

## Design of Pressure Vessel with Metal Lining

### Procedure

This Standard replaces and cancels its previous revision.

The CONTEC - Authoring Subcommittee provides guidance on the interpretation of this Standard when questions arise regarding its contents. The Department of PETROBRAS that uses this Standard is responsible for adopting and applying the sections, subsections and enumerates thereof.

**Technical Requirement:** A provision established as the most adequate and which shall be used strictly in accordance with this Standard. If a decision is taken not to follow the requirement ("non-conformity" to this Standard) it shall be based on well-founded economic and management reasons, and be approved and registered by the Department of PETROBRAS that uses this Standard. It is characterized by imperative nature.

**Recommended Practice:** A provision that may be adopted under the conditions of this Standard, but which admits (and draws attention to) the possibility of there being a more adequate alternative (not written in this Standard) to the particular application. The alternative adopted shall be approved and registered by the Department of PETROBRAS that uses this Standard. It is characterized by verbs of a nonmandatory nature. It is indicated by the expression: **[Recommended Practice]**.

Copies of the registered "non-conformities" to this Standard that may contribute to the improvement thereof shall be submitted to the CONTEC - Authoring Subcommittee.

Proposed revisions to this Standard shall be submitted to the CONTEC - Authoring Subcommittee, indicating the alphanumeric identification and revision of the Standard, the section, subsection and enumerate to be revised, the proposed text, and technical/economic justification for revision. The proposals are evaluated during the work for alteration of this Standard.

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## CONTEC

Comissão de Normalização  
Técnica

## SC - 02

Tanks and Vessels

### Introduction

*PETROBRAS Technical Standards are prepared by Working Groups - WG (consisting specialized of Technical Collaborators from Company and its Subsidiaries), are commented by Company Units and its Subsidiaries, are approved by the Authoring Subcommittees - SCs (consisting of technicians from the same specialty, representing the various Company Units and its Subsidiaries), and ratified by the Executive Nucleus (consisting of representatives of the Company Units and its Subsidiaries). A PETROBRAS Technical Standard is subject to revision at any time by its Authoring Subcommittee and shall be reviewed every 5 years to be revalidated, revised or cancelled. PETROBRAS Technical Standards are prepared in accordance with PETROBRAS Technical Standard [N-1](#). For complete information about PETROBRAS Technical Standards see PETROBRAS Technical Standards Catalog.*

## Foreword

This Standard is the English version (issued in 12/2012) of PETROBRAS N-1707 REV. C 11/2010. In case of doubt, the Portuguese version, which is the valid document for all intents and purposes, shall be used.

## 1 Scope

1.1 This Standard establishes the requirements which are complementary to ASME BPVC [Section VIII](#) for the design and fabrication of pressure vessel with metallic lining of stainless steel, nickel and nickel alloys.

1.2 This Standard complements PETROBRAS Standards [N-253](#) and [N-268](#), which shall be adhered to in all applicable subjects.

1.3 This Standard applies to designs starting as of its date of issuance.

1.4 This Standard contains only Technical Requirements.

## 2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document applies.

PETROBRAS [N-133](#) - Soldagem;

PETROBRAS [N-253](#) - Projeto de Vaso de Pressão;

PETROBRAS [N-268](#) - Fabricação de Vaso de Pressão;

PETROBRAS [N-1591](#) - Ligas Metálicas e Metais - Identificação Através de Testes pelo Ímã e por Pontos;

PETROBRAS [N-1594](#) - Ensaio Não-Destrutivo - Ultra-Som;

PETROBRAS [N-1596](#) - Ensaio Não Destrutivo - Líquido Penetrante;

ASME BPVC [Section II Part A](#) - Ferrous Material Specifications;

ASME BPVC [Section VIII](#) - Rules for Construction of Pressure Vessels;

ASTM [A 262](#) - Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels<sup>1</sup>;

AWS [A4.2](#) - Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Ferritic-Austenitic Stainless Steel Weld Metal.

NOTE For documents referred in this Standard and for which only the Portuguese version is available, the PETROBRAS department that uses this Standard should be consulted for any information required for the specific application.

## 3 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

**3.1****pressure vessel with metal lining**

vessel built with base material covered with metallic material which is resistant to corrosion, manufactured from clad plates or by weld overlay

NOTE Clad plates may be obtained by co-lamination, vacuum explosion or conventional explosion, the latter being limited to 19mm base material minimum thickness.

**3.2****PWHT**

post weld heat treatment

**4 Design****4.1 Thicknesses**

4.1.1 Regardless of lining type, only the base material thickness shall be considered for mechanical strength. The lining shall only be considered as overthickness for corrosion, erosion or protection against fluid contamination.

4.1.2 For clad plates, the final thickness shall consider the minimum thickness of both base material and metallic lining, including the fabrication tolerances.

4.1.3 When it is not specified, lining thickness shall not be lower than the following values:

- a) clad plates with stainless steels lining: 3.0mm;
- b) clad plates with nickel or nickel alloys lining: 3.0mm;
- c) weld overlay: 3.0mm, deposited without dilution.

**4.2 Vessel's Dimensional Limitations**

4.2.1 The vessel's minimum internal diameter with metal lining shall be 610mm. In case it needs a smaller diameter, the vessel shall be manufactured integrally with the lining material.

4.2.2 For plates which are clad by conventional explosion, the base material thickness shall be at least 19mm.

**4.3 Materials**

4.3.1 Clad plates shall adhere to the applicable requirements of the material specifications SA-263, SA-264 or SA-265, from ASME BPVC [Section II Part A](#).

NOTE All plates shall be supplied with a certificate, proving the execution of the shear strength test.

4.3.2 Welding consumables shall comply with standard PETROBRAS [N-133](#).

4.3.3 Material specification of internal accessories shall comply with the material specifications of the vessel component which it is welded. Therefore, if it is welded to the lining, shall adhere to the material specification of the lining, if it is welded to the base metal, adhere to the material specification of the base metal and apply the metal lining by weld overlay.

4.3.4 The metal lining of the flanges shall be executed by weld overlay.

4.3.5 For equipment submit to PWHT with lining in austenitic stainless steel, even if not specified, the lining material shall be less susceptible to sensitization (with low carbon or stainless steel stabilized), due to exposure to temperatures higher than 450°C.

#### **4.4 Preparation of the Weld Groove for Cladded Plate**

The preparation of the weld groove for cladded plate shall be according to Figure A.1.

#### **4.5 Internal Parts Welded to the Shell and Heads**

4.5.1 All internal accessories shall be welded directly on the metal lining, except when local loading exceeds the resistance of the bond between the lining and the base metal, in which case it shall be welded directly to the base metal.

4.5.2 Materials of internal parts and the filler metal shall be resistant to corrosion and be compatible with the lining material.

#### **4.6 Nozzles**

##### **4.6.1 General Requirements**

Weld overlay of flanges and blind flanges shall be done according to Figure A.2. Lining on the gasket face of the flanges shall be machined for the finishing specified on the design.

##### **4.6.2 Nozzle Construction**

4.6.2.1 Nozzles with a nominal diameter up to 1 1/2" shall be integrally built with LWN flange as shown in Figure A-3. For vessels with a Ferritic stainless steel lining, the flange shall be made of austenitic stainless steel. For linings on austenitic stainless steel or nickel or nickel alloys, the flange shall be made of the same lining material.

4.6.2.2 Nozzles with nominal diameter from 2" to 4" (inclusive), shall be integrally built with LWN or WN flange with a neck made of seamless tube, as in Figure A.3 or with weld overlay lining, as in Figure A.4.

4.6.2.3 Nozzles with nominal diameter from 6" to 12" (inclusive), shall be made of a WN flange with a neck made of seamless tube, with weld overlay lining, as in Figure A.4.

4.6.2.4 Nozzles with nominal diameter of 14" and greater, the neck shall be made of a cladded plate or by weld overlay, as in Figures A.4 and A.5. When made of cladded plates, only a longitudinal weld is allowed.

4.6.2.5 When the nozzle has an internal projection, the details in Figures A.6 and A.7 shall apply.

## **5 Fabrication**

### **5.1 General Requirements**

5.1.1 Vessels with metal lining subject to PWHT shall have their procedure previously approved by PETROBRAS.

5.1.2 Lining with weld overlay of nickel or nickel alloys shall be made with more than one layer, with special caution to prevent iron contamination. In order to check such contamination, perform a copper sulfate test as specified on 6.3.

5.1.3 For head fabrication, the forming process shall not damage the metal lining nor reduce its thickness below what is specified on the design.

5.1.4 The lining shall be mechanically removed, and the use of a graphite electrode is not acceptable.

### **5.2 Welding**

5.2.1 All welding requirements shall be in accordance with PETROBRAS [N-133](#).

5.2.2 For austenitic stainless steel, the ferrite number content in the weld overlay shall be between 3 FN and 8 FN, measured with a ferritescope calibrated according to AWS [A4.2](#).

5.2.3 The welding procedure shall include an intergranular corrosion test according to ASTM [A 262](#) Practice A.

5.2.4 For vessels with clad plates, clad restoring on the welded joints of the base metal shall be made with at least two passes, with the base metal welding being totally covered by the first pass. The removal of up to 1.0mm of base metal is allowed, provided the base metal thickness is not lower than the minimum required.

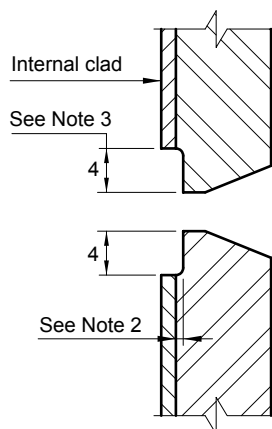
## **6 Inspection and Tests**

6.1. Cladded plates for vessels shall be ultrasonically tested according to standard PETROBRAS [N-1594](#) and specification SA-578/SA-578M of ASME BPVC [Section II Part A](#), except when indicated otherwise.

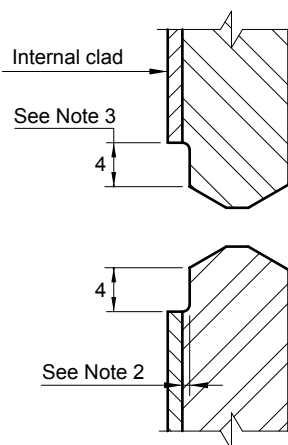
6.2 All clad restoring welds and all welds overlay shall be examined by liquid penetrant (PT), according to PETROBRAS [N-1596](#).

6.3 A copper sulfate check shall be conducted according to standard PETROBRAS [N-1591](#) on welds on clad plates with nickel or nickel alloys, in order to show there is no free iron ion contamination. This test shall also be specified in order to check the clad restoring of the entire base metal prior to the deposition of the last layer pass with nickel or nickel alloys weld.

## Appendix A - Figures



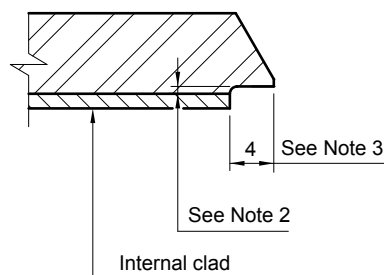
For plates 26-thick or less



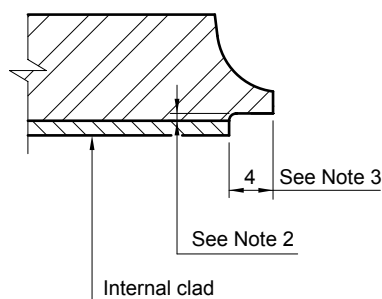
For plates thicker than 26

Joints

Longitudinal and circumferential



For plates 26-thick or less



For plates thicker than 26

**Manual welding**

**Automatic welding**

NOTE 1 Dimensions in millimeters.

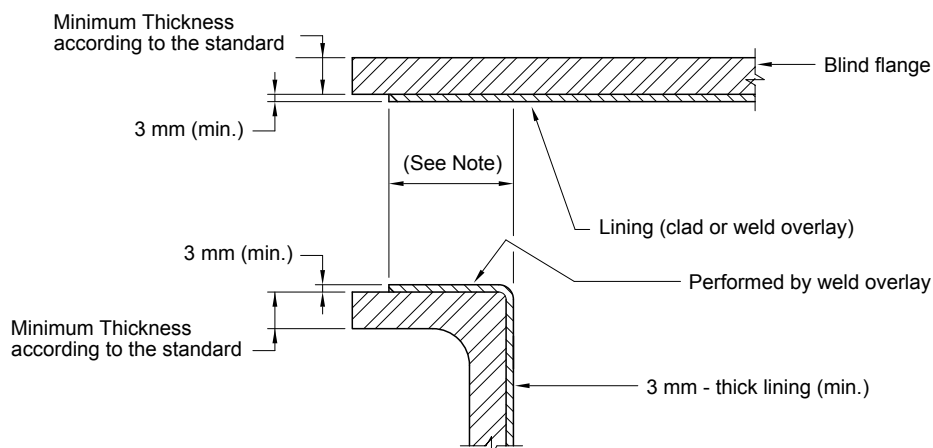
NOTE 2 Maximum allowed depth on base metal when removing lining = 1.0 mm.

NOTE 3 The manufacturer shall remove lining so as to prevent weld metal contamination, respecting the recommended minimum value.

**Figure A.1 - Groove Preparations for Cladded Plates**

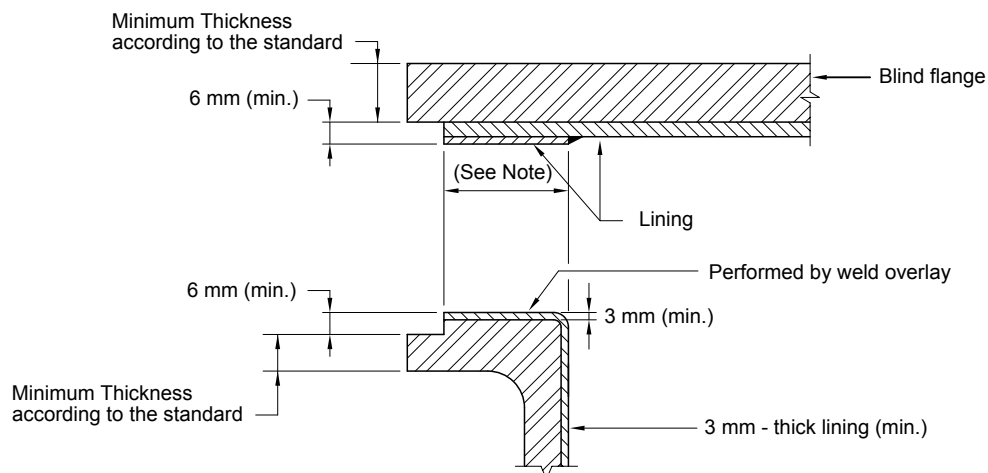
## Raised Face Flange for Pressure Ratings 150 and 300

### Type 1

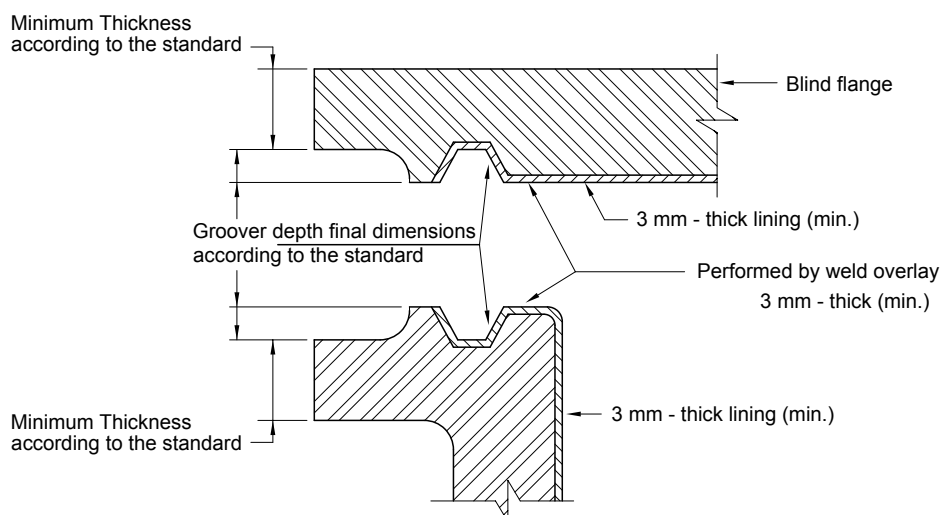


## Raised Face Flange for Pressure Ratings Above 300

### Type 2

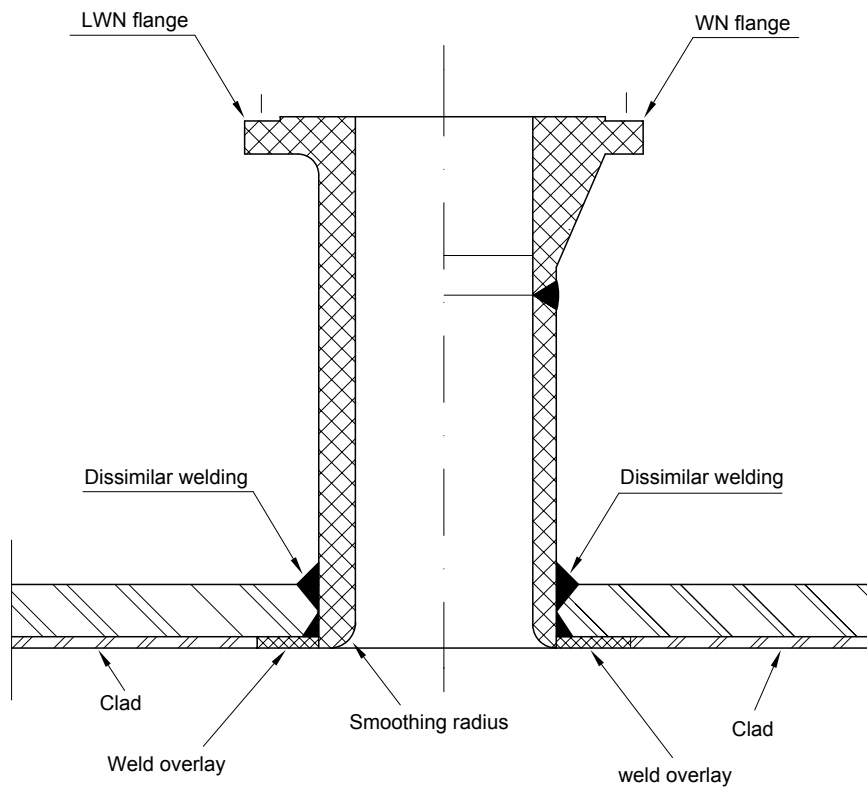


## Ring-Type Gasket Face Flange

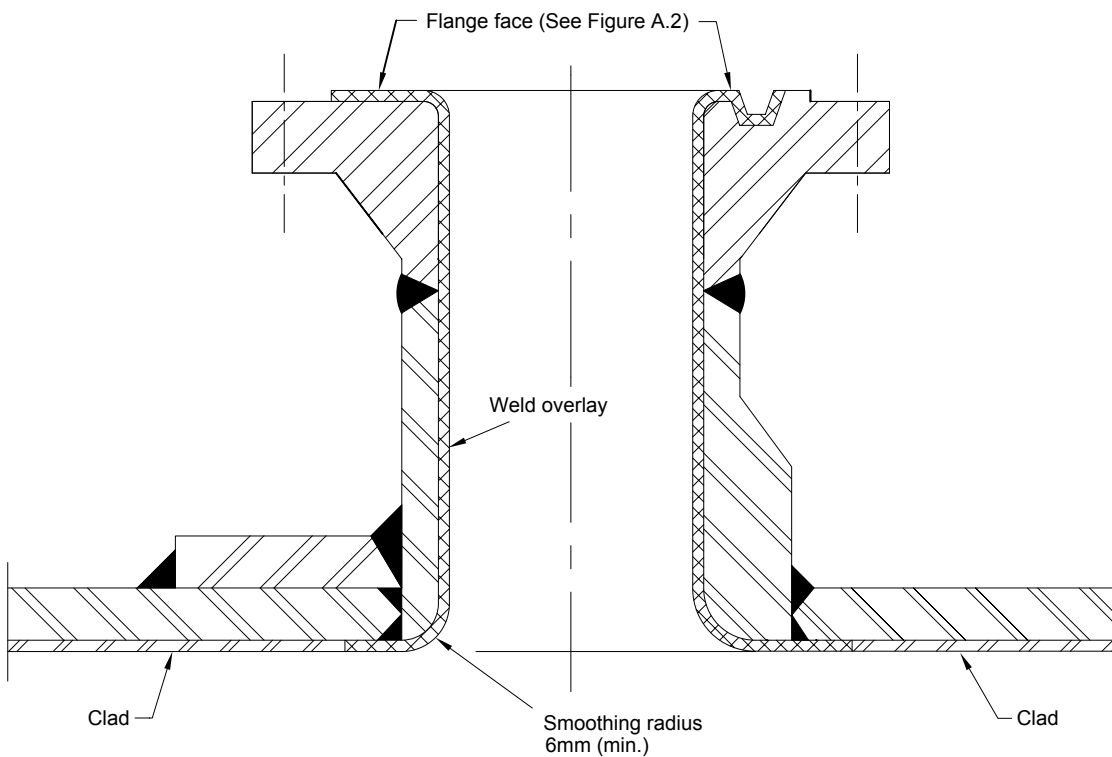


NOTE Flange face finishing shall be done as specified on the equipment drawing.

**Figure A.2 - Flange Face Lining**



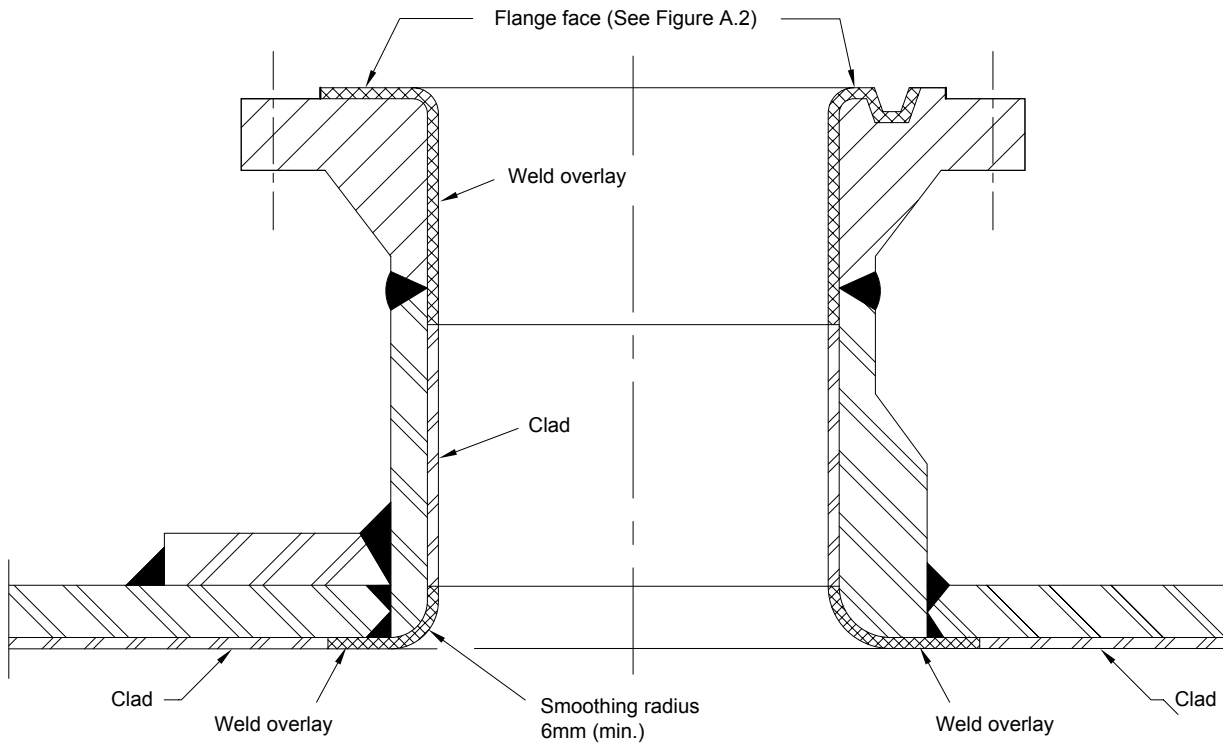
**Figure A.3 - Integral nozzle without Metal Lining**



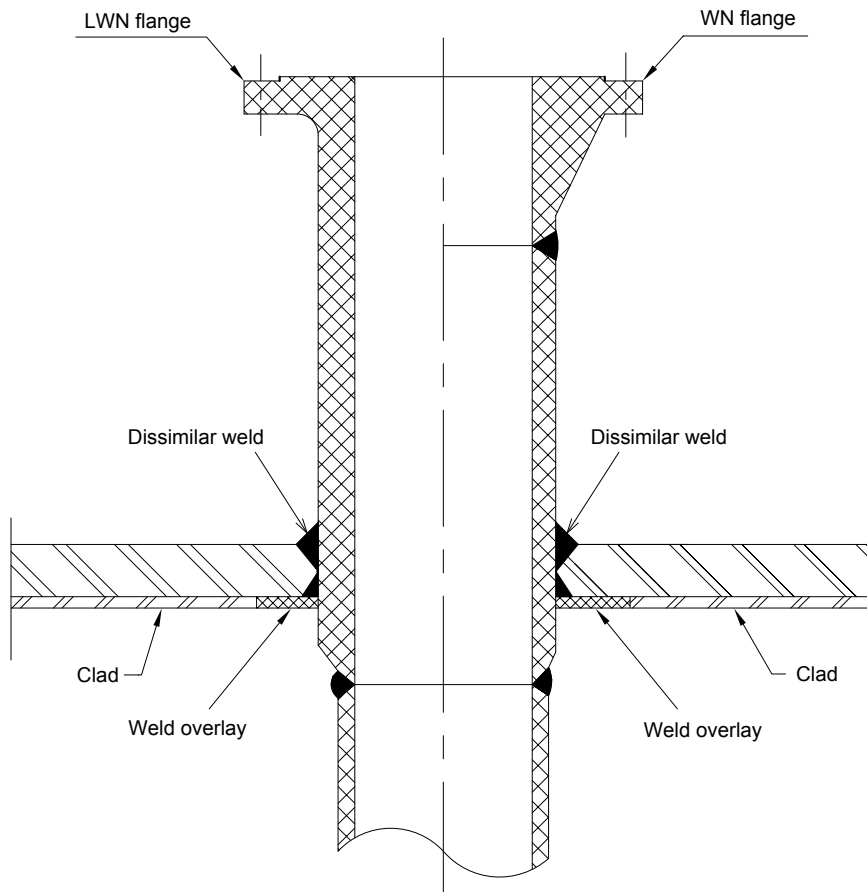
NOTE Weld details are only illustrative and shall be specified by the equipment manufacturer.

**Figure A.4 - Nozzle with Metal Lining by Weld Overlay**



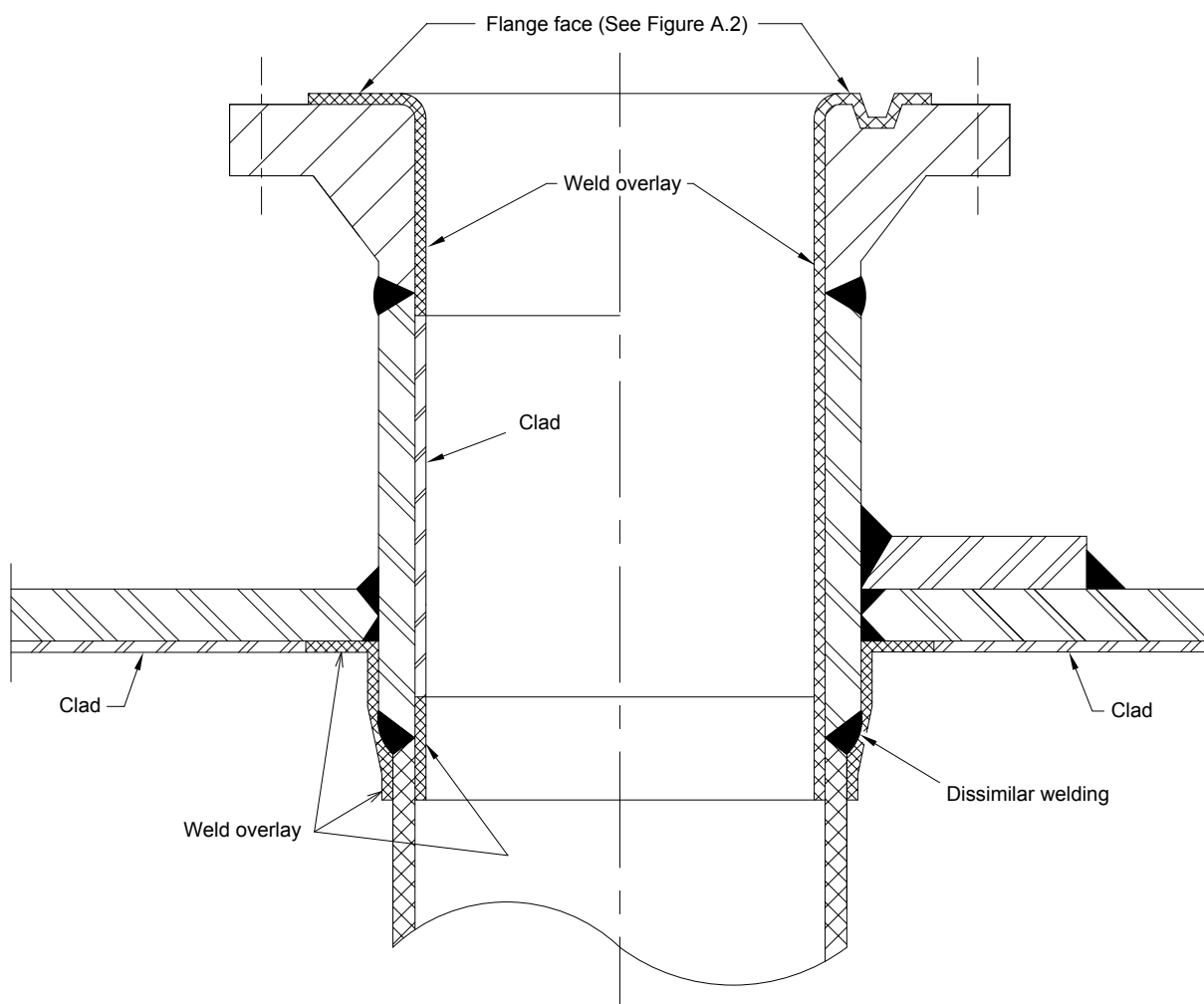


**Figure A.5 - Nozzle with Claddead Neck**



NOTE Weld details are only illustrative and shall be specified by the equipment manufacturer.

**Figure A.6 - Integral Nozzle with Integral Projection**



NOTE Weld details are only illustrative and shall be specified by the equipment manufacturer.

**Figure A.7 - Nozzle Internal projection with Cladded Plate or by Weld Overlay**

