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REPORT ON

RUPTURE PROPERTIES AT 1200°F OF 18-8+Ti (TYPE 321) STAINLESS STEEL TUBING

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RUPTURE PROPERTIES AT 1200°F OF 18-8+Ti (TYPE 321) STAINLESS STEEL TUBING

The high temperature properties of production tubes of Type 321 18-8+Ti stainless steel tubing were investigated using creep-rupture tests at 1200°F. Specimens were taken from approximately 2-inch O. D. by 0.250-inch wall tubes from two different heats. The final heat treatment given the tubes was a water quench from 2060°F. This treatment was selected to give a grain size of the order of ASTM 5 to 7.

SUMMARY AND CONCLUSIONS

The rupture tests indicated a stress for rupture in 100,000 hours at 1200°F for the tubing of 9600 psi. Elongation in the rupture tests was good.

The two tubes from different heats had nearly identical rupture properties.

The 100, 000 hour rupture strength at 1200°F of 9600 psi was within the range but on the low side of published data for Type 321 steel heat-treated at or above 2000°F. The tubing, therefore, had rupture strengths of the order expected for the product.

MATERIAL

The specimens supplied for this investigation were taken from Type 321 tubes manufactured from two commercial heats.

The chemical analysis reported for the two heats by the Timken Roller Bearing Company were as follows:

Heat No.	C	Mn	P	S	Si	Cr	Ni	Mo	Cu	Ti
18532	0.057	1.33	0.020	0.010	0.54	18.06	12.86	0.06	0.50	0.48
18958	0.047	1.50	0.009	0.009	0.49	17.95	12.28	0.08	0.10	0.55

Both tubes (2" O.D. by 1/4" wall) were water quenched from 2060°F after fabricating. The ASTM grain size was reported to be predominately 5-7.

The specimens (22" long strips with a gage section approximately 2-1/2 inches long, 1/2-inch wide and .3 inches thick) were machined from longitudinal sections of the tube.

RESULTS

Four rupture tests at 1200°F on specimens from Heat 18532 (Table I), with the longest deviation test being 3040 hours, gave a stress-rupture time curve (Figure 1) which extrapolated to give a stress for rupture in 100,000 hours of 9600 psi. Two tests on specimens from Heat 18958 indicated rupture strengths slightly lower. The difference was, however, not significant.

Elongation of the rupture specimens first increased with rupture time and then decreased, with the elongation of the 3040 hour specimens being 13.5 percent.

The time-elongation curve for the most prolonged test (Figure 2) showed brief periods of first and second stage creep in comparison to third-stage creep. The rupture test on the specimen from Heat 18532 at 23000 psi had a longer rupture time and less elongation than was indicated by the other three specimens from this tube.

The original microstructures of the two tubes (Plates 1 and 2) were similar. The grain size appeared to be 5 to 8 rather than the reported 5 to 7 with the tube from Heat 18958 being perhaps slightly finer grained. The specimen which ruptured in 3040 hours showed the usual precipitation at the grain boundaries and the appearance of the new phase generally considered to be sigma phase (Plate 3).

The specimen tested at 23000 psi which required a longer time to rupture than indicated by the other tests had no obvious structural difference (Plate 4) to account for the abnormally long rupture time. There were fewer small grains, a condition which could account for the observed difference.

DISCUSSION

The creep-rupture properties of Type 321 steel is being subjected to extensive study by producers and users. At present it is generally considered that cold worked and annealed material can have a wide range in properties depending on the final heat treating temperature. Tubing of the type investigated is subject to this variation.

The estimated stress for rupture in 100,000 hours at 1200°F of 9600 psi indicates that the tubing tested had rupture strengths of the order contemplated for the grade of steel in the form of tubing. This is shown by Figure 3 which compares 100,000 hour rupture strengths for Type 321 steel when heat treated at 2000°F or higher. While the tubing tested is on the low side of the range, the rupture strength is within the range anticipated for the steel.

While only two tests were carried out on the specimens from the tube from Heat 18958, the close agreement with the results for the other tube indicate that there was no significant difference between the two tubes. A more prolonged test would have been certain to agree with the indication from the shorter tests.

The grain size of the metallographic specimens examined showed the small amount of grain growth which the 2060°F treatment was selected to give. There were perhaps somewhat smaller grains present (ASTM8) than was indicated by the Timken evaluation of the grain size.

The structural changes observed were those to be expected for the heat treatment and grain size involved. As is usual the appearance of "sigma phase" during testing of the relatively fine grained structure was accompanied by good ductility in the rupture tests. The early appearance of third stage creep and a prolonged period of third-stage creep is to be expected for the grain size and structural changes observed.

Table I

STRESS RUPTURE DATA AT 1200°F FOR STRIP SPECIMEN FROM TYPE 321 TUBES

(Water Quenched from 2060°F - Grain Size 5-8)

Heat No.	Stress (psi)	Rupture Time (hours)	Elongation (% in 2 inches)
18532	30,000	96	13.0
18532	23,000	983	12.5
18532	20,000	1195	20.5
18532	17,000	3040	13.5
18958	30,000	75.9	13.0
18958	23,000	388.	22.5