# HASTELLOY® G-35® alloy

## Principal Features

**A nickel alloy with exceptional resistance to “wet process” phosphoric acid**

HASTELLOY® G-35® alloy (UNS N06035) was designed to resist “wet process” phosphoric acid ($P_2O_5$), which is used in the production of fertilizers. Tests in real-world solutions indicate that G-35 alloy is far superior to other metallic materials in this acid. It was also designed to resist localized attack in the presence of chlorides, since this can be a problem beneath deposits in evaporators used to concentrate “wet process” phosphoric acid. Furthermore, G-35 alloy is much less susceptible to chloride-induced stress corrosion cracking than the stainless steels and nickel-chromium-iron alloys traditionally used in “wet process” phosphoric acid.

As a result of its very high chromium content, G-35® alloy is extremely resistant to other oxidizing acids, such as nitric, and mixtures containing nitric acid. It possesses moderate resistance to reducing acids, as a result of its appreciable molybdenum content, and, unlike other nickel-chromium-molybdenum alloys, it is very resistant to “caustic de-alloying” in hot sodium hydroxide.

HASTELLOY® G-35® alloy is available in the form of plates, sheets, strips, billets, bars, wires, pipes, tubes, and covered electrodes. Applications include $P_2O_5$ evaporator tubes.

## Nominal Composition

**Weight %**

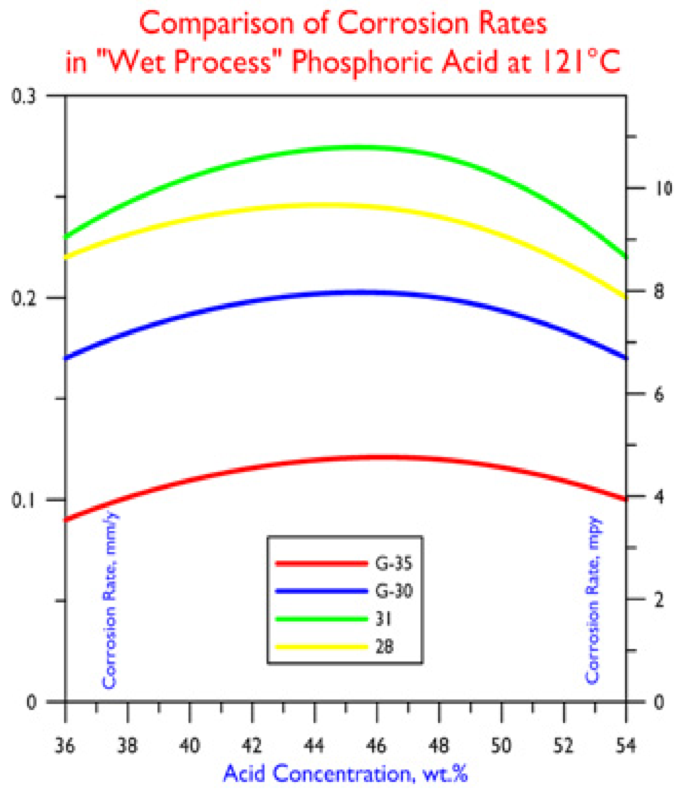
| | |
|---|---|
| **Nickel:** | 58 Balance |
| **Cobalt:** | 1 max. |
| **Chromium:** | 33.2 |
| **Molybdenum:** | 8.1 |
| **Tungsten:** | 0.6 max. |
| **Iron:** | 2 max. |
| **Manganese:** | 0.5 max. |
| **Aluminum:** | 0.4 max. |
| **Silicon:** | 0.6 max. |
| **Carbon:** | 0.05 max. |
| **Copper:** | 0.3 max. |

# Resistance to "Wet Process" Phosphoric Acid

"Wet process" phosphoric acid ($P_2O_5$), which is made by reacting phosphate rock with sulfuric acid, is one of the most important industrial chemicals, being the primary source of phosphorus for agrichemical fertilizers. As produced, it contains many impurities, and has a $P_2O_5$ concentration of only about 30%, because of the large amount of rinse water needed to separate it from the other main reaction product, calcium sulfate. Typical impurities include unreacted sulfuric acid, various metallic ions, fluoride ions, and chloride ions. The fluoride ions tend to form complexes with the metallic ions, and are therefore less of a problem than the chloride ions, which strongly influence electrochemical reactions between "wet process" phosphoric acid and metallic materials. Particulate matter (for example, silica particles) can also be present in "wet process" acid.

The main use of metallic materials is in the concentration process, where the "wet process" acid is taken through a series of evaporation steps, involving metallic tubing. Typically, the $P_2O_5$ concentration is raised to 54% during this process. The concentration effect upon the corrosivity of the acid is somewhat offset by the fact that the impurity levels drop as the concentration increases.

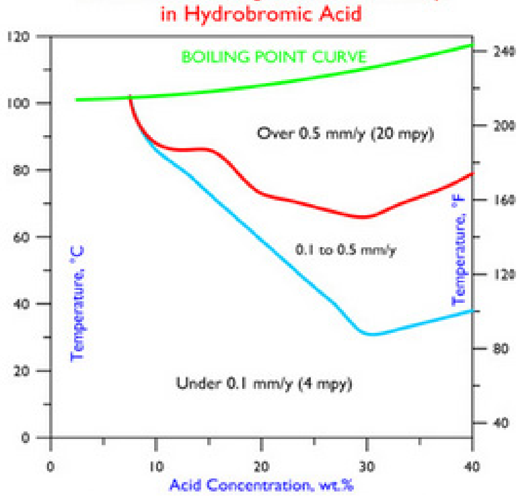
The following chart, comparing G-35® alloy with competitive materials, is based on tests in three concentrations (36, 48, and 54%) of "wet process" phosphoric acid (supplied by a producer in Florida, USA) at 121°C (250°F).



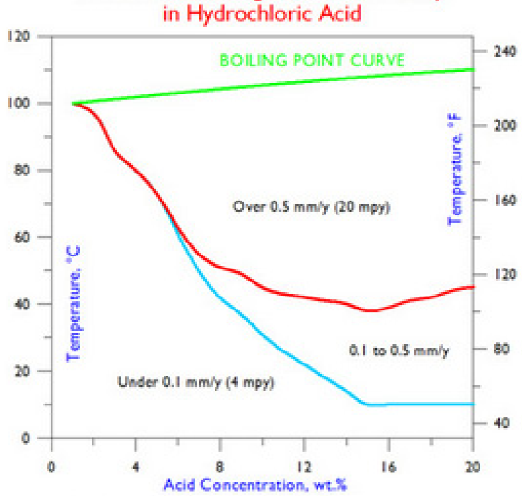
# Iso-Corrosion Diagrams

Each of these iso-corrosion diagrams was constructed using numerous corrosion rate values, generated at different acid concentrations and temperatures. The blue line represents those combinations of acid concentration and temperature at which a corrosion rate of 0.1 mm/y (4 mils per year) is expected, based on laboratory tests in reagent grade acids. Below the line, rates under 0.1 mm/y are expected. Similarly, the red line indicates the combinations of acid concentration and temperature at which a corrosion rate of 0.5 mm/y (20 mils per year) is expected. Above the line, rates over 0.5 mm/y are expected. Between the blue and red lines, corrosion rates are expected to fall between 0.1 and 0.5 mm/y.

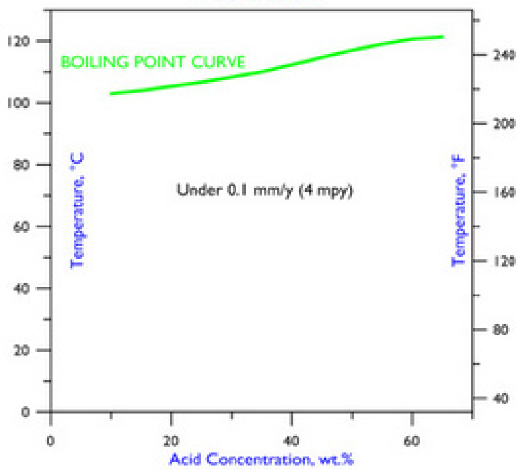
Iso-Corrosion Diagram for G-35 Alloy
in Hydrobromic Acid



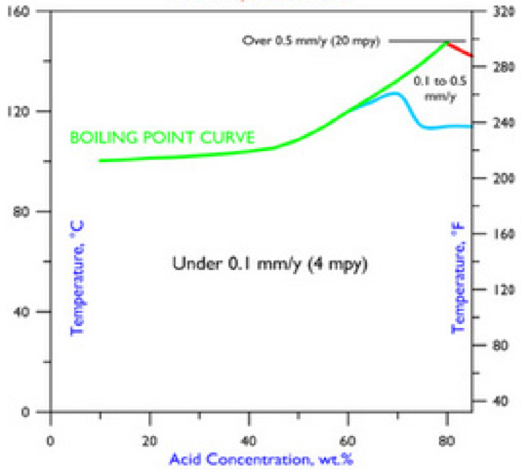

Iso-Corrosion Diagram for G-35 Alloy
in Hydrochloric Acid



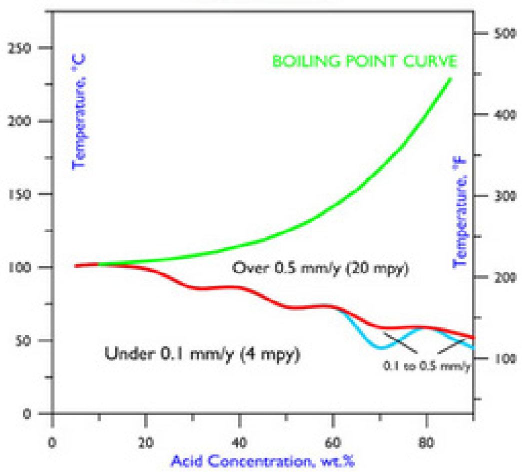

Iso-Corrosion Diagram for G-35 Alloy
in Nitric Acid




Iso-Corrosion Diagram for G-35 Alloy
in Phosphoric Acid

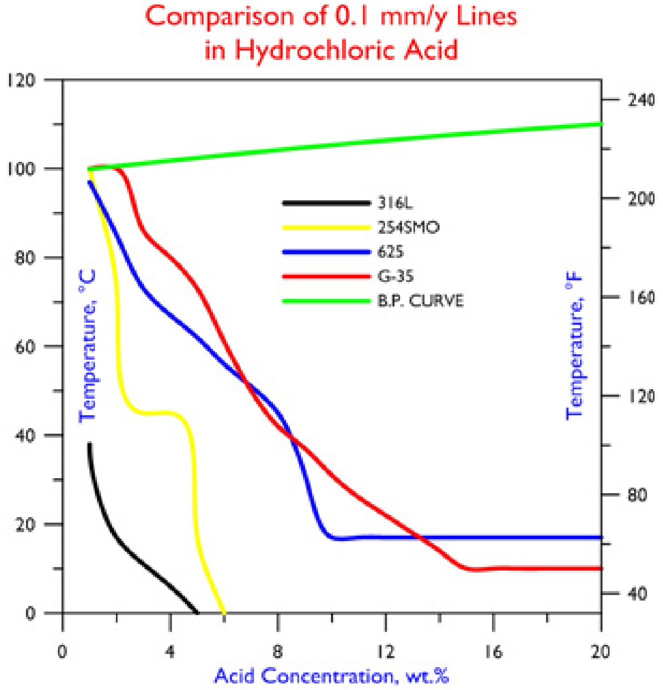


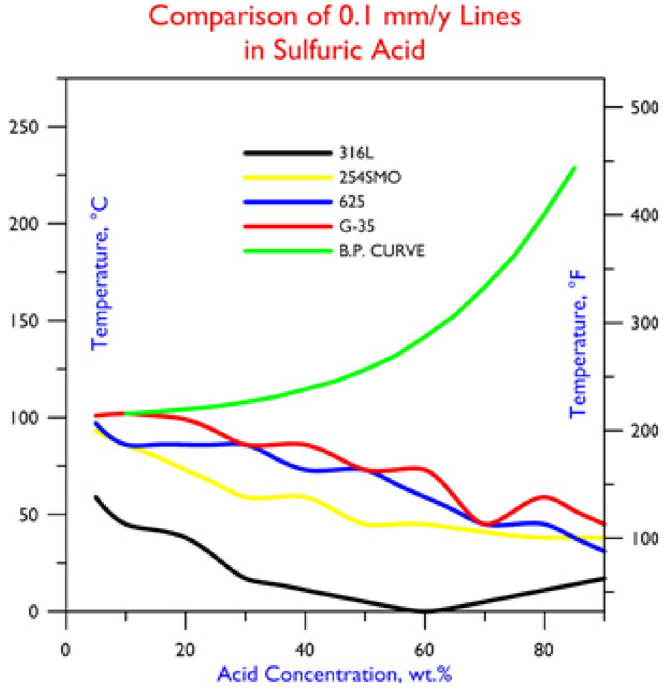

Iso-Corrosion Diagram for G-35 Alloy
in Sulfuric Acid



# Comparative 0.1 mm/y Line Plots

To compare the performance of HASTELLOY® G-35® alloy with that of other materials, it is useful to plot the 0.1 mm/y lines. In the following graphs, the lines for G-35® alloy are compared with those of 625 alloy, 254SMO alloy, and 316L stainless steel, in hydrochloric and sulfuric acids. Note that the lines for G-35® alloy are close to those for 625 alloy. The hydrochloric acid concentration limit of 20% is the azeotrope, above which corrosion tests are less reliable.



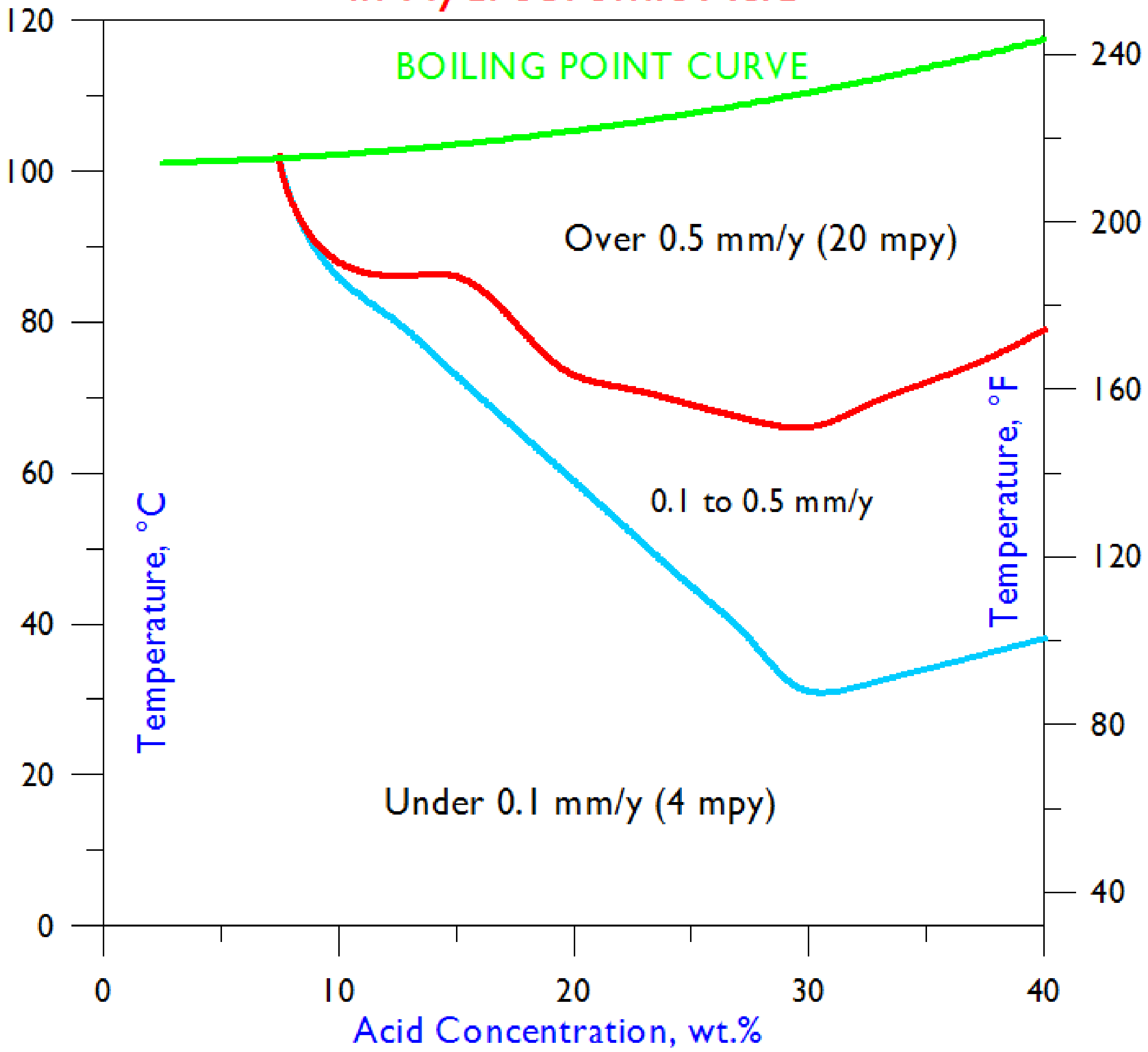
# Selected Corrosion Data

**Hydrobromic Acid**

| Conc. Wt.% | 50°F 10°C | 75°F 24°C | 100°F 38°C | 125°F 52°C | 150°F 66°C | 175°F 79°C | 200°F 93°C | 225°F 107°C | Boiling |
|---|---|---|---|---|---|---|---|---|---|
| 2.5 | - | - | - | - | <0.01 | - | <0.01 | - | <0.01 |
| 5 | - | - | - | - | <0.01 | - | <0.01 | - | <0.01 |
| 7.5 | - | - | - | - | <0.01 | - | <0.01 | - | 0.02 |
| 10 | - | - | - | - | <0.01 | <0.01 | 1.12 | - | - |
| 15 | - | - | - | - | <0.01 | 0.41 | 1.89 | - | - |
| 20 | - | - | - | <0.01 | 0.44 | 1.12 | - | - | - |
| 25 | - | - | - | - | - | - | - | - | - |
| 30 | - | 0.01 | 0.14 | 0.26 | 0.46 | 0.84 | - | - | - |
| 40 | - | - | 0.1 | 0.17 | 0.31 | 0.48 | - | - | - |

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Job 17-04.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.

Iso-Corrosion Diagram for G-35 Alloy in Hydrobromic Acid



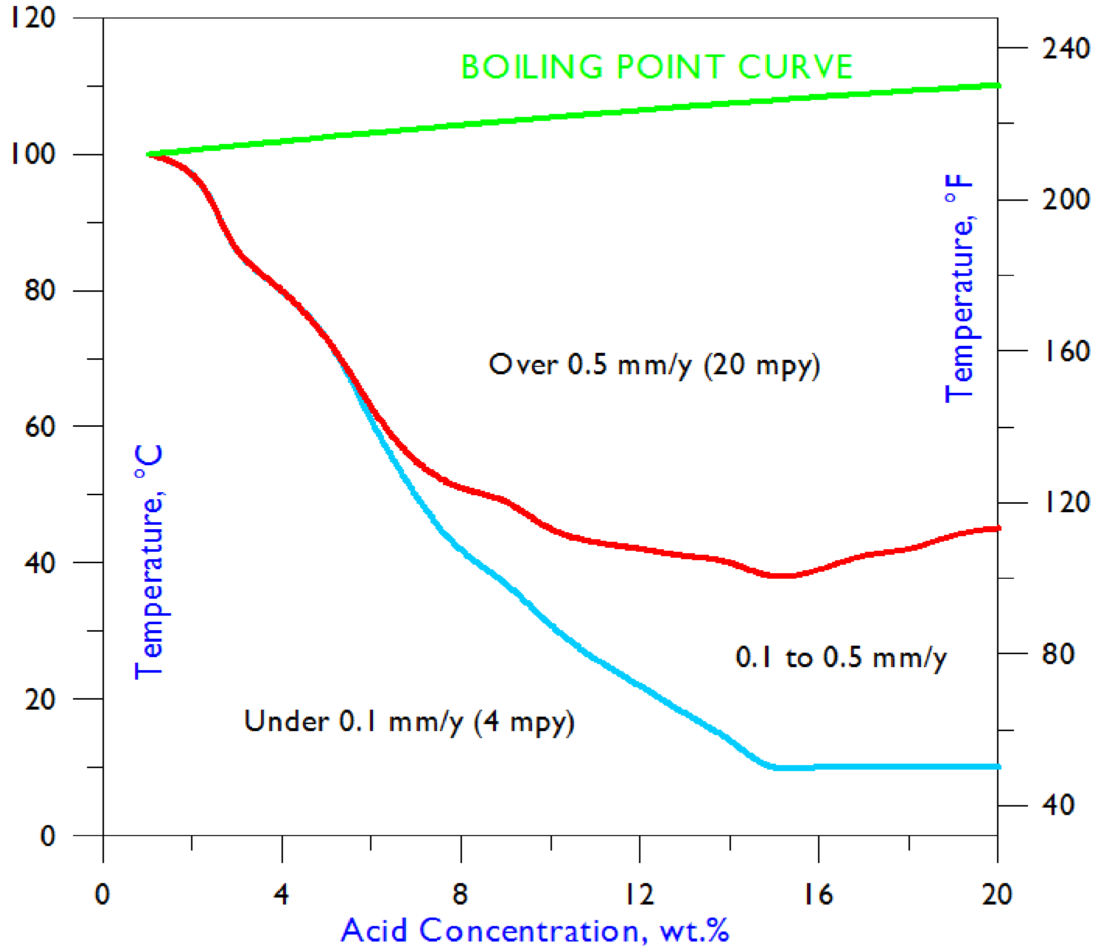
## Selected Corrosion Data Continued

**Hydrochloric Acid**

| Conc. Wt.% | 50°F 10°C | 75°F 24°C | 100°F 38°C | 125°F 52°C | 150°F 66°C | 175°F 79°C | 200°F 93°C | 225°F 107°C | Boiling |
|---|---|---|---|---|---|---|---|---|---|
| 1 | - | - | - | - | - | - | - | - | 0.05 |
| 1.5 | - | - | - | - | - | - | - | - | - |
| 2 | - | - | - | - | - | - | <0.01 | - | 0.05 |
| 2.5 | - | - | - | <0.01 | <0.01 | <0.01 | 17.83 | - | - |
| 3 | - | - | - | - | <0.01 | <0.01 | - | - | - |
| 3.5 | - | - | - | - | - | - | - | - | - |
| 4 | - | - | - | - | - | - | - | - | - |
| 4.5 | - | - | - | - | - | - | - | - | - |
| 5 | - | - | <0.01 | - | <0.01 | 1.23 | 17.08 | - | - |
| 7.5 | - | - | <0.01 | 0.47 | 0.97 | - | - | - | - |
| 10 | - | <0.01 | 0.17 | 1.49 | - | - | - | - | - |
| 15 | 0.09 | 0.19 | 0.52 | - | - | - | - | - | - |
| 20 | 0.08 | 0.15 | 0.42 | - | - | - | - | - | - |

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Job 44-02.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.

### Iso-Corrosion Diagram for G-35 Alloy in Hydrochloric Acid



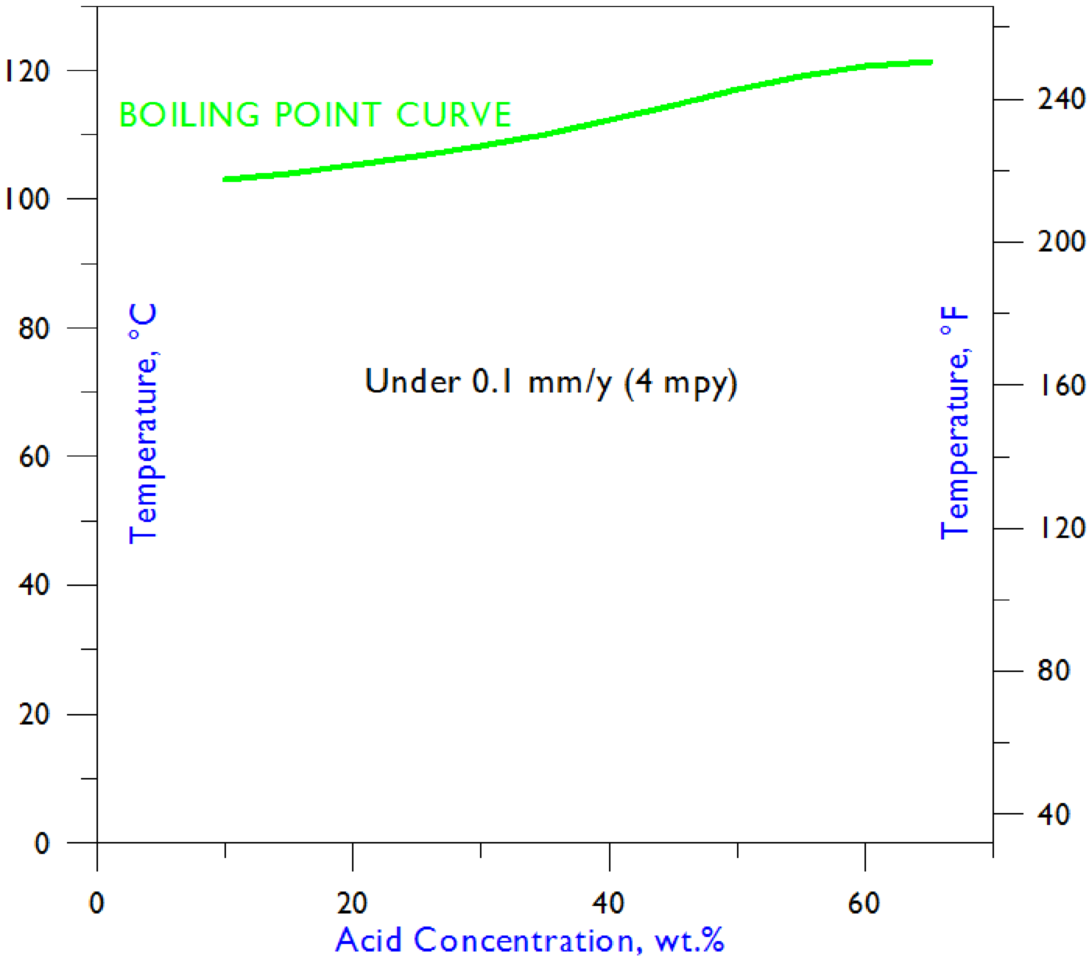
# Selected Corrosion Data Continued

**NitricAcid**

| Conc. Wt.% | 50°F 10°C | 75°F 24°C | 100°F 38°C | 125°F 52°C | 150°F 66°C | 175°F 79°C | 200°F 93°C | 225°F 107°C | Boiling |
|---|---|---|---|---|---|---|---|---|---|
| 10 | - | - | - | - | - | - | - | - | - |
| 20 | - | - | - | - | - | - | - | - | <0.01 |
| 30 | - | - | - | - | - | - | - | - | - |
| 40 | - | - | - | - | - | - | - | - | 0.01 |
| 50 | - | - | - | - | - | - | - | - | 0.03 |
| 60 | - | - | - | - | - | - | - | - | 0.06 |
| 65 | - | - | - | - | - | - | - | - | 0.07 |
| 70 | - | - | - | - | - | - | - | - | 0.1 |

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Job 6-03.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.

Iso-Corrosion Diagram for G-35 Alloy in Nitric Acid

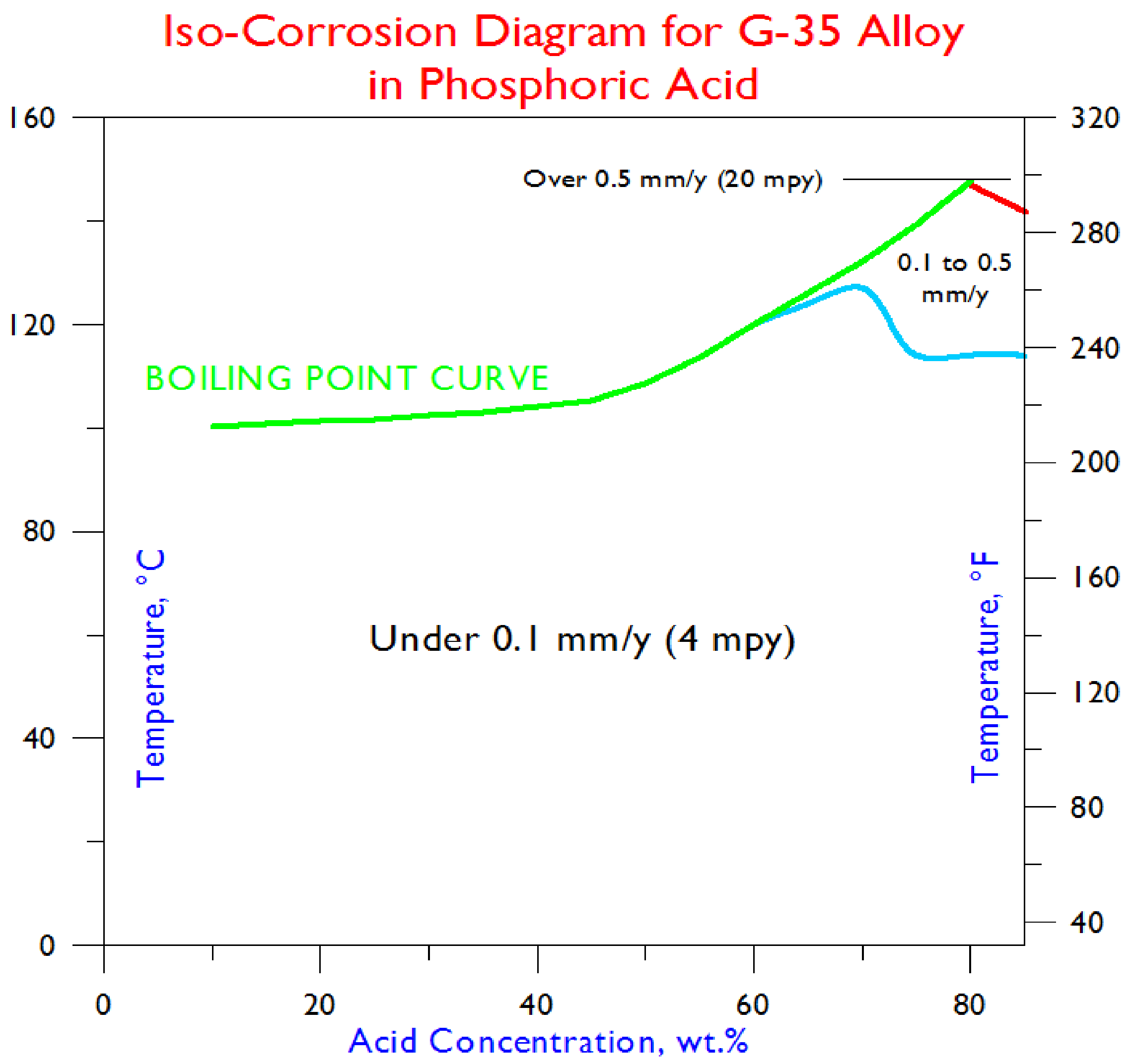


# Selected Corrosion Data Continued

**Phosphoric Acid**

| Conc. Wt.% | 125°F 52°C | 150°F 66°C | 175°F 79°C | 200°F 93°C | 225°F 107°C | 250°F 121°C | 275°F 135°C | 300°F 149°C | Boiling |
|---|---|---|---|---|---|---|---|---|---|
| 50 | - | - | - | - | - | - | - | - | 0.01 |
| 60 | - | - | - | - | - | - | - | - | 0.01 |
| 65 | - | - | - | - | - | - | - | - | 0.17 |
| 70 | - | - | - | - | 0.01 | 0.09 | - | - | 0.11 |
| 75 | - | - | - | - | - | 0.12 | - | - | 0.3 |
| 80 | - | - | - | - | 0.07 | 0.12 | 0.37 | - | 0.42 |
| 85 | - | - | - | - | 0.07 | 0.14 | 0.31 | 0.71 | 0.99 |

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Jobs 5-03 and 30-04.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.



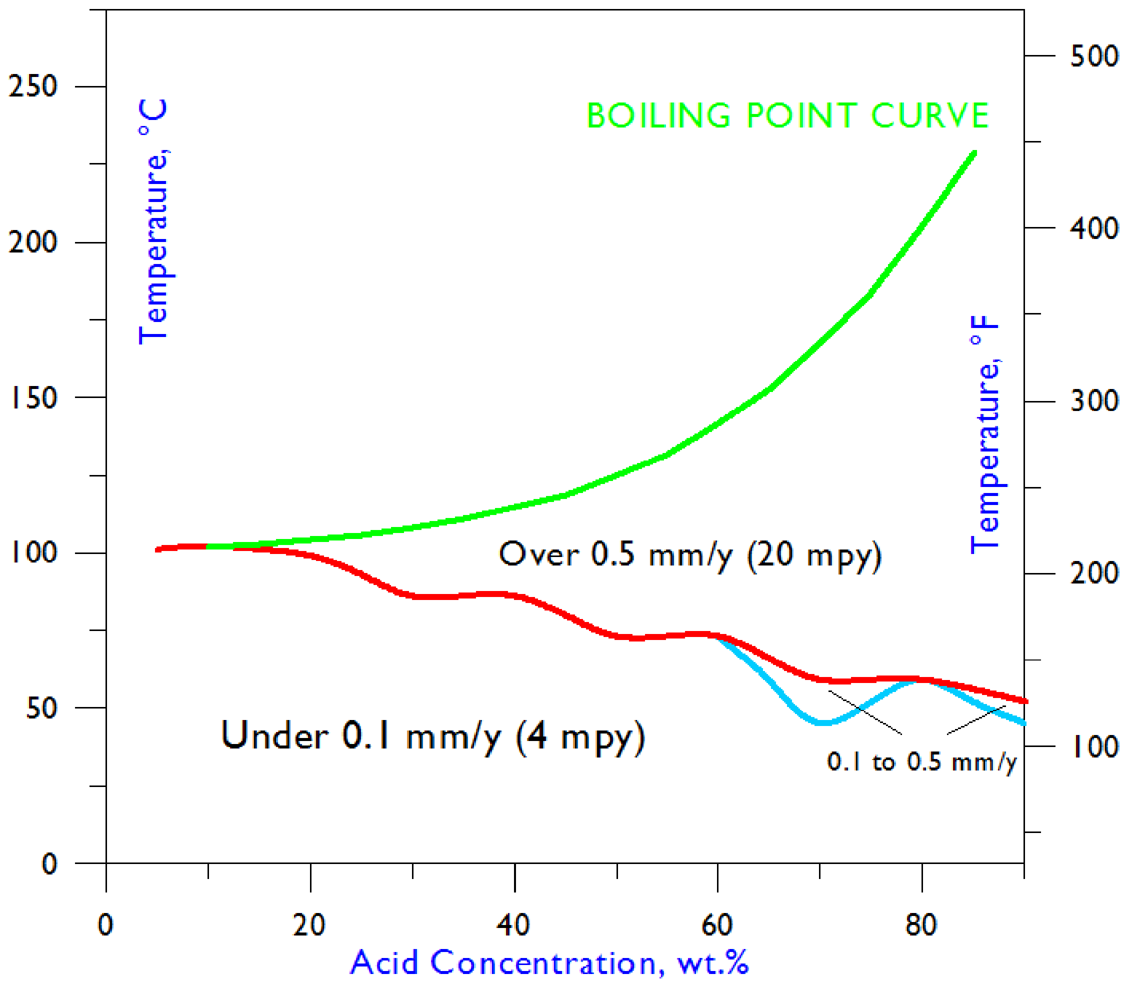
# Selected Corrosion Data Continued

**Sulfuric Acid**

| Conc. Wt.% | 75°F 24°C | 100°F 38°C | 125°F 52°C | 150°F 66°C | 175°F 79°C | 200°F 93°C | 225°F 107°C | 250°F 121°C | 275°F 135°C | 300°F 149°C | 350°F 177°C | Boiling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | - | - | - | - | - | - | - | - | - | - | - | - |
| 3 | - | - | - | - | - | - | - | - | - | - | - | - |
| 4 | - | - | - | - | - | - | - | - | - | - | - | - |
| 5 | - | - | - | - | - | - | - | - | - | - | - | 0.07 |
| 10 | - | - | - | - | - | <0.01 | - | - | - | - | - | 0.11 |
| 20 | - | - | - | - | - | 0.01 | - | - | - | - | - | 0.59 |
| 30 | - | - | - | - | <0.01 | 2.62 | - | - | - | - | - | - |
| 40 | - | - | - | <0.01 | <0.01 | 5.41 | - | - | - | - | - | - |
| 50 | - | - | - | <0.01 | 2.30 | - | - | - | - | - | - | - |
| 60 | - | - | - | <0.01 | 2.45 | - | - | - | - | - | - | - |
| 70 | - | <0.01 | 0.32 | 1.62 | - | - | - | - | - | - | - | - |
| 80 | - | <0.01 | <0.01 | 2.54 | - | - | - | - | - | - | - | - |
| 90 | - | <0.01 | 0.54 | 3.12 | - | - | - | - | - | - | - | - |
| 96 | - | <0.01 | 0.50 | 2.84 | - | - | - | - | - | - | - | - |

All corrosion rates are in millimeters per year (mm/y); to convert to mils (thousandths of an inch) per year, divide by 0.0254.
Data are from Corrosion Laboratory Job 45-02.
All tests were performed in reagent grade acids under laboratory conditions; field tests are encouraged prior to industrial use.

## Iso-Corrosion Diagram for G-35 Alloy in Sulfuric Acid



# Selected Corrosion Data (Reagent Grade Solutions, mm/y)

| Chemical | Concentration wt.% | 100°F 38°C | 125°F 52°C | 150°F 66°C | 175°F 79°C | 200°F 93°C | Boiling |
|---|---|---|---|---|---|---|---|
| Acetic Acid | 99 | - | - | - | - | - | <0.01 |
| Chromic Acid | 10 | - | - | 0.15 | - | - | - |
| | 20 | - | - | 0.85 | - | - | - |
| Formic Acid | 88 | - | - | - | - | - | 0.07 |
| Hydrobromic Acid | 2.5 | - | - | <0.01 | - | <0.01 | <0.01 |
| | 5 | - | - | <0.01 | - | <0.01 | <0.01 |
| | 7.5 | - | - | <0.01 | - | <0.01 | 0.02 |
| | 10 | - | - | <0.01 | <0.01 | 1.12 | - |
| | 15 | - | - | <0.01 | 0.42 | 1.89 | - |
| | 20 | - | <0.01 | 0.44 | 1.12 | - | - |
| | 30 | 0.14 | 0.26 | 0.46 | 0.84 | - | - |
| | 40 | 0.1 | 0.17 | 0.31 | 0.48 | - | - |
| Hydrochloric Acid | 1 | - | - | - | - | - | 0.05 |
| | 2 | - | - | - | - | <0.01 | 0.05 |
| | 2.5 | - | <0.01 | <0.01 | <0.01 | 17.83 | - |
| | 3 | - | - | <0.01 | <0.01 | - | - |
| | 5 | <0.01 | - | <0.01 | 1.23 | - | - |
| | 7.5 | <0.01 | 0.47 | 0.97 | - | - | - |
| | 10 | 0.17 | 1.49 | - | - | - | - |
| | 15 | 0.52 | - | - | - | - | - |
| | 20 | 0.42 | - | - | - | - | - |
| Nitric Acid | 20 | - | - | - | - | - | <0.01 |
| | 40 | - | - | - | - | - | 0.01 |
| | 50 | - | - | - | - | - | 0.03 |
| | 60 | - | - | - | - | - | 0.06 |
| | 65 | - | - | - | - | - | 0.07 |
| | 70 | - | - | - | - | - | 0.1 |
| Phosphoric Acid | 50 | - | - | - | - | - | 0.01 |
| | 60 | - | - | - | - | - | 0.01 |
| | 70 | - | - | - | - | - | 0.11 |
| | 75 | - | - | - | - | - | 0.3 |
| | 80 | - | - | - | - | - | 0.42 |
| Sulfuric Acid | 10 | - | - | - | - | <0.01 | 0.11 |
| | 20 | - | - | - | - | 0.01 | 0.59 |
| | 30 | - | - | - | <0.01 | 2.62 | - |
| | 40 | - | - | <0.01 | <0.01 | - | - |
| | 50 | - | - | <0.01 | 2.3 | - | - |
| | 60 | - | - | <0.01 | 2.45 | - | - |
| | 70 | <0.01 | 0.32 | 1.62 | - | - | - |
| | 80 | <0.01 | <0.01 | 2.54 | - | - | - |
| | 90 | <0.01 | 0.54 | 3.12 | - | - | - |
| | 96 | <0.01 | 0.5 | 2.84 | - | - | - |

# Resistance to Pitting and Crevice Corrosion

HASTELLOY® G-35® alloy exhibits good resistance to chloride-induced pitting and crevice attack, forms of corrosion to which some of the austenitic stainless steels are particularly prone. To assess the resistance of alloys to pitting and crevice attack, it is customary to measure their Critical Pitting Temperatures and Critical Crevice Temperatures in acidified 6 wt.% ferric chloride, in accordance with the procedures defined in ASTM Standard G 48. These values represent the lowest temperatures at which pitting and crevice attack are encountered in this solution, within 72 hours.

| Alloy | Critical Pitting Temperature in Acidified 6% $FeCl_3$ | | Critical Crevice Temperature in Acidified 6% $FeCl_3$ | |
|---|---|---|---|---|
| | °F | °C | °F | °C |
| **315L** | 59 | 15 | 32 | 0 |
| **254SMO** | 40 | 60 | 86 | 30 |
| **28** | 113 | 45 | 64 | 17.5 |
| **31** | 163 | 72.5 | 109 | 42.5 |
| **G-30®** | 154 | 67.5 | 100 | 37.5 |
| **G-35®** | **203** | **95** | **133** | **45** |
| **625** | 212 | 100 | 104 | 40 |

# Resistance to Stress Corrosion Cracking

One of the chief attributes of the nickel alloys is their resistance to chloride-induced stress corrosion cracking. A common solution for assessing the resistance of materials to this extremely destructive form of attack is boiling 45% magnesium chloride (ASTM Standard G 36), typically with stressed U-bend samples. As is evident from the following results, G-35® alloy is much more resistant to this form of attack than the comparative, austenitic stainless steels. The tests were stopped after 1,008 hours (six weeks).

| Alloy | Time to Cracking |
|---|---|
| **316L** | 2 h |
| **254SMO** | 24 h |
| **28** | 36 h |
| **31** | 36 h |
| **G-30®** | 168 h |
| **G-35®** | **No Cracking in 1,008 h** |
| **625** | No Cracking in 1,008 h |

# Corrosion Resistance of Welds

To assess the resistance of welds to corrosion, Haynes International has chosen to test all-weld-metal samples, taken from the quadrants of cruciform assemblies, created using multiple gas metal arc (MIG) weld passes. Interestingly, the resistance of all-weld-metal samples of G-35® alloy to key, inorganic acids is close to that of the wrought, base metal, and even exceeds it in concentrated sulfuric acid.

| | Concentration | Temperature | | Corrosion Rate | | | |
|---|---|---|---|---|---|---|---|
| | | | | Weld Metal | | Wrought Base Metal | |
| **Chemical** | **wt.%** | **°F** | **°C** | **mpy** | **mm/y** | **mpy** | **mm/y** |
| $H_2SO_4$ | 30 | 150 | 66 | <0.4 | <0.01 | 0.4 | 0.01 |
| $H_2SO_4$ | 50 | 150 | 66 | <0.4 | <0.01 | <0.4 | <0.01 |
| $H_2SO_4$ | 70 | 150 | 66 | 56.3 | 1.43 | 63.8 | 1.62 |
| $H_2SO_4$ | 90 | 150 | 66 | 66.5 | 1.69 | 122.8 | 3.12 |
| HCl | 5 | 100 | 38 | <0.4 | <0.01 | <0.4 | <0.01 |
| HCl | 10 | 100 | 38 | 9.4 | 0.24 | 6.7 | 0.17 |
| HCl | 15 | 100 | 38 | 22 | 0.56 | 20.5 | 0.52 |
| HCl | 20 | 100 | 38 | 17.7 | 0.45 | 16.5 | 0.42 |
| $HNO_3$ | 70 | Boiling | | 4.7 | 0.12 | 3.9 | 0.1 |

# Physical Properties

| Physical Property | British Units | | Metric Units | |
|---|---|---|---|---|
| Density | RT | 0.297 lb/in³ | RT | 8.22 g/cm³ |
| Electrical Resistivity | RT | 46.5 µohm.in | RT | 1.18 µohm.m |
| | 200°F | 46.8 µohm.in | 100°C | 1.19 µohm.m |
| | 400°F | 47.4 µohm.in | 200°C | 1.20 µohm.m |
| | 600°F | 47.7 µohm.in | 300°C | 1.21 µohm.m |
| | 800°F | 48.2 µohm.in | 400°C | 1.22 µohm.m |
| | 1000°F | 49.0 µohm.in | 500°C | 1.24 µohm.m |
| | 1200°F | 49.4 µohm.in | 600°C | 1.25 µohm.m |
| Thermal Conductivity | RT | 70 Btu.in/h.ft².°F | RT | 10 W/m.°C |
| | 200°F | 82 Btu.in/h.ft².°F | 100°C | 12 W/m.°C |
| | 400°F | 98 Btu.in/h.ft².°F | 200°C | 14 W/m.°C |
| | 600°F | 113 Btu.in/h.ft².°F | 300°C | 16 W/m.°C |
| | 800°F | 127 Btu.in/h.ft².°F | 400°C | 18 W/m.°C |
| | 1000°F | 143 Btu.in/h.ft².°F | 500°C | 19 W/m.°C |
| | - | - | 600°C | 23 W/m.°C |
| Mean Coefficient of Thermal Expansion | 77-200°F | 6.8 µin/in.°F | 21-100°C | 12.3 µm/m.°C |
| | 77-400°F | 7.0 µin/in.°F | 21-200°C | 12.6 µm/m.°C |
| | 77-600°F | 7.4 µin/in.°F | 21-300°C | 13.2 µm/m.°C |
| | 77-800°F | 7.5 µin/in.°F | 21-400°C | 13.4 µm/m.°C |
| | 77-1000°F | 7.7 µin/in.°F | 21-500°C | 13.6 µm/m.°C |
| | - | - | 21-600°C | 14.1 µm/m.°C |
| Thermal Diffusivity | RT | 0.11 ft²/h | RT | 0.028 cm²/s |
| | 200°F | 0.12 ft²/h | 100°C | 0.031 cm²/s |
| | 400°F | 0.13 ft²/h | 200°C | 0.034 cm²/s |
| | 600°F | 0.15 ft²/h | 300°C | 0.038 cm²/s |
| | 800°F | 0.17 ft²/h | 400°C | 0.042 cm²/s |
| | 1000°F | 0.18 ft²/h | 500°C | 0.045 cm²/s |
| | - | - | 600°C | 0.048 cm²/s |
| Specific Heat | RT | 0.11 Btu/lb.°F | RT | 450 J/kg.°C |
| | 200°F | 0.11 Btu/lb.°F | 100°C | 470 J/kg.°C |
| | 400°F | 0.12 Btu/lb.°F | 200°C | 490 J/kg.°C |
| | 600°F | 0.12 Btu/lb.°F | 300°C | 510 J/kg.°C |
| | 800°F | 0.13 Btu/lb.°F | 400°C | 530 J/kg.°C |
| | 1000°F | 0.13 Btu/lb.°F | 500°C | 530 J/kg.°C |
| | - | - | 600°C | 600 J/kg.°C |
| Dynamic Modulus of Elasticity | RT | 29.6 x 10⁶ psi | RT | 204 GPa |
| | 600°F | 27.4 x 10⁶ psi | 300°C | 190 GPa |
| | 800°F | 26.5 x 10⁶ psi | 400°C | 184 GPa |
| | 1000°F | 25.7 x 10⁶ psi | 500°C | 179 GPa |
| | 1200°F | 24.7 x 10⁶ psi | 600°C | 174 GPa |
| Melting Range | 2430-2482°F | - | 1332-1361°C | - |

# Impact Strength

| Plate Thickness | | Test Temperature | | Impact Strength* | |
|---|---|---|---|---|---|
| in | mm | °F | °C | ft.lbf | J |
| 0.75 | 19.1 | RT | RT | >264 | >358 |

*Charpy V-Notch Samples

# Tensile Strength & Elongation

| Form | Thickness/ Bar Diameter | | Test Temperature | | 0.2% Offset Yield Strength | | Ultimate Tensile Strength | | Elongation |
|---|---|---|---|---|---|---|---|---|---|
| | in | mm | °F | °C | ksi | MPa | ksi | MPa | % |
| Sheet | 0.125 | 3.2 | RT | RT | 50 | 345 | 107 | 738 | 60 |
| Sheet | 0.125 | 3.2 | 200 | 93 | 43 | 296 | 101 | 696 | 63 |
| Sheet | 0.125 | 3.2 | 400 | 204 | 36 | 248 | 93 | 641 | 64 |
| Sheet | 0.125 | 3.2 | 600 | 316 | 31 | 214 | 89 | 614 | 70 |
| Sheet | 0.125 | 3.2 | 800 | 427 | 30 | 207 | 86 | 593 | 74 |
| Sheet | 0.125 | 3.2 | 1000 | 538 | 27 | 186 | 80 | 552 | 68 |
| Sheet | 0.125 | 3.2 | 1200 | 649 | 26 | 179 | 75 | 517 | 68 |
| Plate | 0.5 | 12.7 | RT | RT | 46 | 317 | 100 | 689 | 72 |
| Plate | 0.5 | 12.7 | 200 | 93 | 41 | 283 | 97 | 669 | 74 |
| Plate | 0.5 | 12.7 | 400 | 204 | 33 | 228 | 88 | 607 | 75 |
| Plate | 0.5 | 12.7 | 600 | 316 | 29 | 200 | 82 | 565 | 71 |
| Plate | 0.5 | 12.7 | 800 | 427 | 30 | 207 | 78 | 538 | 77 |
| Plate | 0.5 | 12.7 | 1000 | 538 | 26 | 179 | 72 | 496 | 75 |
| Plate | 0.5 | 12.7 | 1200 | 649 | 24 | 165 | 68 | 469 | 74 |
| Bar | 1 | 25.4 | RT | RT | 46 | 317 | 103 | 710 | 66 |
| Bar | 1 | 25.4 | 200 | 93 | 41 | 283 | 98 | 676 | 70 |
| Bar | 1 | 25.4 | 400 | 204 | 35 | 241 | 89 | 614 | 71 |
| Bar | 1 | 25.4 | 600 | 316 | 30 | 207 | 84 | 579 | 71 |
| Bar | 1 | 25.4 | 800 | 427 | 31 | 214 | 81 | 558 | 73 |
| Bar | 1 | 25.4 | 1000 | 538 | 28 | 193 | 75 | 517 | 72 |
| Bar | 1 | 25.4 | 1200 | 649 | 23 | 159 | 69 | 476 | 71 |

RT= Room Temperature

## Welding & Fabrication

HASTELLOY® G-35® alloy is very amenable to the Gas Metal Arc (GMA/MIG), Gas Tungsten Arc (GTA/TIG), and Shielded Metal Arc (SMA/Stick) welding processes. Matching filler metals (i.e. solid wires and coated electrodes) are available for these processes, and welding guidelines are given in our “Welding and Fabrication” brochure.

Wrought products of HASTELLOY® G-35® alloy are supplied in the Mill Annealed (MA) condition, unless otherwise specified. This solution annealing procedure has been designed to optimize the alloy’s corrosion resistance and ductility. Following all hot forming operations, the material should be re-annealed, to restore optimum properties. The alloy should also be re-annealed after any cold forming operations that result in an outer fiber elongation of 7% or more. The annealing temperature for HASTELLOY® G-35® alloy is 1121°C (2050°F), and water quenching is advised (rapid air cooling is feasible with structures thinner than 10 mm (0.375 in). A hold time at the annealing temperature of 10 to 30 minutes is recommended, depending on the thickness of the structure (thicker structures need the full 30 minutes). More details concerning the heat treatment of HASTELLOY® G-35® alloy are given in our “Welding and Fabrication” brochure.

HASTELLOY® G-35® alloy can be hot forged, hot rolled, hot upset, hot extruded, and hot formed. However, it is more sensitive to strain and strain rates than the austenitic stainless steels, and the hot working temperature range is quite narrow. For example, the recommended start temperature for hot forging is 1204°C (2200°F) and the recommended finish temperature is 954°C (1750°F). Moderate reductions and frequent re-heating provide the best results, as described in our “Welding and Fabrication” brochure. This reference also provides guidelines for cold forming, spinning, drop hammering, punching, and shearing of the HASTELLOY® alloys. G-35® alloy is stiffer than most austenitic stainless steels, and more energy is required during cold forming. Also, G-35® alloy work hardens more readily than most austenitic stainless steels, and may require several stages of cold work, with intermediate anneals.

While cold work does not usually affect the resistance of HASTELLOY® G-35® alloy to general corrosion, and to chloride-induced pitting and crevice attack, it can affect resistance to stress corrosion cracking. For optimum corrosion performance, therefore, the re-annealing of cold worked parts (following an outer fiber elongation of 7% or more) is important.

# Specifications & Codes

**Specifications**

| HASTELLOY® G-35® alloy (N06035) | |
|---|---|
| **Sheet, Plate & Strip** | SB 575/B 575<br>P= 43 |
| **Billet, Rod & Bar** | SB 574/B 574<br>B 472<br>P= 43 |
| **Coated Electrodes** | SFA 5.11/ A 5.11 (ENiCrMo-22)<br>F= 43 |
| **Bare Welding Rods & Wire** | SFA 5.14/ A 5.14 (ERNiCrMo-22)<br>F= 43 |
| **Seamless Pipe & Tube** | SB 622/B 622<br>P= 43 |
| **Welded Pipe & Tube** | SB 619/B 619<br>SB 626/B 626<br>P= 43 |
| **Fittings** | SB 366/B 366<br>SB 462/B 462<br>P= 43 |
| **Forgings** | SB 564/B 564<br>SB 462/B 462<br>P = 43 |
| **DIN** | No. 2.4643 NiCr33Mo8 |
| **TÜV** | - |
| **Others** | NACE MR0175<br>ISO 15156<br>ASME Code Case<br>No. 2484 |

## Codes

| HASTELLOY® G-35® alloy | | | |
|---|---|---|---|
| UNS | | N06035 | |
| ASME | Section I | - | |
| | Section III | Class 1 | - |
| | | Class 2 | - |
| | | Class 3 | - |
| | Section VIII | Div. 1 | 800°F (427°C)[1] |
| | | Div. 2 | - |
| | Section XII | - | |
| | B16.5 | 800°F (427°C)[2] | |
| | B16.34 | 800°F (427°C)[2] | |
| | B31.1 | - | |
| | B31.3 | 800°F (427°C)[1] | |
| VdTÜV (doc #) | | - | |

[1]Approved material forms: Plate, Sheet, Bar, Forgings, fittings, welded pipe/tube, seamless pipe/tube
[2]Approved material forms: Plate, Bar, Forgings, seamless pipe/tube