

## Haynes Hastelloy® C-22HS, Nickel Alloy Plate, Age-hardened

Category : Metal , Nonferrous Metal , Nickel Alloy

### Material Notes:

Outstanding Corrosion Resistance, High Strength HASTELLOY® C-22HSTM alloy is corrosion-resistant, nickel-chromium-molybdenum alloy which can be heat treated to obtain a strength approximately double that of other C-type alloys. Importantly, the corrosion resistance and ductility of the alloy remain excellent when in the high strength condition. In addition to its high uniform corrosion resistance in oxidizing as well as reducing environments, the as-heat treated C-22HS alloy possesses high resistance to chloride-induced pitting and crevice corrosion attack. C-22HS alloy is available in the form of plate, sheet, strip, billet, bar, wire, pipe, and tube. Heat Treatment: The high strength of C-22HS alloy is derived from the formation of strengthening particles of Ni<sub>2</sub>(Mo,Cr) which form during the patented two-step age-hardening heat treatment. The approximately 48 hour heat treatment, 1300°F (705°C) FC to 1125°F (605°C)/32 hours/AC, is described in more detail on page 14. Solution Annealed and Filler Wire Applications: C-22HS alloy may also be considered for applications which do not require the high strength imparted by the heat treatment. In the annealed condition, C-22HS alloy has even higher corrosion-resistance, particularly with regard to localized corrosive attack. This localized attack resistance also makes the alloy an attractive candidate as a general-purpose filler metal or weld overlay. Applications: Agitators and blenders Shafting Fan blades and hubs Fasteners Springs Valves Dies Screws Wellhead parts Rings and gaskets Heat Treatment: Wrought forms of C-22HS alloy are furnished in the solution annealed condition, unless otherwise specified. The standard solution annealing treatment consists of heating to 1975°F (1080°C) followed by rapid air-cooling or water quenching. Parts which have been hot formed should be solution annealed prior to final fabrication or installation. To use the alloy in the high-strength condition, it is necessary to age-harden using a two step treatment of 1300°F (705°C) for 16 hours, furnace cooling to 1125°F (605°C) and holding at that temperature for 32 hours, followed by an air cool. Cold or hot-worked structures should normally be given a full solution anneal prior to performing the age-hardening treatment. Forming: C-22HS alloy has excellent forming characteristics, and cold forming is the preferred method of shaping. The alloy can be easily cold worked due to its good ductility. The alloy is generally stiffer than the austenitic stainless steels; therefore more energy is required during cold forming. For further information on the fabrication of C-type alloys, please consult publication H-2010. Machining: C-22HS alloy may be machined in either the solution annealed or age-hardened condition. Carbide or ceramic tools are recommended. For use in the age-hardened condition, it is suggested to rough machine in the annealed condition. After performing the age-hardening heat treatment, light machining may be performed to achieve desired final dimensions. Data provided by the manufacturer, Haynes International, Inc.

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[http://www.lookpolymers.com/polymer\\_Haynes-Hastelloy-C-22HS-Nickel-Alloy-Plate-Age-hardened.php](http://www.lookpolymers.com/polymer_Haynes-Hastelloy-C-22HS-Nickel-Alloy-Plate-Age-hardened.php)

| Physical Properties | Metric    | English                  | Comments     |
|---------------------|-----------|--------------------------|--------------|
| Density             | 8.60 g/cc | 0.311 lb/in <sup>3</sup> | annealed     |
|                     | 8.64 g/cc | 0.312 lb/in <sup>3</sup> | age-hardened |

| Mechanical Properties      | Metric   | English    | Comments             |
|----------------------------|----------|------------|----------------------|
| Hardness, Rockwell C       | 30       | 30         | Average Age-hardened |
| Tensile Strength, Ultimate | 1232 MPa | 178700 psi | No thermal exposure  |
|                            | 1227 MPa | 178000 psi |                      |

| Mechanical Properties   | Metric<br>@ Treatment Temp. 427<br>Â°C,<br>Time 3.60e+6 sec | English<br>@ Treatment Temp. 801<br>Â°F,<br>Time 1000 hour | Comments<br>Room temp test after thermal exposure |
|-------------------------|-------------------------------------------------------------|------------------------------------------------------------|---------------------------------------------------|
|                         | 1265 MPa                                                    | 183500 psi                                                 |                                                   |
|                         | @Treatment Temp. 427<br>Â°C,<br>Time 1.44e+7 sec            | @Treatment Temp. 801<br>Â°F,<br>Time 4000 hour             | Room temp test after thermal exposure             |
|                         | 1278 MPa                                                    | 185400 psi                                                 |                                                   |
|                         | @Treatment Temp. 427<br>Â°C,<br>Time 2.88e+7 sec            | @Treatment Temp. 801<br>Â°F,<br>Time 8000 hour             | Room temp test after thermal exposure             |
|                         | 1281 MPa                                                    | 185800 psi                                                 |                                                   |
|                         | @Treatment Temp. 593<br>Â°C,<br>Time 3.60e+6 sec            | @Treatment Temp.<br>1100 Â°F,<br>Time 1000 hour            | Room temp test after thermal exposure             |
|                         | 1303 MPa                                                    | 189000 psi                                                 |                                                   |
|                         | @Treatment Temp. 593<br>Â°C,<br>Time 1.44e+7 sec            | @Treatment Temp.<br>1100 Â°F,<br>Time 4000 hour            | Room temp test after thermal exposure             |
|                         | 1308 MPa                                                    | 189700 psi                                                 |                                                   |
|                         | @Treatment Temp. 593<br>Â°C,<br>Time 2.88e+7 sec            | @Treatment Temp.<br>1100 Â°F,<br>Time 8000 hour            | Room temp test after thermal exposure             |
| Tensile Strength, Yield | 747 MPa                                                     | 108000 psi                                                 | 0.2%. Room temp test after thermal exposure       |
|                         | @Treatment Temp. 427<br>Â°C,<br>Time 3.60e+6 sec            | @Treatment Temp. 801<br>Â°F,<br>Time 1000 hour             |                                                   |
|                         | 774 MPa                                                     | 112000 psi                                                 |                                                   |
|                         | @Treatment Temp. 427<br>Â°C,<br>Time 1.44e+7 sec            | @Treatment Temp. 801<br>Â°F,<br>Time 4000 hour             | 0.2%. Room temp test after thermal exposure       |
|                         | 793 MPa                                                     | 115000 psi                                                 |                                                   |
|                         | @Treatment Temp. 427<br>Â°C,<br>Time 2.88e+7 sec            | @Treatment Temp. 801<br>Â°F,<br>Time 8000 hour             | 0.2%. Room temp test after thermal exposure       |
|                         | 815 MPa                                                     | 118000 psi                                                 |                                                   |
|                         | @Treatment Temp. 593<br>Â°C,<br>Time 3.60e+6 sec            | @Treatment Temp.<br>1100 Â°F,<br>Time 1000 hour            | 0.2%. Room temp test after thermal exposure       |
|                         | 824 MPa                                                     | 120000 psi                                                 |                                                   |
|                         | @Treatment Temp. 593<br>Â°C,<br>Time 1.44e+7 sec            | @Treatment Temp.<br>1100 Â°F,<br>Time 4000 hour            | 0.2%. Room temp test after thermal exposure       |

| Mechanical Properties | Metric <sup>Pa</sup>                             | English <sup>psi</sup>                          | Comments                                    |
|-----------------------|--------------------------------------------------|-------------------------------------------------|---------------------------------------------|
|                       | @Treatment Temp. 593<br>Â°C,<br>Time 2.88e+7 sec | @Treatment Temp.<br>1100 Â°F,<br>Time 8000 hour | 0.2%. Room temp test after thermal exposure |
|                       | 742 MPa                                          | 108000 psi                                      | No thermal exposure                         |
|                       | @Strain 0.200 %                                  | @Strain 0.200 %                                 |                                             |
| Elongation at Break   | 40.2 %                                           | 40.2 %                                          | No thermal exposure                         |
|                       | 26.9 %                                           | 26.9 %                                          | Room temp test after thermal exposure       |
|                       | @Treatment Temp. 593<br>Â°C,<br>Time 2.88e+7 sec | @Treatment Temp.<br>1100 Â°F,<br>Time 8000 hour |                                             |
|                       | 36.1 %                                           | 36.1 %                                          | Room temp test after thermal exposure       |
|                       | @Treatment Temp. 593<br>Â°C,<br>Time 1.44e+7 sec | @Treatment Temp.<br>1100 Â°F,<br>Time 4000 hour |                                             |
|                       | 41.2 %                                           | 41.2 %                                          | Room temp test after thermal exposure       |
|                       | @Treatment Temp. 593<br>Â°C,<br>Time 3.60e+6 sec | @Treatment Temp.<br>1100 Â°F,<br>Time 1000 hour |                                             |
|                       | 41.3 %                                           | 41.3 %                                          | Room temp test after thermal exposure       |
|                       | @Treatment Temp. 427<br>Â°C,<br>Time 2.88e+7 sec | @Treatment Temp. 801<br>Â°F,<br>Time 8000 hour  |                                             |
|                       | 43.2 %                                           | 43.2 %                                          | Room temp test after thermal exposure       |
|                       | @Treatment Temp. 427<br>Â°C,<br>Time 1.44e+7 sec | @Treatment Temp. 801<br>Â°F,<br>Time 4000 hour  |                                             |
|                       | 44.8 %                                           | 44.8 %                                          | Room temp test after thermal exposure       |
|                       | @Treatment Temp. 427<br>Â°C,<br>Time 3.60e+6 sec | @Treatment Temp. 801<br>Â°F,<br>Time 1000 hour  |                                             |
| Reduction of Area     | 49.7 %                                           | 49.7 %                                          | No thermal exposure                         |
|                       | 26.2 %                                           | 26.2 %                                          | Room temp test after thermal exposure       |
|                       | @Treatment Temp. 593<br>Â°C,<br>Time 2.88e+7 sec | @Treatment Temp.<br>1100 Â°F,<br>Time 8000 hour |                                             |
|                       | 43.9 %                                           | 43.9 %                                          | Room temp test after thermal exposure       |
|                       | @Treatment Temp. 593<br>Â°C,<br>Time 1.44e+7 sec | @Treatment Temp.<br>1100 Â°F,<br>Time 4000 hour |                                             |
|                       | 57 %                                             | 57 %                                            |                                             |

| Mechanical Properties | Metric<br>@ Treatment Temp. 427<br>Â°C,<br>Time 3.60e+6 sec | English<br>@ Treatment Temp. 801<br>Â°F,<br>Time 1000 hour | Comments<br>Room temp test after thermal exposure |
|-----------------------|-------------------------------------------------------------|------------------------------------------------------------|---------------------------------------------------|
|                       | 57.2 %                                                      | 57.2 %                                                     |                                                   |
|                       | @Treatment Temp. 427<br>Â°C,<br>Time 2.88e+7 sec            | @Treatment Temp. 801<br>Â°F,<br>Time 8000 hour             | Room temp test after thermal exposure             |
|                       | 57.5 %                                                      | 57.5 %                                                     |                                                   |
|                       | @Treatment Temp. 593<br>Â°C,<br>Time 3.60e+6 sec            | @Treatment Temp. 1100<br>Â°F,<br>Time 1000 hour            | Room temp test after thermal exposure             |
|                       | 58.1 %                                                      | 58.1 %                                                     |                                                   |
|                       | @Treatment Temp. 427<br>Â°C,<br>Time 1.44e+7 sec            | @Treatment Temp. 801<br>Â°F,<br>Time 4000 hour             | Room temp test after thermal exposure             |
| Modulus of Elasticity | 181 GPa                                                     | 26300 ksi                                                  | Dynamic                                           |
|                       | @Temperature 600 Â°C                                        | @Temperature 1110<br>Â°F                                   |                                                   |
|                       | 195 GPa                                                     | 28300 ksi                                                  | Dynamic                                           |
|                       | @Temperature 500 Â°C                                        | @Temperature 932 Â°F                                       |                                                   |
|                       | 205 GPa                                                     | 29700 ksi                                                  | Dynamic                                           |
|                       | @Temperature 400 Â°C                                        | @Temperature 752 Â°F                                       |                                                   |
|                       | 209 GPa                                                     | 30300 ksi                                                  | Dynamic                                           |
|                       | @Temperature 300 Â°C                                        | @Temperature 572 Â°F                                       |                                                   |
|                       | 211 GPa                                                     | 30600 ksi                                                  | Dynamic                                           |
|                       | @Temperature 200 Â°C                                        | @Temperature 392 Â°F                                       |                                                   |
|                       | 218 GPa                                                     | 31600 ksi                                                  | Dynamic                                           |
|                       | @Temperature 100 Â°C                                        | @Temperature 212 Â°F                                       |                                                   |
|                       | 223 GPa                                                     | 32300 ksi                                                  | Dynamic                                           |
|                       | @Temperature 25.0<br>Â°C                                    | @Temperature 77.0 Â°F                                      |                                                   |
| Charpy Impact         | 99.0 J                                                      | 73.0 ft-lb                                                 | No thermal exposure                               |
|                       | @Temperature -196<br>Â°C                                    | @Temperature -321<br>Â°F                                   |                                                   |
|                       | 151 J                                                       | 111 ft-lb                                                  | No thermal exposure                               |
|                       | @Temperature 25.0<br>Â°C                                    | @Temperature 77.0 Â°F                                      |                                                   |

| Mechanical Properties | Metric                                           | English                                         | Comments                                 |
|-----------------------|--------------------------------------------------|-------------------------------------------------|------------------------------------------|
|                       | @Treatment Temp. 593<br>Â°C,<br>Time 2.88e+7 sec | @Treatment Temp.<br>1100 Â°F,<br>Time 8000 hour | Room temp test after thermal<br>exposure |
|                       | 66.0 J                                           | 48.7 ft-lb                                      |                                          |
|                       | @Treatment Temp. 593<br>Â°C,<br>Time 1.44e+7 sec | @Treatment Temp.<br>1100 Â°F,<br>Time 4000 hour | Room temp test after thermal<br>exposure |
|                       | 112 J                                            | 82.6 ft-lb                                      |                                          |
|                       | @Treatment Temp. 427<br>Â°C,<br>Time 2.88e+7 sec | @Treatment Temp. 801<br>Â°F,<br>Time 8000 hour  | Room temp test after thermal<br>exposure |
|                       | 118 J                                            | 87.0 ft-lb                                      |                                          |
|                       | @Treatment Temp. 427<br>Â°C,<br>Time 1.44e+7 sec | @Treatment Temp. 801<br>Â°F,<br>Time 4000 hour  | Room temp test after thermal<br>exposure |
|                       | 127 J                                            | 93.7 ft-lb                                      |                                          |
|                       | @Treatment Temp. 593<br>Â°C,<br>Time 3.60e+6 sec | @Treatment Temp.<br>1100 Â°F,<br>Time 1000 hour | Room temp test after thermal<br>exposure |
|                       | 136 J                                            | 100 ft-lb                                       |                                          |
|                       | @Treatment Temp. 427<br>Â°C,<br>Time 3.60e+6 sec | @Treatment Temp. 801<br>Â°F,<br>Time 1000 hour  | Room temp test after thermal<br>exposure |

| Thermal Properties | Metric                         | English                        | Comments |
|--------------------|--------------------------------|--------------------------------|----------|
| CTE, linear        | 11.6 Âµm/m-Â°C                 | 6.44 Âµin/in-Â°F               |          |
|                    | @Temperature 25.0 -<br>100 Â°C | @Temperature 77.0 -<br>212 Â°F |          |
|                    | 12.0 Âµm/m-Â°C                 | 6.67 Âµin/in-Â°F               |          |
|                    | @Temperature 25.0 -<br>200 Â°C | @Temperature 77.0 -<br>392 Â°F |          |
|                    | 12.4 Âµm/m-Â°C                 | 6.89 Âµin/in-Â°F               |          |
|                    | @Temperature 25.0 -<br>300 Â°C | @Temperature 77.0 -<br>572 Â°F |          |
|                    | 12.7 Âµm/m-Â°C                 | 7.06 Âµin/in-Â°F               |          |
|                    | @Temperature 25.0 -<br>400 Â°C | @Temperature 77.0 -<br>752 Â°F |          |
|                    | 13.1 Âµm/m-Â°C                 | 7.28 Âµin/in-Â°F               |          |
|                    | @Temperature 25.0 -            | @Temperature 77.0 -            |          |

| Thermal Properties     | 500 °C<br>Metric            | 932 °F<br>English            | Comments |
|------------------------|-----------------------------|------------------------------|----------|
|                        | 13.3 Åµm/m-Å°C              | 7.39 Åµin/in-Å°F             |          |
|                        | @Temperature 25.0 - 600 Å°C | @Temperature 77.0 - 1110 Å°F |          |
| Specific Heat Capacity | 0.412 J/g-Å°C               | 0.0985 BTU/lb-Å°F            |          |
|                        | @Temperature 25.0 Å°C       | @Temperature 77.0 Å°F        |          |
|                        | 0.434 J/g-Å°C               | 0.104 BTU/lb-Å°F             |          |
|                        | @Temperature 100 Å°C        | @Temperature 212 Å°F         |          |
|                        | 0.451 J/g-Å°C               | 0.108 BTU/lb-Å°F             |          |
|                        | @Temperature 200 Å°C        | @Temperature 392 Å°F         |          |
|                        | 0.465 J/g-Å°C               | 0.111 BTU/lb-Å°F             |          |
|                        | @Temperature 300 Å°C        | @Temperature 572 Å°F         |          |
|                        | 0.477 J/g-Å°C               | 0.114 BTU/lb-Å°F             |          |
|                        | @Temperature 400 Å°C        | @Temperature 752 Å°F         |          |
|                        | 0.488 J/g-Å°C               | 0.117 BTU/lb-Å°F             |          |
|                        | @Temperature 500 Å°C        | @Temperature 932 Å°F         |          |
|                        | 0.504 J/g-Å°C               | 0.120 BTU/lb-Å°F             |          |
|                        | @Temperature 600 Å°C        | @Temperature 1110 Å°F        |          |
| Thermal Conductivity   | 11.8 W/m-K                  | 81.9 BTU-in/hr-ftÅ²-Å°F      |          |
|                        | @Temperature 25.0 Å°C       | @Temperature 77.0 Å°F        |          |

| Electrical Properties  | Metric                | English               | Comments |
|------------------------|-----------------------|-----------------------|----------|
| Electrical Resistivity | 0.0000980 ohm-cm      | 0.0000980 ohm-cm      |          |
|                        | @Temperature 25.0 Å°C | @Temperature 77.0 Å°F |          |
|                        | 0.000100 ohm-cm       | 0.000100 ohm-cm       |          |
|                        | @Temperature 100 Å°C  | @Temperature 212 Å°F  |          |
|                        | 0.000104 ohm-cm       | 0.000104 ohm-cm       |          |
|                        | @Temperature 200 Å°C  | @Temperature 392 Å°F  |          |
|                        | 0.000108 ohm-cm       | 0.000108 ohm-cm       |          |
|                        | @Temperature 300 Å°C  | @Temperature 572 Å°F  |          |

| Electrical Properties | 0.000112 ohm-cm<br>Metric | 0.000112 ohm-cm<br>English | Comments |
|-----------------------|---------------------------|----------------------------|----------|
|                       | @Temperature 400 Â°C      | @Temperature 752 Â°F       |          |
|                       | 0.000115 ohm-cm           | 0.000115 ohm-cm            |          |
|                       | @Temperature 500 Â°C      | @Temperature 932 Â°F       |          |
|                       | 0.000117 ohm-cm           | 0.000117 ohm-cm            |          |
|                       | @Temperature 600 Â°C      | @Temperature 1110<br>Â°F   |          |

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