ENGINEERING RESEARCH INSTITUTE
THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICH.

REPORT ON

PROPERTIES OF AN ASTM A106, GRADE B CARBON STEEL PIPE

By

R. Jackowski

J. W. Freeman

Project 842
Report 214

August 23, 1957

THE TIMKEN ROLLER BEARING COMPANY
STEEL AND TUBE DIVISION
CANTON, OHIO

PROPERTIES OF AN ASTM A106, GRADE B CARBON STEEL PIPE

The investigation covered by this report was made to evaluate the tensile and rupture properties of ASTM-A106, Grade B, carbon steel pipe. It was carried out as the Timken Roller Bearing Company's contribution to a cooperative program of Petroleum and Chemical Panel of the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals. Several organizations evaluated typical samples of carbon steel in plate and pipe form to establish typical properties for carbon steel products.

Stress-rupture properties were measured at 1000°F and short-time tensile properties at 80°, 200°, 400°, 600°, 800°, and 1000°F.

SUMMARY

The rupture strengths at 1000°F determined for the carbon steel pipe material were as follows:

Stress (psi) for rupture in			
100-hour	1000-hour	10,000-hour	100,000-hour
17,500	11,300	7,300	4,800

Tensile properties from 80° to 1000°F are given in the text.

The tensile and rupture properties were in general equal to or higher than the average values published for carbon steel. This is to be expected for as-rolled carbon steel made to coarse grained melting practice. As would be expected for steel made by this melting practice the tensile tests showed strain aging.

TEST MATERIALS

The tensile specimens submitted for this investigation were taken from a section of a hot rolled carbon steel pipe. The pipe was 8-5/8-inches OD by 0.906 inch in wall thickness. It had been manufactured from a heat made to coarse-grained melting practice by the National Tube Company.

The pipe was reported to be ASTM - A106 Grade B pipe having the following reported compositions:

Chemical Composition (Percent)							
C	Mn	P	S	Si	Cr	Ni	Mo
0.265	0.73	0.011	0.022	0.20	0.02	0.03	0.02

RESULTS AND DISCUSSION

Stress-rupture tests were conducted at 1000°F. The data obtained are presented in Table I and shown as a stress-rupture time curve in Figure 1. The rupture strengths and elongation values at fracture established were as follows:

Stress (psi) for rupture in			Fracture Elongation (%)	
100-hour	1000-hour	10,000-hour	100-hour	1000-hour
17,500	11,300	7,300	55.0	55.0

The data were as consistent as would be expected for specimens cut from a large pipe.

Time-elongation data were obtained for the longer time tests. These data are presented in the creep curves of Figure 2. The curves are in line with what is to be expected for the material.

Duplicate tensile tests were run at 80°, 200°, 400°, 600°, 800° and 1000°F. The stress-strain curves obtained from the tensile tests are presented in Figures 3 and 4. The tensile properties derived from the tensile tests are tabulated in Table II. Figure 5 shows the effect of temperatures on the tensile properties.

Very sharp yield points were obtained in most of the tests up to 400°F. This prevented obtaining strain data to plot good stress-strain curves and only "drop-of-the-beam" yield strengths are reported in those cases.

The higher tensile strength obtained from 400° to 600°F is in all probability due to strain aging during testing. Above 400°F the tensile strengths, offset yield strengths and the proportional limit decreased with temperature. The ductility of the carbon steel pipe decreased to a minimum at 400°F and than increases considerabley above 400°F.

Metallographic examination of the original structure, Plate 1, shows a matrix of ferrite together with a fine lamellar pearlite. During prolonged rupture testing at 1000°F the pearlite underwent spheroidization as shown in Plate No. 2. Shown also in Plate 2 are the fracture and the surface adjacent the fracture.

The tensile and rupture properties of the carbon steel pipe were in general equal to or slightly higher than average of most published data. This would be anticipated for material from as-rolled pipe, particularly when made to coarse grained practice. The coarse grained practice obviously left the material susceptible to strain aging.

TABLE I

STRESS-RUPTURE DATA AT 1000°F FOR ASTM A106, GRADE B CARBON STEEL PIPE

Stress (psi)	Rupture Time (hours)	Elongation (% in 2 in.)	Reduction of Area (%)
32,200	S.T.T.T.*	57.0	80.7
18,000	85	55.0	77.7
15,000	251	54.0	75.6
12,000	572	53.5	69.5
11,500	572	59.5	72.8
9,000	3171	45.0	61.5

* - Average of 2 tests

TABLE II

TENSILE PROPERTIES OF ASTM A106, GRADE B CARBON STEEL PIPE

Temp. (°F)	Tensile Strength (psi)	Offset Yield Stress (psi) 0.1%	Offset Yield Stress (psi) 0.2%	Proportional Limit (psi)	Elongation (% in 2 in.)	Reduction of Area (%)
80	72,500	38,500*	--	35,000	34.5	60.5
80	70,750	35,600	37,200	29,000	33.0	60.0
Average	71,625	37,050	37,200	32,000	33.8	60.3
200	66,500	36,000*	--	27,000	31.0	61.5
200	67,750	39,250*	--	29,000	29.0	61.0
Average	67,125	37,675		28,000	30.0	61.3
400	78,000	36,500*	--	26,000	20.0	52.0
400	76,750	36,000*	--	26,000	20.5	49.0
Average	77,375	36,250		26,000	20.3	50.5
600	74,000	28,100	31,600	14,000	34.0	61.5
600	72,500	28,500	32,200	14,000	36.0	63.0
Average	73,250	28,300	31,900	14,000	35.0	62.3
800	56,800	26,600	29,900	13,000	38.5	74.0
800	57,000	27,600	31,100	13,000	34.0	74.5
Average	56,900	27,100	30,500	13,000	36.3	74.3
1000	32,400	19,700	22,400	8,000	50.0	79.5
1000	32,000	20,000	22,200	8,000	64.0	81.9
Average	32,200	19,850	22,300	8,000	57.0	80.7

* - Yield Point by drop of beam method.