

## **CM 939 Weldable® Alloy**

Recent studies by CM show the above alloy is amenable to a two (2) step heat treatment [4 hrs/2120° F (1160°C) GFQ + 20 hrs/1553°F (845°C) AC] which was originally developed for and is used with standard IN 939 alloy. The two (2) step heat treatment confers appreciable increases in 0.2% proof stress and stress to 1.0% creep, compared to the original four (4) step heat treat work with CM 939 Weldable alloy, with commensurate reductions in ductility. [Tables 1 and 2, Figs 1, 2 and 3].

This two (2) step heat treatment may be particularly applicable to latter stage vane segments and vane rings for both aero and industrial gas turbines.

**TABLE 1**

### **CM 939 Weldable® Tensile Properties**

2120°F (1160°C)/4 hrs AC + 1553°F (845°C)/20 hrs. AC  
Concorde Test Bars, Heat 4V1015, LA 9581 HT (Mold 4) - Heat 6V2201, LA 9640 HT (Mold 63)

| <b>Test Temperature</b> | <b>ID</b> | <b>0.2%<br/>PS (ksi)</b> | <b>TS<br/>(ksi)</b> | <b>%<br/>Elong [4D]</b> | <b>%<br/>RA</b> |
|-------------------------|-----------|--------------------------|---------------------|-------------------------|-----------------|
| <b>RT (70F)</b>         | 4 B       | 132.9                    | 165.9               | 4.1                     | 5.1             |
|                         | 63 E      | 137.5                    | 164.5               | 4.2                     | 5.5             |
| <b>800°F [427°C]</b>    | 4 C       | 123.2                    | 154.8               | 6.5                     | 10.0            |
|                         | 63 F      | 125.3                    | 162.3               | 7.1                     | 10.5            |
| <b>1100°F [593°C]</b>   | 4 D       | 120.7                    | 156.1               | 8.2                     | 11.5            |
|                         | 63 G      | 117.4                    | 159.3               | 10.0                    | 13.1            |
| <b>1400°F [760°C]</b>   | 4 E       | 120.4                    | 145.0               | 6.0                     | 8.3             |
|                         | 63 H      | 124.0                    | 147.4               | 4.3                     | 5.9             |
| <b>1550°F [843°C]</b>   | 4F        | 104.4                    | 115.0               | 6.8                     | 8.7             |
|                         | 63J       | 104.1                    | 114.9               | 6.0                     | 9.2             |

Machining and testing source: Joliet Metallurgical Laboratories

**TABLE 2**

**CM 939 Weldable® Creep-Rupture Properties**

2120°F (1160°C)/4 hrs AC + 1553°F (845°C)/20 hrs. AC  
 Concorde Test Bars, Heat 4V1015, LA 9581 HT (Mold 4) - Heat 6V2201, LA 9640 HT (Mold 63)

| Test Conditions                                  | ID   | Rupture Life hrs. | % Elong [4D] | % RA | Time to 1% Creep hrs. | Time to 2% Creep hrs. |
|--------------------------------------------------|------|-------------------|--------------|------|-----------------------|-----------------------|
| <b>1500°F/30.0 ksi</b><br><b>[816°C/207 MPa]</b> | 4 G  | 5197.1            | 2.0          | 2.9  | 5155.9                | –                     |
|                                                  | 4 R  | 5156.9            | 2.3          | 2.6  | 4952.2                | –                     |
| <b>1600°F/27.0 ksi</b><br><b>[871°C/186 MPa]</b> | 4 H  | 893.7             | 6.3          | 10.8 | 686.3                 | 792.9                 |
|                                                  | 4 S  | 1013.7            | 7.4          | 8.5  | 777.1                 | 912.8                 |
| <b>1650°F/20.0 ksi</b><br><b>[899°C/138 MPa]</b> | 63 A | 1177.9            | 10.3         | 14.1 | 777.0                 | 952.7                 |
|                                                  | 63 B | 1085.1            | 10.1         | 14.8 | 702.1                 | 866.5                 |
|                                                  | 4 J  | 380.5             | 11.2         | 11.5 | 262.3                 | 306.8                 |
| <b>1650°F/25.0 ksi</b><br><b>[899°C/172 MPa]</b> | 4 P  | 447.3             | 7.4          | 16.3 | 325.2                 | 381.8                 |
|                                                  | 63 C | 430.2             | 12.2         | 19.3 | 291.8                 | 342.2                 |
|                                                  | 63 D | 422.6             | 10.8         | 16.6 | 283.1                 | 333.7                 |
| <b>1700°F/12.0 ksi</b><br><b>[927°C/83 MPa]</b>  | 4 K  | 2424.8            | 5.6          | 5.9  | 1705.2                | 2160.4                |
|                                                  | 4 N  | 2192.8            | 4.7          | 4.8  | 1582.3                | 1994.7                |
| <b>1700°F/15.0 ksi</b><br><b>[927°C/103 MPa]</b> | 4 L  | 1042.6            | 6.7          | 6.6  | 718.1                 | 889.3                 |
|                                                  | 4 M  | 916.9             | 6.6          | 11.3 | 655.3                 | 812.8                 |

Machining and testing source: Joliet Metallurgical Laboratories

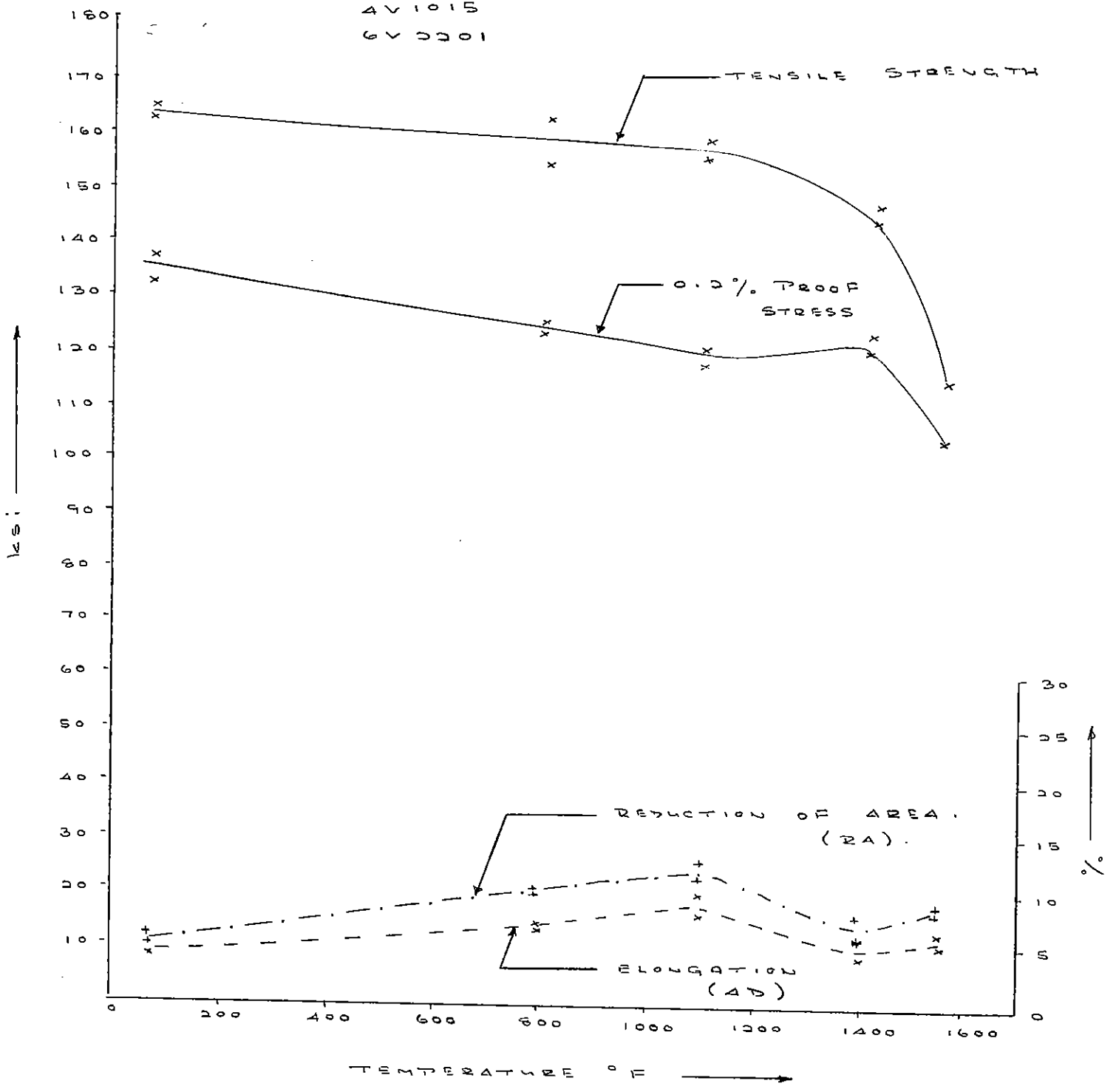
CM has now successfully melted 22 heats (210,000 lbs) of CM 939 Weldable alloy from the initial 250 lb developmental heats to production heats in the CM 5,000 lb., 8,000 lb and 15,000 lb VIM furnaces, including 50R/50V heats.



FIG. 1. CM 93A WELDABLE - TENSILE PROPERTIES  
 CTS TEST BARS - CM HEAT TREAT.  
 [COLCORDE] MACHINED [LOW STRESS  
 GROUP] & TESTED BY  
 FOLLET.

HEAT TREATMENT - 2120°F (1160°C) | 4 hrs AC +  
 1523°F (845°C) | 20 hrs AC.

CM HEATS:  
 4V1015  
 6V0201



4.128104

LABORATORY MILLER

CREEP DATA  
STRESS TO 1.0%  
CM 939 WELDABLE

CM 939 WELDABLE  
4 STAGE HEAT TREAT  
1.0% CREEP  
TIME RANGE 40-1700 hrs  
CM HEATS 5V0018  
[12 DATA] 5V0019  
POINTS

CM 939 WELDABLE  
2 STAGE HEAT TREAT  
2120°F / 4 hrs AC +  
1553°F / 20 hrs AC  
1.0% CREEP - TIME  
RANGE 262 - 5156 hrs  
CM HEATS 5V0018  
[12 DATA] 5V0019  
POINTS

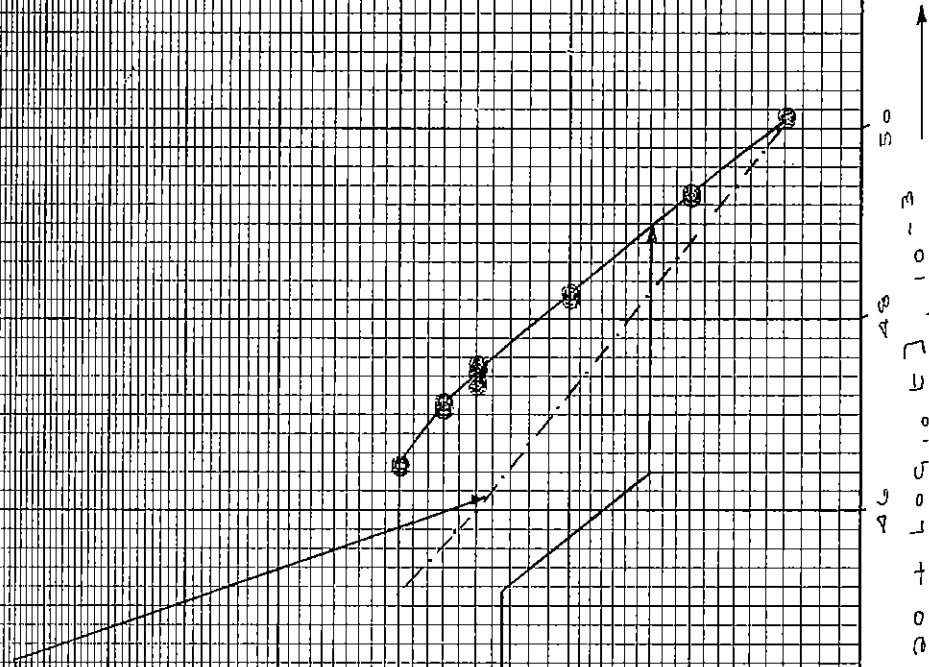


FIG 2

$T = (T + 460) [20 + \log_{10} T] \cdot 10^{-3}$

LAPSON - MILLER

STRESS - RUPTURE  
CM 939 WELDABLE  
VS IN 738 LC

QTA 222  
CE  
CM (PSA) DATA  
2 STAGE HEAT TREAT  
2100°F / 4 HRS AC +  
1475°F / 8 HRS AC  
CM HEATS 3V1301 3V1351  
3V1322 3V1439

CM 939 WELDABLE  
2 STAGE HEAT TREAT  
2120°F / 4 HRS AC +  
1553°F / 20 HRS AC  
LIFE RANGE 380 - 5197  
HRS  
CM HEATS 5V0018  
6V0201  
4V1015  
[14 DATA POINTS]

IN 738 LC AVERAGE  
INCO DATA  
CEC  
LIFE RANGE 50 - 3000  
HRS  
2050°F / 2 HRS AC +  
1550°F / 24 HRS AC

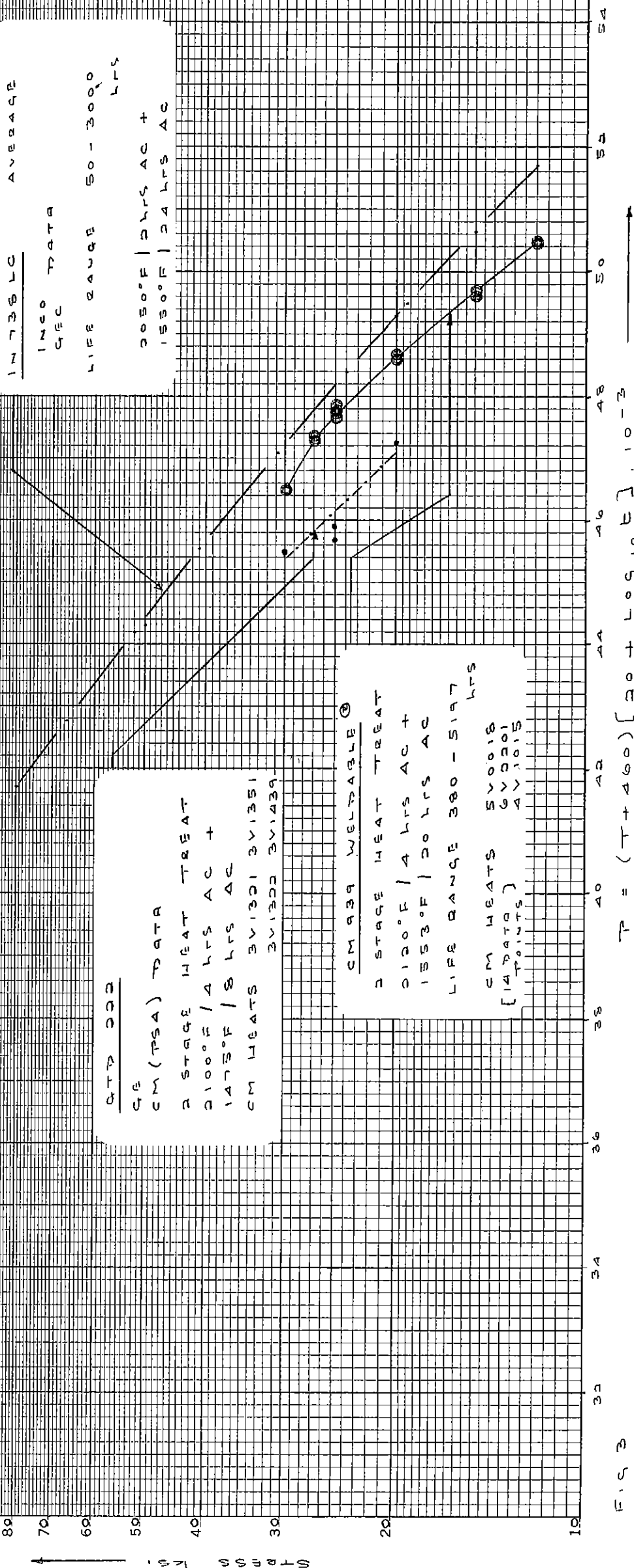


FIG 3 T = (T+460) [20 + LOG t] . 10^-3