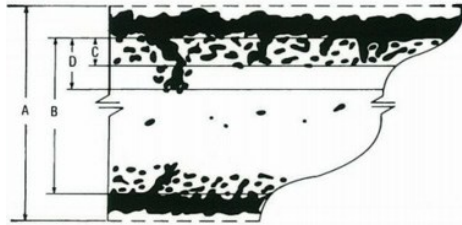


HAYNES[®] 188 alloy

Oxidation Resistance

HAYNES[®] 188 alloy exhibits very good resistance to both air and combustion gas oxidizing environments, and can be used for long-term continuous exposure at temperatures up to 2000°F (1095°C). For exposures of short duration, 188 alloy can be used at higher temperatures.



1. Metal Loss = (A - B)/2
2. Average Internal Penetration = C
3. Maximum Internal Penetration = D
4. Average Metal Affected = ((A - B)/2) + C
5. Maximum Metal Affected = ((A - B)/2) + D

Comparative Oxidation Resistance in Flowing Air, 1008 Hours

| Alloy | 1800°F (980°C) | | | | 2000°F (1095°C) | | | | 2100°F (1150°C) | | | |
|------------------------|--------------------------|-----------|------------|----------|--------------------------|-----------|------------|-----------|--------------------------|------------|------------|------------|
| | Average Metal Affected** | | Metal Loss | | Average Metal Affected** | | Metal Loss | | Average Metal Affected** | | Metal Loss | |
| | mils | µm | mils | µm | mils | µm | mils | µm | mils | µm | mils | µm |
| 188 | 1.1 | 28 | 0.1 | 3 | 3.7 | 94 | 0.5 | 13 | 10.7 | 272 | 8.6 | 218 |
| 230[®] | 1.5 | 38 | 0.2 | 5 | 3.3 | 84 | 0.5 | 13 | 4.4 | 112 | 1.2 | 30 |
| X | 1.5 | 38 | 0.2 | 5 | 4.4 | 112 | 1.3 | 33 | 6.1 | 115 | 3.6 | 91 |
| 625 | 1.9 | 48 | 0.4 | 10 | 7.8 | 198 | 3.5 | 89 | 20.2 | 513 | 18.3 | 465 |
| 617 | 2.0 | 51 | 0.3 | 8 | 3.8 | 97 | 0.6 | 15 | 5.2 | 132 | 1.0 | 25 |

*Flowing air at a velocity of 7.0 ft/min (213.4 cm/min) past the samples. Samples cycled to room temperature once per week.

**Metal Loss + Average Internal Penetration

Oxidation Test Parameters

Burner rig oxidation tests were conducted by exposing samples 3/8 in. x 2.5 in. x thickness (9 mm x 64 mm x thickness), in a rotating holder, to products of combustion of No. 2 fuel oil burned at a ratio of air to fuel of about 50:1. (Gas velocity was about 0.3 mach). Samples were automatically removed from the gas stream every 30 minutes and fan-cooled to near ambient temperature and then reinserted into the flame tunnel.

Comparative Burner Rig Oxidation Resistance 1000 Hour Exposure at 1800°F (980°C)

| 1000 Hour Exposure at 1800°F (980°C), 30 Minute Cycles | | | | | | |
|--|------------|-----------|------------------------|-----------|------------------------|-----------|
| Alloy | Metal Loss | | Average Metal Affected | | Maximum Metal Affected | |
| | mils | µm | mils | µm | mils | µm |
| 188 | 1.1 | 28 | 3.2 | 81 | 3.9 | 99 |
| 230[®] | 2.8 | 71 | 5.6 | 142 | 6.4 | 163 |
| 617 | 2.4 | 61 | 5.7 | 145 | 6.9 | 175 |
| 625 | 3.7 | 94 | 6.0 | 152 | 6.6 | 168 |
| X | 4.3 | 109 | 7.3 | 185 | 8.0 | 203 |

Comparative Burner Rig Oxidation Resistance at 2000°F (1095°C) for 500 Hours

| 500 Hour Exposure at 2000°F (1095°C), 30 Minute Cycles | | | | | | |
|--|-----------------------------|-----|------------------------|-----|------------------------|-----|
| Alloy | Average Metal Loss Per Side | | Average Metal Affected | | Maximum Metal Affected | |
| | mils | µm | mils | µm | mils | µm |
| 230® | 7.1 | 180 | 9.9 | 251 | 11.8 | 300 |
| 188 | 10.9 | 277 | 13.1 | 333 | 14.1 | 358 |
| X | 11.6 | 295 | 14.0 | 356 | 15.1 | 384 |
| 617 | 13.3 | 338 | 20.9 | 531 | 21.2 | 538 |
| 625 | Consumed | | | | | |

188 comparative burner rig

*625 was consumed

Water Vapor Oxidation Data

| Air + 20% H ₂ O at 1800°F (982°C), 1008 hours, cycled weekly | | | | |
|---|------------|----|------------------------|-----|
| Alloy | Metal Loss | | Average Metal Affected | |
| | mils | µm | mils | µm |
| 214® | 0.04 | 1 | 0.64 | 16 |
| 230® | 0.19 | 5 | 1.59 | 40 |
| 625 | 0.36 | 9 | 1.66 | 42 |
| 188 | 0.18 | 5 | 1.48 | 38 |
| X | 0.27 | 7 | 1.77 | 45 |
| 617 | 0.39 | 10 | 1.99 | 50 |
| 556® | 0.35 | 9 | 1.85 | 47 |
| HRa€120® | 0.38 | 10 | 2.08 | 53 |
| 800HT | 2.47 | 63 | 5.07 | 129 |
| HRa€160® | 0.77 | 20 | 5.57 | 141 |