The thickness of the corrosion resistant weld metal overlay cladding deposited by manual processes shall be verified by electrical or mechanical means. One examination shall be made for every head, shell course, or any other pressure-retaining component for each welding process used. The location of examinations shall be chosen by the Inspector except that, when the Inspector has been duly notified in advance and cannot be present or otherwise make the selection, the fabricator may exercise his own judgment in selecting the locations.

UCL-24 MAXIMUM ALLOWABLE WORKING TEMPERATURE

(a) When the design calculations are based on the thickness of base material exclusive of lining or cladding thickness, the maximum service metal temperature of the vessel shall be that allowed for the base material.

(b) When the design calculations are based on the full thickness of base material with corrosion resistant integral or weld metal overlay cladding as permitted in UCL-23(c), the maximum service metal temperature shall be the lower of the values allowed for the base material referenced in Table UCS-23, UF-6, or UHT-23 and listed in Section II, Part D, Subpart 1, Table 1A, or refer to UCL-23(c) for corrosion resistant weld metal overlay cladding and the cladding material referenced in Table UHA-23 or Tables UNF-23.1 through UNF-23.5.

(c) The use of corrosion resistant integral or weld metal overlay cladding or lining material of chromium-alloy stainless steel with a chromium content of over 14% is not recommended for service metal temperatures above 800°F (425°C).

UCL-25 CORROSION OF CLADDING OR LINING MATERIAL

(a) When corrosion or erosion of the cladding or lining material is expected, the cladding or lining thickness shall be increased by an amount that in the judgment of the user will provide the desired service life.

(b) Telltale Holes. The requirements of UG-25(e) and UG-46(b) shall apply when telltale holes are used in clad or lined vessels, except that such holes may extend to the cladding or lining.

UCL-26 THICKNESS OF SHELLS AND HEADS UNDER EXTERNAL PRESSURE

The thickness of shells or heads under external pressure shall satisfy the requirements of the Part of Subsection C applicable to the base material. The cladding may be included in the design calculations for clad material to the extent provided in UCL-23(b) and UCL-23(c).

UCL-27 LOW TEMPERATURE OPERATIONS

The base materials used in the construction of vessels shall satisfy the requirements of UCS-66, UCS-67, UCS-68, Part UF, or UHT-5.

UCL-28 FABRICATION

UCL-29 GENERAL

The rules in the following paragraphs apply specifically to pressure vessels and vessel parts constructed of base material with corrosion resistant integral or weld metal overlay cladding and those having applied corrosion resistant linings, and shall be used in conjunction with the general requirements for Fabrication in Subsection A, and with the specific requirements for Fabrication in Subsection B that pertain to the method of fabrication used.

UCL-30 JOINTS IN INTEGRAL OR WELD METAL OVERLAY CLADDING AND APPLIED LININGS

(a) The types of joints and welding procedure used shall be such as to minimize the formation of brittle weld composition by the mixture of metals of corrosion resistant alloy and the base material.

(b) When a shell, head, or other pressure part is welded to form a corner joint, as in Figure UW-13.2, the weld shall be made between the base materials either by removing the clad material prior to welding the joint or by using weld procedures that will assure the base materials are fused. The corrosion resistance of the joint may be provided by using corrosion resistant and compatible weld filler material or may be restored by any other appropriate means.

NOTE: Because of the different thermal coefficients of expansion of dissimilar metals, caution should be exercised in design and construction under the provisions of these paragraphs in order to avoid difficulties in service under extreme temperature conditions, or with unusual restraint of parts such as may occur at points of stress concentration.

UCL-31 WELD METAL COMPOSITION

Welds that are exposed to the corrosive action of the contents of the vessel should have a resistance to corrosion that is not substantially less than that of the corrosion resistant integral or weld metal overlay cladding or lining. The use of filler metal that will deposit weld metal with practically the same composition as the material joined is recommended. Weld metal of different composition may be used provided it has better mechanical properties in the opinion of the manufacturer, and the user is satisfied that its resistance to corrosion is satisfactory for the intended service. The columbium content of columbium-stabilized austenitic stainless steel weld metal shall not exceed 1.00%, except when a higher columbium content is permitted in the base material welded.

UCL-32 ADD (b) and (c) paragraphs below UCL-27(a)

(b) When an applied corrosion resistant lining is used in accordance with UCL-23(a), the impact test exemption temperature of the component shall consider the base material only.

(c) When a corrosion resistant integral cladding is used in accordance with UCL-23(b) or UCL-23(c), the impact test exemption temperature of the component shall be the warmer of the two values determined for the base material and the integral cladding material. The impact test exemption temperature for the integral cladding material shall be determined in accordance with UHA or UNF as applicable.
3.3.4.2 Forgings are unacceptable if:
(a) The straight beam examination results show one or more discontinuities which produce indications accompanied by a complete loss of back reflection not associated with or attributable to the geometric configuration.
(b) Angle beam examination results show one or more discontinuities which produce indications exceeding in amplitude the indication from the calibration notch.

3.3.4.3 In the case of straight beam examination, the following conditions shall be reported to the purchaser for his consideration and approval prior to shipment of the forging:
(a) Forgings containing one or more indications with amplitudes exceeding adjacent back reflections.
(b) Forgings containing one or more discontinuities which produce traveling indications accompanied by reduced back reflections. A traveling indication is defined as an indication that displays sweep movement of the oscilloscope screen at constant amplitudes as the transducer is moved.

3.3.4.4 In the case of angle beam examination, the following conditions shall be reported to the purchaser for his consideration and approval prior to shipment of the forging:
(a) Indications having an amplitude exceeding 50% of the calibration block amplitude.
(b) Clusters of indications located in a small area of the forging with amplitudes less than 50% of the calibration notch amplitude. A cluster of indications is defined as three or more indications exceeding 10% of the standard calibration notch amplitude and located in any volume approximately a 50 mm (2 in.) or smaller cube.

3.3.4.5 Additional nondestructive examination procedures or trepanning may be employed to resolve questions of interpretation of ultrasonic indications.

3.3.5 MAGNETIC PARTICLE AND LIQUID PENETRANT EXAMINATION OF FORGINGS

3.3.5.1 Following final machining by the manufacturer, all accessible surfaces of forgings having a nominal thickness greater than 100 mm (4 in.), such as contour and variable-thickness nozzles, integrally hubbed tubesheets, standard or custom flanges, and other forgings that are contour shaped or machined to essentially the finished product configuration prior to heat treatment, shall be examined by the magnetic particle method in accordance with ASTM A275/A275M or by the liquid penetrant method in accordance with ASTM E165. The evaluation of indications detected by the magnetic particle method or by the liquid penetrant method and the acceptance standards shall be in accordance with Part 7 of this Division.

3.3.5.2 Unacceptable imperfections shall be removed and the areas shall be reexamined to ensure complete removal of the unacceptable imperfection. Unless prohibited by the material specification, the forgings may be repair welded with the approval of the vessel Manufacturer. Repairs shall be made utilizing welding procedures that have been qualified in accordance with Section IX. The repaired forging shall meet all requirements of this Division.

3.3.6 INTEGRAL AND WELD METAL OVERLAY CLAD BASE METAL

3.3.6.1 Applied Linings. Material used for applied corrosion resistant lining may be any metallic material of weldable quality, provided all applicable requirements of this Division are satisfied.

3.3.6.2 Design Calculations Based on Total Thickness.
(a) Base material with corrosion resistant integral or weld metal overlay cladding used in construction in which the design calculations are based on total thickness including cladding (4.1.9) shall consist of base plate listed in one of the material tables in Part 3 and shall conform to one of the following specifications or utilize weld metal overlay cladding meeting the requirements of this Division.
(1) SA-263, Specification for Corrosion-Resisting Chromium-Steel Clad Plate, Sheet and Strip;
(2) SA-264, Specification for Corrosion-Resisting Chromium-Nickel Steel Clad Plate, Sheet and Strip; or
(3) SA-265, Specification for Nickel and Nickel-Base Alloy Clad Steel Plate.
(b) Base material with corrosion resistant integral cladding in which any part of the cladding is included in the design calculations, as permitted in (a), that is constructed of multiple cladding plates welded together prior being bonded to the base material shall have the cladding-alloy-to-cladding-alloy welding that is performed prior to bonding to the base material:
(1) performed by a Manufacturer holding a Certificate of Authorization.
(2) radiographically examined for their full length in the manner prescribed in 7.5.3. In place of radiographic examination, welds may be ultrasonically examined for their full length (see 7.5.5).
(3) be supplied with a Partial Data Report if that welding is not performed by the vessel Manufacturer.
3.3.6.3 Design Calculations Based on Base-Plate Thickness. Clad plate used in constructions in which the design calculations are based on the base-plate thickness, exclusive of the thickness of the cladding material, may consist of any base-plate material satisfying the requirements of Part 3 and any metallic integral or weld metal overlay cladding material of weldable quality that meets the requirements of 6.5 of this Division.

3.3.6.4 Shear Strength of Bond of Integrally Clad Plates. Integrally clad plates in which any part of the cladding is included in the design calculations, as permitted in 4.1.9, shall show a minimum shear strength of 140 MPa (20 ksi) when tested in the manner described in the plate specification. One shear test shall be made on each such clad plate and the results shall be reported on the test report. A shear or bond strength test is not required for weld metal overlay cladding.

3.3.6.5 Removal of Cladding for Mill Tension Tests. When any part of the cladding thickness is specified an allowance for corrosion, such added thickness shall be removed before mill tension tests.

3.3.7 CLAD TUBESHEETS

3.3.7.1 Tube-to-tubesheet welds in the cladding of either integral or weld metal overlay clad tubesheets may be considered strength welds (full or partial), provided the welds meet the design requirements of 4.18.10. In addition, when the strength welds are to be made in the clad material of integral clad tubesheets, the integral clad material to be used for such tubesheets shall meet the requirements in (a) and (b) for any combination of clad and base materials. The shear strength test and ultrasonic examination specified in (a) and (b) are not required for weld metal overlay clad tubesheets.

(a) Integral clad material shall be shear strength tested in accordance with SA-263. One shear test shall be made on each integral clad plate or forging, and the results shall be reported on the material test report.

(b) Integral clad material shall be ultrasonically examined for bond integrity in accordance with SA-578, including Supplementary Requirement S1, and shall meet the acceptance criteria given in SA-263 for Quality Level Class 1.

3.3.7.2 When the design calculations for clad tubesheets are based on the total thickness including the cladding, the clad material shall meet any additional requirements specified in 3.3.6.

3.3.7.3 When tubesheets are constructed using linings or integral cladding that does not meet the requirements of 3.3.7.1(a) and 3.3.7.1(b), the strength of the tube-to-tubesheet joint shall not be dependent upon the connection between the tubes and the lining or integral cladding, as applicable.

3.3.7.4 When the tubes are strength welded (full or partial) to integral or weld metal overlay clad tubesheets, $S_t$ shall be the allowable stress value of the integral cladding or the wrought material whose chemistry most closely approximates that of the weld metal overlay cladding. The thickness of the integral or weld metal clad overlay material shall be sufficient to prevent any of the strength weld from extending into the base material.

3.4 SUPPLEMENTAL REQUIREMENTS FOR Cr–Mo STEELS

3.4.1 GENERAL

3.4.1.1 The rules in 3.4 include supplemental requirements for fabrication and testing for Cr-Mo steels. The materials and appropriate specifications covered by this paragraph are listed in Table 3.1.

3.4.1.2 Certification that the requirements of 3.4 have been satisfied shall be shown on the Manufacturer’s Data Report Form.

3.4.2 POSTWELD HEAT TREATMENT

The final postweld heat treatment shall be in accordance with the requirements of 6.4.2 of this Division.

3.4.3 TEST SPECIMEN HEAT TREATMENT

3.4.3.1 Two sets of tension specimens and one set of Charpy impact specimens shall be tested. One set each of the tension specimens shall be exposed to heat treatment Condition A. The second set of tension specimens and the set of Charpy specimens shall be exposed to heat treatment Condition B.

(a) Condition A – Temperature shall be no lower than the actual maximum vessel-portion temperature, less 14°C (25°F). Time at temperature shall be no less than 80% of the actual holding time of the vessel portion exposed to the maximum vessel-portion temperature.

(b) Condition B – Temperature shall be no higher than the actual minimum vessel-portion temperature, plus 14°C (25°F). Time at temperature shall be no more than 120% of the actual hold time of the vessel portion exposed to the minimum vessel-portion temperature.
least the most severe condition of coincident pressure and temperature expected in normal operation. Only the chambers that come within the scope of this Division need be constructed in compliance with its provisions. Additional design requirements for chambers classified as jacketed vessels are provided in 4.11.

4.1.8.2 Common Element Design. It is permitted to design each common element for a differential pressure less than the maximum of the design pressures of its adjacent chambers (differential pressure design) or a mean metal temperature less than the maximum of the design temperatures of its adjacent chambers (mean metal temperature design), or both, only when the vessel is to be installed in a system that controls the common element operating conditions.

(a) Differential Pressure Design (Dependent Pressure Chamber). When differential pressure design is permitted, the common element design pressure shall be the maximum differential design pressure expected between the adjacent chambers. The common element and its corresponding differential pressure shall be indicated in the “Remarks” section of the Manufacturer’s Data Report (see 2.3.4) and marked on the vessel (see Annex 2-F). The differential pressure shall be controlled to ensure the common element design pressure is not exceeded.

(b) Mean Metal Temperature Design (Dependent Pressure Chamber). When mean metal temperature design is used, the maximum common element design temperature determined in accordance with 4.1.5.2(d) may be less than the greater of the maximum design temperatures of its adjacent chambers; however, it shall not be less than the lower of the maximum design temperatures of its adjacent chambers. The common element and its corresponding design temperature shall be indicated in the “Remarks” section of the Manufacturer’s Data Report (see 2.3.4) and marked on the vessel (see Annex 2-F). The fluid temperature, flow and pressure, as required, shall be controlled to ensure the common element design temperature is not exceeded.

4.1.9 CLADDING AND WELD OVERLAY

4.1.9.1 The design calculations for integrally clad plate or overlay weld clad plate may be based on a thickness equal to the nominal thickness of the base plate plus $S_c/S_b$ times the nominal thickness of the cladding, less any allowance provided for corrosion, provided all of the following conditions are met.

(a) The clad plate conforms to one of the specifications listed in the tables in Part 3 or is overlay weld clad plate conforming to Part 3.

(b) The joints are completed by depositing corrosion resisting weld metal over the weld in the base plate to restore the cladding.

(c) The allowable stress of the weaker material is at least 70% of the allowable stress of the stronger material.

4.1.9.2 When $S_c$ is greater than $S_b$, the multiplier $S_c/S_b$ shall be taken equal to unity.

4.1.10 INTERNAL LININGS

Corrosion resistant or abrasion resistant linings are those not integrally attached to the vessel wall, i.e., they are intermittently attached or not attached at all. In either case, such linings shall not be given any credit when calculating the thickness of the vessel wall.

4.1.11 FLANGES AND PIPE FITTINGS

(a) ASME B16.5, Pipe Flanges and Flanged Fittings, NPS 1/2 Through NPS 24 Metric/Inch Standard

(b) ASME B16.9, Factory-Made Wrought Buttwelding Fittings

(c) ASME B16.11, Forged Fittings, Socket-Welding and Threaded

(d) ASME B16.15, Cast Copper Alloy Threaded Fittings, Classes 125 and 250

(e) ASME B16.20, Metallic Gaskets for Pipe Flanges

(f) ASME B16.24, Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves, Classes 150, 300, 600, 900, 1500, and 2500

(g) ASME B16.47, Large Diameter Steel Flanges, NPS 26 Through NPS 60 Metric/Inch Standard

Pressure–temperature ratings shall be in accordance with the applicable standard except that the pressure–temperature ratings for ASME B16.9 and ASME B16.11 fittings shall be calculated as for straight seamless pipe in accordance with the rules of this Division including the maximum allowable stress for the material.

4.1.11.3 A forged nozzle flange (i.e., long weld neck flange) may be designed using the ASME B16.5/B16.47 pressure–temperature ratings for the flange material being used, provided all of the following are met.