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# **RAILSAFE**

Education, Qualification and Certification

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## **RAIL WELDING – ALUMINOTHERMIC WELDING PROCEDURE SPECIFICATION**

Interim document of the European Welding Federation  
Prepared by RAILS SAFE



RAILSAFE is a LEONARDO DA VINCI  
Community Vocational Training Action Programme Project

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## Foreword – the RAILS SAFE Project

This document has been prepared by RAILS SAFE project partner ISQ with the assistance of TWI, IIS and VSRT.

ISQ developed this guideline with the support of the Portuguese Railway Authority – REFER.

The RAILS SAFE project aims for well-trained and qualified welders. In the project the cause for weld failures and rejects will be analysed. An education, training, qualification and certification system for railway track welders will be developed, using the best of existing national material, but with a fresh look at rejects and failure prevention and thus on quality and safety. As far as welding processes are concerned, RAILS SAFE's main attention will go to aluminothermic welding.

The objectives of this project are to harmonise education, qualification and certification to make exchange of welders for national railway authorities and companies in the European Union possible and to assure the quality of and access to continuing vocational education and certification for life-long competences and better employability of railway welders across national borders. The harmonisation will comprise the performance objectives and curriculum for education and training (not the training material), examination, qualification (European diploma) and certification (European certificate, database of certified welders).

RAILSAFE is a collaboration between the following organizations:

TWI Ltd  
Ir. J.B. van den Brug Raadgevend Ingenieur (RI)  
Schweißtechnische Lehr- und Versuchsanstalt Hannover (SLV)  
Istituto Italiano della Saldatura (IIS)  
Volker Stevin Rail & Traffic (VSRT)  
European Federation for Welding, Joining and Cutting (EWF)  
Instituto de Soldadura e Qualidade (ISQ)  
Svetskommissionen (Swedish Welding Commission) (SWC)  
Prva Zvaracska a.s. (PZ) (First Welding Company)

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## Scope and purpose

The current practice in the rail welding industry is for the supplier of aluminothermic welding equipment and consumables (the 'process supplier') to produce a 'manual' describing in detail the correct application of its variant of the process to the range of rail welding situations normally encountered. This 'Process Manual' then forms the basis for rail welder training in that process variant, and for ensuring the correct execution of welds on site.

Process Manuals can be large documents and do not particularly lend themselves to day-to-day use by site welding teams. The current document provides a mechanism for distilling from a Process Manual all the essential data needed by a welder to execute a weld correctly in a specific set of circumstances. In most other types of welding, the term that is widely used and accepted for such a document is a 'welding procedure specification' and it seems appropriate to adopt the term for the kind of specification described by the current document.

This document specifies minimum requirements for the content of a welding procedure specification for the aluminothermic welding process of rails, by defining all variables important for the correct reproduction and understanding of the welding procedure by those involved in the welding activity.

The variables listed in this document are those influencing the quality of the welded joint.

This document could also act as a guidance on the requirements for a harmonised aluminothermic welding process manual which can be used to satisfy the requirements of the prEN 14730-1:2003 process manual that as to be submitted with the request for approval.

The laboratory tests and requirements for the approval of the aluminothermic welding process using welds produced in workshop conditions are specified in prEN 14730-1:2003.

The requirements for the approval of the aluminothermic rail welder are specified in prEN 14730-2:2003.

## 1. Normative references

This document incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this document only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 13674-1, *Railway applications – Track – Rail – Part 1: Vignole railway rails 46 kg/m and above*

EN ISO 4063, *Welding and allied processes – Nomenclature of processes and reference numbers. (ISO 4063:1998)*

prEN 14969, *Railway applications – Track – Qualification of railway trackworks contractors*

prEN 14730-1:2003, *Railway applications – Track – Aluminothermic welding of rails – Part 1: Approval of welding processes*

prEN 14730-2:2003, *Railway applications – Track – Aluminothermic welding of rails – Part 2: Qualification of aluminothermic welders, approval of contractors and acceptance of welds.*

## 2. Terms and definitions

For the purpose of this document, the following terms and definitions apply:

**welding procedure specification (WPS):** a document that provides all the required variables of the welding procedure and which has been approved for use.

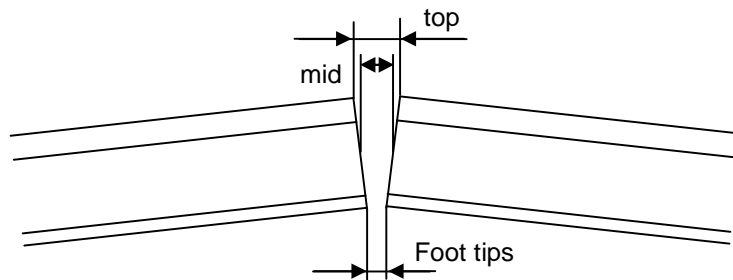
**preliminary welding procedure specification (pWPS):** a document that provides all the required variables of the welding procedure and which has to be approved.

**welding procedure qualification record (WPQR):** record comprising all necessary data needed for the approval of a preliminary welding procedure specification

**portion:** individually packed iron oxide ( $Fe_2O_3$ ) and aluminium metal powder sufficient for one weld.

**mould:** two or three pieces of refractory material (sand) that sustain the molten metal while it solidifies.

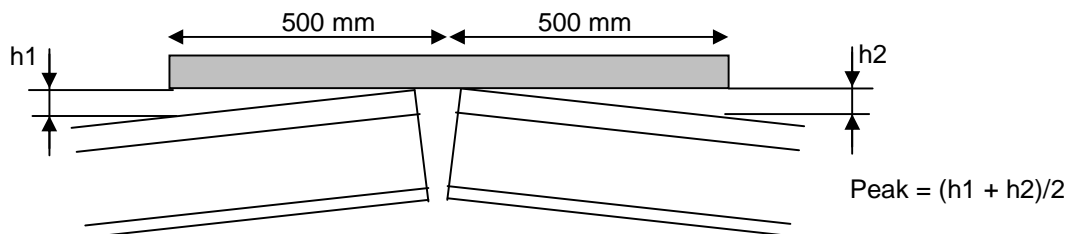
**nominal welding gap:** free space between the two rail section top. The welding gap shall be measured after weld alignment (peaking) at the running surface, web mid point and both foot tips. The maximum gap is the maximum at any of the above points and minimum the minimum of any of the above points. See figure below.



$$\text{Max gap} = \max\{\text{top} + \text{mid} + \text{foot tip 1} + \text{foot tip 2}\}$$

$$\text{Min gap} = \min\{\text{top} + \text{mid} + \text{foot tip 1} + \text{foot tip 2}\}$$

**vertical alignment:** is defined by the following figure for a peaked alignment (Note: dipped alignment is the opposite of a peaked one and it is measured in the centre).



**horizontal alignment:** Alignment of the two rail sections measured from the inside of the track.

**ballastless track:** track not supported by ballast, generally a track which is constructed either on sleepers embedded in concrete or asphalt or on a concrete slab.

**high speed lines:** lines that come within the scope of the Technical Specification of Interoperability (S.T.I) of the infrastructure sub-system of the trans European high speed rail network. Conventional lines are all other than high speed ones.

**conductor rail:** additional rails (or rail) provided on electric railways where power is transmitted to trains from the track. Often referred to as the 'third rail' or 'current rail'.

### **3. Technical content of the aluminothermic welding procedure specification (WPS)**

A aluminothermic welding procedure specification (pWPS/WPS) shall provide all the necessary information required to make a specific weld. The information required for the pWPS/WPS is given in clauses 4.1 to 4.10.

An example of the pWPS/WPS format is shown in annex A.

#### **4.1. Related to the rail welding contractor**

- Identification of the contractor;
- Identification of the aluminothermic WPS (Reference number);
- Reference to the welding procedure qualification record (WPQR) or other documents as required (e.g. see prEN 14730-1 and prEN 14969)

#### **4.2. Work description**

- Identification of the type track and line where the weld are to be made. (e.g. Ballast track / ballastless track, high speed lines/conventional lines; conductor rail)
- Number of persons (rail welder / rail welder assistant) needed to perform the welding operation
- Dealing with any differences in rail profile or rail head wear.

#### **4.3. Related to the parent material, rail(s)**

- Identification of the material(s) and reference standard(s);
- Number(s) of the group as given in EN 13674-1.
- Identification of the rail(s) profile as given in EN 13674-1 and/or rail(s) profile drawing (optional).

#### **4.4. Special limitations on local conditions**

- Description of any limitations on the local conditions (e.g. minimum ambient temperature)

#### **4.5. Related to the welding equipment / consumables**

##### **4.5.1. Kit reference**

- if applicable, manufacturer, trade name and designation of welding kit.

##### **4.5.2. Portion**

- Trade name and/or designation
- Composition. Elements weight

- Shelf life period
- Storage precautions

NOTE: Some applications may require the identification of the weld metal composition instead of the portion composition (see ANSI/AWS D15.2-94)

#### **4.5.3. Mould**

- Trade name and/or designation
- Number of pieces
- Shelf life period
- Storage precautions

#### **4.5.4. Crucible / reaction chamber**

- Trade name and/or designation
- Refractory chemical nature
- Storage precautions
- Maximum number of welds

NOTE: The designation shall be related and identify the internal crucible geometry - prEN 14730-1:2003 may require the internal crucible geometry drawing.

#### **4.5.5. Tapping system**

- Trade name and/or designation
- Refractory chemical nature
- Releasing mechanism

NOTE: The designation shall be related and identify the tapping system geometry - prEN 14730-1:2003 may require the tapping system geometry drawing.

#### **4.5.6. Pouring system**

- Trade name and/or designation

NOTE: The designation, shall be related and identify the pouring system geometry. A pouring system geometry drawing may be required.

### **4.6. Related to the joint**

#### **4.6.1. Joint preparation**

- Identification of the rail end preparation/cutting method, e.g. sawed / abrasive disc
- Rail stressing equipment (if used)
- Identification the pre-welding cleaning method for oxide, dirt, grease, burns, fins and/or moisture removal
- Identification of special precautions to be observed, e.g.:
  - o looseness of the rails to be welded;
  - o remove defects from the joint than can disturb the mould placement;
  - o holes axes shall be at 100mm (minimum) from weld area;
  - o over tightening the base plate or mould clamp screws may cause cracking of the mould and subsequent leaking of the molten metal;

#### **4.6.2. Joint design**

- A sketch of the joint design/configuration;
- Identification of the following dimensions:
  - o (Nominal) welding gap
  - o Vertical alignment (Flatness / Dip);
  - o Horizontal alignment

NOTE: The method for measuring the vertical and horizontal alignment may influence the dimension.

#### **4.6.3. Requirements for datum marking**

- Datum marking information (e.g. number of marks; position; checking intervals and amount of movement accepted; corrections to be made if necessary)

#### **4.6.4. Requirements on mould adjustments**

- Mould adjustment information (e.g. maximum mould depth removal; mould areas required to fit; other indications)

### **4.7. Weld details:**

#### **4.7.1. Pre-heating**

- Heating equipment reference
- Identification of the method and fuel type to be used (composition of the mixture and partial pressures)
- The minimum temperature applied at the start of welding
- Rail length from weld face to be pre heated

NOTE: The minimum temperature applied at the start of welding and the rail length from face to be pre heated can be substituted by expressing the time (duration) and joint location to apply the heating.

#### **4.7.2. Ignition**

- The method to be used

#### **4.7.3. Critical process timings / temperatures / mould removing instructions**

- Time from ignition to tap:
- Rate of cooling or time/temperature until mould removal
- Time/temperature before course grinding
- Time/temperature before trains can pass

#### **4.7.4. Stripping**

- Stripping equipment
- Method description / Mould removing instructions
- Removal of rail stressing equipment (if used)

#### **4.7.5. Final grinding**

- Method to be used;
- Machine to be used, manufacturer and trade name
- Maximum grinding length
- Finished profile requirements

#### **4.8. Weld collar geometry**

- A sketch of the weld collar geometry as indicated in prEN 14730-1, clause 5.5.2
- Identification of the following dimensions:
  - o Weld collar width (W1)
  - o Maximum collar depths at section B-B (D1, D2)
  - o Minimum collar depths at section B-B (d1, d2)
  - o Riser cross section at foot
  - o Riser cross section at neutral axis;
  - o Number of risers.
  - o Position of risers

#### **4.9. Inspection**

- Description of the inspection to be done by the welder and the acceptance requirements. (e.g. identification of the weld; profile requirements)

#### **4.10. Safety information**

- Critical safety information about the welding process and subsequent operations (e.g. preheating; cutting; grinding) shall be presented in the pWPS/WPS, e.g.
  - o **DANGER: INTRODUCTION OF MOISTURE TO THE ALUMINOTHERMIC WELDING PROCEDURE PROCESS MAY CAUSE SERIOUS OR FATAL INJURY.** Molten steel and hot slag can cause serious explosion upon coming into contact into snow, ice, standing water, frozen blast or soil
  - o Improper or careless luting (sealing) of the mould may cause leakage of the molten metal;
  - o Personnel must wear railroad approved safety glasses at all times.
  - o Slag basin should be emptied only after the slag has completely solidified.
  - o Solid slag should be disposed of in such a manner as not to pose any hazard to operating personnel

## Annex 1 Welding procedure specification (WPS)

ALUMINOTHERMIC WELDING PROCEDURE SPECIFICATION				
<b>1. GENERAL</b>				
Manufacturer				
WPS Reference number				
WPQR Reference number				
<b>2. WORK DESCRIPTION</b>				
Type of track / line				
Number of persons needed				
___ Rail welders      ___ Rail welder assistants				
Rail profile/ rail head wear differences				
<b>3. RAIL(S) - PARENT MATERIAL</b>				
Material / Standard designation				
welded to				
(EN 13674-1) Group				
welded to				
(EN 13674-1) Profile				
welded to				
<b>4. LIMITATIONS ON LOCAL CONDITIONS</b>				
Description				
<b>5. CONSUMABLES</b>				
Kit reference (manufacturer and designation)				
	<b>Designation / Ref. No.</b>	<b>Storage precautions</b>	<b>Shelf life period</b>	<b>Other</b>
<b>Portion</b>				<b>Elements weight composition:</b>
<b>Mould</b>				<b>Number of pieces:</b>
<b>Crucible</b>			---	<b>Refractory chemical nature:</b> <b>Maximum number of welds:</b>
<b>Tapping system</b>		---	---	<b>Refractory chemical nature:</b> <b>Releasing mechanism:</b>
<b>Pouring system</b>		---	---	---

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<b>WPS ref.</b>	<b>Date</b>	<b>Approved by</b>	<b>Page N.o</b>
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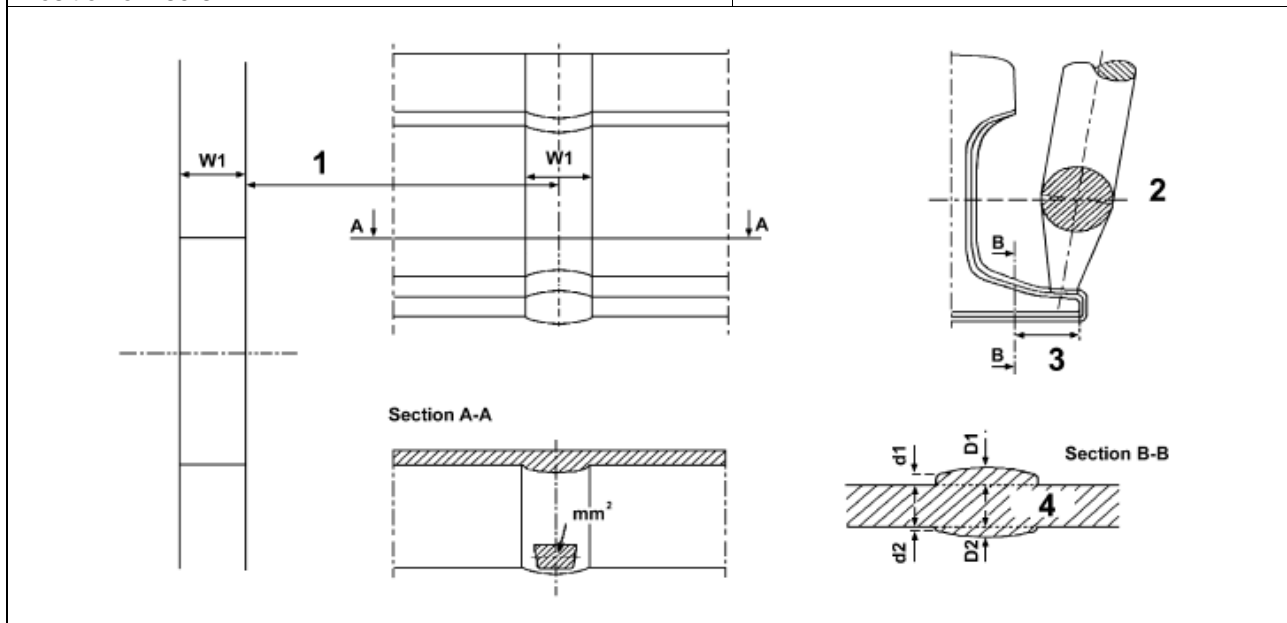
**ALUMINOTHERMIC WELDING PROCEDURE SPECIFICATION**

<b>6. JOINT DETAILS</b>			
Rail end preparation/cutting method			
Rail stressing equipment			
Pre-welding cleaning method			
Special precautions			
<b>Joint relevant dimensions</b>			
Vertical alignment (mm)		Sketch area	
Horizontal alignment (mm)			
Nominal welding gap (mm)			
<b>Requirements for datum marking</b>			
<b>Requirements on mould adjustments</b>			
<b>7. WELD DETAILS</b>			
Heating equipment			
Method / Fuel type pre heating gas pressure			
Temperature / time			
Length from weld face to be pre heated			
<b>Ignition method</b>			
<b>Critical process timings / temperatures</b>			
Time / temperature from ignition to tap			
Rate of cooling or time/temperature until mould removal			
Time/temperature before course grinding			
Time/temperature before trains can pass			
<b>Stripping</b>			
Mould removing instructions			
Equipment			
Method description			
Removal of rail stressing equipment			
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**ALUMINOTHERMIC WELDING PROCEDURE SPECIFICATION**

<b>Final Grinding</b>	
Equipment	
Method description	
Maximum grinding length (mm)	
Finished profile requirements	

<b>8. WELD COLLAR / INTERNAL MOULD GEOMETRY</b>	
Weld collar width (W1)	
Maximum collar depths at section B-B (D1 and D2)	
Minimum collar depths at section B-B (d1 and d2)	
Riser cross-section at foot	
Riser cross-section at neutral axis	
Number of risers	
Position of risers	



<b>9. INSPECTION REQUIREMENTS</b>	
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<b>10. SAFETY INFORMATION</b>	
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<b>WPS ref.</b>	<b>Date</b>	<b>Approved by</b>	<b>Page N.o</b>
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