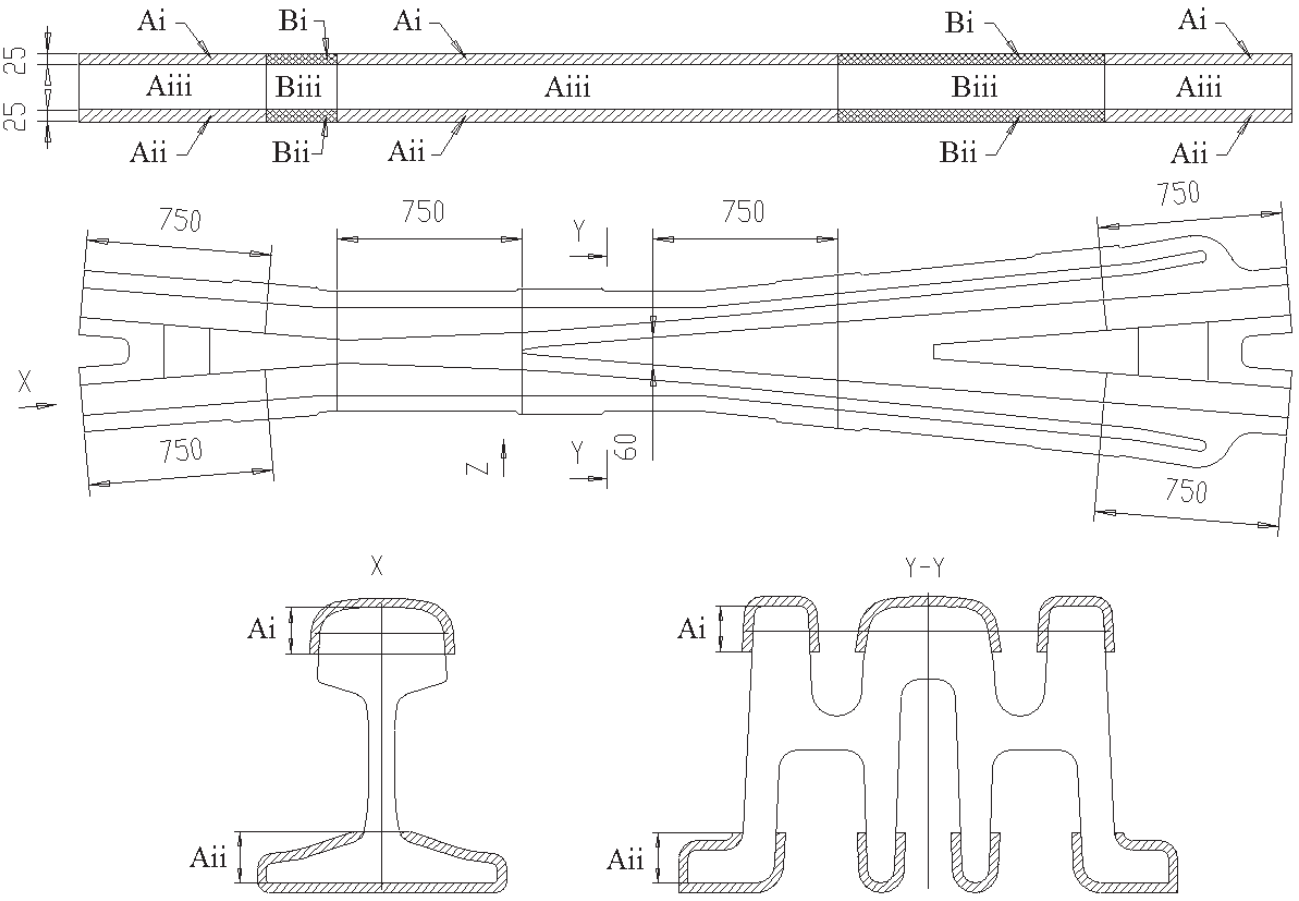


Figure 1 — Definition of surface zones

6.3.3 Machined surfaces

The maximum levels of arithmetical roughness are:

— wheel contact area: Ra 6,3 µm;

— surfaces without wheel contact: Ra 12,5 µm;

— fishplate areas: Ra 6,3 µm.

6.3.4 Tolerances

Dimensions of non-machined areas of the casting areas shall comply with tolerances given by ISO 8062 – CT11 unless otherwise agreed between the customer and supplier.

Dimensional tolerances for machined castings shall be referenced on detail drawings for the crossing component. Basic dimensional requirements are given in EN 13232-6 and EN 13232-7.

6.4 Internal soundness

6.4.1 General

Check all zones on sample castings over the full length, using radiography according to 7.6.1.

6.4.2 Definition of zones and acceptance levels

If the customer requires different quality levels than those stated in the table below, they shall be agreed at the time of tender.

In areas with greater width additional radiographs may be taken to determine the location of indications where possible.

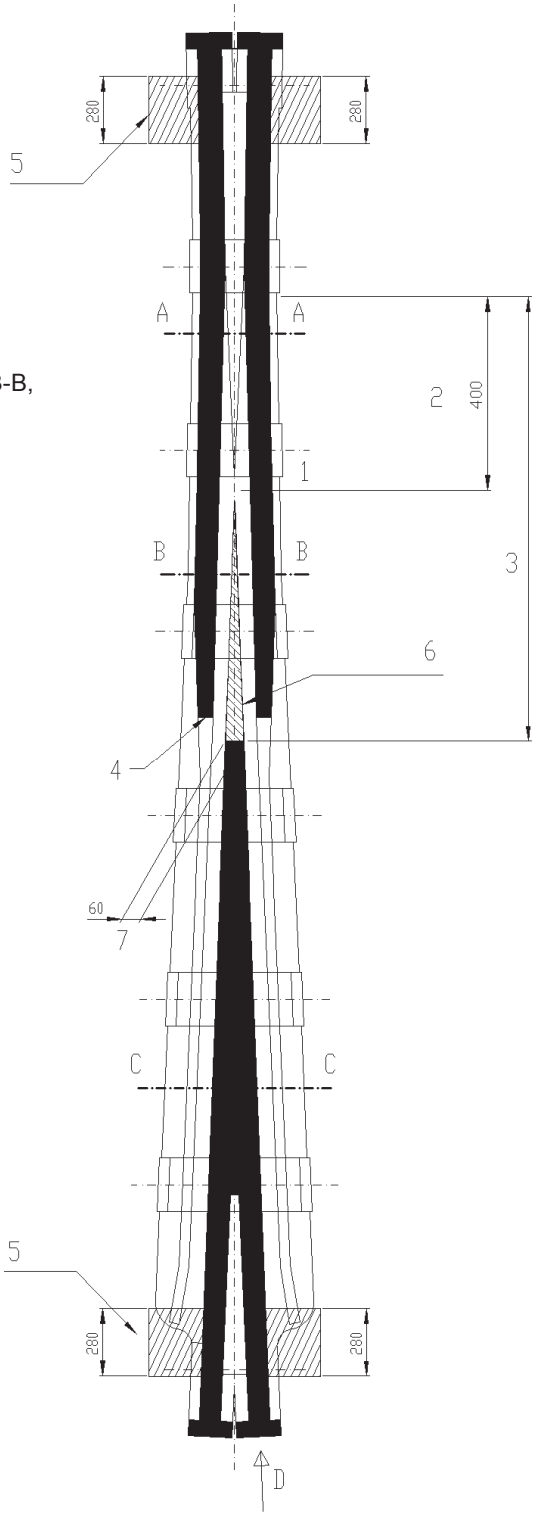
Acceptance levels according to ASTM E446, ASTM E280 and ASTM E186 for the zones of test are illustrated in Figures 2 to 6 and Table 3.

Table 3 — Inspection zone

Zone	Location	Acceptance level	See Figure
Zone 1	running surface and rail weldable endpieces	A1 – B1 – C1	2, 3, 4, 6
Zone 2	under running surface on the nose up to 60 mm nose width	A3 – B3 – C3	2, 3
Zone 3	below Zone 1; wing rail limited by a distance of 400 mm from theoretical point towards wing front rearwards up to the end of the running surface	A3 – B3 – C3	3
Zone 4	changes of section (below Zone 1)	A3 – B3 – C3	2, 5
Zone 5	web of the leg ends of fishplated crossings for the whole length of the fishplate	A3 – B3 – C3	6
Rest	all other zones of the crossing	A3 – B3 – C4	All
A = Gas porosity B = Inclusions (sand and slag) C = Shrinkage			

The minimum depths of the different zones are post machining.

Dimensions in millimetres



NOTE 1 For section A-A and B-B, see Figure 3.

NOTE 2 For section C-C, see Figure 4.

NOTE 3 For view on D, see Figure 6.

Key

1 theoretical point rearwards
2 theoretical point toward wing front
3 wheel transfer area
4 end of running table
5 zone 4
6 zone 2 under zone 1
7 thickness of vee measured at 14 mm below running surface

Figure 2 — Crossing

Dimensions in millimetres

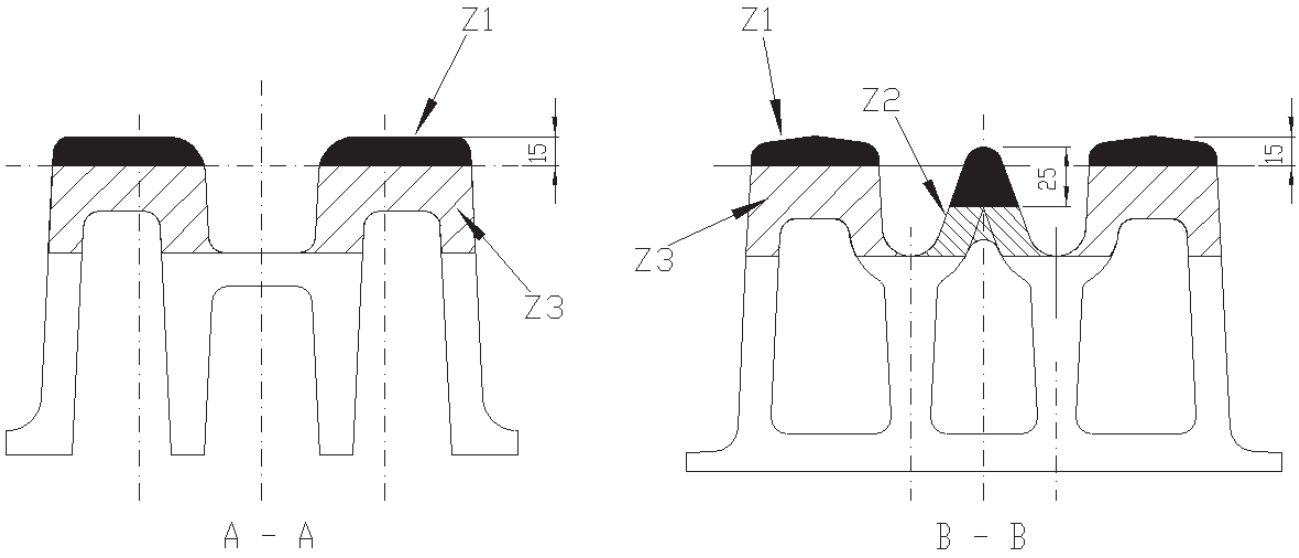


Figure 3 — Wheel transfer area

Dimensions in millimetres

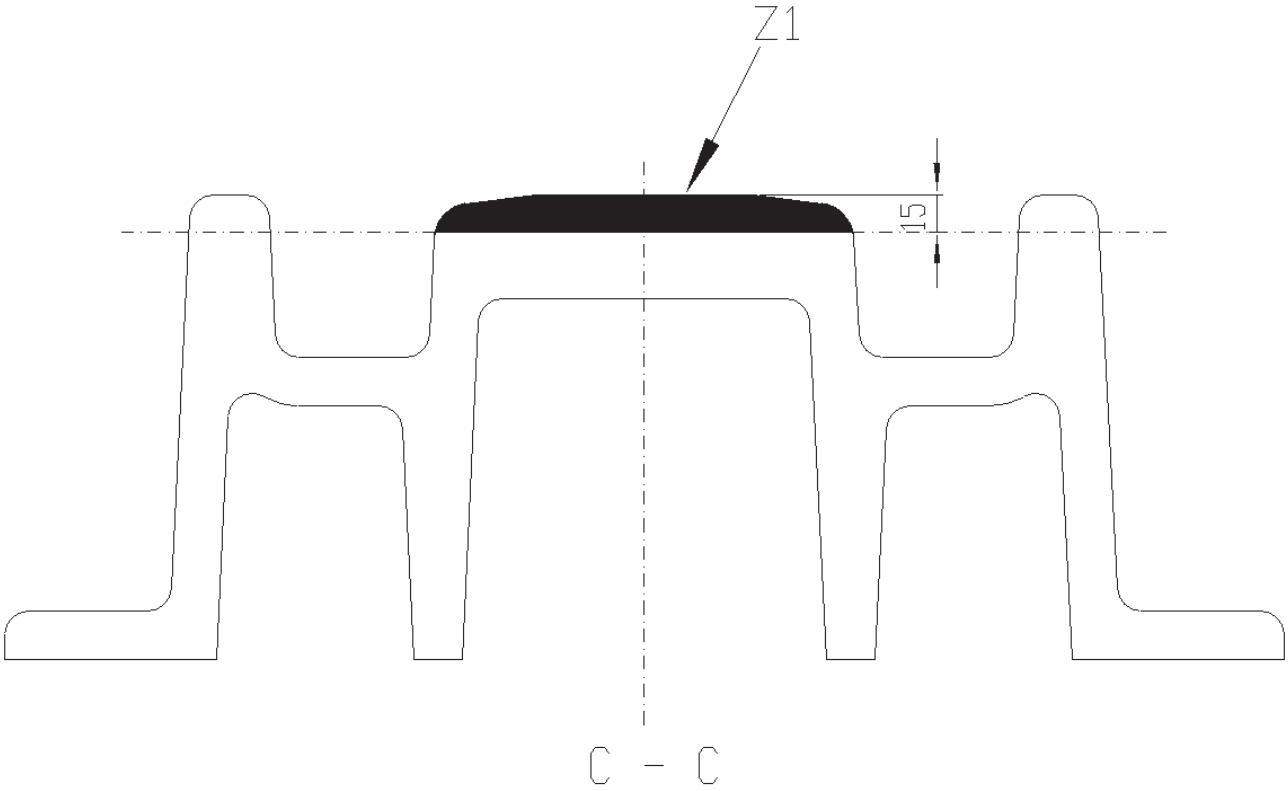
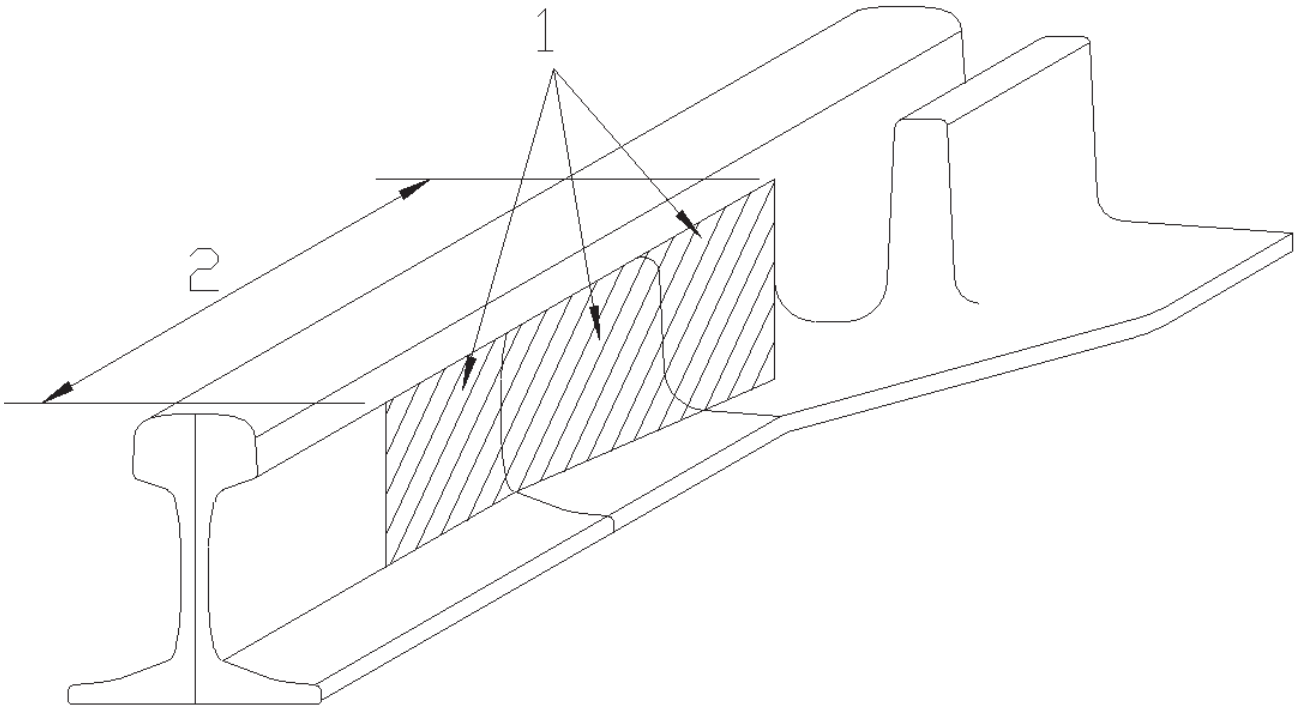


Figure 4 — Remaining length of crossing

Dimensions in millimetres

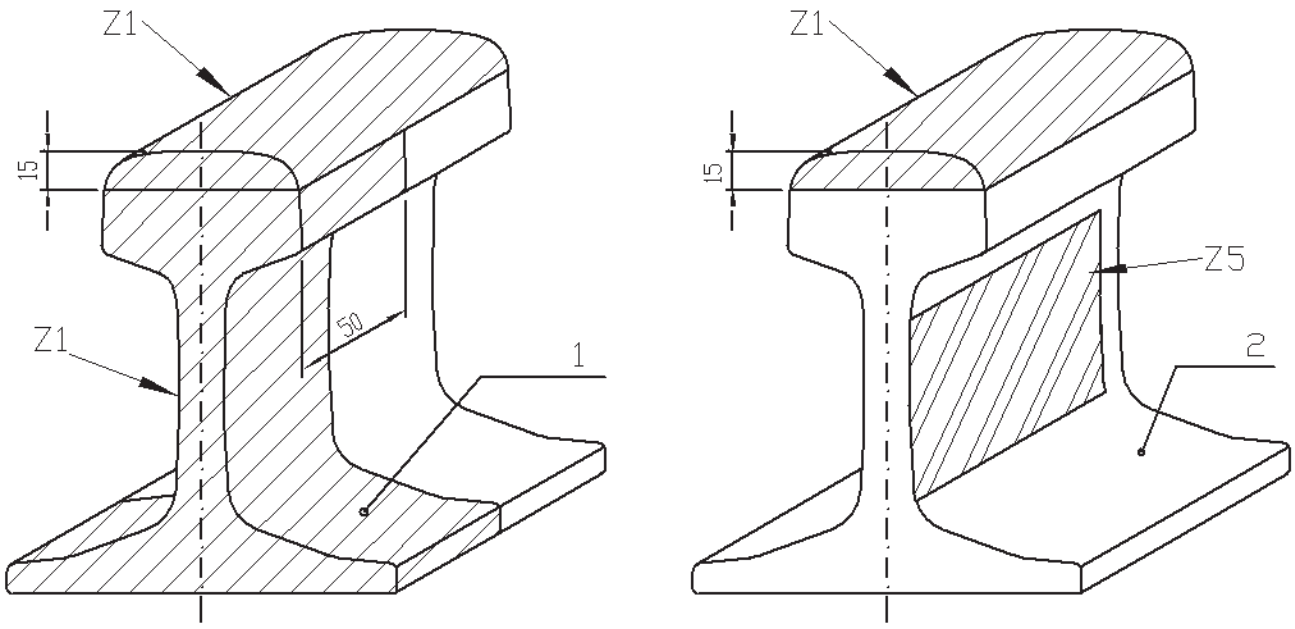


Key

1 change of section from rail profile to main body
2 minimum 280

Figure 5 — Changes of section

Dimensions in millimetres



Key

1 crossing endpiece to be welded
2 leg end of fishplated crossing

Figure 6 — View D

6.4.3 Frequency for radiographic examination

One in every 50 crossings of each pattern type shall be checked by radiography in the following locations:

a) the nose – zones 1 and 2 up to where nose width equals 60 mm;

b) the wheel transfer area – zones 1 and 3;

c) leg ends – 50 mm back from as-cast end face;

d) changes of sections – minimum coverage to be 280 mm centred on the change of section.

If the levels are not met, the customer shall be informed; the production shall be stopped and the process shall be reviewed. Failure to meet the above minimum radiographic acceptance levels will render the examined crossing scrap, unless a concession is granted by the customer for the affected crossing.

6.5 Foundry practice

The use of chaplets is not permitted unless agreed with the customer at the tender stage.

7 Acceptance tests

7.1 Chemical analysis

The chemical composition according to 6.1 shall be checked from each cast or batch of liquid steel.

7.2 Impact bend

The efficiency of the heat treatment shall be checked by an impact test. This test shall be done for each melt and heat treatment charge.

Test pieces for impact testing shall have a 30 mm × 30 mm (± 1 mm) section and a length of 200 mm. The test piece shall be cast together with each casting and shall only be separated from it after heat treatment.

The impact test piece shall be un-machined, the edges may have a chamfer of not exceeding 1 mm. Prior to the test the bars shall be notched in a press to a semi-circle (radius 1,5 mm, depth 1,5 mm) on one face.

The test piece shall then be placed horizontally on two knife-edge supports (radius 2 mm) at an ambient temperature of 20 °C ± 10 °C spaced 160 mm apart, notch downwards and mid-way between the two supports. The test piece shall withstand 3 successive blows of a 50 kg weight, radius 50 mm, falling freely from a height of 3 m onto the surface opposite the notch.

The test piece shall withstand 3 impacts. Cracking from the notch is acceptable to a maximum depth of 7 mm.

If the sample fails the impact test, a metallographic examination shall be performed on the failed test piece, to examine the microstructure present and to identify the cause of failure.

If the sample fails due to embrittlement a new heat treatment followed by another impact test shall be done if agreed by the customer.

Other mechanical tests approved by the customer may be used.

7.3 Metallographic examination

If specified at the time of tender, a metallographic examination, on an optical microscope, with a magnification of 100 × shall be undertaken. The type and location of the sample has to be agreed between the customer and supplier.

7.4 Visual inspection

Each casting shall be subject to visual inspection according to 6.3. The inspection shall be done according to EN 1370. The light level during inspection shall not be less than 350 lx.

7.5 Dye penetrant testing

Every piece shall be checked in accordance with EN 571-1. Acceptance shall be in accordance with EN 1371-1 quality level SP1. No linear indication shall be allowed. Minimum requirement for tested zones: machined surface of wheel transfer area (400 mm in front of theoretical point until point width of 60 mm; see Figure 2) and weld ends 50 mm (see Figure 6).

Testing shall be undertaken in the finished condition.

7.6 Radiography

7.6.1 General

If testing frequency is not specified in the tender documents, the minimum testing frequency shall be 1 in 50 castings from the same pattern.

7.6.2 Method of radiography

Radiography shall be undertaken in accordance with the requirements of EN 444:1994, class A, verified in accordance with EN 462-3:1996 by the use of wire type Image Quality Indicators. Staff undertaking radiography shall be qualified to EN 473.

8 Additional requirements for pre-hardened crossings

8.1 Qualification

8.1.1 Generally

The process shall be approved by manufacturing a cast manganese crossing with pre-hardened running surface.

The following tests shall be carried out.

8.1.2 Dye penetration test

The acceptance criteria are the same as specified in 7.5. To demonstrate that the pre-hardening process has no detrimental effects on the casting, the cast manganese crossing shall be dye penetration tested after pre-hardening. All the pre-hardened surfaces shall be tested.

8.1.3 Hardness requirements

Minimum surface hardness on the running surface, down to 10 mm on the gauge corner as shown in Figure 7 shall be 321 HBW. Other hardness testing equipment with a ball indenter, which allows a conversion into Brinell, may be used.

The sub-surface hardness at a depth of 5 mm shall be a minimum 280 HBW.

Sub-surface hardness testing shall be tested at the frequency specified in 8.3.

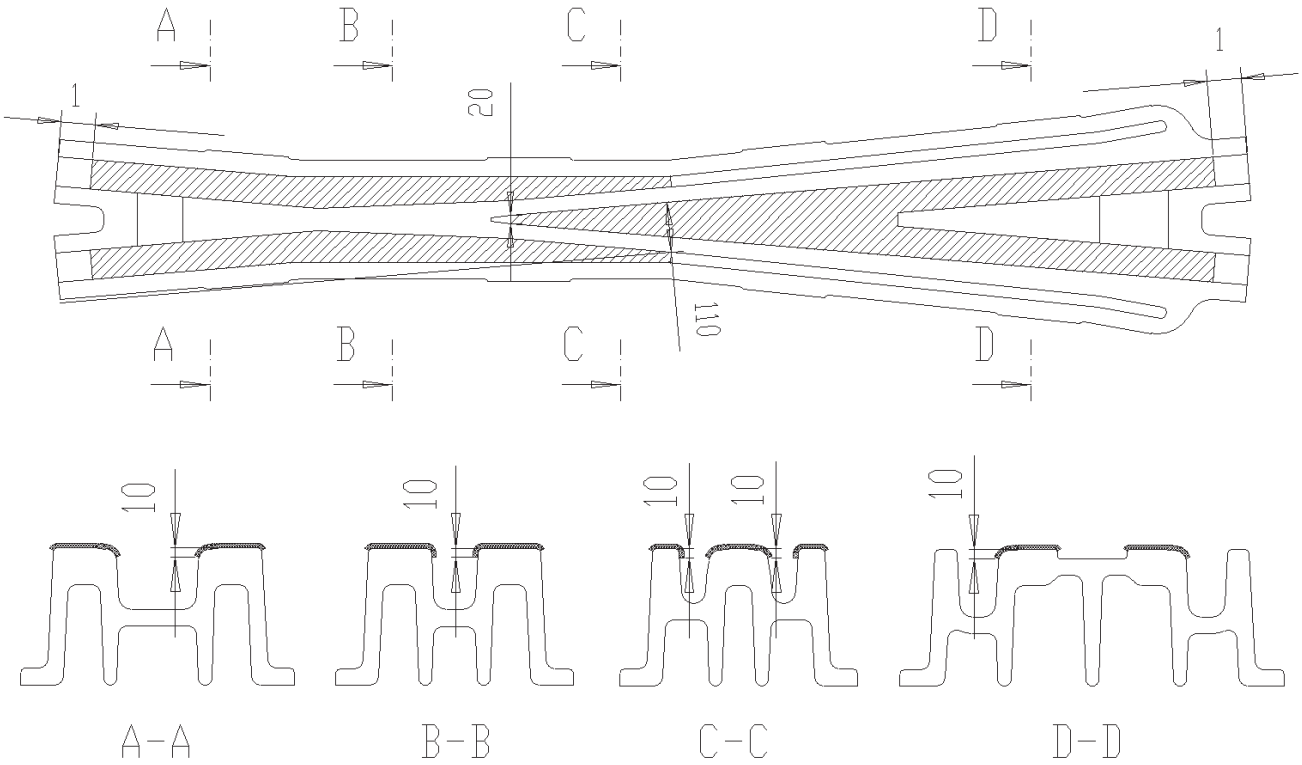
Higher hardness may be required (e.g. for heavy haul). In this case, it shall be specified by the customer.

Depth of hardening profiles shall be measured on transverse sections according to Figure 8.

The depth hardness profile shall be measured with Vickers HV30 down to a depth of 20 mm. The distance between hardness indentations shall be 1 mm. Additional hardness tests at 5 mm from the running surface shall be done. A different test method can be agreed between customer and supplier. The hardness profile shall show a smooth transition from surface to base hardness.

Any significant modification in the manufacturing or hardening process, which may influence the depth of hardening, requires re-qualification of the process.

Dimensions in millimetres



Key

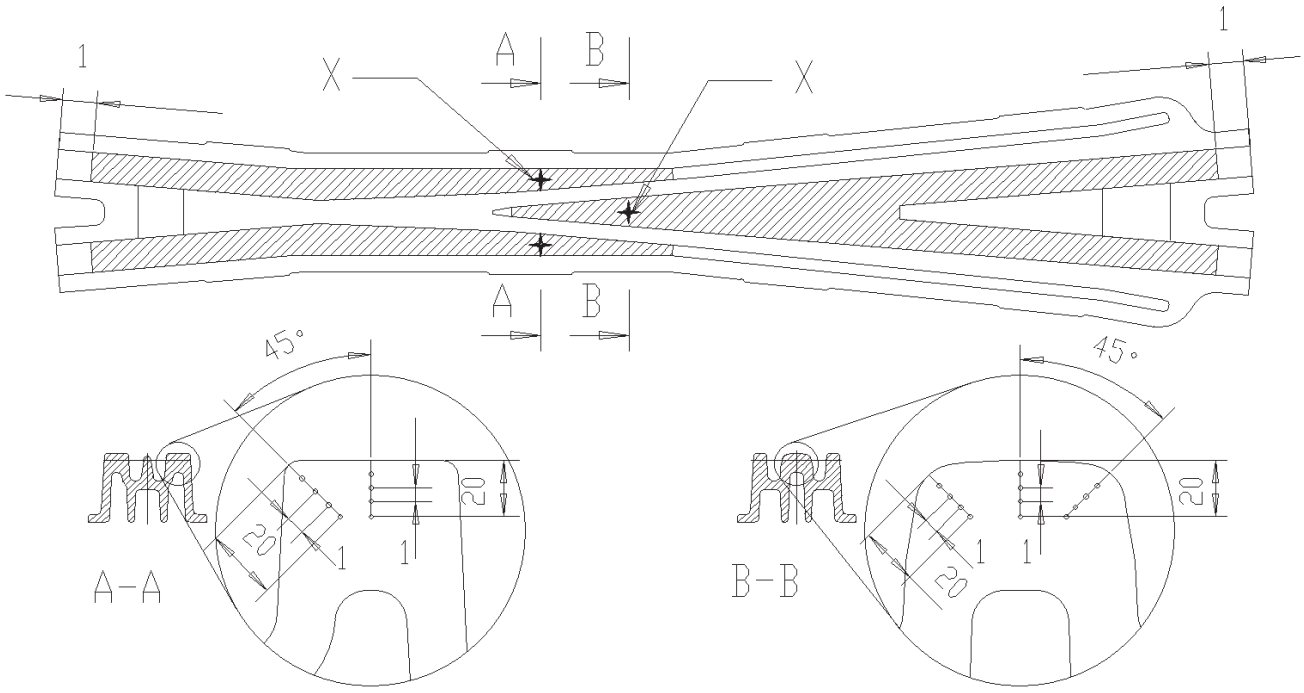
1 unhardened zone

Figure 7 — Running surface

For crossings with welded legs, an area of unhardened surface may exist, following the flash butt welding process. This area shall be a maximum of 75 mm from the leg end.

If requirements for pre-hardening differ from this, then these requirements shall be agreed between customer and supplier.

Dimensions in millimetres



Key

1 unhardened zone

Figure 8 — Transverse sections

8.2 Production tests

Surface hardness shall be tested on every pre-hardened crossing. The locations of hardness testing are shown at locations “X” in Figure 8. Dye penetration test is specified according to 7.5.

8.3 Monitoring of pre-hardening process

Every 2 years tests according to 8.1 shall be repeated on cast manganese rail profile sections with a minimum length of 500 mm. Depth hardness profile shall be measured on one transverse section that is taken out of this rail at least 200 mm from the end.

9 Weld rectification of surface discontinuities

9.1 Qualification of the weld procedure and the welder

Weld procedure and welder qualification shall be agreed between manufacturer and customer according to EN ISO 11970.

9.2 Definition of rectification zones, max. dimensions of excavations

R 1: Welded and fishplated length ends (see Figure 6).

R 2: Running surface and running edge on the transfer area (see Figure 2, item 3).

R 3: Running surface and running edge out of transfer area (see Figure 2, not item 3).

R 4: Un-machined surfaces on the transfer area and change of section “rail profile part/solid part” (see Figures 2 and 5).

R 5: All other parts.

Table 4 — Definition of rectification zones – Dimensions of excavations

Zone	Limits of excavation (mm)	
	depth (mm)	length (mm)
R 1	8 [a]	80
R 2	8 [a]	80
R 3	8 [a]	80
R 4	2/3 of thickness, maximum 15	80
R 5	2/3 of thickness, maximum 15	100
[a] Below final machined surface.		

Larger excavations may be repaired at the discretion of the customer.

The summation of the weld repaired areas on the contact surface shall not exceed 5 % of the total contact surface area of the crossing.

9.3 Testing of weld rectification

The weld rectifications shall be retested by the method that the original discontinuity was detected and dye penetration testing according to the requirements of 7.5.

9.4 Welding records

Repairs of excavations longer than 20 mm shall be recorded. These records shall include as a minimum:

— location of weld repair;

— size of excavation;

— identification of crossing;

— welder identification.

10 Identification and marking

Each crossing shall have an identification marking cast or fixed on the crossing. The design of marking shall be agreed between customer and supplier.

The following information shall be clearly marked:

— foundry mark;

— month and the last two digits of year of casting;

— crossing type (rail profile, geometry, left hand, right hand);

— unique identification number.

Other markings (e.g. name of network, pre-hardening, theoretical intersection point of the gauge lines) may be specified by the customer at the time of tender.

The identification marks concerning dispatch shall be agreed between customer and supplier.

11 Documentation

All production and quality records shall to be retained by the manufacturer for a period according to national laws and regulations. Customer shall have the right to access to view these records.

Certificates according to EN 10204 shall be supplied on customer's request.

12 Non-common cast manganese crossings

Sketches in this standard show common crossings. All other types of cast manganese crossings shall comply with this European Standard when they have comparable surfaces or sections, i.e. obtuse crossings, vees, cradles etc.

Acceptance levels for sections or surfaces not covered by this standard shall be agreed with the supplier and customer at the tender stage.

Bibliography

[1] ASTM E186, *Standard Reference Radiographs for Heavy-Walled (2 to 4 ½ in. [51 mm to 114 mm]) Steel Castings*

[2] ASTM E280, *Standard Reference Radiographs for Heavy-Walled (4 ½ to 12 in. [114 mm to 305 mm]) Steel Castings*

[3] ASTM E446, *Standard Reference Radiographs for Steel Castings up to 2 in. [51 mm] in Thickness*

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