

# ALLOY DATA SHEET KHRSA

## HEAT RESISTANT ALLOY

REVISION: 06/00

### DESCRIPTION

KHRSA is a modification of KHR48N alloy in which the tungsten has been raised to 13% to provide higher strength for service at temperatures in excess of 2200 °F. The alloy possesses the greatest oxidation resistance and high temperature strength of the Kubota family of alloys, making this alloy suitable for many harsh operating environments.

### COMPOSITION

|              | <b>C</b> | <b>Mn</b> | <b>Si</b> | <b>Cr</b> | <b>Ni</b> | <b>W</b> | <b>P</b> | <b>S</b> | <b>Al</b> |
|--------------|----------|-----------|-----------|-----------|-----------|----------|----------|----------|-----------|
| Min. (Wt. %) | 0.40     | 0.3       |           | 28        | 47        | 12.0     | -        | -        | Addition  |
| Max. (Wt. %) | 0.50     | 0.6       | 0.5       | 31        | 51        | 14.0     | 0.04     | 0.04     |           |

### APPLICATIONS

Radiant heater tubes and fittings, hangers and tube supports, furnace rolls, steel mill skids and rails, heat treatment furnace fixtures.

### PRODUCT FORMS

Horizontal and vertical centrifugal castings; static castings.

### PHYSICAL PROPERTIES

|                                  |         |            |  |
|----------------------------------|---------|------------|--|
| Density (lb/in <sup>3</sup> )    | 0.313   |            |  |
| Melting Solidus                  | 2398 °F |            |  |
| Melting Liquidus                 | 2460 °F |            |  |
| Thermal Conductivity             | 5.80    | @ 70 °F    |  |
| (Btu ft / ft <sup>2</sup> hr °F) | 14.74   | @ 1652 °F  |  |
|                                  | 15.71   | @ 1832 °F  |  |
|                                  | 16.68   | @ 2012 °F  |  |
| Thermal Expansion                | 7.78    | 68-1472 °F |  |
| (10 <sup>-6</sup> in/in °F)      | 9.39    | 68-1832 °F |  |

### COMPARATIVE OXIDATION LOSS

| Alloy         | 100 hr test mass loss (mm/yr) |             |             |
|---------------|-------------------------------|-------------|-------------|
|               | 1832 °F                       | 2012 °F     | 2192 °F     |
| KHR 35H       | 0.30                          | 0.81        | --          |
| KHR 48N       | 0.22                          | 0.77        | 1.10        |
| <b>KHR SA</b> | <b>0.06</b>                   | <b>0.10</b> | <b>0.32</b> |
| KHR S2        | 0.26                          | 0.37        | --          |
| KHR S3        | --                            | 0.23        | --          |

### MECHANICAL PROPERTIES (Typical Values - Centrifugal Castings)

|                                | 70 °F | 1652 | 1832 | 2012 | 2192 °F | Min Value (CC) |
|--------------------------------|-------|------|------|------|---------|----------------|
|                                |       |      |      |      |         | 70 °F          |
| U.T.S. (ksi)                   | 77    | 40   | 30   | 19   | 11      | 68             |
| Y.S. (ksi)                     | 43    | 21   | 15   | 10   | 5       | 38             |
| El. (%)                        | 9     | 12   | 13   | 16   | 22      | 4.0            |
| Hardness (BHN)                 | 258   | 171  | 160  | 136  |         |                |
| Modulus (x10 <sup>3</sup> ksi) | 26.7  | 11.9 | 10.4 |      |         |                |

### Typical Room Temperature Aged Tensile Results - 100 hour Aging

| Aging Temp. (°F) | 932 | 1112 | 1292 | 1472 | 1652 | 1832 |
|------------------|-----|------|------|------|------|------|
| U.T.S. (ksi)     | 112 | 105  | 105  | 105  | 102  | 103  |
| Y.S. (ksi)       | 69  | 61   | 64   | 64   | 63   | 62   |
| El. (%)          | 4.7 | 4.5  | 3.8  | 3.7  | 4.2  | 5.5  |
| Hardness (BHN)   | 237 | 242  | 242  | 242  | 242  | 237  |

### SERVICE TEMPERATURE

The combination of high strength and excellent resistance to oxidation and carburization make this alloy suitable for long term service at temperatures up to 2200 °F.

**WELDABILITY**

Procedures for welding KHRSA alloy are available from Kubota Metal Corporation.

**CREEP-RUPTURE PROPERTIES**

Long term creep-rupture properties were extrapolated from Larson-Miller Parameter versus stress plots.

|              |      | <b><u>RUPTURE-STRESS-KSI</u></b> |             |             |             |             |             |             |    |
|--------------|------|----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|----|
| <u>HOURS</u> |      | <u>1600</u>                      | <u>1700</u> | <u>1800</u> | <u>1900</u> | <u>2000</u> | <u>2100</u> | <u>2200</u> | °F |
| 100          | AVG. | 12.62                            | 9.43        | 6.86        | 4.84        | 3.29        | 2.16        | 1.36        |    |
|              | MIN  | 10.12                            | 7.57        | 5.50        | 3.88        | 2.64        | 1.72        | 1.07        |    |
| 1000         | AVG. | 9.94                             | 7.17        | 5.01        | 3.37        | 2.18        | 1.35        | 0.81        |    |
|              | MIN  | 7.98                             | 5.76        | 4.02        | 2.70        | 1.73        | 1.06        | 0.62        |    |
| 10,000       | AVG. | 7.70                             | 5.33        | 3.56        | 2.27        | 1.39        | 0.82        | 0.47        |    |
|              | MIN  | 6.18                             | 4.28        | 2.85        | 1.81        | 1.09        | 0.63        | 0.34        |    |
| 100,000      | AVG. | 5.84                             | 3.87        | 2.45        | 1.48        | 0.86        | 0.48        | 0.26        |    |
|              | MIN  | 4.69                             | 3.10        | 1.95        | 1.17        | 0.66        | 0.35        | 0.17        |    |

|               |      | <b><u>CREEP-STRESS-KSI</u></b> |             |             |             |             |             |             |    |
|---------------|------|--------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|----|
| <u>%/HOUR</u> |      | <u>1600</u>                    | <u>1700</u> | <u>1800</u> | <u>1900</u> | <u>2000</u> | <u>2100</u> | <u>2200</u> | °F |
| 0.0001        | AVG. | -                              | 3.25        | 2.65        | 2.07        | 1.54        | 1.08        | 0.72        |    |

Note: Creep-rupture stresses are subject to periodic revisions as the results from long term tests become available.

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