REPORT

ON

RUPTURE CHARACTERISTICS OF 12 Cr, 2-1/4 Mo, 1/4 V (LAPALOY) STEEL AT 1100° AND 1200°F

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RUPTURE CHARACTERISTICS OF 12 Cr, 2-1/4 Mo, 1/4 V (LAPALOY) STEEL AT 1100° AND 1200°F

The purpose of this investigation was to determine the rupture characteristics at 1100° and 1200°F of a heat of 12 Cr - 2 1/4 Mo - 1/4 V steel (Lapaloy) made by the Timken Roller Bearing Company.

Lapaloy is a Mo + V modification of the 12 Cr martensitic steel proposed for use in the steam-power and gas-turbine industries.

In addition to determining the rupture strength, metallographic examinations were made of the original and of the most prolonged rupture specimens.

SUMMARY

The Lapaloy tested had the following rupture properties at 100 and 1000 hours:

Temp (°F)	Rupture Strength (psi)		Rupture Elongation (%)	
	100-hr	1000-hr	100-hr	1000-hr
1100	41,500	(29,000)	25	20
1200	22,000	13,000	30	(45)

The heat of Lapaloy tested at 1100°F was not much better in 100-hours rupture strength than 12 Cr 3 Mo oil-quenched material and slightly weaker at 1000 hours. There appeared to be no difference in ductility. It did have higher ductility and about equal strength to the 12 Cr 3 Mo steel normalized from 1900°F.

The rupture strength values at 1100°F of the Timken made heat of Lapaloy were on or below the low side of the range of values reported in literature for the alloy. The 1000-hour strength at 1200°F fell below the reported range.

The structure of this heat consisted essentially of tempered martensite and of a small amount of delta ferrite in the form of stringers.

TEST MATERIALS

Machined 0.505-inch-diameter specimens were supplied from rolled bar stock from a one-ton heat of Lapaloy reported to have the following composition:

Heat No.	C	Mn	P	S	Si	Cr	Ni	Mo	V
02449	.26	1.12	.015	.019	.68	12.17	.19	2.25	.30

The material for the specimens was heat treated as follows:

1750°F, 1 hour at heat, air cool - 341/352 BHN
1900°F, 1 hour at heat, air cool - 555 BHN
1300°F temper for 4 hours, air cooled - 285 BHN

For rupture testing at stresses over 40,000 psi, the specimens were remachined to 0.400-inch diameter to bring the load requirements within the capacity of the stress-rupture units.

RESULTS

The stress-rupture data obtained for this investigation are listed in Table I and the established stress-rupture time curves are shown in Figure 1. The 100-hour and 1000-hour rupture strengths and rupture

elongation values obtained from the data are as follows:

Temperature (°F)	Rupture Strength (psi)		Rupture Elongation (%)	
	100-hr	1000-hr	100-hr	1000-hr
1100	41,500	(29,000)	25	20
1200	22,000	13,000	30	(45)

The structure of the original material and of the fractured specimens taken from the longest time rupture tests at 1100° and 1200°F were examined microscopically. The original structure is shown in Plate 1. The appearance of the fracture, the surface adjacent to the fracture, and the structure of the interior after testing at 1100° and 1200°F are shown in Plates 2 and 3 respectively.

DISCUSSION

The rupture strength and elongation of Lapaloy, Heat 02449, are compared with those of 12 Cr 3 Mo steel, previously investigated in Figure 2 and with data reported in literature in the following tabulation:

Steel	Heat No.	Heat Treatment	BHN	Rupture Strength (psi)		Rupture Elong. (%)	
				100-hr	1000-hr	100-hr	1000-hr
		Rupture Strength at 1100°F					
Lap-aloy	02449	N 1750° + N 1900°F + Temper 1300°F	285	41,500	(29,000)[a]	25	(20)
12 Cr 3 Mo	02718[b]	N 1900°F + 6 hrs at 1150°F	321/352	44,500	28,000	20	15
12 Cr 3 Mo	02718[b]	OQ 2115°F + 6 hrs at 1200°F	286/302	37,500	31,000	24	--
Lap-aloy	(c)	OQ 2000°F + Temper	--	--	25,000/43,000	--	--

Steel	Heat No.	Heat Treatment	BHN	Rupture Strength (psi) 100-hr	Rupture Strength (psi) 1000-hr	Rupture Elong. (%) 100-hr	Rupture Elong. (%) 1000-hr
		Rupture Strength at 1200°F					
Lapaloy	02449	N 1750° + N 1900° + Temper 1300°F	285	22,000	13,000	30	(45)
Lapaloy	(c)	OQ 2000°F + Temper	--	19,000/ 29,000	15,700/ 20,000	--	--

(a) Figures in brackets indicate extrapolation of the stress-rupture time curves.

(b) Data for the 12 Cr 3 Mo steel taken from Report No. 197.

(c) Range of values found in literature based on the Larson Miller parameter, T (25 + log t.).

The rupture strength of Lapaloy at 1100°F is higher at 100 hours and lower at 1000 hours than that of the 2115°F oil-quenched 12 Cr 3 Mo steel. The available data do not show any difference in ductility.

Comparison with the 12 Cr 3 Mo steel normalized from 1900°F indicates that the strength of Lapaloy is about equal for 1000 hours, but lower for 100 hours. The ductility of the Lapaloy was slightly higher.

Only one rupture test at 1200°F for the normalized 12 Cr 3 Mo material was available for comparison. The two materials gave identical results at the same stress as may be seen from the following tabulation:

Material	Stress (psi)	Rupture Time (hours)	Elongation (%)	Reduction of Area (%)
Lapaloy	27,000	41.3	29.0	81.0
12 Cr 3 Mo	27,000	40.0	34.0	78.5

The rupture strength of the heat of Lapaloy tested at 1100°F falls on the low side of the range of values reported for Lapaloy in literature. The 1000-hour strength at 1200°F was below that of the reported range.

Microscopic examination of the original material indicated that the structure consisted of tempered martensite and delta ferrite. The final normalizing temperature of 1900°F resulted in a rather fine-grained structure.

The ruptured specimens showed a transgranular type of failure at the fracture at both 1100° and 1200°F. The surface adjacent to the fracture gave no indications of intergranular oxidation. The only change observed in the structure after testing was an increase in the tempering of martensite.

TABLE I

Rupture Data for Lapaloy at 1100° and 1200°F

(Heat 02449, Air Cooled from 1750°F, Air Cooled from 1900°F and Tempered 4 Hours at 1300°F - 285 Brinell.)

Stress (psi)	Rupture Time (hours)	Elongation (% in 2 in.)	Reduction of Area (%)
		1100°F	
50,000	11.9	27.0	73.0
46,000	31.3	26.0	74.5
39,000	350	23.5	72.0
36,000	399	28.5	72.0
33,000	543	21.5	71.0
		1200°F	
33,000	15.6	32.0	82.0
27,000	41.3	29.0	81.0
16,000	423	47.5	82.5

Missing Figures 1 and 2, also Plates No. 1,2,3
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