AGREEMENT

Number:	V-DK-006
Titel:	**The application of section 9.4 "Tube connections" of EN 12952-5 as regards the attachment of tubes in drums of water-tube boilers by expanded-welded joints without subsequent heat treatment**
Signatories:	FDBR Vd-TÜV VGB
Publication Date:	December 2013

Agreement Steam Boilers 006
2013-12

between

FDBR FDBR e. V. Fachverband Anlagenbau, Düsseldorf

VdTÜV Verband der TÜV e. V., Berlin

VGB VGB PowerTech e. V., Essen

on

the application of section 9.4 “Tube connections” of EN 12952-5 as regards the attachment of tubes in drums of water-tube boilers by expanded-welded joints without subsequent heat treatment

Preamble

This agreement is intended to supplement the pertinent rules and regulations. It is a collection of experience made, recommendations and, where required, a concretization of the rules and regulations, which, to the best of our knowledge, reflects the state-of-the-art at its date of publication. This agreement aims at ensuring the operational safety of steam boiler plants and their components.

No liability will be taken for the correctness of the contents of this agreement. Patents and other protective rights shall be clarified under the responsibility of the user.

The associations having participated in the establishment of this guideline will appreciate the support and further development of its contents through other national and international associations/institutions.

Contents

1 Scope

Expanded-welded joints shall be used for unheated tubes only.

The requirements of this instruction sheet shall apply accordingly to operationally loaded drums within the course of repairs where expanded tube connections are renewed.

2 Definitions

Expanded-welded joints are connections where tubes are inserted in drum holes, are caused by adequate expansion to come into intimate metallic contact with the containing tube hole, with the tube end then being seal-welded to the drum internal surface.

3 General requirements

Within production, tubes may be attached to drums by expansion and seal welding (types of attachment to DIN 28187: SA, AS, SE, ES)[1] – welding with intimate metallic contact of outside tube surface, AS – intimate metallic contact and welding, SE – welding and expanding, ES – expanding and welding).

Final tube expansion may be obtained by roller-expanding the tubes or mechanical-hydraulic tube expansion. The limit value of the tube expand ratio (for definition see DIN 28187, Annex A) is defined in clause 4.3.

Depending on drum wall thickness, the inner surface areas/depths[2] of the drum holes may be provided with expanding grooves or not.

3.1 Drum materials

The table in section 5 lists the materials for which heat treatment can be renounced.

3.2 Tube materials

The following tube materials may be used:

P235GH, P265GH, P295GH, P355GH, 16Mo3

The chemical composition (cast analysis) of the base material 16Mo3 shall satisfy the following condition: Cr + Ni ≤ 0,30%.

3.3 Drum wall thickness

The limit values shown in the table of section 5 apply to the drum wall thickness.

---

[1] Note: SA – welding with intimate metallic contact of outside tube surface, AS – intimate metallic contact and welding, SE – welding and expanding, ES – expanding and welding

[2] Note: bearing part

3.4 Tube outside diameter

The tube outside diameter is limited to $d_a \leq 114{,}3$ mm.

In the following d is defined as the pertinent average tube hole diameter.

3.5 Minimum pitch dimensions of drum holes

3.5.1 Longitudinal pitch

The minimum dimension for the longitudinal pitch t_l referred to the average drum hole diameter without allowances is: $t_l \geq 2 \bullet d$

3.5.2 Circumferential pitch

The minimum dimension for the circumferential pitch t_u referred to the average drum hole diameter without allowances is: $t_u \geq 1.4 \bullet d$

4 Expansion of tubes during expanding prior to welding

4.1 Preparation

Drum holes, drum internal surface as well as the outer and inner surface of the tube ends to be expanded shall be cleaned to be free from dirt, rust, scale, grease, anticorrosive agents, or the like.

The surface roughness R_a of the drum hole shall not exceed 6,3 µm. In addition, the hole surfaces shall not show spiral or longitudinal score marks (scratches) that may cause leakage. The roughness and cleanliness of the drum holes shall be checked hole by hole and be documented.

The tube ends shall show white metal finish over the expanded length and be straight on a length of $2 \bullet d$.

The drum holes and tube ends shall be clean and dry prior to tube insertion.

4.2 Insertion of tubes

The tubes shall be inserted starting from the drum axis in radial direction from right to left.

The ends of the tubes shall project through the drum not less than 8 nor more than 12 mm.

The tubes may be fixed with bolted clamps.

Tack welding is not permitted.

Greater tube end projections shall be machined upon welding.

4.3 Tube expansion to provide metallic contact

Provision of metallic tube contact in the drum hole is intended to remove the clearance between tube and drum hole and forms the basis for the tube expand ratio. A tube expand ratio of 4% is aimed at during expansion for tube metallic contact.

“In the case of drum hole wall thicknesses up to 40 mm the tube shall be expanded over the full drum hole depth, and in case of greater wall thicknesses only over a depth of 40 mm starting from the inner drum hole wall. In the case of smaller tube diameters an expanded length of 30 mm will suffice.” (cf. VGB-R 501 H, clause 29.1.1).

4.4 Expanding

Expanding shall start with expanding tests. The working pressure required for expanding to obtain the desired tube expand ratio shall be determined on the drum holes measured before to obtain their exact dimensions. (cf. VGB-R 501 H, clause 29.1.2).

The expanding tests shall be recorded to document:

- the inner tube diameter prior to expanding,
- the inner tube diameter upon expanding,
- the inner tube diameter upon welding, if performed,
- the inner tube diameter upon 2nd expanding step.

Where the correct working pressure has been determined, all tubes shall be expanded with this pressure.

The correct selection of expansion parameters shall be checked by at least one expanding test performed on a tube.

The tubes shall be expanded such as to form intimate metallic contact with the containing drum holes. It shall be possible to insert the tubes without exerting force on them. The drum holes shall be clean, circular, free from cracks and, as largely as possible, free from score marks (scratches). Score marks will only be permitted to the extent specified by the purchaser. Out-of-roundness that may disturb and/or work hardening from prior expanding/rerolling steps shall be removed. The drum hole edges shall be smoothed off, but not on the side where the tubes will be welded. The tube ends shall be deburred. Tubes and nozzles intended to be seal-welded shall be expanded without flaring (see Figure 1).

Rolling defects such as expanding with contact on one side only, rolling-over at drum hole ends etc. are not permitted. Prior to seal welding, the expanded tubes/nozzles shall be visually examined to detect inadmissible rolling defects.

5 Welding and test conditions for various drum materials

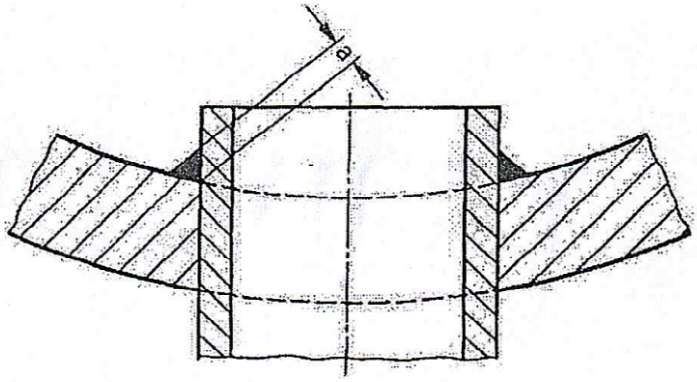
Drum material	Wall thickness [mm]	Work piece temperature or pre-heat temperature	Examination for freedom from cracks to section 8
P235GH, P265GH	Unlimited	≈ 20 °C	no
P295GH	≤ 30	≈ 20 °C	no
16Mo3 P355GH	> 30	> 50 °C	yes
Alloyed drum materials if their suitability has been proved by an expert analysis and opinion report issued by a notified body / an approved inspection body	According to the expert analysis and opinion report issued by notified body / approved inspection body		

6 Principles of welding work

6.1 The areas to be welded shall be preheated to section 5 and the heat input shall be maintained during welding.

The welding sequence shall follow a welding procedure sheet aiming at minimising the residual stresses to be expected.

6.2 The fillet weld – e.g. to **Figure 1** – shall be welded with two layers, with the start and end of the layers being offset to each other. Further details of weld layout shall be laid down in the welding procedure qualification.



Hinweis: Grafik gedreht!

Figure 1: Fillet weld on expanded-welded joint

6.3 The design throat thickness shall be ≤ 5 mm.

6.4 In case of manual metal-arc welding (process 111) basic-type covered electrodes shall be used.

6.5 Checking of the arc or electrode ignition on the drum wall outside the fillet weld area is not permitted. Poor restarts, porosity and crater cracks shall principally be removed prior to welding over.

6.6 Welding shall only be performed by welders who have been approved by a competent third party for the purpose of Annex I (3.1.2) of the Pressure Equipment Directive (PED) 97/23/EC.

6.7 As regards the evaluation of the welds, quality level C to DIN EN ISO applies.

7 Re-rolling of welded tube joints

To avoid shrinkage stresses, flaring of tube ends is required upon welding in the case of tube joints on drum materials such as P355GH and other alloyed drum materials. Flaring shall be made at room temperature to obtain approx. 0,2% of the tube diameter.

8 Examination for freedom from cracks

The examination for freedom from cracks shall be made at random on tube joints with a suitable surface crack detection method in accordance with the table in section 5.

The extent of examination on the material P355GH and other alloyed drum materials shall be at least 25%.

9 Welding procedure qualification

The manufacturer shall evidence that a welding procedure qualification has been approved by a competent third party for the purpose of Annex I (3.1.2) of the Pressure Equipment Directive (PED) 97/23/EC.

10 Evidence to be delivered

Prior to the beginning of work, the manufacturer of roller-expansion joints shall establish a procedure specification sheet to determine all essential steps and quality parameters. This shall include the determination of optimum rolling parameters, i.e. drum hole dimensions, tube dimensions incl. tolerances and tube expand ratio, and wherever required, nozzle annealing records.

Where drum holes have to be re-bored, a supplementary stress analysis is required.

It shall be documented for all drum holes bored that the quality criteria for roll-expanding and welding laid down in the manufacturer's procedure specification sheet have been adhered to.

The inspector of the notified body / approved inspection body shall perform random production checks.

11 Referenced literature

DIN EN ISO 5817	Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections
DIN EN ISO 15614-1:2012-06	Specification and qualification of welding procedures for metallic materials. Welding procedure test. Arc and gas welding of steels and arc welding of nickel and nickel alloys
DIN EN 12952-5:2012-01	Water-tube boilers and auxiliary installations-part 5: Workmanship and construction of pressure parts of the boiler
DIN 28187:2009-09	Shell-and-tube heat exchangers - Tube-to-tubesheet joints
VGB-R 501 H: 2002	Guideline for the construction and inspection of high-capacity steam boilers

Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment (Pressure Equipment Directive – PED), as worded 20th November 2003

12 Former agreements and effective date

This agreement VDK-006 shall replace the agreement 1977/3.

FDBR e. V. Fachverband Anlagenbau

Düsseldorf, 4th December 2013

Signed: Dr. Maaß

VdTÜV Verband der Technischen Überwachungs-Vereine e.V.

Berlin, 6th December 2013

Signed: Dr. Brüggemann

VGB PowerTech e.V.

Essen, 3rd December 2013

Signed: Christensen