AK STEEL 17-7 PH® STAINLESS STEEL provides valuable property combinations particularly well suited for aerospace applications. This special alloy also provides benefits for other applications requiring formability, high strength and good corrosion resistance, as well as excellent properties for flat springs, belleville (conical spring) washers, eyelets, and strain gauges at temperatures up to 600 °F (316 °C).
Product Description

AK Steel 17-7 PH Stainless Steel is a semi-austenitic precipitation-hardening stainless steel that provides high strength and hardness, excellent fatigue properties, good corrosion resistance and minimum distortion upon heat treatment. It is easily formed in the annealed condition, then hardened to high strength levels by simple heat treatments to Conditions RH 950 and TH 1050. The exceptionally high strength of Condition CH 900 offers many advantages where limited ductility and workability are permissible.

In its heat-treated condition, this alloy provides exceptional mechanical properties at temperatures up to 900 °F (482 °C). Its corrosion resistance in both Conditions TH 1050 and RH 950 is superior to that of the hardenable chromium types. In some environments, corrosion resistance approximates that of the austenitic chromium nickel stainless steels. In Condition CH 900, its general corrosion resistance is comparable to that of Type 304. Fabricating practices recommended for other chromium-nickel stainless steels can be used for this material.

### Composition (wt %)

<table>
<thead>
<tr>
<th>Element</th>
<th>(wt %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.09 max.</td>
</tr>
<tr>
<td>Manganese</td>
<td>1.00 max.</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.040 max.</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.030 max.</td>
</tr>
<tr>
<td>Silicon</td>
<td>1.00 max.</td>
</tr>
<tr>
<td>Chromium</td>
<td>16.00 – 18.00</td>
</tr>
<tr>
<td>Nickel</td>
<td>6.50 – 7.75</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.75 – 1.50</td>
</tr>
</tbody>
</table>

### AVAILABLE FORMS

AK Steel 17-7 PH Stainless Steel is produced in sheet and strip in thicknesses from 0.015 – 0.19 in. (0.38 – 4.66 mm). Material is supplied in Condition A, ready for fabrication by the user. Sheet and strip material 0.050 in. (1.27 mm) and thinner are also produced in the hard-rolled Condition C for applications requiring maximum strength.

### SPECIFICATIONS

The following specifications are listed without revision indications.
Contact ASTM Headquarters, AMS Division of SAE or Department of Defense Index for latest revisions.

- **AMS 5528** Sheet, Strip and Plate
- **AMS 5529** Sheet and Strip – Cold Rolled
- **ASTM A 693** Plate, Sheet and Strip  
  (Listed as Grade 631 - UNS S17700)

The values shown in this bulletin were established in U.S. customary units. The metric equivalents may be approximate.
17-7 PH® STAINLESS STEEL

Standard Heat Treatments

AK Steel 17-7 PH Stainless Steel requires three essential steps in heat treating:
1) Austenite conditioning
2) Cooling to transform the austenite to martensite
3) Precipitation hardening

Table 1 presents the procedures for heat treating material in Condition A to Conditions TH 1050 and RH 950.

TABLE 1 – STANDARD HEAT TREATMENTS

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition A</td>
<td>Heat to 1400 ± 25 °F (760 ± 14 °C) Hold for 90 minutes</td>
</tr>
<tr>
<td></td>
<td>Heat to 1750 ± 15 °F (954 ± 8 °C) Hold for 10 minutes Air cool to room temperature Results in Condition A 1750</td>
</tr>
<tr>
<td></td>
<td>Heat to 1050 ± 10 °F (566 ± 5.5 °C) Hold for 90 minutes Air cool to room temperature Results in Condition TH 1050</td>
</tr>
<tr>
<td></td>
<td>Heat to 950 ± 10 °F (510 ± 5.5 °C) Hold for 60 minutes Air cool to room temperature Results in Condition RH 950</td>
</tr>
</tbody>
</table>

Note: Full TH 1050 properties may not be developed when PH 15-7 Mo® Stainless Steel (cold worked) is heat treated to Condition TH 1050. However, full properties will be developed by using one of the following methods:
1) Re-anneal the fabricated part to Condition A and heat treat to Condition TH 1050.
2) Heat treat fabricated part to an RH 1050 Condition.
3) Use a modified TH 1050 heat treatment. For further information on this heat treatment, contact AK Steel or your distributor.

No variation in properties is encountered when heat treating fabricated parts to Condition RH 950.

The highest strength levels obtainable from AK Steel 17-7 PH Stainless Steel are produced by Condition CH 900. To obtain these properties, Condition A material is transformed to martensite at the mill by cold reduction to Condition C. Hardening to Condition CH 900 is accomplished with a single, low-temperature heat treatment.
# Mechanical Properties

## TABLE 2 – TYPICAL ROOM TEMPERATURE MECHANICAL PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Condition</th>
<th>A</th>
<th>T</th>
<th>TH 1050</th>
<th>A 1750</th>
<th>R 100</th>
<th>RH 950</th>
<th>C</th>
<th>CH 900</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTS, ksi. (MPa)</td>
<td></td>
<td>120</td>
<td>145</td>
<td>200</td>
<td>133</td>
<td>175</td>
<td>230</td>
<td>230</td>
<td>295</td>
</tr>
<tr>
<td>0.2% YS, ksi. (MPa)</td>
<td></td>
<td>45</td>
<td>100</td>
<td>185</td>
<td>42</td>
<td>115</td>
<td>210</td>
<td>190</td>
<td>275</td>
</tr>
<tr>
<td>Elongation % in 2” (50.8 mm)</td>
<td></td>
<td>35</td>
<td>9</td>
<td>8</td>
<td>19</td>
<td>9</td>
<td>7</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Rockwell Hardness</td>
<td></td>
<td>885</td>
<td>C31</td>
<td>B85</td>
<td>C48</td>
<td>C44</td>
<td>C52</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## TABLE 3 – PROPERTIES ACCEPTABLE FOR MATERIAL SPECIFICATION*

<table>
<thead>
<tr>
<th>Property</th>
<th>Condition</th>
<th>A</th>
<th>TH 1050</th>
<th>RH 950</th>
<th>C</th>
<th>CH 900</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTS, ksi. (MPa)</td>
<td></td>
<td>150</td>
<td>max.</td>
<td>180 min.</td>
<td>210 min.</td>
<td>200 min.</td>
</tr>
<tr>
<td>0.2% YS, ksi. (MPa)</td>
<td></td>
<td>55</td>
<td>max.</td>
<td>150 min.</td>
<td>190 min.</td>
<td>175 min.</td>
</tr>
<tr>
<td>Elongation % in 2” (50.8 mm)</td>
<td></td>
<td>20 min.</td>
<td>–</td>
<td>6 min.</td>
<td>5 min.</td>
<td>1 min.</td>
</tr>
<tr>
<td>Fatigue Strength (10⁷ cycles), ksi. (MPa)</td>
<td></td>
<td>Transverse Direction</td>
<td>203 (1400)</td>
<td>218 (1503)</td>
<td>300 (2068)</td>
<td>240 (1655)</td>
</tr>
</tbody>
</table>

*Material 0.010 in. (0.25 mm) and thicker. Selection of hardness scale is determined by material condition and thickness. Where necessary, superficial hardness readings are converted to Rockwell B or C.

## TABLE 4 – FATIGUE STRENGTH AND ENDURANCE LIMIT

<table>
<thead>
<tr>
<th>Condition</th>
<th>Property</th>
<th>TH 1050</th>
<th>C</th>
<th>CH 900</th>
<th>RH 950</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endurance Limit (15 x 106 cycles), ksi. (MPa)</td>
<td>Heat Treated Surface</td>
<td>63.5 (438)</td>
<td>–</td>
<td>–</td>
<td>77.5 (534)</td>
</tr>
<tr>
<td></td>
<td>Pickled Surface</td>
<td>62.5 (431)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Vapor Blasted Surface</td>
<td>82.1 (566)</td>
<td>–</td>
<td>–</td>
<td>100.0 (690)</td>
</tr>
<tr>
<td></td>
<td>Polished Surface (120 grit)</td>
<td>88.3 (608)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Fatigue Strength (10⁷ cycles), ksi. (MPa)</td>
<td>Heat Treated, Pickled or Polished Surface</td>
<td>–</td>
<td>–</td>
<td>82.3 (567)</td>
<td>–</td>
</tr>
<tr>
<td>0.2% Compressive Yield Strength, ksi. (MPa)</td>
<td>Transverse Direction</td>
<td>203 (1400)</td>
<td>218 (1503)</td>
<td>300 (2068)</td>
<td>240 (1655)</td>
</tr>
</tbody>
</table>
# Mechanical Properties

## TABLE 5 – TYPICAL ELEVATED TEMPERATURE SHORT-TIME TENSILE PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Temperature, °F (°C)</th>
<th>75 (24)</th>
<th>300 (149)</th>
<th>500 (260)</th>
<th>600 (316)</th>
<th>700 (371)</th>
<th>800 (427)</th>
<th>900 (482)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTS, ksi. (MPa)</td>
<td>Condition TH 1050</td>
<td>193 (1331)</td>
<td>179 (1234)</td>
<td>167 (1151)</td>
<td>162 (1117)</td>
<td>156 (1076)</td>
<td>143 (986)</td>
<td>124 (855)</td>
</tr>
<tr>
<td></td>
<td>Condition RH 950</td>
<td>230 (1586)</td>
<td>208 (1434)</td>
<td>195 (1345)</td>
<td>189 (1303)</td>
<td>181 (1248)</td>
<td>160 (1103)</td>
<td>133 (917)</td>
</tr>
<tr>
<td></td>
<td>Condition CH 900</td>
<td>261 (1805)</td>
<td>248 (1710)</td>
<td>228 (1572)</td>
<td>222 (1531)</td>
<td>–</td>
<td>207 (1427)</td>
<td>182 (1258)</td>
</tr>
<tr>
<td>0.2% YS, ksi. (MPa)</td>
<td>Condition TH 1050</td>
<td>182 (1255)</td>
<td>170 (1172)</td>
<td>160 (1103)</td>
<td>155 (1069)</td>
<td>146 (1007)</td>
<td>130 (896)</td>
<td>100 (690)</td>
</tr>
<tr>
<td></td>
<td>Condition RH 950</td>
<td>217 (1496)</td>
<td>192 (1324)</td>
<td>176 (1213)</td>
<td>169 (1165)</td>
<td>162 (1117)</td>
<td>137 (945)</td>
<td>114 (786)</td>
</tr>
<tr>
<td></td>
<td>Condition CH 900</td>
<td>245 (1695)</td>
<td>233 (1610)</td>
<td>214 (1476)</td>
<td>203 (1403)</td>
<td>–</td>
<td>176 (1115)</td>
<td>143 (989)</td>
</tr>
<tr>
<td>Elongation</td>
<td>Condition TH 1050</td>
<td>10.0</td>
<td>8.0</td>
<td>4.5</td>
<td>4.0</td>
<td>4.5</td>
<td>6.2</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>Condition RH 950</td>
<td>6.0</td>
<td>4.5</td>
<td>4.5</td>
<td>5.0</td>
<td>7.0</td>
<td>12.0</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>Condition CH 900</td>
<td>5.0</td>
<td>4.0</td>
<td>3.0</td>
<td>3.0</td>
<td>–</td>
<td>5.0</td>
<td>6.0</td>
</tr>
</tbody>
</table>

## TABLE 6 – STRESS TO RUPTURE

<table>
<thead>
<tr>
<th>Property</th>
<th>Temperature, °F (°C)</th>
<th>600 (316)</th>
<th>700 (371)</th>
<th>800 (427)</th>
<th>900 (482)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In 100 Hours, Stress, ksi. (MPa)</td>
<td>Condition TH 1050</td>
<td>170 (1172)</td>
<td>130 (896)</td>
<td>110 (758)</td>
<td>78 (538)</td>
</tr>
<tr>
<td></td>
<td>Condition RH 950</td>
<td>188 (1296)</td>
<td>169 (1165)</td>
<td>113 (779)</td>
<td>61 (421)</td>
</tr>
<tr>
<td></td>
<td>Condition CH 900</td>
<td>220 (1517)</td>
<td>194 (1338)</td>
<td>135 (931)</td>
<td>53 (3651)</td>
</tr>
<tr>
<td>In 1000 Hours, Stress, ksi. (MPa)</td>
<td>Condition TH 1050</td>
<td>158 (1089)</td>
<td>122 (841)</td>
<td>90 (620)</td>
<td>52 (358)</td>
</tr>
<tr>
<td></td>
<td>Condition RH 950</td>
<td>180 (1241)</td>
<td>146 (1007)</td>
<td>92 (634)</td>
<td>44 (303)</td>
</tr>
<tr>
<td></td>
<td>Condition CH 900</td>
<td>216 (1489)</td>
<td>180 (1241)</td>
<td>73 (503)</td>
<td>36 (248)</td>
</tr>
<tr>
<td>Elongation</td>
<td>Condition TH 1050</td>
<td>19.0</td>
<td>21.0</td>
<td>21.0</td>
<td>30.0</td>
</tr>
<tr>
<td></td>
<td>Condition RH 950</td>
<td>13.0</td>
<td>21.0</td>
<td>15.0</td>
<td>33.0</td>
</tr>
<tr>
<td></td>
<td>Condition CH 900</td>
<td>10.0</td>
<td>11.0</td>
<td>20.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Elongation</td>
<td>Condition TH 1050</td>
<td>17.0</td>
<td>24.0</td>
<td>23.0</td>
<td>40.0</td>
</tr>
<tr>
<td></td>
<td>Condition RH 950</td>
<td>11.5</td>
<td>17.0</td>
<td>26.0</td>
<td>26.0</td>
</tr>
<tr>
<td></td>
<td>Condition CH 900</td>
<td>8.0</td>
<td>9.0</td>
<td>9.0</td>
<td>12.0</td>
</tr>
</tbody>
</table>
# Mechanical Properties

## TABLE 7 – CREEP STRENGTH

<table>
<thead>
<tr>
<th>Stress in ksi (MPa) to produce</th>
<th>Temperature, °F (°C)</th>
<th>600 (316)</th>
<th>700 (371)</th>
<th>800 (427)</th>
<th>900 (482)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1% permanent deformation in 1000 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition TH 1050</td>
<td>87.0 (600)</td>
<td>57.0 (393)</td>
<td>40.0 (276)</td>
<td>15.0 (103)</td>
<td></td>
</tr>
<tr>
<td>Condition RH 950</td>
<td>105.0 (724)</td>
<td>60.0 (414)</td>
<td>31.0 (214)</td>
<td>12.5 (86)</td>
<td></td>
</tr>
<tr>
<td>0.2% permanent deformation in 1000 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition TH 1050</td>
<td>105.0 (724)</td>
<td>70.0 (483)</td>
<td>45.0 (310)</td>
<td>18.0 (124)</td>
<td></td>
</tr>
<tr>
<td>Condition RH 950</td>
<td>126.0 (869)</td>
<td>87.0 (600)</td>
<td>36.0 (248)</td>
<td>14.0 (96)</td>
<td></td>
</tr>
</tbody>
</table>
Physical Properties

TABLE 8 – PHYSICAL PROPERTIES

<table>
<thead>
<tr>
<th></th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Density, lbs./in.³ (g/cm³)</td>
<td>0.282 (7.81)</td>
</tr>
<tr>
<td>Modulus of Elasticity, ksi. (GPa)</td>
<td>–</td>
</tr>
<tr>
<td>Electrical Resistivity, µΩ•cm</td>
<td>80</td>
</tr>
<tr>
<td>Magnetic Permeability, H/m</td>
<td></td>
</tr>
<tr>
<td>@ 25 oersteds</td>
<td>1.4 – 3.4</td>
</tr>
<tr>
<td>@ 50 oersteds</td>
<td>1.4 – 3.6</td>
</tr>
<tr>
<td>@ 100 oersteds</td>
<td>1.4 – 3.5</td>
</tr>
<tr>
<td>@ 200 oersteds</td>
<td>1.4 – 3.2</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.4 – 3.6</td>
</tr>
<tr>
<td>Thermal Conductivity, BTU/hr./ft²/°F (W/m/K)</td>
<td></td>
</tr>
<tr>
<td>300 °F (149 °C)</td>
<td>–</td>
</tr>
<tr>
<td>500 °F (260 °C)</td>
<td>–</td>
</tr>
<tr>
<td>840 °F (449 °C)</td>
<td>–</td>
</tr>
<tr>
<td>900 °F (482 °C)</td>
<td>–</td>
</tr>
<tr>
<td>Mean Coefficient of Thermal Expansion in./in./°F (μm/m/K)</td>
<td></td>
</tr>
<tr>
<td>70 – 200 °F (21 – 93 °C)</td>
<td>8.5 x 10⁻⁸ (15.3)</td>
</tr>
<tr>
<td>70 – 400 °F (21 – 204 °C)</td>
<td>9.0 x 10⁻⁸ (16.2)</td>
</tr>
<tr>
<td>70 – 600 °F (21 – 316 °C)</td>
<td>9.5 x 10⁻⁸ (17.1)</td>
</tr>
<tr>
<td>70 – 800 °F (21 – 427 °C)</td>
<td>9.6 x 10⁻⁸ (16.0)</td>
</tr>
</tbody>
</table>

Variations in heat-treating temperatures have negligible effect on electrical resistivity. Annealing, transforming and hardening treatment variations of ± 100 °F (56 °C) will not cause the resistivity to vary outside ± 3% from the listed value. Electrical resistivity value for Condition T is 107 µΩ•cm.

No appreciable change in effective magnetic permeability exists in either Condition A or Condition TH 1050 between room temperature and 500 °F (260 °C).

DIMENSIONAL CHANGES

When AK Steel 17-7 PH Stainless Steel is heat treated from Condition A to either Condition RH 950 or TH 1050, a net dimensional expansion of approximately 0.004 in./in. (0.1016 mm/mm) occurs. This dimensional change is the result of first, an expansion of about 0.0045 in./in. (0.1143 mm/mm) resulting from the transformation treatment and a contraction of about 0.0005 in./in. (0.0127 mm/mm) resulting from the precipitation-hardening treatment.

Heat treating Condition C to Condition CH 900 results in a contraction of about 0.0005 in./in. (0.0127 mm/mm).
Corrosion Resistance

Corrosion resistance of AK Steel 17-7 PH Stainless Steel in Conditions TH 1050 and RH 950 is generally superior to that of the standard hardenable chromium types of stainless steels such as Types 410, 420 and 431, but is not quite as good as chromium-nickel Type 304. Corrosion resistance in Condition CH 900 approaches that of Type 304 stainless steel in most environments.

ATMOSPHERIC EXPOSURE

In coastal exposure, samples show considerably better corrosion resistance than hardened chromium stainless steels such as Type 410. Although there is little difference between any successive two ratings shown in Table 9, samples indicated the following order of corrosion resistance based on general appearance:

1. Type 301
2. AK Steel 17-7 PH Stainless Steel in Condition CH 900
3. AK Steel 17-7 PH Stainless Steel in Condition TH 1050
4. AK Steel 17-7 PH Stainless Steel in Condition RH 950

In all heat-treated conditions, the alloy, like other types of stainless steel, will develop superficial rust in some environments. For example, in a marine atmosphere, stainless steels show evidence of rusting after relatively short exposure periods. However, after exposure for one or two years, the amount of rust present is little more than that which was present at six months.

CHEMICAL MEDIA

Hundreds of accelerated laboratory corrosion tests have been conducted on the precipitation-hardening stainless steels since their development. Table 9 shows typical corrosion rates for AK Steel 17-7 PH Stainless Steel and Type 304 in seven common reagents. Sheet coupons and chemically pure laboratory reagents were used. Consequently, the data can be used only as a guide to comparative performance.

### TABLE 9 – CORROSION RATES IN VARIOUS MEDIA, MILS PER YEAR*

<table>
<thead>
<tr>
<th>Corrosive Medium</th>
<th>AK Steel 17-7 PH SS</th>
<th>Type 304</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TH 1050</td>
<td>RH 950</td>
</tr>
<tr>
<td>H2SO4 – 95 °F (35 °C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1%</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>2%</td>
<td>0.9</td>
<td>0.7</td>
</tr>
<tr>
<td>5%</td>
<td>124</td>
<td>132</td>
</tr>
<tr>
<td>H2SO4 – 176 °F (80 °C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1%</td>
<td>50</td>
<td>297</td>
</tr>
<tr>
<td>2%</td>
<td>374</td>
<td>884(2)</td>
</tr>
<tr>
<td>HCl – 95 °F (35 °C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5%</td>
<td>65</td>
<td>4</td>
</tr>
<tr>
<td>1%</td>
<td>695(2)</td>
<td>447(3)</td>
</tr>
<tr>
<td>HNO3 – Boiling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25%</td>
<td>19</td>
<td>20.4</td>
</tr>
<tr>
<td>50%</td>
<td>70</td>
<td>81</td>
</tr>
<tr>
<td>65%</td>
<td>128</td>
<td>136</td>
</tr>
<tr>
<td>Formic Acid – 176 °F (80 °C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5%</td>
<td>2.7</td>
<td>4.3</td>
</tr>
<tr>
<td>10%</td>
<td>5.5</td>
<td>5.7</td>
</tr>
<tr>
<td>Acetic Acid – Boiling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33%</td>
<td>3.1</td>
<td>5.6</td>
</tr>
<tr>
<td>60%</td>
<td>12.3</td>
<td>3.0</td>
</tr>
<tr>
<td>H3PO4 – Boiling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20%</td>
<td>7.0</td>
<td>18</td>
</tr>
<tr>
<td>50%</td>
<td>24</td>
<td>46</td>
</tr>
<tr>
<td>70%</td>
<td>104</td>
<td>315</td>
</tr>
<tr>
<td>NaOH – 176 °F (80 °C)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30%</td>
<td>13.1</td>
<td>3.7</td>
</tr>
<tr>
<td>NaOH – Boiling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30%</td>
<td>67</td>
<td>58</td>
</tr>
</tbody>
</table>

*Rates were determined by total immersion for five 48-hour periods. Specimens were activated during last three test periods in the 65% nitric acid. Rate is average of number of periods indicated in parentheses, if fewer than five periods were run.
Corrosion Resistance

CORROSION RESISTANCE AND COMPATIBILITY IN ROCKET FUELS

Oxygen – While oxygen is highly reactive chemically, liquid oxygen is noncorrosive to most metals. The precipitation hardening stainless steels experience no problem in this medium.

Ammonia – AK Steel 17-7 PH Stainless Steel is satisfactory for handling ammonia.

Hydrogen – Liquid hydrogen and gaseous hydrogen at low temperatures are noncorrosive.

STRESS CRACKING IN MARINE ENVIRONMENTS

The precipitation-hardening stainless steels, like the hardenable chromium stainless steels, may be subject to stress corrosion cracking when stressed and exposed to some corrosive environments. The tendency is related to the type of stainless steel, its hardness, the level of tensile stress and the environment.

AK Steel has conducted stress cracking tests on the precipitation-hardening alloys in a marine atmosphere 82 ft. (25 m) from the waterline using two-point loaded bent-beam specimens.

Data reported here are the results of multiple specimens exposed at stress levels of 50 and 75% of the actual yield strength of the materials tested. Test specimens were 0.050 in. (0.127 mm) thick heat treated to Conditions TH 1050 and RH 950. Specimens in Condition CH 900 were 0.041 in. (1.04 mm) thick. The long dimension of all specimens was cut transverse to the rolling direction.

When comparing the various heat-treated conditions, the data show that AK Steel 17-7 PH Stainless Steel has the greatest resistance to stress cracking in Condition CH 900. Likewise, Condition TH 1050, although somewhat less resistant than Condition CH 900, appears to be more resistant to stress cracking than Condition RH 950.

Table 10 summarizes the test data. In addition, in the mild industrial atmosphere in midwest United States, specimens stressed at 90% of their yield strength had not broken after 730 days of exposure.

TABLE 10 – SUMMARY OF STRESS-CRACKING TESTS IN COASTAL EXPOSURE

<table>
<thead>
<tr>
<th>Heat Treatment</th>
<th>Stressed at 50% of the 0.2% Yield Strength</th>
<th>Stressed at 50% of the 0.2% Yield Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stress, ksi. (MPa)</td>
<td>Days to Failure</td>
</tr>
<tr>
<td>TH 1050</td>
<td>100.8 (694)</td>
<td>No failures in 746 days</td>
</tr>
<tr>
<td>TH 1050</td>
<td>89.0 (614)</td>
<td>No failures in 746 days</td>
</tr>
<tr>
<td>RH 950</td>
<td>111.6 (769)</td>
<td>30.2</td>
</tr>
<tr>
<td>RH 950</td>
<td>110.2 (759)</td>
<td>116 (1)**</td>
</tr>
<tr>
<td>CH 900</td>
<td>142.8 (986)</td>
<td>No failures in 746 days</td>
</tr>
</tbody>
</table>

Exposed Marine Atmosphere

**( ) Number in brackets indicates number of failed specimens unbroken after 746 days.

***Range of broken specimens only. Remainder of 5 specimens unbroken after 746 days.

NOTE: All tests made in transverse direction. Tests discontinued after 746 days of exposure.
FORMABILITY
AK Steel 17-7 PH® Stainless Steel in Condition A can be formed comparably to Type 301. It work hardens rapidly and may require intermediate annealing in deep drawing or in forming intricate parts. Springback is similar to that of Type 301.
This alloy is extremely hard and strong in Condition C. Therefore, fabrication techniques for such materials must be used.

WELDABILITY
The precipitation hardening class of stainless steels is generally considered to be weldable by the common fusion and resistance techniques. Special consideration is required to achieve optimum mechanical properties by considering the best heat-treated conditions in which to weld and which heat treatments should follow welding. This particular alloy is generally considered to have poorer weldability compared to the most common alloy of this stainless class, AK Steel 17-4 PH® Stainless Steel. A major difference is the high Al content of this alloy, which degrades penetration and enhances weld slag formation during arc welding. Also, the austenite conditioning and precipitation hardening heat treatments are both required after welding to achieve high strength levels. When a matching weld filler is needed, AMS 5824/UNS S17780 is most often specified.

HEAT TREATMENT
HEAT TREATING AND ANNEALING
For in-process annealing, the alloy should be heated to 1950 ± 25 °F (1066 ± 14 °C) for three minutes for each 0.1 in. (2.5 mm) of thickness, and air cooled. This treatment may be required to restore the ductility of cold-worked material so that it can take additional drawing or forming. Although most formed or drawn parts do not require re-annealing prior to hardening, annealing is required on severely formed or drawn parts to be heat treated to Condition TH 1050 if full response to heat treatment is required. Annealing is unnecessary in the case of the RH 950 heat treatment.

EQUIPMENT AND ATMOSPHERE
Selection of heat-treating equipment depends to some extent on the nature of the particular parts to be treated. However, heat source, atmosphere and control of temperatures are the primary considerations.
Furnaces fired with oil or natural gas are difficult to use in the heat treatment of stainless steels, particularly if combustion control is uncertain and if flame impingement on the parts is possible. Electric furnaces, gas-and oil-fired radiant tube furnaces or vacuum furnaces generally are used for heat treating this material.
Air provides a satisfactory furnace atmosphere for heat treating and annealing operations. Controlled reducing atmospheres such as dissociated ammonia or bright annealing gas introduce the hazard of nitriding and/or carburizing or decarburizing and should not be used.

CLEANING PRIOR TO ANNEALING OR HEAT TREATING
Thorough cleaning of parts and assemblies prior to heat treatment greatly facilitates scale removal and is necessary for the development of uniform properties. Removal of oils and lubricants with solvents also assures that the steel will not be carburized from this source. Carburized AK Steel 17-7 PH Stainless Steel will not respond properly to heat treatment.
Cleaning may be accomplished by the following two step procedure:
1. Vapor degrease or solvent clean. This step removes oil, grease and drawing lubricants.
2. Mechanical scrubbing with mild abrasive cleaners, Oakite 33 or similar proprietary cleaners to remove dirt or other insoluble materials. All traces of cleaners should be removed by rinsing thoroughly with warm water.
A light, tightly adherent, uniform-appearing oxide after heat treatment is evidence of proper cleaning.
Properties

COATINGS
Protective coatings offer little advantage in reducing oxidation of the metal surface during heat treatments if the parts are thoroughly cleaned. However, when thorough cleaning is impractical, coatings may be beneficial. If such coatings are used, extreme caution must be exercised to provide free air circulation around the coated parts, or carburization may result.

SCALE REMOVAL
Scale develops during most heat-treating operations. The amount and nature of the scale formation varies with the cleanliness of the parts, the furnace atmosphere and the temperature and time of heat treatment. A variety of descaling methods may be employed, and the method chosen often depends upon the facilities available. A tabulation of the recommended scale removal methods after various heat treatments is shown in Table 11.

<table>
<thead>
<tr>
<th>Heat Treated to Condition</th>
<th>Preferred Methods After Heat Treatment</th>
<th>Secondary Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Wet Grit Blast(1) or Pickle(2)</td>
<td>Scale Condition and Pickle(3)</td>
</tr>
<tr>
<td>CH 900</td>
<td>Wet Grit Blast(1) or Pickle(2)</td>
<td>–</td>
</tr>
<tr>
<td>A 1750</td>
<td>Wet Grit Blast(1)</td>
<td>Pickle(2) or Scale Condition and Pickle(3)</td>
</tr>
<tr>
<td>T and R 100</td>
<td>Wet Grit Blast(1)</td>
<td>Pickle(2) or Scale Condition and Pickle(3)</td>
</tr>
<tr>
<td>TH 1050 and RH 950</td>
<td>Wet Grit Blast(1)</td>
<td>Pickle(2) or Scale Condition and Pickle(3)</td>
</tr>
</tbody>
</table>

(1) Wet Grit Blasting processes are widely used and are highly satisfactory. These methods eliminate the hazard of intergranular attack from acid pickling. Added advantages are better fatigue strength and corrosion resistance.

(2) 10% HNO₃ + 2% HF at 110 – 140 °F (49 – 60 °C) for three minutes maximum. Removal of loosened scale may be facilitated by the use of high-pressure water or steam spray. Scale-conditioning treatment is unnecessary for parts that have been thoroughly cleaned. Uniform pickling of the entire surface is evidence of a well-cleaned part. A spotty scale and non-uniform removal is evidence of a poorly cleaned part, and a scale conditioning process is necessary prior to pickling.

(3) Scale conditioners:
   (a) Kolene Process
   (b) DuPont Hydride Process
   (c) Caustic permanganate (boiling 10% NaOH + 3% KMnO₄ for one hour)

(4) Use caustic permanganate scale conditioning followed by HNO₃ – HF pickle only. Do not use fused salts. The use of fused salts on AK Steel 17-7 PH Stainless Steel in Condition A 1750 will prevent the steel from developing maximum transformation upon subsequent refrigeration.

(5) Scale condition and pickle as in method 3. The Virgo and Kolene salt baths may be operated at temperatures up to 1100 °F (593 °C) so that the hardening and scale conditioning treatment may be combined if desired. However, the operation of a salt bath at such temperatures should be checked with the manufacturer before proceeding.

Some degree of intergranular penetration occurs during any pickling operation. However, the penetration from the short-time pickling of this material in Condition CH 900 is generally slight. Other conditions are more susceptible to intergranular penetration during pickling. Consequently, pickling should be avoided or carefully controlled if it must be used for such removal.

The standard 10% HNO₃ + 2% HF acid bath may be used for removal of light discoloration or heat tint produced by the final hardening treatment at 900 – 1200 °F (482 – 649 °C), providing immersion times are kept short (in the order of one minute or less).
AK Steel is a leading producer of flat-rolled carbon, stainless and electrical steel products, primarily for the automotive, infrastructure and manufacturing, including electrical power, and distributors and converters markets. Through its subsidiaries, the company also provides customer solutions with carbon and stainless steel tubing products, die design and tooling, and hot- and cold-stamped components. Headquartered in West Chester, Ohio (Greater Cincinnati), the company has approximately 9,500 employees at manufacturing operations in the United States, Canada and Mexico, and facilities in Western Europe. Additional information about AK Steel is available at www.aksteel.com.

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Data referring to material properties are the result of tests performed on specimens obtained from specific locations of the products in accordance with prescribed sampling procedures; any warranty thereof is limited to the values obtained at such locations and by such procedures. There is no warranty with respect to values of the materials at other locations.

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