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Design and strength assessment of welded structures from aluminium alloys in railway applications

Technical Code DVS 1608

Replaces May 1983 edition

This technical code is the revised version of the technical code DVS 1608 from May 1983. The revision was initiated to incorporate the new requirements for the assessment of weld performance classes imposed by EN 15085 – taking into account the strength- and safety requirements for welded joints in railway vehicle design. The notch stress concept has been included as a method of evaluation in addition to the nominal stress concept. The procedure to prove static strength has been incorporated as well.

The validity of this technical code has to be agreed between supplier and contracting body.

The technical code was written by representatives of the railway vehicle industry, of "DB AG", of the "Eisenbahn-Bundesamt (EBA)" and of "IMA Materialforschung und Anwendungstechnik GmbH Dresden".

Content:

1 Introduction

This technical code contains recommendations for design and specifications for the design of welded constructions of aluminium alloys as well as a comprehensive table of different types of welded joints (structural details) that are established in railway vehicle design in reference to safety, operability, lightweight design, economic assembly and maintenance.

The procedure to verify the static strength and the fatigue strength of base material and of welded joints is described.

A structural detail catalogue has been prepared for the proof of the endurance strength using the nominal stress concept. In this catalogue, joint details are assigned to the weld performance classes according to DIN EN 15085-3 and to the structural detail

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curves or endurance strength values which have resulted from the revision of the DVS 1608:1983 and which are also an integral part of this technical code. Together with the consideration of different safety categories the requirements of DIN EN 15085 are fulfilled.

The endurance strength limit values relate to the base material as well as to welded component joints in railway applications and to the load assumptions and manufacturing conditions applicable here. That must be considered if these endurance strength values are applied in other fields. The catalogue for welded joints in Appendix B does not make any claim to be complete.

In addition to the nominal stress concept the notch stress concept is introduced as a method for evaluation.

S-N curves (Woehler curves) are given for the fatigue strength verification for the nominal stress concept as well as for the notch stress concept. Thus, an evaluation of the fatigue strength, respectively of the operational durability, based on the cumulative damage approach is enabled.

This technical code is to help structural and design engineers to design welded joints in a way that loads are efficiently sustained by the structure. Additionally, this guideline supports welding and quality assurance engineers for quality and welding issues.

2 Scope

This technical code applies to the design and evaluation of static and fatigue strength in base material and arc welded joints of aluminium alloys used in railway applications, which are listed in the series of standards DIN 5513 as well as DVS 1623. This technical bulletin has to be applied in designs with wall thicknesses of $t \geq 1.5$ mm.

The following alloys are suggested for railway applications:

- Extruded profiles:
  EN AW-6005A, EN AW-6082, EN AW-6060, EN AW-6106
- Sheets, plates and strips:
  EN AW-5083, EN AW-5454, EN AW-5754, EN AW-6082
- Aluminium casting:
  EN AC 21000, EN AC 42000, EN AC 43300, EN AC 51300
- Forgings:
  EN AW-5754, EN AW-5083, EN AW-6005A, EN AW-6082

Semi-finished products made from the alloy EN AW-7020 (AlZn4.5Mg1) show an inherent risk with respect to stress corrosion cracking and to exfoliation corrosion sensitivity.

The design conditions of railway vehicles and the uncertainties due to the influences during operation require that the recommendations of the aluminium producer in reference to the manufacturing methods and to the methods of corrosion protection (e.g. anodizing, coating, painting, heat treating) are strictly followed if the alloy EN AW-7020 is used. Therefore, the use of alloy EN AW-7020 is not recommended for new designs.

If new materials or other wall thicknesses are used, it is necessary to check the applicability of the strength stipulations included in this technical code.

3 Weld process in production and quality assurance

For the design of welded joints in railway applications the requirements of DIN EN 15085 shall be considered.

The design drawings shall be generated following the requirements of DIN EN 15085-3 and of the technical bulletin DVS 1610.

Note:
When adapting drawings of existing welded designs, that were created according to withdrawn regulations (e.g. DIN 6700), to DIN EN 15085, the requirements of the technical bulletin DVS 1623 have to be met. This requirement especially applies when updating the weld performance class and the related inspection class to prove the weld quality (e.g., NDT).

According to DIN EN 15085 a welded structure in railway applications has to meet the requirements of weld ability according to DIN 8528-1. In detail the following applies:

- The weld ability of the materials is given if the requirements of the standards of DIN EN 15085-3, chapter 6.1., are met.
- The weld ability of the welding filler material is given, if these filler materials are qualified and selected for the particular material according to DIN EN 15085-4, chapter 5.3.
- The welding security of the design is given, if the design withstands the loadings in reference to the material behaviour. The requirements of DIN EN 15085-3 and DIN EN 15085-4 have to be met.
- The welding ability in the fabrication is guaranteed, if the structure is manufactured while paying attention to the certification level and to the welding processes possible in the plant.

In addition to the weld ability of the design it is also necessary to assure that the design allows for inspections (prescribed non-destructive evaluation methods have to be possible) and for proper maintenance according to DIN 27201-3 (see also technical bulletin DVS 1620).

The stipulations of DIN EN 15085-2, Appendix A, apply to the assignment of the components and the parts to the certification levels. For the classification of the welded joints to the weld performance classes, Section 8 of this technical code includes simplified definitions with which the stipulations of DIN EN 15085-3, Table 2, are fulfilled. Furthermore details for specifying the safety requirements are listed which comply with DIN EN 15085-3, Appendix G.

Note:
It is important to consider that the categorization of the weld performance class also implies the categorization of the certification level of the components, because the certification level primarily depends on the weld performance class according to DIN EN 15085-2.

Welded designs in railway application complying with DIN EN 15085 are subjected to a weld inspection according to technical bulletin DVS 1620.

3.1 Planning of weld process and design-related recommendations

In the design of welded railway vehicles the manufacturability of the weld joints has to be checked together with the welding engineer.

Welding sequence plans have to be created for complex designs (see technical bulletin DVS 1610).

The weld joint types as well as the requirements with respect to the weld performance class and the inspection effort are to be defined together by the design engineer, the structural engineer and the welding engineer.

3.2 Requirements for production facilities

The workshops in which aluminium is processed must be spatially separated from those in which there are any dusts, gases or fumes which may exert a detrimental influence on the corrosion resistance of aluminium or on the weld quality. If welding is used for any repair activities on the load-bearing vehicle structure, it is necessary to use suitable clamping jigs.

In analogy to the technical code for the workshops, a room temperature of at least 12°C must be guaranteed for the welding of aluminium alloys.

The temperature must be prevented from dropping below this minimum value for the following reasons:

- the manual skills of the welders are restricted,
- higher shrinkage stresses increase the risk of cracking,
- the parameters confirmed at the normal temperature in the welding procedure specifications are no longer assured due to worse penetration behaviour,

Increased condensation water formation may give rise to porosity during welding.