



# Engineering Standard

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SAES-W-015

13 December 2011

Strip Lining Application

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Document Responsibility: Welding Standards Committee

## Saudi Aramco DeskTop Standards

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Revised paragraphs are indicated in the right margin

Primary contact: Awwami, Adnan Ni'Mah on 966-3-8809516

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## 1 Scope

- 1.1 This standard specifies the welding and testing requirements for installing a corrosion-resistant strip lining in process equipment as a field modification.

The application of this standard is primarily for pressure vessels, including heat exchangers. This standard is to be considered as a supplement to [SAES-W-010](#). These requirements are in addition to the requirements of ASME SEC VIII and ASME SEC IX.

*Commentary Notes:*

*For new construction where corrosion resistant lining is specified, most SAES equipment standards prohibit the use of strip lining and require cladding or weld overlay.*

*This standard does not apply to Monel sheathing of offshore structures.*

- 1.2 Additional requirements may be contained in Scopes of Work, Drawings, or other Instructions or Specifications pertaining to specific items of work.
- 1.3 Any reference to Consulting Services Department (CSD) shall be interpreted as the CSD Welding Specialist or a representative designated by CSD.
- 1.4 This entire standard may be attached to and made a part of purchase orders.

## 2 Conflicts and Deviations

- 2.1 Any conflicts between this Standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.
- 2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

## 3 References

Unless stated otherwise, all Codes, Standards, and Drawings referenced in this Standard shall be of the latest issue (including revisions, addenda, and supplements) and are considered a part of this Standard.

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### 3.1 Saudi Aramco References

#### Saudi Aramco Engineering Procedure

[SAEP-302](#)

*Instructions for Obtaining a Waiver of a  
Mandatory Saudi Aramco Engineering  
Requirement*

#### Saudi Aramco Engineering Standards

[SAES-W-010](#)

*Welding Requirements for Pressure Vessels*

[SAES-W-014](#)

*Weld Overlays and Welding of Clad Materials*

#### Saudi Aramco Standard Drawing

[AB-036367](#)

*Joint Preparation and Welding Details - Alloy and  
Clad Pressure Vessels and Heat Exchangers*

### 3.2 Industry Codes and Standards

#### American Society of Mechanical Engineers

*ASME SEC VIII D1*

*Rules for Construction of Pressure Vessels*

*ASME SEC VIII D2*

*Rules for Construction of Pressure Vessels,  
Alternative Rules*

*ASME SEC IX*

*Welding and Brazing Qualifications*

## 4 General

- 4.1 All strip lining shall conform with ASME SEC VIII requirements (Division 1 or Division 2, as appropriate) and the requirements of this standard.

*Commentary Note:*

*Refer to ASME SEC VIII D1, Part UCL and ASME SEC VIII D2, Part 4, 6 and 7 for specific requirements.*

- 4.2 Acceptable welding processes are SMAW, GMAW (including short-circuiting mode), and GTAW.

*Commentary Note:*

*The use of the short-circuiting mode of GMAW is permitted for strip lining applications even though it is prohibited for general vessel fabrication.*

- 4.3 Strip lining shall not be used for the following applications:

- a) For applications with maximum design temperatures above 427°C.
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- b) If post weld heat treatment is required after installation of the lining.
  - c) For hydrogen service.
- 4.4 The lining material shall be suitable for the service conditions (e.g., corrosion resistance, service fluid, operating conditions). The lining material shall be either 316L stainless steel or Monel unless another material is specified in the Engineering Design and is approved by CSD.
- 4.5 The size of strips shall be determined as follows:

- 4.5.1 The lining material shall be at least 2 mm thick for Monel and at least 3 mm thick for austenitic stainless steel.

*Commentary Note:*

*Strips less than 3 mm thickness are easier to handle but are more prone to welding difficulties during installation and buckling during service. Thicknesses above 3.5 mm are difficult to handle and to form to the proper curvature.*

- 4.5.2 Monel strips shall be 100 mm wide maximum if the strip thickness is less than 3 mm and 150 mm wide maximum if the strip thickness is 3 mm or greater.
- 4.5.3 The width of 316L stainless steel strips and all other austenitic stainless steel materials shall vary according to operating temperature as follows:

<b>Temperature</b>	<b>Maximum Width</b>
Up to 316°C	100 mm
Over 316°C	75 mm

- 4.5.4 For other materials, the width of the strips shall be determined by CSD based on the material specification and design temperature but shall not exceed 100 mm.
- 4.5.5 The length of strips may be varied to suit the particular component to be lined, although the optimum length is about 750 - 1000 mm based on ease of handling and fitup.
- 4.5.6 Cutting of sheet and strip material shall be done using shearing, mechanical cutting, or plasma cutting. Thermal cutting methods other than plasma are not permitted.

## 5 Lining Methods

- 5.1 The lining may be attached to the component shell by either of two acceptable methods:
- a) Butt-welded method ("tiled method").
  - b) Lap method ("shingle method").

Plug welded linings are not acceptable.

- 5.2 Butt-welded ("tiled") linings shall be attached as shown in Figure 1, with a three pass (minimum) weld attaching the individual strips to the component shell and to each adjacent strip. The first two passes (Welds A and B of Figure 1) are fillet welds that attach each strip to the component shell. If these two fillet welds do not overlap, then an additional fill pass (or passes) (Weld C) shall be made between the fillet welds. A final covering pass (or passes) (Weld D) is made on top of and completely covers the first passes. The final covering pass shall provide a low dilution weld (see 6.1 regarding chemical analysis requirements for the procedure qualification).

*Commentary Note:*

*It is critical that the final covering pass(es) completely cover the previous layers and has at least one complete layer between it and the base metal in order to provide a low dilution weld deposit where it is in contact with the service fluid. If potential corrosion problems of the attachment welds due to weld dilution effects are a significant concern, then the lap welded method should be selected.*

- 5.3 Lap welded ("shingled") linings are attached as shown in Figure 2, with single pass fillet welds (multipass is acceptable) attaching each strip to either the component shell (Figure 2, Weld 1) or to the adjacent overlapped strip (Figure 2, Weld 2).

*Commentary Note:*

*Since only the top welds attaching one lining strip to the adjacent strip underneath is in contact with the service fluid, there are no requirements governing dilution with the base metal since a filler metal matching the lining material is used for this weld.*

- 5.4 For Monel linings, all welding shall use ENiCu-7/ERNiCu-7 consumables. ||

For 316L linings, all welding shall use E309MoL/ER309LMo consumables for all passes or ENiCrFe-3/ERNiCr-3 for all passes (mixing of the electrode types is not permitted). If nickel-based electrodes are used, their suitability for the operating conditions and service fluid shall be evaluated.

*Commentary Note:*

*Nickel-based materials may not be suitable for some applications, such as high temperature sulfur-containing environments.*

ENiCrMo-3/ERNiCrMo-3 are acceptable substitutes for ENiCrFe-3/ ERNiCr-3.

- 5.5 For component shells, the orientation of the strips shall be circumferential. For vertical components using the lap method, the lap shall be downward (the upper strip shall lap on top of the lower strip, i.e., self-draining).
- 5.6 All welds shall be continuous.
- 5.7 Heads shall be lined using the same methods as required for the shells except that the orientation of strips shall be as shown in Figure 3.
- 5.8 Connections less than 300 mm diameter may be lined using a “one-piece” liner as shown in Figure 4. A 50 mm wide lining ring shall be used to bridge between the shell lining and the connection lining. The ring shall be installed after the nozzle is welded to the component shell and both the shell and nozzle linings have been completed. For flanged connections, the strip lining inside the connection shall be installed onto a weld overlay on the bore and flange face, as shown in Figure 4 and Standard Drawing [AB-036367](#).

Connections 300 mm diameter and larger shall use strip lining.

*Commentary Note:*

*Nozzles may be weld overlaid (refer to [SAES-W-014](#)) or clad as an alternative to strip lining. The use of solid alloy connections is prohibited by other vessel standards.*

## 6 Qualification Requirements

- 6.1 The welding procedure for attaching the lining shall be qualified in accordance with ASME SEC IX, using the following test coupons. Existing ASME SEC IX procedures using general butt weld or fillet welding qualifications are not acceptable.

For the butt-weld ("tiled") method, the test piece shall consist of two adjacent 100 mm x 50 mm minimum size liner pieces that are welded completely around their circumferences onto a 10 mm minimum thickness base material of the appropriate P-number. The PQR liner thickness shall be selected so that the actual production liner thickness is within the qualification range as specified in 6.2.2. The weld between the two adjacent strips shall be completed in the sequence as shown in Figure 1.

For the lap weld (“shingle”) method, the test shall consist of a 100 mm x 50 mm minimum size liner piece that is welded completely around its circumference onto a 10 mm minimum thickness base material of the appropriate P-number. Another similar or smaller size liner piece shall be lapped over the first strip and fillet welded around its entire circumference.

Each test piece, including the butt-weld (“tiled”) method, shall be sectioned, polished, and etched in at least one location across the long axis weld and examined in accordance with ASME SEC IX QW-218 and applicable sections of ASME Section VIII Div. 1 or Div. 2. The butt-weld method test piece shall also have the weld deposit chemistry analyzed for the final covering pass (Figure 1, Weld D). The analysis shall include Ni, Cr, Cu, Mo, and Fe. The measured deposit chemistry shall meet the following requirements:

#### **Monel Lining Weld**

Fe	7% maximum
Ni	57% minimum
Cu	23% minimum

#### **316L Lining Weld**

Cr	17.0% minimum
Ni	10.5% minimum
Mo	2.0% minimum

### **6.2 Essential Variables**

The following shall be considered essential variables in addition to those specified in ASME SEC IX.

- 6.2.1 Any change in the P-number for either the base material or the lining material.
  - 6.2.2 For lining thicknesses less than 3 mm, the minimum lining thickness shall be restricted to the actual lining thickness used for the PQR.
  - 6.2.3 Any change in the F-Number, A-Number, or AWS classification for the electrode or consumable.
  - 6.2.4 For SMAW and GMAW, the size of electrode used for the PQR shall be the maximum size qualified.
  - 6.2.5 Any change in the current type or polarity.
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- 6.2.6 For GMAW, any change in the mode of transfer.
- 6.2.7 Any change in position.
- 6.2.8 For the vertical position, any change in the direction of welding (vertical up to vertical down or vice-versa).

### 6.3 Performance qualification

All welders shall be qualified in accordance with ASME SEC IX.

## 7 Installation Requirements

- 7.1 The inside surface of the component to be lined shall be cleaned thoroughly by sandblasting, grit blasting, bead blasting, or grinding. The cleaned surface shall be inspected for defects. Any defect that affects the rating of the component must be repaired before the lining is installed.
- 7.2 All handling of lining strips shall be done to maintain its full corrosion resistance.

### *Commentary Notes:*

*Iron contamination by use of steel tools shall be prevented.*

*All tools and equipment coming in contact with the lining material shall not result in any surface contamination. Only stainless steel wire brushes or non-metallic grinding materials shall be used.*

- 7.3 Pre-rolling of the sheets is permitted for all applications and is required for diameters less than 609 mm.
- 7.4 The strip installation and welding sequences, including the number and spacing of tack welds, shall minimize distortion, buckling, and warpage of the lining during welding.

The individual strips shall be installed with a close fit to the base material

- 7.5 An air pressure test or a vacuum box test shall be performed on all exposed welds. After completely welding the circumference of each strip, the air or vacuum test shall be conducted. Any leaks or defects shall be repaired before installing the next strip.

The air test shall be performed by installing a 3.75-6.35 mm tapped nipple in the lining and testing with a dry inert gas at 5-10 psi. All welds in the section being tested shall be coated with a soap solution. After satisfactory completion of the air test, the tapped nipple shall be removed and a weld bead shall be made over the test hole or a small patch shall be fillet welded over the hole. The electrode



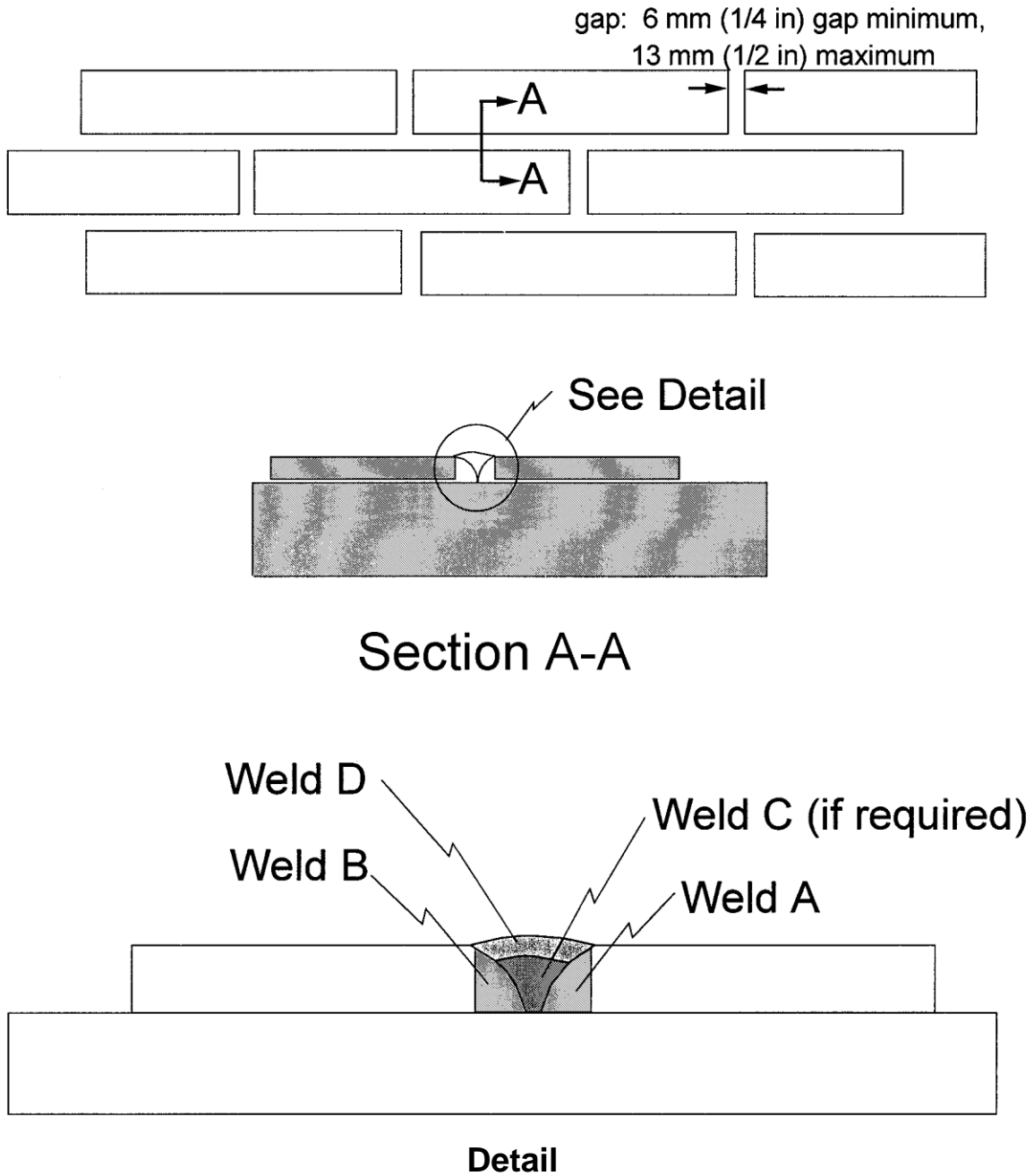
shall be the same type as specified in 5.4. The welds sealing the test hole shall be inspected using liquid penetrant.

**Revision Summary**

13 December 2011

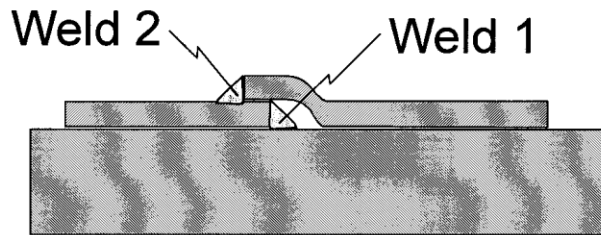
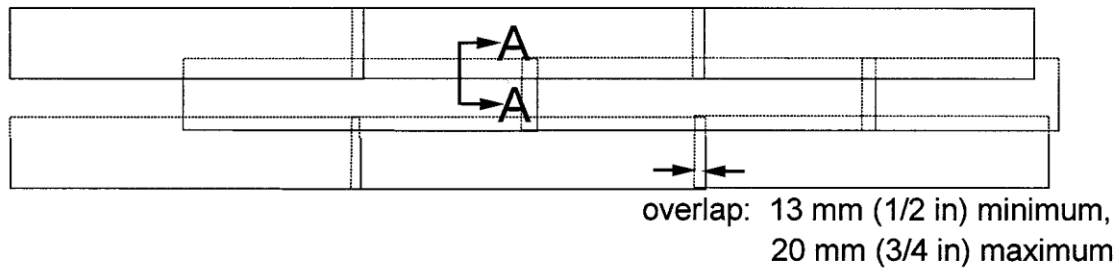
Revised the "Next Planned Update". Reaffirmed the contents of the document and reissued with minor changes.

**Figure 1 – Butt-Welded Design**



**Figure 2 – Lap-Welded Design**

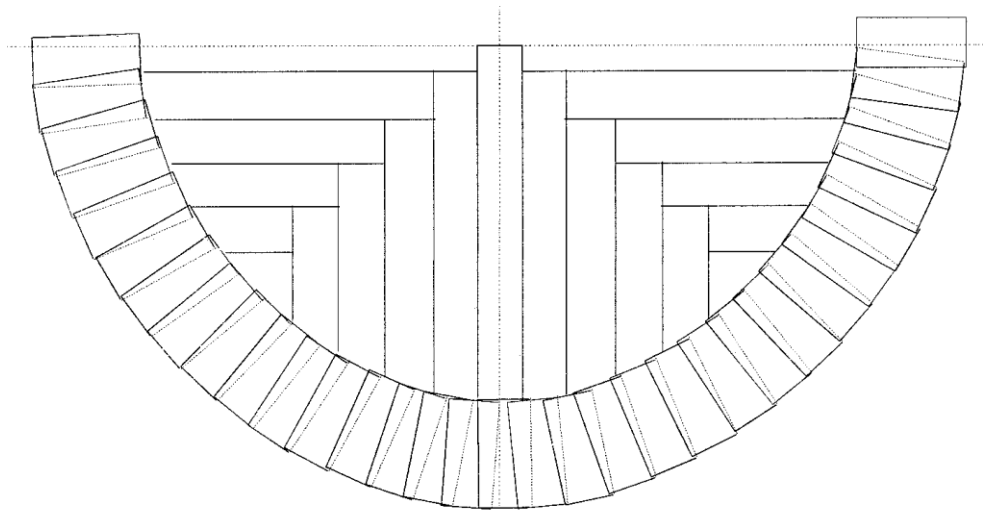
**LAP-WELDED DESIGN**



**Section A-A**

### Figure 3 – Lining Arrangement for Heads

### Symmetrical About Centerlines



**Figure 4 – Lining Arrangement for Small Connections**

