PART UNF

General

UNF-1	Scope	203
UNF-3	Uses	203
UNF-4	Conditions of Service	203

Materials

UNF-5	General	203
UNF-6	Nonferrous Plate	203
UNF-7	Forgings	203
UNF-8	Castings	203
UNF-12	Bolt Materials	204
UNF-13	Nuts and Washers	204
UNF-14	Rods, Bars, and Shapes	204
UNF-15	Other Materials	204

Design

UNF-16	General	204
UNF-19	Welded Joints	204
UNF-23	Maximum Allowable Stress Values	204
UNF-28	Thickness of Shells Under External Pressure	205
UNF-30	Stiffening Rings	205
UNF-33	Formed Heads, Pressure on Convex Side	205
UNF-56	Postweld Heat Treatment	205
UNF-57	Radiographic Examination	206
UNF-58	Liquid Penetrant Examination	206
UNF-65	Low Temperature Operation	206

Fabrication

UNF-75	General	206
UNF-77	Forming Shell Sections and Heads	207
UNF-78	Welding	207
UNF-79	Requirements for Postfabrication Heat Treatment due to Straining	207

Inspection and Tests

UNF-90	General	208
UNF-91	Requirements for Penetrameter	208
UNF-95	Welding Test Plates	208

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Marking and Reports

UNF-115 General 210

Pressure Relief Devices

UNF-125 General Vessels 210

Appendix NF Characteristics of the Nonferrous Materials (Informative and Nonmandatory)

NF-1 Purpose 210
NF-2 General 210
NF-3 Properties 210
NF-4 Magnetic Properties 210
NF-5 Elevated Temperature Effects 210
NF-6 Low Temperature Behavior 210
NF-7 Thermal Cutting 210
NF-8 Machining 210
NF-9 Gas Welding 211
NF-10 Metal Arc Welding 211
NF-11 Inert Gas Metal Arc Welding 211
NF-12 Resistance Welding 211
NF-13 Corrosion 211
NF-14 Special Comments 211
Aluminum 211
Nickel 211
Titanium or Zirconium 211

Figure

UNF-79 Illustration of Cold Forming Operations for Flaring, Swaging, and Upsetting of Tubing 209

Table

UNF-79 Postfabrication Strain Limits and Required Heat Treatment 208

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PART UNF
REQUIREMENTS FOR PRESSURE VESSELS CONSTRUCTED OF NONFERROUS MATERIALS

GENERAL

UNF-1 SCOPE

The rules in Part UNF are applicable to pressure vessels and vessel parts that are constructed of nonferrous materials and shall be used in conjunction with the general requirements in Subsection A, and with the specific requirements in Subsection B that pertain to the method of fabrication used.

UNF-3 USES

Some of the uses of nonferrous materials are to resist corrosion, to facilitate cleaning of vessels for processing foods, to provide strength or scaling-resistance at high temperatures, and to provide notch toughness at low temperatures.

UNF-4 CONDITIONS OF SERVICE

Specific chemical compositions, heat-treatment procedures, fabrication requirements, and supplementary tests may be required to assure that the vessel will be in its most favorable condition for the intended service. This is particularly true for vessels subject to severe corrosion. These rules do not indicate the selection of nonferrous material suitable for the intended service or the amount of the corrosion allowance to be provided. It is recommended that users assure themselves by appropriate tests, or otherwise, that the nonferrous material selected will be suitable for the intended service both with respect to corrosion and to retention of satisfactory mechanical properties during the desired service life, taking into account any heating or heat treatment that might be performed during fabrication. See also Appendix 6, 6-400, of Section II, Part D.

MATERIALS

UNF-5 GENERAL

(a) All nonferrous materials subject to stress due to pressure shall conform to one of the specifications given in Section II and shall be limited to those listed in Table UNF-23 except as otherwise provided in UG-10 and UG-11.

(b) Appendix NF of this Division of Section VIII and the paragraph entitled *Basis of Purchase* and the appendix of the applicable material specification contain information relative to the fabricating characteristics of the material. They are intended to help the manufacturer in ordering the correct material, and in fabricating it, and to help the producer to select the material best able to fulfill the requirements of the fabricating procedures to be used.

UNF-6 NONFERROUS PLATE

Approved specifications for nonferrous plates are given in Table UNF-23. A tabulation of allowable stress values at different temperatures is given in Table 1B of Section II, Part D (see UG-5).

UNF-7 FORGINGS

Approved specifications for nonferrous forgings are given in Table UNF-23. A tabulation of allowable stress values at different temperatures is given in Table 1B of Section II, Part D (see UG-6).

UNF-8 CASTINGS

Approved specifications for nonferrous castings are given in Table UNF-23. A tabulation of allowable stress values at different temperatures is given in Table 1B of Section II, Part D. These stress values are to

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be multiplied by the casting quality factors of UG-24. Castings that are to be welded shall be of a weldable grade.

UNF-12 BOLT MATERIALS

(a) Approved specifications for bolt materials are given in Table UNF-23. A tabulation of allowable stress values at different temperatures is given in Table 3 of Section II, Part D.

(b) When bolts are machined from heat treated, hot rolled, or cold worked material and are not subsequently hot worked or annealed, the allowable stress values in Table 3 to be used in design shall be based on the condition of the material selected.

(c) When bolts are fabricated by hot-heading, the allowable stress values for annealed material in Table 3 shall apply unless the manufacturer can furnish adequate control data to show that the tensile properties of hot rolled bars or hot finished forgings are being met, in which case the allowable stress values for the material in the hot finished condition may be used.

(d) When bolts are fabricated by cold heading, the allowable stress values for annealed material in Table 3 shall apply unless the manufacturer can furnish adequate control data to show that higher design stresses, as agreed upon, may be used. In no case shall such stresses exceed the allowable stress values given in Table 3 for cold worked bar stock.

(e) Ferrous bolts, studs, and nuts may be used provided they are suitable for the application. They shall conform to the requirements of UCS-10 and 11.

UNF-13 NUTS AND WASHERS

Nuts and washers may be made from any suitable material listed in Table UNF-23. Nuts may be of any dimension or shape provided their strength is equal to that of the bolting, giving due consideration to bolt hole clearance, bearing area, thread form and class of fit, thread shear, and radial thrust from threads [see U-2(g)].

UNF-14 RODS, BARS, AND SHAPES

Rods, bars and shapes shall conform to one of the specifications in Table UNF-23.

UNF-15 OTHER MATERIALS

(a) Other materials, either ferrous or nonferrous, may be used for parts of vessels provided that they are suitable for the purpose intended.

(b) The user shall satisfy himself that the coupling of dissimilar metals will have no harmful effect on the corrosion rate or service life of the vessel for the service intended.

(c) Other materials used in conjunction with nonferrous metals shall meet the requirements given for those materials in other parts of this Division.

DESIGN

UNF-16 GENERAL

The rules in the following paragraphs apply specifically to the design of pressure vessels and vessel parts of nonferrous materials and shall be used in conjunction with the general requirements for *Design* in Subsection A, and with the specific requirements for *Design* in Subsection B that pertain to the method of fabrication used.

UNF-19 WELDED JOINTS

(a) For vessels constructed of titanium or zirconium and their alloys, all joints of Categories A and B shall be of Type No. (1) or No. (2) of Table UW-12.

(b) Titanium or zirconium and their alloys shall not be welded to other materials.

(c) For vessels constructed of UNS N06625, all joints of Categories A and B shall be Type No. (1) or No. (2) of Table UW-12. All joints of Categories C and D shall be Type No. (1) or No. (2) of Table UW-12 when the design temperature is 1000°F (538°C) or higher.

UNF-23 MAXIMUM ALLOWABLE STRESS VALUES

(a) Tables 3 (for bolting) and 1B (other materials) in Section II, Part D give the maximum allowable stress values at the temperatures indicated for materials conforming to the specifications listed therein. Values may be interpolated for intermediate temperatures [see UG-23 and UG-31(a)]. For vessels designed to operate at a temperature colder than −20°F (−29°C), the allowable stress values to be used in design shall not exceed those given for temperatures of −20°F to 100°F (−29°C to 38°C).

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(b) Shells of pressure vessels may be made from welded pipe or tubing listed in Tables UNF-23.1, UNF-23.2, UNF-23.3, UNF-23.4, and UNF-23.5.

(c) When welding or brazing is to be done on material having increased tensile strength produced by hot or cold working, the allowable stress value for the material in the annealed condition shall be used for joint design. One-piece heads and seamless shells may be designed on the basis of the actual temper of the material.

(d) When welding or brazing is to be done on material having increased tensile strength produced by heat treatment, the allowable stress value for the material in the annealed condition shall be used for the joint design unless the stress values for welded construction are given in Table 1B or 3 in Section II, Part D or unless the finished construction is subjected to the same heat treatment as that which produced the temper in the "as-received" material, provided the welded joint and the base metal are similarly affected by the heat treatment.

UNF-28 THICKNESS OF SHELLS UNDER EXTERNAL PRESSURE

(a) Cylindrical and spherical shells under external pressure shall be designed by the rules in UG-28, using the applicable figures in Subpart 3 of Section II, Part D and the temperature limits of UG-20(c).

(b) Examples illustrating the use of the charts in the figures for the design of vessels under external pressure are given in Appendix L.

UNF-30 STIFFENING RINGS

Rules covering the design and attachment of stiffening rings are given in UG-29 and UG-30.

UNF-33 FORMED HEADS, PRESSURE ON CONVEX SIDE

Ellipsoidal, torispherical, hemispherical, and conical heads having pressure on the convex side (minus heads) shall be designed by the rules of UG-33, using figures in Subpart 3 of Section II, Part D having NFA, NFC, NFN, NFT, and NFZ designators. Examples illustrating the application of this paragraph are given in Appendix L.

UNF-56 POSTWELD HEAT TREATMENT

(a) Postweld heat treatment of nonferrous materials is not normally necessary nor desirable.

(b) Except as in (c), (d), and (e) below, no postweld heat treatment shall be performed except by agreement between the user and the Manufacturer. The temperature, time and method of heat treatment shall be covered by agreement.

(c) If welded, castings of SB-148, Alloy CDA 954 shall be heat treated after all welding at 1150°F–1200°F (621°C–649°C) for $1\frac{1}{2}$ hr at temperature for the first inch of cross section thickness plus $\frac{1}{2}$ hr for each additional inch of section thickness. Material shall then be air cooled.

(d) Within 14 days after welding, all products of zirconium Grade R60705 shall be heat treated at 1000°F–1100°F for a minimum of 1 hr for thicknesses up to 1 in. plus $\frac{1}{2}$ hr for each additional inch of thickness. Above 800°F (427°C), cooling shall be done in a closed furnace or cooling chamber at a rate not greater than 500°F/hr (278°C/hr) divided by the maximum metal thickness of the shell or head plate in inches but in no case more than 500°F/hr (278°C/hr). From 800°F (427°C), the vessel may be cooled in still air.

(e) Postweld Heat Treatment of UNS Nos. N08800, N08810, and N08811 Alloys

(1) Pressure boundary welds and welds to pressure boundaries in vessels with design temperatures above 1000°F fabricated from UNS No. N08800 (Alloy 800), UNS No. N08810 (Alloy 800H), and UNS No. N08811 (Alloy 800HT) shall be postweld heat treated. The postweld heat treatment shall consist of heating to a minimum temperature of 1625°F (885°C) for $1\frac{1}{2}$ hr for thicknesses up to 1 in. (25 mm), and for $1\frac{1}{2}$ hr + 1 hr/in. of thickness for thicknesses in excess of 1 in. (25 mm). Cooling and heating rates shall be by agreement between the purchaser and fabricator. As an alternative, solution annealing in accordance with the material specification is acceptable. Postweld heat treatment of tube-to-tubesheet and expansion bellows attachment welds is neither required nor prohibited.

(2) Except as permitted in (3) below, vessels or parts of vessels that have been postweld heat treated in accordance with the requirements of this paragraph shall again be postweld heat treated after welded repairs have been made.

(3) Weld repairs to the weld metal and heat affected zone in welds joining these materials may be made after the final PWHT, but prior to the final hydrostatic test, without additional PWHT. The weld

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repairs shall meet the requirements of (e)(3)(a) through (e)(3)(d) below.

(a) The Manufacturer shall give prior notification of the repair to the user or to his designated agent and shall not proceed until acceptance has been obtained.

(b) The total repair depth shall not exceed $\frac{1}{2}$ in. (13 mm) or 30% of the material thickness, whichever is less. The total depth of a weld repair shall be taken as the sum of the depths for repairs made from both sides of a weld at a given location.

(c) After removal of the defect, the groove shall be examined. The weld repair area must also be examined. The liquid penetrant examination method, in accordance with Appendix 8, shall be used.

(d) The vessel shall be hydrostatically tested after making the welded repair.

UNF-57 RADIOGRAPHIC EXAMINATION

(a) Vessels or parts of vessels constructed of nonferrous materials shall be radiographed in accordance with the requirements of UW-11.

(b) In addition, for vessels constructed of titanium or zirconium and their alloys, all joints of Categories A and B shall be fully radiographed in accordance with UW-51.

(c) Welded butt joints in vessels constructed of materials listed in Table UNF-23.3, with the exception of alloys 200 (UNS No. N02200), 201 (UNS No. N02201), 400 (UNS No. N04400), 401 (UNS No. N04401), and 600 (UNS No. N06600), shall be examined radiographically for their full length as prescribed in UW-51 when the thinner of the plate or vessel wall thicknesses at the welded joint exceeds $\frac{3}{8}$ in. (10 mm).

(d) Where a defect is removed and welding repair is not necessary, care shall be taken to contour notches or corners. The contoured surface shall then be reinspected by the same means originally used for locating the defect to be sure it has been completely removed.

UNF-58 LIQUID PENETRANT EXAMINATION

(a) All welds, both groove and fillet, in vessels constructed of materials covered by UNS N06625 (for Grade 2 only in SB-443, SB-444, and SB-446), UNS N10001, and UNS N10665 shall be examined for the detection of cracks by the liquid penetrant method. This examination shall be made following heat treatment if heat treatment is performed. All cracks shall be removed by grinding, or grinding and filing. Where a defect is removed and welding repair is not necessary, care shall be taken to contour notches or corners. The contoured surface shall then be reinspected by the same means originally used for locating the defect to be sure it has been completely removed.

(b) All joints in vessels constructed of titanium or zirconium and their alloys shall be examined by the liquid penetrant method of Appendix 8.

(c) Welded joints in vessels or parts of vessels, constructed of materials listed in Table UNF-23.3, with the exception of alloys 200 (UNS No. N02200), 201 (UNS No. N02201), 400 (UNS No. N04400), 405 (UNS No. N04405), and 600 (UNS No. N06600), shall be examined by the liquid penetrant method when they are not required to be fully radiographed.

(d) Laser welded lap joints are exempt from liquid penetrant examination requirements of (a), (b), and (c) above.

UNF-65 LOW TEMPERATURE OPERATION

The materials listed in Table UNF-23, together with deposited weld metal within the range of composition for material in that Table, do not undergo a marked drop in impact resistance at subzero temperature. Therefore, no additional requirements are specified for wrought aluminum alloys when they are used at temperatures down to −452°F (−269°C); for copper and copper alloys, nickel and nickel alloys, and cast aluminum alloys when they are used at temperatures down to −325°F (−198°C); and for titanium or zirconium and their alloys used at temperatures down to −75°F (−59°C). The materials listed in Table UNF-23 may be used at lower temperatures than those specified herein and for other weld metal compositions provided the user satisfies himself by suitable test results such as determinations of tensile elongation and sharp-notch tensile strength (compared to unnotched tensile strength) that the material has suitable ductility at the design temperature.

FABRICATION

UNF-75 GENERAL

The rules in the following paragraphs apply specifically to the fabrication of pressure vessels and vessel parts that are constructed of nonferrous materials and shall be used in conjunction with the general requirements for *Fabrication* in Subsection A, and with the

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specific requirements for *Fabrication* in Subsection B that pertain to the method of fabrication used.

UNF-77 FORMING SHELL SECTIONS AND HEADS

(a) The following provisions shall apply in addition to the general rules for forming given in UG-79.

(b) The selected thickness of material shall be such that the forming processes will not reduce the thickness of the material at any point below the minimum value required by the design computation.

(c) Relatively small local bulges and buckles may be removed from formed parts for shells and heads by hammering or by local heating and hammering. For limiting temperatures see Appendix NF.

(d) A shell section that has been formed by rolling may be brought true-to-round for its entire length by pressing, rolling, or hammering.

01 UNF-78 WELDING

Welding of titanium or zirconium and their alloys is to be by the gas-shielded tungsten arc process, the gas-shielded metal arc (consumable-electrode) process, the plasma arc welding process, the electron beam process, or the laser beam process, meeting the requirements of Section IX.

UNF-79 REQUIREMENTS FOR POSTFABRICATION HEAT TREATMENT DUE TO STRAINING

UNF-79(a) The following rules shall apply in addition to general rules for forming given in UNF-77.

UNF-79(a)(1) If the following conditions prevail, the cold formed areas of pressure-retaining components manufactured of austenitic alloys shall be solution annealed by heating at the temperatures given in Table UNF-79 for 20 min/in. (20 min/25 mm) of thickness or 10 min, whichever is greater, followed by rapid cooling:

(a) the finishing-forming temperature is below the minimum heat-treating temperature given in Table UNF-79; and

(b) the design metal temperature and the forming strains exceed the limits shown in Table UNF-79.

UNF-79(a)(2) Forming strains shall be calculated as follows:

(a) cylinders formed from plate:

$$\%strain = \frac{50t}{R_f}\left(1 - \frac{R_f}{R_o}\right)$$

(b) spherical or dished heads formed from plate:

$$\%strain = \frac{75t}{R_f}\left(1 - \frac{R_f}{R_o}\right)$$

(c) tube and pipe bends: the larger of

$$\%strain = \frac{100r}{R_o}$$

or

$$\%strain = \left(\frac{t_A - t_B}{t_A}\right)100$$

(d) tube or pipe flares, swages, or upsets (see Fig. UNF-79); the larger of either the outside diameter or inside diameter hoop strain. The absolute value of the largest strain is to be used as the basis for evaluation:

(1) outside diameter hoop strain:

$$\%strain = \frac{(D - D_f)}{D}100$$

(2) inside diameter hoop strain:

$$\%strain = \frac{(d - d_f)}{d}100$$

(3) axial strain:

$$\%strain = \frac{(L - L_f)}{L}100$$

(4) radial strain:

$$\%strain = \frac{(t - t_f)}{t}100$$

where

D = original outside diameter of the pipe or tube
D_f = outside diameter of the pipe or tube after forming
d = original inside diameter of the pipe or tube
d_f = inside diameter of the pipe or tube after forming
L = original length of the constant volume process zone for the tube or pipe in flaring, swaging, or upsetting forming operations
L_f = final length of the constant volume process zone

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TABLE UNF-79
POSTFABRICATION STRAIN LIMITS AND REQUIRED HEAT TREATMENT

Grade	UNS Number	Limitation in Lower Temperature Range: For Design Temperature, °F (°C), Exceeding	Limitation in Lower Temperature Range: For Design Temperature, °F (°C), But Less Than or Equal To	Limitation in Lower Temperature Range: And Forming Strains Exceeding, %	Limitations in Higher Temperature Range: For Design Temperature, °F (°C), Exceeding	Limitations in Higher Temperature Range: And Forming Strain Exceeding, %	Minimum Heat Treatment Temperature, °F (°C), When Design Temperature and Forming Strain Limits are Exceeded [Note (1)]
617	N06617	1000 (538)	1250 (676)	15	1250 (676)	10	2100 (1149)
800	N08800	1100 (593)	1250 (676)	15	1250 (676)	10	1800 (982)
800H	N08810	1100 (593)	1250 (676)	15	1250 (676)	10	2050 (1121)
...	N08811	1100 (593)	1250 (676)	15	1250 (676)	10	2050 (1121)

GENERAL NOTES:
(a) The limits shown are for cylinders formed from plates, spherical or dished heads formed from plate, and tube and pipe bends.
(b) For flares, swages, and upsets, the forming strain limits shall be half those tabulated in this Table. When the forming strains cannot be calculated as shown in UNF-79(a), the forming strain limits shall be half those tabulated in this Table [see UNF-79(b)].

NOTE:
(1) Rate of cooling from heat-treatment temperature is not subject to specific control limits.

for the tube or pipe in flaring, swaging, or upsetting forming operations

R_f = nominal bending radius to center line of pipe or tube

R_o = original radius (equal to infinity for a flat plate)

r = nominal outside radius of pipe or tube

t = nominal thickness of the plate, pipe, or tube before forming

t_A = measured average wall thickness of pipe or tube

t_B = measured minimum wall thickness of the extrados of the bend

t_f = nominal thickness of the cylindrical portion after forming

V = volume of the cylindrical process zone prior to forming

$= (\pi/4)(D^2 - d^2)$

$V = V_f$, i.e., forming is a constant volume process

V_f = volume of the cylindrical process zone after forming

$= (\pi/4)(D_f^2 - d_f^2)$

UNF-79(b) When forming strains cannot be calculated as shown in (a) above, the manufacturer shall have the responsibility to determine the maximum forming strain. In such instances, the forming limits for flares, swages, or upsets in Table UNF-79 shall apply.

INSPECTION AND TESTS

UNF-90 GENERAL

The rules in the following paragraphs apply specifically to the inspection and testing of pressure vessels and vessel parts that are constructed of nonferrous materials and shall be used in conjunction with the general requirements for *Inspection Tests* in Subsection A, and with the specific requirements for *Inspection and Tests* in Subsection B that pertain to the method of fabrication used.

UNF-91 REQUIREMENTS FOR PENETRAMETER

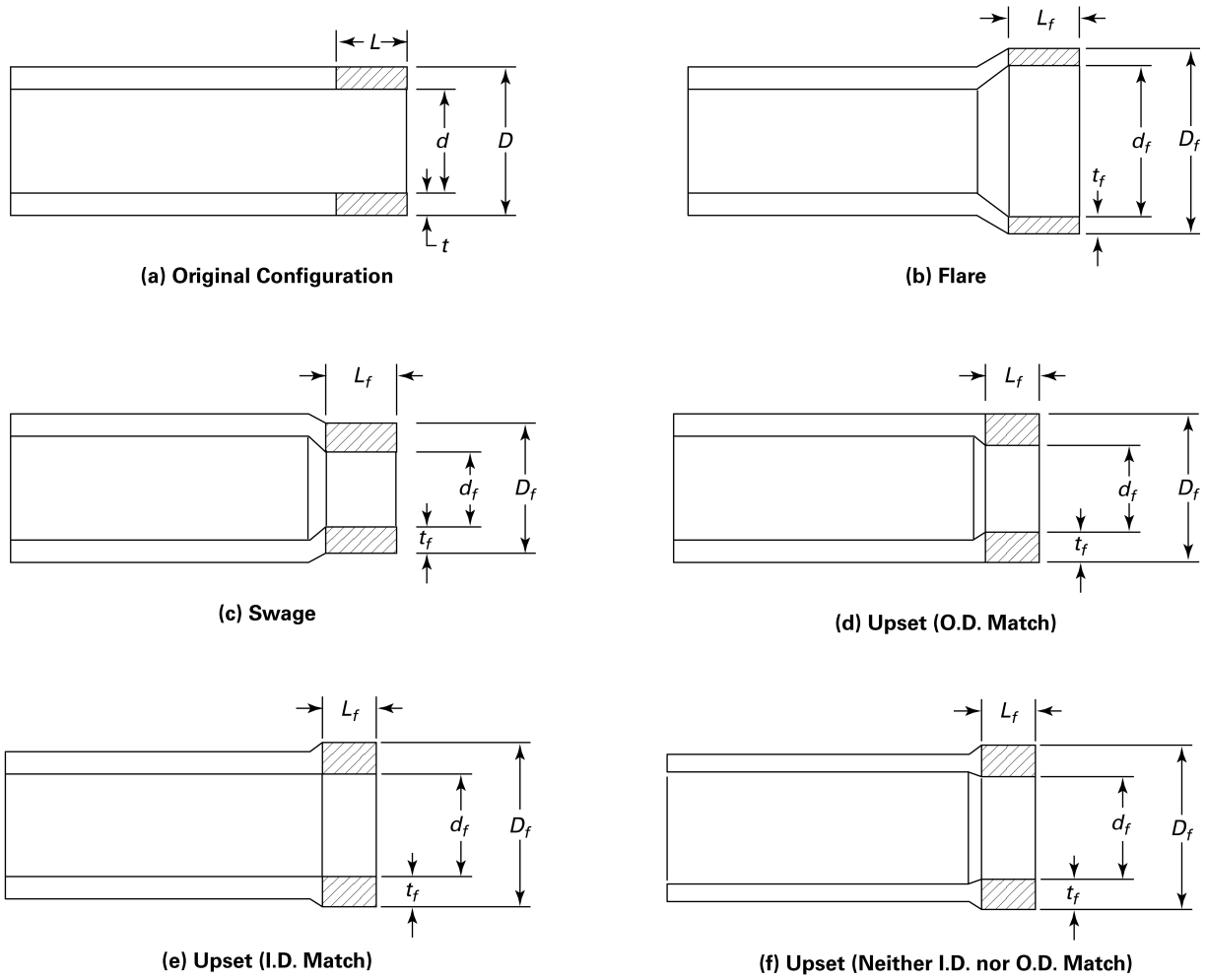
If the filler metal is radiographically similar[1] to the base metal, the penetrameter may be placed adjacent to the weld; otherwise it shall be placed on the deposited weld metal.

UNF-95 WELDING TEST PLATES

If a vessel of welded titanium or zirconium and their alloys construction incorporates joints of Category A or B as described in UW-3, a production test plate of the same specification, grade, and thickness shall be made of sufficient size to provide at least one face and one root bend specimen or two side bend specimens dependent upon plate thickness. Where longitudinal joints are involved, the test plate shall be attached to one end of the longitudinal joint and welded continuously with the joint. Where circumferential joints only are involved, the test plate need not be attached but shall be welded along with the joint and each welder

[1] This is defined in Section V, SE-142, 4.1.1 and Appendix A1.

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GENERAL NOTE: $V = V_f$

FIG. UNF-79 ILLUSTRATION OF COLD FORMING OPERATIONS
FOR FLARING, SWAGING, AND UPSETTING OF TUBING
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or welding operator shall deposit weld metal in the test plate at the location and proportional to that deposited in the production weld. Test plates shall represent each welding process or combination of processes or a change from machine to manual or vice versa. At least one test plate is required for each vessel provided not over 100 ft of Category A or B joints are involved. An additional test plate, meeting the same requirements as outlined above, shall be made for each additional 100 ft of Category A or B joints involved. The bend specimens shall be prepared and tested in accordance with Section IX, QW-160. Failure of either bend specimen constitutes rejection of the weld.

MARKING AND REPORTS

UNF-115 GENERAL

The provisions for marking and reports in UG-115 through UG-120 shall apply without supplement to pressure vessels constructed of nonferrous materials.

PRESSURE RELIEF DEVICES

UNF-125 GENERAL VESSELS

The provisions for pressure relief devices in UG-125 through UG-136 shall apply without supplement to pressure vessels constructed of nonferrous materials.

APPENDIX NF CHARACTERISTICS OF THE NONFERROUS MATERIALS (INFORMATIVE AND NONMANDATORY)

NF-1 PURPOSE

This Appendix summarizes the major properties and fabricating techniques suitable for the nonferrous materials.

NF-2 GENERAL

The nonferrous materials can be formed and fabricated into a variety of types of assemblies with the same types of fabricating equipment as are used for steel. The details of some fabricating procedures vary among the several nonferrous materials and differ from those used for steel because of differences in the inherent mechanical properties of these materials. Detailed information regarding procedures best suited to the several metals may be obtained from the literature of the material producers, and from other reliable sources such as the latest editions of handbooks issued by the American Welding Society and the American Society for Metals.

NF-3 PROPERTIES

The specified mechanical properties, as listed in Tables 1B and 3 of Section II, Part D, show a wide range of strengths. The maximum allowable stress values show a correspondingly wide range and a variable relationship to service temperature. The maximum temperature listed for any material is the temperature above which that material is not customarily used. Section II, Part D, Table NF-1 gives additional mechanical properties, while physical properties are given in Section II, Part D, Table NF-2.

NF-4 MAGNETIC PROPERTIES

See Appendix 6, 6-410, of Section II, Part D.

NF-5 ELEVATED TEMPERATURE EFFECTS

See Appendix 6, 6-420, of Section II, Part D.

NF-6 LOW TEMPERATURE BEHAVIOR

See Appendix 6, 6-430, of Section II, Part D.

NF-7 THERMAL CUTTING

In general, nonferrous materials cannot be cut by the conventional oxyacetylene cutting equipment commonly used for steel. They may be melted and cut by oxyacetylene, powder cutting carbon arc, oxygen arc, and other means. When such thermal means for cutting are employed a shallow contaminated area adjacent to the cut results. This contamination should be removed by grinding, machining, or other mechanical means after thermal cutting and prior to use or further fabrication by welding.

NF-8 MACHINING

The nonferrous materials can be machined with properly sharpened tools of high-speed steel or cemented-

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carbide tools. A coolant is necessary and should be used copiously. In general, the tools should have more side and top rake than required for cutting steel and the edges should be keen and smooth. Comparatively high speeds and fine feeds give best results. Information can be obtained from the material producers and the Metals Handbook for conditions to give optimum results.

NF-9 GAS WELDING

The commonly used gas processes for welding aluminum-base materials employ oxyhydrogen or oxyacetylene flames whereas only the latter produces sufficient heat for welding the copper-base and nickel-base alloys. For the aluminum, nickel and cupro-nickel alloys a neutral to slightly reducing flame should be used, whereas for copper base materials the flame should be neutral to slightly oxidizing. A suitable flux, applied to the welding rod and the work, shall be used except that no flux is required for nickel. Boron-free and phosphorus-free fluxes are required for nickel–copper alloy and for nickel–chromium–iron alloy. Residual deposits of flux shall be removed.

NF-10 METAL ARC WELDING

Metal arc welds can be made with standard dc equipment using reversed polarity (electrode-positive) and coated electrodes. A slightly greater included angle in butt welds for adequate manipulation of the electrode is required.

NF-11 INERT GAS METAL ARC WELDING

Both the consumable and nonconsumable electrode processes are particularly advantageous for use with the nonferrous materials. Best results are obtained through the use of special filler metals.

NF-12 RESISTANCE WELDING

Electric resistance welding, which includes spot, line or seam, and butt or flash welding, can be used with the nonferrous materials. Proper equipment and technique are required for making satisfactory welds.

NF-13 CORROSION

See Appendix 6, 6-440, of Section II, Part D.

NF-14 SPECIAL COMMENTS

Aluminum

See Appendix 6, 6-451, of Section II, Part D.

Nickel

See Appendix 6, 6-452, of Section II, Part D.

Titanium or Zirconium

See Appendix 6, 6-453, of Section II, Part D.

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