**HAYNES International** CORROSION-RESISTANT ALLOYS

# HASTELLOY® C-276 ALLOY

Excellent corrosion-resistance to both oxidizing and reducing media and excellent resistance to localized corrosion attack.

## Contents



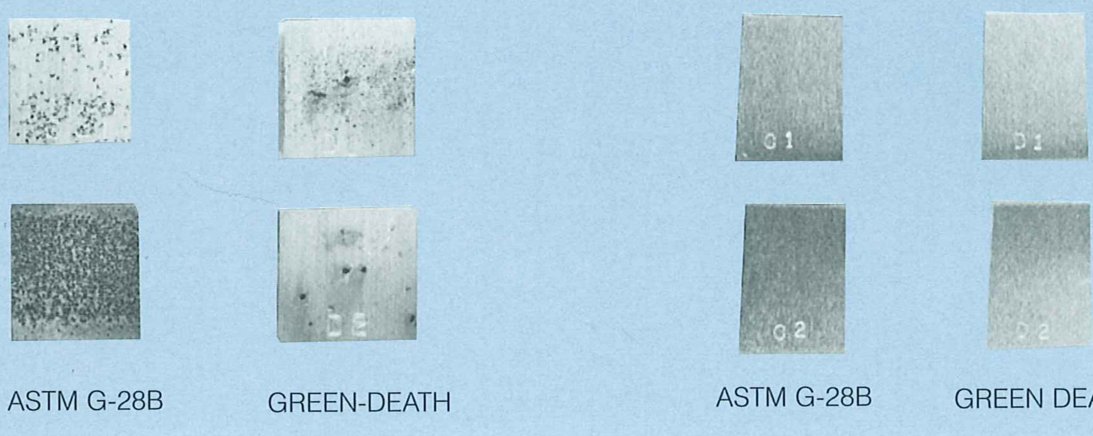
H-2002D

## HASTELLOY® : THE NAME TO TRUST

In aggressive/corrosive service, when nothing else works, many industries have traditionally turned to HASTELLOY® C-276 alloy. Many years of outstanding performance in a variety of industrial applications have confirmed the advantages of using the alloy. Materials engineers in the chemical processing and other industries have grown accustomed to specifying its high performance based on laboratory testing, field trials and/or prior experience.

Some "generic" alloy N10276 products fail to measure up to the performance industry expects from HASTELLOY C-276 alloy which is produced via exacting processes, and backed by years of experience in chemistry control, thermal-mechanical processing, testing and qualifications to rigid standards.

| UNS N10276 (SOURCE X) | | HASTELLOY® C-276 ALLOY |
|---|---|---|
| MILL ANNEALED | | MILL ANNEALED |
| 373 MPY | ASTM G-28A[1] | 238 MPY |
| 2752 MPY | ASTM G-28B[2] | 49 MPY |
| 1535 MPY | GREEN DEATH[3] | 24 MPY |
| PITTING | | NO ATTACK |




[1] ASTM G-28A = 50% $H_2SO_4$ + 42g/l $Fe_2(SO_4)_3$ (Boiling)
[2] ASTM G-28B = 23% $H_2SO_4$ + 1.2% HCl + 1% $Fe_2Cl_3$ + 1% $CuCl_2$ (Boiling)
[3] GREEN DEATH = 11.5% $H_2SO_4$ + 1.2% HCl + 1% $Fe_2Cl_3$ + 1% $CuCl_2$ (Boiling)

**When the alloy is specified by the UNS Number, discerning questions should be asked for assurance of HASTELLOY C-276 alloy performance:**

- Does the product possess the clean, homogeneous microstructure so important for good resistance to aqueous corrosion?
- How does the product perform in tough environments (e.g., rigorous pitting conditions) for which this material is most often specified?
- Is the corrosion resistance of the welded product, in a discriminating test, up to par?

# PRINCIPAL FEATURES

## Excellent Resistance to Corrosion

HASTELLOY® C-276 alloy is a nickel-molybdenum-chromium wrought alloy that is generally considered a versatile corrosion-resistant alloy. C-276 alloy is an improved wrought version of alloy C in that it usually doesn't need to be solution heat-treated after welding and has vastly improved fabricability. This alloy resists the formation of grain-boundary precipitates in the weld heat-affected zone, thus making it suitable for most chemical process applications in the as-welded condition. However, in environments where attack of the C-276 alloy weld joint is experienced, C-22® weld filler materials should be considered (See page 14).

C-276 alloy has excellent resistance to localized corrosion and to both oxidizing and reducing media. Because of its versatility, C-276 alloy can be used where "upset" conditions are likely to occur or in multipurpose plants.

HASTELLOY C-276 alloy has excellent resistance to a wide variety of chemical process environments, including strong oxidizers such as ferric and cupric chlorides, hot contaminated media (organic and inorganic), chlorine, formic and acetic acids, acetic anhydride, and seawater and brine solutions. It is used in flue gas desulfurization systems because of its excellent resistance to sulfur compounds and chloride ions encountered in most scrubbers. C-276 alloy has excellent resistance to pitting and to stress-corrosion cracking. It is also one of the few materials that withstands the corrosive effects of wet chlorine gas, hypochlorite, and chlorine dioxide.

## Fabricated by a Variety of Methods

HASTELLOY C-276 alloy can be forged, hot-upset, and impact extruded. Although the alloy tends to work-harden, it can be successfully deep-drawn, spun, press formed or punched. All of the common methods of welding can be used to weld HASTELLOY C-276 alloy, although the oxyacetylene process is not recommended. Special precautions should be taken to avoid excessive heat input.

Detailed fabricating information is available in the booklet, Fabrication of HAYNES® Corrosion-Resistant Alloys. Ask for booklet H-2010.

## Available in Wrought Form

HASTELLOY C-276 alloy is available in the form of plate, sheet, strip, billet, bar, wire, covered electrodes, pipe, tubing, pipe fittings, flanges, and fittings.

## Heat-Treatment

Wrought forms of HASTELLOY C-276 alloy are furnished in the solution heat-treated condition unless otherwise specified. C-276 alloy is normally solution heat-treated at 2050°F (1121°C) and rapid quenched. If possible, parts which have been hot-formed should be solution heat-treated prior to final fabrication or installation.

## ASME Boiler and Pressure Vessel Code

HASTELLOY C-276 alloy plate, sheet, strip, bar, tubing, and pipe are covered by ASME specifications SB-574, SB-575, SB-619, SB-622, and SB-626 under UNS number N10276.

# NOMINAL CHEMICAL COMPOSITION, (CONSISTS OF ABOUT) WEIGHT PERCENT*

| Ni[a] | Co | Cr | Mo | W | Fe | Si | Mn | C | Others |
|---|---|---|---|---|---|---|---|---|---|
| 57 | 2.5** | 16 | 16 | 4 | 5 | 0.08** | 1** | 0.01** | V-0.35** |

*The undiluted deposited chemical composition of alloy C-276 covered electrodes has 0.02 percent maximum carbon, 0.20 percent maximum silicon, 0.03 percent maximum phosphorus, and 0.015 percent maximum sulfur.
**Maximum
[a]= As Balance

## AVERAGE PHYSICAL PROPERTIES

| Physical Property | Temperature, °F | British Units | Temperature,°C | Metric Units |
|---|---|---|---|---|
| Density | 72 | 0.321 lb./in³ | 22 | 8.89 g/cm³ |
| Melting Range | 2415-2500 | | 1323-1371 | |
| Electrical Resistivity | 75 | 51 microhm-in. | 24 | 1.30 microhm-m |
| Mean Coefficient of Thermal Expansion | 75-200 | 6.2 microinches/in.-°F | 24-93 | 11.2 x $10^{-6}$m/m•K |
| | 75-400 | 6.7 microinches/in.-°F | 24-204 | 12.0 x $10^{-6}$m/m•K |
| | 75-600 | 7.1 microinches/in.-°F | 24-316 | 12.8 x $10^{-6}$m/m•K |
| | 75-800 | 7.3 microinches/in.-°F | 24-427 | 13.2 x $10^{-6}$m/m•K |
| | 75-1000 | 7.4 microinches/in.-°F | 24-538 | 13.4 x $10^{-6}$m/m•K |
| Thermal Conductivity | -270 | 50 Btu-in./ft.²-hr.-°F | -168 | 7.2 W/m•K |
| | -100 | 60 Btu-in./ft.²-hr.-°F | -73 | 8.6 W/m•K |
| | 0 | 65 Btu-in./ft.²-hr.-°F | -18 | 9.4 W/m•K |
| | 100 | 71 Btu-in./ft.²-hr.-°F | 38 | 10.2 W/m•K |
| | 200 | 77 Btu-in./ft.²-hr.-°F | 93 | 11.1 W/m•K |
| | 400 | 90 Btu-in./ft.²-hr.-°F | 204 | 13.0 W/m•K |
| | 600 | 104 Btu-in./ft.²-hr.-°F | 316 | 15.0 W/m•K |
| | 800 | 117 Btu-in./ft.²-hr.-°F | 427 | 16.9 W/m•K |
| | 1000 | 132 Btu-in./ft.²-hr.-°F | 538 | 19.0 W/m•K |
| Specific Heat (Calculated) | Room | 0.102 Btu/lb.-°F | Room | 427 J/Kg•K |

## AVERAGE DYNAMIC MODULUS OF ELASTICITY

| Form | Condition | Test Temperatures °F (°C) | Average Dynamic Modulus of Elasticity, $10^6$ psi (GPa) |
|---|---|---|---|
| Plate | Heat-treated at 2050°F (1121°C), Rapid Quenched | Room | 29.8 (205) |
| | | 400 (204) | 28.3 (195) |
| | | 600 (316) | 27.3 (188) |
| | | 800 (427) | 26.4 (182) |
| | | 1000 (538) | 25.5 (176) |

## FORMABILITY

| Form | Condition | Average Olsen Cup Depth in. | mm |
|---|---|---|---|
| Sheet, 0.044 in. (1.1mm) thick | Heat-treated at 2050°F (1121°C), Rapid Quenched | 0.48* | 12.2* |

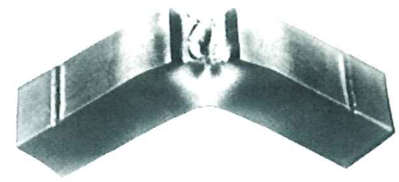
*Average of six tests.

## AVERAGE IMPACT STRENGTH, PLATE

| Condition | "U" Notch Impact Strength at –320°F ft.-lb. | (–196°C) J |
|---|---|---|
| Solution Heat-Treated at: 2050°F (1121°C), Rapid Quenched | 263* | 357 |
| Aged 100 hrs. at: | | |
| 500°F (260°C) | 250 | 339 |
| 1000°F (538°C) | 96 | 130 |
| Aged 1000 hrs. at: | | |
| 1000°F (538°C) | 64 | 87 |

*Five of six specimens did not break.

## Cryogenic Notch Toughness



This "U" notch specimen of alloy C-276 did not break under the hammer blow of the impact tester at -320°F (-196°C).

## AVERAGE TENSILE DATA, SOLUTION HEAT-TREATED

| Form | Test Temperature °F (°C) | Ultimate Tensile Strength Ksi* | Yield Strength at 0.2% offset, Ksi* | Elongation in 2 in. (50.8mm) % |
|---|---|---|---|---|
| Sheet 0.078 iin. (2.0mm) thick | Room | 114.9 | 51.6 | 61 |
| | 400 (204) | 100.6 | 42.0 | 59 |
| | 600 (316) | 98.8 | 35.9 | 68 |
| | 800 (427) | 94.3 | 32.7 | 67 |
| Sheet, 0.094 in. (2.4mm) thick | 400 (204) | 101.0 | 39.9 | 58 |
| | 600 (316) | 97.6 | 33.5 | 64 |
| | 800 (427) | 93.5 | 29.7 | 64 |
| Sheet, 0.063 to 0.187 in. (1.6 to 4.7mm) thick | 400 (204)[1] | 100.8 | 42.1 | 56 |
| | 600 (316)[2] | 97.0 | 37.7 | 64 |
| | 800 (427)[2] | 95.0 | 34.8 | 65 |
| | 1000 (538)[2] | 88.9 | 33.8 | 60 |
| Plate, 3/16 to 1 in. (4.8 to 25.4mm) thick | 400 (204)[3] | 98.9 | 38.2 | 61 |
| | 600 (316)[3] | 94.3 | 34.1 | 66 |
| | 800 (427)[3] | 91.5 | 32.7 | 60 |
| | 1000 (538)[3] | 87.2 | 32.8 | 59 |
| Plate, 1 in. (25.4mm) thick | Room | 113.9 | 52.9 | 59 |
| | 600 (316) | 96.3 | 36.2 | 63 |
| | 800 (427) | 94.8 | 30.5 | 61 |

*Ksi can be converted to MPa (megapascals) by multiplying by 6.895.

1-Average of 25 tests.
2-Average of 34-36 tests.
3-Average of 9-11 tests.

## AVERAGE ROOM TEMPERATURE HARDNESS

| Form | Hardness, Rockwell |
|---|---|
| Sheet** | Rb 90 |
| Plate*** | Rb 87 |

**Average of 49 tests.
***Average of 35 tests.

## COMPARATIVE AQUEOUS CORROSION DATA

| Media | Concentration, percent by weight | Test Temp., °F (°C) | Average Corrosion Rate per year, mils* C-276 alloy | C-22® alloy | C-4 alloy | 625 alloy |
|---|---|---|---|---|---|---|
| Acetic Acid | 99 | Boiling | < 1 | Nil | Nil | < 1 |
| Ferric Chloride | 10 | Boiling | 2 | 1 | 140 | 7325 |
| Formic Acid | 88 | Boiling | 1 | < 1 | 2 | 9 |
| Hydrochloric Acid | 1 | Boiling | 13 | 3 | 25 | 1 |
| | 1.5 | Boiling | 32 | 14 | 64 | 353 |
| | 2 | 194 (90) | 1 | Nil | 31 | Nil |
| | 2 | Boiling | 51 | 61 | 82 | 557 |
| | 2.5 | 194 (90) | 12 | < 1 | 34 | 72 |
| | 2.5 | Boiling | 85 | 141 | 44 | 605 |
| | 10 | Boiling | 288 | 400 | 228 | 642 |
| Hydrochloric Acid + 42 g/l $Fe_2(SO_4)_3$ | 1 | 200 (93) | 41 | 2 | – | 238 |
| | 5 | 150 (66) | 5 | 2 | 3 | 2 |
| Hydrochloric Acid + 2% HF | 5 | 158 (70) | 26 | 59 | 34 | 123 |
| Hydrofluoric Acid | 2 | 158 (70) | 9 | 9 | 17 | 20 |
| | 5 | 158 (70) | 10 | 14 | 15 | 16 |
| $P_2O_5$ (Commercial Grade) | 38 | 185 (85) | 9 | 2 | – | 1 |
| | 44 | 240 (116) | 100 | 21 | – | 23 |
| | 52 | 240 (116) | 33 | 11 | – | 12 |
| $P_2O_5$ + 2000 ppm Cl | 38 | 185 (85) | 12 | 1 | – | 2 |
| $P_2O_5$ + 0.5% HF | 38 | 185 (85) | 45 | 7 | – | 9 |
| Nitric Acid | 10 | Boiling | 7 | < 1 | 7 | < 1 |
| | 65 | Boiling | 888 | 134 | 217 | 21 |
| Nitric Acid + 6% HF | 5 | 140 (60) | 207 | 67 | 204 | 73 |
| Nitric Acid + 25% $H_2SO_4$ + 4% NaCl | 5 | Boiling | 64 | 12 | 97 | 713 |
| Nitric Acid + 1% HCl | 5 | Boiling | 8 | < 1 | 11 | 1 |
| Nitric Acid + 2.5% HCl | 5 | Boiling | 21 | 2 | 26 | < 1 |
| Nitric Acid + 15.8% HCl | 8.8 | 126 (52) | 33 | 4 | 114 | > 10,000 |

*To convert mils per year (mpy) to mm per year, divide by 40.

## COMPARATIVE AQUEOUS CORROSION DATA CONTINUED

| Media | Concentration, percent by weight | Test Temp., °F (°C) | Average Corrosion Rate per year, mils* C-276 alloy | C-22® alloy | C-4 alloy | 625 alloy |
|---|---|---|---|---|---|---|
| Sulfuric Acid | 2 | 150 (66) | <1 | Nil | Nil | Nil |
| | 2 | Boiling | 6 | 5 | 6 | 6 |
| | 5 | 174 (79) | 1 | <1 | 1 | <1 |
| | 5 | Boiling | 12 | 9 | 16 | 16 |
| | 10 | Boiling | 19 | 12 | 25 | 37 |
| | 20 | 150 (66) | <1 | <1 | <1 | <1 |
| | 20 | 174 (79) | 3 | 1 | 2 | 13 |
| | 20 | Boiling | 39 | 33 | 36 | 91 |
| | 30 | 150 (66) | 1 | <1 | <1 | <1 |
| | 30 | 174 (79) | 4 | 3 | 3 | 27 |
| | 30 | Boiling | 55 | 64 | 73 | 227 |
| | 40 | 100 (38) | <1 | <1 | <1 | <1 |
| | 40 | 150 (66) | 1 | <1 | 9 | 1 |
| | 40 | 174 (79) | 10 | 9 | 15 | 35 |
| | 50 | 100 (38) | Nil | <1 | <1 | 1 |
| | 50 | 150 (66) | 4 | 1 | 13 | 25 |
| | 50 | 174 (79) | 12 | 16 | 25 | 58 |
| | 60 | 100 (38) | <1 | <1 | 1 | <1 |
| | 70 | 100 (38) | Nil | Nil | 2 | <1 |
| | 80 | 100 (38) | <1 | Nil | <1 | <1 |
| Sulfuric Acid + 0.1% HCl | 5 | Boiling | 33 | 26 | 49 | 151 |
| Sulfuric Acid + 0.5% HCl | 5 | Boiling | 49 | 61 | 91 | 434 |
| Sulfuric Acid + 1% HCl | 10 | 158 (70) | 11 | <1 | 24 | 121 |
| Sulfuric Acid + 1% HCl | 10 | 194 (90) | 45 | 94 | 66 | 326 |
| Sulfuric Acid + 1% HCl | 10 | Boiling | 116 | 225 | 192 | 869 |
| Sulfuric Acid + 2% HF | 10 | Boiling | 22 | 29 | 26 | 55 |
| Sulfuric Acid + 200 ppm Cl– | 25 | 158 (70) | 12 | 11 | 37 | 110 |
| Sulfuric Acid + 200 ppm Cl– | 25 | Boiling | 186 | 215 | 182 | 325 |
| Sulfuric Acid + 1.2% HCl + 1% $FeCl_3$ + 1% Cu $Cl_2$ | 11.5 | Boiling | 42 | 3 | 837 | 1815 |
| Sulfuric Acid + 1.2% HCl + 1% $FeCl_3$ + 1% Cu $Cl_2$ (ASTMG28B) | 23 | Boiling | 55 | 8 | 2155 | 2721 |
| Sulfuric Acid + 42 g/l $Fe_2(SO_4)_3$ (ASTMG28A) | 50 | Boiling | 250 | 40 | 143 | 23 |

*To convert mils per year (mpy) to mm per year, divide by 40.

## CREVICE-CORROSION DATA IN 10% FERRIC CHLORIDE AT ROOM TEMPERATURE FOR 10 DAYS

| Alloy | Number of Attacked Crevices* | Maximum Depth of Penetration, mils** |
|---|---|---|
| HASTELLOY® C-276 alloy | 0 | 0 |
| HASTELLOY C-22® alloy | 0 | 0 |
| HAYNES® 625 alloy | 11 | 3 |
| Type 317LM Stainless Steel | 20 | 12 |
| Alloy No. 904L | 23 | 19 |
| 20Cb-3® alloy | 24 | 76 |
| Alloy 825 | 24 | 125 |

*Maximum possible number of crevices was 24.
**To convert mils per year (mpy) to mm per year, divide by 40.
20Cb-3 is a trademark of Carpenter Technology Corporation.

## COMPARATIVE CREVICE-CORROSION TEST DATA IN 10% FERRIC CHLORIDE

| Alloy | Average Corrosion Rate, mils per year* | | |
|---|---|---|---|
| | 77°F (25°C) | 122°F (50°C) | 167°F (75°C) |
| HASTELLOY C-276 alloy | 0.2 | 0.2 | 1.4 |
| HASTELLOY C-22 alloy | 0.1 | 0.1 | 0.5 |
| HASTELLOY C-4 alloy | 0.3 | 0.5 | 20 |
| FERRALIUM® 255 alloy | 0.4 | 811 | 663 |
| HAYNES 625 alloy | 1.5 | 124 | 510 |
| 20Cb-3 alloy | 205 | 380 | 700 |
| Type 316L Stainless Steel | 312 | 460 | 780 |
| Alloy 825 | 730 | 707 | 680 |

*Average corrosion rate on duplicate samples even though most corrosion occurred under crevice. Tests were for 100 hours with grooved block.
To convert mils per year (mpy) to mm per year, divide by 40.

## COMPARATIVE STRESS-CORROSION CRACKING DATA

| Alloy | Time, hrs. to crack in 45% Magnesium Chloride at 309°F (154°C) |
|---|---|
| Type 304 Stainless Steel | 1-2 |
| Type 316L Stainless Steel | 1-2 |
| 20Cb-3 alloy | 22 |
| Alloy 825 | 46 |
| HAYNES 625 alloy | No cracks - 1000 |
| HASTELLOY G-30® alloy | No cracks - 1000 |
| HASTELLOY C-276 alloy | No cracks - 1000 |
| HASTELLOY C-22 alloy | No cracks - 1000 |

## COMPARATIVE IMMERSION CRITICAL PITTING AND CRITICAL CREVICE-CORROSION TEMPERATURES IN OXIDIZING NaCl-HCl SOLUTION

The chemical composition of the solution used in this test is as follows: 4% NaCl + 0.1% $Fe_2(SO_4)_3$ + 0.021 M HCl. This solution contains 24,300 ppm chlorides and is acidic (pH2). In both pitting and crevice-corrosion testing the solution temperature was varied in 5°C increments to determine the lowest temperature at which pitting-corrosion initiated (observed by examination at a magnification of 40X of duplicate samples) after a 24-hour exposure period (Pitting Temperature), and the lowest temperature at which crevice-corrosion initiated in a 100-hour exposure period (Crevice-Corrosion Temperature).

| Alloy | Critical Pitting Temperature °C | °F | Critical Crevice-Corrosion Temperature °C | °F |
|---|---|---|---|---|
| HASTELLOY® C-22® alloy | >150 | >302 | 102 | 212 (Boiling) |
| HASTELLOY C-276 alloy | 150 | 302 | 80 | 176 |
| HASTELLOY C-4 alloy | 140 | 284 | 50 | 122 |
| HAYNES® 625 alloy | 90 | 194 | 50 | 122 |
| HASTELLOY G-30® alloy | 70 | 158 | 40 | 104 |
| FERRALIUM® 255 alloy | 50 | 122 | 35 | 95 |
| Alloy 904L | 45 | 113 | 20 | 68 |
| Type 317LM Stainless Steel | 35 | 95 | 15 | 59 |
| Type 317L Stainless Steel | 25 | 77 | 10 | 50 |
| Alloy 825 | 25 | 77 | ≤-5 | ≤23 |
| 20Cb-3® alloy | 20 | 68 | ≤-5 | ≤23 |
| Type 316 Stainless Steel | 20 | 68 | ≤-5 | ≤23 |

20Cb-3 is a trademark of Carpenter Technology Corporation.

## COMPARATIVE IMMERSION CREVICE-CORROSION TEMPERATURES IN 6% FERRIC CHLORIDE SOLUTION (ASTM G48; MTI Project)

The chemical composition of the solution used in this test is as follows: 6% $Fe_2Cl_3$. In the crevice-corrosion test, the solution temperature was varied in 2.5°C increments to determine the lowest temperature at which crevice corrosion initiated in a 24-hour exposure period (Crevice-Corrosion Temperature).

| Alloy | Crevice-Corrosion Temperature °C | °F |
|---|---|---|
| HASTELLOY C-22 alloy | >100 | >212 |
| HASTELLOY C-276 alloy | 95 | 203 |
| HASTELLOY C-4 alloy | 42.5 | 109 |
| HAYNES 625 alloy | 40 | 104 |
| HASTELLOY G-30 alloy | 30 | 86 |
| Nickel 200 | 30 | 86 |
| FERRALIUM 255 alloy | 45 | 113 |
| Alloy 904L | 5 | 41 |
| Type 317 Stainless Steel | 2.5 | 37 |

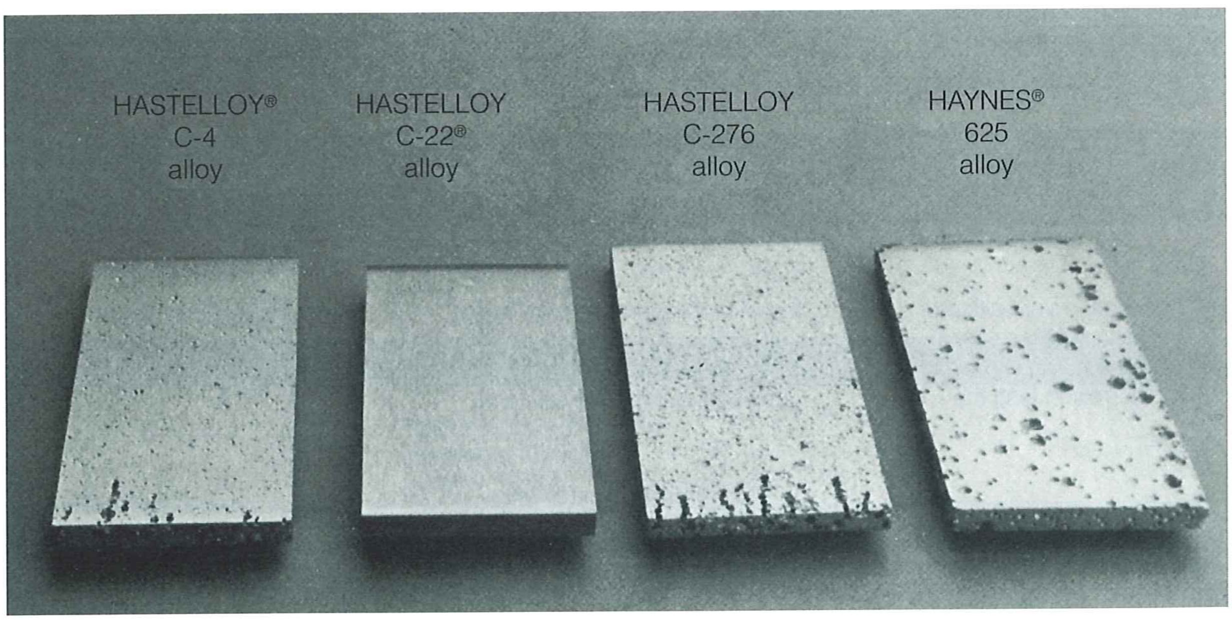
## COMPARATIVE CRITICAL PITTING TEMPERATURES IN OXIDIZING $H_2SO_4$-HCl SOLUTION

The chemical composition of the solution used in this test is as follows: 11.5% $H_2SO_4$ + 1.2% HCl + 1% $FeCl_3$ + 1% $CuCl_2$. This test environment is a severely oxidizing acid solution which is used to evaluate the resistance of alloys to localized corrosion. It is considerably more aggressive than the oxidizing NaCl-HCl test. Experiments were performed in increments of solution temperature of 5 deg. C for a 24-hour exposure period to determine the critical pitting temperature, i.e. the lowest temperature at which pitting corrosion initiated (observed at a magnification of 40X of duplicate samples.)

| Alloy | Critical Pitting Temperature °C | °F |
|---|---|---|
| HASTELLOY® C-22® alloy | 120 | 248 |
| HASTELLOY C-276 alloy | 110 | 230 |
| HASTELLOY C-4 alloy | 90 | 194 |
| HAYNES® 625 alloy | 75 | 167 |

## HASTELLOY ALLOYS EXCEL IN PITTING RESISTANCE

As a class, C-type alloys excel in pitting corrosion resistance. However, comparison tests in a severe pitting environment show HASTELLOY C-22 alloy to be in a class by itself.

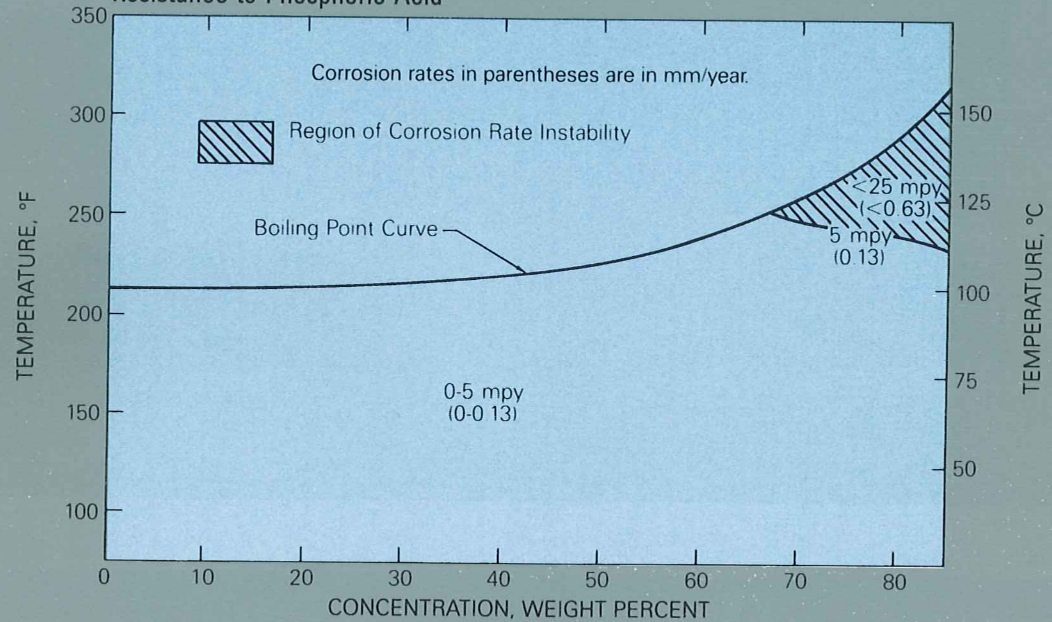



Samples were subjected to a solution of 11.5% $H_2SO_4$ + 1.2% HCl + 1% $FeCl_3$ + 1% $CuCl_2$.
Solutions for coupons 625 and C-4 were at 102°C, while C-276 and C-22 were at 125°C.

# ISOCORROSION DIAGRAMS

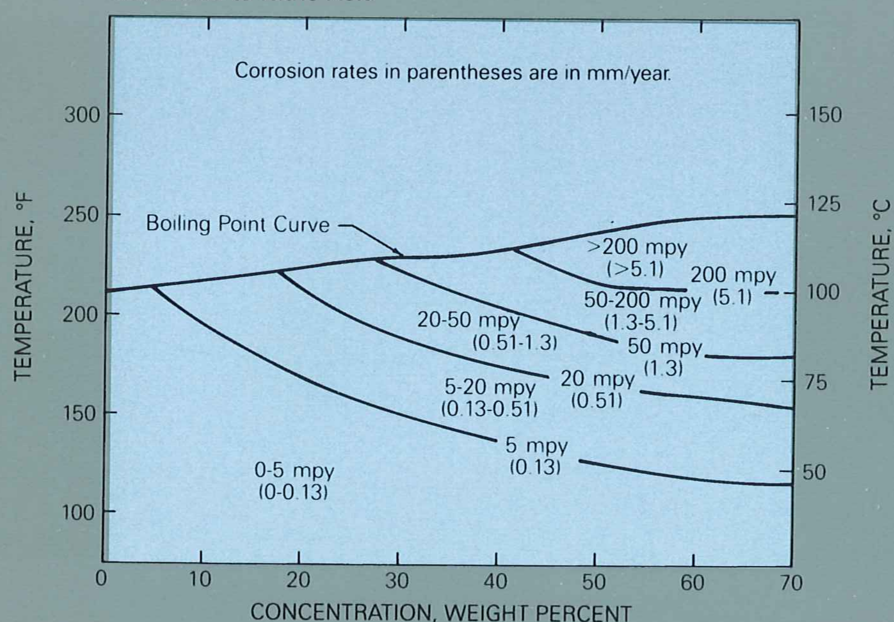
The isocorrosion diagrams shown on this and subsequent pages were plotted using data obtained in laboratory tests in reagent grade acids. These data should be used only as a guide. It is recommended that samples be tested under actual plant conditions.

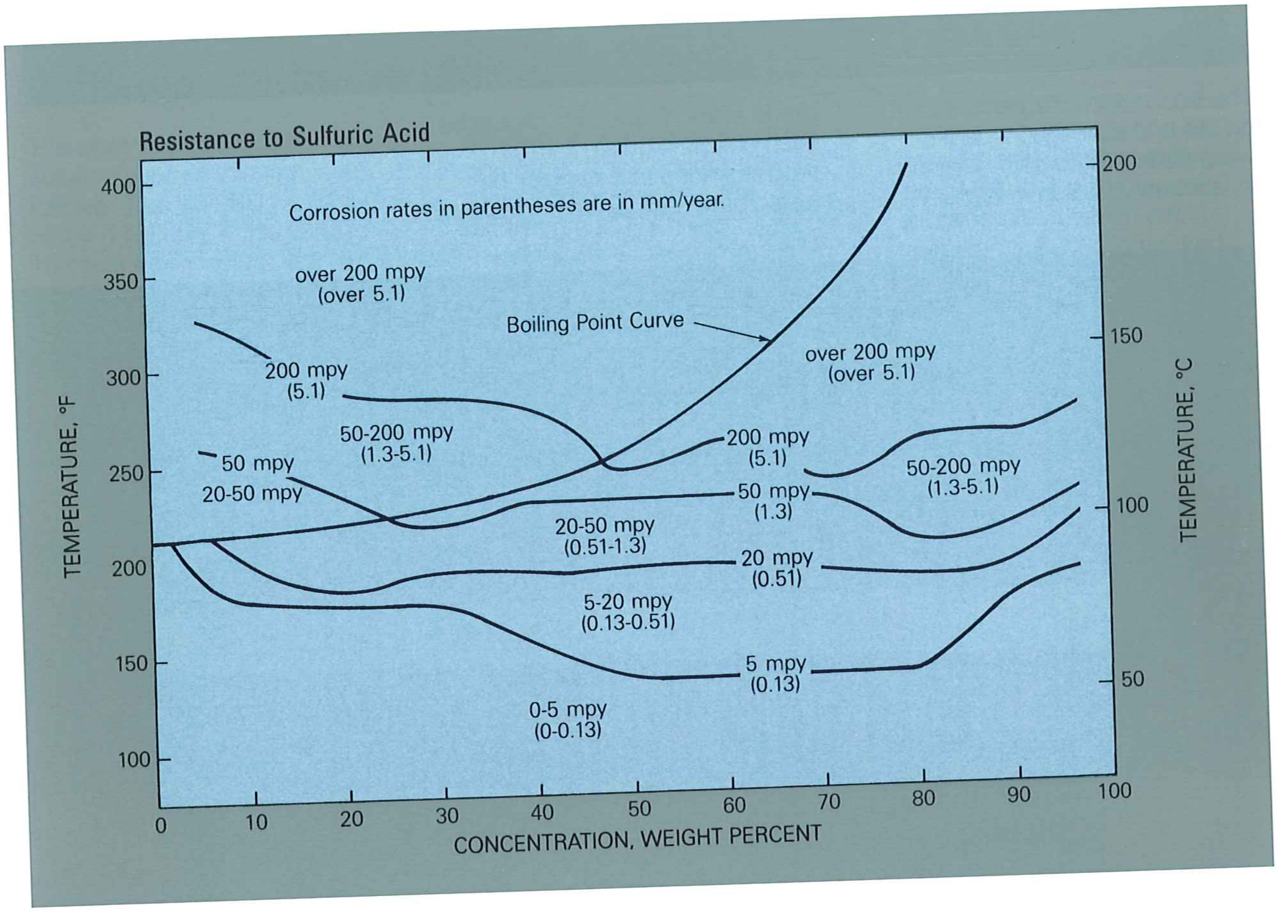
Resistance to Phosphoric Acid

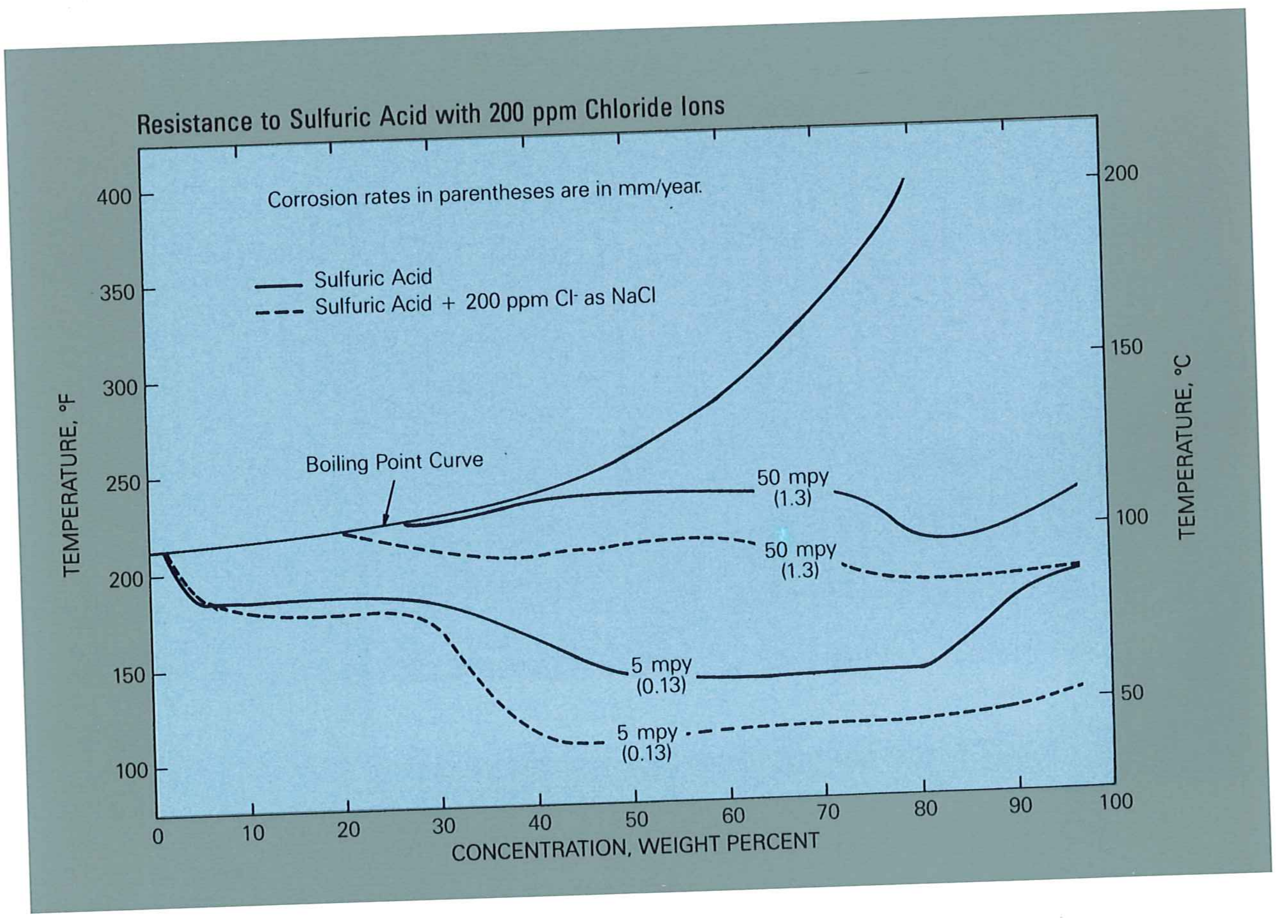



*All test specimens were heat-treated at 2050°F (1121°C), rapid quenched and in the unwelded condition.

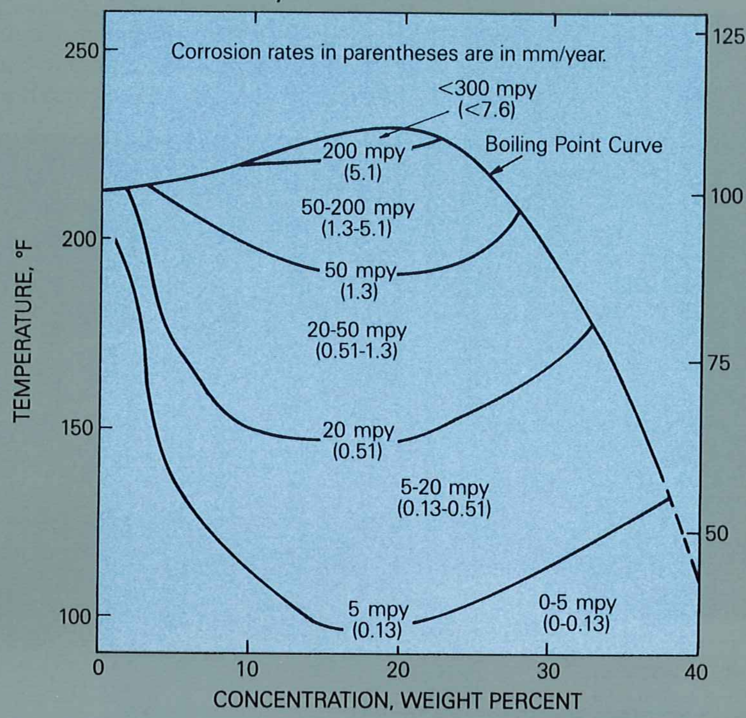
Resistance to Nitric Acid



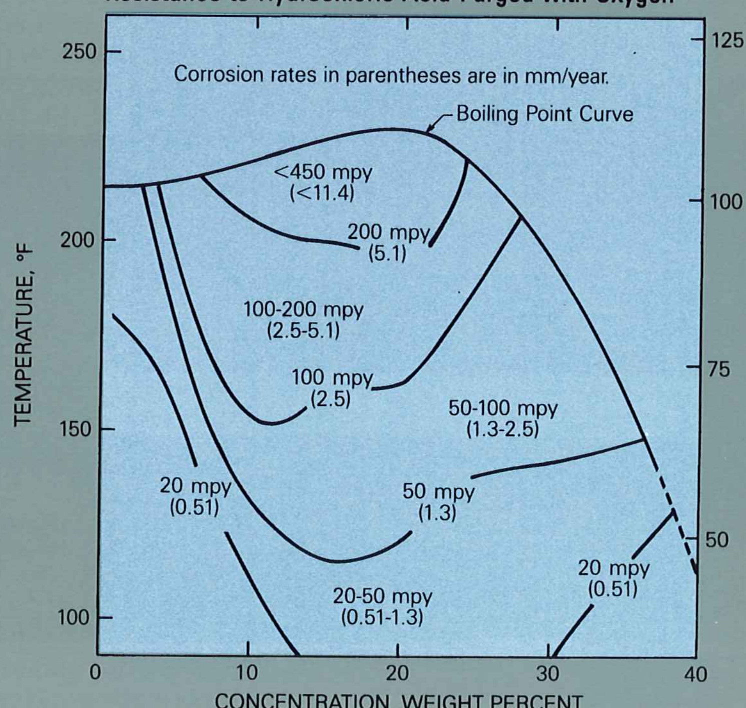

Resistance to Sulfuric Acid
Corrosion rates in parentheses are in mm/year.
over 200 mpy
(over 5.1)
Boiling Point Curve
over 200 mpy
(over 5.1)
200 mpy
(5.1)
50-200 mpy
(1.3-5.1)
50 mpy
20-50 mpy
200 mpy
(5.1)
50-200 mpy
(1.3-5.1)
50 mpy
(1.3)
20-50 mpy
(0.51-1.3)
20 mpy
(0.51)
5-20 mpy
(0.13-0.51)
5 mpy
(0.13)
0-5 mpy
(0-0.13)
TEMPERATURE, °F
TEMPERATURE, °C
CONCENTRATION, WEIGHT PERCENT


Resistance to Sulfuric Acid with 200 ppm Chloride Ions
Corrosion rates in parentheses are in mm/year.
Sulfuric Acid
Sulfuric Acid + 200 ppm Cl- as NaCl
Boiling Point Curve
50 mpy
(1.3)
50 mpy
(1.3)
5 mpy
(0.13)
5 mpy
(0.13)
TEMPERATURE, °F
TEMPERATURE, °C
CONCENTRATION, WEIGHT PERCENT

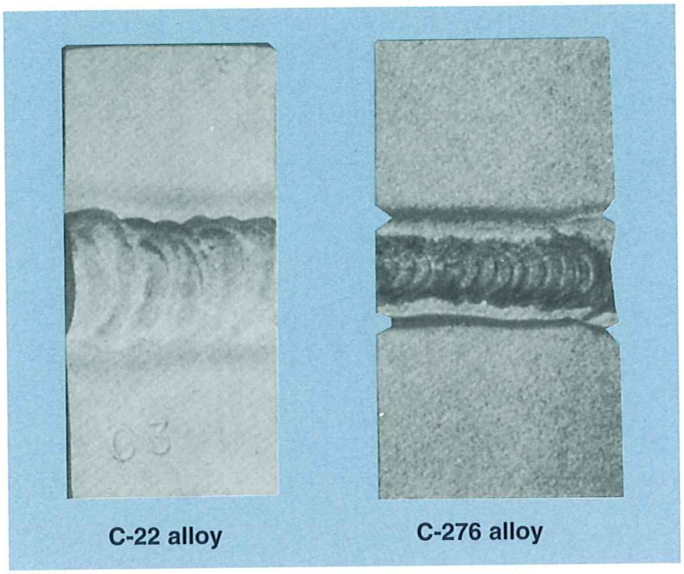
## Resistance to Hydrochloric Acid



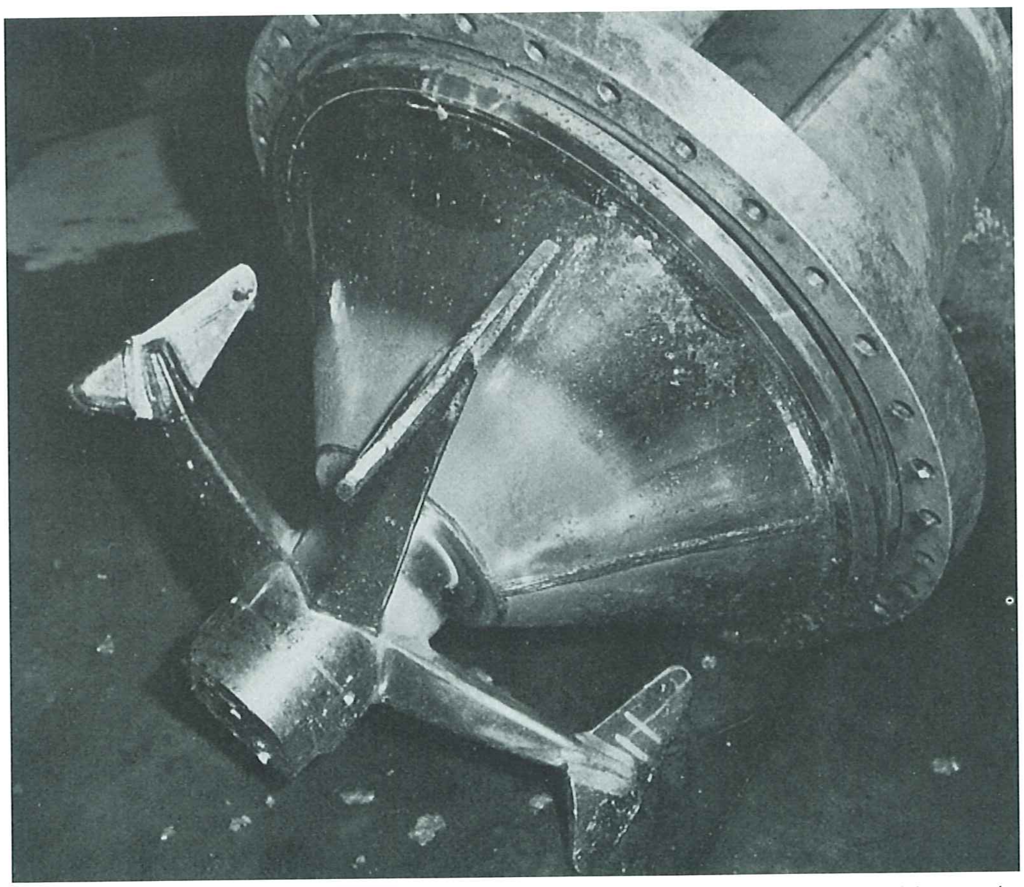

## Resistance to Hydrochloric Acid Purged with Oxygen



# Improved Corrosion Resistance of HASTELLOY® C-22® Weldments




*Corrosion behavior of welded samples showing the improved performance of C-22 alloy over that of C-276 alloy.*



*Weld overlays of HASTELLOY C-22 alloy were used to protect C-276 alloy weldments in this bleach plant mixer.*

# STANDARD PRODUCTS

**By Brand or Alloy Designation:**

HAYNES International

## HASTELLOY® Family of Corrosion-Resistant Alloys

B-3®, C-4, C-22®, C-276, C-2000®, C-22HS®, G-30®, G-35®, G-50®, HYBRID-BC1™, and N

## HASTELLOY Family of Heat-Resistant Alloys

S, W, and X

## HAYNES® Family of Heat-Resistant Alloys

25, R-41, 75, HR-120®, HR-160®, 188, 214®, 230®, 230-W®, 242®, 263, 282®, 556®, 617, 625, 65SQ®, 718, X-750, MULTIMET®, NS-163™, and Waspaloy

## Corrosion-Wear Resistant Alloy

ULTIMET®

## Wear-Resistant Alloy

6B

## HAYNES Titanium Alloy Tubular

Ti-3Al-2.5V

**Standard Forms:** Bar, Billet, Plate, Sheet, Strip, Coils, Seamless or Welded Pipe & Tubing, Pipe Fittings, Flanges, Fittings, Welding Wire, and Coated Electrodes



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