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## THE ADVANTAGES OF NEW GENERATION HARDNESS MEASUREMENT METHODS

**Abstract:** Persistent demands for increasing train frequency and train speeds have resulted in an increase of higher axle loads and the associated stresses in railway tracks. Welding of tracks, as modern joining process, evade weak spots, that exist on fishplate joints, which lead to a higher reliability and safety of the track. Although the performance of the welds improved with further developments of the welding process, defects in welds are still a large cost factor for the railways.

This paper describes quality requirements for welding process from EN 14730 series of standards, applicable to tram and standard railway tracks. As a part of this paper, quality requirements for restoration of rails by electric arc welding by EN 15594:2009 will be described, too.

**Keywords:** quality requirements, aluminothermic welding, railway tracks, laboratory test, welding restoration

### 1. INTRODUCTION

After new standard for railway tracks, EN 13674-1 in 2003. [1], in EU countries during 2006 is accepted standard EN 14811 (Railway applications - Track - Special purpose rail - Grooved and associated construction) for tram and special purpose rails [2]. Adopting of standards 14730 -1 (Railway applications - Track - Aluminothermic welding of rails - Part 1: Approval of welding processes) and EN 14732-2 (Railway applications - Track - Aluminothermic welding of rails - Part 2: Qualification of aluminothermic welders, approval of contractors and acceptance of welds) ended a process of issuing of major standards related with new quality requirements for railway and tram tracks [3,4,5]. All requirements from this group of standards are implemented in guidelines of European Welding federation (EWF)

and TC CEN committee 256 [6].

### 2. GENERAL SCOPE OF REQUIREMENTS

All above mentioned standards have clearly defined acceptance tests developed in order to monitor the properties of the rail steels and rails and associated construction rail profiles (like grooved, for example) that are of importance for the production of grooved rails and associated construction rail profiles and which comply with the demands of commuter railways.

It is also significant to emphasize all these standards are performance-based. They recognizes the European quality management standard EN ISO 9001 and requires manufacturers to offer the latest proven technology consistently to satisfy

the demanding quality of the required product. The important new aspect in this group of standards is the integration of a clause on quality management and testing in order to assure the end product integrity.

In order to ensure that the quality management systems are consistent for all manufacturers and that all purchasers can be sure about the consistency of the product quality of these safety-related components, the standards recommends that the manufacturer operates a quality management system at least equivalent to the requirements of EN ISO 9001. This makes it possible to dispense with detailed requirements on tests and comprehensive testing.

All these standards are applicable to all procurements covered by the European Procurement Directive (93/38/EEC of 14 June 1993). Additionally, CEN has requested a performance-based standard taking into account safety requirements and the application of the most recent technologies.

For example the EN 13674-1 has two major divisions:

- 1) qualifying tests;
- 2) acceptance tests.

The qualifying tests introduce a number of performance requirements not previously seen in national or international standards. They also include typical results from relevant acceptance tests. Rail grading is based on hardness rather than tensile strength. The acceptance tests have been designed to control those characteristics of the rail steel and rail that are of relevance to the production of high quality rails and the demands of the railway. The steel grades covered by this part of EN 13674 reflect trends in railway usage and heat treated rails are included. The standard includes rail profiles for Vignole rails having a linear mass 46 kg/m and above.

In EN 14811, in comparison with EN 13674-1, the qualifying tests are practically replaced with manufacture

requirements aiming on product integrity. These two standard, although similar in structure, can't be directly compared because of different levels in requirements of product integrity.

The standard EN 13674-1 reflects this change in philosophy from the traditional content of rail standards. A review was undertaken of the most commonly used rail standards of the world. All relevant aspects important to both user and manufacturer were considered with the aim of ensuring that all of the content had specific usefulness and relevance. For example rail grading and much of the standard has been based on hardness rather than tensile strength. Whilst the two are directly related, hardness is very quick and cheap to carry out and provides more relevant guidance to the user particularly where properties vary in different parts of the profile. Since many rail manufacturers would have not previously carried out proving trials, the standard includes a prerequisite for all manufacturers to prove conformity against a set of qualifying test criteria at the time of tendering.

The Qualifying tests include all "normal" acceptance test results plus new "type-casting" features such as fracture toughness, fatigue and residual stress. To provide users with the necessary confidence, acceptance limits have been based on results from rail known to have performed well in demanding track installations. One aspect of the standard which is a complete break from tradition is the inclusion of quality assurance and inspection clause as part of product integrity.

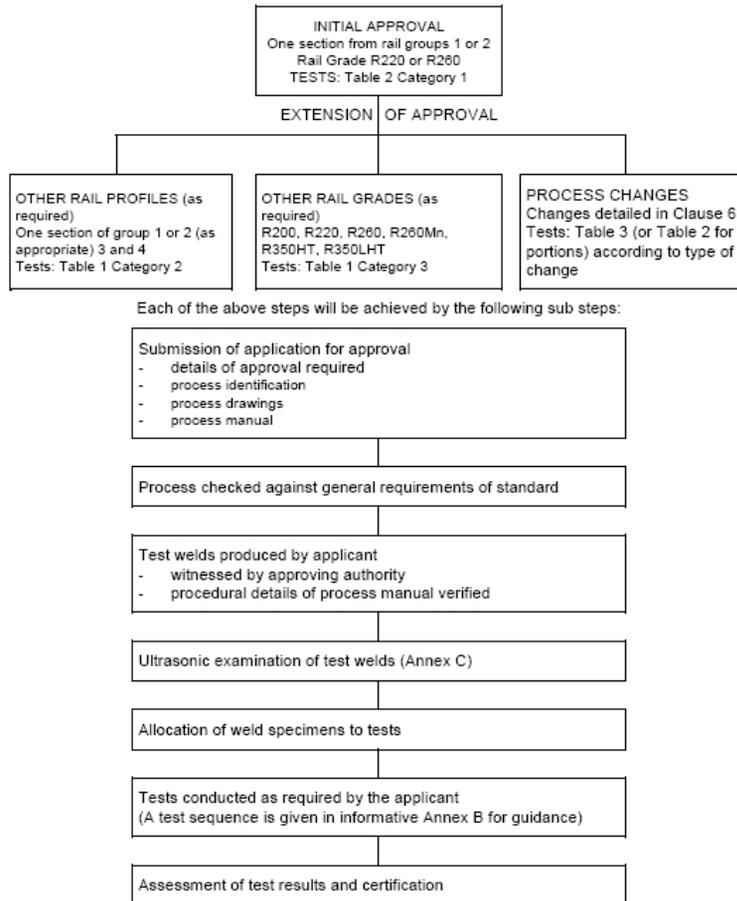
### **3. SCOPE OF WELDING REQUIREMENTS**

The standard EN 14730-1 defines the laboratory tests and requirements for approval of an aluminothermic welding process using welds produced in workshop conditions.

It applies to the joining of new, Vignole rails as described in EN 13674-1 of the same profile and steel grade.

Compliance with the requirements of this standard does not of itself ensure the suitability of a welding process for specific conditions of track and traffic. The standard does not cover welds made between different rail sections, differently worn rails and different rail grades. In

addition to the definitive requirements this standard also requires the items detailed in Clause 4 (Information to be supplied by the railway authority) to be documented. For compliance with this standard, it is important that both the definitive requirements and the documented items be satisfied.



**Figure 1 – Schematic diagram for steps in welding process approval**

The scope of welding requirements shall are:

- a) The process shall be capable of being carried out on track where the maximum can be 180 mm. It shall be capable of being carried out in track, at or near trackside or in a workshop.
- b) The aluminothermic welding portion shall be packed to avoid the risk of moisture contamination in proscribed storage conditions. The portion shall be identified by markings on the package.

- c) The mould shall be pre-fabricated for the rail profiles to be welded and be identified by markings on the package.
  - d) The crucible shall be tapped automatically (automatic tapping) and shall have a device to limit spattering.
  - e) Pre-heating shall comply with any limitations of the railway authority as specified in Clause 4 (Information to be supplied by the railway authority). The pre-heating tools shall operate at temperatures down to 0 °C without the need for special precautions.
  - f) The process shall not damage the rail. When applying for approval, the following documents shall be submitted:
    - The process manual (The process supplier shall produce a manual identifying all the consumable materials and equipment used, as well as the operating method to be followed for all steps of welding. The manual shall specify the critical parameters of the welding process and their safe bounds.
    - Drawing with the required measurements
    - Chemical analysis ranges and tolerances
- General scheme of steps in approval is given in Fig. 1 and the suggested sequence of laboratory tests on Fig 2.

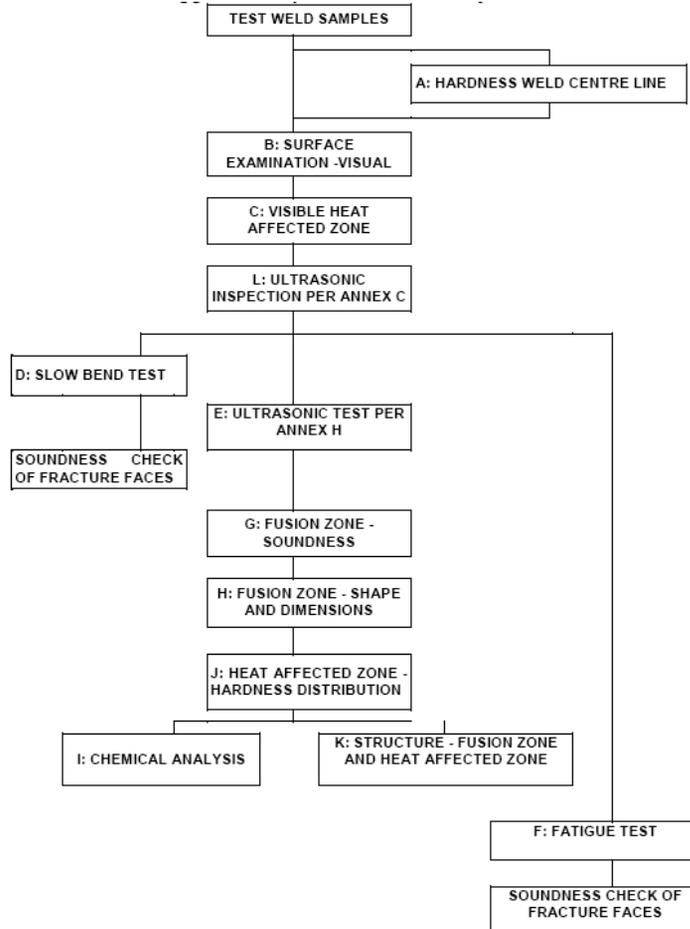


Figure 2 – Suggested sequence of laboratory tests

#### 4. SCOPE OF REQUIREMENTS FOR WELDERS

The standard EN 14730-2 covers:

- qualifications of aluminothermic welders;
- approval of aluminothermic welding contractors;
- Acceptance of welds.

The minimum information requirements shown in Annex A and B of this standard are normative. The format is informative. The standard contains "alternative requirements" in certain clauses, which enable a railway authority to select a position that will protect those principles which might be considered as "sovereign rights."

When installing aluminothermic welds in track across Europe, railway authorities, process suppliers and contractors shall comply with rules, regulations and codes of practice pertaining to the country where the work is executed.

The initial training and testing shall be conducted in a training establishment. The process supplier shall provide the process manual and determine the duration of training and the minimum number of welds to be made.

The initial training shall be carried out in accordance with the supplier's process manual. In addition to the welding processes the initial training shall include as a minimum:

- basic safety items relating to the process;
- cause and effect of operating outside of the correct processes;
- rail identification;
- basic grinding;
- visual weld inspection.

The training shall conclude with a practical and theoretical test or tests so designed to confirm the trainees' ability to carry out the aluminothermic welding of rails in accordance with the requirements of that supplier's process manual. Upon the

successful completion of training and testing the welder shall be issued with a Diploma in Aluminothermic Welding of Rails by the training establishment. The minimum information to be given on the diploma is:

- Full name of the welder and date of birth;
- Date of examination;
- Number of diploma;
- Process supplier;
- Rail cutting method(s);
- Issuing railway authority;
- Signature of the issuing railway authority;
- Surrender conditions.

The railway authority shall, at any time, withdraw the Permit to Weld upon evidence of poor performance by the welder and ask the employer to return it. The railway authority shall also withdraw the Permit to Weld upon accepted documented notification from the employer. The employer shall return it to the railway authority. Upon request from the employer, the Permit to Weld shall be renewed by the railway authority as may be necessary to reflect the maintenance and/or extension of the welder's skills. Such renewal shall require receipt of the relevant qualifying information from the employer.

#### 5. CONCLUSION

The described standards are significant because they are a complete break from tradition that is the inclusion of quality assurance and inspection clause as part of product integrity.

It is also significant to emphasize all these standards are performance-based. They recognize the European quality management standard EN ISO 9001 and the important new aspect in this group of standards like the integration of a clause on quality management and testing in order to assure the end product integrity.

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