EVALUATION OF THE ELEVATED TEMPERATURE TENSILE AND CREEP-RUPTURE PROPERTIES OF $\frac{1}{2}$Cr-$\frac{1}{2}$Mo, 1Cr-$\frac{1}{2}$Mo, and 1$\frac{1}{4}$Cr-$\frac{1}{2}$Mo-Si STEELS

Prepared for the

METAL PROPERTIES COUNCIL

by G. V. Smith

DS 50

AMERICAN SOCIETY FOR TESTING AND MATERIALS

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REFERENCE: Smith, G.V., Evaluation of the Elevated Temperature Tensile and Creep-Rupture Properties of 1/2 Cr - 1/2 Mo, 1 Cr - 1/2 Mo and 1 1/4 Cr - 1/2 Mo-Si Steels; ASTM Data Series DS 50. American Society for Testing and Materials, 1972.

ABSTRACT: This report evaluates the elevated temperature strength and ductility of three low chromium-molybdenum steels that find extensive service at moderately elevated temperatures--up to perhaps 1100°F. Included in the evaluations are previously unpublished test results gathered by the Metal Properties Council, as well as test results previously published in ASTM Data Series DS 6 (1953)(1) and DS 6S1 (1966)(2).

Employing a normalization procedure that involves ratioing the elevated temperature strength of a particular test lot to the room temperature strength of that same lot, and applying the method of least squares, trend curves depicting the characteristic temperature variations of yield and tensile strengths have been developed.

The rupture and secondary creep rate data have been evaluated by both direct isothermal interpolation or extrapolation, and by time-temperature parameter, to establish the temperature dependencies of the average and minimum stresses to cause rupture in 1000, 10,000 and 100,000 hours and of average and minimum stresses to cause secondary creep rates of 0.1 and 0.01 percent per 1000 hours.

Elongation and reduction of area data are included for both the short time tensile tests and for the rupture tests.

Several summary figures immediately following this abstract, Figs. 1-3, show the temperature dependence of strength properties for the three grades of steel evaluated in this report. In these figures, the yield and tensile strengths trend curves have been computed from the respective ratio trend curves so that they correspond at room temperature to the specified minimum values of common ASTM product specifications.

The body of the report provides in figures, tables and text, details concerning the identity of the individual lots, the evaluation procedures and the results.

KEY WORDS: elevated temperature, tensile strength, yield strength, creep strength, rupture strength, elongation, reduction of area, chromium-molybdenum steels, time-temperature parameter, mechanical properties, data evaluation.

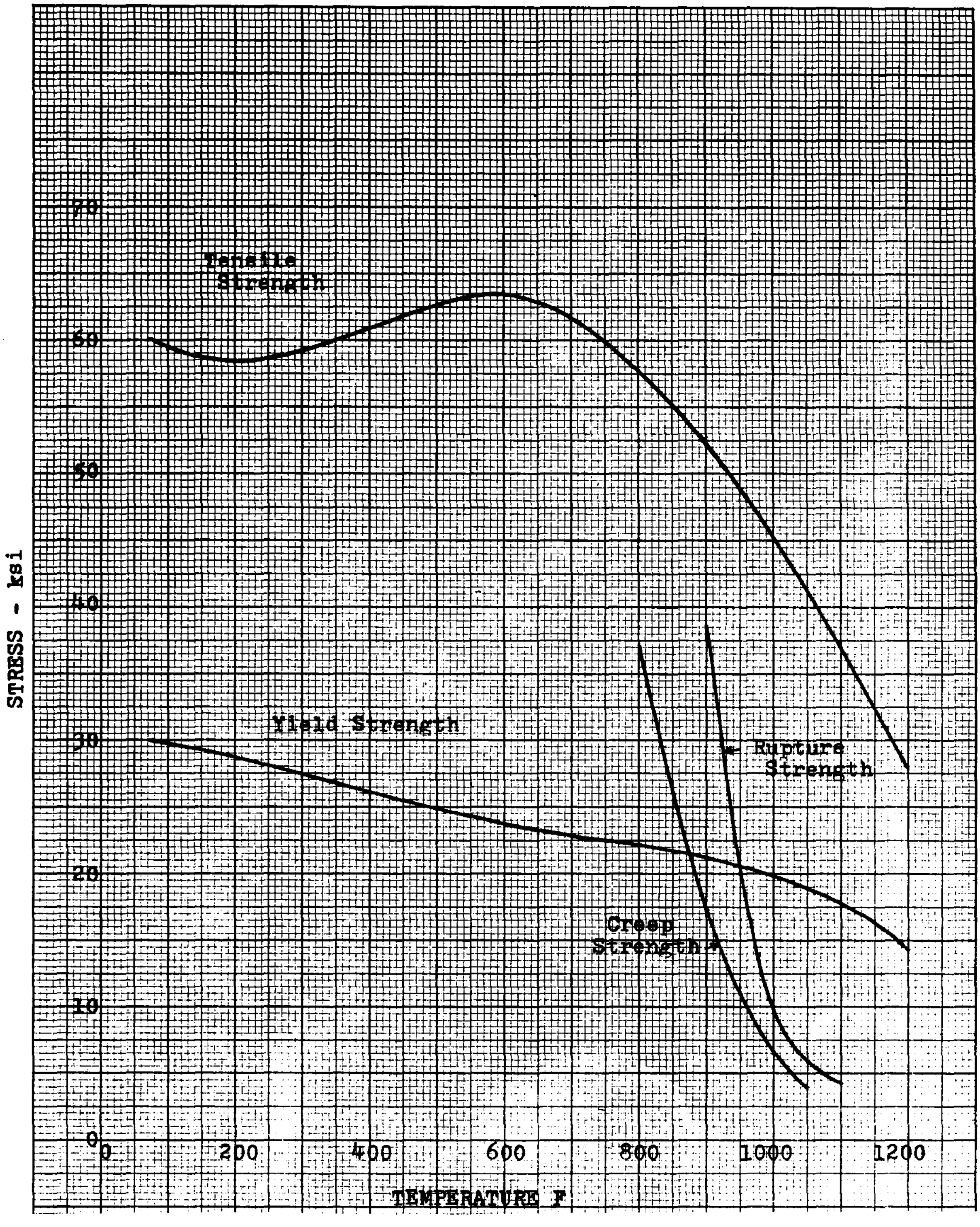

Figure 1. Effect of temperature on yield strength, tensile strength, creep strength (0.01 % per 1000 hours), and rupture strength (100,000 hours) of 1/2 Cr - 1/2 Mo steel. Yield and tensile strengths are adjusted to 30 and 60 ksi at 75 F. Creep and rupture strengths are averages of available data.

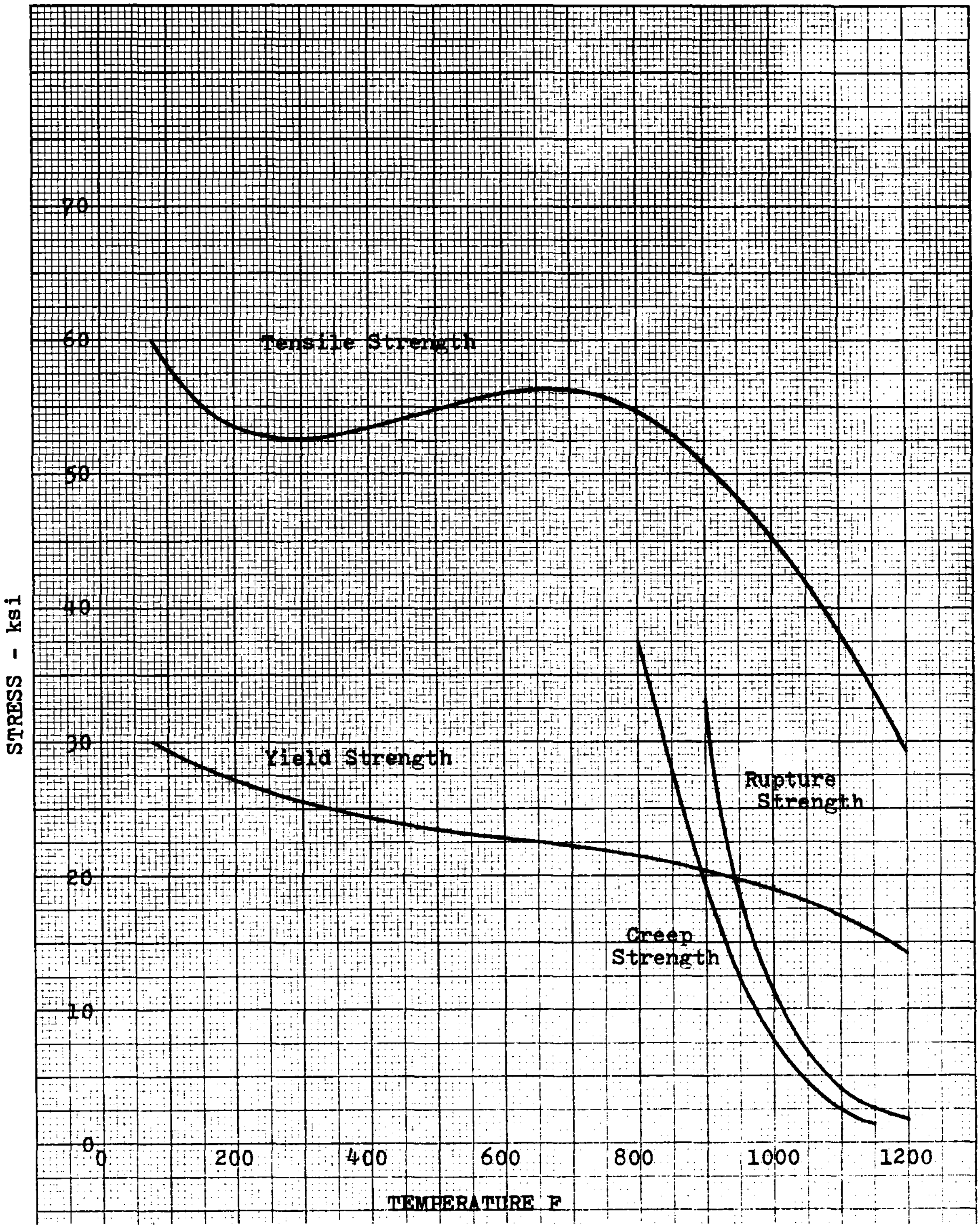

Figure 2. Effect of temperature on yield strength, tensile strength, creep strength (0.01 % per 1000 hours), and rupture strength (100,000 hours) of 1 Cr - 1/2 Mo steel. Yield and tensile strengths are adjusted to 30 and 60 ksi at 75 F. Creep and rupture strengths are averages of available data.

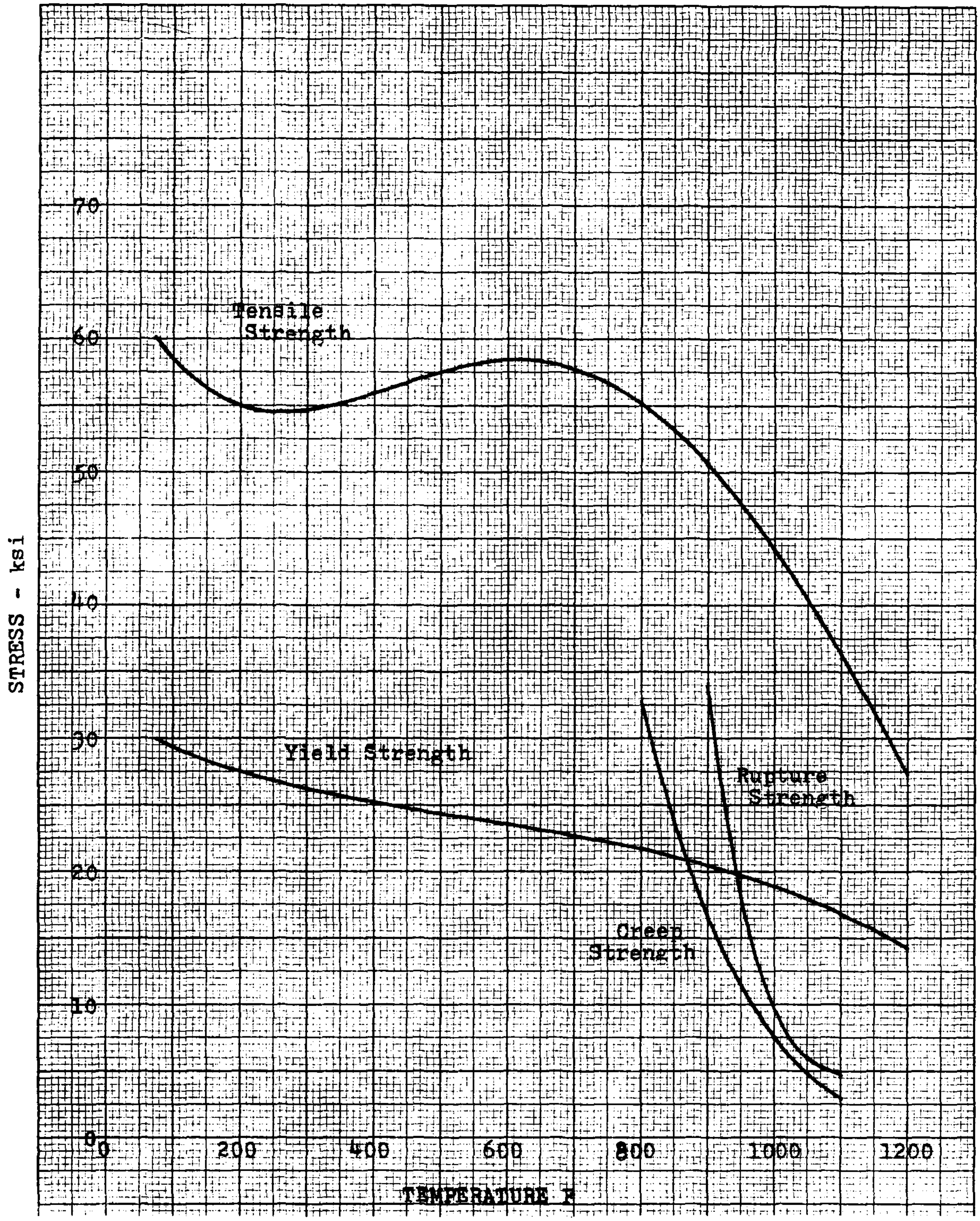

Figure 3. Effect of temperature on yield strength, tensile strength, creep strength (0.01 % per 1000 hours), and rupture strength (100,000 hours) of 1 1/4 Cr - 1/2 Mo - Si steel. Yield and tensile strengths are adjusted to 30 and 60 ksi at 75 F. Creep and rupture strengths are averages of available data.

INTRODUCTION

The evaluations of this report cover three common grades of low chromium-molybdenum steels, containing nominally 1/2 Cr - 1/2 Mo, 1 Cr - 1/2 Mo, and 1 1/4 Cr - 1/2 Mo-Si. The report is another in a continuing series of evaluations sponsored by The Metal Properties Council (MPC) for the purpose of developing engineering design information.

The data that have been evaluated include hitherto unreported test results gathered by MPC from cooperating laboratories and data previously reported in ASTM's DS Data Series Publications[1,2]. All of the data, including those from references 1 and 2, are identified in Table I as to ASTM specification number, deoxidation practice, heat treatment, product form and size, grain size, and data source, in so far as these are known; the chemical compositions of the steels, other than those included in references 1 and 2, are given in Table II. Data representing the different product forms, plate, pipe, tube, bar and casting are included. No additional data for weld metal or weldments were received; the relatively few weld metal and weld joint data previously reported in reference 18 have not warranted evaluation.

The tabular data as well as the evaluations for the three grades of steel considered in this report have been grouped separately, as follows:

Part 1: 1/2 Cr - 1/2 Mo Steels
Part 2: 1 Cr - 1/2 Mo Steels
Part 3: 1 1/4 Cr - 1/2 Mo-Si Steels

In evaluating the data of each Part, a distinction is made in the early stages of the evaluation as to product form, but in the final stage of developing trend curves for the dependence of strength upon temperature for the individual steel grades, the similarity in results makes it seem appropriate to treat the data for different product forms as from single data populations.

The properties that have been evaluated in this report are yield strength, tensile strength, creep strength and rupture strength. Elongation and reduction of area at fracture also are included in the report for both the tensile and rupture tests, when available.

Yield Strength, Tensile Strength, Elongation and Reduction of Area

The original tensile test results except for those previously reported in references 1 and 2 are tabulated in Table III. The tests were presumed to have been conducted generally at strain rates within the limits stipulated in ASTM Recommended Practice E21, and the yield strengths to represent either 0.2% offset or the lower yield point. Unless otherwise noted, elongation at fracture was determined over a 2 inch gage length, and plate test specimens were taken from the quarter thickness position, as prescribed by ASTM Standard Specification A-20. Many of the reported results represent the average of duplicate tests.

The yield and tensile strength data have been evaluated employing a normalizing procedure that has proved useful in prior evaluations (e.g., see references 19-20). By this procedure, the elevated temperature yield and tensile strengths of individual heats are ratioed to the room temperature yield and tensile strengths of the same lots. Then, by the method of least squares, the best fit curve is established for each set of such ratios to provide trend curves in ratio form defining the variation of strength with temperature. By means of the ratio trend curve, it is possible to compute strength-temperature trend curve for any specific room temperature strength level of interest, within the limits encompassed by the original data. Of most general interest is the curve corresponding to (or anchored to) the minimum strength specified in a procurement specification; such a curve may be expected to define the lower bound of values appropriate to that particular specified minimum strength at room temperature.

The tensile test results for the different grades are plotted as dependent on temperature in Figs. 4-6. In each plot, data representing the various product forms are differentiated.

Part 1: 1/2 Cr - 1/2 Mo steels, Figs. 4a,b,c

The yield strength and yield strength ratio results are plotted in Fig. 4a, the tensile strength and tensile strength ratio results are plotted in Fig. 4b, and the elongation and reduction of area results are plotted in Fig. 4c. The number of test results are relatively few, certainly as compared to the other two grades of this report, and inadequate to warrant attempting a differentiation amongst product forms.

The ratioed yield and tensile strength data were evaluated by the method of least squares and the resulting best fit trend curves have been drawn on the plots, and included in Table Va. The tensile strength ratio trend curve falls immediately above room temperature and then rises to a peak at 500-600°F before again trending to lower values. The rise at intermediate temperatures, also commonly observed in carbon and other low alloy ferritic steels, is attributable to dynamic strain aging.[21]

Dynamic strain aging is also manifested in the minima in elongation and reduction of area in the same temperature range as that in which the tensile strength passes through its maximum, Fig. 4c.

Part 2: 1 Cr - 1/2 Mo steels, Figs. 5a,b,c

There were many more data available for this grade than for 1/2 Cr - 1/2 Mo. The normalization procedure was quite effective in minimizing scatter for tensile strength, Fig. 5b, but relatively ineffective for yield strength, Fig. 5a. The scatter in yield strength values is probably inherent, reflecting particularly the difficulty of accurately measuring small strains at elevated temperatures, and the possible presence of residual stresses arising from product straightening and specimen preparation procedures. As judged by the rise in tensile strength ratio to a peak at 600-700°F, this grade also manifests dynamic strain aging, though to a slightly lesser extent than 1/2 Cr - 1/2 Mo steel. The greater scatter of tensile strength ratio at intermediate temperatures no doubt reflects different degrees of sensitivity of different heats to strain aging.

The majority of the data represented plate, with isolated additional data for bar, pipe and casting. Assuming all of the data to represent a common population, the ratio values were evaluated by the method of least squares. The resulting trend curves have been superimposed upon the ratio plots of Figs. 5a and 5b, and are included in Table Va.

Elongation and reduction of area decrease only slightly at intermediate temperatures, and then rise rapidly with further increase in temperature.

Part 3: 1 1/4 Cr - 1/2 Mo-Si steels, Figs. 6a,b,c,d,e

For this popular grade of steel, a relatively large number of data were available. Most of the data represent plate, pipe or tube and bar, with a few data for castings. All of the data have been plotted in Figs. 6a and b, both in absolute and ratio form. The least squares ratio trend curves, assuming no dependence upon product form, have been superimposed upon the ratio plots and included in Table Va. As apparent in the ratio plot of Fig. 6b, this steel, as did the others, exhibits a tendency to dynamic strain aging.

In view of the relatively large number of data and because inspection of the ratio plots does suggest that the plate data may fall low in the scatter bands, additional regression analyses were made for plate only and for all data other than plate. It is of interest that all of the plate data represent material that had been normalized and tempered (ASTM Spec. A387, Grade C), whereas either annealing or normalizing and tempering were employed for pipe-tube and bar. The resulting ratio trend curves are tabulated in Table Vb in comparison with those for the combined product forms. The plate data are also plotted separately in Figs. 6c and 6d along with trend curves for plate and non-plate materials. The trend curves for plate fall lower than for non-plate material at temperatures above about 300°F for yield strength ratio and above about 200°F for tensile strength ratio. In both instances, the discrepancy is greatest at intermediate temperatures. In the case of tensile strength ratio, the differences may reflect simply a somewhat lower strain age sensitivity for the plate material.

The elongation and reduction of area results are plotted in Fig. 6e; they vary with temperature in essentially the same manner as for the 1/2 Cr - 1/2 Mo and 1 Cr - 1/2 Mo steels, falling slightly to about 600°F, and then rising. Above 1400°F, ductility falls abruptly (for the one heat tested), as was earlier indicated for 1/2 Cr - 1/2 Mo steel.

Comparison of Yield and Tensile Strength Trend Curves

The yield and tensile strength ratio trend curves for the three steels (combined product forms) are shown together for comparison in Fig. 7. The overall differences in yield strength ratios are relatively minor--the greatest difference from a combined average for the three grades is on the order of 3%, substantially less than the scatter for individual grades. The differences in tensile strength ratio are greater, at intermediate temperatures, but may well represent only differences in strain aging susceptibility; at temperatures above about 800°F, the differences are inconsequential. For either the yield strength or tensile strength ratios, it seems unlikely that the differences between 1 Cr - 1/2 Mo and 1 1/4 Cr - 1/2 Mo-Si are significant. Moreover in contemplating the differences as to 1/2 Cr - 1/2 Mo steel, note should be taken of the relatively small data sample.

Creep and Rupture Properties

The original data not previously reported in references 1 and 2 are tabulated in Table IV, separated in parts according to nominal grade composition.

The rupture data were evaluated to develop rupture strengths corresponding to rupture in 1000, 10,000 and 100,000 hours, and the creep rate data were evaluated to develop creep strengths corresponding to secondary creep rates of 0.1 and 0.01 percent per 1000 hours. Rupture and creep strengths for other rupture times and other creep rates have not been explicitly developed, but, if desired, may be estimated from the various plots.

Both direct and indirect procedures have been employed in evaluating the rupture and creep data. The direct procedure involves interpolating or extrapolating the isothermal relation between stress and rupture time, or between stress and secondary creep rate, commonly plotted in either instance on log-log coordinates. The indirect procedure involves the concept of time-temperature parameter. The direct evaluations were developed for individual lots, but for reasons given in earlier reports in this series, the character of the available data is such that parameter evaluations have been performed only on a "universalized" basis, i.e., assuming universal values for the parameter constants.

When the direct evaluations required extrapolation, this was performed visually, with weighting of the longer time or slower-rate data. The rupture extrapolations were assumed linear on the log-log plots, but it is recognized that a trend to bilinearity or curvilinearity may develop with increasing temperature, with a resulting possibility of a nonconservative result. Extrapolations were not performed in instances where there seemed a likelihood of curvilinearity. The plots of log stress versus log creep rate generally exhibited curvilinearity at slower rates approaching 0.01% per 1000 hours and extrapolations were performed with recognition of the curvilinearity.

There is an inherent risk in visual extrapolations that the true slope may change beyond the limits of the test results. Whereas a tendency to breaking or curving downward at longer times, especially at the higher test temperatures, is generally accepted, some analysts believe that an upward break may occur in some of the low Cr-Mo steels. Several instances have also been reported in which an apparent double break may have occurred.

As in recent evaluations in this series,[20] two universalized parameters were employed in evaluating the rupture data. The first of these was the well-known Larson-Miller parameter with the generally assumed value of 20 for the constant:

$$T(20 + \log t) = F_1(S);$$

the second parameter was Manson's "compromise" parameter[22]:

$$\log t + \frac{1}{40} \log^2 t - \frac{40{,}000}{T} = F_2(S) \ .$$

In either parameter, T is temperature in degrees Rankin, t is the time in hours, and $F_1(S)$ and $F_2(S)$ signify that the parameters vary with stress.

It is recognized that the parameter constants are not truly universalized constants, but rather vary from one lot of a specific grade to another, and even with heat treatment of a particular lot. However, for the kind of data available for the present evaluations, it is not, in general, possible to develop individual values for the constants, and resort must be had to universalized values. In this connection, it may be of interest to note that Leyda and Rowe[23] determined that the optimal value for the Larson-Miller constant for 7 heats of 1 1/4 Cr - 1/2 Mo-Si steel ranged between 17.9 and 23.1 (average 21.0), which compares favorably with the generally assumed value of 20.

The Larson-Miller parameter was also employed in evaluating the secondary creep rate data. For this purpose, the relation may be written:

$$T(20 - \log r) = F_3(S),$$

where r is the secondary creep rate, expressed as percent per hour.

For all three materials, data were available to temperatures as high as 1200°F, which, owing to the excessive oxidation that may be expected to occur in oxidizing environments, is above the normal service temperature range for these materials.

Part 1: 1/2 Cr - 1/2 Mo steels, Figs. 8-14

To show graphically the quantity of available data and their scatter, all of the time for rupture data have been plotted in Figs. 8a-c; all of the secondary creep data have been plotted in Figs. 9a-c; and all of the percent elongation and reduction of area at rupture data have been plotted in Figs. 10a-f. The number of data is relatively limited. In the isothermal plots, data for the different product forms, bar and pipe, are differentiated. However, no dependence upon product form is evident in the data.

Rupture Strength

The results of the individual lot interpolations or extrapolations are assembled in Table VI, and are plotted in Figs. 12a-c. (The isothermal scatter bands have not been evaluated by the procedure of least squares, as in some earlier evaluations, because of the possibility of bilinearity or curvilinearity). The temperature dependencies of individual lot interpolations or extrapolations have been examined by the method of least squares and the resulting lines of best fit are superimposed upon Figs. 12a-c. Rupture strengths corresponding to 1000, 10,000 and 100,000 hours, derived from these trend curves, are included in Table IX.

The universalized Larson-Miller and Manson compromise parameter scatter bands, representing all test times greater than 5 hours, are shown in Figs. 11a-b. Superimposed upon the scatter bands are mean curves of best fit (third-order) as determined by the method of least squares. Also shown are minimum trend curves derived from the mean curves by subtracting 1.65 multiples of the standard deviation. If certain implicit assumptions, noted previously,[20] hold valid, these minima represent lower bounds for 95 percent of the data; visual inspection demonstrates that this is approximately true. From the master parameter curves of Figs. 11a-b, rupture strengths corresponding to the rupture times of Figs. 12a-c have been computed; the resulting trend curves have been superimposed upon the plots, and included in Table IX. The results by the two parameter procedures agreed very well; for 1000 hours, they were essentially identical; for 10,000 and 100,000 hours, the Larson-Miller result was slightly more conservative at lower temperatures, the Manson result slightly more conservative at higher temperatures.

It is also possible from the master parameter curve to compute the isothermal log stress versus log rupture time curves, and to test visually how well those curves represent the test data. In the present instance such isothermals have been computed from the mean Larson-Miller master parameter curve of Fig. 11a and have been superimposed upon the data of Figs. 8a-c. The test points appear to be reasonably well represented, but it is possible to imagine a slight bias of the computed curves to the high side at shorter times and to the low side at longer times (e.g., study the data at 900°F).

The parameter trend curves are in excellent agreement, for 1000 hours, with that developed directly for the individual lot evaluations, Fig. 12a. However, the parameter trend curves fall below that developed for the individual lot extrapolations for 10,000, Fig. 12b, and for 100,000 hours, Fig. 12c. Unexpectedly, the differences are greater at the lower temperatures, where owing to lessened concern about possible curvilinearity of the isothermal relation, there would be greater confidence than for higher temperatures in the validity of the individual lot extrapolations. For this reason and because of the bias noted for the isothermals, it seems preferable to give greater weight to the results of the individual lot extrapolations. It is also worthy to note that the parameter procedures cannot predict 100,000 hour rupture strengths above 1000°F (unless a very hazardous extrapolation of the master curve, Fig. 11a, is made).

Values of minimum rupture strength have been computed from the mean individual-lot trend curves by subtracting 1.65 multiples of the standard deviation. These values are included in Table IX.

Creep Strength

The results of the individual lot interpolations or extrapolations to develop creep strengths corresponding to secondary creep rates of 0.1 and 0.01% per 1000 hours are included in Table VII, and are plotted in Fig. 14. The temperature variations of creep strength were developed by the method of least squares and are shown on Fig. 14 and in Table X.

The universalized Larson-Miller creep-rate parameter scatter band is shown in Fig. 13, with superimposed mean and minimum trend curves. From the mean master parameter curve, creep strengths corresponding to secondary creep rates of 0.1 and 0.01 percent per 1000 hours have been computed and these have been superimposed on Fig. 14 and included in Table X. For a secondary creep rate of 0.01 percent per 1000 hours, the parameter trend curve is almost identical above about 850°F with that computed from the individual lot evaluations, Fig. 14; for a secondary creep rate of 0.1 percent per 1000 hours, the parameter trend curve is more conservative (by about 10%) over the range 1100°F to about 850°F and then becomes even more conservative.

From the master parameter curve, it is also possible to compute the isothermal log stress versus log secondary creep rate relations, and such curves have been superimposed on the isothermal scatter bands, Figs. 9a-c. Again the test observations appear to be reasonably well represented by the computed curves.

A choice between creep strength developed by the two procedures, i.e. by individual lot analysis or by parameter is not easy. Perhaps because of the relatively few data and the more conservative result, the parameter result should be given the greater weight. Moreover, in contrast with rupture, for which parameter evaluations are of greater interest for extrapolation than for correlating data, for creep strength, extrapolation is frequently unnecessary and the parameter proves of greater value in correlating data.

Minimum creep strengths have been computed by subtracting 1.65 multiples of the standard deviation from the mean master parameter curves and are included in Table X.

Rupture Ductility

Relatively few data were available, especially for reduction of area. Some tendency for low elongation may be observed at longer time, particularly at 900-950°F, where this steel might find most usage. The low elongations suggest the likelihood of intergranular mode fracture and of notch weakening, but no information concerning these possibilities was available.

Part 2: 1 Cr - 1/2 Mo steels, Figs. 15-21

All of the time for rupture data have been plotted in Figs. 15a-c; all of the secondary creep rate data have been plotted in Figs. 16a-c; and all of the rupture ductility data have been plotted in Figs. 17a-g. Again, data for different product forms are differentiated, but no product form dependence is evident on visual examination of the scatter bands.

Rupture Strength

The results of the individual lot interpolations or extrapolations are included in Table VI, and are plotted in Figs. 19a-c. The temperature dependencies of the individual lot strengths, determined by the method of least squares, are also shown in Figs. 19a-c. Rupture strengths corresponding to 1000, 10,000 and 100,000 hours, derived from these trend curves are included in Table IX.

The universalized Larson-Miller and Manson compromise parameter scatter bands, representing all test times greater than five hours, are shown in Figs. 18a and b with superimposed mean and minimum trend lines, as before. From the mean parameter trend curves of Figs. 18a and b, rupture strengths corresponding to the rupture times of Figs. 19a-c have been computed and the resulting trend curves have been superimposed upon the plots of Figs. 19a-c and included in Table IX. The two parameter trend curves again agree very well with one another, with the Manson curve being slightly more conservative at higher temperatures and slightly less conservative at lower temperatures.

Isothermal log stress versus log rupture time curves have been computed from the mean Larson-Miller master parameter curve, Fig. 18a, and these are superimposed on Figs. 15a-c. Visually, the computed isothermals appear to be conservative at 900 and 1050°F, nonconservative at 1100°F, but to represent the data reasonably well at 1000 and 1200°F.

On the whole, the parameter trend curves of Figs. 19a-c agree better with the individual lot trend curve than was the case for 1/2 Cr - 1/2 Mo steel. Again, however, deviations of the parameter trend curves to the conservative side may be noted at lower temperatures. The trend curve representing the individual lots is the more conservative at higher temperatures for the longer times. As before with the 1/2 Cr - 1/2 Mo steel, it seems, on the whole, preferable to give greater weight to the individual lot extrapolations.

Values of minimum rupture strength have been computed from the mean individual lot trend curves as before and are included in Table IX.

Creep Strength

The individual lot determinations of creep strengths corresponding to secondary creep rates of 0.1 and 0.01 percent per 1000 hours are plotted in Fig. 21 and have been included in Table VII. Trend curves developed by the method of least squares are also shown on Fig. 21.

The universalized Larson-Miller secondary creep-rate parameter scatter band for 1 Cr - 1/2 Mo steel is shown in Fig. 20; mean and minimum trend curves, developed by the method of least squares, have been superimposed upon the plot. Creep strengths corresponding to secondary creep rates of 0.1 and 0.01 percent per 1000 hours have been computed from the mean master parameter curve and these have been included in Table X and plotted in Fig. 21. The trend curves by individual lot and by parameter evaluations are in fairly good agreement. Because there are so relatively few individual lot evaluations, it seems preferable to give greater weight to the parameter result in choosing between the two sets of values.

From the master parameter curve, isothermal log stress versus log secondary creep rate curves have also been computed, and these are superimposed upon the isothermal scatter bands, Figs. 16a-c. Reasonable conformance with the sparse data will be noted.

Minimum creep strengths computed from the mean master parameter curve are included in Table X.

Rupture Ductility

As was true of 1/2 Cr - 1/2 Mo steel, the number of ductility data for 1 Cr - 1/2 Mo steel was small. Again there was limited evidence of very low elongation at longer times at 900°F. At 1000°F and higher, there was also evidence for low elongation of some lots even at intermediate rupture times.

Part 3: 1 1/4 Cr - 1/2 Mo-Si steels, Figs. 22-29

The volume of test results for this grade greatly exceeds that for either the 1/2 Cr - 1/2 Mo or 1 Cr - 1/2 Mo steels. The time-for-rupture data are plotted in Figs. 22a-d; the secondary creep rate data have been plotted in Figs. 23a-d; and the rupture ductility data have been plotted in Figs. 24a-h. The data for different product forms are differentiated.

Rupture Strength

Examination of the isothermal rupture scatter bands raises the question of a possible difference in strength of wrought and cast steels. There are slight differences in the chemical requirements. Carbon may be as high as 0.20% in the cast material (ASTM Spec. A217), whereas it is limited to a maximum of 0.15% in some wrought specifications. The minimum silicon of wrought specifications is 0.5% and it may be as much as 1.0%, whereas it is limited in the casting specification to a maximum of 0.60%. In endeavoring to resolve this question, the isothermal scatter bands at 1000 and 1050°F were examined separately, for rupture times beyond 100 hours, for cast and wrought materials by the method of least squares. The results, Fig. 25 show a slight divergence at longer times at 1000°F, and a greater divergence at 1050°F, with cast material exhibiting the greater strength.

The possibility of a difference of strength between cast and wrought 1 1/4 Cr - 1/2 Mo-Si steel was also tested by parameterizing separately all of the wrought and cast data for rupture times exceeding 50 hours. Owing to the extremely large number of test data, and because prior experience had shown reasonably good agreement between the results by the Larson-Miller and Manson compromise parameters, only the former was examined in this instance. The scatter bands for wrought and cast materials are shown in Figs. 26a and b, respectively, with superimposed mean and minimum curves. The scatter bands overlap extensively. To provide for comparison, the two mean curves are redrawn in Fig. 26c. Over the central region of the chart, there is fairly good agreement between the master curves, but divergence is evident at either end (where the possible errors are greater), such that for a given parameter value, the wrought material is the stronger. This is inconsistent with Fig. 25, which, of course, indicates that wrought metal is weaker than cast at longer times at higher temperatures (e.g., compare 100,000 hour rupture strengths at 1050°F). It is of interest to average the master curves for wrought and cast materials. Such an average curve is shown on Fig. 26c; the differences of the individual wrought and cast curves from their average is always less than 10%.

From the three master parameter curves of Fig. 26c, rupture strengths for 1000, 10,000 and 100,000 hours have been computed. The results are included in Table VIII; those for the combined materials have also been plotted in Figs. 27a-c, which will be discussed later.

The average rupture parameter curve has also been used to compute the curves which have been superimposed upon the isothermal log stress versus log rupture time plots, Figs. 22a-d. These computed curves do not appear to represent the data as well as they did for the 1/2 Cr - 1/2 Mo and 1 Cr - 1/2 Mo steels. Thus, for 10,000 hours, the computed curve seems low at 900°F and high at 1000°F.

The results of the individual lot interpolations or extrapolations are included in Table VI, and are plotted in Figs. 27a-c. Wrought and cast materials are differentiated, and the question of possible differences in strength may again be raised. For this reason, the wrought and cast strengths have been subjected to separate and combined regression analyses. The results of these analyses are included in Table VIII. However, to avoid confusion, only the regression lines for the combined product forms have been added to Figs. 27a-c.

The individual regression analyses also suggest differences in strength between cast and wrought materials, confirming the visual impression. The differences are such that there would appear to be a general tendency for the cast material to be weaker at lower temperatures and stronger at higher temperatures, with the crossover temperature tending lower with increasing temperature. However, closer examination of the distribution of data reveals irregularities that conceivably could affect the least squares analyses. Further, study of the temperature variation of strength of individual lots, in the relatively few instances where this is possible, suggests that weak heats tend to be weak both above and below the apparent crossover temperature, and similarly for strong heats; this in turn suggests that the apparent crossover may really reflect an inhomogeneous distribution of data, in the statistical sense. For this reason and because the universalized parameter scatter bands for cast and wrought materials are so nearly the same, Fig. 26c, it seems better to discount the apparent differences revealed by Fig. 27a-c, and earlier in Fig. 25, and, whilst recognizing the possibility of real differences in strength between cast and wrought material, to accept for the present a trend line for the combined data.

The combined cast-wrought trend lines have been drawn on Figs. 27a-c, and are included in Table IX. Fairly good agreement between the combined individual lot and the parameter trend curves may be noted for 1000 hours, but for longer time, there is increasing divergence, both at low and high temperatures, with a crossover at intermediate temperatures. Particularly for 100,000 hours, the parameter curve clearly fails to correspond with the individual lot extrapolations, giving too low a result at 900°F and too high a result at 1000 and 1050°F. Since individual lot extrapolations can be performed with relative confidence at lower temperatures, the discrepancy at 900°F is especially troublesome. Perhaps even more noteworthy is the discrepancy at 900°F for 10,000 hours, also evident in the isothermal plot, Fig. 22a. Finally, when the temperature variations of strength of the individual lots for which tests were made at two or more temperatures are examined, these variations are found to more closely parallel the regression trend curve for the individual lots than that computed from the parameter master curve. This is, of course, to be expected unless there were a maldistribution of the test results (as might have been true in the earlier cast versus wrought comparisons). For these reasons, it seems appropriate to give greater weight to the trend curves developed by way of the individual lot interpolations and extrapolations. This conclusion was reached earlier for both 1/2 Cr - 1/2 Mo and 1 Cr - 1/2 Mo steels.

It is of interest to note that for each one of the three steels included in the present report, extrapolation by parameter has led to somewhat lower 10,000 hour strengths and to significantly lower 100,000 hour strengths than those developed from the individual lot extrapolations, whereas in a previous evaluation of C-Mo steel,(20) fairly good agreement was noted. It is possible that in the three steels of the present report, there are structural changes of a strengthening character occurring at lower temperatures in the vicinity of 900°F, that are not reflected in the test results at higher temperature, and that influence the trend of the master parameter curves.

Values of minimum rupture strength have been computed from the mean individual lot trend curves and are included in Table IX.

Creep Strength

In contrast to the rupture scatter bands, the isothermal creep-rate scatter bands do not exhibit any apparent differences between cast and wrought metal. Nevertheless, the cast and wrought data were parameterized separately, Figs. 28a-b. The scatter bands appear to be completely overlapping and the individually determined least squares trend curves are nearly identical. The deviations are such that the cast material is slightly the weaker at lower parameter values and slightly the stronger at higher parameter values. However, it is to be recognized that the exact shape of the regression lines at the two limits is forced in some degree by the weighting of the mass of data at the center. Because the differences are small, and possibly not statistically significant, it has seemed appropriate to combine the data for wrought and cast steels and establish common trend curves, Fig. 28c.

The results of the individual lot interpolations or extrapolations to develop creep strengths corresponding to secondary creep rates of 0.1 and 0.01 percent per 1000 hours are included in Table VII, and are plotted in Figs. 29a and b. Data for cast and wrought steels are differentiated by symbol; however, visual examination does not suggest differences in strength. Mean trend curves for the combined cast and wrought data showing the variation of creep strength with temperature are also plotted in Figs. 29a and b and included in Table X.

From the mean master parameter curve of Fig. 28c, creep strengths for secondary creep rates of 0.1 and 0.01 percent per 1000 hours have been computed and these have been superimposed on Figs. 29a-b, and included in Table X. The master parameter curve has also been used to compute isothermal log-stress versus log secondary creep rate curves; these have been superimposed upon the isothermal plots, Figs. 23a-d. The agreement between the trend curves computed from the master parameter curves and those computed from the individual-lot evaluations, Figs. 29a-b, is relatively poor, especially for the creep rate of 0.1 percent per 1000 hours. In choosing between the two sets of trend curves it is worthy of note that where it is possible to follow the temperature variation of strength of individual lots, high values at 900 or 950°F tend also to be high at 1000°F, and the individual trend curves exhibit a greater tendency to parallel the parameter trend curves of Figs. 29a-b. Hence, it seems appropriate to choose the parameter trend curves over the individual lot curves.

Minimum creep strengths have been computed from the minimum master parameter curve of Fig. 28c, and are included in Table X.

Rupture Ductility

In contrast to the previous two grades of steel, there were many ductility data available for 1 1/4 Cr - 1/2 Mo-Si steel. At 900 and 950°F, there is an apparent tendency for reduced elongation and reduction of area, of some but not all lots, at longer times. At 1000, 1050 and 1100°F, at which the data were most voluminous, there is also pronounced scatter. Relatively low and high ductility may be noted throughout the range of rupture times, with no clearly defined trends with time, or dependence upon product form, evident. Above 1100°F, this grade of steel finds little usage, and, reflecting this, there are relatively few data.

Comparison of Creep Strength and Rupture Strength Trend Curves

It is of interest to compare the trend curves for the three different grades of steel encompassed in the evaluations of this report. For reasons expressed earlier, the rupture strength trend curves represent individual-lot evaluations, whereas those for creep strength were computed from master parameter curves.

Mean trend curves are compared in Figs. 30a,b and minimum curves are compared in Figs. 31a,b. The mean rupture strength curves of the three grades are in rather good agreement, the mean creep strength curves only slightly less so; there does not seem to be any consistency to the differences, which are at most on the order of 5 percent from a common average.

The minimum strength trend curves exhibit slightly greater differences than did the mean curves, as might be expected. The minimum rupture curve (100,000 hours) for 1/2 Cr - 1/2 Mo steel, in particular, reflects the small number of data for this steel.

It seems possible that the differences in the trend curves are not significant. However, the differences have been assumed to be real in constructing the summary plots, Figs. 1-3.

Acknowledgments

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Table I

Identification of Steels

Code No.	ASTM Spec. No.	Deoxid. Practice	Heat Treatment, °F(1)	Product Form-Size	Grain Size(2)	Ref.	Ref. Code No.
Part 1 - 1/2 Cr - 1/2 Mo Steels							
1-1+	-	-	N1700, T1300	Pipe 8 1/2×1 1/8"w	6-7$_M$	1	1
1-2	-	Al(1/2 lb)	"Annealed"	Pipe 12 3/4×1 1/4"w	-	1	2
1-3	-	-	A1750, T1200	Pipe	4-6	1	3
1-4	-	Al(2 lb)	N1750, T1200	Cast	6-8$_M$	1	4
1-5	-	Al(1/2 lb)	N1675	Pipe 12 3/4×1 1/4"w	-	1	5
1-6	-	Al(2 lb)	N1750, T1200	Cast	6-8$_M$	1	6
1-7	-	-	Mill Anneal, T1200	Pipe 16×1.2"w	-	1,5	7
1-8	A-213	-	Accord. to Spec. A213	Tube 1 1/8×.24"w	-	2	7-25
1-9a	-	-	Accord. to Spec. A213	Bar 3/4"	7-8	2	7-26
1-9b	-	-	Norm. and Tempered	Tube 6 5/8×.86"w	-	2	7-27
1-10	A-213	-	Accord. to Spec. A213	Tube 6 5/8×.86"w	-	2	7-27
1-11	-	Si	N1650	Bar 1"	1-3$_M$	2	7-28
1-12	-	Si-Al(1.3 lb)	Q1650, T1200	Bar 1"	5-7$_M$	2	7-29
1-13	-	Si-Al(2 lb)	N1650	Bar 1"	6-8$_M$	2	7-30
1-14	-	Si-Al(1.3 lb)	A1650	Bar 1"	5-7$_M$	2	7-31
1-15	-	"	N1650	Bar 1"	5-7$_M$	2	7-32
1-16	A182,F2	-	N1625, T1200	Forging	-	3	-
1-17	-	-	"Annealed"	Wrought	-	17	-
1-18	-	-	Normalized & Tempered	"	-	17	-
Part 2 - 1 Cr - 1/2 Mo Steels							
2-1(a)	-	Si-Al(1 1/4 lb)	A1550	Bar 1"	7-8	1	1
2-2	-	-	N1700, T1300	Wrought	-	1	2
2-3(b)	-	Si-Al(1 1/4 lb)	N1650, T1200	Bar 1"	6-8	1	4
2-4	-	Si-Al(1/2 lb)	N1650, T1300	Forged	2-4$_M$	1	5

(1) A-annealed; N-normalized; HR-hot rolled; T-tempered or stress-relieved; Q-quenched; CD-cold drawn, HF-hot finished.

(2) Actual grain size except when identified as M for McQuaid-Ehn

+ Cr content low

(a) Codes 2-1 and 2-12a represent same lot.

(b) Codes 2-3 and 2-12b represent same lot.

Table 1 - continued

Code No.	ASTM Spec. No.	Deoxid. Practice	Heat Treatment, °F	Product Form-Size	Grain Size	Ref.	Ref. Code No.
2-5A	-	-	HR, T1300	Pipe 8"Sch.160	-	1	6
2-5B	-	-	N1700	"	-	1	6
2-5C	-	-	N1700, T1300	"	-	1	6
2-6	-	-	N1700, T1300	Pipe 12"Sch.160	-	1	7
2-7	-	-	HR, T1300	"	-	1	8
2-8	-	-	A1625	"	-	1	9
2-9	-	Al(2 1/4 lb)	Norm. and Temp.	Cast	$7\text{-}8_M$	1	10
2-10	-	-	T1350	Bar 3/4"	-	2	7-36
2-11	-	-	N1675	"Wrought"	-	3	-
2-12a[(a)]	-	-	A1550	Bar 1"	-	4	-
2-12b[(b)]	-	-	N1650, T1200	Bar 1"	-	4	-
2-13	-	-	N1650, T1300	Pipe 12 3/4×1.3"w	-	4	-
2-14[(c)]	-	-	"Stress-Relieved"	Pipe	-	5	-
2-15	-	-	N1750, T1275	Pipe, 8 5/8×.9"w	-	6	-
2-16	-	-	N1750, T1275	Wrought	-	6	-
2-17	-	-	N1750, T1250	Wrought	-	6	-
2-18	-	-	N1750, T1250	Pipe, 10"	-	6	-
2-19	-	-	N1750, T1300	Wrought	-	6	-
2-20	-	-	N1750, T1300	Wrought	-	6	-
2-21	-	-	N1950, T1230	Cast	-	6	-
2-22	-	-	N1922, T1225	Cast	-	6	-
2-23	-	-	N1920, T1220	Cast	-	6	-
2-24	-	-	N1922, T1210	Cast	-	6	-
2-25	-	-	N1922, T1274	Cast	-	6	-
2-26	-	-	N2200, T1274	Cast	-	6	-
2-27	The data of this code no. have proved to be identical with those of code 2-11						
2-28	A-213,T12	-	Hot Finished	Tube 2 1/8×.18"w	-	8	-
2-29	A-213,T12	-	Hot Finished	Tube 2 1/8×.18"w	-	8	-
2-30	A-387B	-	N1750, T1250	Plate 1 5/8"	-	9	-
2-31	A-387B	-	N1675, T1150	Plate 3/4"	-	10	-
2-32*	A-387B	-	Q1725, T1100	Plate 6"	-	11	-
2-33	A-387B	-	N1650, T1200	Plate 1 1/2"	-	12	-
2-34	A-387B	-	N1750, T1340	Plate 3 3/8"	-	5	-
2-35	A-387B	-	N1700, T1325, T1275	Plate 5.6"	-	9	-
2-36	A-387B	-	N1700, T1325, T1275	Plate 5.2"	-	9	-
2-37	A-387B	-	N1700, T1225, T1175	Plate 6"	-	9	-
2-38	A-387B	-	N1700, T1325, T1275	Plate 6"	-	9	-
2-39	A-387B	-	N1675, T1350, T1300	Plate 3"	-	9	-
2-40	A-387B	Si-Al(1.6 lb)	N1660, T1165	Plate 6"	8	14	-

[(a)] Codes 2-1 and 2-12a represent same lot.

[(b)] Codes 2-3 and 2-12b represent same lot.

[(c)] Rupture data same as code 2-4.

* Carbon content and tensile strength of this lot exceeds maximum of current specification.

Table 1 - continued

Code No.	ASTM Spec. No.	Deoxid. Practice	Heat Treatment, °F	Product Form-Size	Grain Size	Ref.	Ref. Code No.
Part 3 - 1 1/4 Cr - 1/2 Mo-Si							
3-1	-	Si-Al(1.5 lb)	A1550	Bar 1"	5-7	1	1
3-2	-	-	N1650	Wrought	-	1	2
3-3	-	Si-Al	N1650, T1200	Bar 1"	7-8	1	3
3-4	-	Al(3 lb)	N1700, T1300	Cast	-	1	4
3-5a	-	-	A1650, T1200	Bar 1"	5M	1	5
3-5b	-	-	N1750, T1375	Bar 1"	5M	1	5
3-6	A-217	Si-Al(2 lb)	N1750, T1250	Cast	-	1	6
3-7	-	Si-Al(3 lb)	-	Cast	-	1	8
3-8	A-217	Si-Al(2 lb)	N1750, T1250	Cast	-	1	9
3-9	A-217	Si-Al(2 lb)	N1750, T1250	Cast	-	1	10
3-10	A-217	Al(2 lb)	N1800, T1325	Cast	-	1	11
3-11	-	-	N1650, T1380	Wrought	9	1	12
3-12	-	Al(2 1/2 lb)	N1750, T1300	Cast	-	1	13
3-13	-	Al(2 lb)	N1750, T1200	Cast	7-8M	1	15
3-14	-	Al(2 lb)	N1750, T1300	Cast	6-8M	1	16
3-15	-	Al(2 lb)	N1750, T1300	Cast	7-8M	1	17
3-16	-	Al(2 lb)	N1750, T1300	Cast	6-8M	1	18
3-17	-	Al(2 lb)	N1750, T1300	Cast	4-7M	1	19
3-18	-	Al(2 lb)	N1750, T1300	Cast	6-8M	1	20
3-19	-	Al(2 lb)	N1750, T1300	Cast	7-8M	1	21
3-20	-	Al(2 lb)	N1750, T1300	Cast	6-8M	1	22
3-21	-	Al(2 lb)	N1750, T1300	Cast	-	1	23
3-22	-	Al(2 lb)	N1750, T1300	Cast	4-8M	1	24
3-23	-	Al(2 lb)	N1750, T1300	Cast	6-8M	1	25
3-24	-	Al(2 lb)	N1750, T1300	Cast	6-8M	1	26
3-25	-	Al(2.4 lb)	N1750, T1300	Cast	8-9	1	27
3-26	-	Al(3 lb)	N1750, T1300	Cast	7-8	1	28
3-27	-	Al(2.5 lb)	N1750, T1300	Cast	6-7	1	29
3-28	-	Al	T1375	Tube, 2×.375"w	-	2	7-38
3-29	-	Al	A1625	" "	-	2	7-39
3-30	-	Al	A1475	Tube, 2×.428"w	-	2	7-40
3-31	-	Al	A1625	Tube, 8.65×1.25"w	-	2	7-41
3-32	-	Al	A1625	Tube, 10.5×1.32"w	-	2	7-42
3-33	-	Al	A1625	Tube, 2.25×.46"w	-	2	7-43
3-34	-	-	A1600 (Isothermal)	Tube, 3×.438"w	-	2	7-44
3-35	-	-	A1575	Tube, 5 9/16×1.25"w	-	2	7-45
3-36	-	-	A1575	Tube	-	2	7-46

Table 1 - continued

Code No.	ASTM Spec. No.	Deoxid. Practice	Heat Treatment, °F	Product Form-Size	Grain Size	Ref.	Ref. Code No.
3-37a	-	-	A1350	Tube	-	2	7-47a
3-37b	-	-	A1610 (Isothermal)	Tube	-	2	7-47b
3-38a	-	-	A1300-1375	Tube 2.5×.360"w	-	2	7-48a
3-38b	-	-	Subcrit. Anneal	Tube 2.0×.380"w	-	2	7-48b
3-39	-	-	N1675, T1350	Pipe 16 1/4×1 7/8"w	-	2	7-49
3-40	-	-	A1750	" "	-	2	7-50
3-41a	-	-	A1750	" "	-	2	7-51a
3-41b	-	-	N1675, T1375	Pipe 12 3/4×1.9"w	-	2	7-51b
3-42a	-	-	A1750	Pipe 16 1/4×1 7/8"w	-	2	7-52a
3-42b	-	-	A1750	Pipe	-	2	7-52b
3-42c	-	-	N1675, T1350	Pipe 16 1/4×1 7/8"w	-	2	7-52c
3-43a	-	-	A1650	Pipe 9.2×2.35"w	-	2	7-53a
3-43b	-	-	A1650	Pipe 7.15×2.8"w	-	2	7-53b
3-44a	-	-	A1650	Pipe 6.23×2.26"w	-	2	7-54a
3-44b	-	-	A1650	"	-	2	7-54b
3-45a	-	-	A1650	Pipe 8 5/8×1.35"w	-	2	7-55a
3-45b	-	-	"	" "	-	2	7-55b
3-46a	-	-	A1650	Pipe 10 3/4×1.9"w	-	2	7-56a
3-46b	-	-	"	" "	-	2	7-56b
3-46c	-	-	"	Pipe 10 3/4×1.67"w	-	2	7-56c
3-47a	-	-	A1650	Pipe 8 5/8×1.18"w	-	2	7-57a
3-47b	-	-	"	" "	-	2	7-57b
3-48a	-	-	A1650	Pipe 10.75×1.75"w	-	2	7-58a
3-48b	-	-	"	Pipe 12 3/4×.84"w	-	2	7-58b
3-49a	-	-	A1575	Bar, 3/4"	-	2	7-59a
3-49b	-	-	Norm and Temp. (A213)	" "	-	2	7-59b
3-50a	-	-	A1650	Bar, 3/4"	-	2	7-60a
3-50b	-	-	"	" "	-	2	7-60b
3-50c	-	-	A1575	" "	-	2	7-60c
3-51	-	-	Norm. and Temp.	Plate	-	2	7-61
3-52	-	-	A1625	Tube 7.75×1.21"w	-	4	-
3-53	-	-	A1625	Tube 3.51×.664"w	-	4	-
3-54(1)	-	-	A1625	Tube 10.5×1.32"w	-	4	-
3-55	-	-	A1625	Tube 8.65×1.25"w	-	4	-
3-56	-	-	A1625	Tube 3.51×.604"w	-	4	-
3-57	-	-	A1625	Tube 6.65×1.35"w	-	4	-
3-58	-	-	A1625	Tube 6.65×1.35"w	-	4	-
3-59	-	-	A1625	" "	-	4	-
3-60(2)	-	-	A1575	Tube	-	3	-
3-61	-	-	A1575	Tube 2" OD	-	3	-
3-62	-	-	A1600 (Isothermal)	Tube 2.5×.378"w	-	3	-
3-63	-	-	A1600 (Isothermal 1)	Tube 2.25×.312"w	-	5	-
3-64	-	-	A1600 (Isothermal 2)	" "	-	5	-
3-65	-	-	A1650 (Isothermal)	" "	-	5	-
3-66	-	-	A1600 (Isothermal)	Tube	-	5	-

(1) Same lot as code 3-32.

(2) Same lot as code 3-36.

Table 1 - continued

Code No.	ASTM Spec. No.	Deoxid. Practice	Heat Treatment, °F	Product Form-Size	Grain Size	Ref.	Ref. Code No.
3-67	-	-	A1600 (Isothermal)	Tube	-	5	-
3-68	-	-	" "	"	-	5	-
3-69	-	-	" "	"	-	5	-
3-70	-	-	" "	"	-	5	-
3-71	-	-	" "	"	-	5	-
3-72	-	-	" "	"	-	5	-
3-73(1)	-	-	A1625	Tube 2.×.375"w	-	4	-
3-74	-	-	"	Tube 2.125×.272"w	-	4	-
3-75	-	-	"	Tube 2.125×.365"w	-	4	-
3-76	-	-	"	" "	-	4	-
3-77	-	-	"	" "	-	4	-
3-78	-	-	"	" "	-	4	-
3-79	-	-	"	Tube 2.125×.272"w	-	4	-
3-80	-	-	"	" "	-	4	-
3-81	-	-	"	" "	-	4	-
3-82	-	-	"	" "	-	4	-
3-83	-	-	"	Tube 2.25×.46"w	-	4	-
3-84	-	-	"	" "	-	4	-
3-85	-	-	A1600 (Isothermal 1)	Tube 2.25×.312"w	-	5	-
3-86	-	-	A1600 (Isothermal 2)	" "	-	5	-
3-87	-	-	A1650 (Isothermal 3)	" "	-	5	-
3-88	-	-	A1600 (Isothermal 1)	Tube 2.25×.312"w	-	5	-
3-89	-	-	A1600 (Isothermal 2)	" "	-	5	-
3-90	-	-	A1600 (Isothermal 3)	" "	-	5	-
3-91	-	-	N1650, T1300	" "	-	5	-
3-92	-	-	" "	" "	-	5	-
3-93	-	-	" "	" "	-	5	-
3-94	-	-	" "	" "	-	5	-
3-95	-	-	" "	" "	-	5	-
3-96	-	-	" "	" "	-	5	-
3-97	-	-	" "	" "	-	5	-
3-98	-	-	N1600, T1300	" "	-	5	-
3-99	-	-	" "	" "	-	5	-
3-100	-	-	A1475	Tube 2.0×.428"w	-	4	-
3-101	-	-	HF, A1350	Tube	-	3	-
3-102	-	-	HF, A1350	Tube	-	3	-
3-103	-	-	HF, A1350	Tube 2.0×.33"w	-	3	-
3-104	-	-	HF, A1300	Tube 2.25×.312"w	-	5	-
3-105	-	-	A1375	Tube 2.0×.375"w	-	4	-
3-106(3)	-	-	CD, A1300-1375	Tube 2.5×.36"w	-	3	-
3-107(4)	-	-	CD, Subcrit. Anneal	Tube 2.0×.38"w	-	3	-
3-108	-	-	CD, A1300	Tube	-	5	-

(1) Same lot as code 3-28.

(2) Same lot as code 3-33.

(3) Same lot as code 3-38a.

(4) Same lot as code 3-38b.

Table 1 - continued

Code No.	ASTM Spec. No.	Deoxid. Practice	Heat Treatment, °F	Product Form-Size	Grain Size	Ref.	Ref. Code No.
3-109	-	-	CD, A1300	Tube 2.25×.312"w	-	5	-
3-110	-	-	CD, A1300	" "	-	5	-
3-111	-	-	A1625	Tube 2.5×.411"w	-	4	-
3-112	-	-	A1625	" "	-	4	-
3-113	-	-	A1625	Tube 2.5×.411	-	4	-
3-114	This code no. is omitted				-	3	-
3-115	-	-	A1650		-	4	-
3-116	-	-	A1750	Pipe	-	3	-
3-117	-	-	"	Pipe	-	3	-
3-118	-	-	"	"	-	3	-
3-119	-	-	"	"	-	3	-
3-120	-	-	"	"	-	3	-
3-121	-	-	N1750, T1300	Pipe	-	3	-
3-122[(1)]	-	-	N1675, T1350	Pipe 16 1/4×1 7/8"w	-	3	-
3-123	-	-	N1675, T1375	Pipe 12 3/4×1.9"w	-	5	-
3-124	-	-	A1575	Bar 3/4"	-	3	-
3-125	-	-	A1575	Bar	-	3	-
3-126	-	-	A1750	Bar	-	3	-
3-127[(2)]	-	-	A1575	Bar	-	3	-
3-128[(3)]	-	-	A1650	Bar 3/4"	-	3	-
3-129	-	-	A1650	Bar 3/4"	-	3	-
3-130	-	-	N1750, T1250	Wrought	-	3	-
3-131	-	-	N1750, T1350	"	-	3	-
3-132[(4)]	-	-	N1700, T1300	Plate	-	3	-
3-133	-	-	N1650, T1300	Bar 1 1/8×1 1/8"	-	5	-
3-134	-	-	A1650	Pipe 10.75×1.67"	-	6	-
3-135	-	-	A1650	Pipe 10.75×1.90"	-	6	-
3-136	-	-	A1650	Pipe 8.63×1.35"	-	6	-
3-137	-	-	A1650	Pipe 8.63×1.35"	-	6	-
3-138	-	-	A1650	Pipe 10.75×1.90	-	6	-
3-139	-	-	A1650	Pipe 9.2(ID)×2.3"	-	6	-
3-140	-	-	A1650	Pipe 6.2(ID)×2.3"	-	6	-
3-141	-	-	A1650	Pipe 6.2(ID)×2.3"	-	6	-
3-142	-	-	A1650	Pipe 12.7×.84"	-	6	-
3-143	-	-	A1650	Pipe 8.6×1.2"	-	6	-
3-144	-	-	A1650	Pipe 10.8×1.8"	-	6	-
3-145	-	-	A1650	Pipe 8.6×1.2"	-	6	-
3-146	-	-	A1650	Pipe 7.2×2.8"	-	6	-
3-147	-	-	-	Pipe 6.0×.97"	-	7	-
3-148	-	-	-	Pipe 10.0×1.2"	-	7	-
3-149	This code number is omitted						

(1) Same lot as code 3-41b.

(2) Same lot as code 3-50c.

(3) Same lot as code 3-50a,b.

(4) Same lot as code 3-51.

Table 1 - continued

Code No.	ASTM Spec. No.	Deoxid. Practice	Heat Treatment, °F	Product Form-Size	Grain Size	Ref.	Ref. Code No.
3-150	-	-	N1650, T1300	Wrought 1.5"	-	7	-
3-151	-	-	Q1650, T1300	" "	-	7	-
3-152	-	-	N1950, T1300	" "	-	7	-
3-153	-	-	Q1950, T1300	" "	-	7	-
3-154	-	Si-Al(1/2 lb)	N1650, T1300	Bar 1"	1-3 M	5	-
3-155	A-213-T11	-	Cont. Ann. 1600→1300	Tube 2.0×.28"w	-	5	-
3-156	"	-	" "	" "	-	5	-
3-157	"	-	" "	" "	-	5	-
3-158	"	-	" "	Tube 2.×.26"w	-	5	-
3-159	"	-	" "	Tube 2.×.34"w	-	5	-
3-160	"	-	A1650→1225	Tube 2.0×.34"w	-	8	-
3-161	"	-	N1725, T1292	Tube 2.0×.20"w	-	8	-
3-162	"	-	"Annealed"	Tube 2 1/2×.20"w	-	8	-
3-163	A-387C	-	N1650, T1200	Plate 7/8"	-	12	-
3-164	A-387C	-	N1675, T1200	Plate 1 3/4"	-	9	-
3-165	A-387C	-	N1675, T1275	Plate 1 3/4"	-	9	-
3-166	A-387C	-	N1675, T1225	Plate 3 1/4"	-	9	-
3-167	A-387C	-	N1675, T1350	Plate 3 1/4"	-	9	-
3-168	A-387C	-	N1700, T1325	Plate 4 1/8"	-	9	-
3-169	A-335,P11	-	A1650→1100	Extrud. Pipe 12 3/4×1.31"w	-	13	-
3-170	A-335,P11	-	" "	"	-	13	-
3-171	"	-	" "	"	-	13	-
3-172	"	-	" "	"	-	13	-
3-173	"	-	" "	"	-	13	-
3-174	"	-	" "	"	-	13	-
3-175	A-335,P11	-	-	Pipe, 6"OD	-	7	-
3-176	"	-	-	Pipe, 6"OD×1 1/4"	-	7	-
3-177a, b,c,d	Identical with 3-150,1,2 and 3						
3-178	-	Si	N1700, T1275	Cast, 4×4×2"	3-5	7	-
3-179	-	Si-Al(1/2 lb)	N1700, T1300	Cast	-	7	-
3-180	-	Si	N1750, T1300	Cast	3-5	7	-
3-181	-	Si	N1750, T1325	Cast	5	7	-
3-182	-	Si	N1750, T1175	Cast	-	7	-
3-183	-	Si	N1750, T1300	Cast	-	7	-
3-184	-	Si	N1750, T1300	Cast	-	7	-
3-185	-	Si	N1750, T1325	Cast	-	7	-
3-186	-	Si	N1650, T1250	Cast	-	7	-
3-187	-	Al(3 lb)	N1650, T1300	Cast	-	7	-
3-188	-	Si	N1825, T1325	Cast	-	7	-
3-189	-	Si	N1650, T1250	Cast	-	7	-
3-190	-	Al(3 lb)	-	Cast	-	7	-
3-191	-	Al(2 1/2 lb)	-	Cast	-	7	-
3-192	-	Al(3 lb)	-	Cast	-	7	-
3-193	-	Al(2 1/2 lb)	-	Cast	-	7	-
3-194	A-217	-	N1750, T1300	Cast	-	15	-
3-195	A-217	-	N1750, T1300	Cast	6-8	15	-

Table 1 - continued

Code No.	ASTM Spec. No.	Deoxid. Practice	Heat Treatment, °F	Product Form-Size	Grain Size	Ref.	Ref. Code No.
3-196	A-217	-	N1750, T1300	Cast	5-8	15	-
3-197	A-217	Al(4 lb)	N1750, T1300	Cast	-	15	-
3-198a	A-356 Gr 6	-	N1750, T1300	Cast, 2"×2"×4"	-	7	-
3-198b	"	-	N1750, N1750, T1300	"	-	7	-
3-198c	"	-	N1750, A1750, T1300	"	-	7	-
3-198d	"	-	N1750, Q1750, T1300	"	-	7	-
3-199a	A-356 Gr 6	No Al	N1825, T1300	Cast	-	7	-
3-199b	"	Al(1/2 lb)	" "	Cast	-	7	-
3-199c	"	Al(2 1/2 lb)	" "	Cast	-	7	-
3-200	(Same as code 3-178)						
3-201	(Same as code 3-193)						
3-202	A-356 Gr 6	-	N1750, T1300	Cast	-	7	-
3-203	"	-	" "	Cast	-	7	-
3-204	(Same as 3-186)						
3-205	A356 Gr 6	-	N1750, T1300	Cast	-	7	-
3-206	"	vacuum degassed	N1700, T1300	Cast	-	7	-
3-207(1)	"	-	N1650, T1300	Cast	-	7	-
3-208(2)	"	-	N1650, T1250	Cast	-	7	-
3-209a	A-426,CP11	-	N1850, T1250	Cast 12"OD×8"id	-	16	-
3-209b	"	-	N1850, N1650, T1250	"	-	16	-

(1) Same as 3-187.

(2) Same as 3-189.

Table II

Chemical Composition of Steels

Code No.	C	Mn	P	S	Si	Cr	Ni	Mo	Cu	Al	N	Other
Part 1 - 1/2 Cr - 1/2 Mo Steels												
1-16	.09	.49	.017	.018	.20	.69	.13	.49	.07	-	-	
1-17	Nominal composition only											
1-18	"	"	"									
Part 2 - 1 Cr - 1/2 Mo Steels												
2-11	.08	.47	.014	.011	.66	.83	.13	.53	.12	-	-	Sn .014
2-12a,b	.10	.36	.011	.014	.25	.97	-	.55	-	-	-	
2-13	.09	.55	-	-	.28	1.02	-	.56	-	-	-	
2-14	.11	.44	.005	.019	.15	.97	.09	.52	.03	.005	.012	
2-15	.09	.43	.017	.030	.30	.98	-	.52	-	-	-	
2-16	.11	.39	.030	.016	.14	.94	-	.54	-	-	-	
2-17	.11	.39	.030	.016	.14	.94	-	.54	-	-	-	
2-18	.09	.22	.019	.019	.48	1.04	.15	.45	-	-	-	
2-19	.10	.30	.014	-	.20	.93	-	.53	-	-	-	
2-20	.11	.46	.019	.019	.19	1.00	-	.55	-	-	-	
2-21	.16	.66	.016	.014	.33	.95	-	.53	-	-	-	
2-22	.14	.69	.030	.020	.69	1.00	.09	.47	-	-	-	
2-23	.23	.68	.012	.020	.42	.99	.15	.53	-	-	-	
2-24	.20	.74	.015	.021	.37	.98	.15	.63	-	-	-	
2-25	.18	.72	.016	.013	.32	.93	-	.54	-	-	-	
2-26	.20	.74	.015	.021	.37	.98	.15	.63	-	-	-	
2-27	.08	.47	.014	.011	.66	.83	.13	.53	-	-	-	Sn
2-28	.10	.52	.021	.025	.23	.83	.15	.52	.19	-	-	.020
2-29	.11	.58	.022	.025	.22	.82	.14	.54	.14	-	-	.021
2-30	.12	.57	.014	.024	.30	1.11	.21	.51	.22	.023	-	
2-31	.17	.59	.012	.024	.21	.91	-	.51	-	-	-	
2-32	.21	.66	.010	.015	.18	1.15	.13	.48	.15	.020	-	
2-33	.13	.53	.010	.028	.24	.96	.35	.49	-	.02		
2-34	.14	.57	.007	.009	.22	.92	.12	.45	.04	-	-	
2-35	.12	.46	.013	.026	.24	.98	.11	.48	.23	.05		
2-36	.14	.51	.009	.022	.27	.91	.14	.47	.23	.005	-	
2-37,38	.15	.49	.013	.034	.26	1.08	.12	.52	.25	.074	-	
2-39	.15	.53	.014	.028	.24	1.04	.18	.49	.19	.035	-	
2-40	.12	.52	.018	.024	.21	.96	.13	.45	-	.043	-	V.003 Ti.004

Table II - continued

Code No.	C	Mn	P	S	Si	Cr	Ni	Mo	Cu	Al	N	Other
Part 3 - 1 1/4 Cr - 1/2 Mo-Si Steels												
3-52	not reported											
3-53	.11	.44	.010	.018	.65	1.23	.17	.53	.12	-	-	
3-54	.13	.45	.013	.030	.78	1.19	.23	.49	-	-	-	
3-55	.10	.47	.010	.020	.66	1.28	.20	.56	.12	-	-	
3-56	.11	.44	.010	.018	.65	1.23	.17	.53	.12	-	-	
3-57	.11	.42	.009	.017	.62	1.20	.15	.53	.14			
3-58	.10	.40	.012	.014	.61	1.20	.18	.53	.12	-	-	
3-59	.11	.43	.010	.019	.64	1.29	.13	.54	.11	-	-	
3-60	.12	.47	.017	.011	.68	1.26	.12	.54	.03	-	-	
3-61	.11	.36	.012	.038	.69	1.20	-	.57	-	-	-	
3-62	.11	.42	.015	.012	.68	1.15	.17	.47	.11	-	-	
3-63,4,5	.10	.50	.011	.010	.66	1.20	-	.51	-	.002	-	
3-66	.09	.48	.016	.010	.70	1.19	.06	.44	.05	.028	-	
3-67	.09	.47	.024	.012	.61	1.15	.03	.46	.05	.037	-	
3-68	.08	.47	.009	.013	.70	1.28	.05	.47	.08	-	-	
3-69	.08	.49	.009	.016	.55	1.21	.06	.44	.05	-	-	
3-70	.09	.52	.013	.019	.70	1.15	.10	.47	.08	.011	-	
3-71	.09	.50	.018	.011	.66	1.18	.20	.53	.05	.014	-	
3-72	.09	.49	.011	.007	.78	1.28	.12	.48	.07	.020	-	
3-73	.08	.39	.013	.020	.66	1.18	.24	.57	-	-	-	
3-74	.10	.37	.010	.019	.58	1.16	.10	.54	.11	-	-	
3-75	.10	.44	.010	.018	.60	1.26	.12	.54	.12	-	-	
3-76	.12	.45	.010	.018	.65	1.28	.17	.53	.12	-	-	
3-77	.11	.44	.012	.015	.64	1.24	.38	.55	.11	-	-	
3-78	.10	.47	.010	.020	.66	1.27	.20	.56	.12	-	-	
3-79	.11	.43	.011	.017	.61	1.27	.19	.54	.12	-	-	
3-80	.11	.41	.011	.023	.62	1.22	.21	.55	.14	-	-	
3-81	.09	.43	.011	.016	.61	1.28	.13	.56	.12	-	-	
3-82	.10	.42	.009	.016	.59	1.19	.19	.56	.10	-	-	
3-83	.12	.41	.010	.017	.64	1.23	.19	.56	.12	-	-	
3-84	.10	.38	.010	.017	.63	1.20	.18	.54	.11	-	-	
3-85,6,7	.10	.50	.011	.010	.66	1.20	-	.51	-	.002	-	
3-88,9,0,1	.10	.50	.011	.010	.66	1.20	-	.51	-	.002	-	
3-92	.13	.47	.011	.015	.79	1.20	-	.53	-	-	-	
3-93	.15	.43	.010	.012	.78	1.12	-	.56	-	-	-	
3-94	.12	.39	.010	.007	.79	1.19	-	.51	-	-	-	
3-95	.12	.47	.010	.013	.70	1.21	-	.54	-	-	-	
3-96	.12	.46	.011	.010	.80	1.14	-	.53	-	-	-	
3-97	.11	.48	.011	.011	.72	1.12	-	.54	-	-	-	
3-98,9	.10	.50	.011	.010	.66	1.20	-	.51	-	.002	-	

Table II - continued

Code No.	C	Mn	P	S	Si	Cr	Ni	Mo	Cu	Al	N	Other
3-100	.10	.39	.015	.020	.64	1.14	.22	.55	.12	-	-	
3-101	.10	.43	.012	.014	.72	1.21	.09	.56	.05	-	-	
3-102	.12	.42	.015	.012	.69	1.25	.16	.49	.07	-	-	
3-103	.11	.49	.022	.012	.77	1.26	.12	.53	.04	-	-	
3-104	.10	.50	.011	.010	.66	1.20	-	.51	-	.002	-	
3-105	.08	.39	.013	.020	.66	1.17	.24	.57	-	-	-	
3-106	.09	.44	.019	.019	.66	1.27	.15	.55	.06	-	-	
3-107	.09	.51	.017	.023	.89	1.38	.18	.62	.09	-	-	
3-108	.10	.42	.007	.007	.64	1.33	.07	.52	.07	-	-	
3-109,10	.10	.50	.011	.010	.66	1.20	-	.51	-	.002	-	
3-111	.13	.43	.012	.015	.63	1.23	.14	.54	-	-	-	
3-112	.09	.40	.010	.010	.66	1.27	.11	.58	-	-	-	
3-113	.12	.39	.013	.013	.65	1.24	.28	.55	-	-	-	
3-115	not available											
3-116	.14	.53	.016	.016	.75	1.34	.11	.53	.10	-	-	
3-117	.11	.46	.020	.018	.73	1.18	.11	.52	.11	-	-	
3-118	.09	.52	.019	.018	.83	1.27	.20	.58	.16	-	-	
3-119	.13	.47	.021	.018	.77	1.24	.11	.60	.11	-	-	
3-120	.12	.42	.021	.017	.71	1.11	.12	.56	.11	-	-	
3-121	.11	.46	.020	.018	.73	1.17	.11	.52	.11	-	-	
3-122	.09	.48	.013	.022	.75	1.30	-	.51	-	-	-	
3-123	.13	.51	-	-	.62	1.29	-	.55	-	-	-	
3-124	.12	.39	.010	.017	.70	1.11	.14	.50	.12	-	-	
3-125,6	.10	.30	.021	.025	.66	1.12	.21	.56	.14	-	-	
3-127	.09	.38	-	-	.63	1.16	.14	.50	.14	-	-	
3-128,9	.12	.39	.010	.017	.70	1.11	.14	.50	.12	-	-	
3-130,1	.10	.39	.021	.025	.66	1.12	.21	.56	.16	-	-	
3-132	not available											
3-133	.06	.51	.019	.012	.61	1.21	.13	.54	-	.006	.012	Ti
3-134	.12	.53	.009	.015	.74	1.30	.18	.59	.17	-	-	.077
3-135	.11	.51	.010	.013	.73	1.32	.10	.56	.11	-	-	.068
3-136	.10	.43	.012	.014	.57	1.21	.10	.54	.12	-	-	
3-137	.11	.47	.010	.019	.61	1.28	.10	.55	.11	-	-	Ti
3-138	.11	.48	.010	.016	.58	1.29	.09	.55	.13	-	-	.061
3-139	.11	.47	.010	.019	.75	1.30	-	.60	-	-	-	
3-140	.10	.48	.009	.015	.73	1.27	-	.58	-	-	-	
3-141	.13	.50	.008	.016	.87	1.29	-	.56	-	-	-	
3-142	.12	.40	.007	.015	.79	1.19	-	.55	-	-	-	
3-143	.10	.49	.009	.016	.80	1.24	-	.56	-	-	-	
3-144	.12	.44	.009	.016	.77	1.28	-	.56	-	-	-	
3-145	.11	.44	.007	.020	.70	1.14	-	.58	-	-	-	
3-146	.12	.43	.008	.018	.70	1.22	-	.58	-	-	-	
3-147	.15	.49	.007	.003	-	1.21	-	.44	-	-	-	
3-148	.12	.44	.022	.032	.75	1.12	-	.52	-	-	-	
3-150,1 2,3	.18	.52	.014	.007	.74	1.17	-	.58	-	-	-	
3-154	.12	.45	.013	.015	.74	1.13	.031	.50	.04	.01	.011	Ti .002
3-155	.09	.46	.011	.015	.74	1.07	.087	.53	.069	.05	.01	
3-156	.09	.47	.012	.014	.71	1.08	.089	.55	.070	.048	.01	
3-157	.09	.49	.010	.013	.69	1.11	.16	.57	.051	.048	.012	
3-158	.09	.47	.016	.016	.64	1.25	.11	.55	.039	.049	.013	
3-159	.09	.46	.016	.016	.65	1.22	.10	.53	.031	.048	.013	

Table II - continued

Code No.	C	Mn	P	S	Si	Cr	Ni	Mo	Cu	Al	N	Other
3-160	.10	.46	.011	.017	.59	1.29	.16	.47	.07	-	-	
3-161	.11	.52	.025	.026	.88	1.17	-	.51	-	-	-	
3-162	.09	.49	.012	.013	.73	1.26	-	.60	-	-	-	
3-163	.13	.55	.016	.026	.54	1.21	.21	.55	-	.018	.012	
3-164, 165	.10	.52	.015	.023	.75	1.20	.17	.45	.15	.020	-	
3-166, 167	.12	.54	.010	.020	.72	1.13	.15	.47	.20	.011	-	
3-168	.11	.42	.016	.018	.72	1.02	.13	.48	.15	.030	-	
3-169	.12	.49	.012	.014	.66	1.23	-	.54	-	-	-	
3-170	.13	.47	.009	.016	.81	1.27	-	.52	-	-	-	
3-171	.14	.50	.010	.010	.62	1.24	-	.54	-	-	-	
3-172	.14	.48	.008	.009	.79	1.33	-	.54	-	-	-	
3-173	.12	.49	.008	.007	.75	1.26	-	.54	-	-	-	
3-174	.10	.46	.008	.013	.72	1.26	-	.54	-	-	-	
3-175	.15	.49	.007	.028	-	1.21	-	.44	-	-	-	
3-176	.12	.44	.022	.032	.75	1.12	-	.52	-	-	-	
3-177a, b,c,d	Identical with 3-150,1,2 and 3											
3-178	.18	.60	.025	.018	.34	1.37	-	.63	-	-	-	
3-179	.16	.66	.008	.015	.36	1.16	.01	.53	.071	.01	-	
3-180	.15	.60	.014	.011	.35	1.22	-	.52	.097	.008	-	
3-181	.17	.61	.011	.010	.31	1.21	.004	.53	.093	-	-	
3-182	.18	.60	.013	.018	.37	1.29	-	.47	-	-	-	
3-183	.15	.57	.009	.011	.38	1.18	-	.49	<.02	<.01	-	
3-184	.19	.67	.017	.019	.47	1.34	-	.61	-	-	-	
3-185	.18	.60	.013	.018	.37	1.29	-	.47	-	-	-	
3-186	.17	.56	.012	.012	.40	1.48	-	.52	-	-	-	
3-187	.14	.66	.009	.012	.50	1.24	.26	.57	.044	.06	-	
3-188	.15	.73	.029	.023	.55	1.47	.15	.49	.14	.01	-	
3-189	.135	.59	.025	.025	.43	1.23	.34	.56	.07	-	-	
3-190	.12	.53	.020	.036	.41	1.16	-	.58	-	.048	-	
3-191	.15	.55	.029	.034	.33	.99	-	.49	-	.046	-	
3-192	.15	.59	.022	.018	.50	1.12	-	.49	-	.049	-	
3-193	.16	.75	.031	.022	.38	1.20	-	.49	-	.049	-	
3-194	.08	.73	.021	.032	.39	1.38	-	.62	.13	-	-	
3-195	.11	.62	.017	.037	.34	1.27	-	.60	.15	-	-	
3-196	.12	.71	.021	.027	.40	1.34	.03	.58	.18	-	-	
3-197	.16	.34	.024	.029	.37	1.34	.05	.50	-	.06	-	
3-198	.15	.62	.004	.010	.42	1.18	-	.45	-	.01	-	
30199a	.15	.69	.023	.020	.52	1.45	-	.47	-	-	-	
3-199b	.14	.73	.025	.020	.54	1.49	-	.48	-	.026	-	
3-199c	.15	.70	.029	.024	.54	1.44	-	.48	-	>.10	-	
3-201	.16	.75	.031	.022	.38	1.20	-	.50	-	.036	-	
3-202	.15	.59	.022	.018	.50	1.12	-	.49	-	.049	-	
3-203	.15	.55	.029	.034	.33	1.00	-	.49	-	.046	-	
3-204	.17	.56	.012	.012	.40	1.48	-	.52	-	-	-	
3-205	.12	.53	.020	.036	.41	1.16	-	.58	-	.081	-	
3-206	.17	.59	.007	.010	.31	1.19	-	.52	-	.006	-	
3-207	.14	.66	.009	.012	.50	1.24	-	.57	-	.06	-	
3-208	.13	.59	.023	.016	.48	1.26	-	.56	-	-	-	
3-209a,b	.11	.58	.018	.017	.66	1.25	-	.55	-	-	-	

Table III

Short-Time Tensile Properties

Code No.	Test Temp. °F	Yield Strength* (1000 psi)	Tensile Strength (1000 psi)	Elong.+ (Percent)	Red. Area (Percent)
Part 1 - 1/2 Cr - 1/2 Mo Steels					
1-16	75	50.7	72.2	33.	64.
	200	50.9	69.4	29.	57.
	300	49.2	69.8	25.	58.
	500	45.6	71.0	21.5	57.
	700	38.4	72.4	25.	52.
	900	37.2	69.5	26.	62.
1-17	80	40.7	67.6	30.	65.
	300	34.2	68.4	23.	61.
	500	31.4	68.2	21.	59.
	700	28.4	67.2	22.	60.
	900	25.1	61.4	28.	65.
	1100	20.1	43.0	40.	75.
	1300	14.5	20.0	55.	88.
	1500	-	6.2	62.	80.
1-18	80	45.0	77.0	27.	60.
	300	42.5	83.0	21.	56.
	500	39.5	84.8	21.	49.
	700	36.0	78.0	25.	60.
	900	31.5	63.0	34.	75.
Part 2 - 1 Cr - 1/2 Mo Steels					
2-13	75	51.6	67.9	33.	-
	900	30.7	64.4	21.	73.
2-14	75	41.6	64.0	36.(1)	71.
2-15	75	45.0	65.0	56.	71.
2-16	75	-	68.1	37.	63.
2-17	75	-	68.0	34.	63.
2-18	75	-	65.7	33.	74.
2-19	75	-	58.7	35.	-

* 0.2% offset, unless noted otherwise.

\+ Elongation in 2 inches unless noted otherwise.

(1) 1 inch gage length.

Table III - continued

Code No.	Test Temp. °F	Yield Strength	Tensile Strength	Elong.	Red. Area
2-22	75	-	81.0	28.	53.
2-23	75	-	80.0	25.	50.
2-24	75	-	99.0	21.5	57.
2-25	75	-	87.5	22.	59.
2-26	75	-	99.0	21.5	57.
2-30	80	47.4	68.2	32.	66.
	600	36.8	65.1	24.	55.
	700	34.1	65.9	24.	55.
	800	39.1	65.5	23.	58.
	900	34.9	63.9	23.	61.
	1000	33.6	57.0	27.	65.
	1100	33.7	48.8	35.	74.
	1200	28.3	35.2	57.	84.
	1300	20.7	23.3	74.	89.
	1400	11.4	13.8	96.	95.
2-31	75	68.9	95.8	26.	61.
	600	64.4	88.6	21.	56.
	700	61.7	89.8	23.	56.
	800	58.5	83.6	23.	62.
	900	60.4	81.0	25.	69.
	1000	-	64.5	-	76.
	1100	-	58.0	28.	76.
2-32	70	87.0	105.0	21.5	53.
	400	76.5	96.0	18.5	57.
	500	76.2	97.0	18.0	55.
	600	76.0	97.7	19.5	58.
	700	73.7	95.5	20.5	60.
	800	66.8	86.0	20.0	65.
	900	66.5	77.0	20.0	69.
	1000	66.0	76.3	22.0	70.
	1100	56.8	62.4	22.0	74.
	1200	33.0	40.0	28.0	83.
2-34	80	45.8	69.6	28.	-
	300	36.5	64.2	26.	72.
	400	-	62.2	26.	69.
	500	38.3	65.6	23.	65.
	600	34.1	65.6	22.	61.
	700	36.5	68.1	24.	61.
	800	33.2	63.4	26.	66.
	900	36.8	62.7	25.	76.
	1000	31.3	53.9	27.	80.
2-35	75	45.5	64.2	34.	69.
	300	32.8	55.5	30.	69.
	500	29.0	56.5	28.	65.
	650	26.8	59.0	27.	63.
	700	24.6	59.8	26.	62.
	750	25.1	60.0	29.	63.
	800	24.6	58.3	29.	64.
	850	22.8	58.0	30.	65.
2-36	75	42.3	68.3	30.	69.
	300	35.0	60.6	30.	63.
	500	33.8	61.0	28.	65.
	650	31.5	63.7	25.	57.

Table III - continued

Code No.	Test Temp. °F	Yield Strength	Tensile Strength	Elong.	Red. Area
	750	27.5	63.8	31.	64.
	800	27.7	62.4	33.	65.
	850	29.5	60.7	31.	68.
2-37	75	45.3	71.9	34.	64.
	300	39.8	61.7	30.	64.
	500	34.9	62.7	27.	63.
	650	30.7	64.7	26.	58.
	700	29.9	62.9	26.	56.
	750	37.4	63.9	26.	62.
	800	35.8	62.7	27.	65.
	850	36.3	59.1	25.	58.
	900	34.2	58.4	28.	69.
2-38	75	44.5	69.8	34.	69.
	300	36.4	61.4	31.	70.
	500	34.6	62.7	27.	67.
	650	31.3	68.2	25.	64.
	700	35.8	67.4	26.	65.
	750	35.1	62.4	28.	67.
	800	36.3	62.4	27.	65.
	850	35.8	59.1	27.	68.
	900	25.6	55.9	29.	71.
2-39	75	42.5	68.5	37.	70.
	750	25.5	65.5	26.	58.
	850	24.4	61.7	25.	58.
2-40	75	37.6	64.4	38.	72.
	850	25.0	59.5	39.	-
	1000	21.5	45.0	25.	-

Part 3 - 1 1/4 Cr - 1/2 Mo-Si Steels

3-111	70	51.6	76.0	-	-
	300	43.6	69.6	-	-
	500	46.0	75.2	-	-
	700	41.8	75.2	-	-
	900	32.5	61.6	-	-
	1000	29.8	53.0	-	-
	1100	27.0	40.2	-	-
3-112	70	44.0	70.0	-	-
	300	37.8	68.0	-	-
	500	38.0	75.6	-	-
	700	27.4	67.0	-	-
	900	28.2	56.8	-	-
	1000	22.4	48.8	-	-
	1100	22.0	40.8	-	-

Table III - continued

Code No.	Test Temp. °F	Yield Strength	Tensile Strength	Elong.	Red. Area
3-113	70	55.2	74.4	-	-
	300	40.0	69.6	-	-
	500	41.0	73.6	-	-
	700	29.0	72.4	-	-
	900	36.2	61.2	-	-
	1000	33.2	53.6	-	-
	1100	23.8	42.2	-	-
3-115	70	50.0	75.0	36.	71.
	1000	27.5	55.0	35.	77.
	1100	25.0	48.0	35.	80.
	1200	18.0	34.0	41.	87.
3-134	75	38.2	74.6	33.	61.
3-135	75	34.0	70.3	34.	65.
3-136	75	36.2	71.2	37.	67.
3-137	75	36.0	71.2	35.	65.
3-138	75	33.7	63.4	36.	65.
3-139	75	38.0	74.9	31.	49.
3-140	75	36.7	72.5	31.	50.
3-141	75	42.5	78.6	32.	58.
3-142	75	39.2	77.2	24.	33.
3-143	75	39.5	78.0	32.	49.
3-144	75	37.7	72.5	28.	47.
3-145	75	40.0	79.4	29.	50.
3-146	75	35.5	72.2	30.	44.
3-147	75	37.2	63.7	39.	68.
3-148	75	46.5	75.7	34.	67.
3-149	75	37.2	63.7	39.	68.
3-150	75	62.4	90.5	31.	70.
3-151	75	76.8	101.0	29.	73.
3-152	75	66.4	93.6	27.	68.
3-153	75	79.0	103.4	26.	70.
3-154	75	-	75.3	36.	74.
3-155	70	40.0	75.0	33.*	76.
	200	36.0	69.0	30.*	75.
	400	35.0	68.0	29.*	74.
	600	36.0	77.0	22.*	73.
	800	32.0	82.0	26.*	71.
	1000	30.0	64.0	32.*	76.
	1050	31.0	57.0	35.*	77.
3-156	70	42.0	78.0	32.*	72.
	200	36.0	71.0	32.*	71.
	400	35.0	70.0	28.*	72.
	600	37.0	81.0	23.*	72.
	800	34.0	86.0	24.*	72.
	1000	31.0	65.0	31.*	77.
	1050	31.0	56.0	35.*	76.
3-157	70	44.0	71.0	32.*	69.
	200	40.0	66.0	31.*	71.
	400	37.0	65.0	27.*	72.
	600	33.0	72.0	24.*	70.

*1 inch gage length.

Table III - continued

Code No.	Test Temp. °F	Yield Strength	Tensile Strength	Elong.	Red. Area
3-157 (cont.)	800	27.0	71.0	26.*	71.
	1000	27.0	51.0	31.*	76.
	1050	25.0	58.0	34.*	76.
3-158	70	43.0	71.0	32.*	76.
	200	38.0	65.0	30.*	75.
	400	39.0	64.0	27.*	74.
	600	30.0	70.0	25.*	72.
	800	26.0	72.0	25.*	73.
	1000	24.0	57.0	30.*	75.
	1050	24.0	51.0	34.*	82.
3-159	70	33.0	74.0	36.*	73.
	200	29.0	68.0	36.*	71.
	400	31.0	66.0	32.*	74.
	600	31.0	76.0	26.*	71.
	800	28.0	81.0	28.*	73.
	1000	28.0	64.0	35.*	77.
	1050	27.0	56.0	39.*	78.
3-160	75	47.8	74.9	32.	71.
	200	44.4	69.2	33.	72.
	400	43.8	69.4	29.	69.
	600	40.8	75.4	25.	67.
	800	37.6	68.6	32.	75.
	1000	31.2	47.6	39.	83.
3-161	75	57.8	80.1	26.	73.
	200	50.5	73.2	23.	72.
	400	59.3	82.5	20.	65.
	600	52.2	81.1	20.	65.
	800	38.4	75.3	22.	70.
	1000	35.9	60.9	22.	80.
	1100	32.8	47.0	29.	85.
3-162	75	47.8	69.2	54.	-
3-163	75	55.5	80.5	33.	72.
	200	52.5	74.8	33.	72.
	300	50.0	72.2	28.	70.
	400	49.5	72.5	28.	68.
	500	46.8	74.8	28.	65.
	600	43.6	77.5	26.	62.
	700	42.1	77.8	26.	66.
	750	36.5	74.8	28.	70.
	800	37.8	74.5	28.	72.
	900	37.0	69.5	28.	74.
	1000	34.2	60.8	30.	78.
	1100	32.2	49.0	36.	85.
	1200	26.6	35.8	45.	90.
	1300	17.0	22.3	51.	94.
	1350	12.4	17.4	72.	96.
	1400	8.5	13.0	65.	96.
	1450	6.8	11.1	75.	83.
	1500	6.4	10.2	104.	71.

*1 inch gage length.

Table III - continued

Code No.	Test Temp. °F	Yield Strength	Tensile Strength	Elong.	Red. Area
3-163	1550	5.9	10.7	85.	58.
(cont.)	1600	6.0	11.0	53.	49.
	1700	4.4	8.5	48.	38.
	1800	3.2	6.6	48.	40.
3-164	75	43.6	75.4	35.	70.
	825	30.6	60.0	31.	76.
3-165	75	46.1	76.4	35.	70.
	825	27.2	63.4	29.	72.
	850	26.0	57.5	33.	77.
3-166	75	50.6	81.9	32.	-
	300	48.2	71.0	29.	68.
	500	44.5	71.8	28.	65.
	600	42.0	74.0	27.	58.
	700	37.5	72.8	25.	-
	750	37.0	69.7	28.	69.
	825	34.0	65.3	28.	-
	900	34.0	60.0	29.	77.
	950	37.5	57.0	31.	77.
3-167	75	49.2	75.4	32.	69.
	300	40.5	69.0	28.	66.
	500	39.5	71.3	25.	64.
	600	36.1	72.4	24.	62.
	700	31.0	71.0	25.	67.
	800	29.1	67.3	29.	67.
	850	31.3	66.3	28.	70.
	900	27.6	60.6	29.	72.
3-168	75	46.5	72.0	34.	63.
	300	37.7	63.6	28.	65.
	500	36.3	65.3	26.	64.
	650	32.7	67.5	25.	60.
	750	30.7	67.5	30.	63.
	800	30.3	65.5	-	64.
	850	27.6	61.5	28.	65.
	900	27.5	58.0	26.	69.
3-169	75	39.5	72.7	32.	64.
3-170	75	47.8	78.3	29.	58.
	900	30.6	57.9	31.	72.
	1000	29.1	48.4	38.	78.
	1100	26.1	37.3	47.	88.
3-171	75	44.0	75.4	29.	57.
3-173	75	48.0	75.0	33.	65.
	900	27.6	56.9	27.	72.
3-174	75	45.7	72.2	30.	64.
3-175	75	37.2*	63.7	39.	68.
	200	36.4*	57.7	37.	71.
	300	37.3*	58.2	30.	67.
	400	33.3	61.6	28.	65.
	500	29.0*	63.2	29.	63.
	600	29.9	67.0	22.	61.
	700	25.7	66.2	29.	67.
	800	29.8	66.9	28.	68.

*Yield point

Table III - continued

Code No.	Test Temp. °F	Yield Strength	Tensile Strength	Elong.	Red. Area
3-175	900	23.4	61.7	27.	71.
(cont.)	1000	24.4	54.4	30.	79.
	1050	24.8	50.2	33.	81.
3-176	75	46.5	75.7	34.	67.
	200	46.0*	68.0	32.	68.
	300	43.3*	69.7	28.	64.
	350	40.3*	70.2	28.	63.
	400	43.0*	71.4	29.	62.
	500	41.6*	75.2	23.	57.
	600	35.4	74.6	23.	50.
	650	35.6	76.0	26.	51.
	700	35.5	75.3	27.	57.
	800	32.0	69.6	26.	60.
	900	31.6	61.7	26.	67.
	950	33.1	58.6	29.	69.
	1000	28.9	52.6	33.	72.
	1050	28.4	47.3	37.	77.
3-177a	75	62.4	90.5	31.	70.
	950	40.2	68.2	29.	79.
	1000	39.3	65.5	31.	83.
	1100	35.4	50.6	40.	88.
3-177b	75	76.8	101.0	29.	73.
	950	59.0	75.4	29.	82.
	1000	56.7	69.8	28.	84.
	1100	48.6	55.6	30.	88.
3-177c	75	66.4	93.6	27.	68.
	950	-	73.6	27.	76.
	1000	-	69.8	27.	80.
	1100	44.4	53.4	25.	86.
3-177d	75	78.9	103.4	26.	70.
	950	60.2	75.2	26.	79.
	1000	59.4	70.7	28.	83.
	1100	51.1	58.6	29.	87.
3-178	75	46.0	78.3	26.	60.
	400	47.4	70.0	25.	66.
	600	48.0	69.6	24.	63.
	700	29.3	61.4	23.	56.
	800	32.3	61.9	25.	58.
	900	30.0	55.7	29.	68.
	1000	31.3	51.2	32.	75.
	1100	26.3	43.1	32.	82.
3-179	75	44.6	73.4	28.	68.
	400	38.7	66.3	25.	64.
	800	31.8	63.7	27.	66.
	900	32.5	59.5	27.	76.
	1000	31.2	54.2	27.	79.
	1100	31.6	46.3	33.	86.
	1200	28.4	35.2	41.	91.

*Yield point

Table III - continued

Code No.	Test Temp. °F	Yield Strength	Tensile Strength	Elong.	Red. Area
3-180	75	55.2	79.0	29.	68.
3-181	75	56.5	81.5	30.	65.
3-182	75	55.2	75.8	29.	71.
3-185	75	67.5	89.0	24.	65.
3-187	75	40.2	70.3	38.	69.
3-189	75	42.0	72.2	32.	66.
3-194	75	59.5	83.0	27.	61.
3-195	75	47.8	73.2	30.	62.
3-196	75	44.0	70.4	32.	69.
3-198a	75	54.0	77.5	29.	72.
3-198b	75	55.5	77.0	29.	71.
3-198c	75	44.5	72.0	32.	70.
3-198d	75	63.0	84.0	28.	73.
3-199a	75	76.0	95.5	20.	53.
3-199b	75	71.5	92.5	20.	44.
3-199c	75	67.5	91.5	24.	57.
3-200	75	49.5	78.5	26.	60.
3-204	75	67.5	89.0	24.	64.
3-207	75	40.0	70.5	38.	69.
3-208	75	42.0	72.0	32.	66.
3-209a	75	51.0	76.2	29.	71.
3-209b	75	30.0	60.0	22.	-

Table IV

Creep and Rupture Data

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours*	Min. Creep Rate-%/hr	At Rupture % Elong.**	At Rupture % Red. Area
Part 1 -- 1/2 Cr - 1/2 Mo Steels						
1-7	900	62.0	19.7	-	31.+	58.
		60.0	272.	-	21.+	22.
		59.0	314.	-	-	-
		58.0	730.	-	18.+	19.
		55.0	2958.	-	8.+	9.
	1050	45.0	13.8	-	22.+	28.
		40.0	62.	-	20.+	21.
		38.0	140.	-	-	-
		35.0	274.	-	15.+	28.
		30.0	851.	-	15.+	28.
	1200	20.0	5.4	-	56.+	89.
		15.0	27.0	-	57.+	91.
		13.0	161.	-	50.+	83.
		10.0	342.	-	45.+	85.
		8.0	782.	-	42.+	86.
	1300	18.3	0.1	-	55.+	95.
		6.0	132.	-	60.+	95.
		3.0	568.	-	20.+	69.
		2.0	1367.	-	27.+	28.
	1400	5.0	6.3	-	80.+	94.
		3.0	50.	-	40.+	90.
		2.0	110.	-	50.+	98.
		1.0	724.	-	16.+	80.

*Tests designated c were terminated before rupture.

**Elongation in 2 inches unless noted otherwise.

+1 inch gage length.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
Part 2 -- 1 Cr - 1/2 Mo Steels						
2-11	1000	28.0	1375.	-	5.5	12.9
		22.0	4007.	-	10.0	13.8
		18.5	5070.	-	9.0	12.9
		17.0	4520	-	5.0	16.0
		17.0	6583.	-	11.0	37.0
	1100	13.8	393.	-	29.0	21.7
		10.75	1789.	-	9.5	18.9
		8.0	4725.	-	7.0	16.6
2-12a	900	50.0	>4000.	-	-	-
		20.0	2000.c	.00009	-	-
		17.0	2000.c	.000036	-	-
		15.0	2000.c	.000019	-	-
	1000	44.0	255.	-	-	-
		40.0	930.	-	-	-
		35.0	1620.	-	-	-
		32.5	2200.	-	-	-
		12.5	2000.c	.000125	-	-
		10.0	2000.c	.00005	-	-
		7.5	2000.c	.0000155	-	-
	1100	35.0	10.	-	-	-
		22.0	130.	-	-	-
		15.0	700.	-	-	-
		13.0	1200.	-	-	-
		6.0	2000.c	.00036	-	-
		4.5	2000.c	.00013	-	-
		3.5	2000.c	.000043	-	-
		3.0	2000.c	.000024	-	-
	1200	16.0	22.	-	-	-
		12.0	51.	-	-	-
		10.0	115.	-	-	-
		5.0	1600.	-	-	-
		2.0	2000.c	.00021	-	-
		1.5	2000.c	.000075	-	-
		1.0	2000.c	.000021	-	-
2-12b	950	50.0	2110.	-	-	-
		20.0	2000.c	.000025	-	-
		17.0	2000.c	.0000165	-	-
		15.0	2000.c	.000011	-	-
	1000	45.0	490.	-	-	-
		35.0	1840.	-	-	-
		27.5	4500.	-	-	-
2-13	1000	40.0	97.	-	-	-
		30.0	670.	-	-	-
		23.0	2130.	-	-	-
2-14	900	59.9	0.1	-	25.[1]	67.
		59.0	474.	-	30.[1]	48.
		58.0	532.	-	28.[1]	44.
		55.0	1402.	-	15.[1]	27.

[1] 1 inch gage length

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
2-14	1050	48.8	0.1	-	35.[(1)]	65.
(cont.)		40.0	42.2	-	25.[(1)]	40.
		35.0	185.	-	17.[(1)]	24.
		30.0	490.	-	18.[(1)]	47.
		27.0	782.	-	39.[(1)]	63.
	1200	28.0	0.4	-	62.[+]	87.
		20.0	5.1	-	57.[+]	90.
		14.0	49.9	-	88.[+]	96.
		8.8	484.	-	76.[+]	90.
		7.6	884.	-	50.[+]	95.
2-15	900	50.0	1677.	-	21.	62.
		52.0	3048.	-	14.	44.
	1000	37.0	863.	-	13.	46.
		32.0	2003.	-	12.	27.
		28.0	3740.	-	15.	61.
	1100	16.0	413.	-	57.	85.
	1200	9.0	315.	-	23.	85.
		13.0	77.	-	37.	90.
2-16	1000	40.0	482.	-	10.	10.
		30.0	3314.	-	8.	15.
	1200	20.0	4.	-	41.	79.
		15.0	36.	-	45.	80.
		10.0	146.	-	23.	67.
2-17	1000	50.0	6.	-	29.	61.
		45.0	98.	-	17.	47.
		35.0	1255.	-	12.	22.
	1200	20.0	22.	-	37.	77.
		10.0	132.	-	33.	68.
2-18	1000	40.0	84.	-	24.	73.
		35.0	786.	-	29.	56.
	1100	20.0	186.	-	59.	81.
		15.0	490.	-	23.	82.
	1200	10.0	175.	-	49.	61.
2-19	1000	40.0	400.	-	21.	50.
	1100	27.0	53.	-	35.	69.
		15.0	1040.	-	33.	84.
	1200	12.0	25.	-	59.	90.
	1300	8.0	11.	-	71.	93.
2-20	1050	35.0	122.	-	17.	63.
	1100	25.0	115.	-	31.	78.
		19.0	421.	-	24.	80.
	1300	8.0	24.	-	36.	90.
2-21	1000	45.0	18.	-	18.	76.
	1050	30.0	204.	-	20.	83.
	1100	35.0	2.	-	23.	84.
	1150	25.0	4.	-	17.	88.
	1200	12.0	143.	-	27.	90.
2-22	1000	40.0	39.	-	25.	82.
	1050	30.0	94.	-	40.	77.

[+] 1 inch gage length.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
2-22	1100	25.0	43.	-	49.	83.
(cont.)	1200	13.0	86.	-	31.	83.
2-23	1100	30.0	24.	-	31.	80.
	1200	20.0	19.	-	40.	87.
		15.0	70.	-	36.	88.
		10.0	562.	-	33.	83.
2-24	1050	40.0	139.	-	6.	21.
		30.0	441.	-	4.	6.
	1100	22.0	295.	-	4.	5.
	1200	15.0	120.	-	6.	17.
		10.0	626.	-	8.	9.
2-25	1000	40.0	41.	-	23.	78.
	1200	15.0	37.	-	29.	86.
	1300	9.0	22.	-	44.	92.
		6.0	164.	-	36.	94.
2-26	1000	40.0	22.	-	23.	74.
	1100	22.0	109.	-	27.	44.
	1250	15.0	17.	-	38.	69.
		10.0	128.	-	24.	34.
2-28	1050	37.0	69.	-	22.	17.7
		30.0	236.	-	13.5	19.3
		25.0	470.	-	10.5	22.
		22.0	761.	-	19.5	23.
		20.0	1100.	-	20.0	29.
2-29	1050	37.0	86.	-	13.0	19.
		30.0	271.	-	14.5	33.
		25.0	573.	-	22.	27.
		22.0	785.	-	23.	33.
		20.0	1024.	-	17.	21.
2-30	850	62.5	15.8	.558	33.	58.
		60.0	130.	.0255	32.	61.
		57.5	2529.	.00109	31.	69.
		47.5	1722.c	.00018	-	-
		40.0	1006.c	.000026	-	-
		37.5	1046.c	.0000006	-	-
	950	50.0	123.	.119	32.	61.
		47.5	261.	.0407	29.	55.
		45.0	572.	.018	28.	43.
		42.5	1418.c	.00414	-	-
		40.0	1750.c	.00102	-	-
		34.0	1000.c	.000115	-	-
	1000	42.5	70.	.215	28.	52.
		40.0	168.	.0786	30.	34.
		37.5	470.	.0161	**	23.
		35.0	787.	.00894	17.	21.
2-33	1000	30.0	3142.	.00063	23.	23.
2-40	1000	35.0	10.6	-	44.	77.
		32.5	40.	-	35.	77.
		27.5	333.	-	26.	44.
		25.0	621.	-	37.	58.

** Fractured at punch mark.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
2-40		16.0	6389.	.00030	-	26.
(cont.)		14.0	14,034.	.00018	42.	-
		12.0	10,600.c	.00010	-	-

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
Part 3 - 1 1/4 Cr - 1/2 Mo-Si Steels						
3-52	1000	45.0	38.	-	26.	39.
		40.0	169.	-	15.	20.
		35.0	483.	-	9.	12.
3-53	1000	45.0	40.	-	-	-
		40.0	249.	-	43.	-
		35.0	711.	-	50.	-
		30.0	1722.	-	38.	-
3-54	1000	9.5	>5000.c	.000022	-	-
	1050	6.0	>5000.c	.000034	-	-
3-55	1050	30.0	90.	-	-	-
		25.0	244.	-	57.	-
3-56	1050	35.0	80.	-	48.	-
		30.0	211.	-	49.	-
3-57	1050	30.0	163.	-	44.	-
		25.0	680.	-	30.	-
		22.0	879.	-	47.	-
3-58	1050	30.0	120.	-	43.	-
		25.0	665.	-	36.	-
		22.0	1022.	-	45.	-
3-59	1050	30.0	192.	-	39.	-
		25.0	461.	-	47.	-
		22.0	1245.	-	47.	-
3-60	1000	2.0	10,390.c	.000005	-	-
3-61	1000	26.0	585.	.0226	32.	54.
		23.0	1237.	.0103	54.	66.
		20.0	1933.	.0060	32.	32.
3-62	1000	38.0	595.	.010	17.	24.
		35.0	932.	.0035	8.	21.
		30.0	2328.	.0107	8.	21.
		30.0	1502.	.0304	18.	36.
		25.0	2477.	.00717	4.5	21.
		25.0	3220.	.00304	6.	18.
	1100	15.0	666.	-	32.	57.
		12.0	2399.	.0035	27.	66.
3-63	1050	40.0	0.8	-	46.	95.
		30.0	30.	1.265	49.	88.
		25.0	118.	.369	73.	89.
		20.0	373.	.095	60.	85.
		15.0	1229.	.022	59.	85.
		12.0	3844.	.0048	34.	81.
3-64	1050	40.0	20.	1.71	40.	83.
		30.0	74.	.299	27.	79.
		25.0	275.	.070	58.	79.
		20.0	548.	.023	60.	85.
		15.0	1852.	.0096	51.	84.
		13.0	2993.	.0057	32.	82.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-65	1050	45.0	36.	.332	38.	78.
		40.0	45.	.231	20.	66.
		30.0	246.	.0276	34.	72.
		25.0	545.	.0102	38.	75.
		20.0	771.	.0050	38.	79.
		17.0	1360.	.0037	30.	64.
		13.0	4196.	.0015	60.	84.
3-66	1050	40.0	6.8	-	35.	56.
		30.0	76.	-	24.	30.
		25.0	137.	-	21.	21.
		20.0	397.	-	14.[(1)]	16.
3-67	1050	40.0	3.7	-	36.	69.
		30.0	33.	-	28.	30.
		25.0	179.	-	16.[(1)]	22.
		20.0	380.	-	24.[(1)]	29.
3-68	1050	40.0	1.1	-	45.	79.
		30.0	46.	-	43.	62.
		25.0	156.	-	44.	60.
		20.0	491.	-	46.	60.
3-69	1050	40.0	5.	-	42.	84.
		30.0	96.	-	53.	83.
		25.0	220.	-	55.	79.
		20.0	712.	-	67.	81.
3-70	1050	40.0	17.	-	38.	75.
		30.0	97.	-	43.	73.
		25.0	261.	-	50.	77.
		20.0	674.	-	58.	80.
3-71	1050	40.0	19.	-	37.	75.
		30.0	144.	-	37.	65.
		25.0	312.	-	35.	64.
		20.0	620.	-	38.	64.
3-72	1050	40.0	4.1	-	40.	84.
		30.0	52.	-	45.	72.
		25.0	144.	-	48.	73.
		20.0	458.	-	54.	78.
3-73	1000	9.5	5000.c	.000011	-	-
		7.8	5000.c	.000007	-	-
	1050	5.5	5000.c	.000060	-	-
3-74	1050	30.0	235.	-	24.	-
		25.0	333.	-	21.	-
3-75	1050	30.0	148.	-	42.	-
		25.0	334.	-	53.	-
3-76	1050	30.0	101.	-	42.	-
		25.0	378.	-	47.	-
3-77	1050	30.0	91.	-	43.	-
		25.0	178.	-	42.	-

[(1)] Broke in gage mark.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-78	1050	30.0	127.	-	-	-
		25.0	277.	-	-	-
3-79	1050	30.0	212.	-	41.	-
		25.0	453.	-	41.	-
3-80	1050	30.0	107.	-	37.	-
		25.0	217.	-	34.	-
3-81	1050	30.0	81.	-	15.	-
		25.0	274.	-	12.	-
3-82	1050	30.0	76.	-	31.	-
		25.0	205.	-	39.	-
3-83	1000	9.5	>3500.c	.000012	-	-
	1050	4.5	>3500.c	.000017	-	-
3-84	1050	30.0	88.	-	26.	-
		25.0	230.	-	23.	-
3-85	1050	40.0	1.2	-	44.	86.
		30.0	23.	1.57	55.	87.
		25.0	123.	.30	63.	89.
		20.0	420.	.056	60.	86.
		15.0	1432.	.018	53.	87.
		13.0	3046.	.00495	52.	81.
3-86	1050	40.0	4.3	-	39.	84.
		30.0	127.	2.12	48.	84.
		25.0	309.	.029	49.	82.
		19.0	655.	.0122	53.	86.
		13.0	3044.	.00387	37.	85.
3-87	1050	45.0	20.	-	36.	70.
		40.0	62.	.920	34.	67.
		30.0	354.	.0276	30.	67.
		25.0	627.	.00962	37.	74.
		14.0	2093.	.00208	46.	78.
		13.0	4150.	-	-	-
3-88	1050	40.0	0.4	-	44.	85.
		30.0	35.	.767	55.	90.
		25.0	137.	.261	58.	88.
		20.0	415.	.0786	71.	88.
		13.0	1685.	.00873	23.(1)	89.
		12.0	2921.	.00558	61.	87.
3-89	1050	40.0	27.	.995	36.	82.
		30.0	180.	.216	40.	82.
		25.0	393.	.106	42.	84.
		15.0	1769.	.0105	52.	80.
		12.5	3761.	.00565	58.	86.
3-90	1050	45.0	40.	.604	30.	65.
		40.0	71.	.218	39.	70.
		30.0	344.	.0259	33.	67.
		25.0	550.	.0113	64.	75.
		14.0	2932.	.00179	37.	74.

(1) Broke in gage mark

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-91	1050	40.0	1.2	-	44.	86.
		30.0	48.	1.00	54.	86.
		25.0	141.	.22	57.	83.
		20.0	533.	.0444	54.	87.
		15.0	1804.	.00895	47.	81.
		13.5	2497.	.00799	43.	77.
3-92	1050	40.0	2.7	-	39.	84.
		30.0	88.	-	46.	73.
		25.0	188.	-	43.	67.
		20.0	812.	-	31.[1]	46.
3-93	1050	40.0	2.9	-	42.	82.
		30.0	140.	-	37.	55.
		25.0	407.	-	29.	44.
		22.0	803.	-	34.	49.
3-94	1050	40.0	12.3	-	37.	83.
		30.0	100.	-	45.	84.
		25.0	217.	-	52.	88.
		20.0	518.	-	55.	89.
3-95	1050	40.0	17.5	-	40.	87.
		30.0	67.	-	52.	87.
		25.0	234.	-	56.	89.
		20.0	515.	-	62.	89.
3-96	1050	40.0	1.6	-	38.	83.
		30.0	115.	-	38.	61.
		25.0	263.	-	42.	54.
		20.0	806.	-	40.	67.
3-97	1050	40.0	0.7	-	36.	86.
		30.0	113.	-	43.	65.
		25.0	211.	-	48.	62.
		20.0	1535.	-	43.	65.
3-98	1050	40.0	0.7	-	48.	88.
		30.0	28.	2.22	57.	88.
		25.0	125.	.347	55.	88.
		20.0	575.	.0409	55.	85.
		16.5	1408.	.011	53.	86.
		14.0	3264.	.00553	40.	82.
3-99	1050	40.0	1.6	-	37.	85.
		30.0	40.	.703	51.	90.
		25.0	204.	.113	51.	85.
		20.0	615.	.035	52.	84.
		14.0	2551.	.00696	43.	80.
3-100	1000	40.0	76.	-	42.	71.
		35.0	513.	-	31.	53.
		30.0	1125.	-	28.	38.
3-101	1000	30.0	198.	-	34.	78.
		24.0	1124.	-	46.	76.
		17.0	6684.c	.0020	-	-
		9.0	4562.c	.00004	-	-
		6.5	10368.c	.000006	-	-

[1] Broke in gage mark.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-101	1100	18.0	158.	.140	53.	-
(cont.)		13.0	1263.	.00925	40.	88.
		6.0	4200.c	.000075	-	-
		4.0	10170.c	.0000085	-	-
3-102	1000	30.0	191.	-	43.	-
		24.0	1082.	.0216	41.	-
	1100	15.0	331.	.070	68.	-
		12.0	1377.	.0085	46.	80.
3-103	1000	30.0	235.	.055	39.	80.
		25.0	686.	.0306	27.	76.
		22.0	1815.	.0156	46.	77.
3-104	1050	40.0	1.9	-	42.	84.
		30.0	48.	.735	50.	78.
		25.0	164.	.254	57.	73.
		20.0	701.	.0759	56.	69.
		16.0	1777.	.0091	44.	77.
		14.5	2498.	.0059	52.	74.
3-105	1000	40.0	26.	-	40.	69.
		39.0	124.	-	35.	60.
		30.0	431.	-	31.	54.
		26.0	1004.	-	26.	47.
		20.0	3871.	-	26.	39.
		7.8	>5000.c	.000028	-	-
		6.0	>5000.c	.000011	-	-
	1050	25.0	114.	-	48.	64.
		18.0	652.	-	43.	61.
		11.5	2773.	-	30.	59.
		5.5	>5000.c	.00010	-	-
	1100	20.0	25.	-	67.	79.
		16.0	114.	-	87.	75.
		12.0	63.0	-	103.	74.
		10.0	896.	-	54.	75.
3-108	1050	40.0	10.1	-	40.	85.
		30.0	108.	-	43.	84.
		25.0	271.	-	53.	86.
		20.0	590.	-	64.	88.
3-109	1050	30.0	10.8	-	54.	89.
		25.0	114.	.317	63.	89.
		20.0	402.	.0794	57.	88.
		15.0	1472.	.0155	54.	93.
		13.0	3322.	.00654	56.	84.
3-110	1050	40.0	0.1	-	39.	90.
		30.0	21.	1.812	50.	88.
		20.0	138.	.346	85.	92.
		13.0	1333.	.0255	60.	86.
		11.3	2497.	.0104	62.	86.
3-116	1000	30.0	403.	-	44.	78.
	1050	27.0	46.	-	46.	81.
	1100	17.0	156.	.133	63.	86.
	1150	10.0	1138.	.0055	34.	79.

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-116	1200	7.5	791.	.0050	32.	86.
(cont.)	1250	6.0	406.	.010	-	90.
3-117	1000	29.0	1009.	-	35.	75.
	1050	25.0	242.	.0347	41.	76.
	1100	17.0	153.	-	67.	83.
	1150	10.0	657.	.0164	51.	85.
	1200	7.5	514.	.0125	-	-
	1250	6.0	362.	.0100	74.	89.
3-118	1000	29.0	206.	-	50.	77.
	1050	25.0	99.	-	64.	83.
	1100	17.0	81.	-	72.	86.
	1150	10.0	547.	.019	47.	83.
	1200	7.5	552.	.010	53.	83.
	1250	6.0	370.	.010	53.	87.
3-119	1000	33.0	61.	-	40.	79.
	1050	25.0	49.	-	56.	84.
	1100	15.0	702.	.0125	36.	58.
	1150	10.0	1254.	.00238	31.	59.
	1200	7.5	777.	.0029	47.	80.
	1250	5.5	520.	.00927	39.	89.
	1000	33.0	31.	-	37.	76.
	1050	25.0	47.	-	61.	83.
	1100	15.0	336.	-	59.	87.
	1150	10.0	769.	.0115	47.	79.
	1200	7.5	664.	.0108	46.	83.
	1250	5.5	309.	.025	59.	90.
3-120	1000	31.5	375.	.0125	36.	72.
	1050	25.0	133.	.150	47.	77.
	1100	15.0	564.	.021	90.	82.
	1150	10.0	1461.	.00215	35.	87.
	1200	7.5	943.	.00287	43.	86.
	1250	6.0	448.	.0057	36.	93.
	1000	31.5	1415.	.00127	20.	64.
	1050	25.0	416.	.00375	36.	73.
	1100	15.0	256.	.0775	56.	83.
	1150	10.0	917.	.0077	44.	84.
	1200	7.5	817.	.00366	42.	88.
	1250	6.0	376.	.01625	50.	90.
3-121	1000	29.0	844.	-	38.	75.
	1050	25.0	177.	-	58.	82.
	1100	16.0	377.	.0183	32.	79.
	1150	10.0	951.	.0044	65.	79.
	1200	7.5	832.	.00464	61.	83.
	1250	5.8	391.	.0180	44.	83.
3-123	950	45.4	0.4	-	34.[1]	80.
		40.0	12.8	-	31.	83.
		37.0	21.5	-	33.[1]	82.
		33.0	289.	-	30.[1]	81.
		29.0	1745.	-	29.[1]	82.

[1] Broke in gage mark.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-123 (cont.)	1050	33.0	1.4	-	42.[1]	87.
		30.0	7.6	-	44.[1]	87.
		26.0	32.	-	42.[1]	88.
		16.5	454.	-	30.[1]	90.
		14.5	1063.	-	67.[1]	91.
3-124	900	38.	4000.c	.00173	-	-
	1000	27.0	322.	-	24.	27.
3-125	1000	26.0	1022.	-	28.	70.
		23.0	2209.	-	40.	65.
		20.0	4389.	-	21.	58.
3-126	1000	26.0	1225.	-	33.	56.
		23.0	1715.	-	36.	58.
3-128	1000	15.0	8930.c	.00123	-	-
	1100	9.0	2326.c	.00127	-	-
3-129	1000	30.0	640.	-	34.	56.
		27.0	909.	-	41.	51.
		20.0	2520.	-	49.	69.
		17.0	4647.	-	50.	74.
		13.5	17473.	-	33.	56.
		15.0	8926.	.00156	-	69.
		8.0	10080.c	.000029	-	-
	1100	16.0	234.	-	57.	78.
		13.0	748.	-	30.	77.
		9.5	4446.	-	34.	66.
		4.0	3835.c	.000043	-	-
3-130	1000	31.2	803.	-	15.	17.8
		30.0	1249.	-	10.	19.5
		27.0	1632.	-	13.0	20.0
		23.0	2736.	-	19.0	33.0
		19.0	4735.	-	28.	38.
		16.5	7364.	-	23.	49.
3-131	1000	28.0	988.	-	34.	52.
		26.0	1035.	-	34.	60.
		23.0	1838.	-	30.	54.
		20.0	2747.	-	46.	67.
	1100	16.0	242.	-	58.	79.
		13.0	946.	-	61.	72.
		10.0	3234.	-	34.	66.
		8.5	6736.	-	28.	58.
3-133	800	71.9	0.1	-	28.	75.
		69.0	22.8	-	30.	74.
		68.0	254.	-	35.	72.
		65.0	1010.	-	31.	75.
	900	59.3	1.6	-	33.	79.
		58.0	124.	-	34.	80.
		57.0	176.	-	35.	80.
		55.0	468.	-	35.	77.
		54.0	878.	-	35.	75.

[1] Broke in gage mark.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-133 (cont.)	1050	45.0	1.8	-	43.	84.
		35.0	34.	-	44.	79.
		30.0	174.	-	32.	66.
		25.0	417.	-	50.	76.
		20.0	850.	-	46.	87.
	1200	20.0	1.8	-	80.	89.
		15.0	15.2	-	79.	91.
		10.0	97.	-	70.	91.
		6.0	875.	-	76.	94.
	1300	10.0	5.8	-	95.	95.
		7.0	27.2	-	80.	93.
		5.0	136.	-	50.	84.
		4.0	255.	-	56.	66.
		3.0	537.	-	30.	47.
		2.4	826.	-	30.	50.
	1400	5.0	5.6	-	113.	98.
		3.0	55.	-	60.	64.
		2.0	144.	-	40.	42.
		1.0	580.	-	48.	55.
3-134	1100	17.0	353.	-	57.	89.
	1150	11.5	426.	-	43.	93.
	1200	9.0	332.	-	61.	94.
3-135	1100	17.0	310.	-	57.	90.
	1150	11.5	420.	-	58.	93.
	1200	9.0	326.	-	38.	93.
3-136	1100	17.0	307.	-	48.	85.
	1150	11.5	354.	-	54.	89.
	1200	9.0	392.	-	38.	92.
3-137	1100	17.0	344.	-	41.	88.
	1150	11.5	447.	-	25.	86.
	1200	9.0	307.	-	60.	93.
3-138	1100	17.0	211.	-	42.	90.
	1150	11.5	395.	-	51.	92.
	1200	9.0	390.	-	42.	94.
3-139	1100	17.0	401.	-	33.	85.
	1150	11.5	620.	-	54.	88.
	1200	9.0	334.	-	39.	87.
3-140	1100	17.0	525.	-	40.	76.
	1150	11.5	930.	-	36.	82.
	1200	9.0	506.	-	25.	84.
3-141	1100	17.0	306.	-	39.	82.
	1150	11.5	401.	-	27.	86.
	1200	9.0	260.	-	47.	92.
3-142	1100	17.0	323.	-	33.	81.
	1150	11.5	401.	-	39.	84.
	1200	9.0	308.	-	53.	86.
3-143	1100	17.0	340.	-	31.	83.
	1150	11.5	532.	-	28.	84.
	1200	9.0	294.	-	38.	91.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-144	1100	17.0	331.	-	50.	83.
	1150	11.5	554.	-	40.	86.
	1200	9.0	185.	-	17.	85.
3-145	1100	17.0	492.	-	29.	81.
	1150	11.5	501.	-	27.	83.
	1200	9.0	299.	-	42.	88.
3-146	1100	17.0	378.	-	22.	79.
	1150	11.5	645.	-	22.	72.
	1200	9.0	394.	-	25.	77.
3-147	900	60.0	609.	-	36.	-
		55.0	3241.	-	23.	-
	950	57.0	37.	-	37.	-
		47.0	1447.	-	22.	-
	1000	46.0	222.	-	27.	-
		38.0	1327.	-	19.	-
		33.0	2341.	-	19.	-
	1050	34.0	224.	-	25.	-
		28.0	757.	-	27.	-
		25.0	968.	-	24.	-
	1100	28.0	63.	-	34.	-
		15.0	731.	-	40.	-
3-148	1000	33.0	467.	-	27.	-
	1050	25.0	186.	-	26.	-
3-150	950	50.0	61.	-	35.	-
	1000	40.0	76.	-	37.	-
	1050	35.0	35.	-	32.	-
	1100	20.0	146.	-	38.	-
3-151	950	50.0	233.	-	29.	-
	1000	40.0	132.	-	35.	-
	1050	35.0	39.	-	39.	-
	1100	20.0	229.	-	35.	-
3-152	950	50.0	357.	-	35.	-
	1000	40.0	207.	-	39.	-
	1050	35.0	87.	-	35.	-
	1100	20.0	450.	-	7.	-
3-153	950	50.0	217.	-	26.	-
	1000	40.0	231.	-	29.	-
	1050	35.0	71.	-	25.	-
	1100	20.0	313.	-	9.	-
3-154	900	61.0	6.2	-	33.	-
		59.8	15.2	-	35.	-
		56.0	62.1	-	35.	-
		54.0	267.	-	39.	-
		52.0	606.	-	35.	-
	1050	40.9	1.9	-	50.	-
		36.0	14.4	-	51.	-
		32.0	56.	-	70.	-
		28.0	143.	-	61.	-
		25.0	253.	-	40.	-
		20.0	688.	-	50.	-

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-154 (cont.)	1200	21.2	2.0	-	79.	-
		18.0	5.1	-	96.	-
		15.0	15.5	-	100.	-
		13.0	36.	-	79.	-
		9.0	180.	-	75.	-
		6.0	965.	-	67.	-
3-155	1000	40.0	240.	.0265	*	-
		35.0	568.	.0088	*	-
		33.0	736.	.00683	*	-
		30.0	908.	.00393	*	-
		25.0	2194.	.00297	8.	-
		21.0	3334.	.00104	8.	-
		19.0	4935.	.00075	15.	-
	1050	30.0	153.	.0445	10.	-
		25.0	366.	.0143	8.	-
		23.0	495.	.0104	12.	-
		17.0	1130.	.00418	**	-
		14.0	2045.	.00233	22.	-
		11.5	3512.	.0010	32.	-
3-156	1000	40.0	176.	.0359	*	-
		37.0	338.	.0122	*	-
		35.0	452.	.0108	7.	-
		30.0	1034.	.00372	*	-
		23.0	2916.	.00106	9.	-
		21.0	4571.	.00057	11.	-
	1050	30.0	175.	.0364	*	-
		28.0	257.	.0223	14.	-
		25.0	347.	.0162	15.	-
		21.0	614.	.00569	8.	-
		15.0	1856.	.00149	34.	-
		14.0	2461.	.00161	25.	-
		12.0	4800.	.00125	32.	-
3-157	1000	35.0	211.	-	*	-
		35.0	311.	-	8.	-
		30.0	480.	-	*	-
		28.0	818.	-	*	-
		25.0	1372.	-	*	-
	1050	30.0	148.	-	13.	-
		25.0	258.	-	*	-
		23.0	324.	-	17.	-
		20.6	565.	-	17.	-
3-158	1000	50.0	74.	-	27.	-
		44.0	274.	.0250	18.	-
		40.0	324.	.0239	21.	-
		40.0	503.	.0115	20.	-

* Failed in the notch.

** Fractured outside gage marks.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-158	1000	35.0	564.	.0111	25.	-
(cont.)	(cont.)	35.0	618.	.00521	25.	-
		25.0	1815.	.00178	35.	-
		21.0	3086.	.00256	42.	-
	1050	30.0	212.	-	35.	-
		28.0	212.	-	52.	-
		27.0	217.	.0606	40.	-
		25.0	364.	.0167	53.	-
		20.0	767.	.0119	53.	-
		16.0	1404.	.0037	48.	-
		14.0	1692.	.00353	47.	-
		12.0	2793.	.00377	54.	-
		10.0	5536.	.00114	31.	-
3-159	1000	50.0	126.	-	*	-
		45.0	193.	-	*	-
		40.0	393.	-	10.	-
		35.0	774.	-	20.	-
		30.0	1467.	-	13.	-
	1050	40.0	45.	-	25.	-
		35.0	148.	-	25.	-
		30.0	173.	-	*	-
		30.0	304.	-	25.	-
		25.0	368.	-	28.	-
		25.0	435.	-	*	-
		23.0	386.	-	24.	-
		20.0	593.	-	63.	-
3-160	1050	33.0	60.	-	40.	55.
		30.0	147.	-	36.	32.
		25.0	278.	-	44.	52.
		20.0	818.	-	36.	44.
		18.0	1472.	-	38.	59.
		15.0	1623.	-	58.	67.
3-161	1050	35.0	45.	-	43.	81.
		30.0	121.	-	44.	80.
		26.0	240.	-	64.	59.
		25.0	194.	-	28.	80.
		20.0	711.	-	50.	79.
		15.0	3930.	-	46.	66.
3-162	900	50.0	8084.	-	7.5	-
		40.0	17105.	-	3.0	-
3-163	900	30.0	>7200.	.000016	-	-
	1000	32.5	830.	.0051	36.	58.
		30.0	1131.	.0030	45.	65.
		25.0	1792.	.00125	58.	74.
	1200	2.5	>4400.	.00017	-	-
	1300	2.5	1414.	.007	34.	54.

*Fractured in notch.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-169	1150	13.0	354.	-	52.	84.
		13.0	285.	-	81.	87.
		11.0	920.	-	69.	82.
		11.0	900.	-	44.	81.
	1200	9.0	532.	-	-	91.
3-170	1150	11.0	905.	-	50.	82.
	1200	7.0	1470.	-	-	79.
3-171	1150	13.0	605.	-	43.	82.
		13.0	645.	-	61.	83.
		11.0	533.	-	28.	81.
		11.0	818.	-	55.	87.
	1200	9.0	843.	-	-	87.
		9.0	723.	-	-	84.
3-172	1150	11.0	605.	-	67.	86.
		11.0	876.	-	58.	86.
	1200	9.0	599.	-	73.	87.
3-173	1000	40.0	166.	-	35.	50.
	1100	16.1	470.	-	47.	87.
	1150	12.0	771.	-	52.	84.
3-174	1000	35.0	744.	-	31.	72.
	1100	14.0	965.	-	44.	72.
	1150	11.0	570.	-	-	84.
		11.0	1237.	-	39.	77.
	1200	7.0	1319.	-	60.	88.
3-178	950	35.0	228.	-	34.	-
		30.0	4390.	.000835	32.	-
		27.0	5773.	.00135	34.	-
		7.0	2000.c	.0000003	-	-
	1000	30.0	482.	.00743	32.	-
		25.0	1811.	.00344	46.	-
		20.0	2346.	.0065	65.	85.
		7.8	2000.c	.000139	-	-
	1050	25.0	271.	-	31.	-
		20.0	1848.	.00190	26.	-
		3.0	2130.c	.0000011	-	-
	1100	20.0	308.	-	43.	-
		20.0	2348.*	.0065	66.	-
		15.0	2156.	.00195	21.	-
		5.0	2130.c	.000125	-	-
	1120	25.0	4.2	-	48.	-
		15.0	193.	-	61.	-
		10.0	5625.	.00071	12.8	-
3-180	1000	32.0	259.	-	40.	-
		32.0	214.	-	51.	-
3-181	1000	32.0	553.	.00175	33.	-
3-182	1025	23.0	3643.	.00085	10.	-
		21.0	4050.	.00054	8.4	-

*Seems unreasonable - omitted.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-183	1000	30.0	396.	-	46.	-
		25.0	2610.	-	42.	-
	1100	20.0	246.	-	44.	-
		15.0	1465.	-	38.	-
	1200	10.0	201.	-	44.	-
3-184	1000	32.0	70.	-	52.	-
3-185	1000	32.0	1910.	-	19.4	-
3-186	1050	20.0	6617.*	.00055*	20.7	-
		7.0	13370.c	.0000187	-	-
3-187	1000	30.0	30.0	-	53.	-
		30.0	33.9	-	60.	-
		20.0	799.	-	91.	-
		16.0	6397.	.00472	56.	-
	1050	13.0	3034.	-	50.	-
	1100	10.0	2085.	-	88.	-
3-188	950	30.0	5520.	.00070	12.2	-
	1000	25.0	2200.	-	26.	-
		20.0	8677.	.00080	26.	-
	1050	18.0	3933.	-	-	-
3-189	1000	30.0	71.	-	51.	-
		20.0	1063.	-	41.	-
	1050	8.0	3200.c	.000233	-	-
3-190	1100	12.0	1675.	.00527	40.	-
3-191	1000	15.0	8336.	.0014	39.	-
3-192	1000	25.0	1919.	.00565	31.	-
	1050	15.0	1872.	.0032	17.8	-
3-193	950	17.0	3066.c	.00035	-	-
	1000	12.0	3017.c	.00045	-	-
	1050	10.0	2914.c	.00135	-	-
3-194	1000	20.0	3336.	.0005	10.0	-
		10.0	2250.c	.000024	-	-
	1100	3.0	2352.c	.000032	-	-
3-195	1000	10.0	1344.c	.000041	-	-
	1100	20.0	45.	.65	50.	-
		15.0	240.	.06	38.	-
		12.0	720.	.0092	12.5	-
		10.0	1220.	.0056	39.0	-
3-196	1000	25.0	156.	-	35.	-
		22.0	1488.	-	-	-
		20.0	1248.	-	20.	-
		15.0	4056.	-	7.0	-
		13.0	7584.c	-	-	-
		10.0	1848.c	-	-	-
3-197	1000	20.0	3960.	.00063	7.0	-
		15.0	1922.c	.000115	-	-
		10.0	1992.c	.000047	-	-
	1100	10.0	1992.	.00253	26.	-
		7.5	1320.c	.000282	-	-
		5.0	1488.c	.000173	-	-

*These values seem unreasonable and have been omitted.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-198a	900	40.0	14677.	.000065	26.	79.
	950	40.0	692.	.00587	26.	78.
		40.0	1962.	.00273	27.	72.
		35.0	6253.	.00108	24.	65.
		35.0	6689.	.00058	25.	48.
		35.0	7364.	.00039.	25.	52.
	1000	40.0	140.	-	30.	81.
		35.0	140.	-	26.	83.
		35.0	327.	-	25.	85.
		30.0	1246.	.00440	36.	-
		30.0	1459.	.00292	30.	94.
		30.0	2251.	.00120	30.	88.
		25.0	1879.	.00295	30.	79.
		25.0	3308.	.00087	27.	77.
		25.0	3856.	.00085	26.	76.
	1050	25.0	309.	-	35.	78.
		25.0	350.	-	36.	85.
		25.0	439.	-	38.	78.
		25.0	554.	.00660	28.	82.
		20.0	1026.	.00540	25.	82.
		20.0	1341.	.00317	48.	87.
		20.0	1400.	.00246	34.	83.
	1100	20.0	154.	-	48.	79.
		20.0	161.	-	39.	88.
		15.0	877.	.0080	58.	89.
		15.0	1010.	.0061	38.	91.
		15.0	1021.	.0060	30.	87.
		10.0	1186.c	.00033	-	-
		10.0	6480.	.00052	37.	44.
	1150	10.0	1470.c	.00213	-	-
		5.0	14310.	.00012	29.	94.
	1200	10.0	205.	-	42.	93.
3-198b	925	42.0	1558.	.00142	24.	78.
		42.0	1919.	.00160	25.	75.
	950	35.0	712.	.00019	33.	85.
		35.0	1792.	.00052	34.	80.
		35.0	2558.	.00029	40.	78.
		30.0	3288.	.0028	28.	79.
		25.0	14582.	.00076	34.	69.
	1000	30.0	396.	-	46.	84.
		25.0	2609.	.0021	42.	72.
		20.0	10284.	.00065	27.	62.
	1050	20.0	1484.	.00516	48.	79.
	1100	20.0	246.	-	44.	77.
		15.0	1465.	.00306	38.	76.
		12.0	980.	.00230	66.	91.
		12.0	2316.	.0020	39.	86.
		12.0	3890.	.00115	41.	85.
	1150	7.0	4114.	.00076	33.	91.
		7.0	2000.c	.00105	-	-

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-198b (cont.)	1200	10.0	201.	-	44.	88.
		5.0	2282.	.00185	58.	94.
		5.0	2284.	.00185	39.	90.
3-198c	950	40.0	3138.	.00007	-	-
		40.0	5606.	.00073	-	-
		30.0	24679.c	.000036	-	-
	1050	25.0	222.	-	35.	87.
		15.0	6971.	.00050	17.	45.
	1100	20.0	478.	.00450	31.	68.
		15.0	1039.	.00550	34.	77.
3-198d	900	50.0	805.	.00128	24.	77.
		45.0	2521.	.00028	32.	79.
		45.0	2814.	.00020	24.	80.
		40.0	4079.	.00016	30.	82.
	950	35.0	1493.	.00019	24.	80.
		35.0	1498.	.00065	29.	84.
		35.0	1728.	.00063	32.	83.
	1000	25.0	2296.	.00190	25.	86.
	1050	25.0	241.	-	43.	85.
		25.0	259.	-	40.	83.
		15.0	2222.	.00080	31.	75.
		10.0	38200.c	.00013	-	-
	1100	20.0	201.	-	35.	75.
		20.0	213.	-	33.	85.
		15.0	1318.	.00292	39.	88.
		12.0	1730.	.0027	33.	78.
		12.0	2250.	.0022	44.	91.
		10.0	4110.	.0013	37.	84.
	1150	8.0	1639.	.0033	32.	87.
		8.0	2070.	.0029	41.	92.
		8.0	2224.	.0023	46.	90.
	1200	5.0	1421.	.0053	54.	94.
		5.0	1708.	.0029	53.	94.
		5.0	1946.	.0031	53.	95.
3-199a	950	30.0	5519.	.00097	12.	28.
	1000	25.0	2201.	.00273	26.	61.
		20.0	8677.	.00090	26.	56.
	1050	18.0	3933.	.00183	23.	36.
		12.0	23926.	.00025	11.5	24.
3-199b	950	30.0	2223.	.00175	14.5	21.
	1000	25.0	1433.	.0050	18.0	40.
		20.0	5835.	.00094	8.7	15.6
	1050	18.0	2389.	.00275	14.0	20.
		12.0	14502.	.00045	7.5	20.
3-199c	1000	25.0	785.	.0020	13.5	20.
		20.	2806.	.00214	12.5	22.
	1050	18.0	856.	.0070	13.5	10.9
		12.0	8105.	.00041	5.5	6.1
3-202	1000	25.0	1919.	.00467	31.	44.
	1050	15.0	1872.	.00225	18.	34.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-203	1000	15.0	8335.	.00100	39.	49.
3-205	1100	12.0	1676.	.00460	40.	62.
3-206	900	40.0	2212.	.00078	26.	74.
		40.0	3278.	.00190	20.	75.
	950	40.0	213.	-	28.	79.
		40.0	581.	.0062	34.	79.
	1000	30.0	200.	-	37.	84.
	1050	20.0	696.	.0066	27.	84.
		20.0	718.	.0083	48.	87.
	1100	15.0	512.	-	47.	89.
		15.0	543.	-	44.	92.
	1150	10.0	560.	.0022	-	-
		10.0	1582.	-	47.	94.
	1175	9.0	585.	.00883	63.	94.
		9.0	668.	.0090	46.	94.
3-207*	950	28.0	740.	-	46.	80.
		23.0	3097.	.0060	60.	79.
	1000	16.0	4479.c	.00624	-	-
		16.0	6379.	.00373	56.	70.
		12.5	31824.	.00042	26.	-
		10.0	>80280.	.000034	-	-
	1050	13.0	3034.	.0070	50.	67.
		10.0	19857.	.00072	27.	57.
		8.0	49130	.00013	-	70.
	1100	10.0	2086.	.00646	89.	88.
3-208	950	28.0	1076.	.0085	56.	80.
		23.0	5970.	.00164	47.	81.
	1000	16.0	3526.	.0050	45.	86.
		16.0	4864.	.00425	55.	78.
		12.5	42470.	.00030	-	88.
	1050	13.0	2976.	.0060	61.	89.
		10.0	40388.	.00018	-	92.
	1100	10.0	4022.	.000226	55.	90.
3-209a	1000	30.0	90.	.10	46.	-
		25.0	245.	.053	49.	-
		20.0	1345.	.0088	88.	-
		15.0	1100.c	.00073	-	-
		11.0	1750.c	.000050	-	-
		7.8	3840.c	.0000012	-	-
	1100	15.0	6.6	-	56.	-
		13.5	738.	.007	56.	-
		12.5	859.	.0049	70.	-
		10.0	2092.	.0013	38.	-
		8.0	2060.c	.00080	-	-
		6.0	2010.c	.00016	-	-
		4.0	2010.c	.00001	-	-

*Same lot as 3-187.

Table IV - continued

Code No.	Temp. °F	Stress-ksi	Test Duration-Hours	Min. Creep Rate-%/hr	% Elong.	% Red. Area
3-209a	1200	6.5	932.	.0043	82.	-
(cont.)		5.0	1285.	.0022	60.	-
		1.2	2010.c	<.000001	-	-
3-209b	1000	43.0	25.8	.11	30.	-
		40.0	265.	.014	10.	-
		35.0	851.	.0032	7.	-
		29.0	1413.	.0019	4.	-
		27.5	1667.	.0012	3.	-
		20.0	2070.c	.0000013*	-	-

*Appears unreasonable; therefore omitted.

Table Va

Ratio of Elevated Temperature Yield and Tensile Strengths to Strengths at Room Temperature

(combined product forms)

Temp. °F	Yield Strength Ratio			Tensile Strength Ratio		
	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo	1 Cr - $\frac{1}{2}$ Mo	$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo	1 Cr - $\frac{1}{2}$ Mo	$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si
75	1.0	1.0	1.0	1.0	1.0	1.0
100	.990	.977	.982	.990	.975	.975
200	.958	.904	.923	.971	.890	.916
300	.913	.850	.878	.988	.876	.912
400	.867	.812	.842	1.016	.890	.933
500	.828	.784	.812	1.042	.915	.959
600	.791	.762	.784	1.060	.935	.973
700	.764	.741	.755	1.025	.936	.962
800	.735	.715	.721	.962	.910	.920
900	.703	.681	.680	.879	.851	.844
1000	.660	.633	.626	.752	.759	.736
1100	.590	.566	.558	.614	.636	.602
1200	.475	.476	.471	.464	.490	.455
1300	.333	.357	.363	.314	.332	.310
1400	-	.204	.229	.192	.177	.188
1500	-	-	-	.129	-	-

Table Vb

Effect of Product Form on Elevated Temperature Yield and Tensile Strength Ratios of $1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si Steel

Temp. °F	Yield Strength Ratio			Tensile Strength Ratio		
	Combined	Plate	Non-Plate	Combined	Plate	Non-Plate
75	1.0	1.0	1.0	1.0	1.0	1.0
100	.982	.982	.982	.975	.975	.975
200	.923	.932	.926	.916	.907	.912
300	.878	.883	.885	.912	.893	.913
400	.842	.840	.852	.933	.906	.943
500	.812	.800	.824	.959	.924	.977
600	.784	.760	.798	.973	.932	.996
700	.755	.719	.769	.962	.919	.987
800	.721	.675	.735	.920	.876	.942
900	.680	.625	.693	.844	.801	.859
1000	.626	.567	.639	.736	.696	.742
1100	.558	.498	.570	.602	.569	.603
1200	.471	.417	.482	.455	.429	.455
1300	.363	.320	.373	.310	.292	.321
1400	.229	.207	.238	.188	.178	.229
1500	-	.074	-	-	.112	-

Table VI

Summary of Rupture Strengths (ksi)
Individual Heats

	TEMPERATURE °F								
Code No.	800	850	900	950	1000	1050	1100	1150	1200
Part 1 -- 1/2 Cr - 1/2 Mo Steels									
1000 hours									
1-1				36.0		16.8	11.6		
1-7			57.0			29.0			7.4
1-8			52.0		26.5		10.4		
1-9a			45.0		26.0		10.0		
1-9b				49.0					
1-10			62.0		37.0		15.7		
1-11			64.0			27.5			5.9
1-12			64.0			18.5			4.3
1-13						19.5			4.6
1-14			49.0			16.3			5.4
1-15			60.0			20.0			5.2
10,000 hours									
1-1				32.0		9.2	5.9		
1-7			53.0						
1-8			43.0		13.0		6.1		
1-9a			39.0		15.5		6.0		
1-9b				38.5					
1-10			45.0		23.0		9.7		
1-11			59.0			19.7			3.3
1-12			59.0						
1-13						10.0			2.4
1-14						10.3			3.4
1-15						12.0			3.0

Table VI - continued

Code No.	800	850	900	950	1000	1050	1100	1150	1200
	TEMPERATURE °F								
100,000 hours									
1-7			49.0						
1-8			35.0		6.6		3.5		
1-9a			33.5		9.4		3.6		
1-9b				30.0					
1-10			32.5		14.5		6.1		
1-12			54.0						
Part 2 -- 1 Cr - 1/2 Mo Steels									
1000 hours									
2-1 (2-12a)					39.0		13.8		5.6
2-2					35.0				5.5
2-3 (2-12b)					39.0				
2-4			56.0			26.5			7.3
2-10			52.0		25.5		10.1		
2-11					31.0		12.0		
2-13					27.0				
2-15			51.0		36.0				
2-16					35.5				
2-17					36.0				
2-18					34.5		12.2		
2-19							15.1		
2-20							16.0		
2-23									8.6

Table VI - continued

Code No.	TEMPERATURE °F 800	850	900	950	1000	1050	1100	1150	1200
2-24						24.5			8.9
2-28						20.0			
2-29						20.1			
2-30		58.0		43.0	34.0				
2-40					22.5				
<u>10,000 hours</u>									
2-1 (2-12a)					23.0		7.8		3.0
2-2									3.1
2-3 (2-12b)					22.5				
2-4			47.0						4.3
2-10			40.0		15.3		6.4		
2-11					15.1		7.0		
2-13					17.0				
2-15					22.4				
2-16					25.5				
2-28						10.7			
2-30		56.0							
2-40					14.7				
<u>100,000 hours</u>									
2-1 (2-12a)					13.0		4.5		1.7
2-3 (2-12b)					12.9				
2-10			31.0		9.1		4.0		
2-11					7.7				
2-15					13.5				
2-30		54.0							
2-40					9.6				

Table VI - continued

Code No.	800	850	900	950	1000	1050	1100	1150	1200
					TEMPERATURE °F				
Part 3 -- 1 1/4 Cr - 1/2 Mo - 3/4 Si									
1000 hours									
3-4					25.0				
3-5b				38.0					
3-6					24.5	13.9			
3-8						16.4			
3-9						13.8			
3-10							13.7		
3-28					26.0	15.4	11.0		
3-29					33.0	19.0	11.8		
3-30					32.5	19.8			
3-31					29.0				
3-32					25.0	16.2			
3-33					30.0	20.8			
3-34					30.5		12.0		
3-35					31.5		12.4		
3-36					27.5		11.1		
3-37a					23.6		12.3		
3-37b					38.5		13.0		
3-38a					25.9		11.9		
3-38b					19.0				
3-39			46.0		22.0		10.9		
3-40			58.0		36.0		12.5		
3-41a			45.0		26.5		12.4		
3-41b			49.0		28.0		10.4		
3-42a			55.0		31.0		13.0		
3-42b							15.0		
3-42c					30.5		11.2		
3-49a					33.0		13.2		
3-49b					24.5		13.0		
3-50a					27.0				
3-50b							12.4		
3-50c					23.0				
3-51						16.9			
3-52					32.0				
3-53					32.5				
3-57						22.0			
3-58						23.0			
3-59						22.5			
3-61					23.9				
3-62					33.5		13.9		
3-63						15.8			
3-64						17.3			
3-65						18.2			
3-66						16.2			
3-68						17.1			
3-69						18.1			

Table VI - continued

Code No.	800	850	900	950	1000	1050	1100	1150	1200
	TEMPERATURE °F								
3-70						18.5			
3-71						17.5			
3-72						17.2			
3-75						19.4			
3-76						21.4			
3-78						18.6			
3-79						20.3			
3-80						17.1			
3-81						20.4			
3-82						19.0			
3-84						18.5			
3-85						16.5			
3-86						17.8			
3-87						20.0			
3-88						15.9			
3-89						18.2			
3-90						20.1			
3-91						17.0			
3-92						18.1			
3-93						21.0			
3-94						17.0			
3-95						16.8			
3-96						19.0			
3-97						21.0			
3-98						16.9			
3-99						17.7			
3-100					30.3				
3-101					24.2		13.2		
3-102					24.1		12.7		
3-103					24.0				
3-104						18.5			
3-105					26.0	15.8			
3-108						18.0			
3-109						16.4			
3-110						13.9			
3-123				29.8		14.3			
3-125					26.1				
3-126					28.5				
3-129					26.0		12.2		
3-130					30.5				
3-131					28.0		12.9		
3-133	65.0		53.0			19.0			5.8
3-147			58.0	48.0	38.5	24.5	13.9		
3-154			51.0			18.5			6.0
3-155					32.0	17.9			
3-156					29.8	17.0			
3-157						17.2			
3-158					30.0	17.8			
3-159					32.5	18.0			

Table VI - continued

Code No.	800	850	900	950	1000	1050	1100	1150	1200
				TEMPERATURE °F					
3-160						18.7			
3-161						19.2			
3-163					30.5				
3-169								10.9	
3-174								11.0	
3-178				32.0	27.0	21.5	16.8		
3-183					27.5		16.0		
3-187				26.9	19.7				
3-188					28.3				
3-189				28.0	20.0				
3-195							10.6		
3-196					22.3				
3-198a				40.0	29.7	21.0	15.0		
3-198b				36.5	27.3		14.8		6.5
3-198c						19.8	15.0		
3-198d			51.0			18.1	14.9		
3-199a					27.5	23.4			
3-199b					26.5	21.8			
3-199c					23.7	17.6			
3-207						15.0			
3-209a					20.8		12.0		6.0
3-209b					33.0				

10,000 hours

3-4					19.0				
3-6					18.5	8.4			
3-8						9.4			
3-9						7.2			
3-10							7.9		
3-28					16.9	7.7	6.0		
3-29					16.8	9.5	5.3		
3-30					21.5	10.0			
3-31					19.8				
3-32					16.9	10.3			
3-33					21.8	9.5			
3-34					16.5		7.0		
3-35					17.2		6.9		
3-36					15.2		6.9		

Table VI - continued

Code No.	800	850	900	950	1000	1050	1100	1150	1200
					TEMPERATURE °F				
3-37a					15.3		8.6		
3-37b					17.0		8.1		
3-38a					14.6		8.0		
3-38b					11.9				
3-39			33.0		14.2		7.2		
3-40			45.0		18.7		7.1		
3-41a			40.0		14.9		7.7		
3-41b			43.0		14.4		6.5		
3-42a			47.0		18.9		7.9		
3-42b							9.6		
3-42c			46.0		16.0		7.4		
3-49a					18.9		7.9		
3-49b					15.9		8.3		
3-50a			33.8		14.2				
3-50b							8.2		
3-50c					13.7				
3-51						11.0			
3-53					21.5				
3-59						16.0			
3-62					18.0		9.2		
3-63						9.6			
3-64						9.5			
3-65						10.0			
3-69						11.2			
3-70						11.4			
3-72						11.2			
3-85						10.1			
3-86						9.3			
3-87						9.5			
3-88						8.8			
3-89						9.4			
3-90						9.0			
3-91						9.6			
3-94						9.7			
3-96						11.7			
3-97						14.2			
3-98						11.1			
3-99						10.1			
3-100					20.8				
3-101					18.7		9.3		
3-102					18.0		8.6		
3-103					17.1				
3-104						9.7			
3-105					16.5	7.7			
3-109						10.3			
3-110						8.3			
3-123				26.0		9.9			
3-125					16.1				
3-129					15.1		8.3		

Table VI - continued

Code No.	800	850	900	950	1000	1050	1100	1150	1200
	TEMPERATURE °F								
3-130					15.0				
3-131					13.3		7.8		
3-133	60.0		49.0			9.6			
3-147			51.0	42.0	23.0		7.8		
3-154			47.0			11.0			
3-155					15.0	8.1			
3-156					17.2	10.2			
3-158					15.7	8.1			
3-159					14.1				
3-160						10.6			
3-161						12.4			
3-162			45.0						
3-163					13.6				
3-178				27.7	19.3	16.2	11.8		
3-183					21.9		11.0		
3-187(207)				19.9	14.9				
3-188					19.4				
3-189(208)				20.6	14.7				
3-198a				33.0	20.0	12.8	9.1		
3-198b				26.2	20.0		8.9		3.4
3-198c						14.0			
3-198d			37.5			12.0	8.0		
3-199a					19.2	14.3			
3-199b					18.2	13.0			
3-199c					15.8	11.3			
3-207						11.0			
3-208						11.3			
3-209a					14.7				
100,000 hours									
3-6						5.2			
3-28					10.9	3.8			
3-29					7.9	4.8	2.5		
3-30						5.1			
3-31					13.0				
3-32					11.3	6.7			
3-34					9.0		3.7		
3-35					8.4		3.8		
3-36					8.3		4.3		

Table VI - continued

Code No.	TEMPERATURE °F 800	850	900	950	1000	1050	1100	1150	1200
3-37a					10.1		5.8		
3-37b					7.6		5.1		
3-38a					8.4		5.4		
3-38b					7.4				
3-39			24.0		9.2		4.9		
3-40			35.0		9.9		4.5		
3-41a			33.0		8.3		4.8		
3-41b			37.5		7.4		4.1		
3-42a			39.0		10.2		4.8		
3-42b							5.6		
3-42c			31.0		7.8		4.9		
3-49a					11.0		4.8		
3-49b					10.7		5.3		
3-50a					7.6				
3-50b							5.4		
3-50c					8.4				
3-51						7.3			
3-63						5.8			
3-64						5.3			
3-65						5.7			
3-85						6.2			
3-86						5.0			
3-89						4.8			
3-98						7.1			
3-105					10.4				
3-109						6.6			
3-123				22.5					
3-125					10.0				
3-129					9.5		5.6		
3-130					7.3				
3-131							4.8		
3-147			45.0						
3-155						3.7			
3-156					10.2	6.2			
3-158					8.1	3.8			
3-161						8.0			
3-178				24.0					
3-187(207)					11.2				
3-188					13.2				
3-189(208)				16.7	10.9				
3-198a				26.5			5.6		
3-198b				18.9	13.8				
3-198c						10.0			
3-198d			27.0			8.8	4.4		
3-199a					13.7	8.8			
3-199b						7.7			
3-199c						7.5			
3-207(187)						6.7			
3-208						9.1			

Table VII

Summary of Creep Strengths (ksi)

Individual Heats

	TEMPERATURE °F								
Code No.	800	850	900	950	1000	1050	1100	1150	1200
Part 1 -- 1/2 Cr - 1/2 Mo									
0.1 percent per 1000 hours									
1-1				19.0		8.5	-		
1-3			35.0		12.0		3.6		
1-6					8.5				
1-10			42.0		20.2		7.9		
0.01 percent per 1000 hours									
1-1				12.4		5.5	-		
1-3	34.5		22.5		5.5		1.3		
1-5			14.5						
1-6					3.8				
1-10			26.0		10.2		3.4		
Part 2 -- 1 Cr - 1/2 Mo Steels									
0.1 percent per 1000 hours									
2-1(2-12a)			21.5		12.0		4.3		1.6
2-5c			24.0						
2-30		45.0		33.0					
2-40					12.0				

	TEMPERATURE °F									
Code No.	750	800	850	900	950	1000	1050	1100	1150	1200
0.01 percent per 1000 hours										
2-1 (2-12a)				13.2		6.7		2.4		0.78
2-3 (2-12b)					14.3					
2-5A						10.5				
2-5B				26.0						
2-6				26.5		11.0				
2-7				19.0						
2-8				20.0						
2-30			35.0							
2-40						6.4				
Part 3 -- 1 1/4 Cr - 1/2 Mo - 3/4 Si										
0.1 percent per 1000 hours										
3-5a	38.0		34.0		22.0	18.0				
3-5b					23.0					
3-7						9.6				
3-8							8.0			
3-9							7.5			
3-11						7.8				
3-13				21.0		9.7		4.7		
3-15						9.8				
3-16						9.9				
3-19						10.0				
3-20						11.5				
3-23								4.9		
3-34						12.5		3.9		
3-35						16.5		5.4		
3-36						10.9				
3-37b						19.0		5.6		
3-38a						7.0		4.8		
3-38b						6.6				
3-40				43.0		17.0		4.9		
3-41a				36.0		7.6		4.8		
3-42a				43.0		16.4		5.0		
3-42b								7.9		
3-49a						18.0				
3-49b						11.5		7.2		

Table VII - continued

Code No.	TEMPERATURE °F 750	800	850	900	950	1000	1050	1100	1150	1200
3-101						10.2		6.3		
3-105						10.9	5.5			
3-129						9.8				
3-155						11.2	5.6			
3-156						13.7	6.1			
3-178					20.8	7.0	9.6	4.5		
3-194						14.2				
3-197						13.2		5.0		
3-198a								7.2	4.7	
3-198b					26.0	13.0				
3-198c					34.0					
3-198d				39.0			9.2			
3-199a						12.3	9.7			
3-199b						13.1	8.1			
3-199c							8.9			
3-207						11.2	7.6			
3-208						10.4	9.1			
3-209a						11.8		5.9		
0.01 percent per 1000 hours										
3-5a	34.0		22.0		17.0	13.0				
3-5b					17.3					
3-7						7.6				
3-8						6.4	6.0			
3-9							5.1			
3-11						4.8				
3-13				13.0		4.6		1.8		
3-14								2.8		
3-17						9.0				
3-20						8.1				
3-21						8.4				
3-23								2.3		
3-29						9.1				
3-34						4.1		1.9		
3-35						8.0		2.4		
3-36						4.0				
3-37b						10.0				
3-38a						4.0		2.0		
3-38b						3.8				
3-83						8.9	3.8			

Table VII - continued

Code No.	TEMPERATURE °F									
	750	800	850	900	950	1000	1050	1100	1150	1200
3-101						7.0		4.1		
3-105						5.8				
3-129						6.7				
3-163				27.0						
3-178					15.2	-	5.7			
3-194						7.4				
3-197						6.8				
3-207						7.5				
3-209a						9.0		3.8		

Table VIII

Mean Rupture Strength of $1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si Steel (ksi)

Part a - 1000 hours

Temp. °F	Individ. Strength-Temp. Regression			Larson-Miller Parameter Scatter Band		
	Wrought	Cast	Combined	Wrought	Cast	Combined
850	-	-	-	(61.0)	-	-
900	51.2	48.6	50.0	50.5	43.5	47.0
950	41.8	34.3	38.8	38.0	34.5	36.0
1000	28.4	24.8	27.0	27.1	26.2	26.7
1050	18.1	18.4	18.3	18.6	19.2	18.9
1100	12.5	14.1	12.9	13.0	13.7	13.3
1150	10.5	-	10.3	9.4	9.4	9.4
1200	-	-	-	(7.0)	(6.2)	(6.6)

Part b - 10,000 hours

Temp. °F	Individ. Strength-Temp. Regression			Larson-Miller Parameter Scatter Band		
	Wrought	Cast	Combined	Wrought	Cast	Combined
800	-	-	-	(60.0)	-	-
850	-	-	-	49.0	42.5	45.0
900	43.4	35.1	42.4	36.0	33.0	34.5
950	29.3	26.4	28.2	25.1	24.7	24.9
1000	16.7	17.4	16.8	17.0	17.7	17.4
1050	9.96	11.7	10.4	11.6	12.3	11.9
1100	7.69	9.2	7.94	8.3	8.2	8.25
1150	-	-	-	(6.4)	(5.4)	(5.9)
1200	-	-	-	-	-	-

Part c - 100,000 hours

Temp. °F	Individ. Strength--Temp. Regression			Larson-Miller Parameter Scatter Band		
	Wrought	Cast	Combined	Wrought	Cast	Combined
800	-	-	-	48.5	42.0	45.0
850	-	-	-	35.0	32.2	33.6
900	34.6	27.7	34.1	23.9	23.7	23.8
950	18.3	20.6	18.5	15.9	16.7	16.3
1000	9.23	12.9	9.88	11.3	10.7	11.0
1050	5.43	7.73	5.99	7.7	7.3	7.5
1100	4.67	5.03	4.73	-	(4.75)	-
1150	-	-	-	-	-	-
1200	-	-	-	-	-	-

Table IXa

Summary Comparison of 1000 hour Rupture Strengths (ksi)
(combined product forms)

Average

Temp. °F	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo Individ.	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo Parameter LM	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo Parameter M	1 Cr - $\frac{1}{2}$ Mo Individ.	1 Cr - $\frac{1}{2}$ Mo Parameter LM	1 Cr - $\frac{1}{2}$ Mo Parameter M	$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si Individ.	$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si Parameter LM
800	-	-	-	-	-		-	-
850	-	63.5	65.0	54.0	53.0	54.0	-	56.5
900	55.9	54.5	55.7	55.1	47.0	48.8	50.0	47.0
950	43.8	42.0	42.0	45.5	40.0	41.6	38.8	36.3
1000	30.5	29.4	28.8	32.3	30.1	31.1	27.0	26.7
1050	19.7	19.0	18.6	21.2	21.0	21.0	18.3	18.6
1100	12.3	12.0	12.0	13.6	13.8	13.6	12.9	13.1
1150	7.6	7.7	7.7	9.3	9.4	9.2	10.3	9.4
1200	5.36	-	-	6.98	7.0	6.8	-	-

Minimum by individual lot evaluation

Temp. °F	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo	1 Cr - $\frac{1}{2}$ Mo	$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si
850	-	40.9	-
900	41.1	41.7	39.7
950	32.2	34.4	30.8
1000	22.4	24.5	21.5
1050	14.5	16.0	14.5
1100	9.08	10.3	10.3
1150	3.94	5.3	8.18
1200	-	-	-

Table IXb

Summary Comparison of 10,000 hour Rupture Strengths (ksi)
(combined product forms)

Average

	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo			1 Cr - $\frac{1}{2}$ Mo			$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si	
	Individ.	Parameter		Individ.	Parameter		Individ.	Parameter
Temp. °F		LM	M		LM	M		LM
800	-	63.0	65.0	-	52.5	53.0	-	56.0
850	-	53.0	55.2	55.5	47.2	48.5	-	45.5
900	48.5	39.5	40.0	43.9	38.7	40.0	42.4	34.5
950	30.1	26.7	26.3	30.1	28.0	29.0	28.2	24.9
1000	18.8	16.7	16.3	18.9	19.0	18.4	16.8	17.2
1050	11.7	10.4	10.0	11.4	12.2	11.5	10.4	11.9
1100	7.3	-	-	6.99	8.3	7.8	7.9	8.2
1150	4.55	-	-	4.55	-	-	-	5.9
1200	2.82	-	-	3.42	-	-	-	-

Minimum by individual lot evaluation

Temp. °F	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo	1 Cr - $\frac{1}{2}$ Mo	$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si
850	-	40.9	-
900	33.6	32.4	32.2
950	21.0	22.1	21.4
1000	13.1	13.9	12.7
1050	8.10	8.41	7.91
1100	5.03	5.16	6.03
1150	3.12	3.4	-

Table IXc

Summary Comparison of 100,000 hour Rupture Strengths (ksi)
(combined product forms)

Average

Temp. °F	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo Individ.	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo Parameter LM	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo Parameter M	1 Cr - $\frac{1}{2}$ Mo Individ.	1 Cr - $\frac{1}{2}$ Mo Parameter LM	1 Cr - $\frac{1}{2}$ Mo Parameter M	$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si Individ.	$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si Parameter LM
800	-	52.0	55.0	-	47.0	48.3	-	45.0
850	-	38.5	39.0		37.9	39.5	-	33.6
900	38.5	25.1	24.1	33.1	27.0	26.8	34.1	23.8
950	20.0	15.5	14.2	18.7	17.6	16.0	18.5	16.3
1000	9.6	9.4	8.8	11.0	11.2	10.0	9.88	11.0
1050	5.8	-	-	6.7	7.6	6.8	5.99	7.5
1100	4.25	-	-	4.04	-	-	4.73	-
1150	-	-	-	2.6	-	-	-	-
1200	-	-	-	1.74	-	-	-	-

Minimum by individual lot evaluation

Temp. °F	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo	1 Cr - $\frac{1}{2}$ Mo	$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si
850	-	40.8	-
900	23.5	23.1	23.3
950	12.1	13.2	13.0
1000	5.86	7.8	6.85
1050	3.51	4.7	4.10
1100	2.60	2.83	3.28
1150	-	1.81	-
1200	-	1.22	-

Table Xa

Summary Comparison of Creep Strengths - 0.1% per 1000 hours (ksi)
(combined product forms)

Average

Temp. °F	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo		1 Cr - $\frac{1}{2}$ Mo		$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si	
	Individ.	Parameter	Individ.	Parameter	Individ.	Parameter
750	-	-	-	-	-	-
800	-	51.8	-	49.5	-	43.3
850	-	38.5	46.0	37.0	41.5	33.0
900	35.0	27.2	29.0	28.2	33.0	24.6
950	21.7	18.2	18.2	20.0	21.0	17.5
1000	13.3	11.8	11.3	13.6	12.0	12.1
1050	8.2	7.4	7.2	8.8	7.25	8.1
1100	5.1	4.5	4.5	5.3	5.4	5.25
1150	-	-	2.8	3.0	-	3.2
1200	-	-	1.78	1.72	-	-

Minimum - computed by parameter

Temp. °F	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo	1 Cr - $\frac{1}{2}$ Mo	$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si
800	32.1	33.2	27.2
850	23.0	25.7	20.8
900	16.6	19.2	15.3
950	11.2	13.5	11.0
1000	7.3	9.1	7.6
1050	4.6	5.8	5.1
1100	2.75	3.47	3.2
1150	-	2.0	2.03
1200	-	1.16	-

Table Xb

Summary Comparison of Creep Strengths - 0.01% per 1000 hours (ksi)
(combined product forms)

Average

Temp. °F	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo		1 Cr - $\frac{1}{2}$ Mo		$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si	
	Individ.	Parameter	Individ.	Parameter	Individ.	Parameter
750	-	-	-	-	-	-
800	46.0	37.0	-	37.5	-	32.8
850	28.3	26.0	32.3	27.7	22.8	23.7
900	17.3	17.3	21.2	19.1	19.5	16.7
950	10.5	10.8	13.3	12.4	12.6	11.3
1000	6.5	6.6	8.1	7.6	7.15	7.5
1050	3.95	3.9	4.6	4.5	4.0	4.75
1100	2.44	-	2.67	2.55	2.6	2.8
1150	-	-	1.4	1.35	-	-
1200	-	-	.76	-	-	-

Minimum - computed by parameter

Temp. °F	$\frac{1}{2}$ Cr - $\frac{1}{2}$ Mo	1 Cr - $\frac{1}{2}$ Mo	$1\frac{1}{4}$ Cr - $\frac{1}{2}$ Mo-Si
800	23.0	25.5	20.7
850	16.2	18.8	15.0
900	10.6	12.9	10.5
950	6.7	8.3	7.1
1000	4.1	5.2	4.65
1050	2.4	3.0	2.90
1100	-	1.68	-

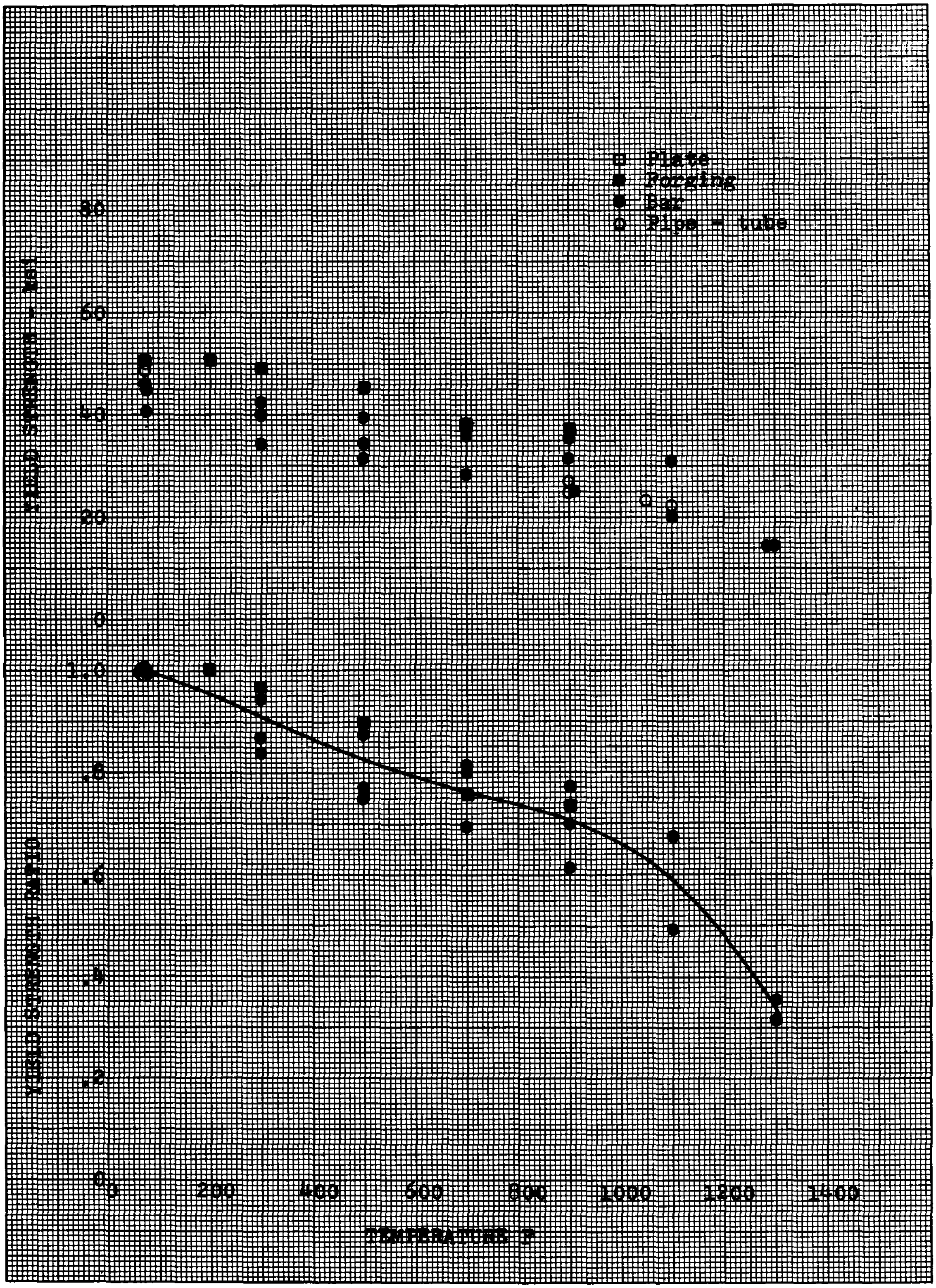


Figure 4a. Variation of yield strength of 1/2 Cr - 1/2 Mo steel with temperature.

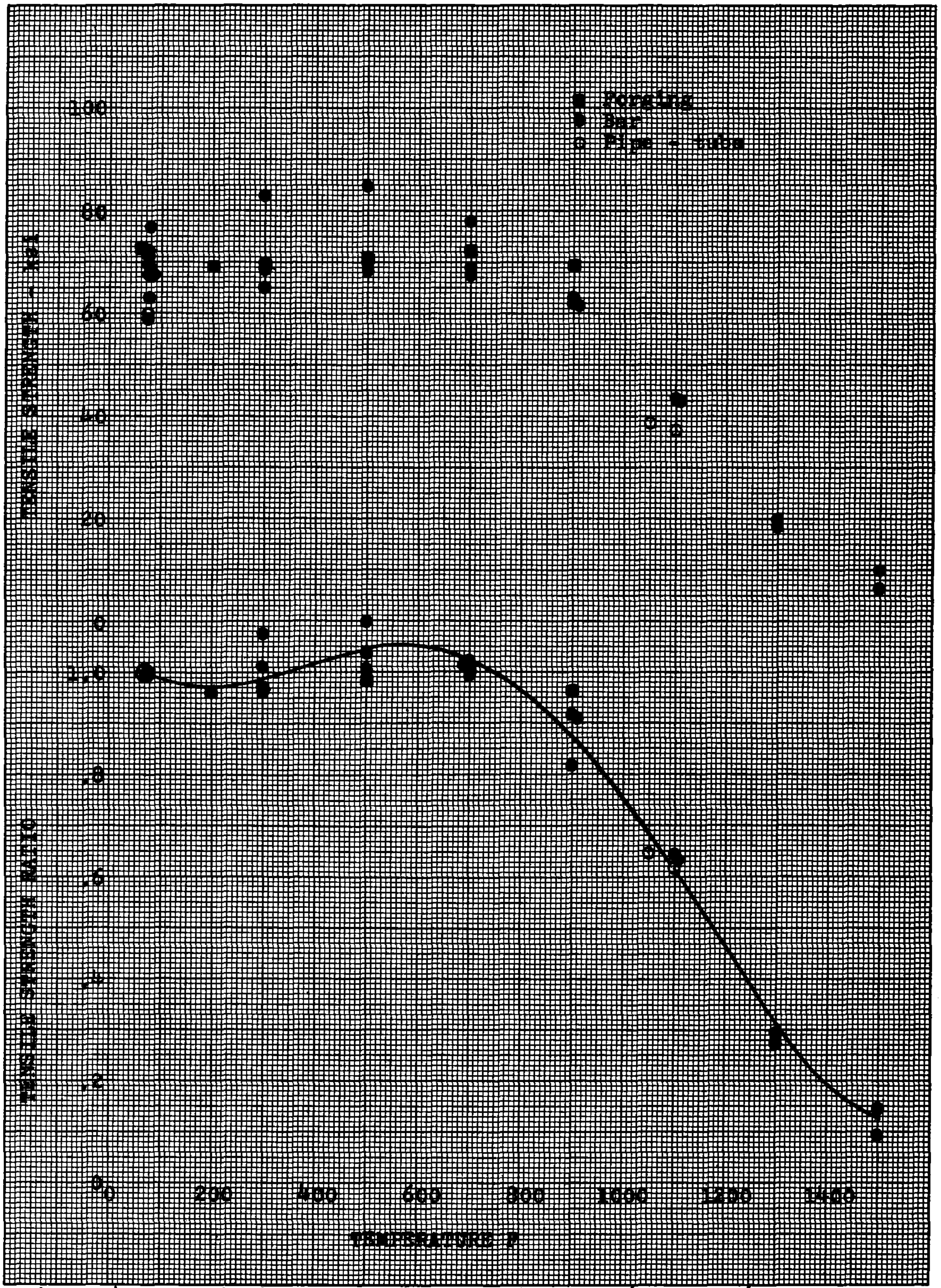


Figure 4b. Variation of tensile strength of 1/2 Cr - 1/2 Mo steel with temperature.

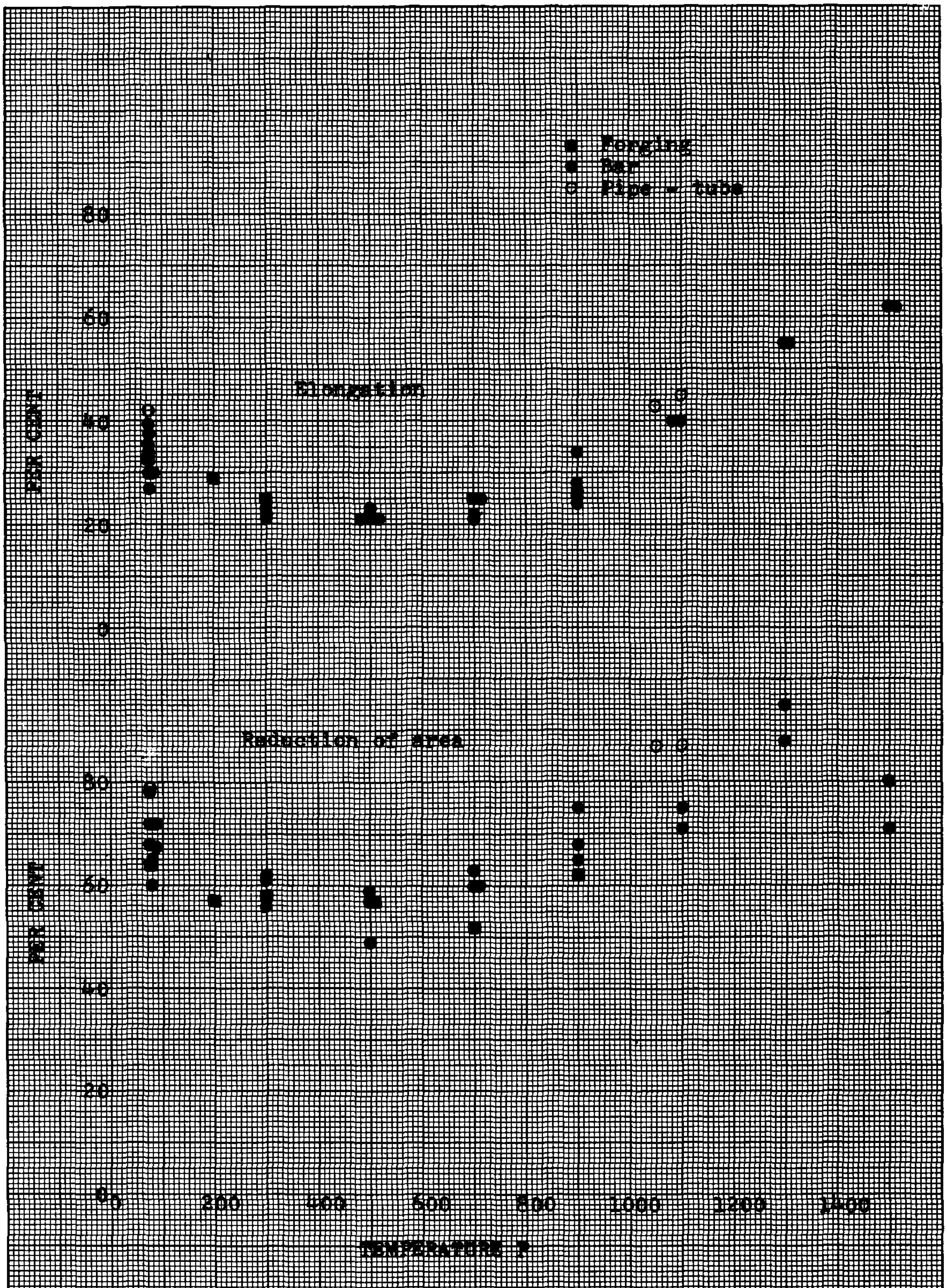


Figure 4c. Variation of elongation and reduction of area of 1/2 Cr - 1/2 Mo steel with temperature.

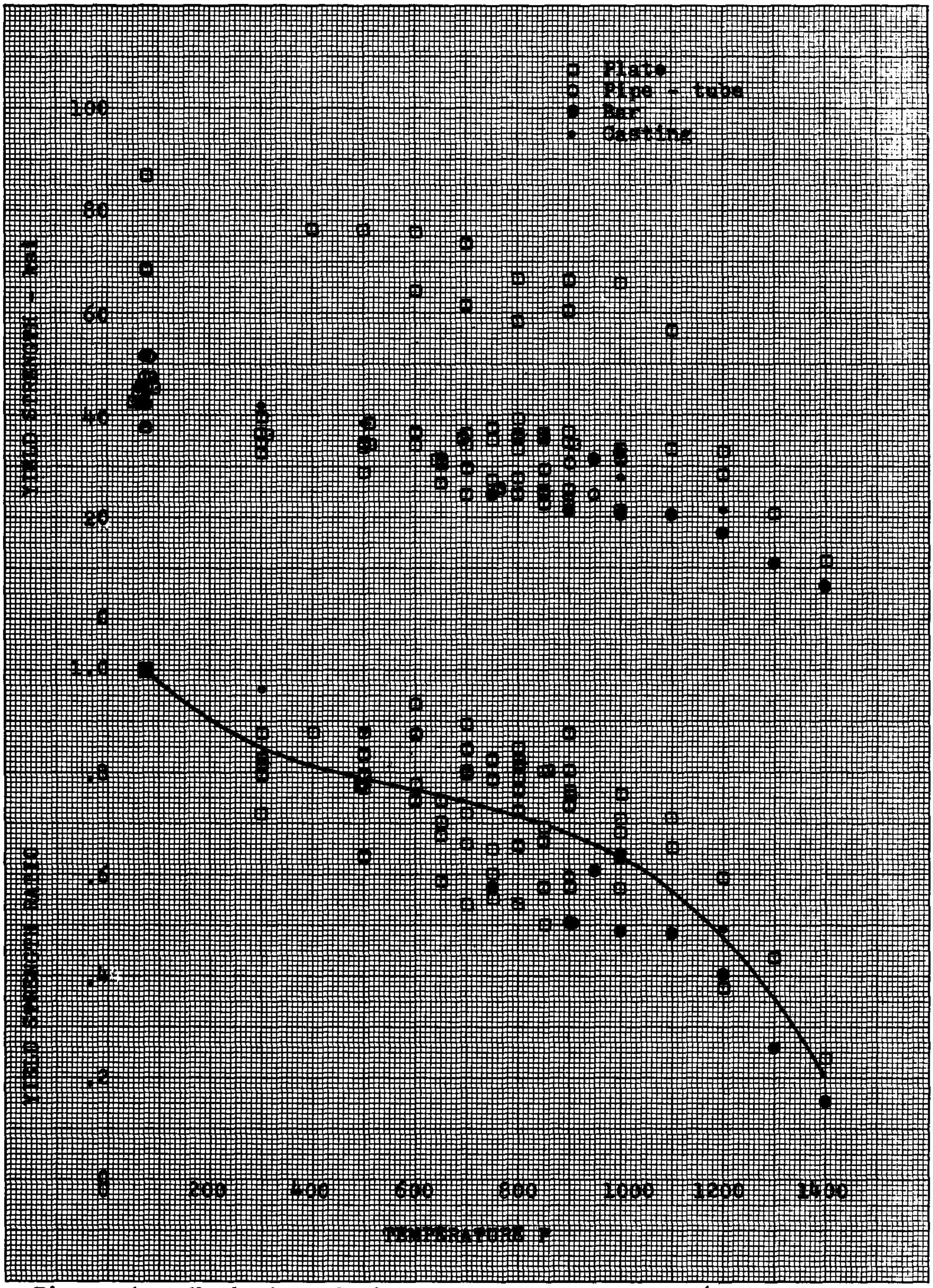


Figure 5a. Variation of yield strength of 1 Cr - 1/2 Mo steel with temperature.

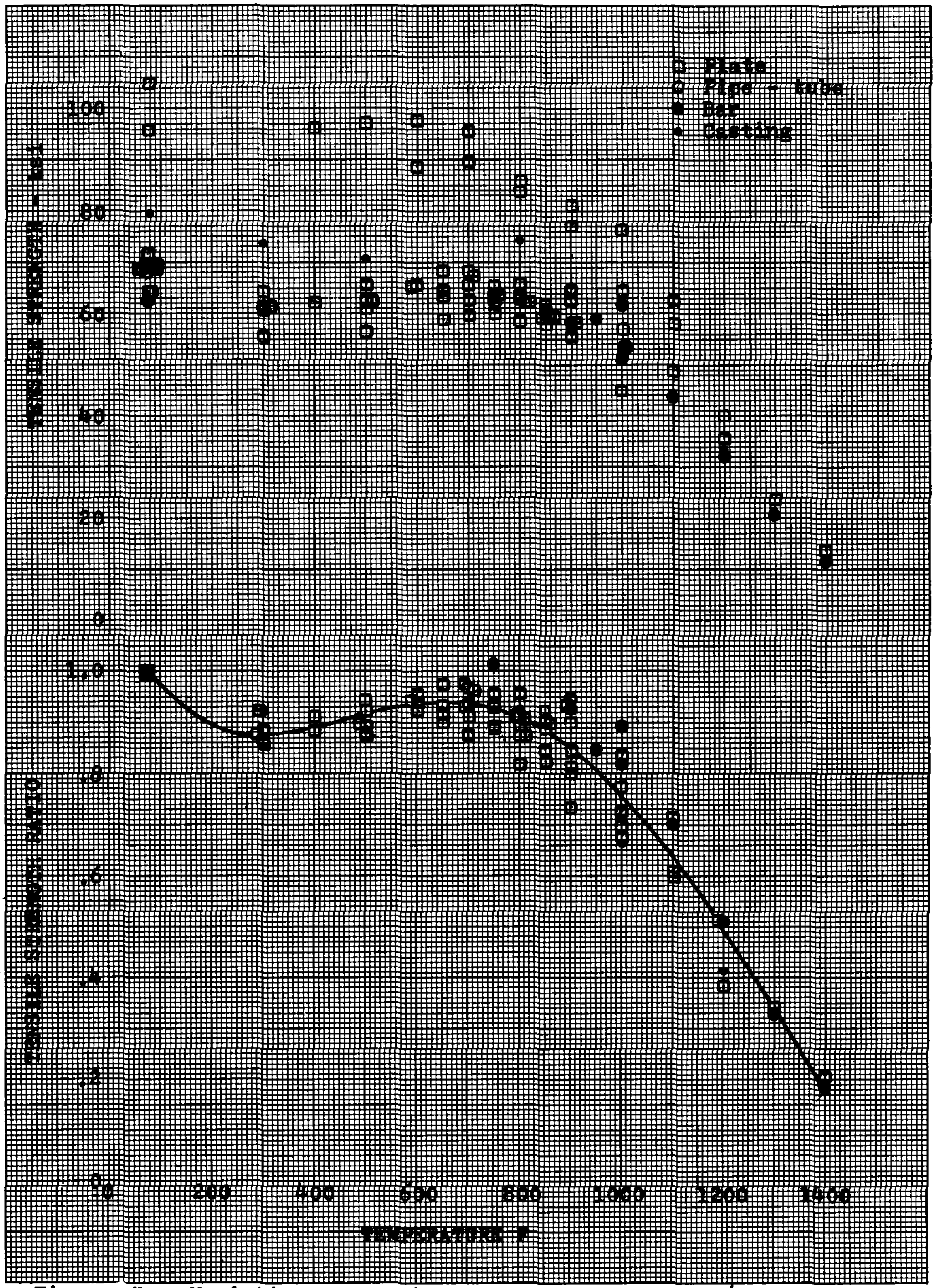


Figure 5b. Variation of tensile strength of 1 Cr - 1/2 Mo steel with temperature.

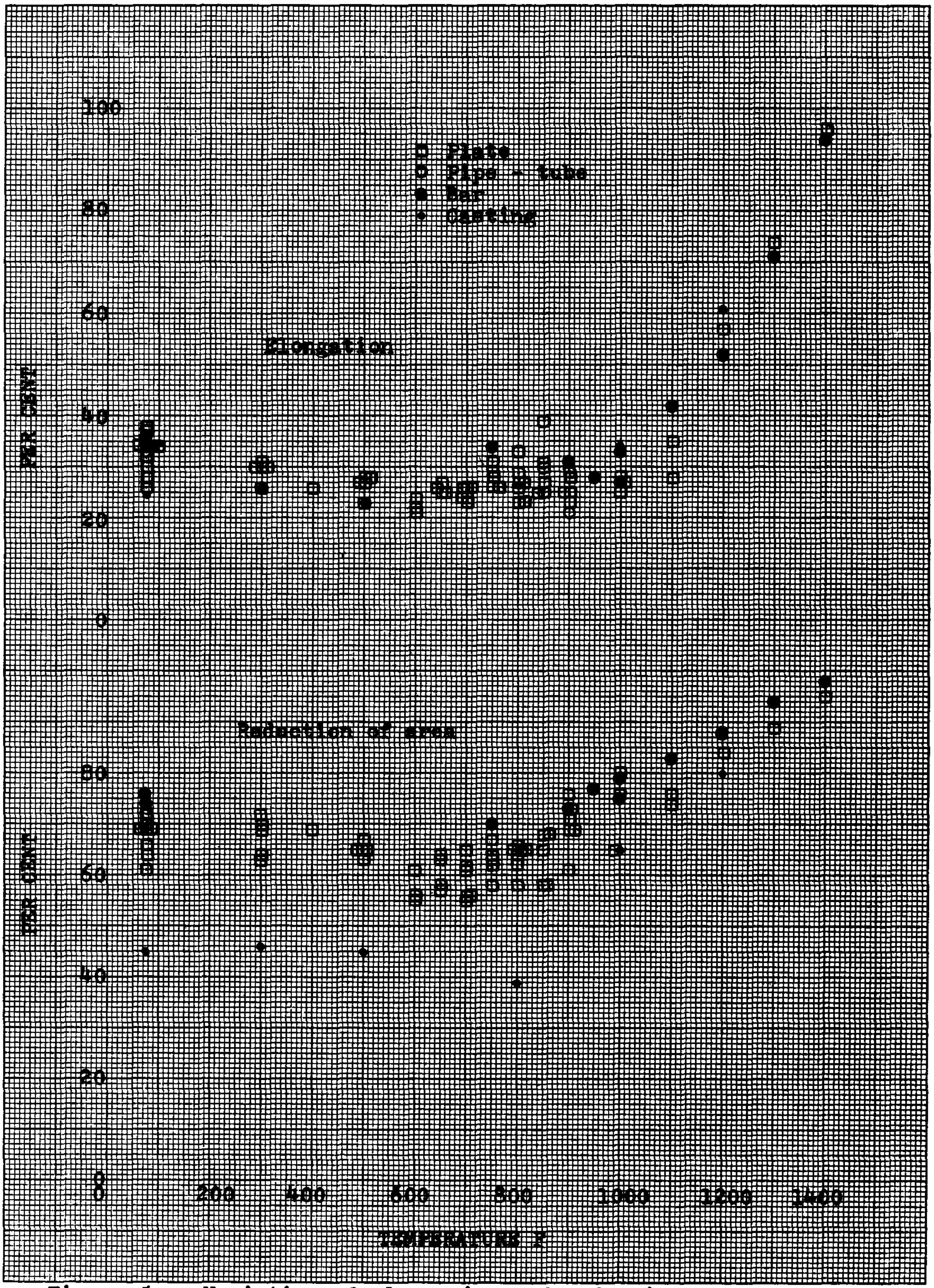


Figure 5c. Variation of elongation and reduction of area of 1 Cr - 1/2 Mo steel with temperature.

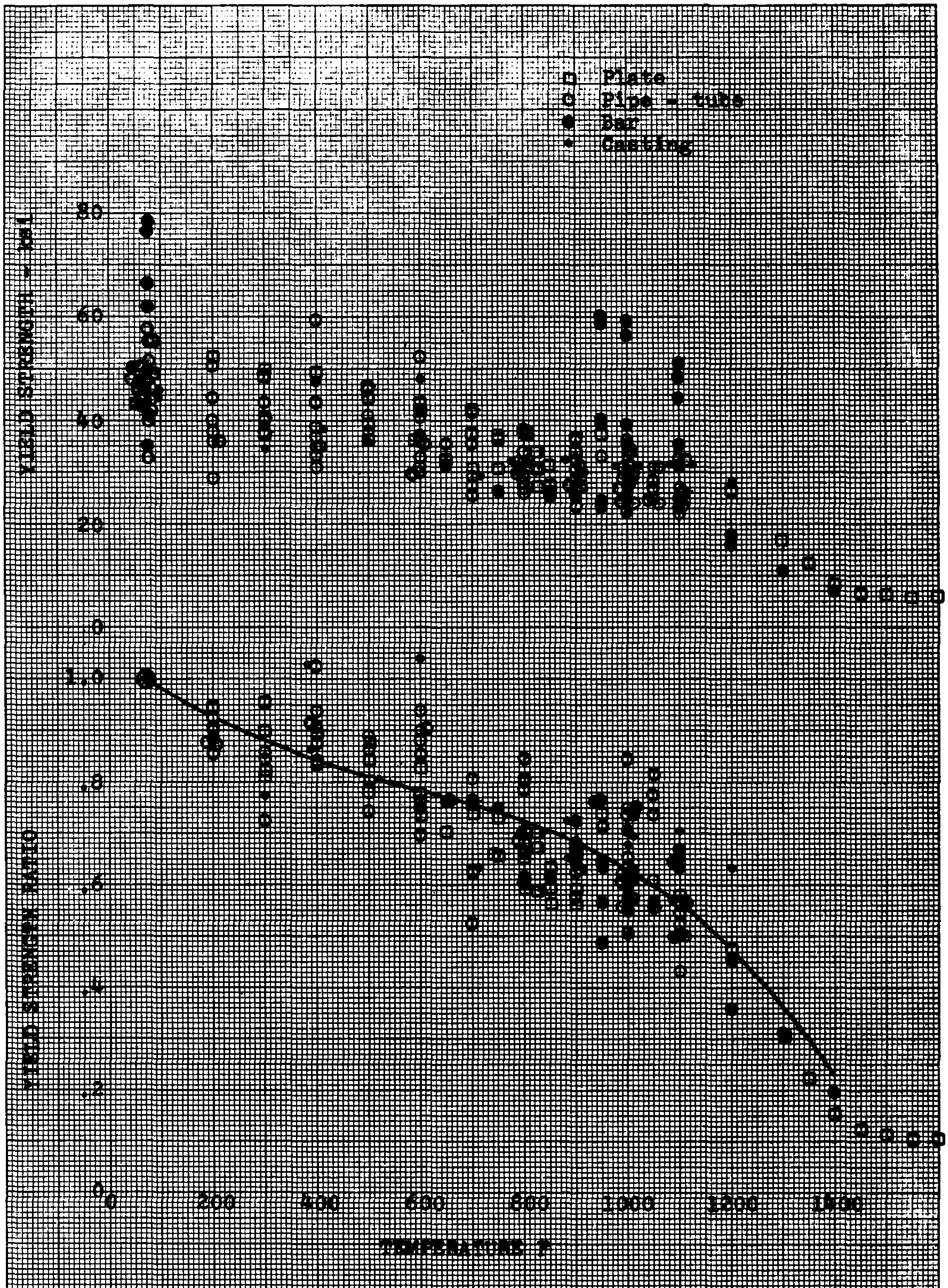


Figure 6a. Variation of yield strength of 1 1/4 Cr - 1/2 Mo - Si steel, all product forms, with temperature.

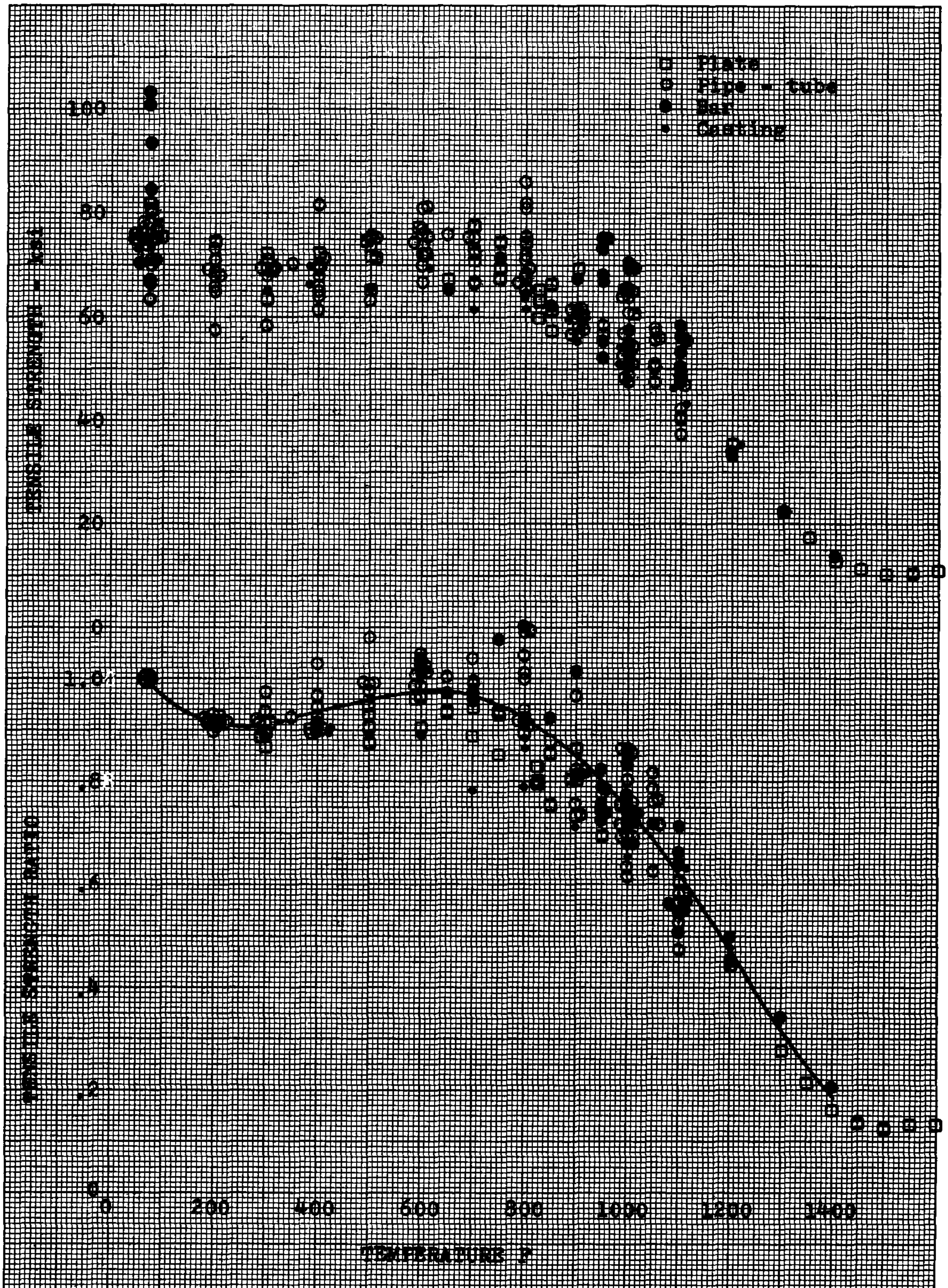


Figure 6b. Variation of tensile strength of 1 1/4 Cr - 1/2 Mo - Si steel, all product forms, with temperature.

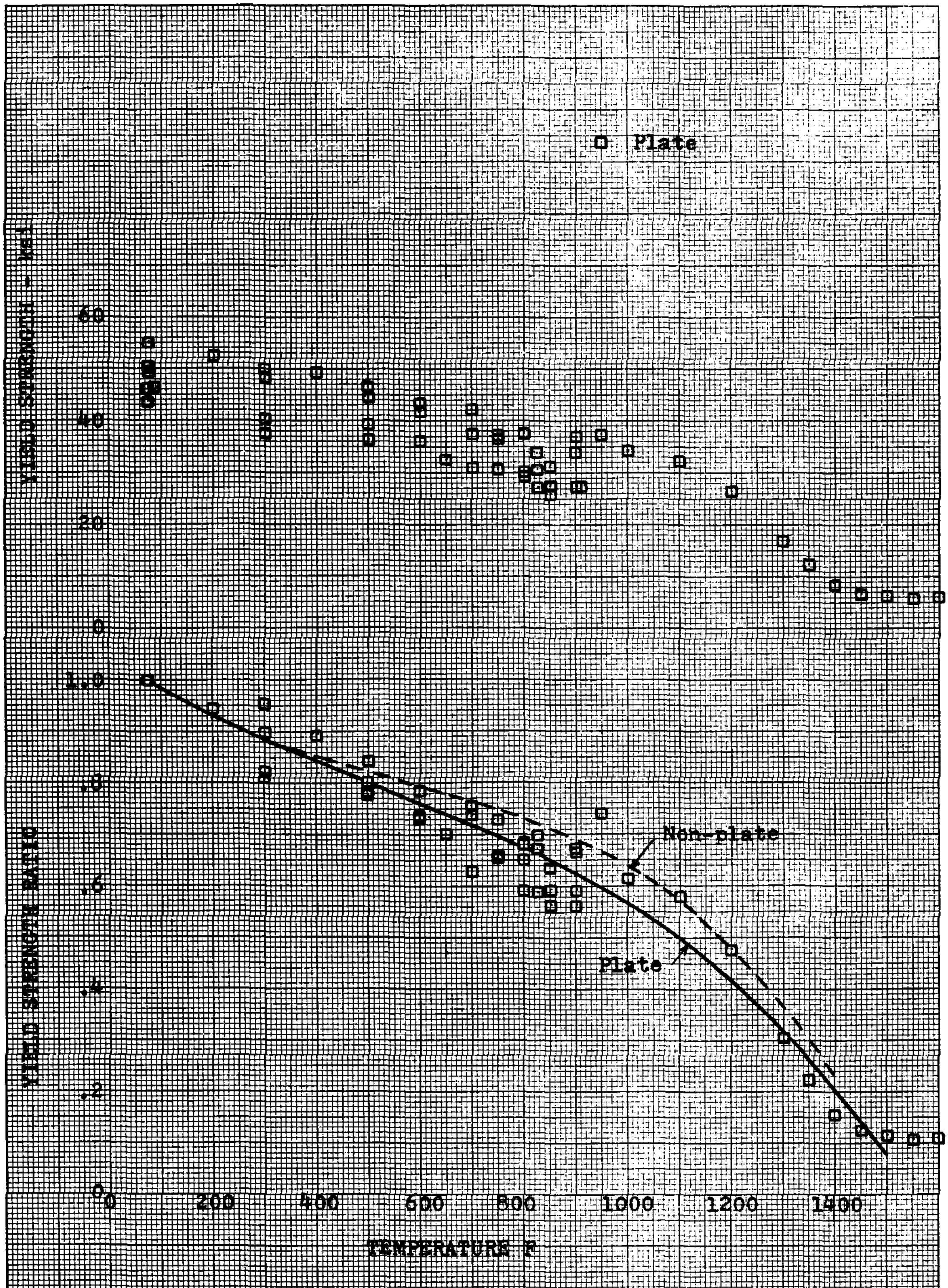


Figure 6c. Variation of yield strength of 1 1/4 Cr - 1/2 Mo - Si *steel plate with temperature.*

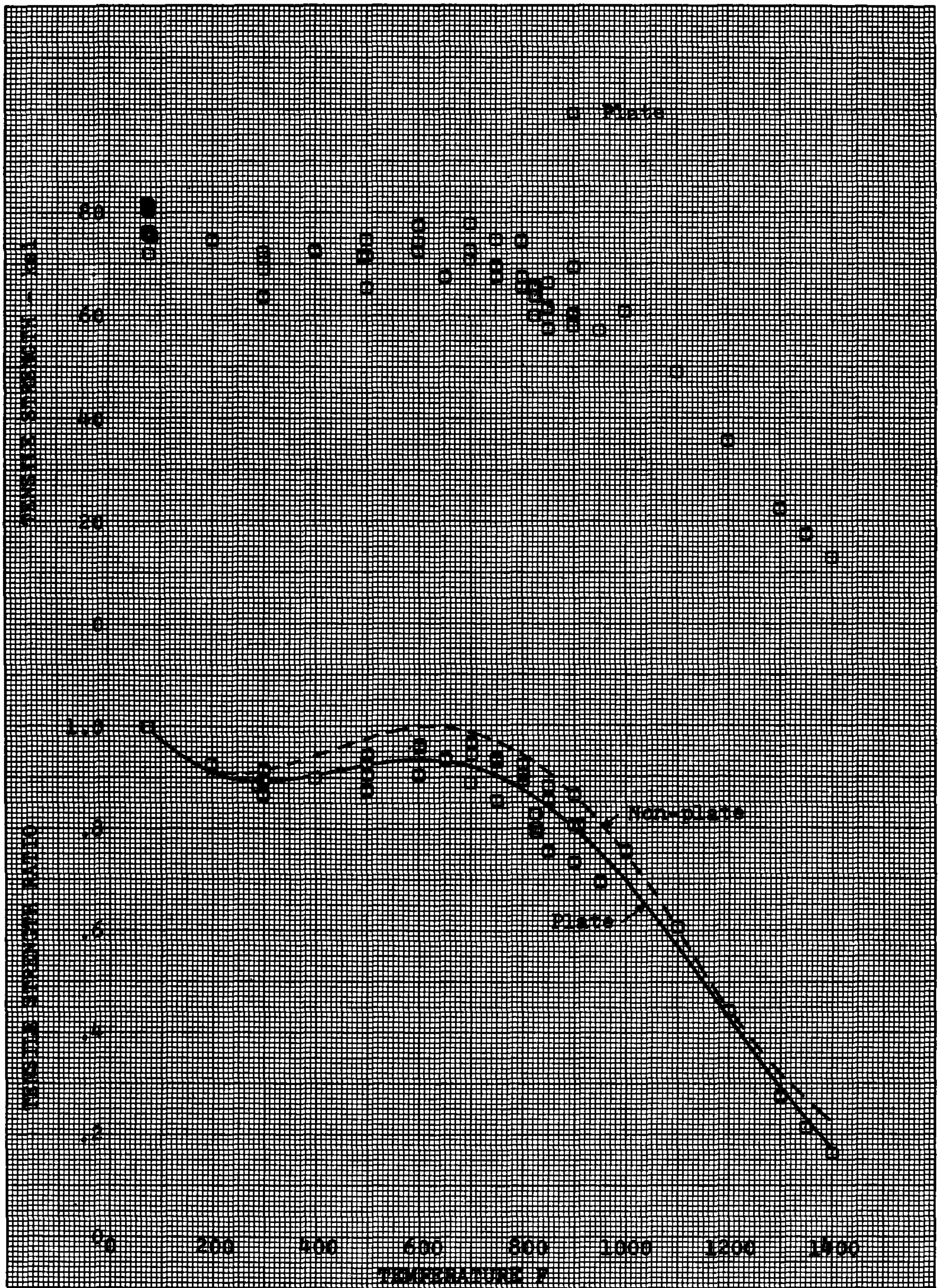


Figure 6d. Variation of tensile strength of 1 1/4 Cr - 1/2 Mo - Si steel plate with temperature.

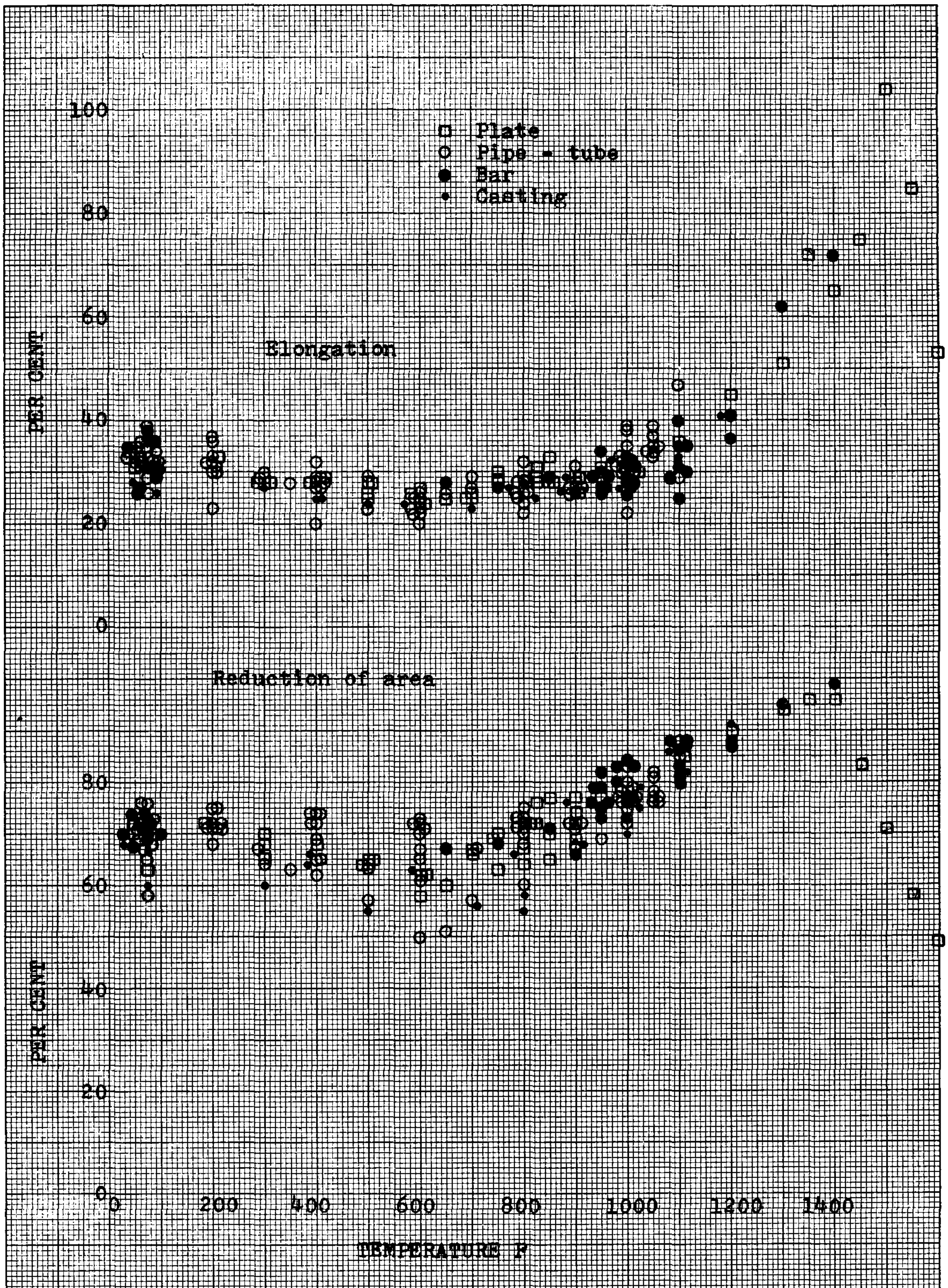


Figure 6e. Variation of elongation and reduction of area of 1 1/4 Cr 1/2 Mo - Si steel, all product forms, with temperature.

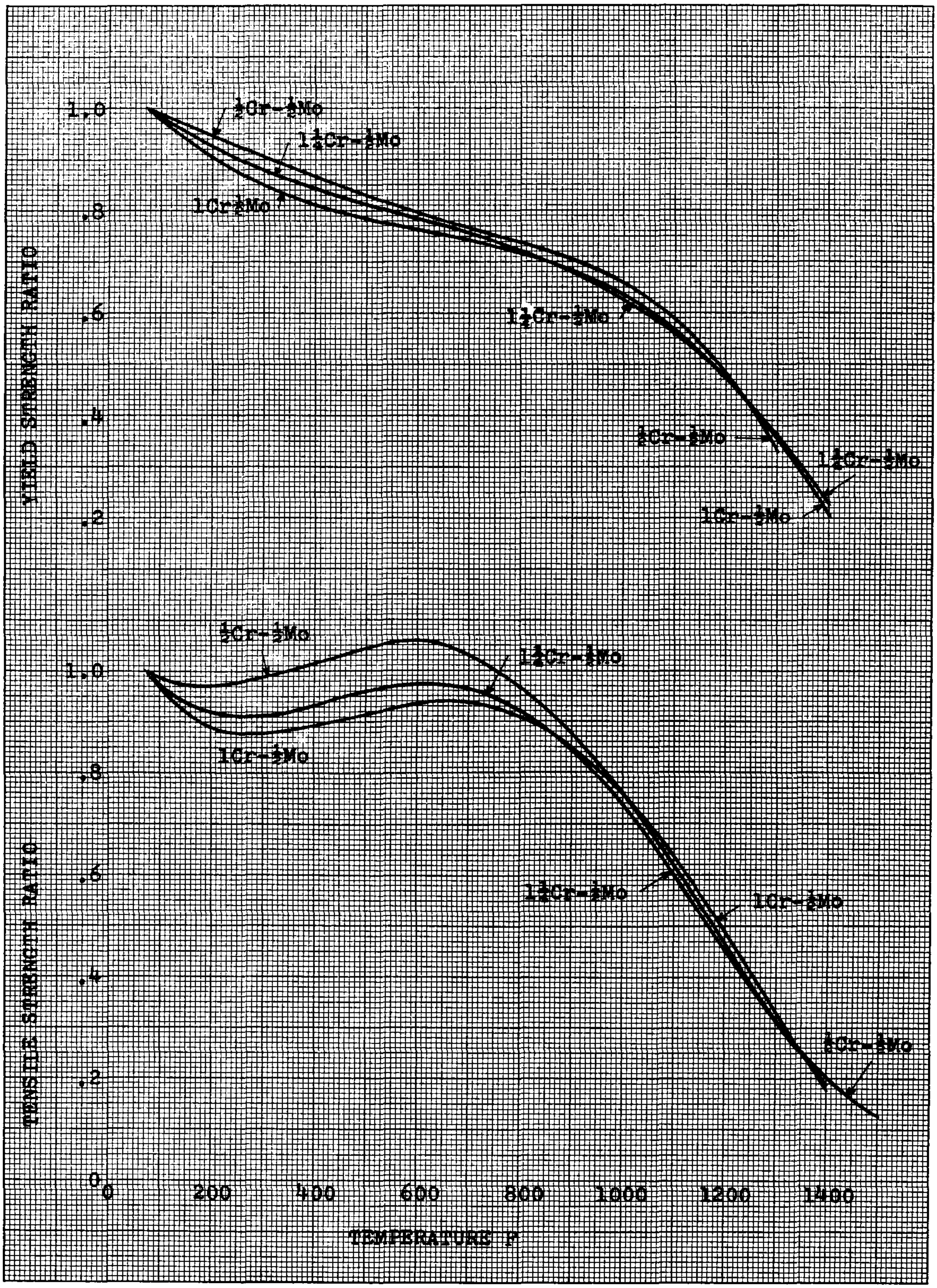


Figure 7. Comparison of trend curves.

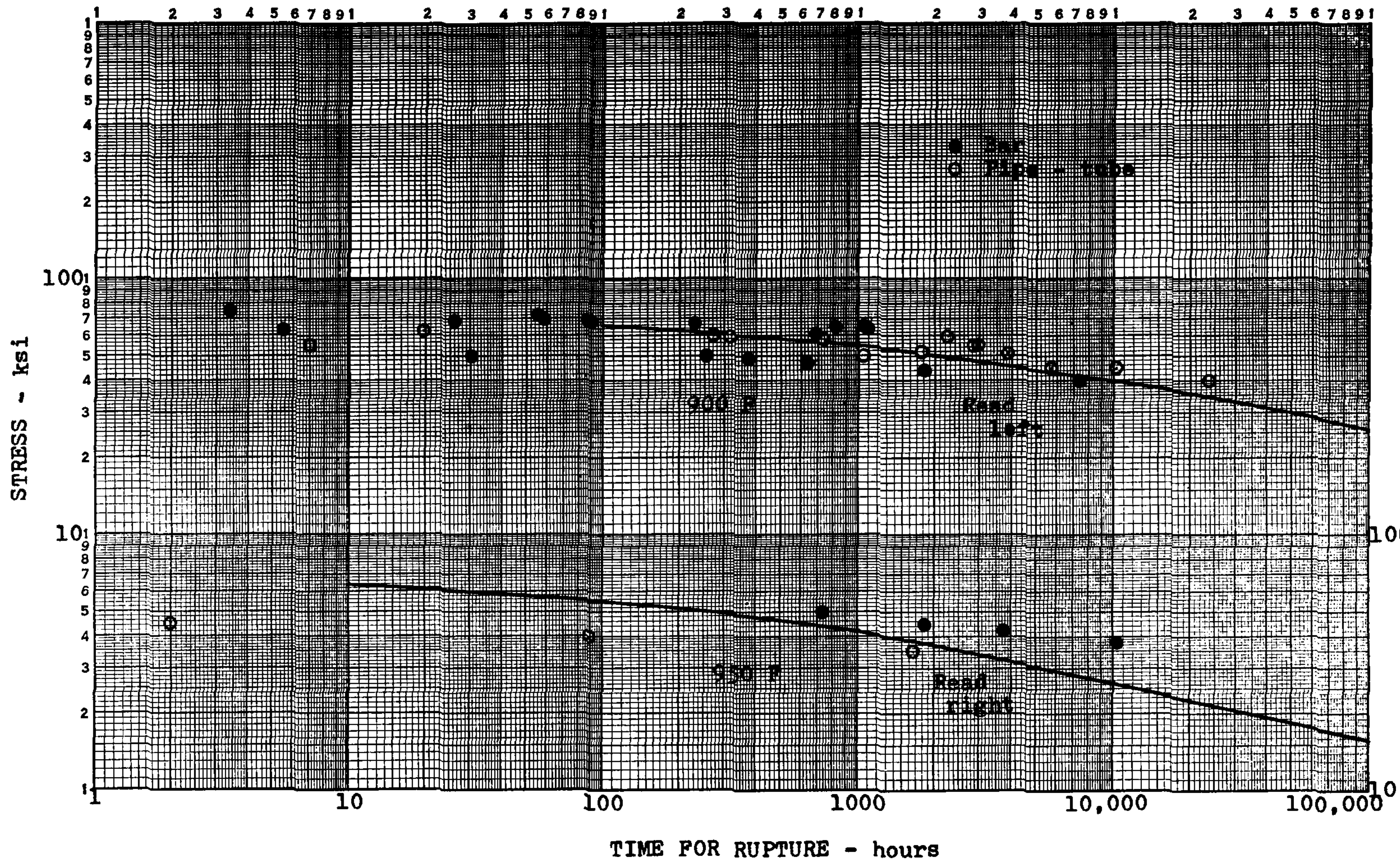


Figure 8a. Stress vs. time for rupture of 1/2 Cr - 1/2 Mo steel. The superimposed curves were computed from the Larson-Miller master curve, Fig. 11a.

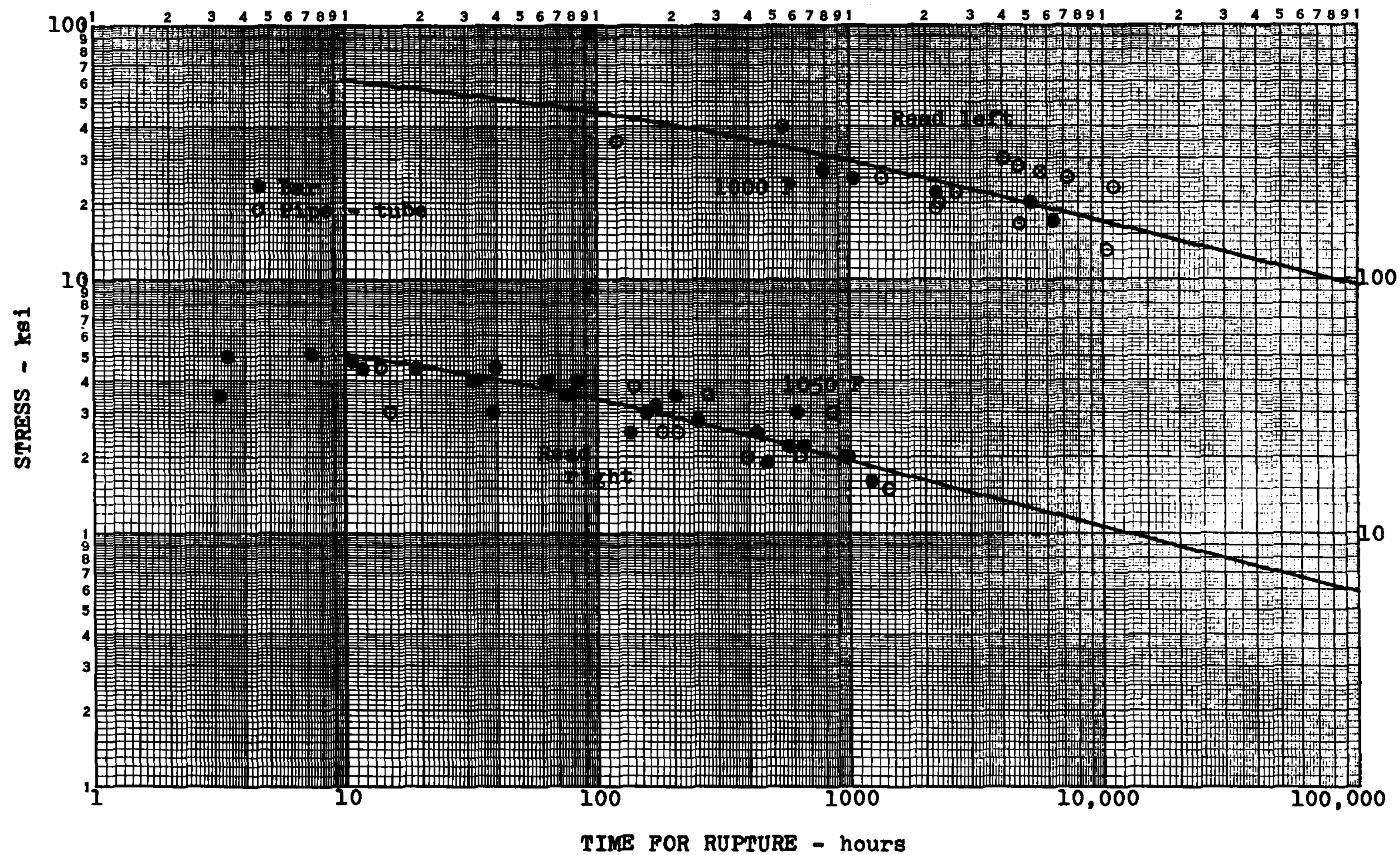


Figure 8b. Stress vs. time for rupture of 1/2 Cr - 1/2 Mo steel. The superimposed curves were computed from the Larson-Miller master curve, Figure 11a.

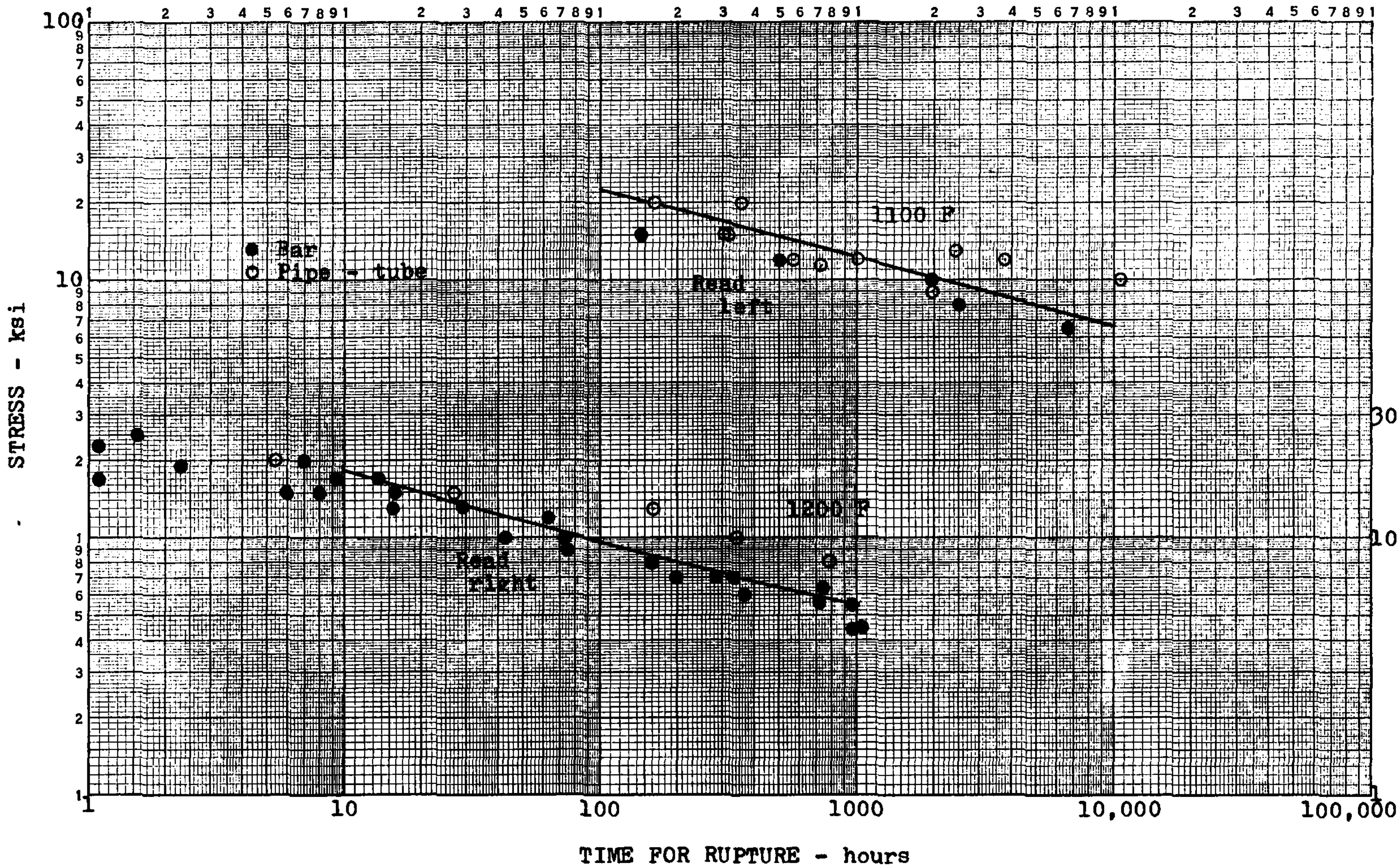
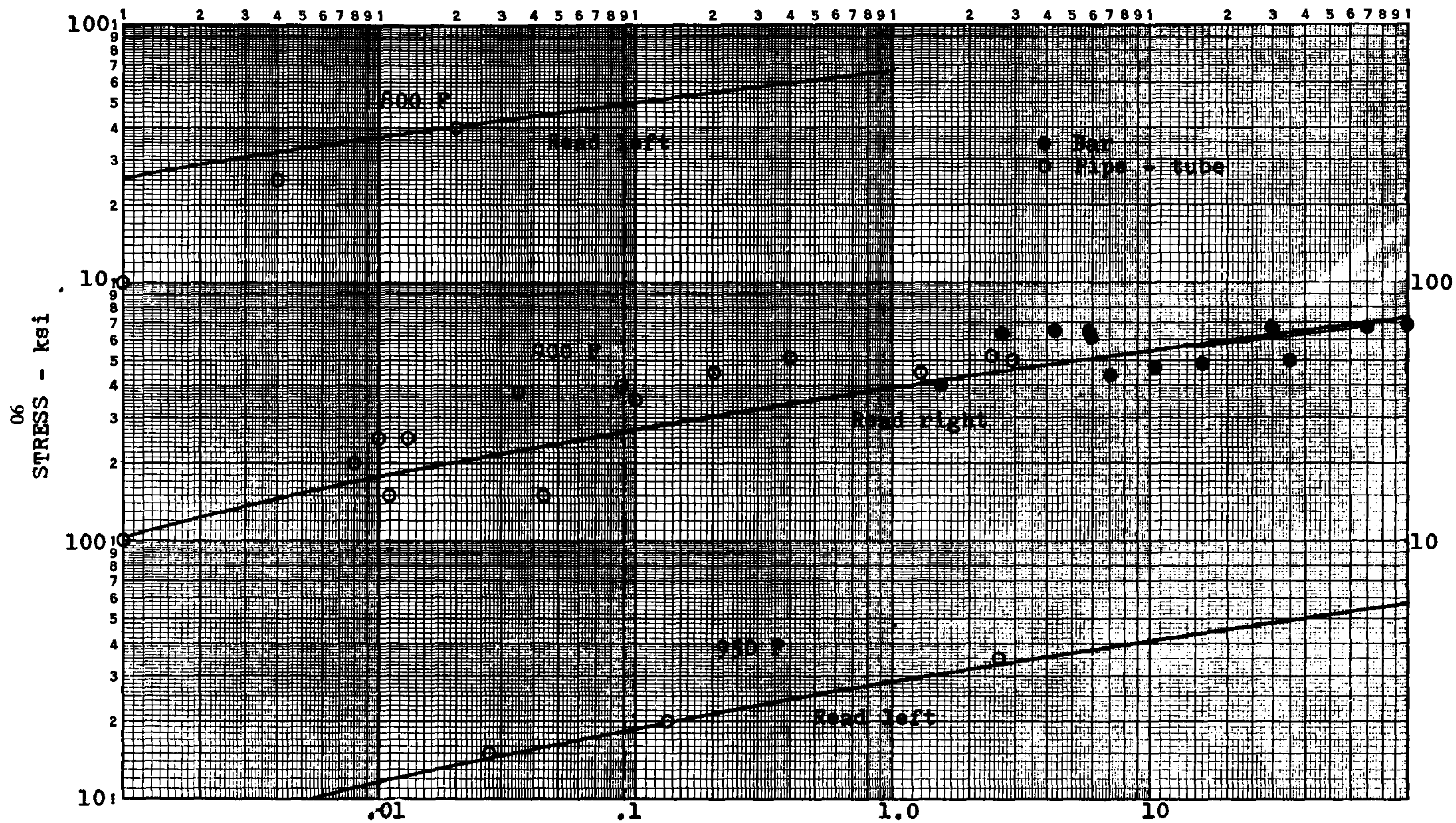


Figure 8c. Stress vs. time for rupture of 1/2 Cr - 1/2 Mo steel. The superimposed curves were computed from the Larson-Miller master curve, Fig. 11a.



CREEP RATE - per cent per 1000 hours

Figure 9a. Stress vs secondary creep rate for 1/2 Cr - 1/2 Mo steel. The superimposed curves were computed from the Larson- Miller master curve, Figure 13.

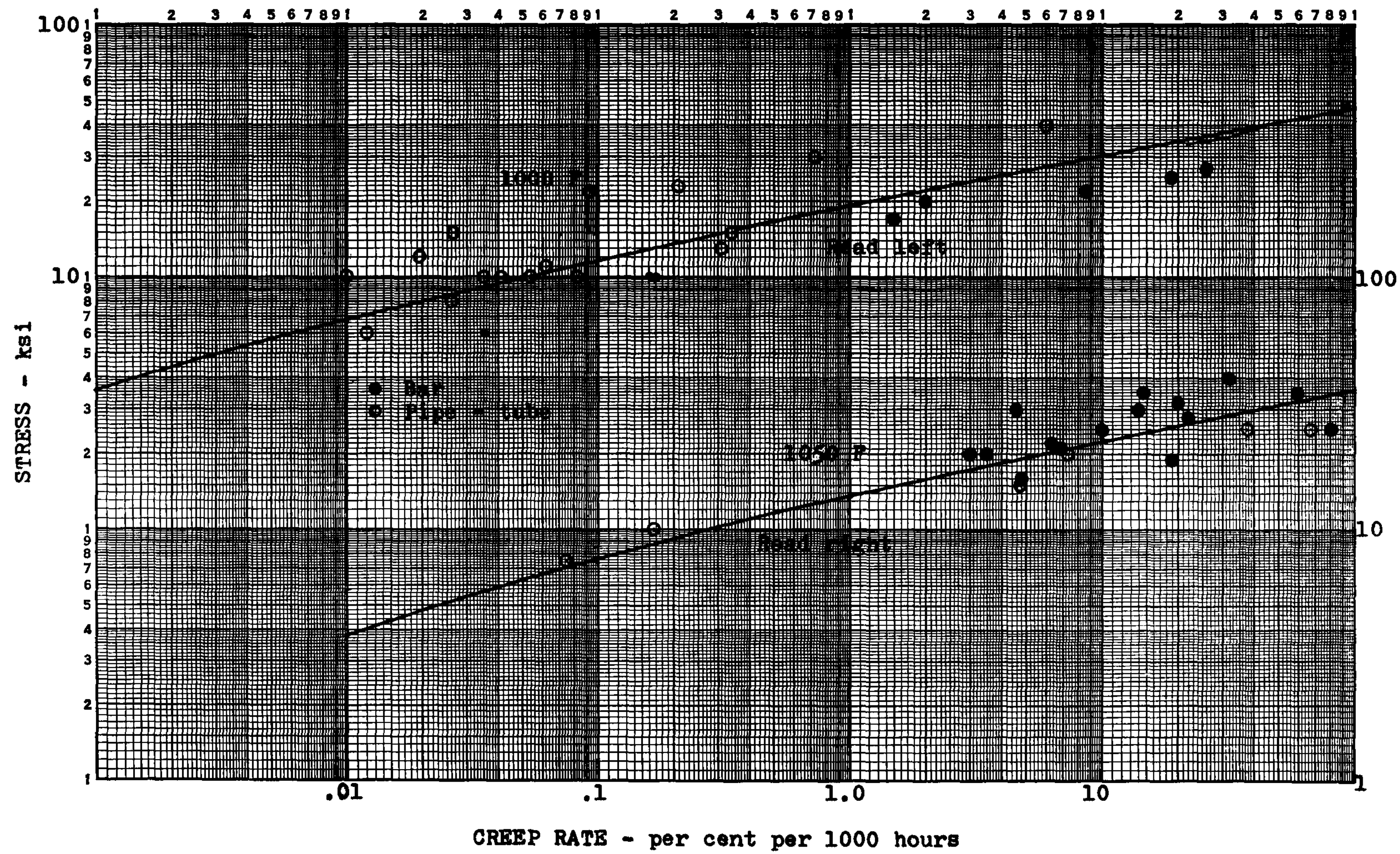


Figure 9b. Stress vs. secondary creep rate for 1/2 Cr - 1/2 Mo steel. Thesuper-imposed curves were computed from the Larson-Miller master curve, Figure 13.

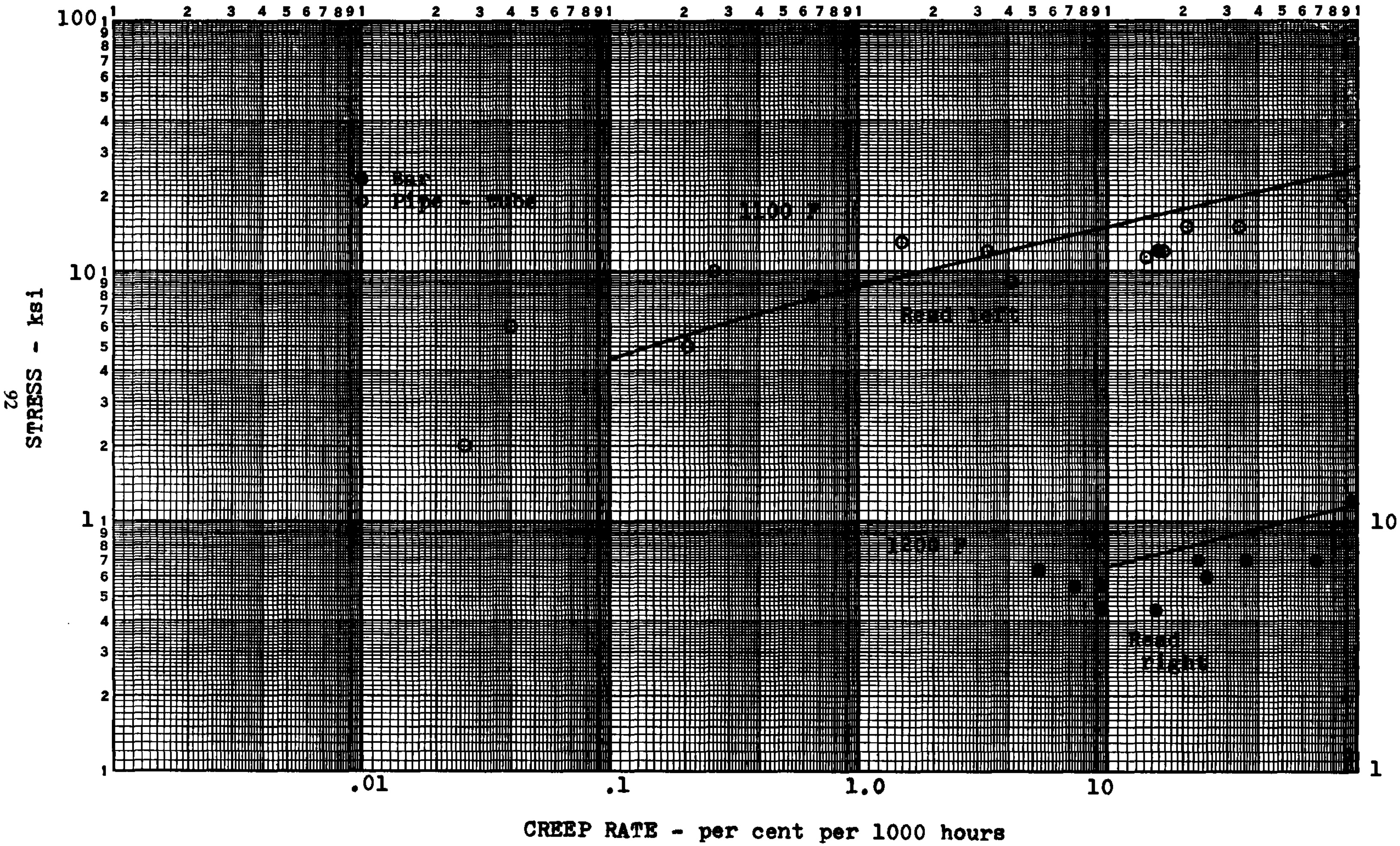


Figure 9c. Stress vs. secondary creep rate for 1/2 Cr - 1/2 Mo steel. The superimposed curves were computed from the Larson-Miller master curve, Figure 13.

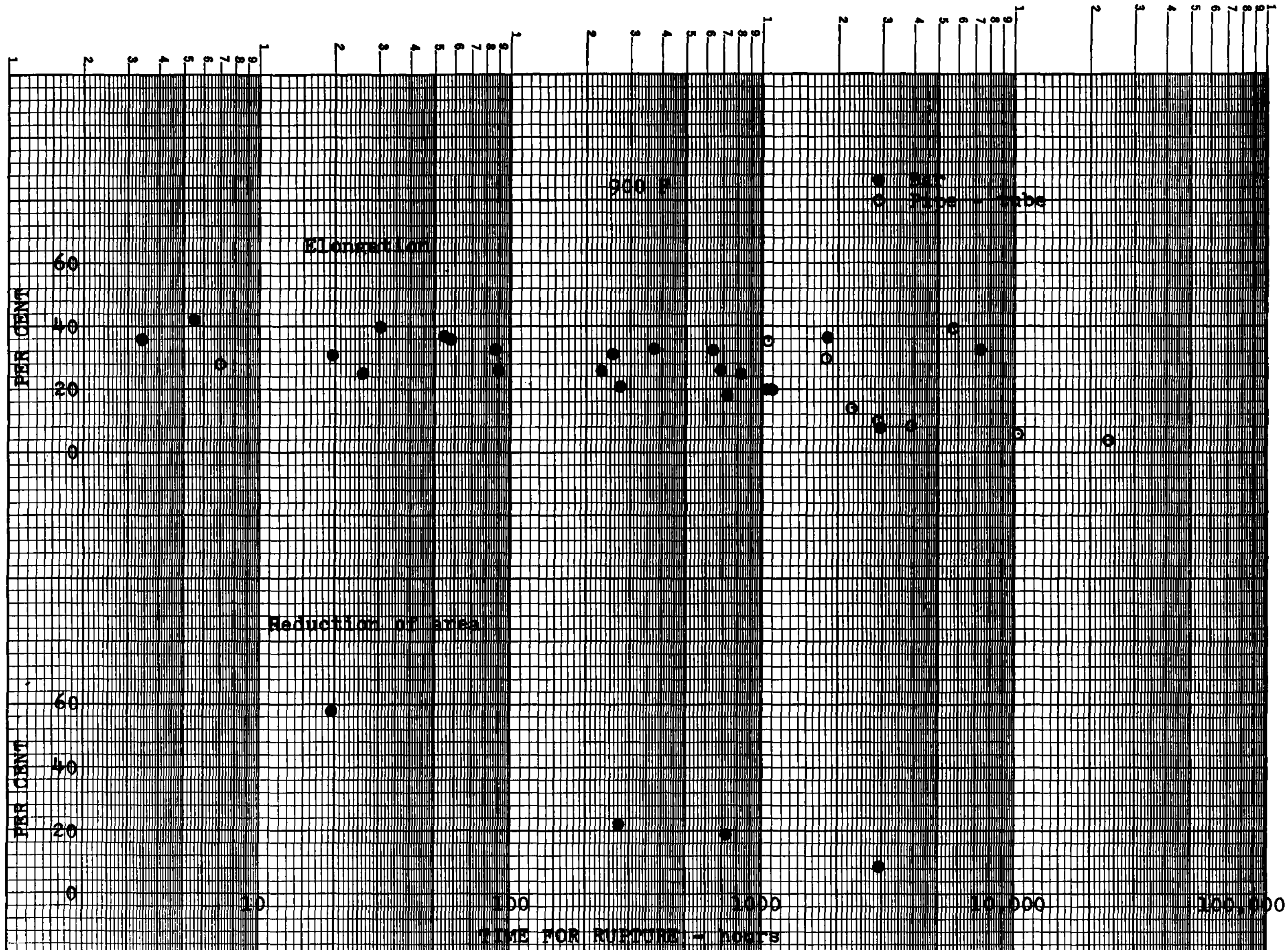


Fig. 10a. Variation of rupture ductility of 1/2 Cr - 1/2 Mo steel with time for rupture.

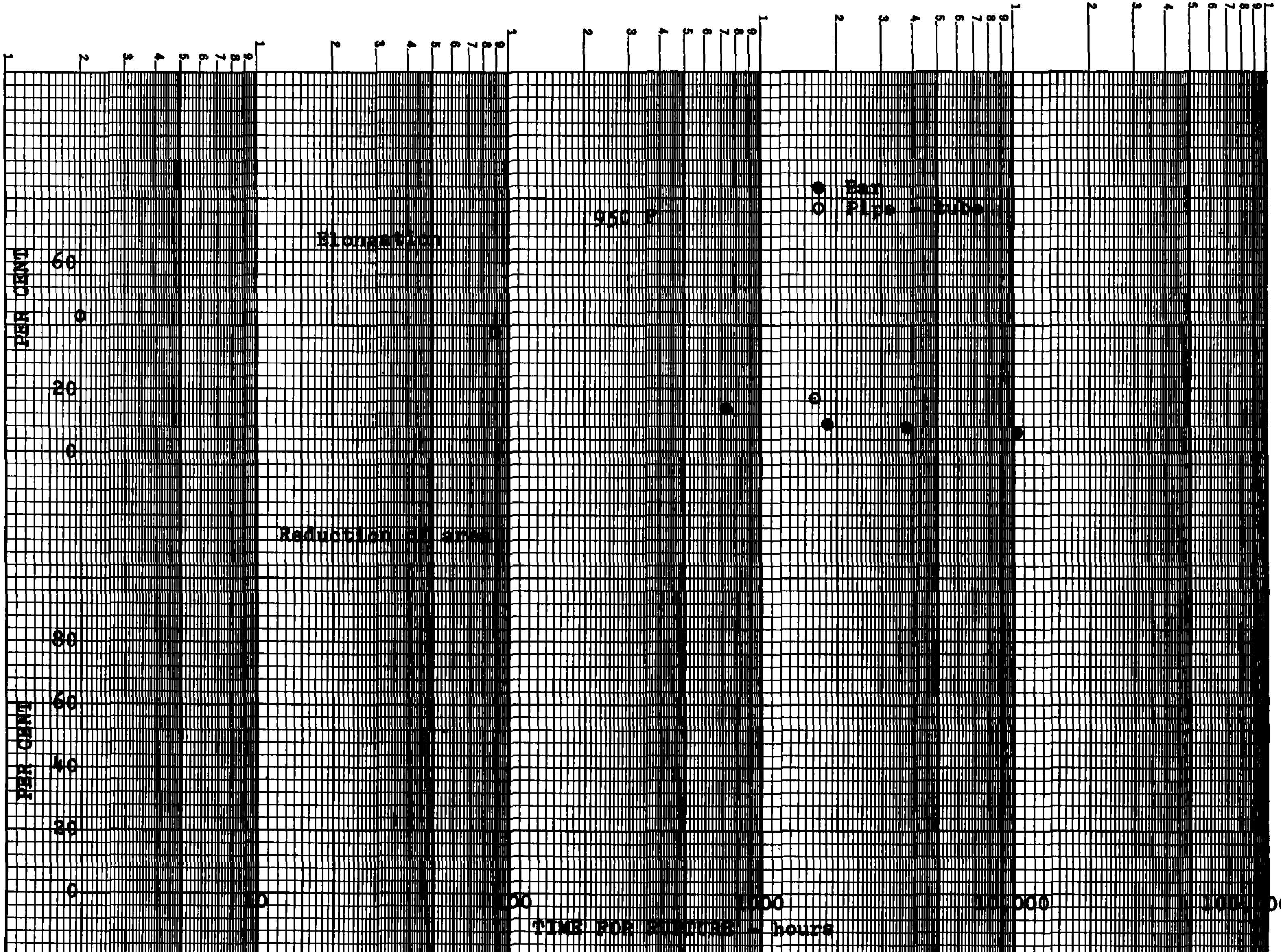


Fig. 10b. Variation of rupture ductility of 1/2 Cr - 1/2 Mo steel with time for rupture.

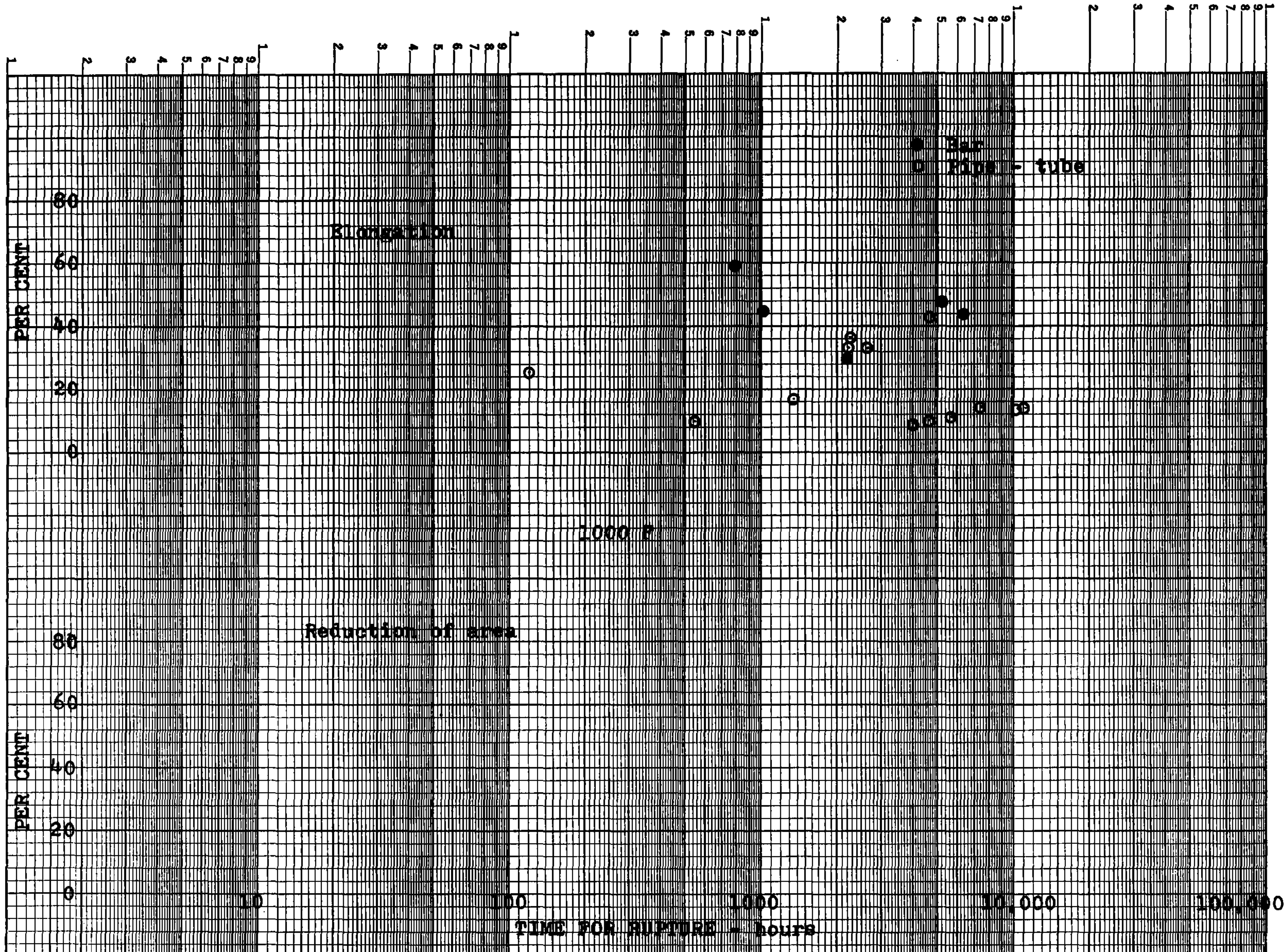


Fig. 10c. Variation of rupture ductility of 1/2 Cr - 1/2 Mo steel with time for rupture.

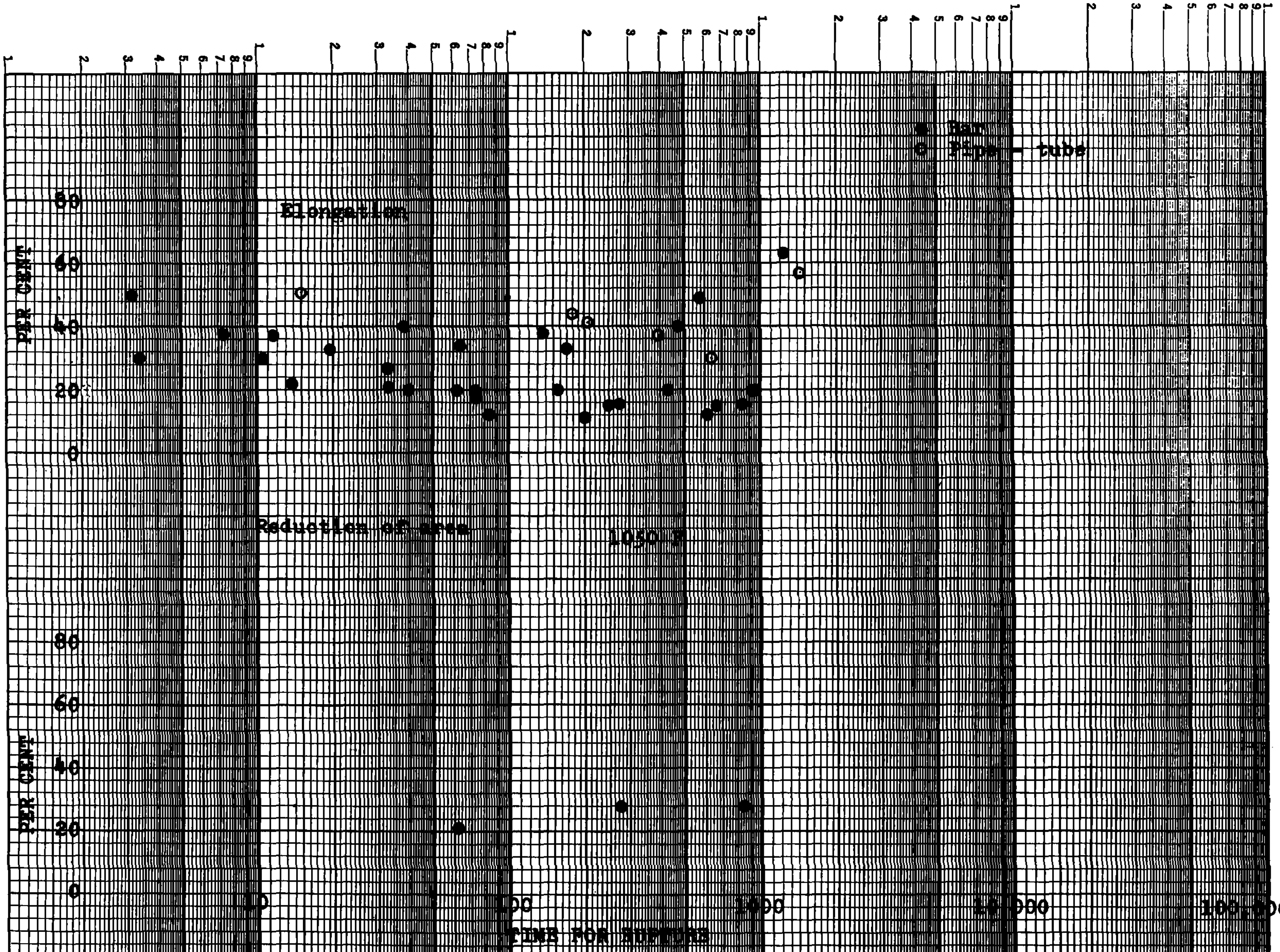


Fig. 10d. Variation of rupture ductility of 1/2 Cr - 1/2 Mo steel with time for rupture.

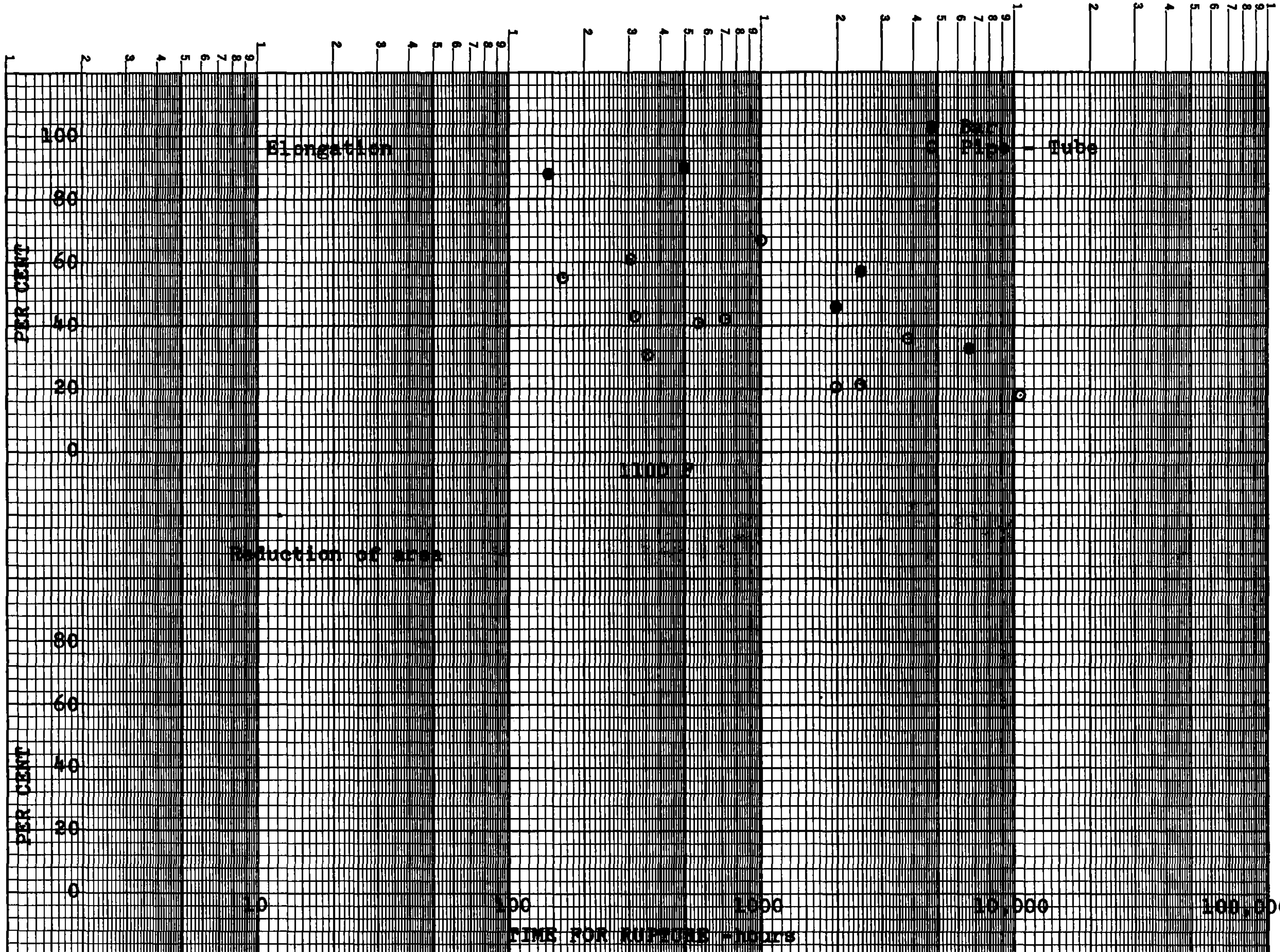


Fig. 10e. Variation of rupture ductility of 1/2 Cr - 1/2 Mo steel with time for rupture.

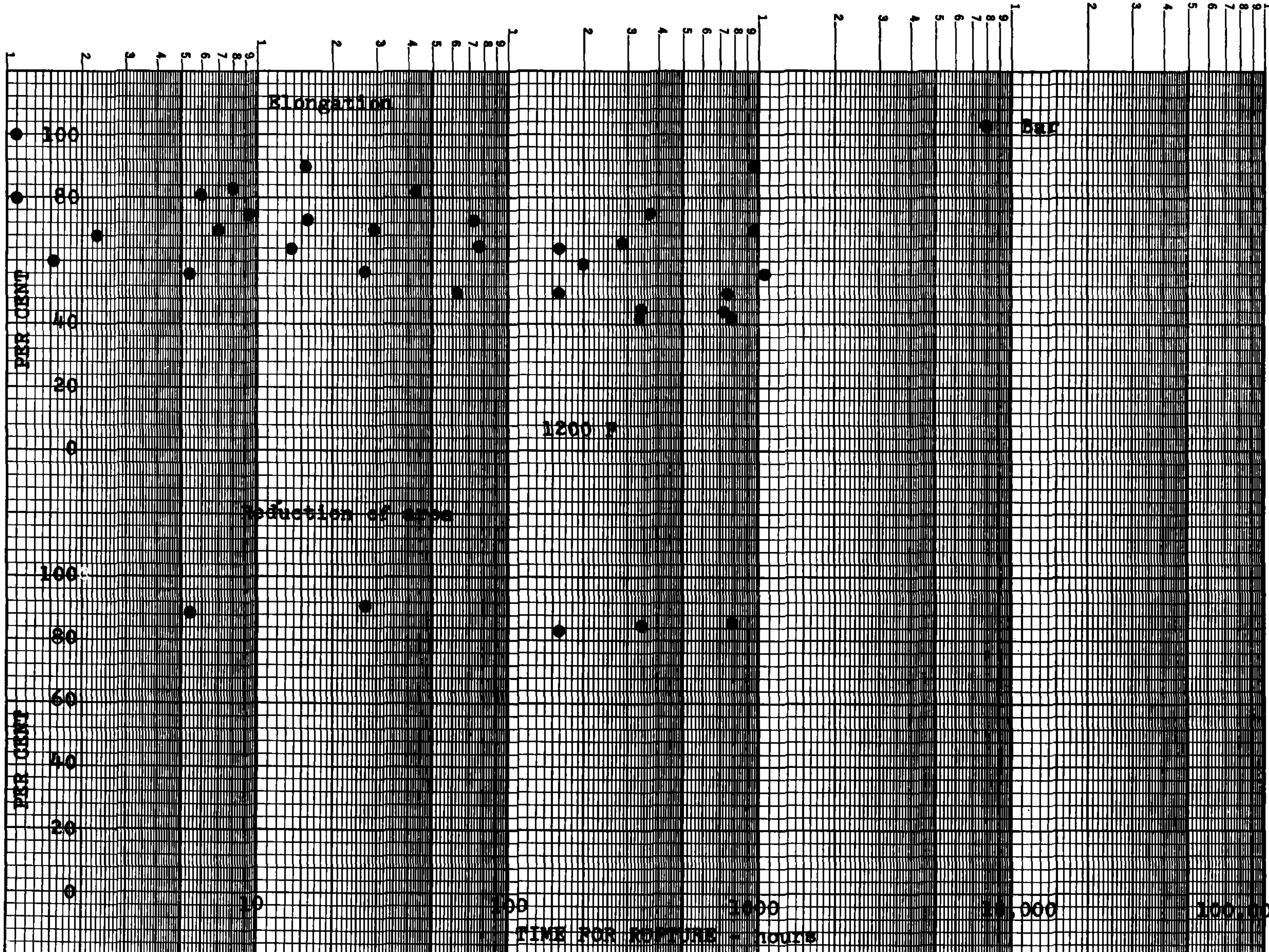


Fig. 10f. Variation of rupture ductility of 1/2 Cr - 1/2 Mo steel with time for rupture.

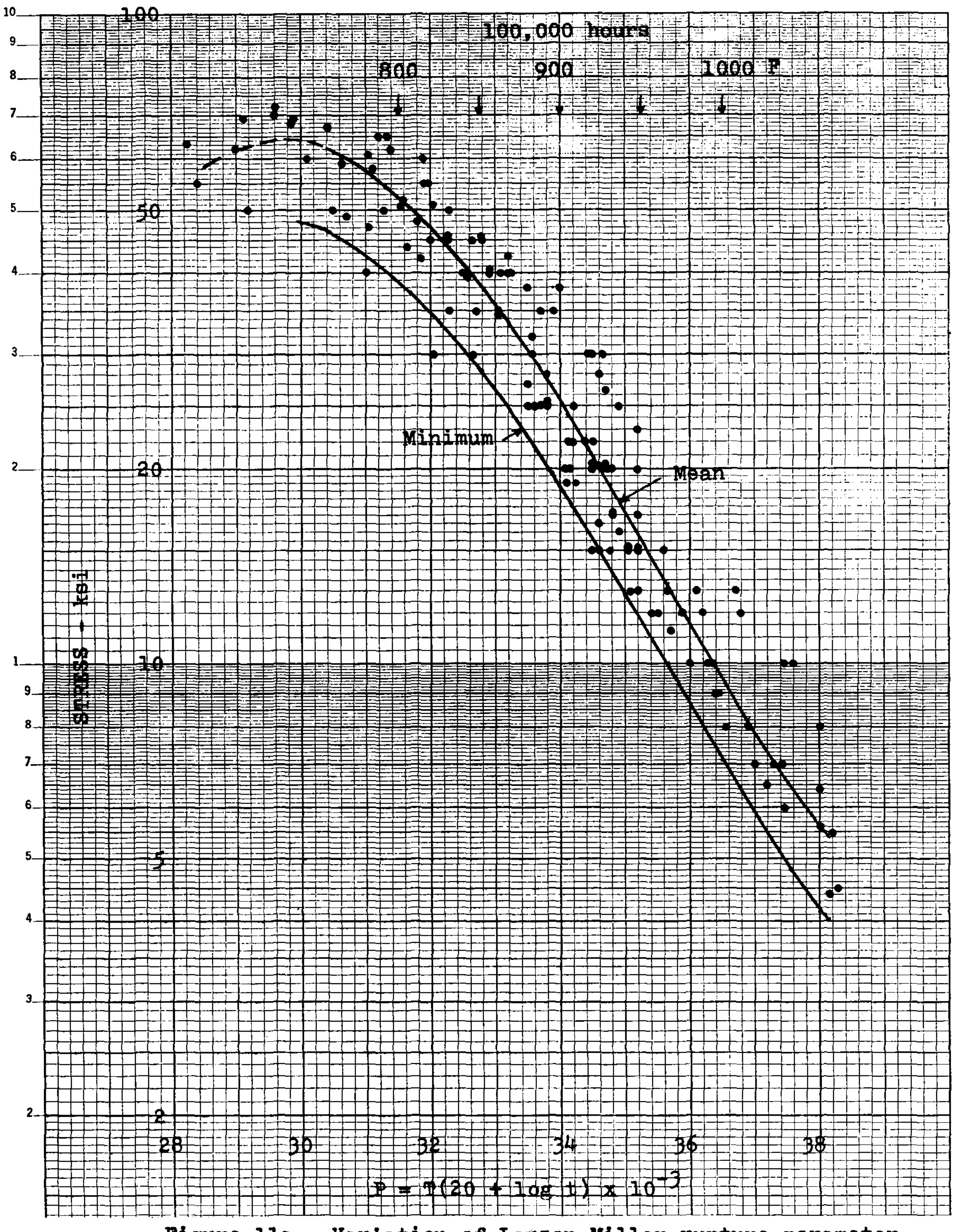


Figure 11a. Variation of Larson-Miller rupture parameter with stress for 1/2 Cr - 1/2 Mo steel.

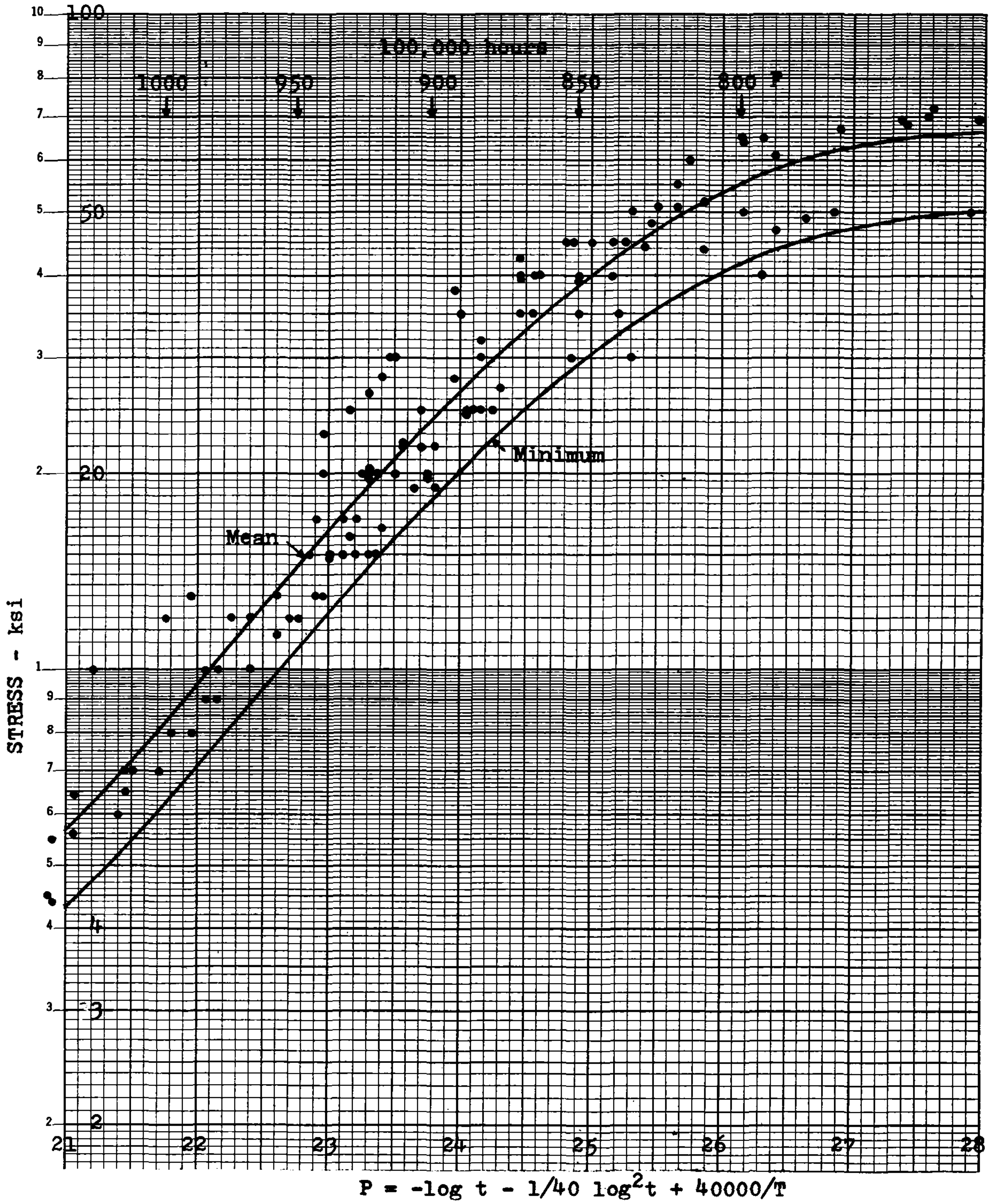


Figure 11b. Variation of Manson compromise rupture parameter with stress for 1/2 Cr - 1/2 Mo steel.

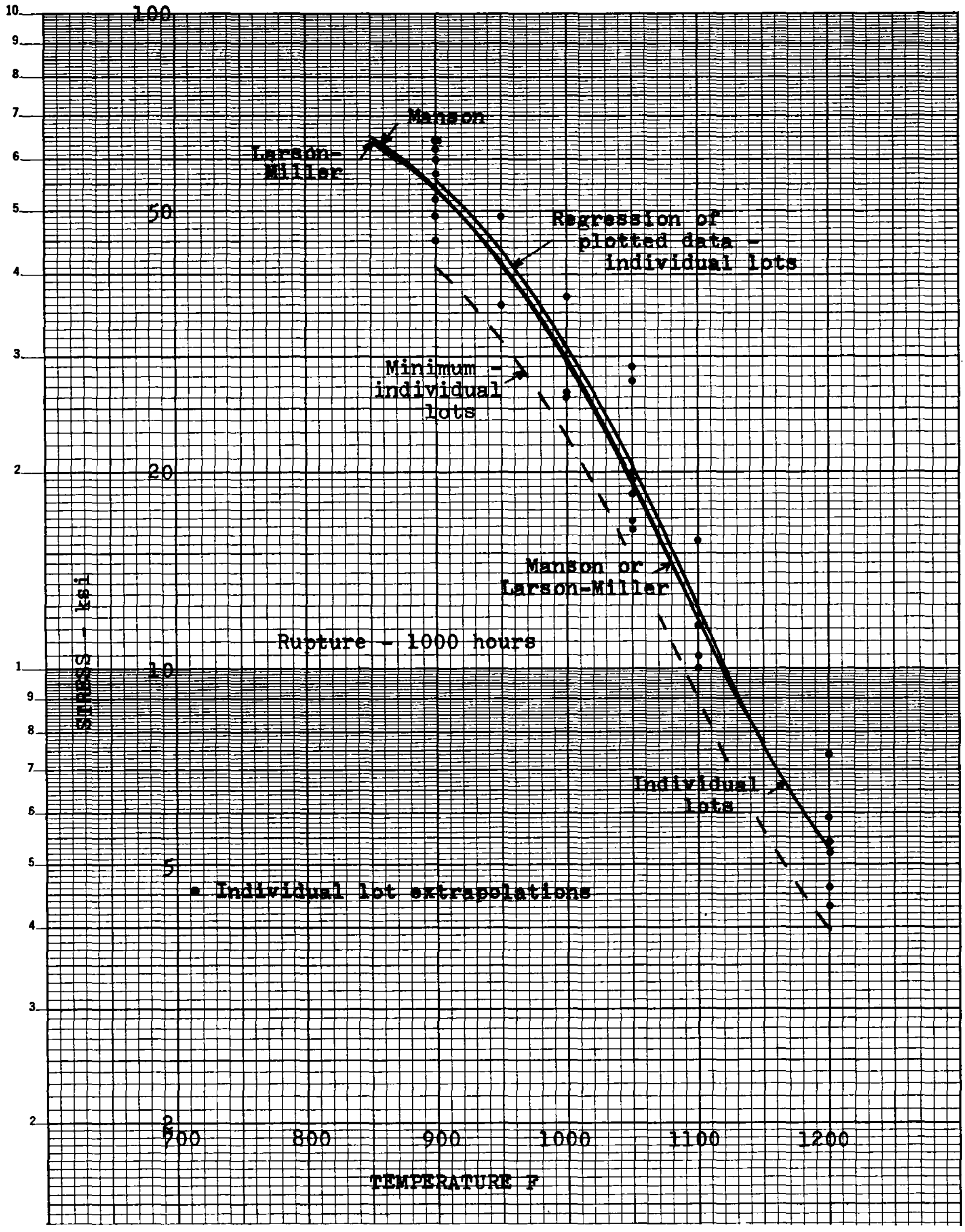


Figure 12a. Variation of rupture strength of 1/2 Cr - 1/2 Mo steel with temperature.

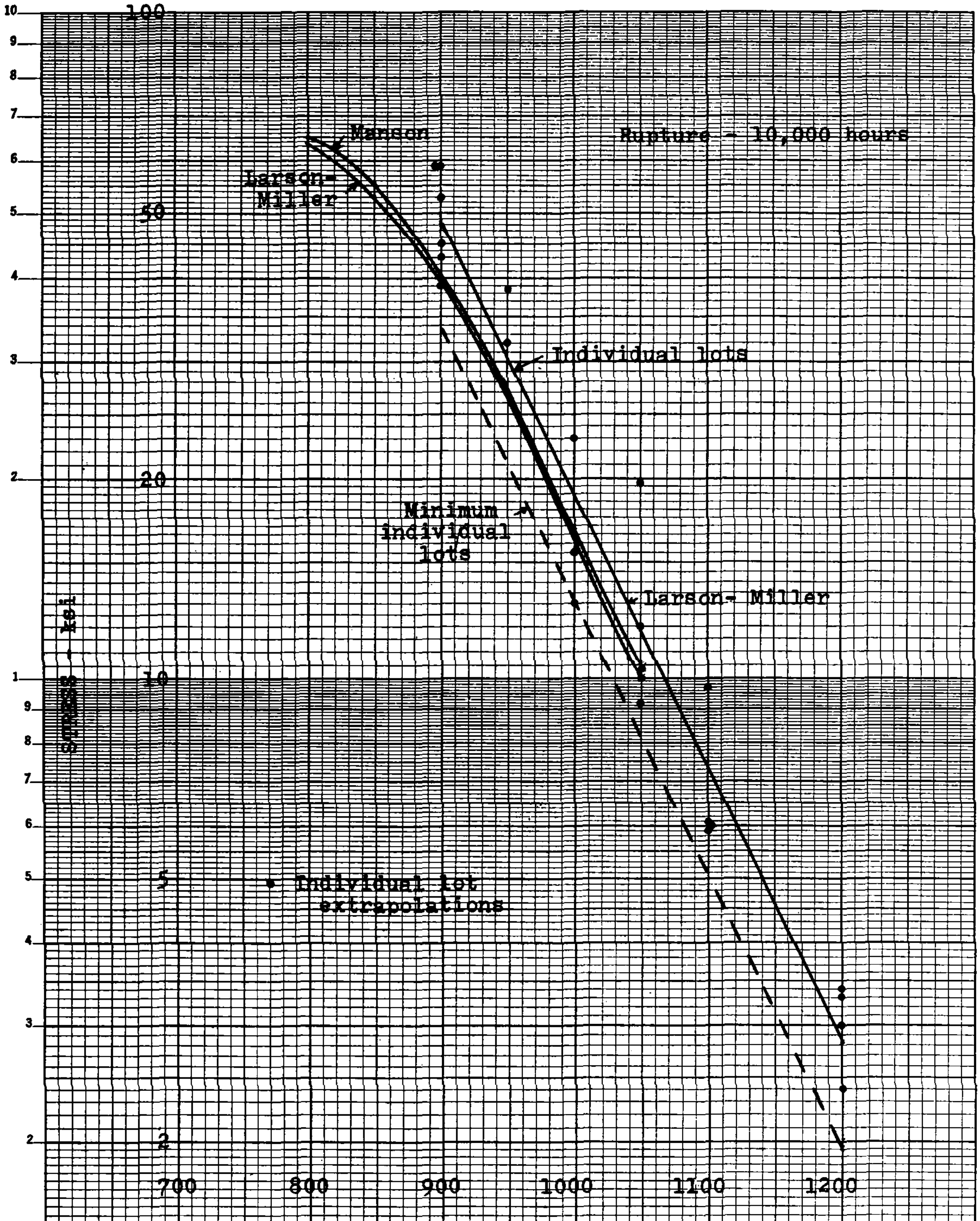


Figure 12b. Variation of rupture strength of 1/2 Cr - 1/2 Mo steel with temperature.

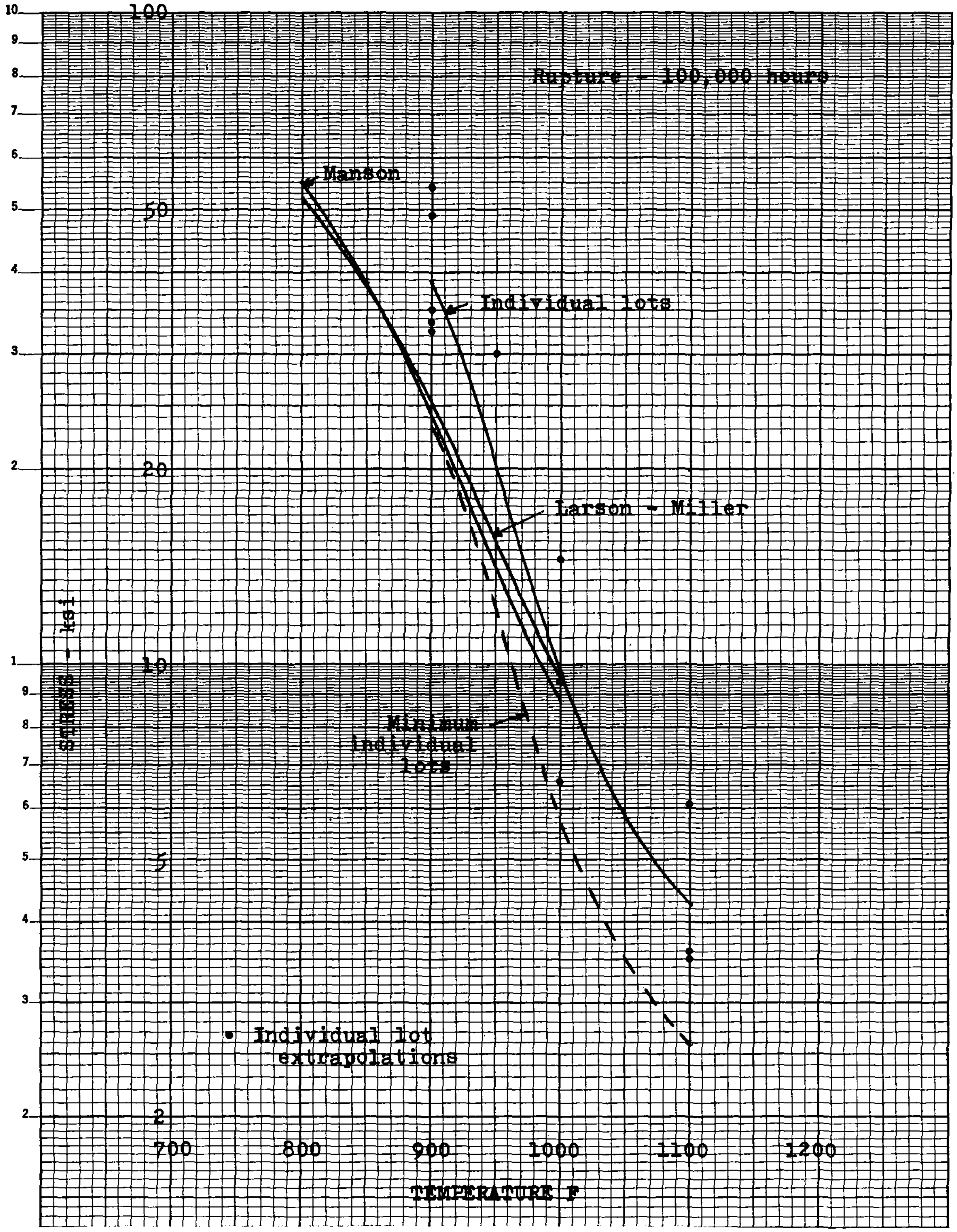


Figure 12c. Variation of rupture strength of 1/2 Cr - 1/2 Mo steel with temperature.

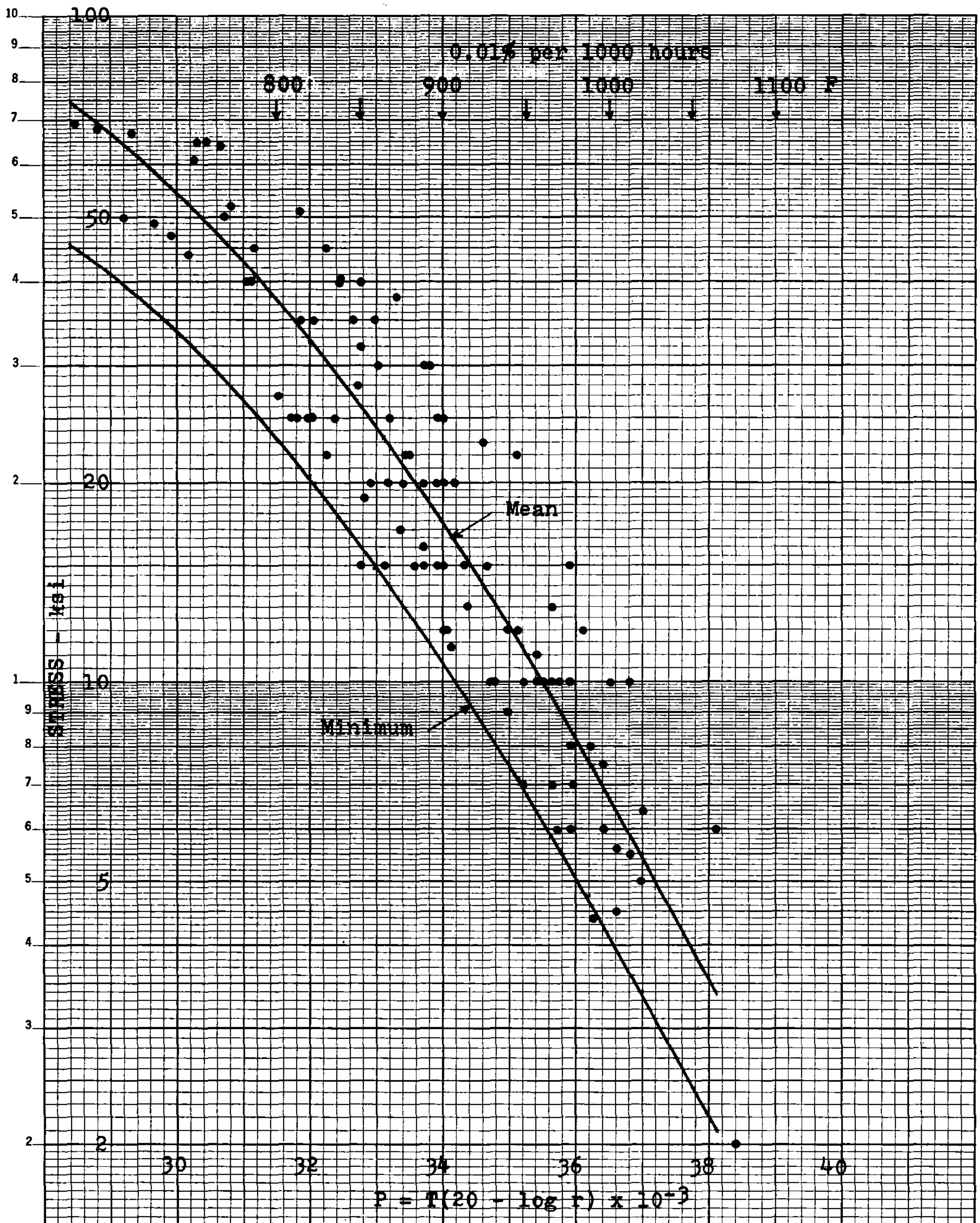


Figure 13. Variation of Larson Miller creep rate parameter with stress for 1/2 Cr - 1/2 Mo steel.

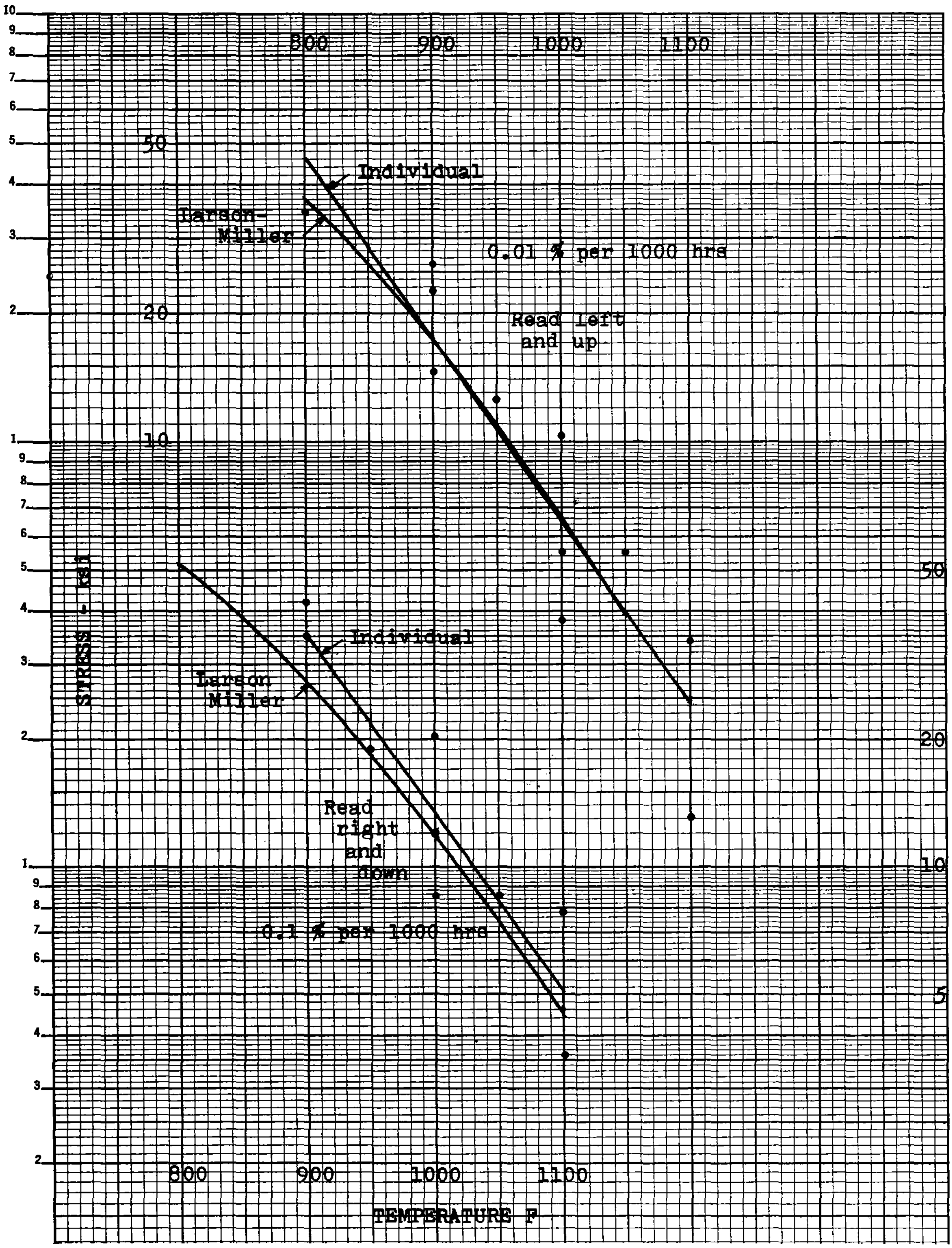


Figure 14. Variation of creep strength of 1/2 Cr - 1/2 Mo steel with temperature.

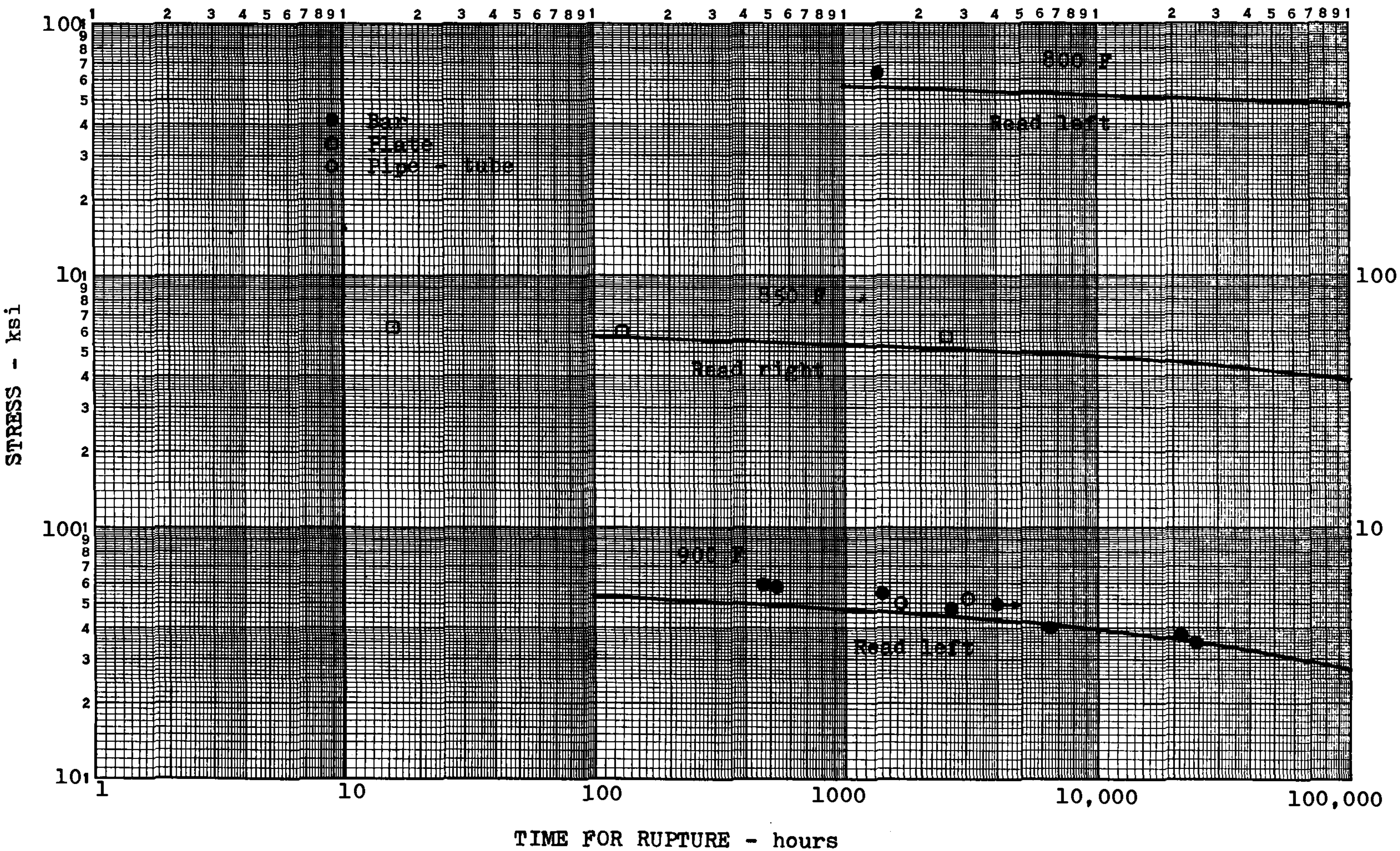


Fig. 15a. Stress vs. time for rupture of 1 Cr - 1/2 Mo steel. The superimposed curves were computed from the Larson-Miller master curve, Figure 18a.

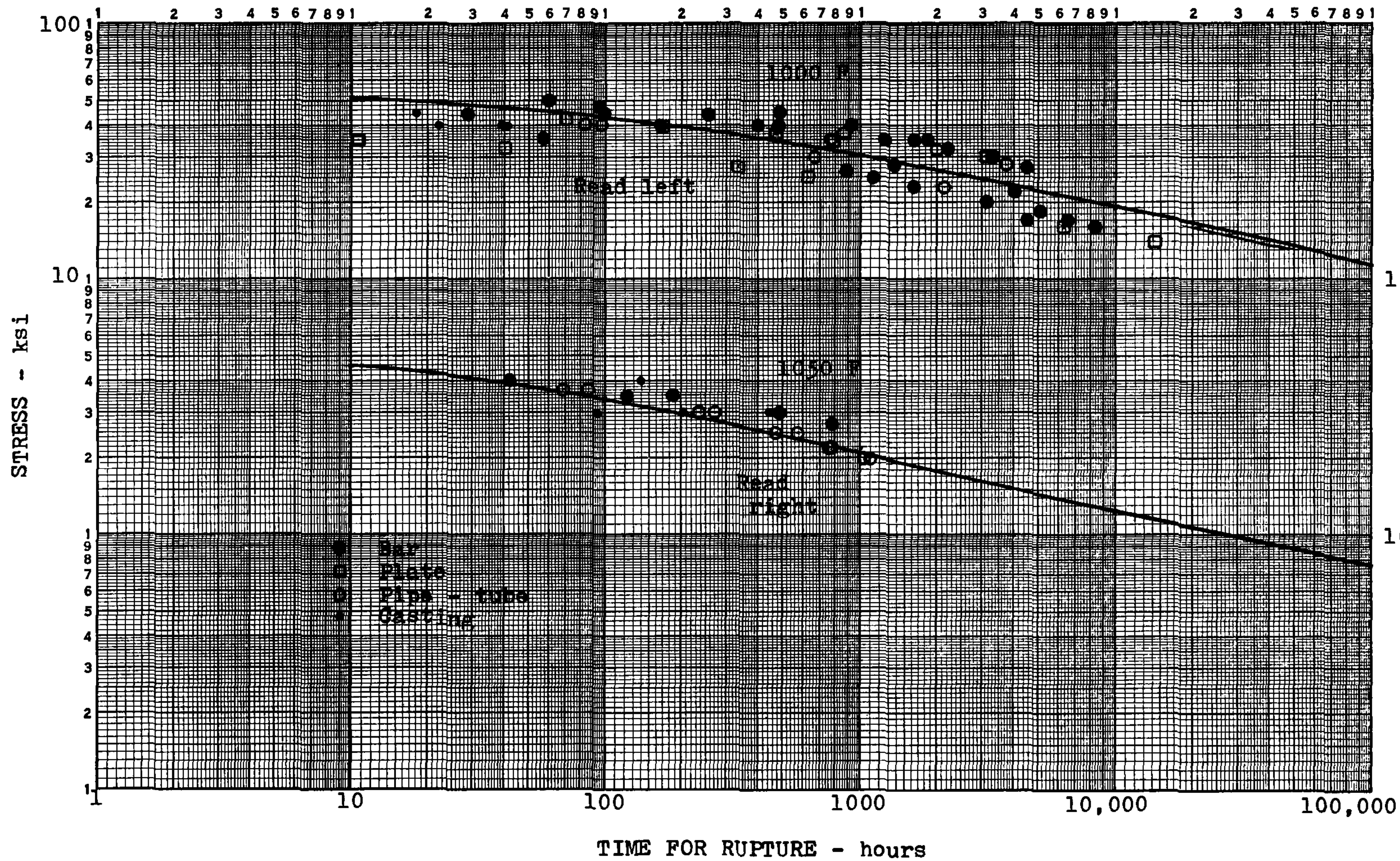


Fig. 15b. Stress vs. time for rupture of 1 Cr - 1/2 Mo steel. The superimposed curves were computed from the Larson - Miller master curve, Figure 18a.

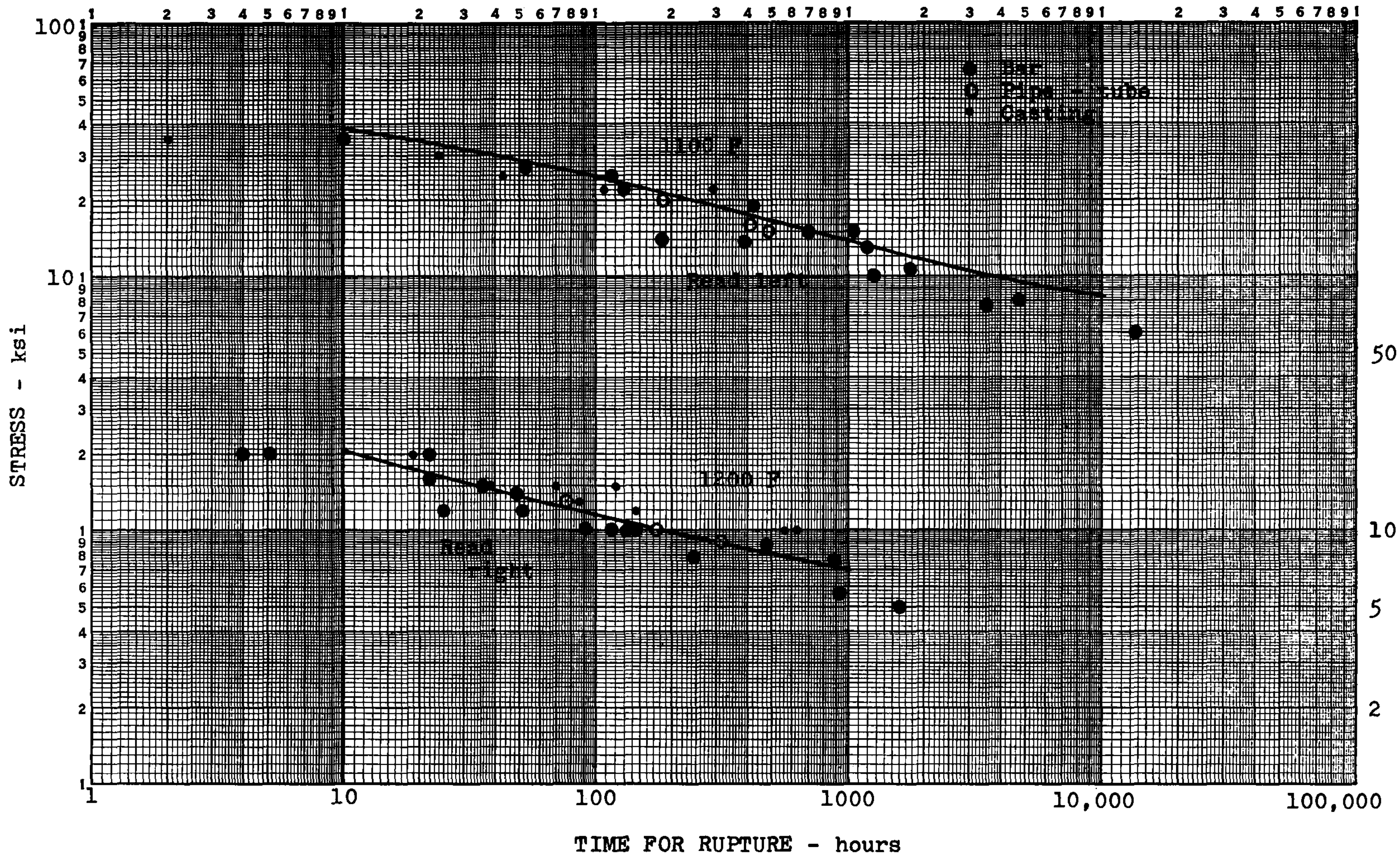


Fig. 15c. Stress vs. time for rupture of 1 Cr - 1/2 Mo steel. The superimposed curves were computed from the Larson - Miller curve, Figure 18a

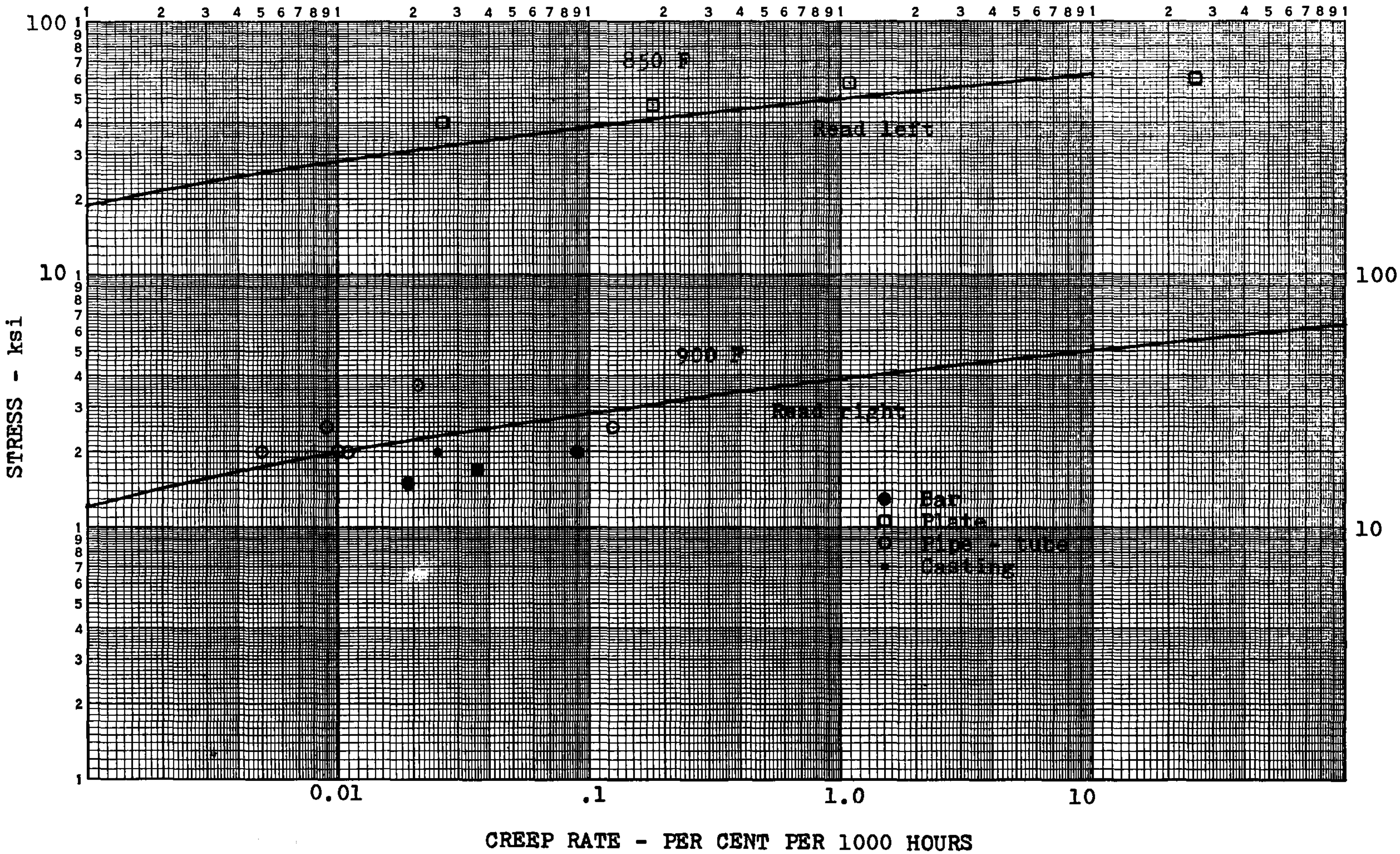


Figure 16a. Stress vs. secondary creep rate for 1 Cr - 1/2 Mo steel. The superimposed curves were computed from the Larson - Miller master curve, Figure 20.

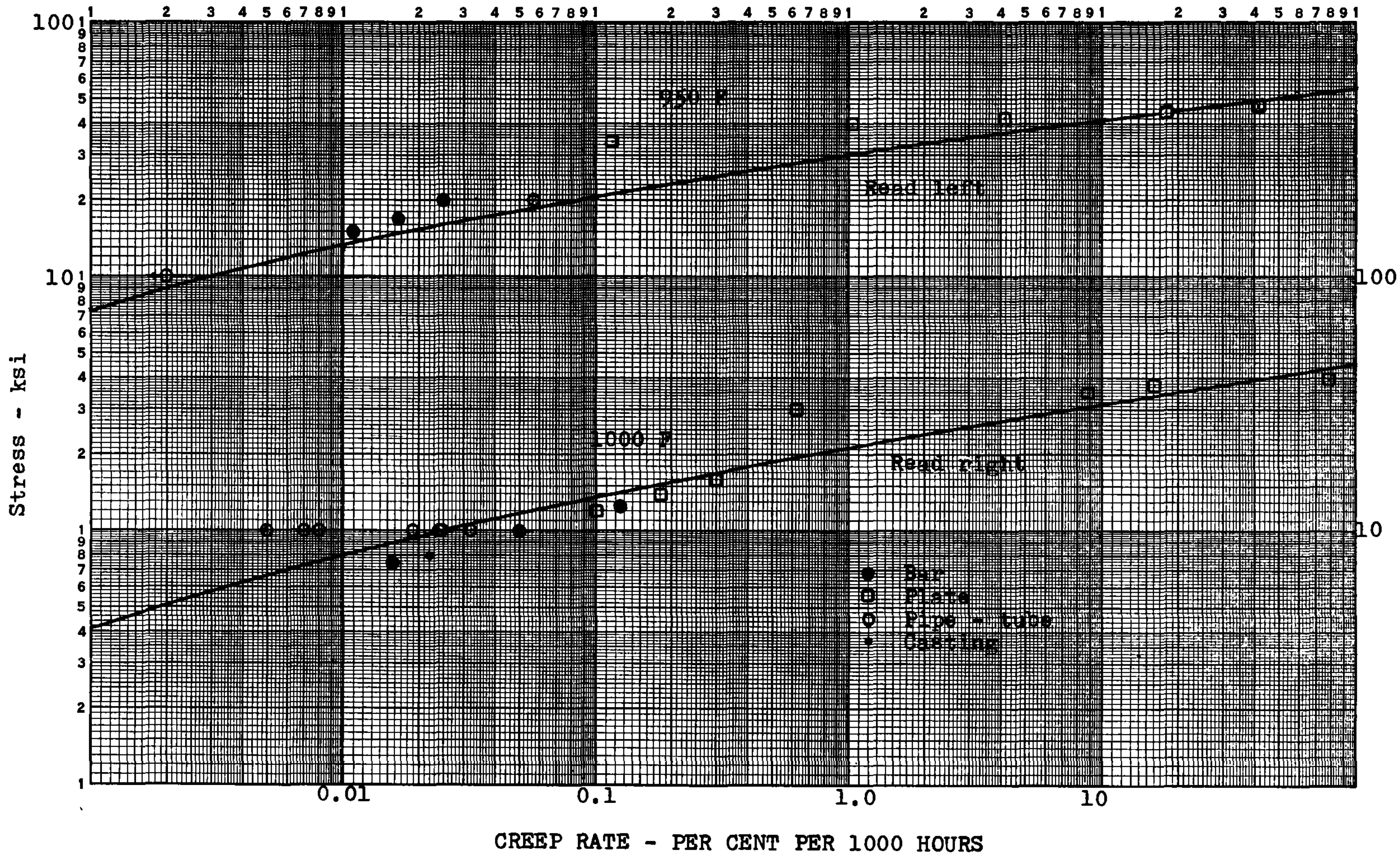


Figure 16b. Stress vs. secondary creep rate for 1 Cr - 1/2 Mo steel. The superimposed curves were computed from the Larson - Miller master curve, Figure 20.

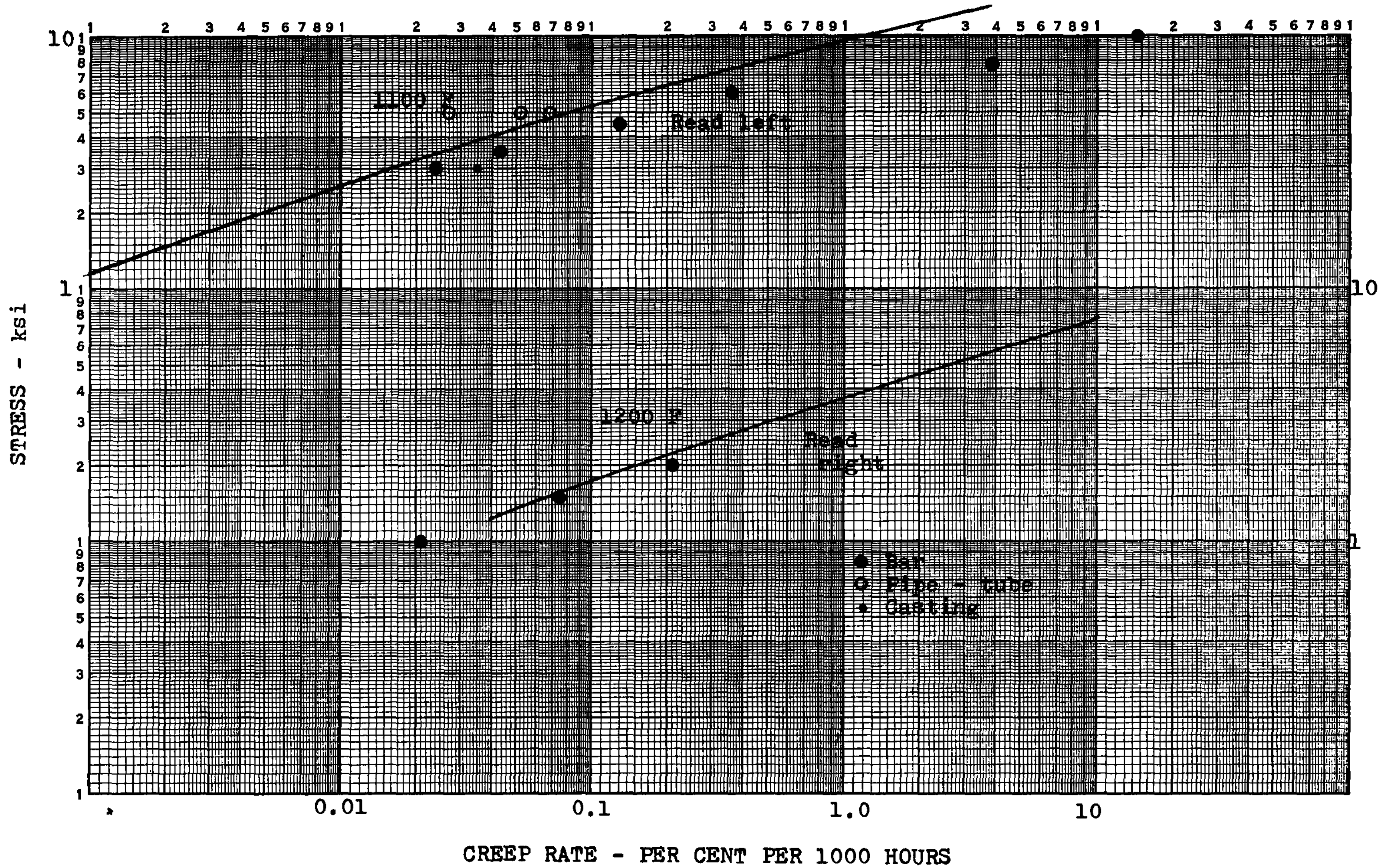


Figure 16c. Stress vs. secondary creep rate for 1 Cr - 1/2 Mo steel. The superimposed curves were computed from the Larson - Miller master curve, Figure 20.

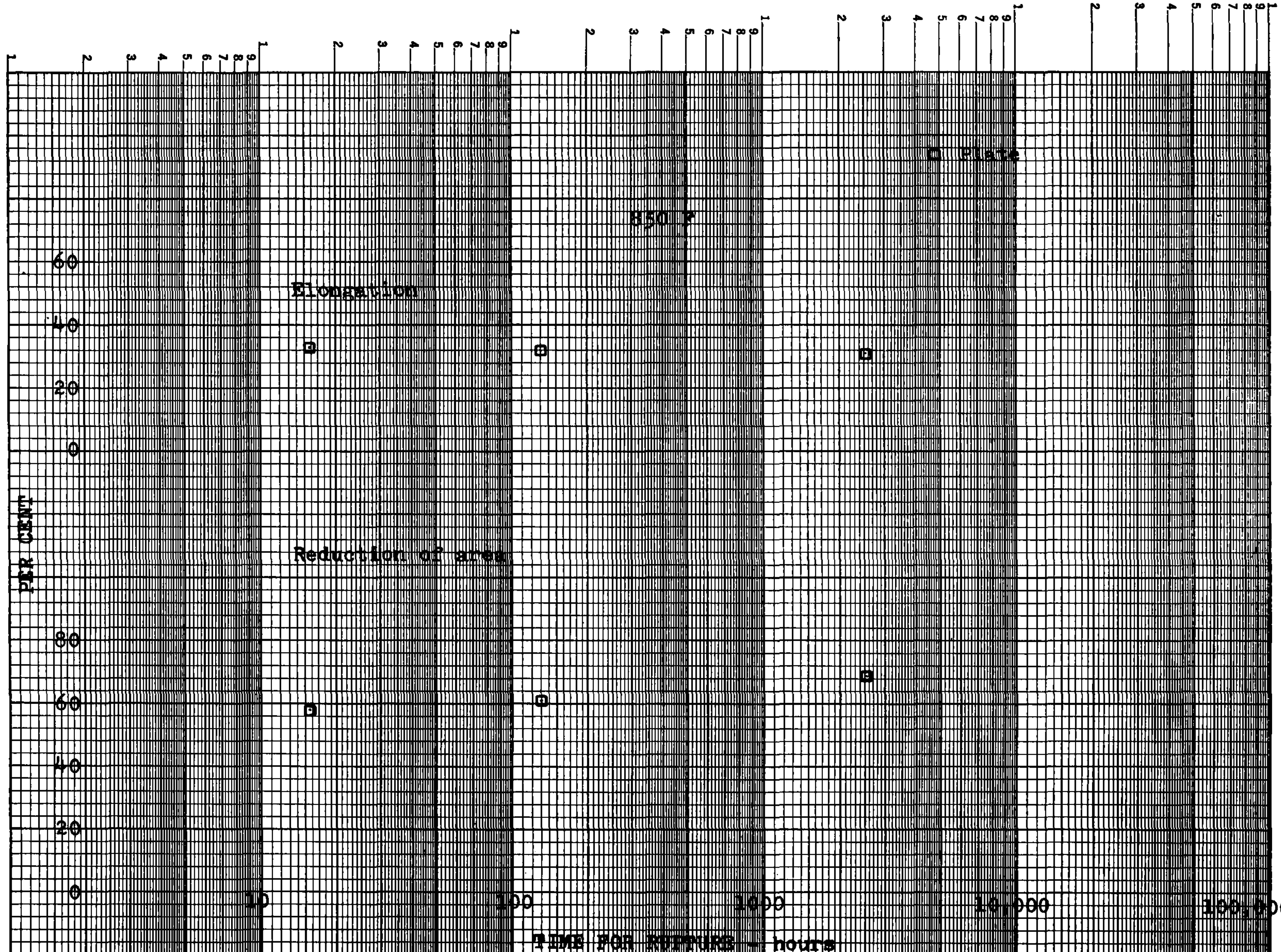


Fig. 17a. Variation of rupture ductility of 1 Cr - 1/2 Mo steel with time for rupture.

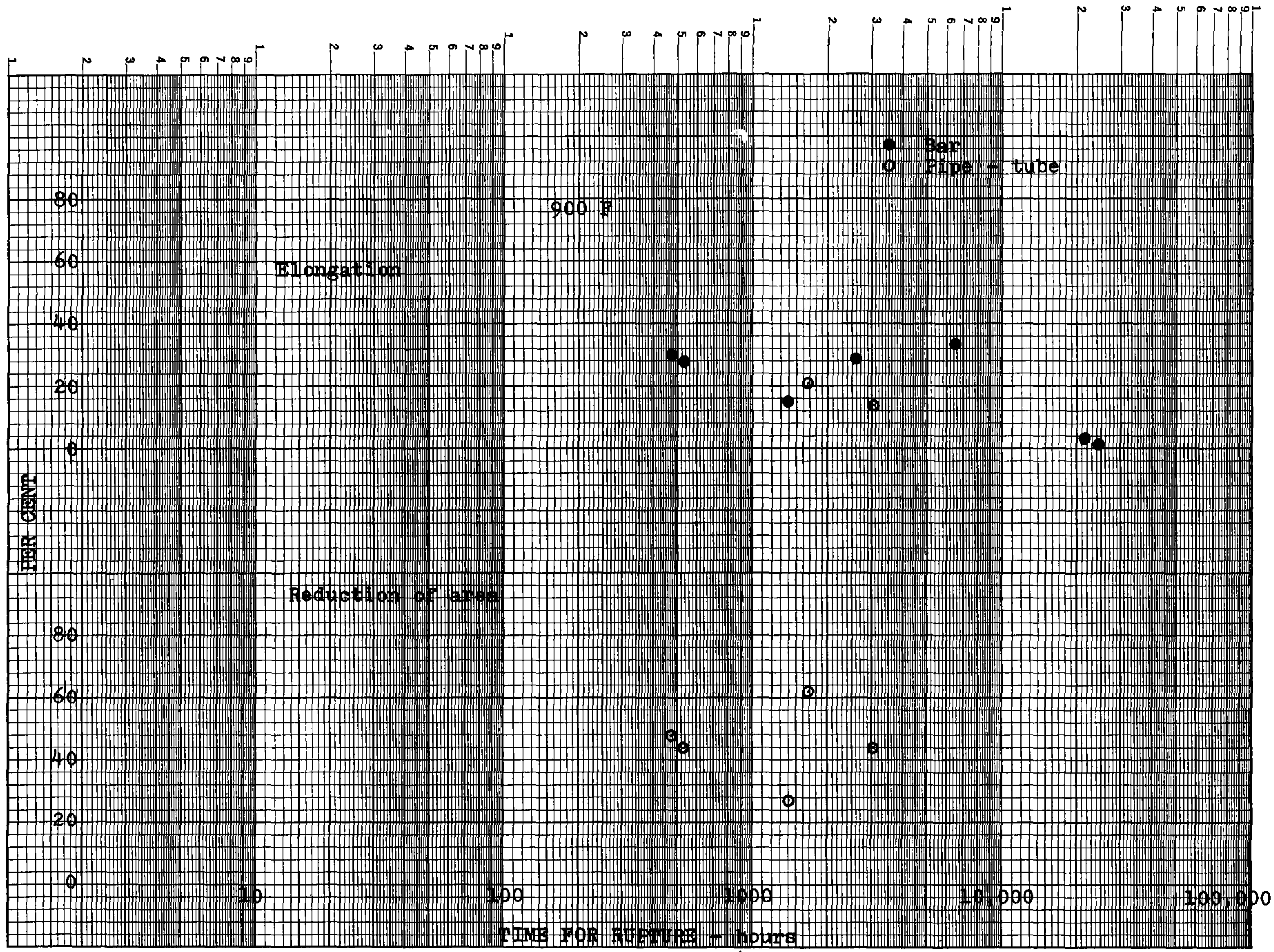


Fig. 17b. Variation of rupture ductility of 1 Cr - 1/2 Mo steel with time for rupture.

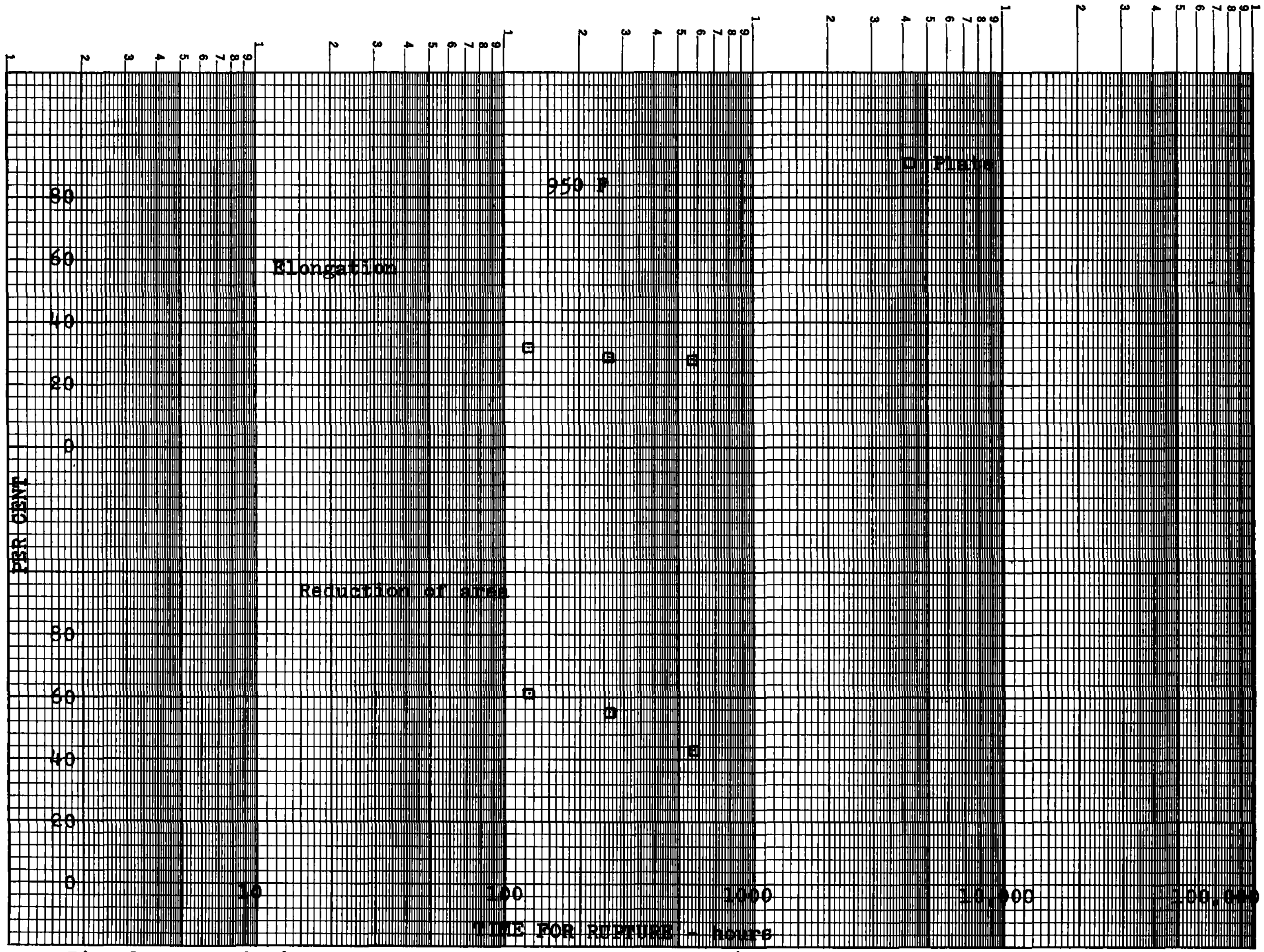


Fig. 17c. Variation of rupture ductility of 1 Cr - 1/2 Mo steel with time for rupture.

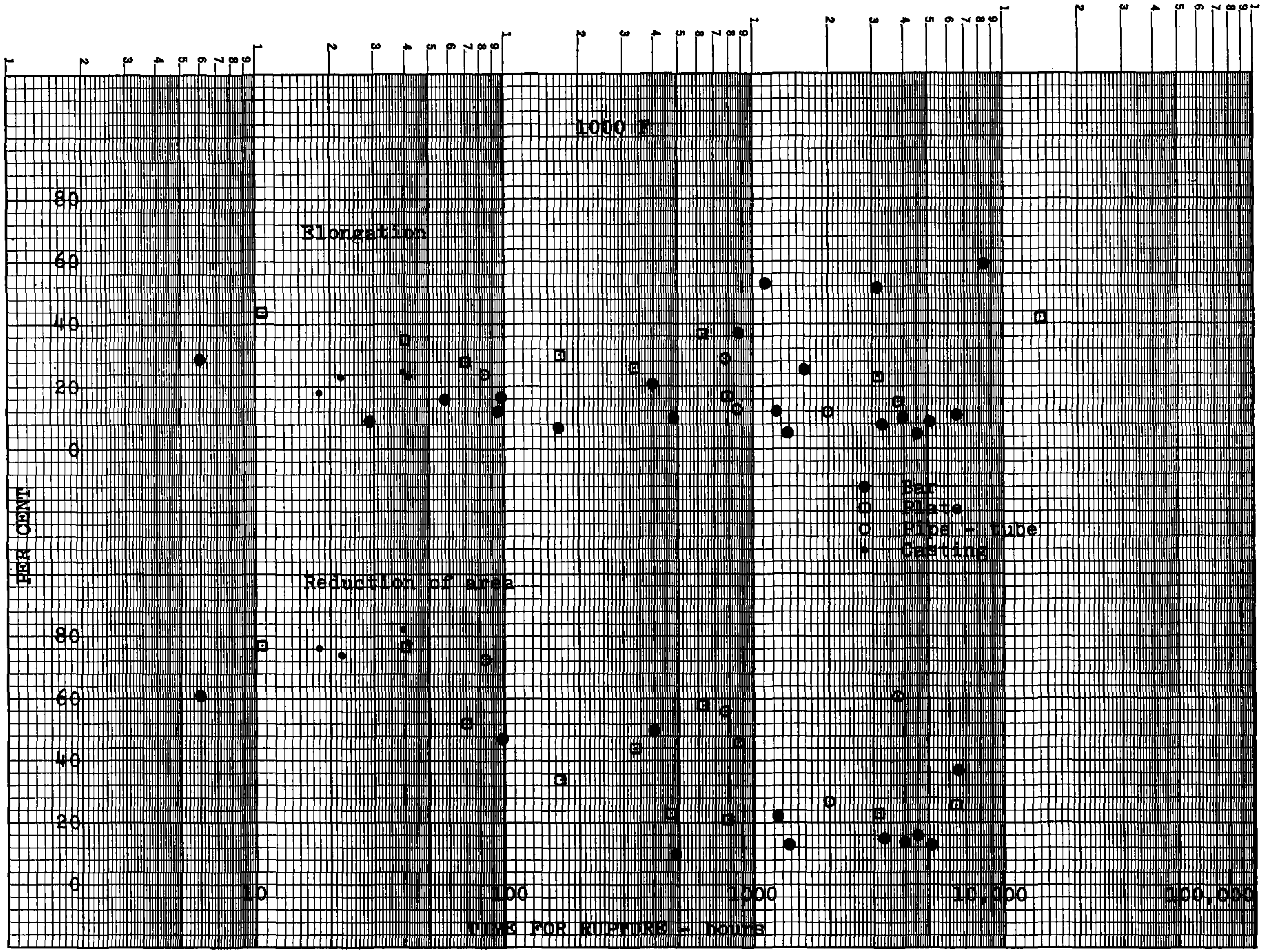


Fig. 17d. Variation of rupture ductility of 1 Cr - 1/2 Mo steel with time for rupture.

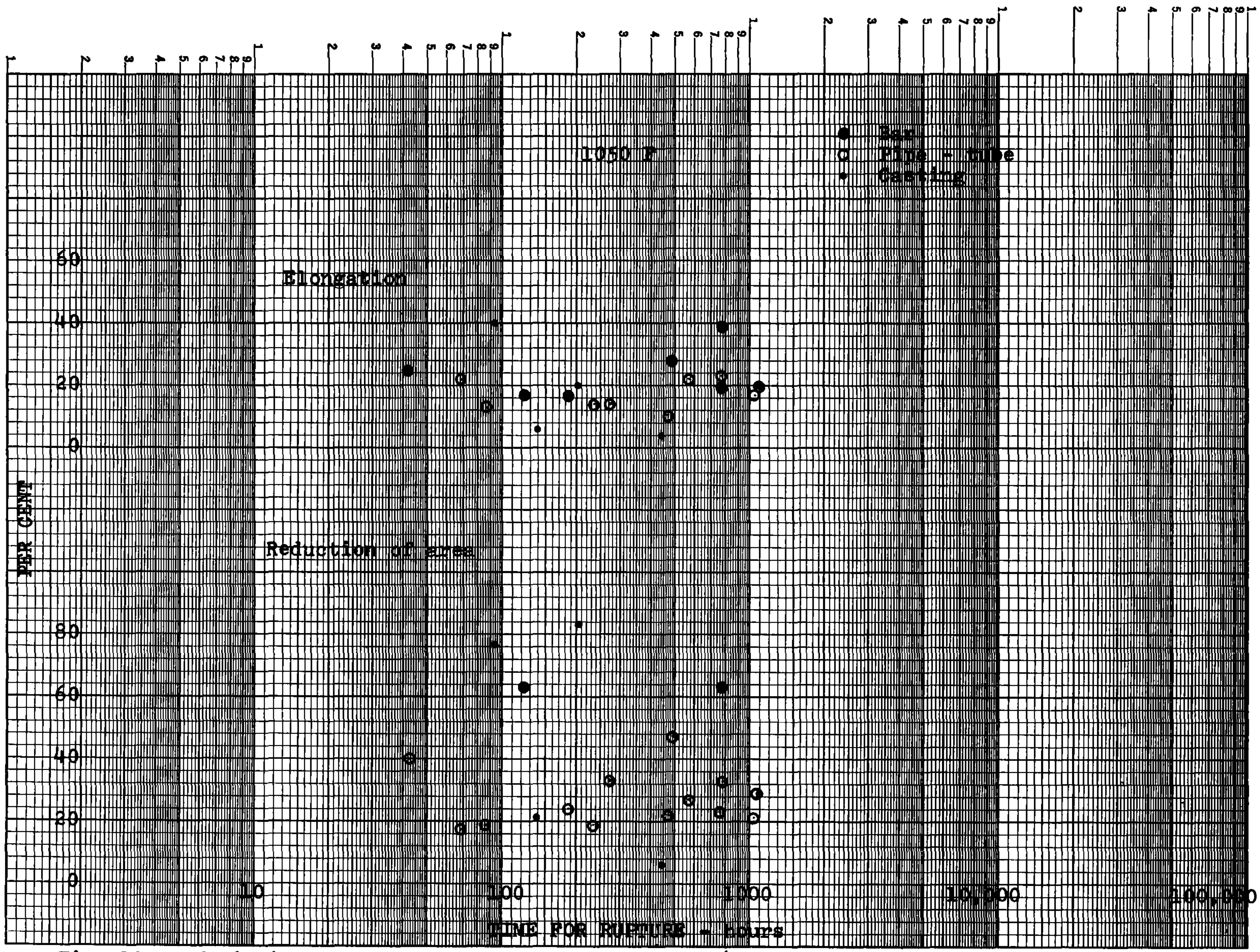


Fig. 17e. Variation of rupture ductility of 1 Cr - 1/2 Mo steel with time for rupture.

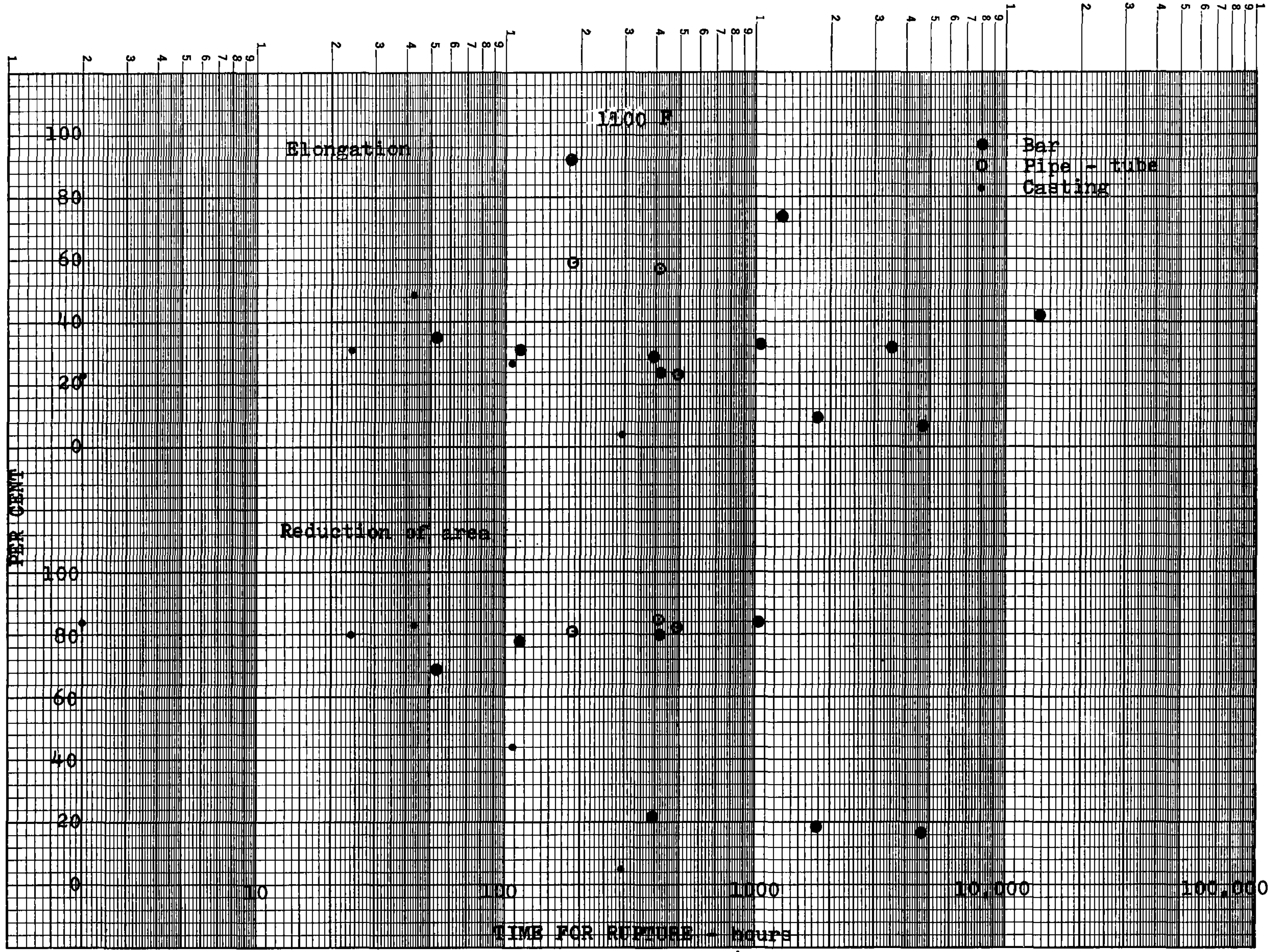
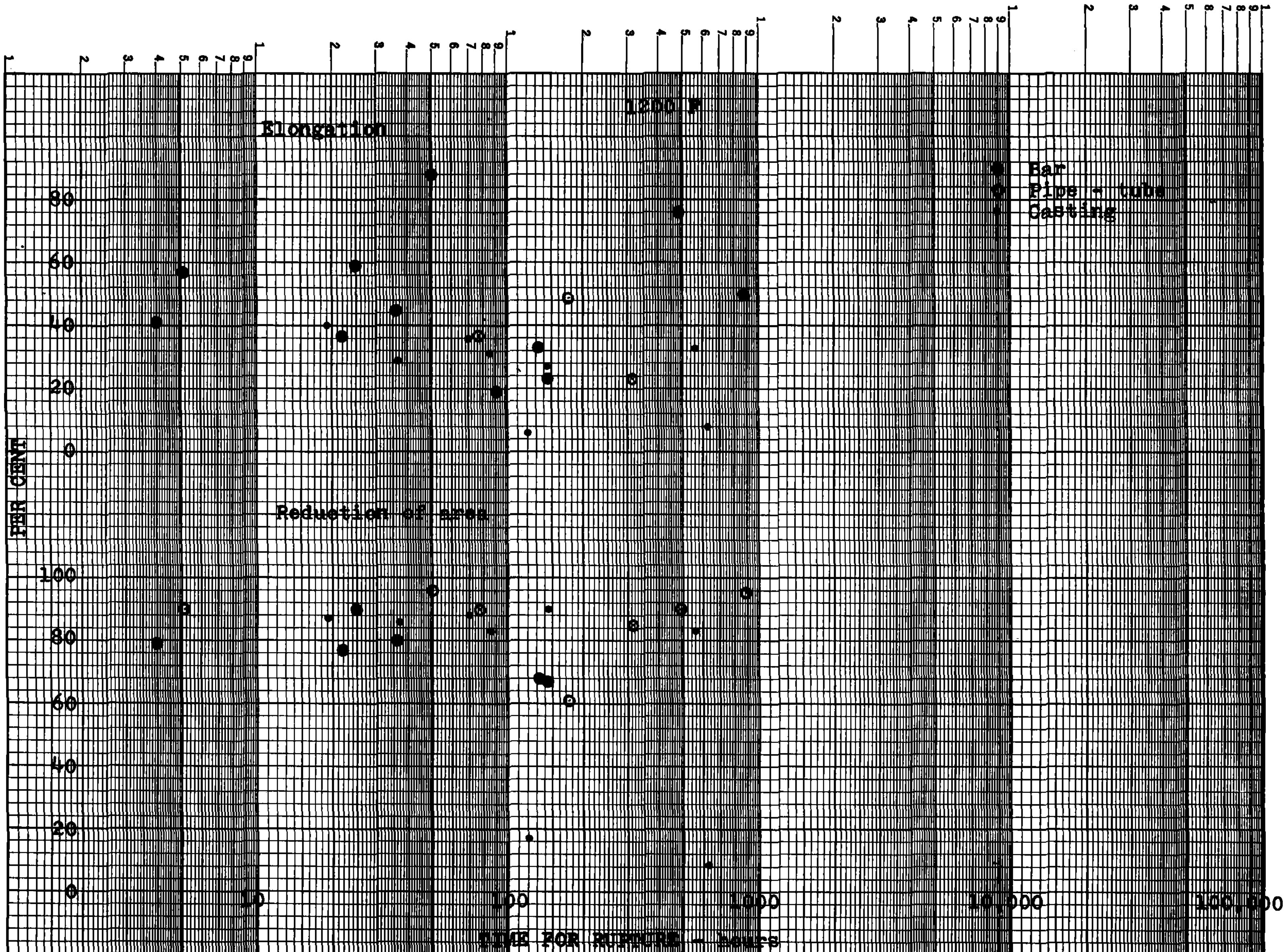


Fig. 17f. Variation of rupture ductility of 1 Cr - 1/2 Mo steel with time for rupture.



Figl 17g. Variation of rupture ductility of 1 Cr - 1/2 Mo steel with time for rupture.

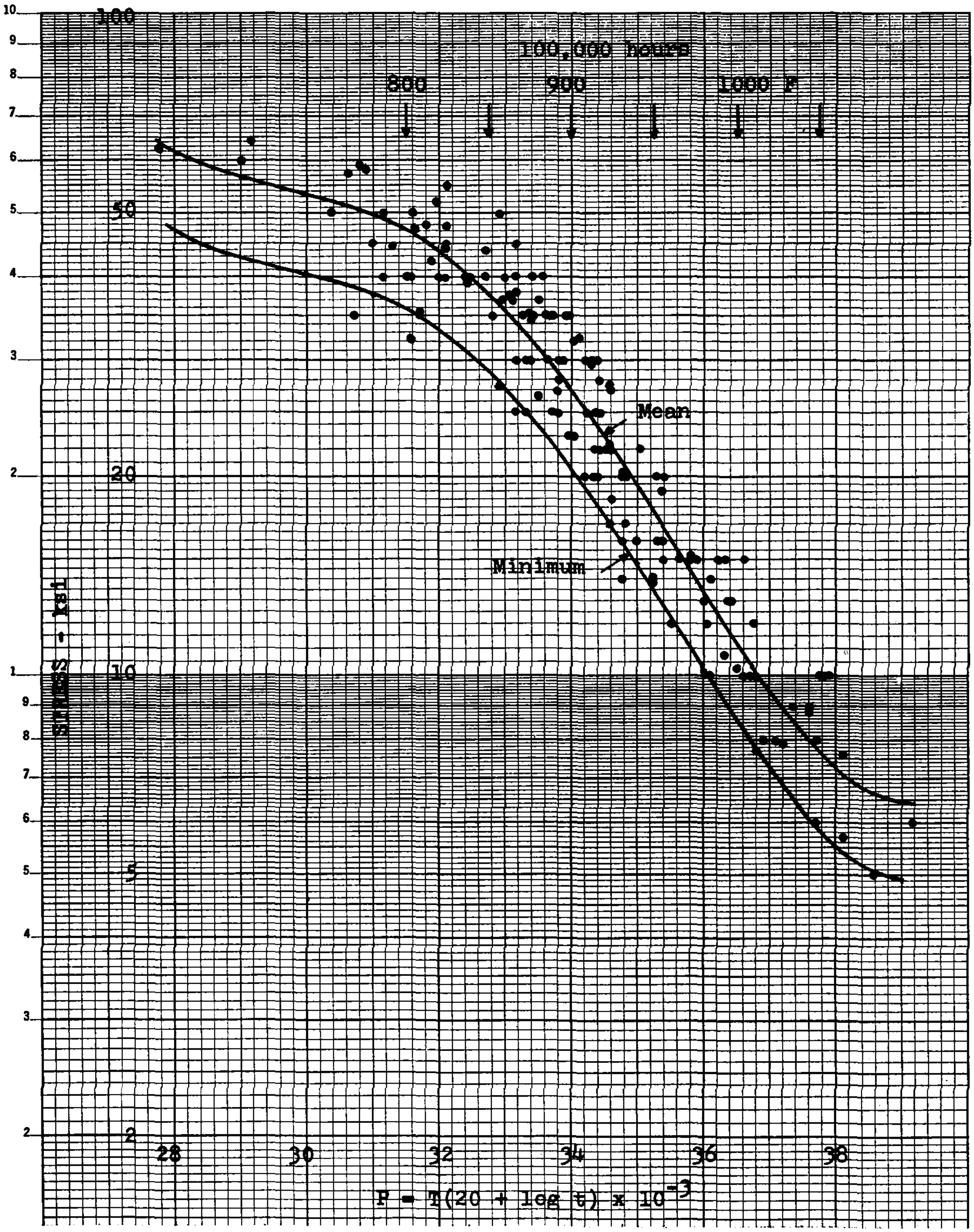


Figure 18a. Variation of Larson - Miller rupture parameter with stress for 1 Cr - 1/2 Mo steel

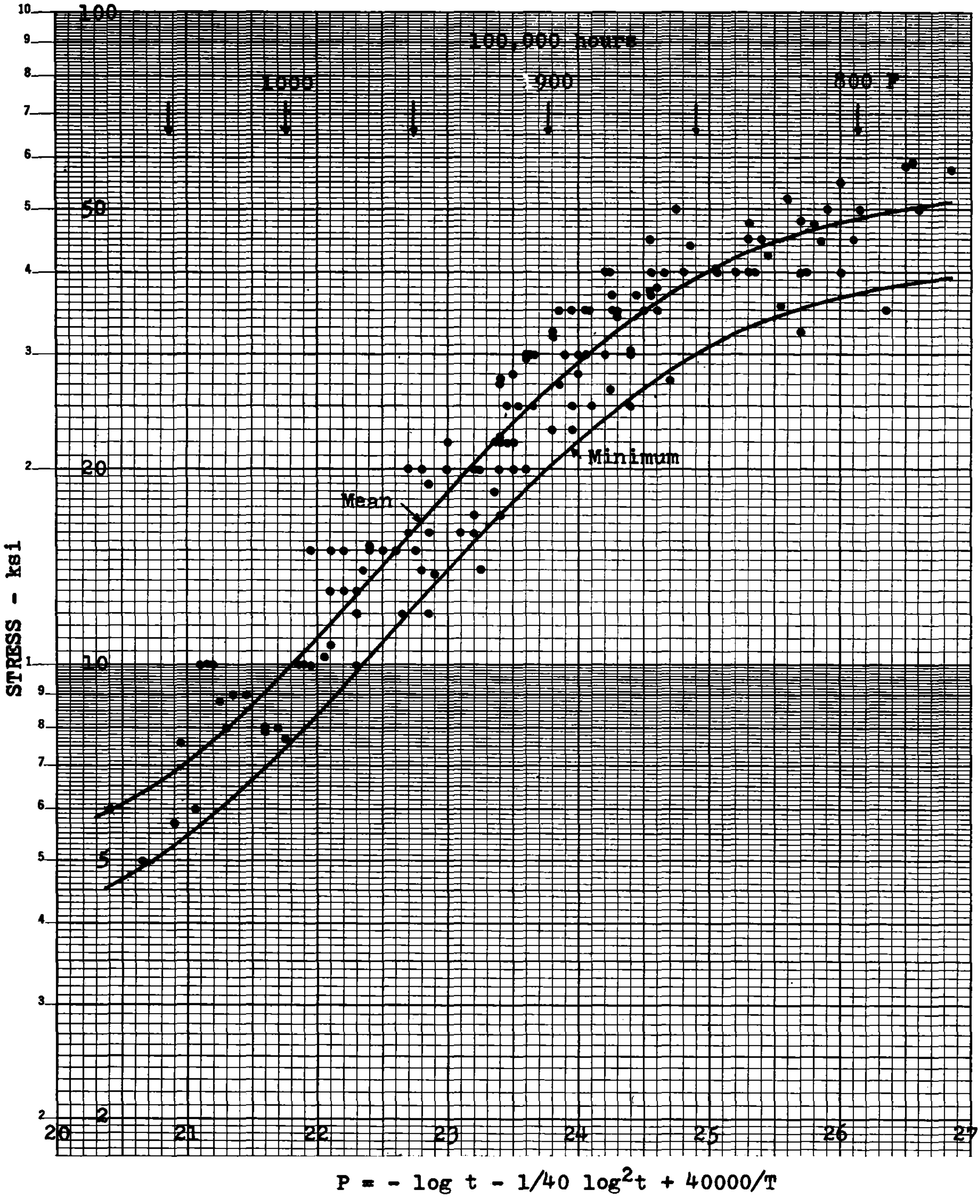


Figure 18b. Variation of Manson compromise rupture parameter with stress for 1 Cr - 1/2 Mo steel.

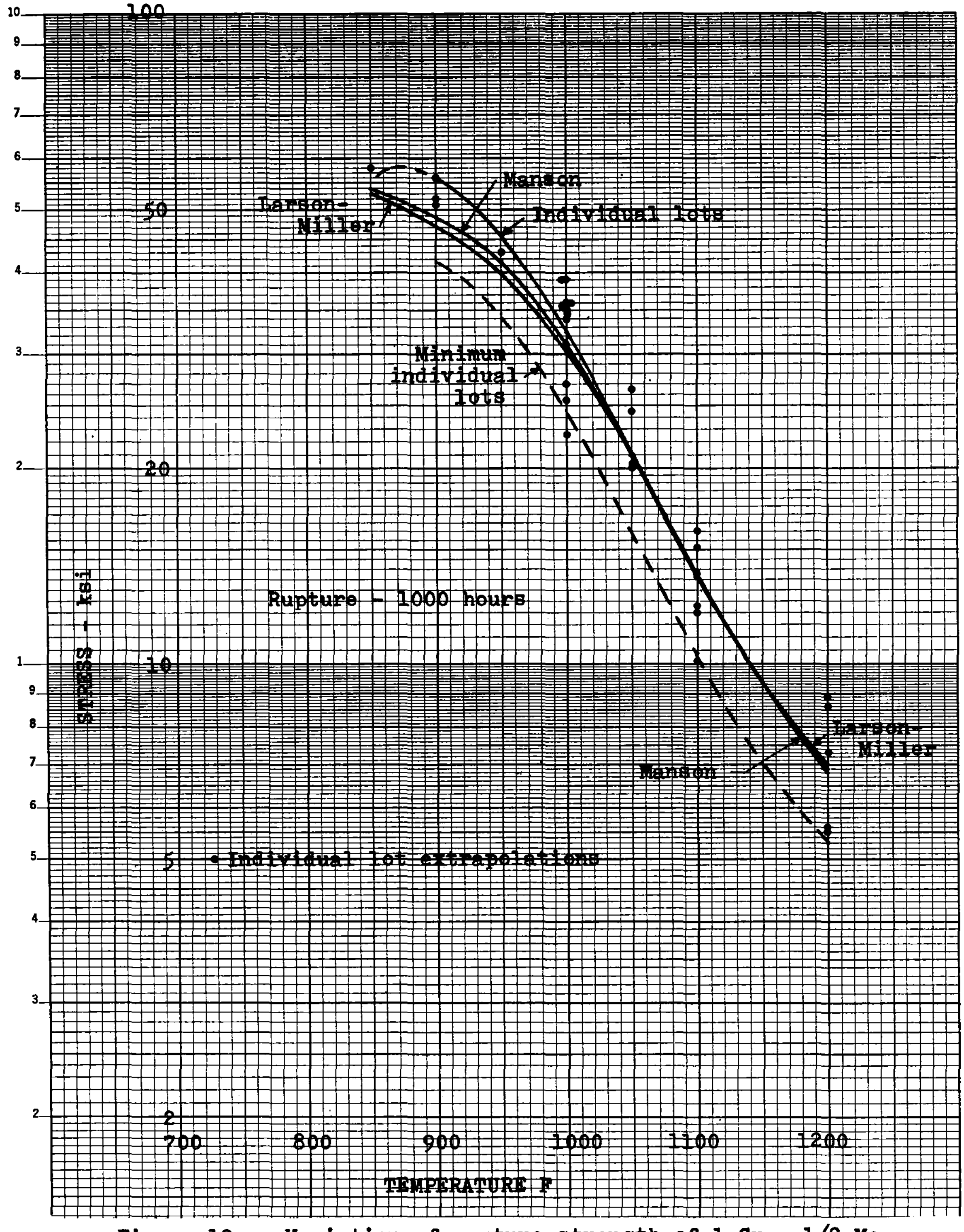


Figure 19a. Variation of rupture strength of 1 Cr - 1/2 Mo steel with temperature.

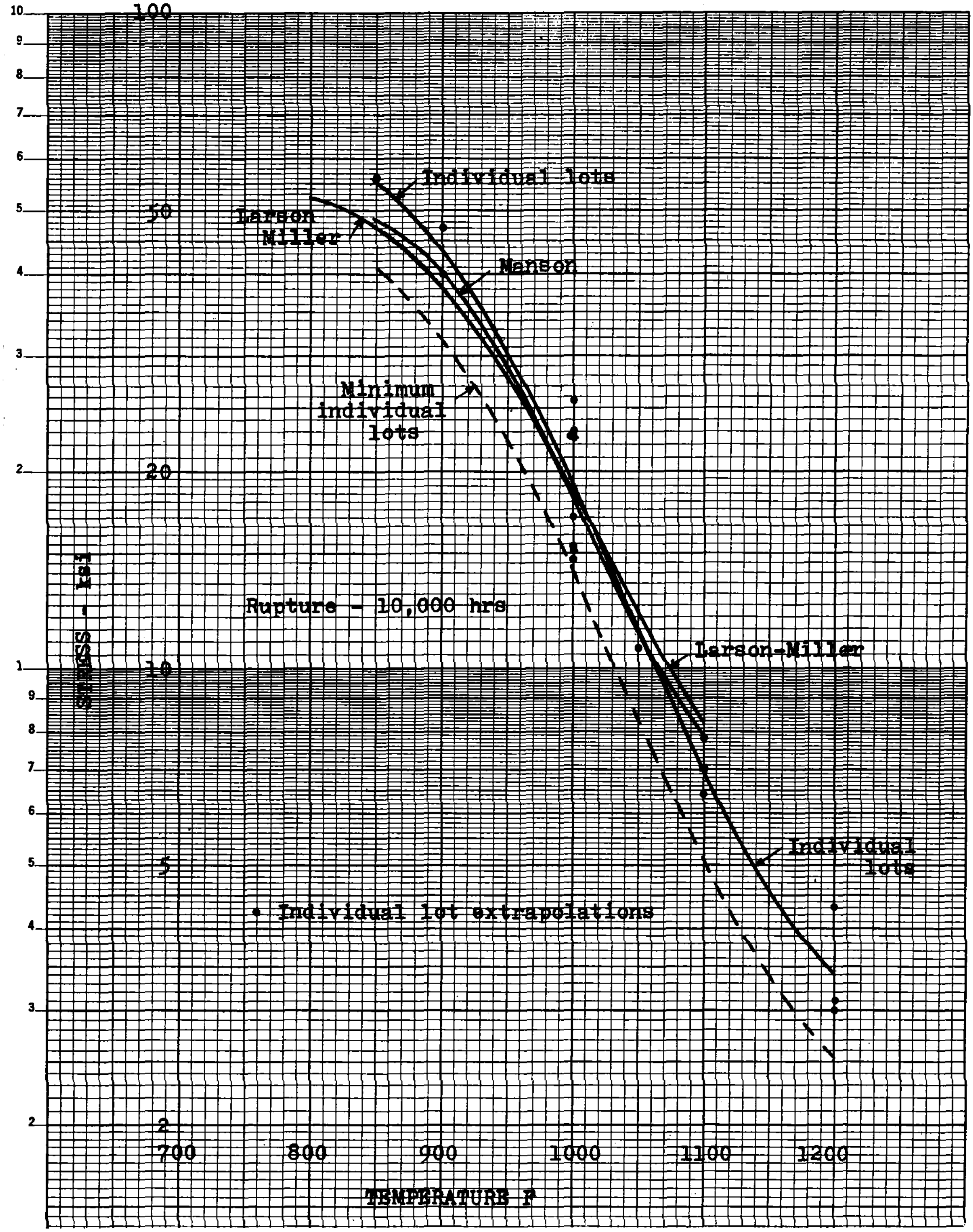


Figure 19b. Variation of rupture strength of 1 Cr - 1/2 Mo steel with temperature.

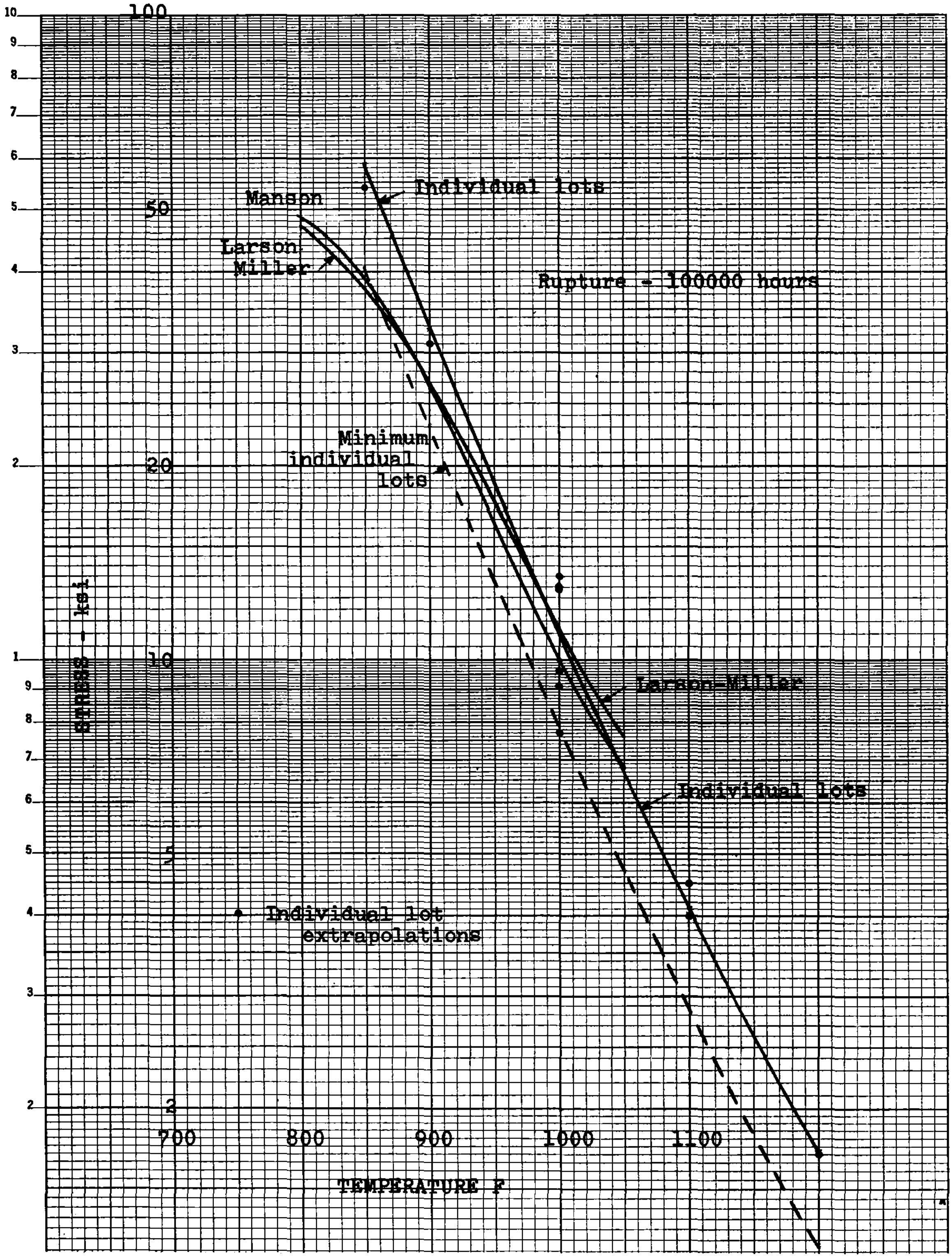


Figure 19c. Variation of rupture strength of 1 Cr - 1/2 Mo steel with temperature.

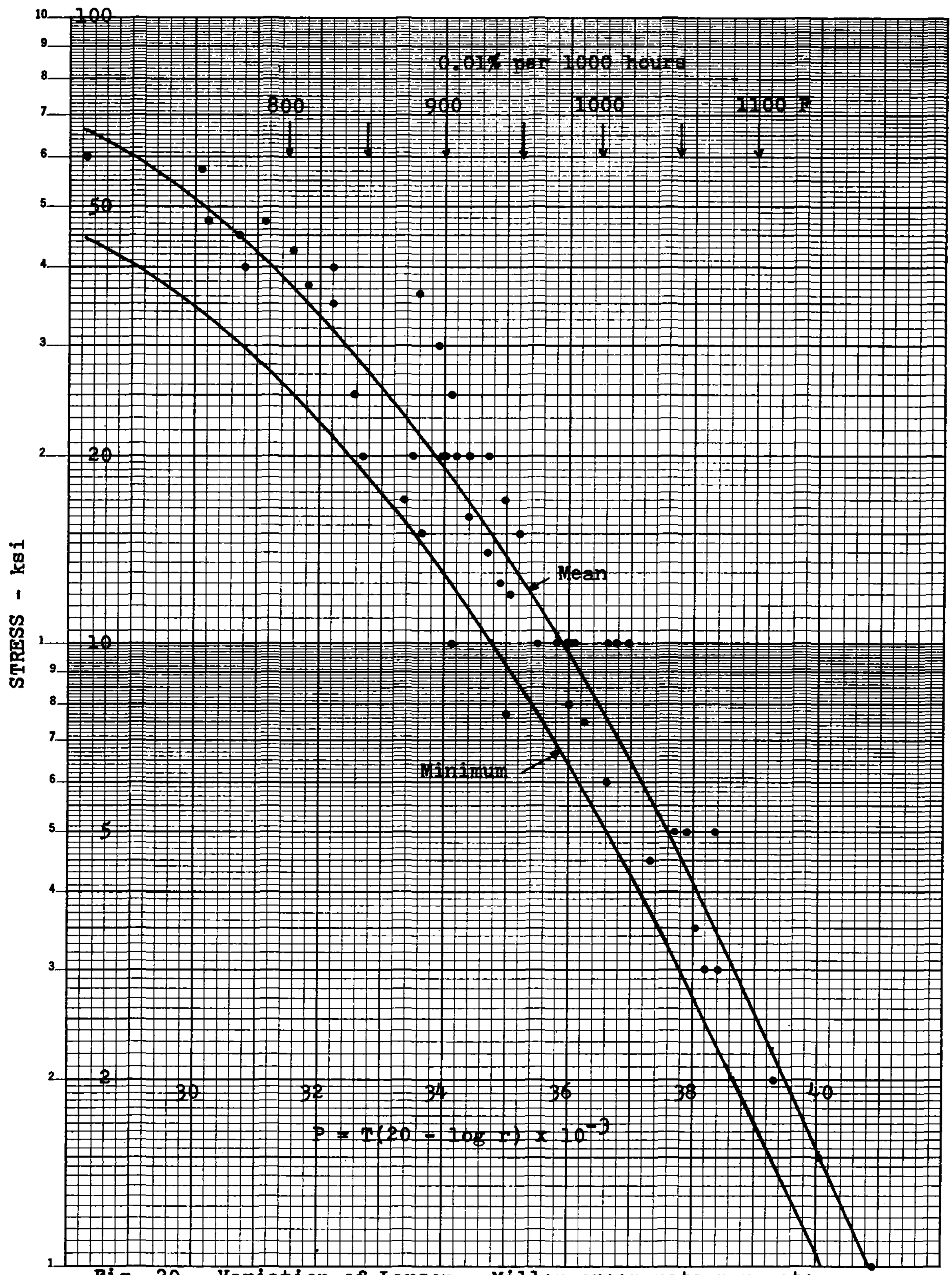


Fig. 20. Variation of Larson - Miller creep rate parameter with stress for 1 Cr - 1/2 Mo steel.

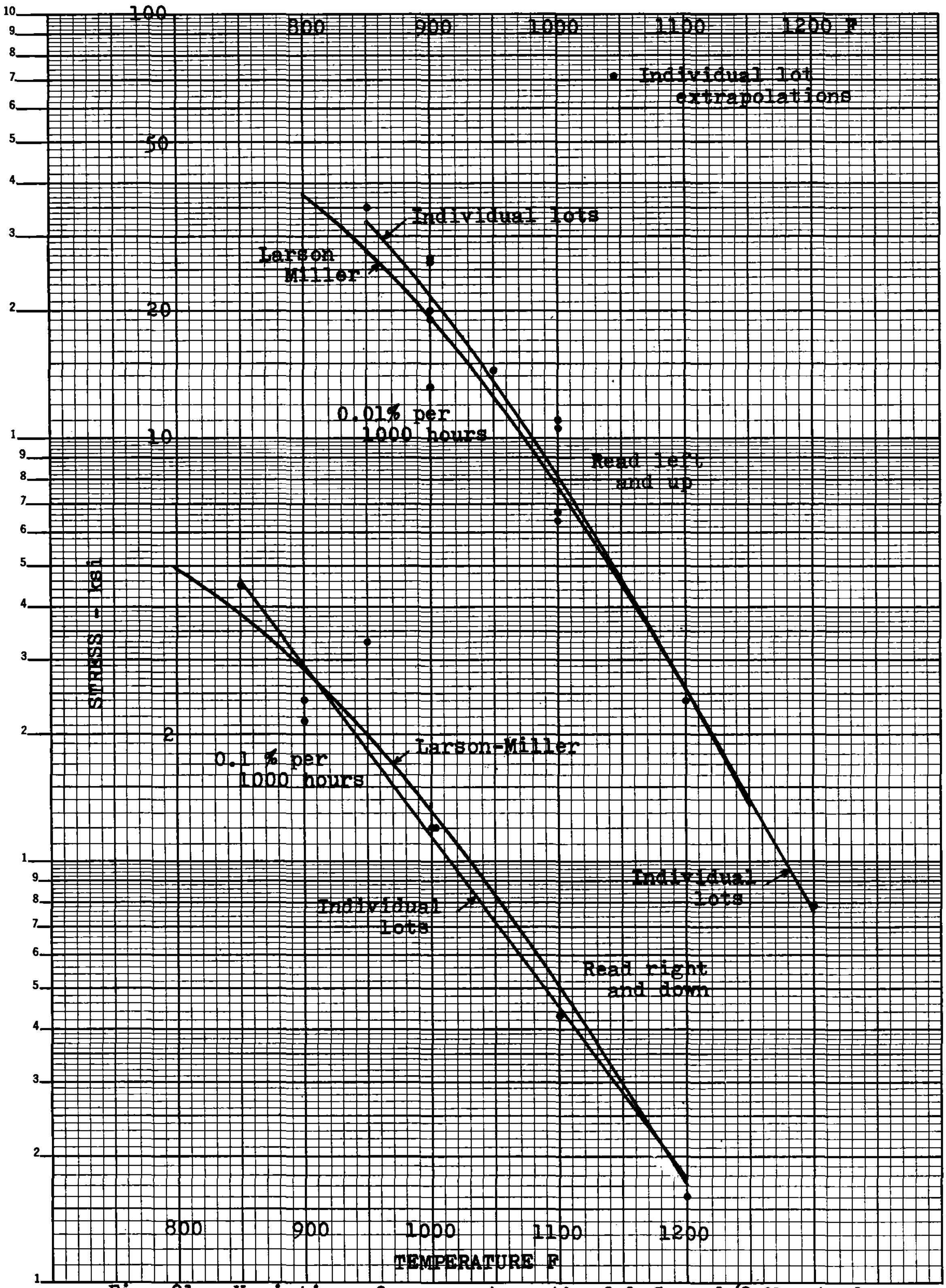


Fig. 21. Variation of creep strength of 1 Cr - 1/2 Mo steel with temperature.

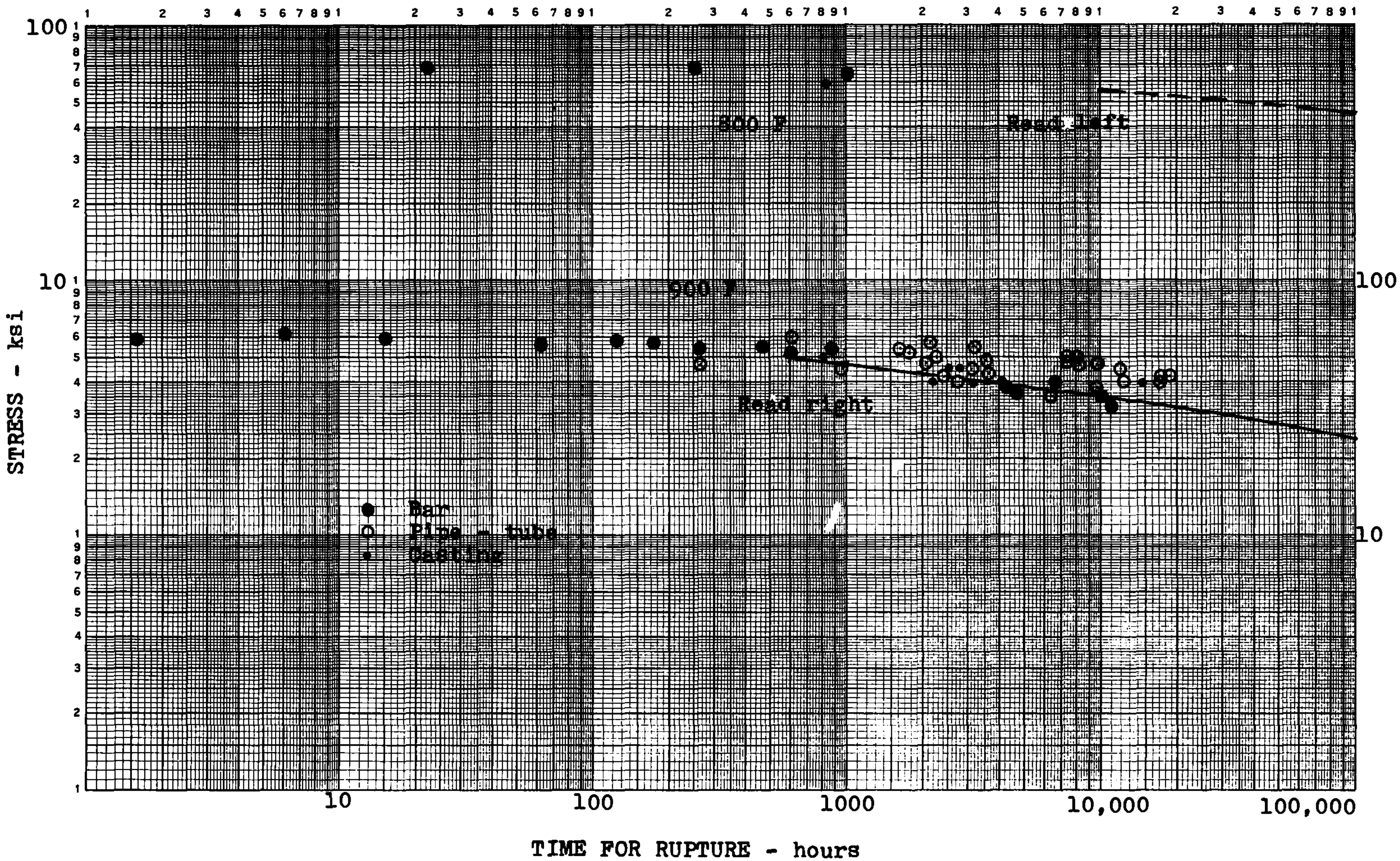


Fig. 22a. Stress vs time for rupture of 1 1/4 Cr - 1/2 Mo - Si steel. The superimposed curves were computed from the average Larson - Miller master curve, Figure 26c.

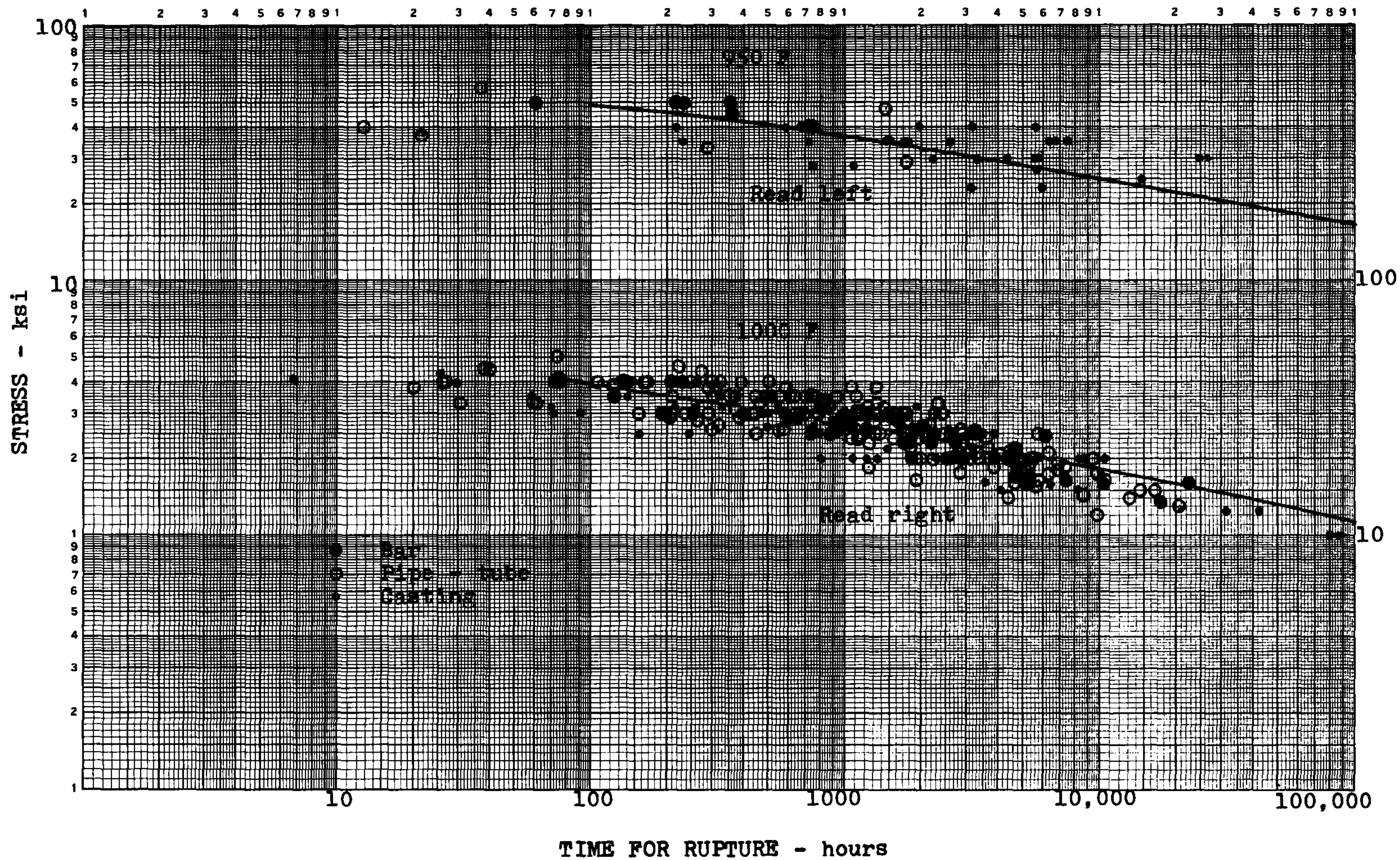
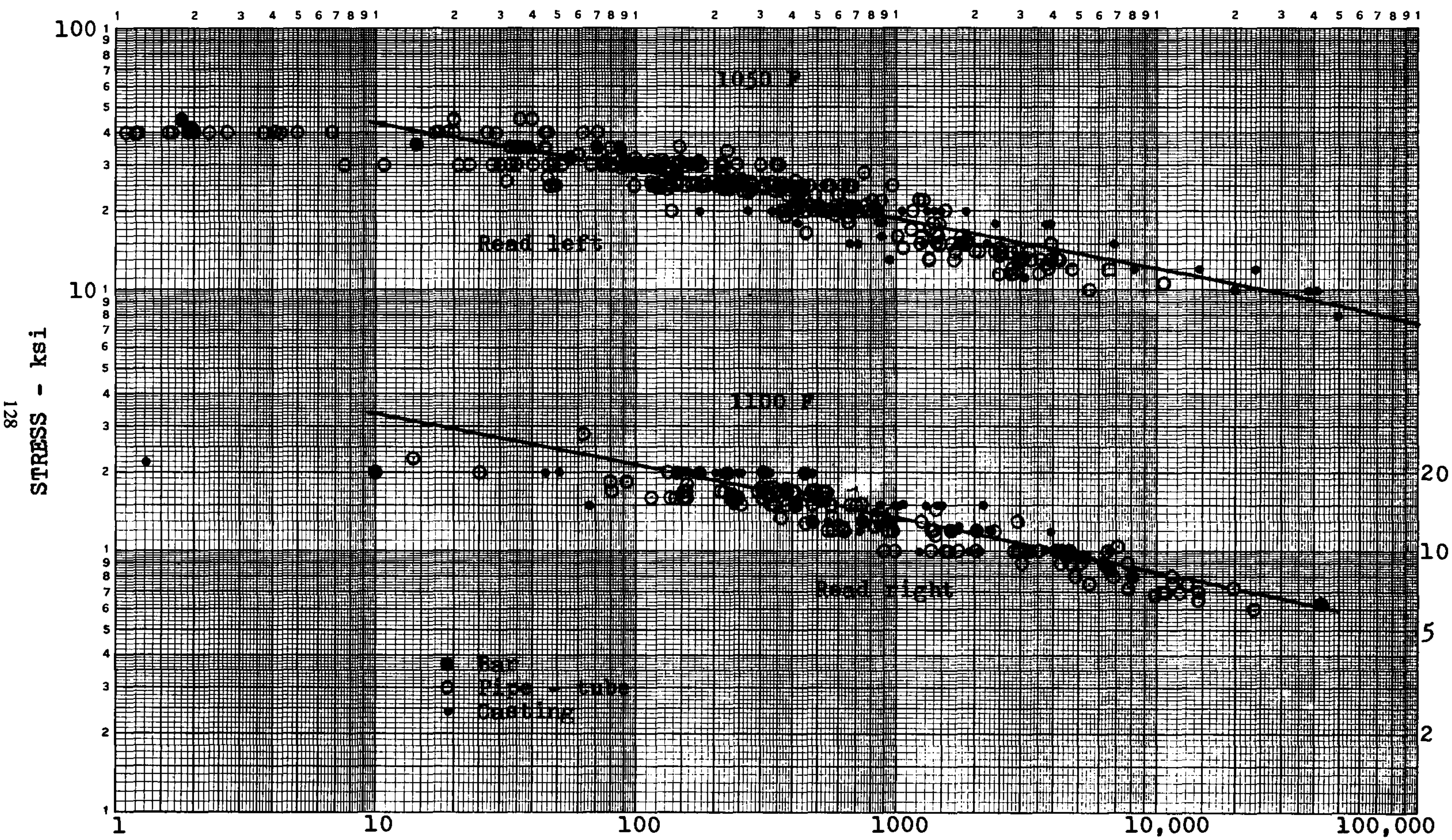


Fig. 22b. Stress vs time for rupture of 1 1/4 Cr - 1/2 Mo - Si steel. The superimposed curves were computed from the average Larson - Miller master curve, Figure 26c.



TIME FOR RUPTURE - hours

Fig. 22c. Stress vs time for rupture of 1 1/4 Cr - 1/2 Mo - Si steel. The superimposed curves were computed from the average Larson - Miller master curve, Figure 26c.

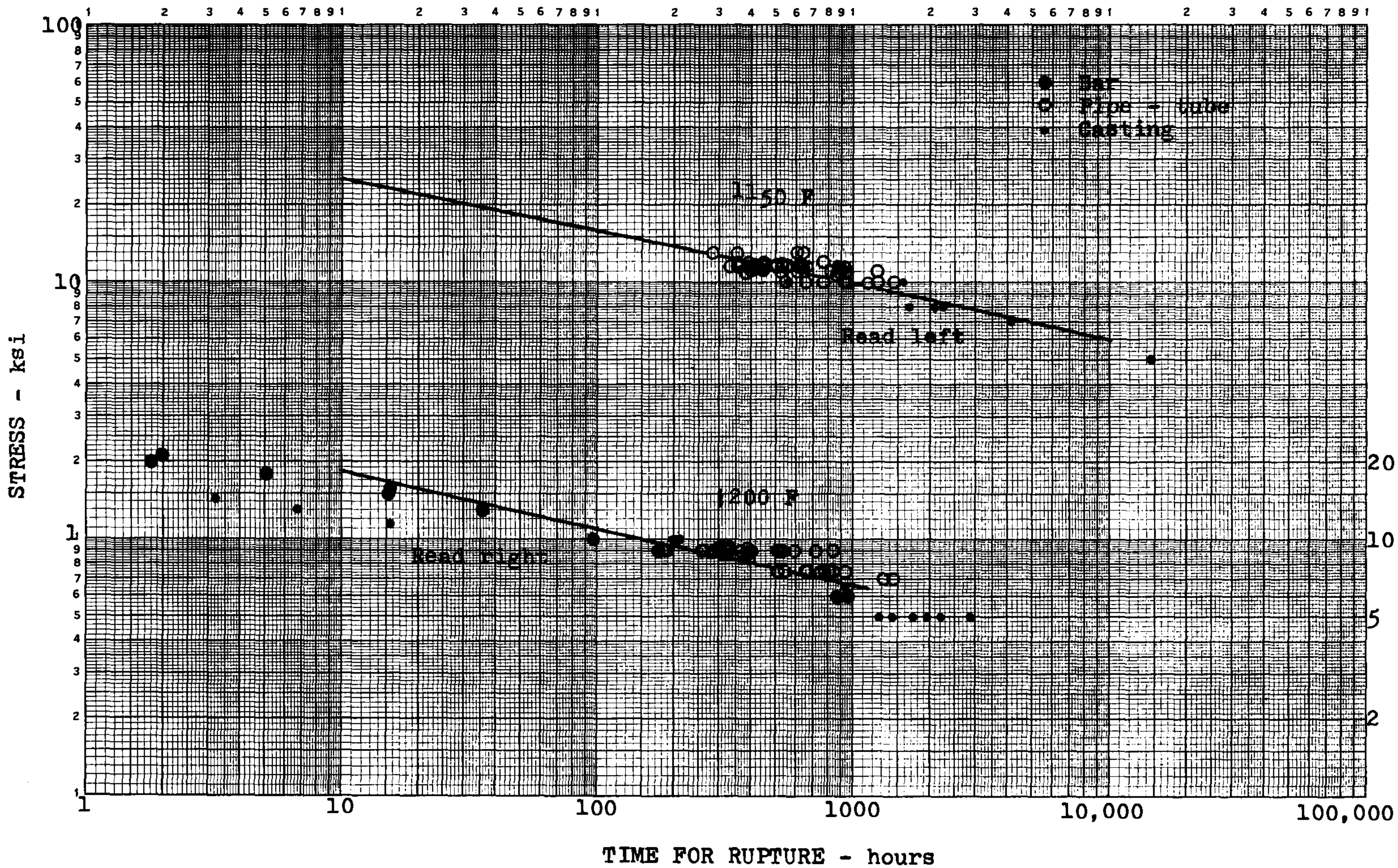


Fig. 22d. Stress vs time for rupture of 1 1/4 Cr - 1/2 Mo - Si steel. The superimposed curves were computed from the average Larson - Miller master curve, Figure 26c.

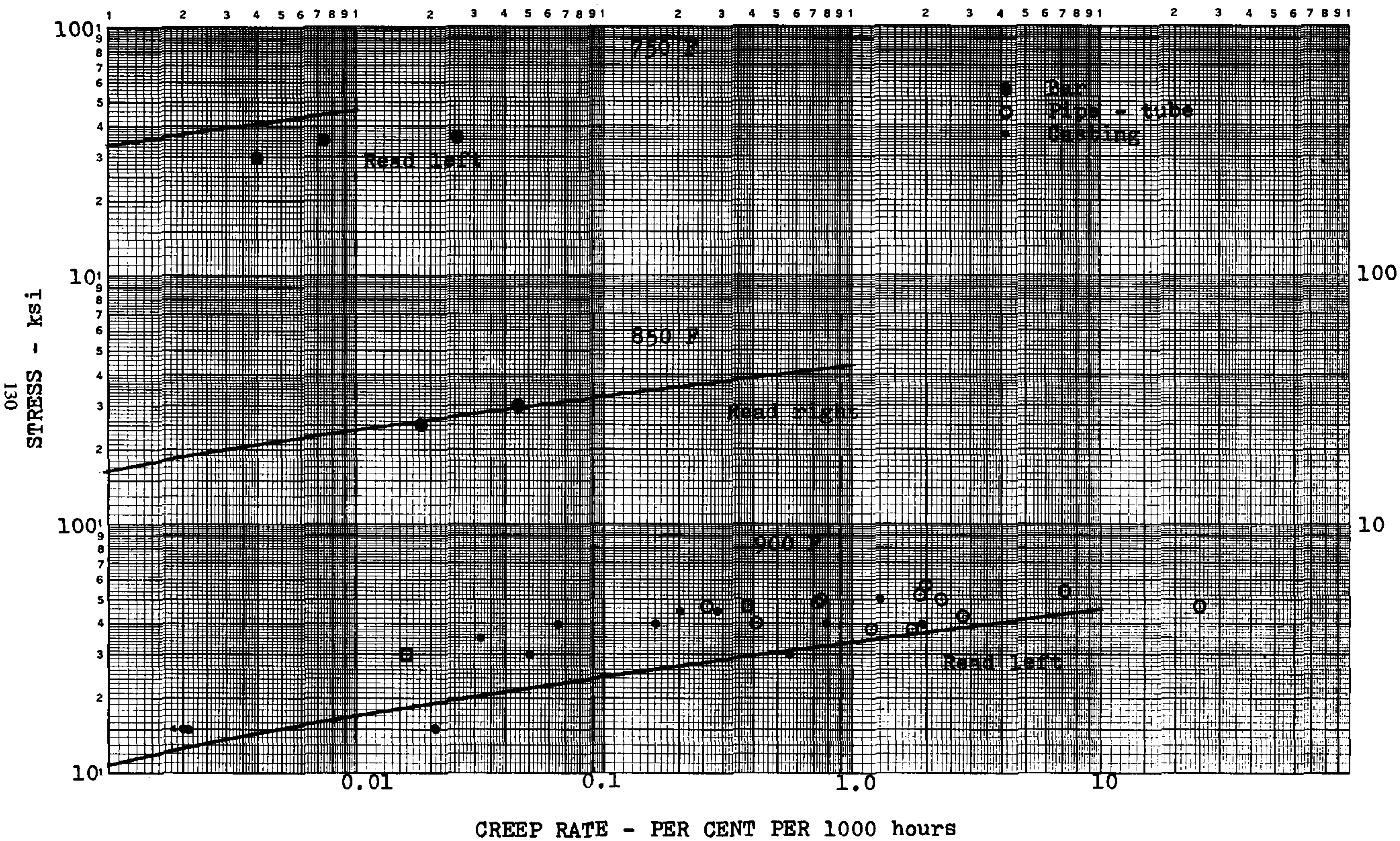


Fig. 23a. Stress vs. secondary creep rate for 1 1/4 Cr - 1/2 Mo - Si steel. The superimposed curves were computed from the mean Larson - Miller master curve, Figure 28c.

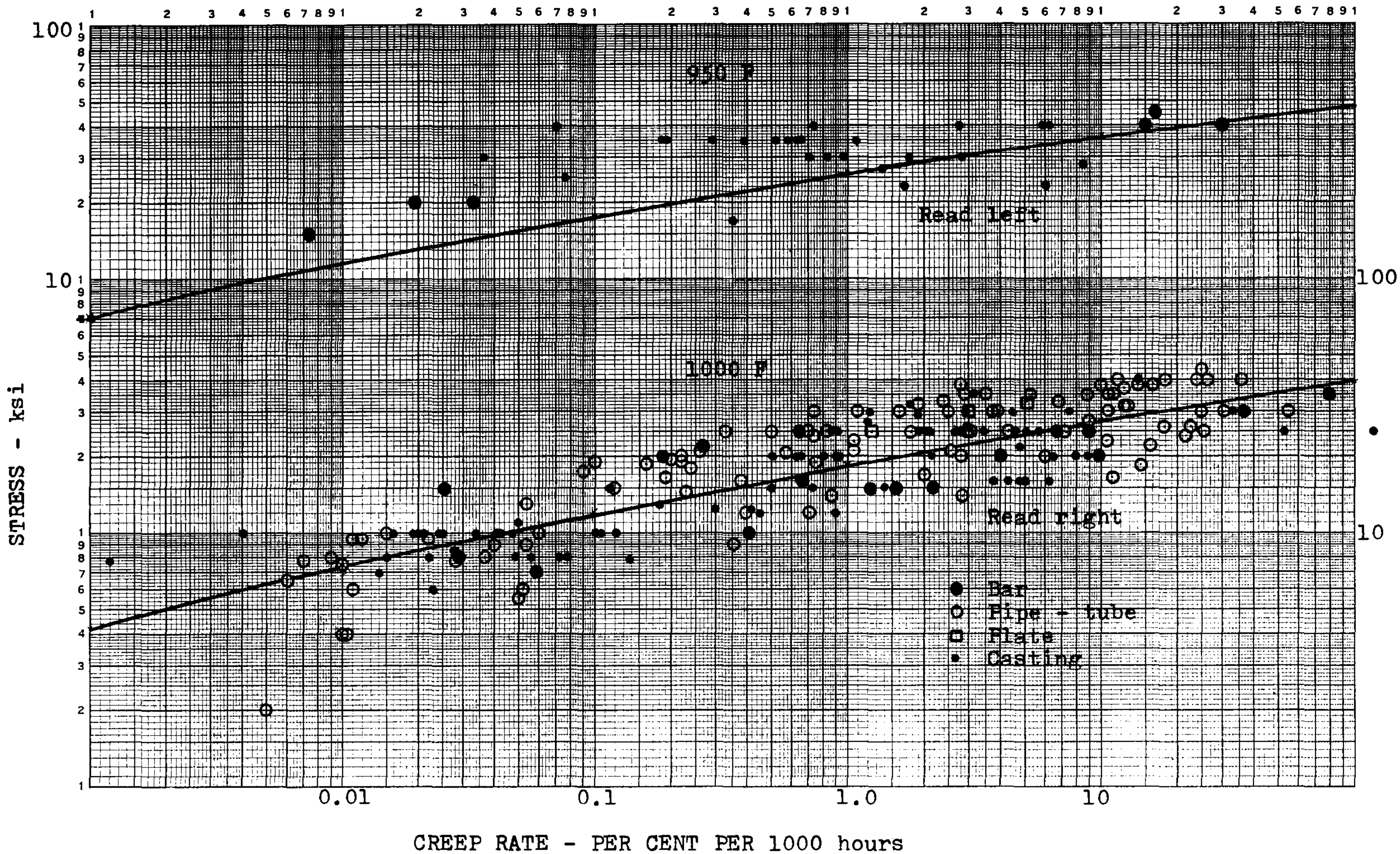


Fig. 23b. Stress vs. secondary creep rate for 1 1/4 Cr - 1/2 Mo - Si steel. The superimposed curves were computed from the mean Larson - Miller master curve, Figure 28c.

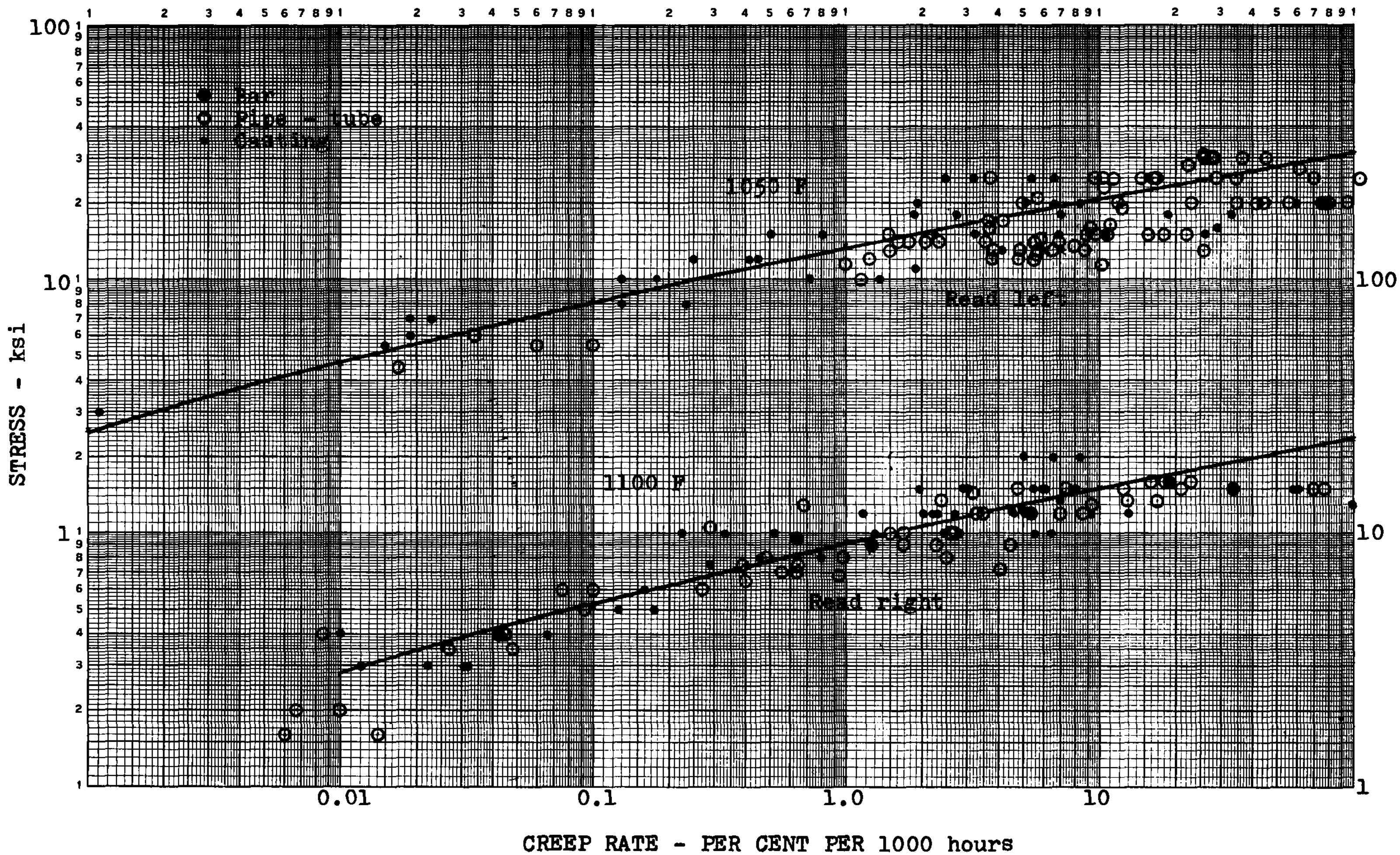


Fig. 23c. Stress vs secondary creep rate for 1 1/4 Cr - 1/2 Mo - Si steel. The superimposed curves were computed from the mean Larson - Miller master curve, Figure 28c.

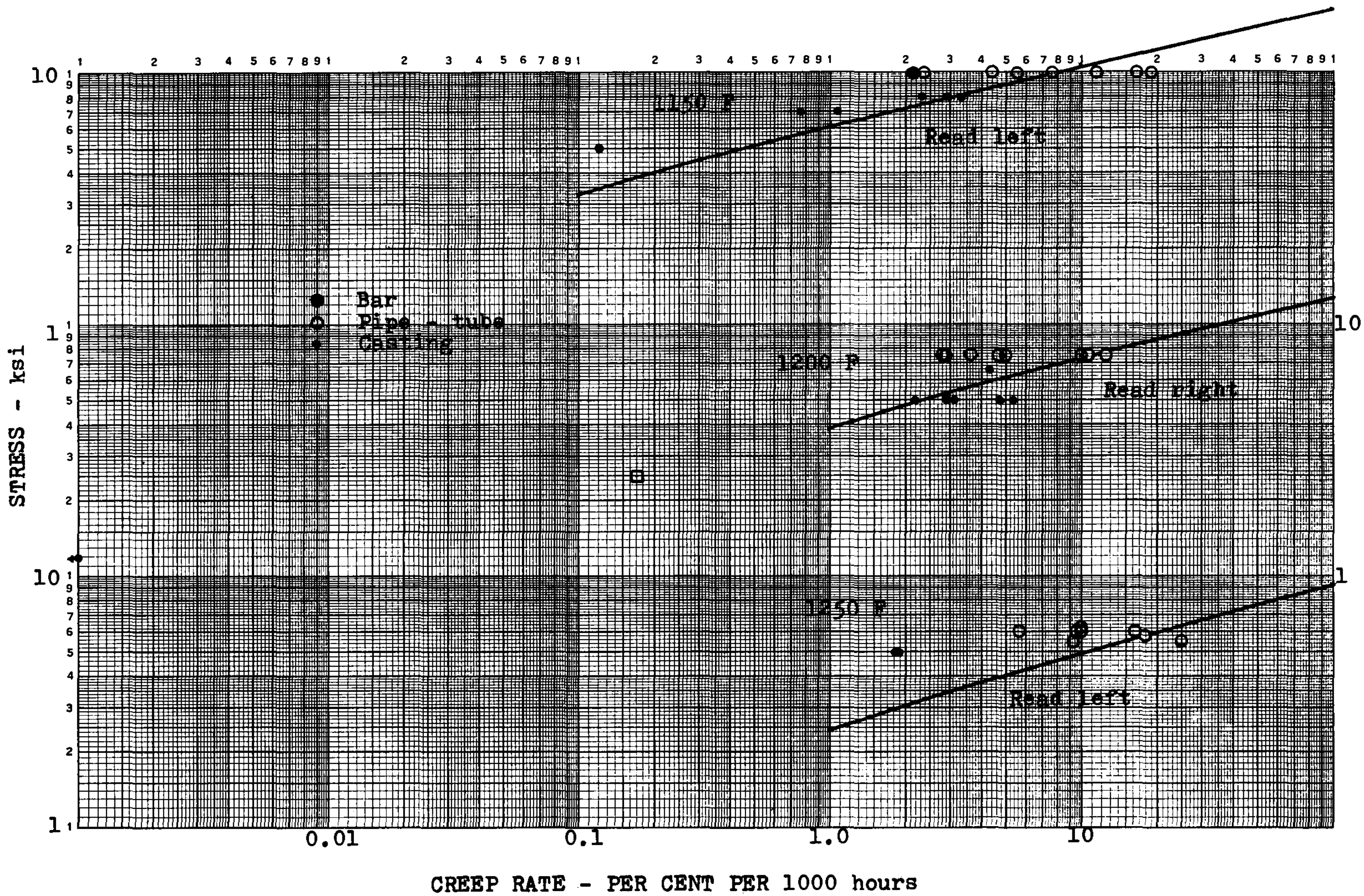


Fig. 23d. Stress vs. secondary creep rate for 1 1/4 Cr - 1/2 Mo - Si steel. The superimposed curves were computed from the mean Larson - Miller master curve, Fig. 28c.

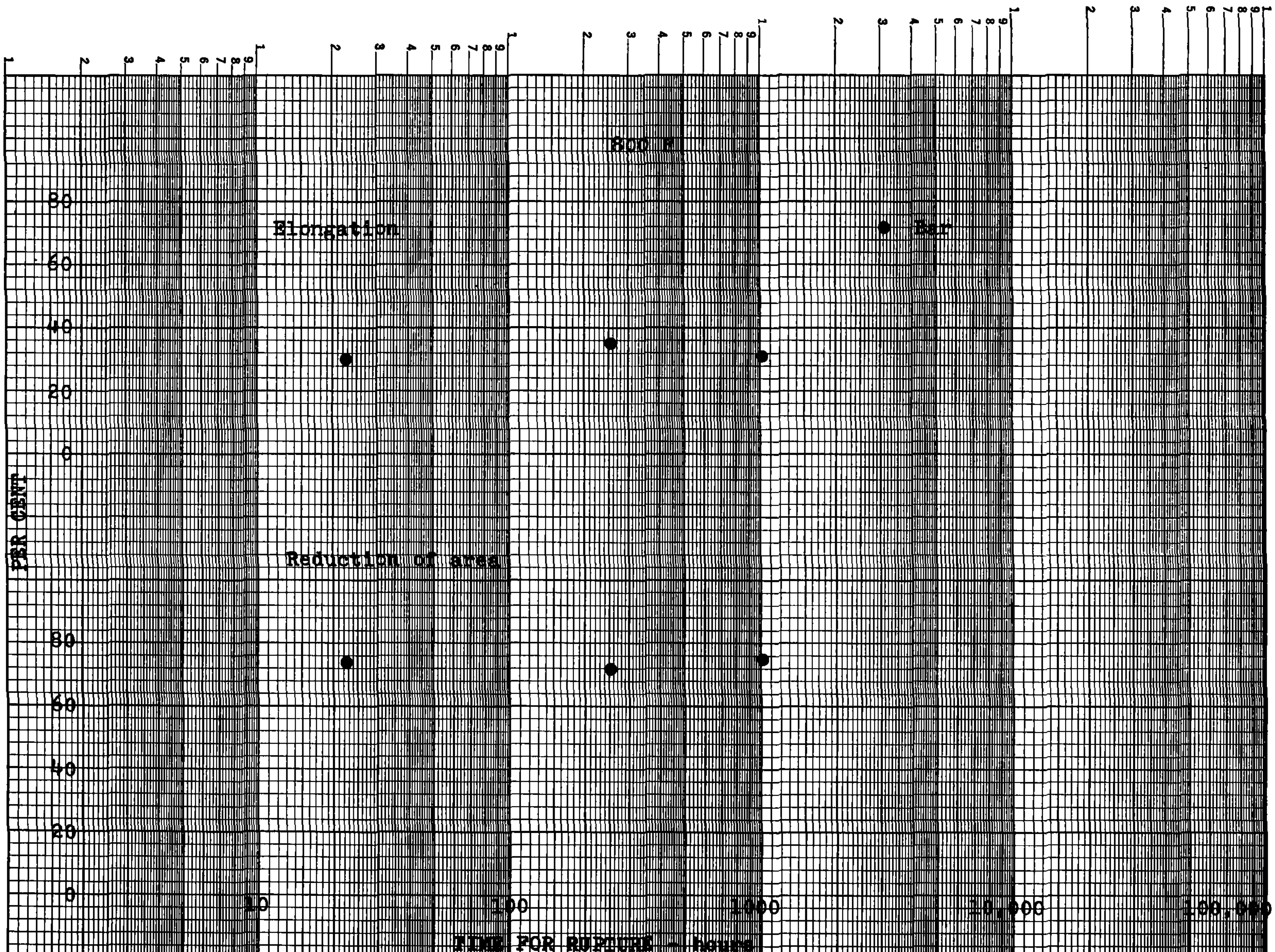


Fig. 24a. Variation of rupture ductility of 1 1/4 Cr - 1/2 Mo - Si steel with time for rupture.

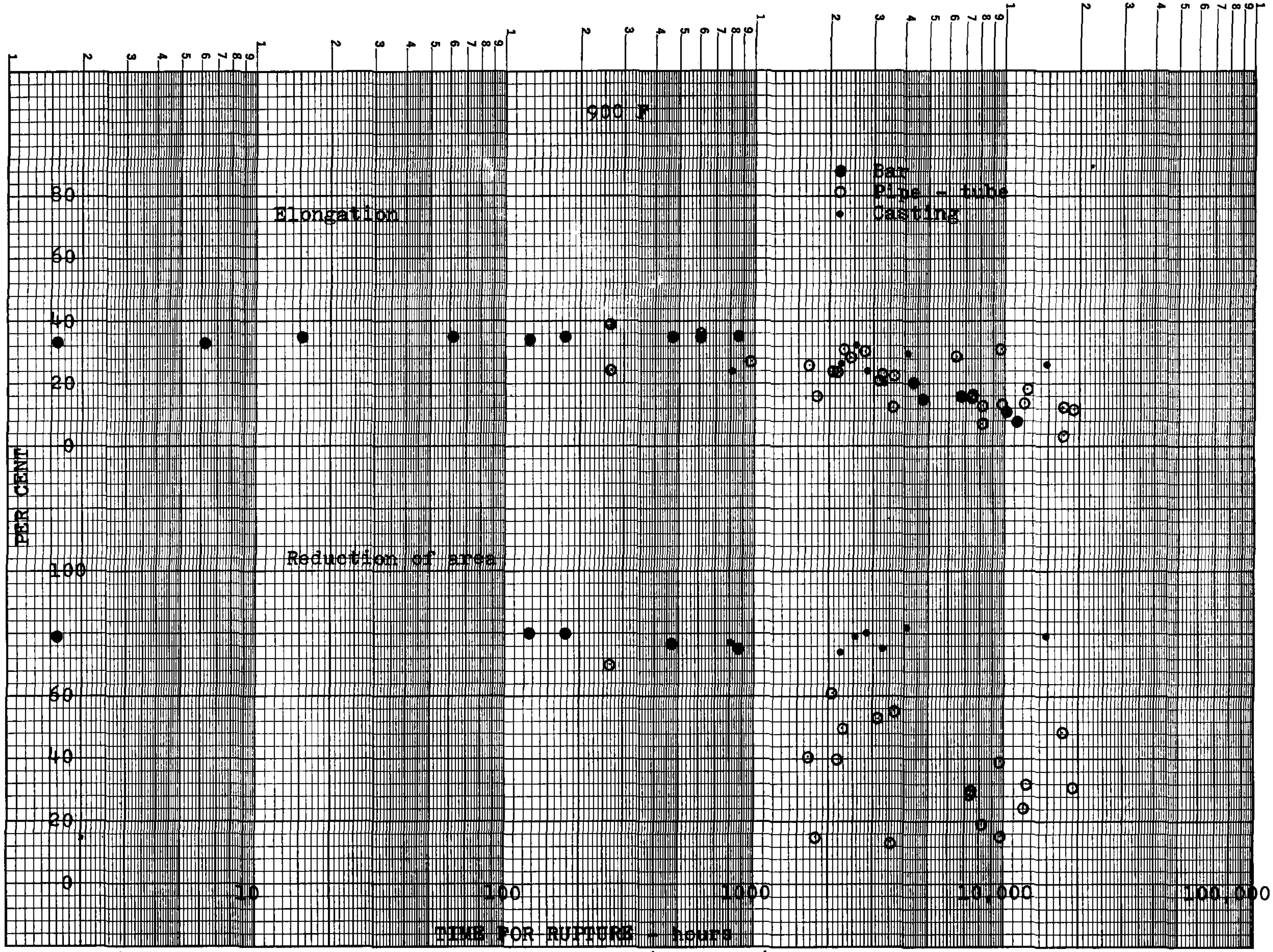


Fig. 24b. Variation of rupture ductility of 1 1/4 Cr - 1/2 Mo - Si steel with time for rupture.

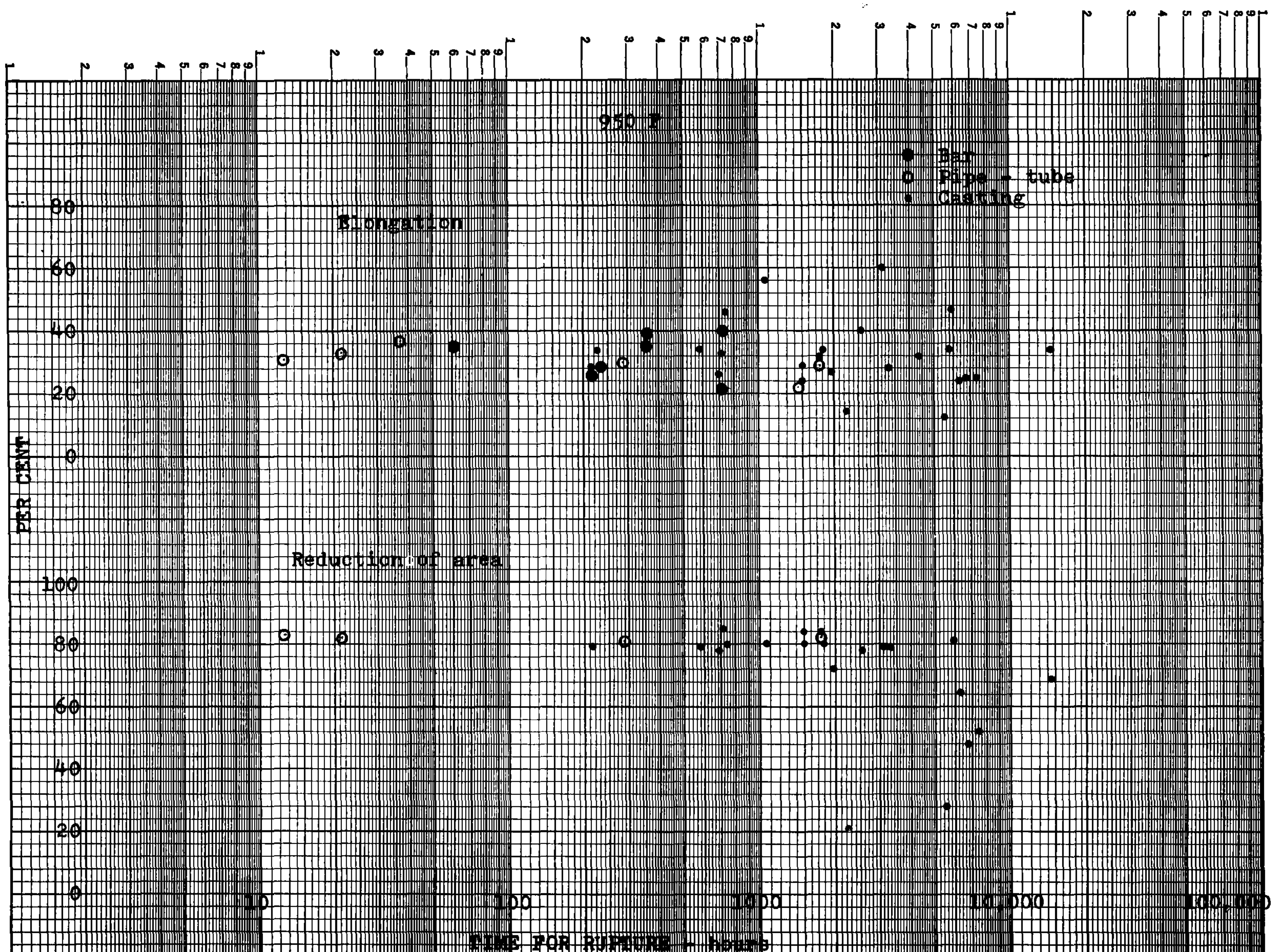


Fig. 24c. Variation of rupture ductility of 1 1/4 Cr - 1/2 Mo - Si steel with time for rupture.

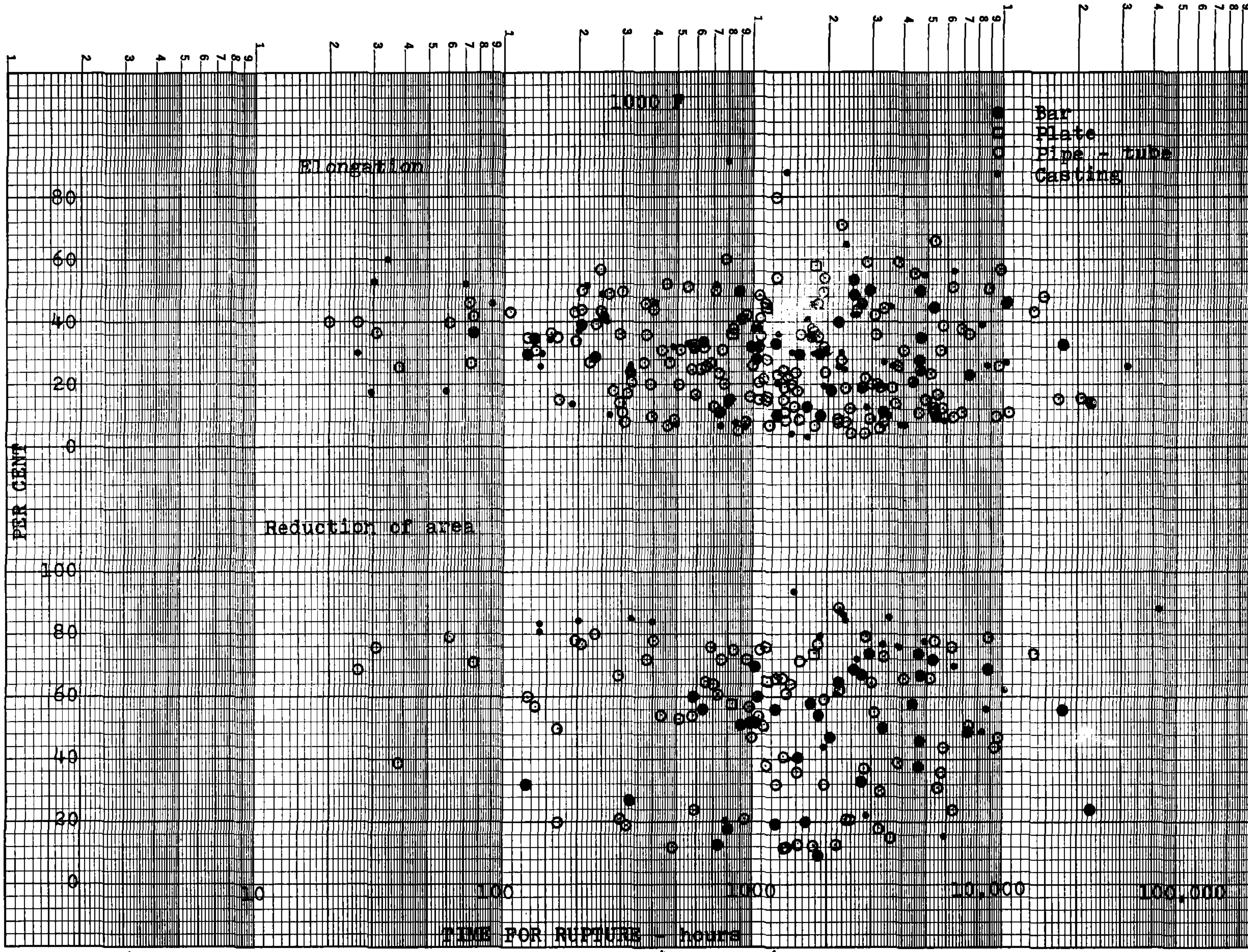


Fig. 24d. Variation of rupture ductility of 1 1/4 Cr - 1/2 Mo - Si steel with time for rupture.

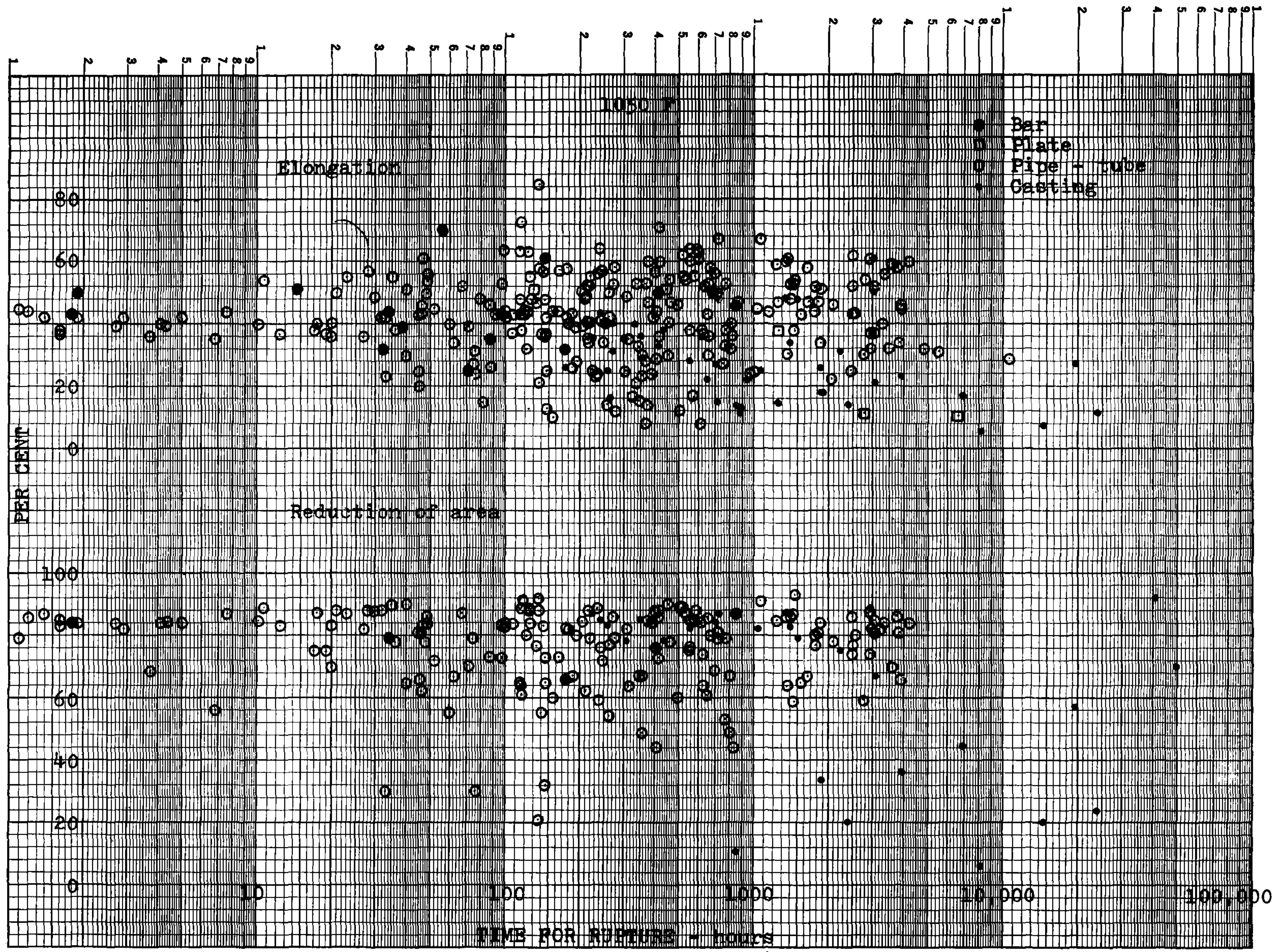


Fig. 24e. Variation of rupture ductility of 1 1/4 Cr - 1/2 Mo - Si steel with time for rupture.

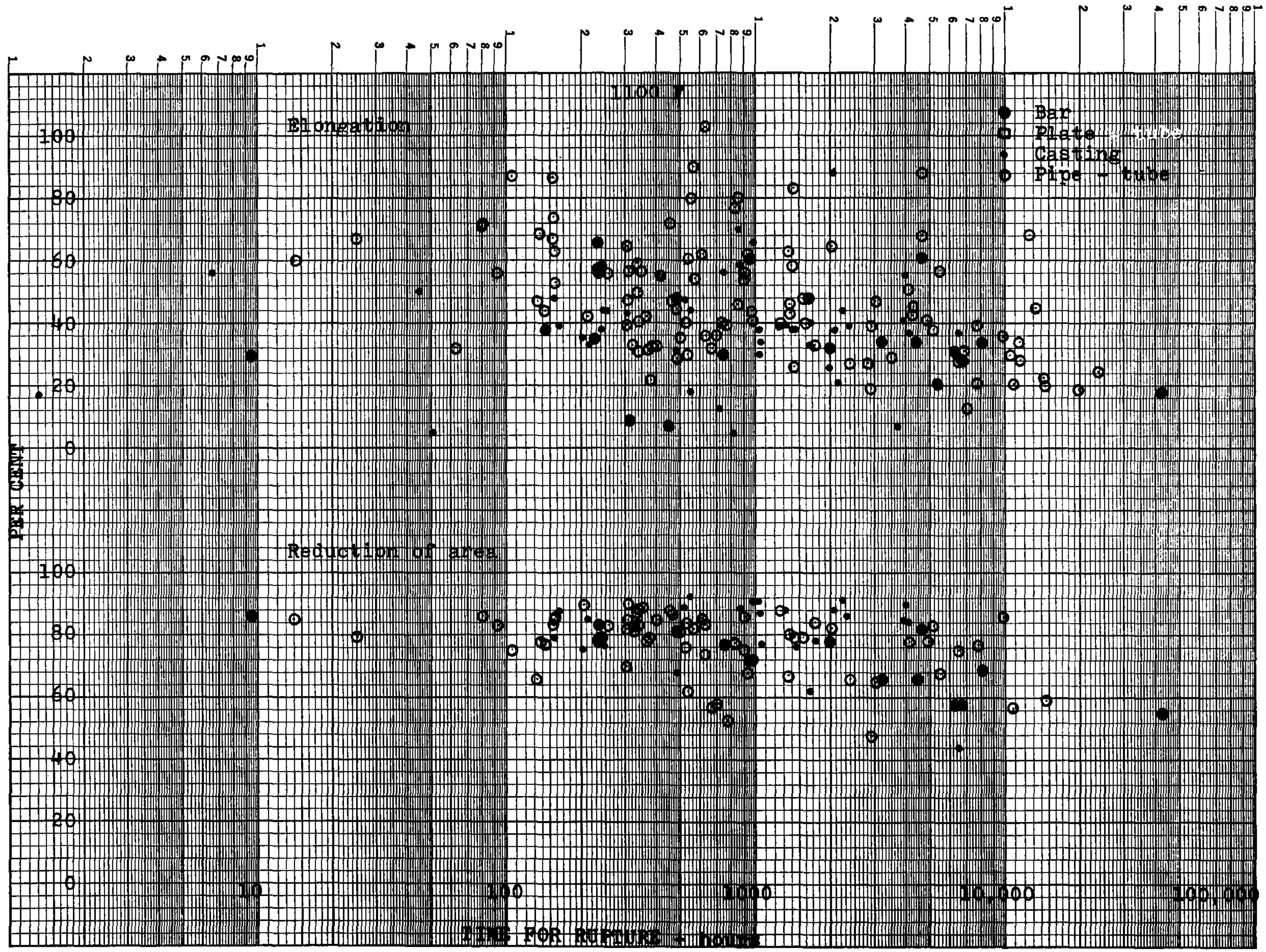


Fig. 24f. Variation of rupture ductility of 1 1/4 Cr - 1/2 Mo - Si steel with time for rupture.

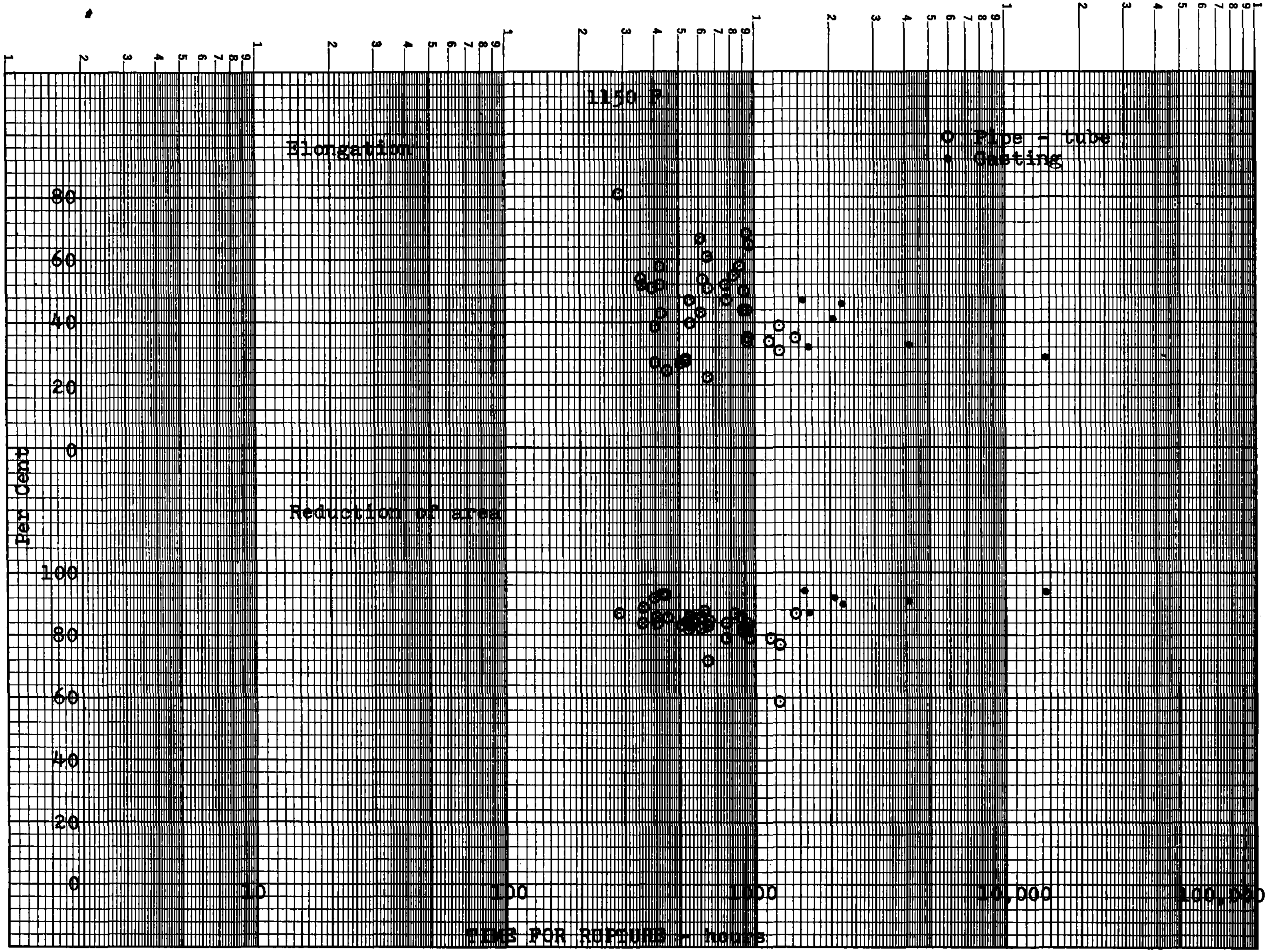


Fig. 24g. Variation of rupture ductility of 1 1/4 Cr - 1/2 Mo - Si steel with time for rupture.

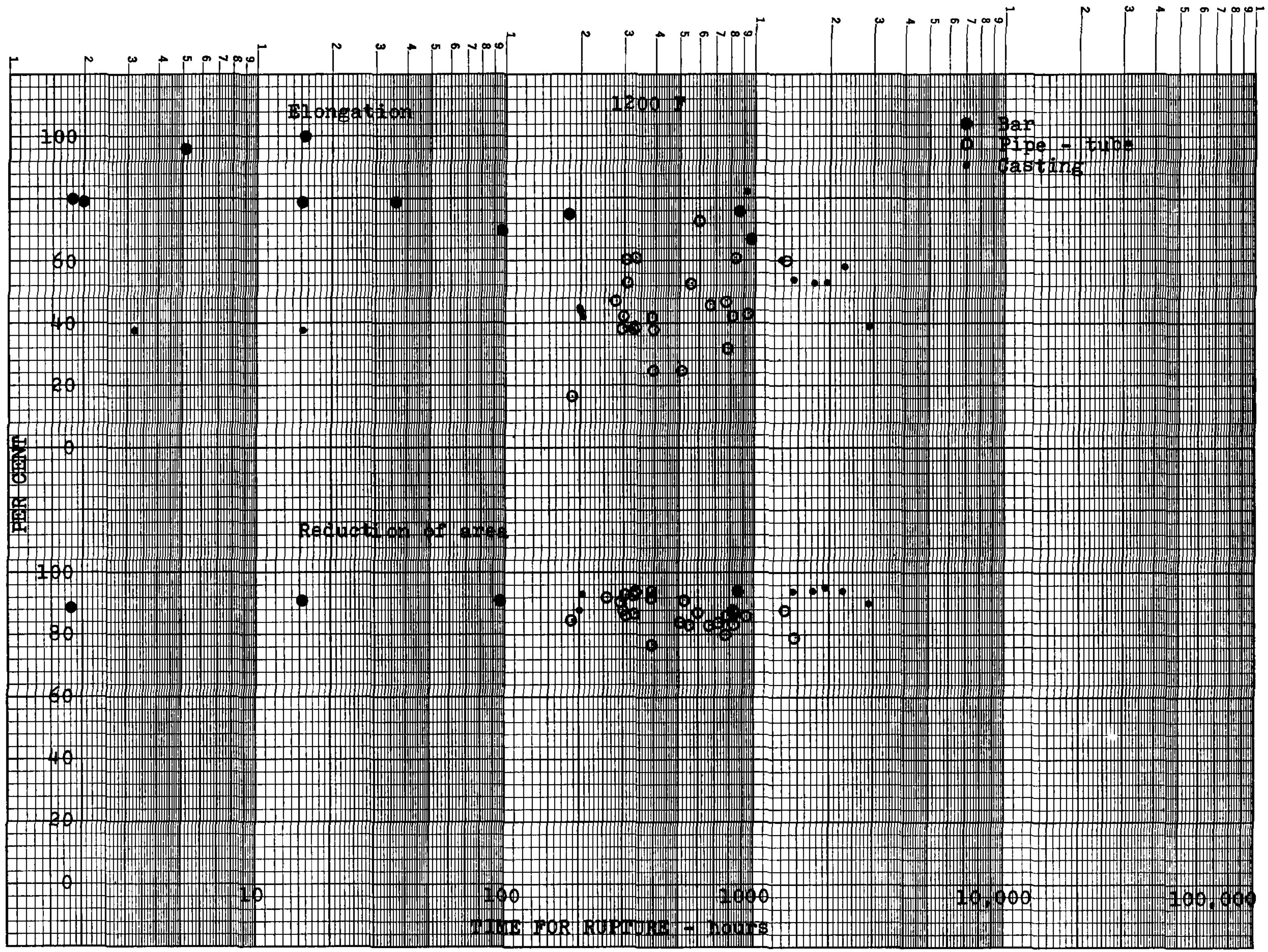


Fig. 24h. Variation of rupture ductility of 1 1/4 Cr - 1/2 Mo - Si steel with time for rupture.

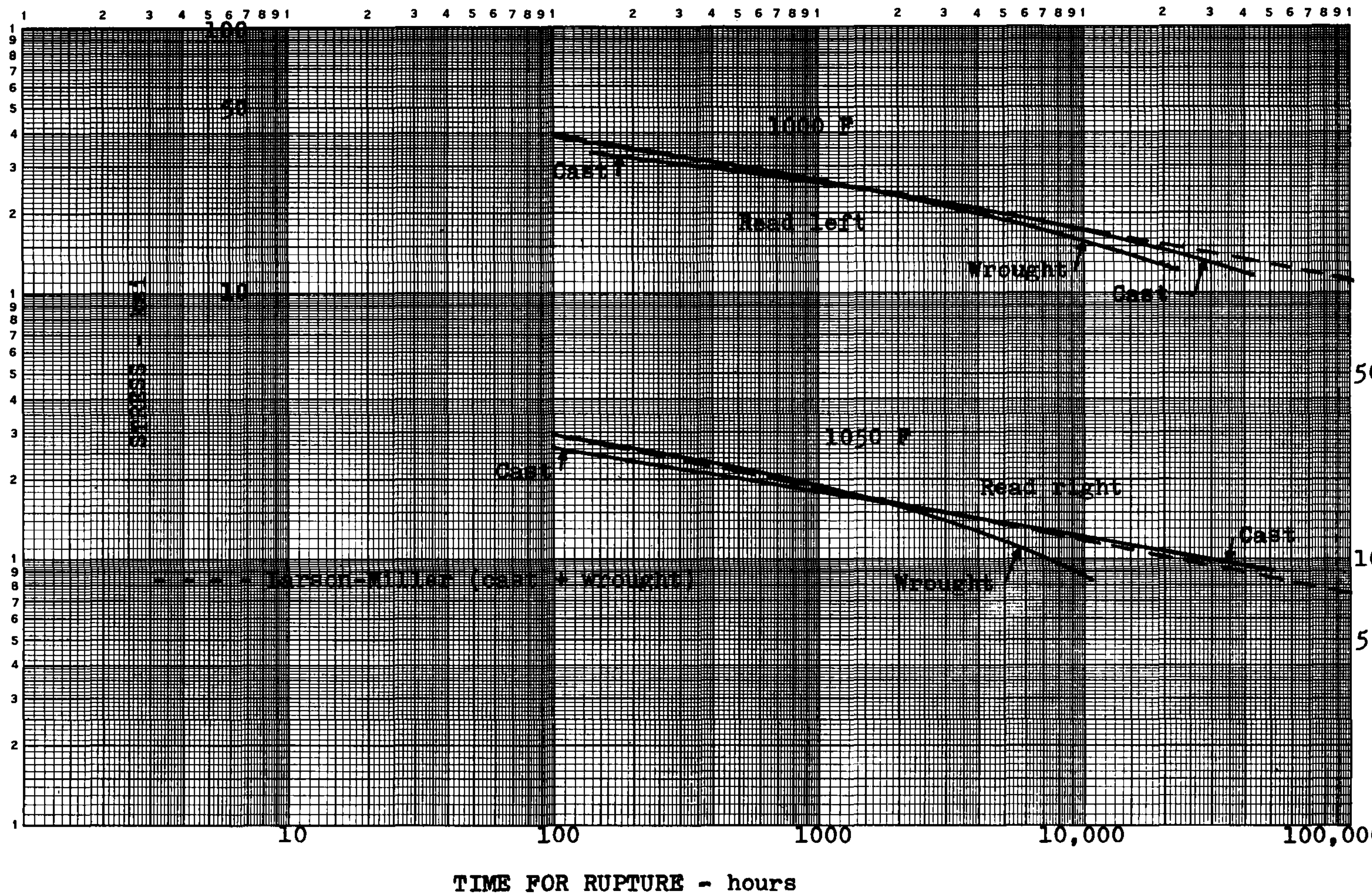


Fig. 25. Comparison of the least squares results for the variation of time-for-rupture with stress for cast and wrought 1 1/4 Cr - 1/2 Mo - Si steel at 1000 and 1050 F. Also shown are curves computed from the Larson-Miller master curve for combined wrought and cast steels.

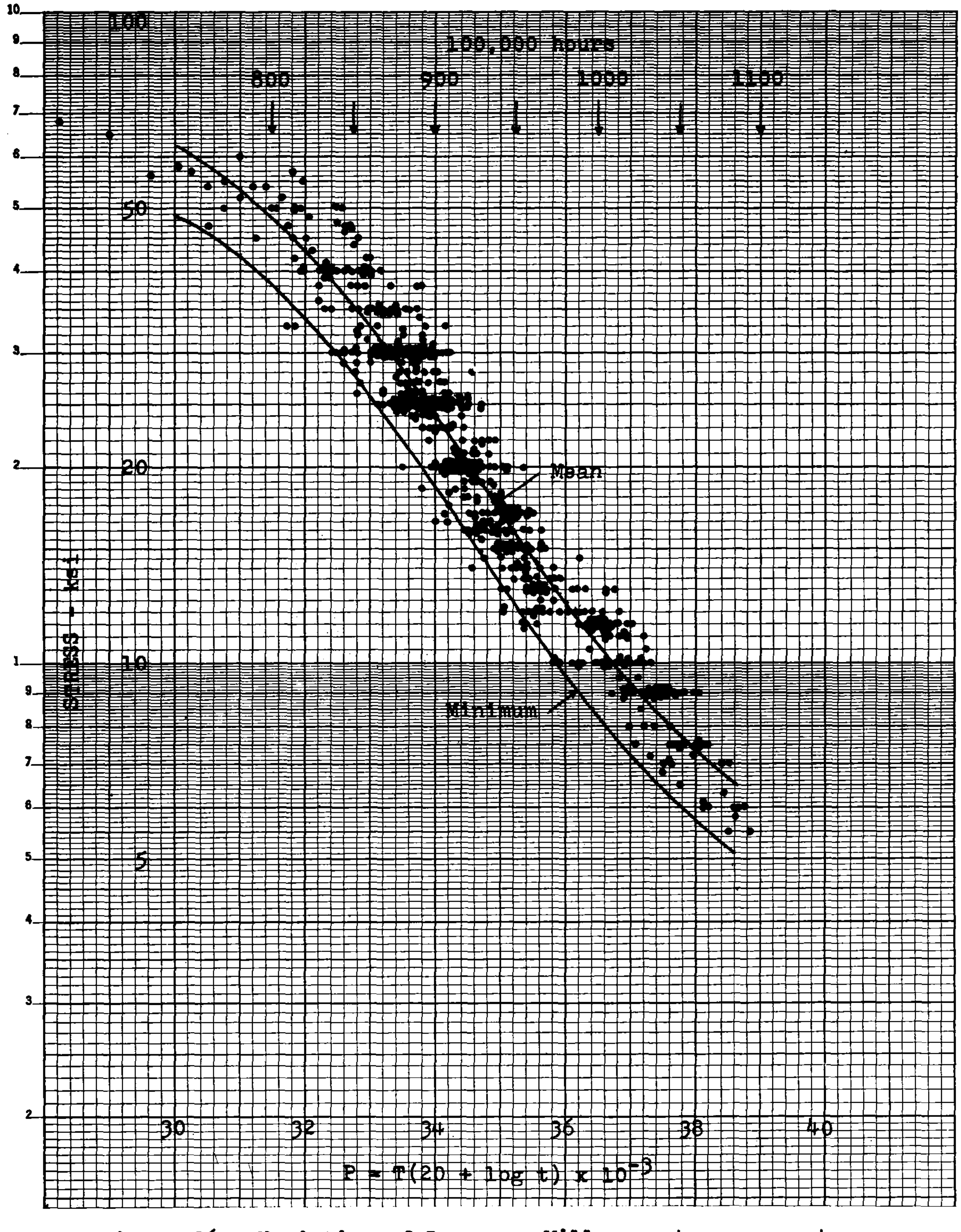


Figure 26a Variation of Larson - Miller rupture parameter with stress for wrought 1 1/4 Cr 1/2 Mo - Si steel.

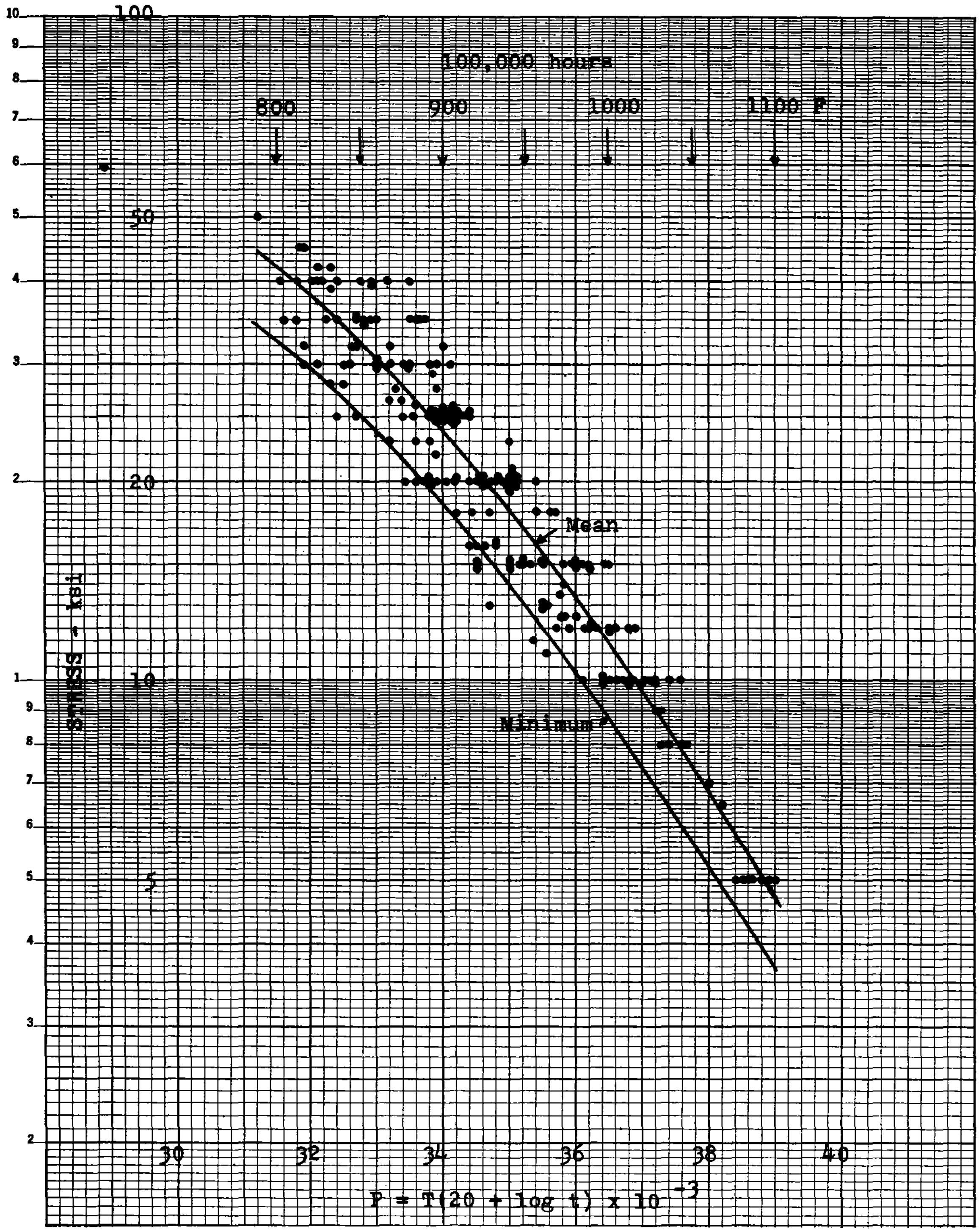


Fig. 26b. Variation of Larson - Miller rupture parameter with stress for cast 1 1/4 Cr - 1/2 Mo - Si steel.

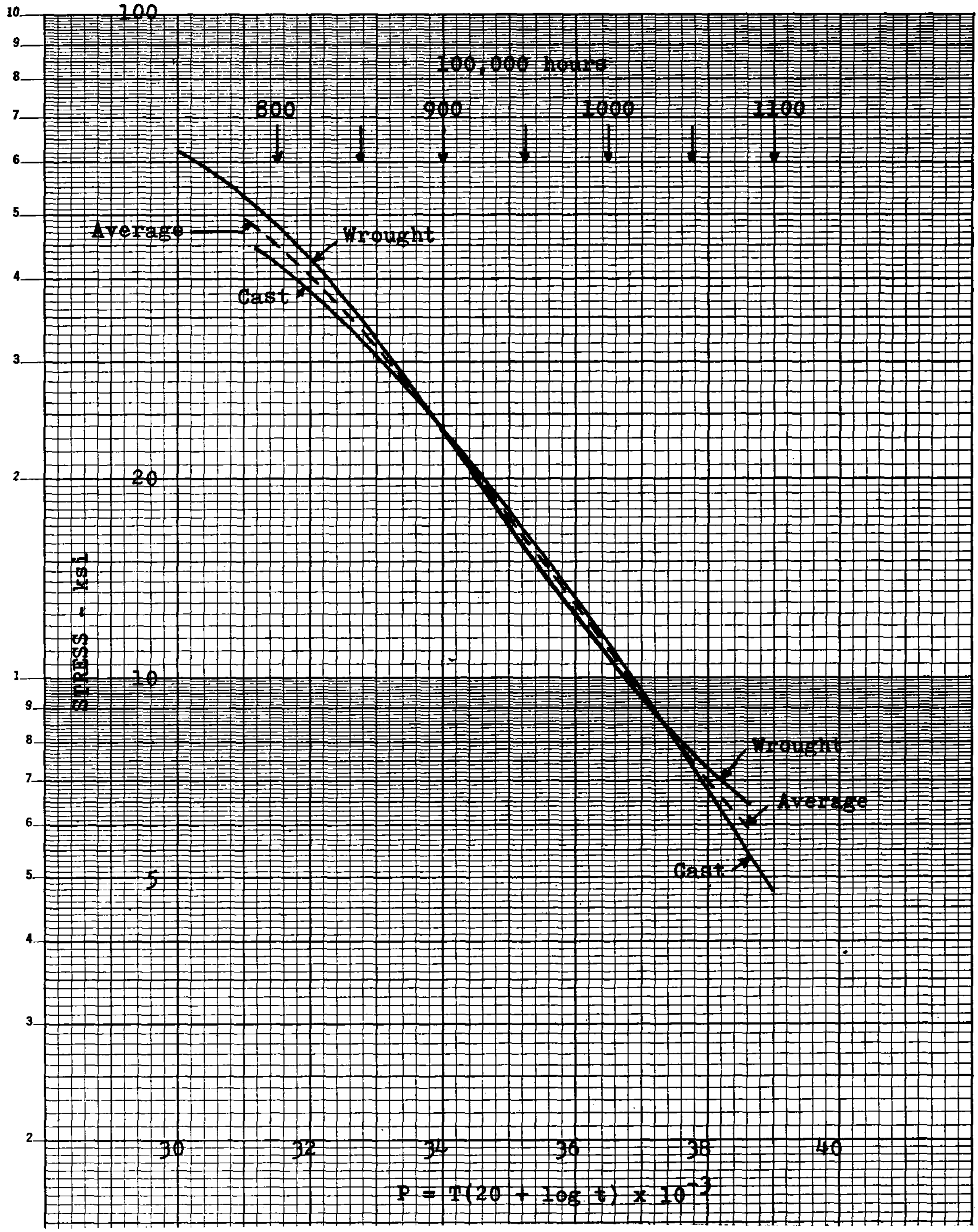


Fig. 26c. Variation of Larson - Miller rupture parameter with stress for wrought, cast and combined cast and wrought 1 1/4 Cr - 1/2 Mo - Si steel.

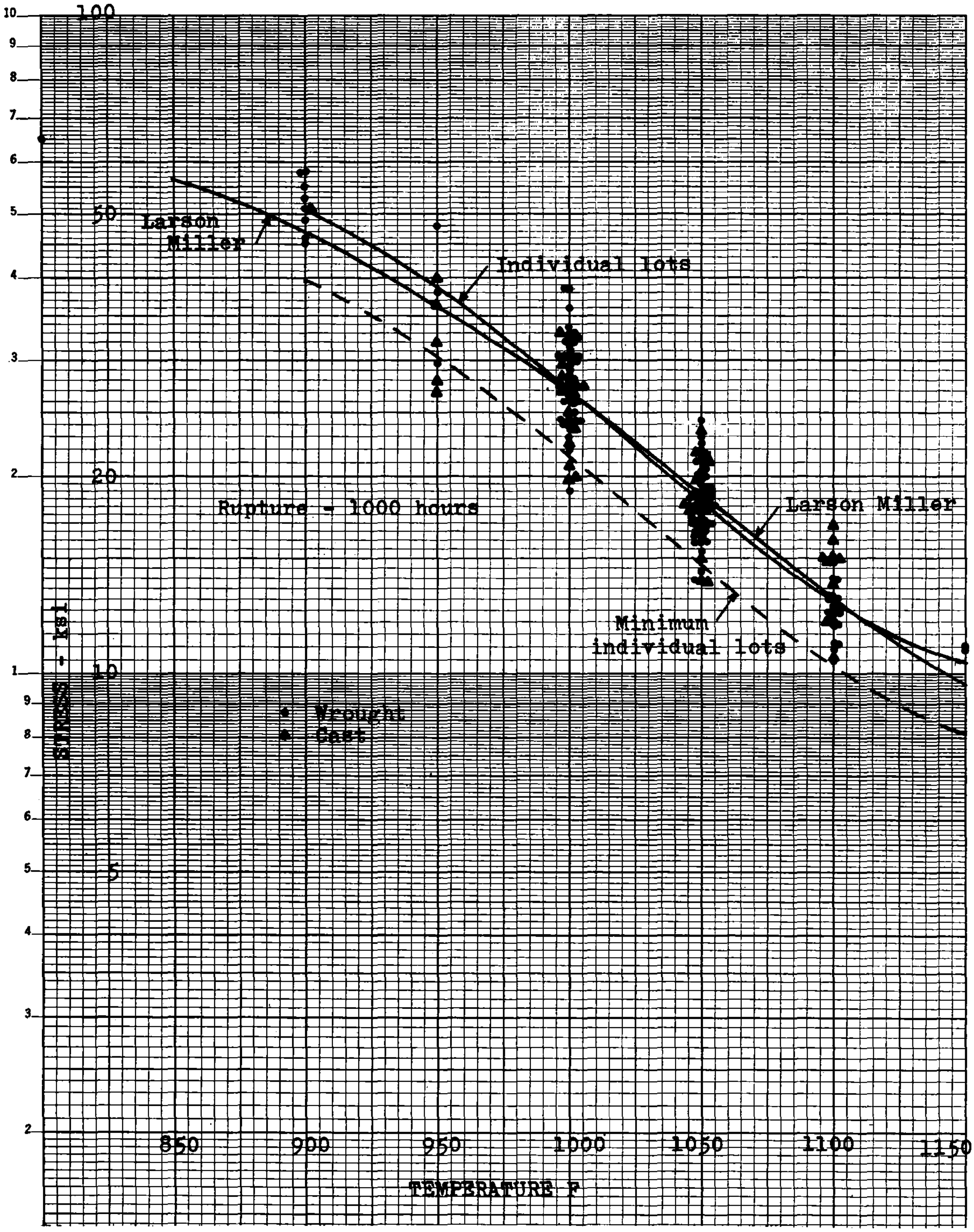


Fig. 27a. Variation of rupture strength of 1 1/4 Cr - 1/2 Mo - Si steel with temperature.

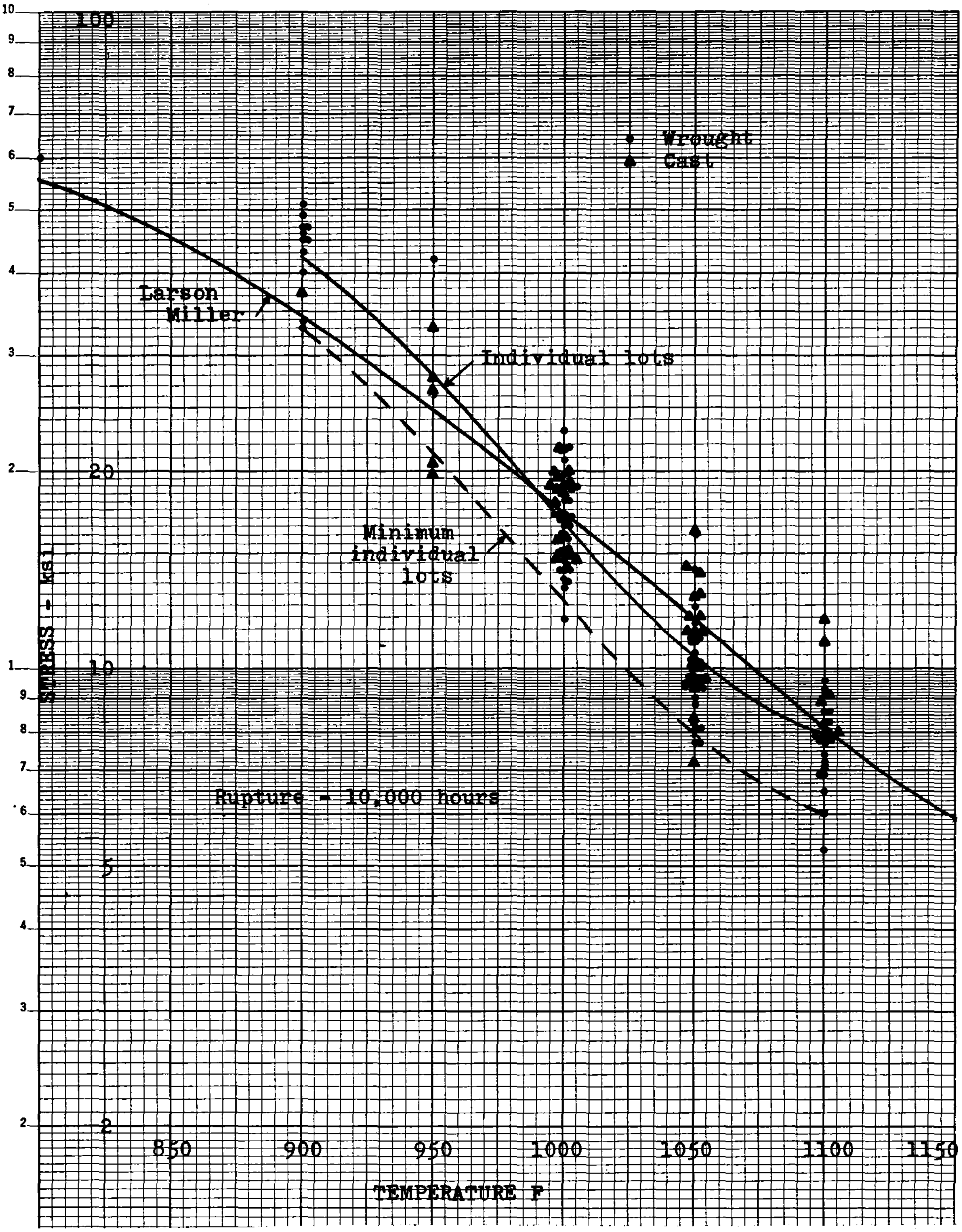


Fig. 27b. Variation of rupture strength of 1 1/4 Cr - 1/2 Mo - Si steel with temperature.

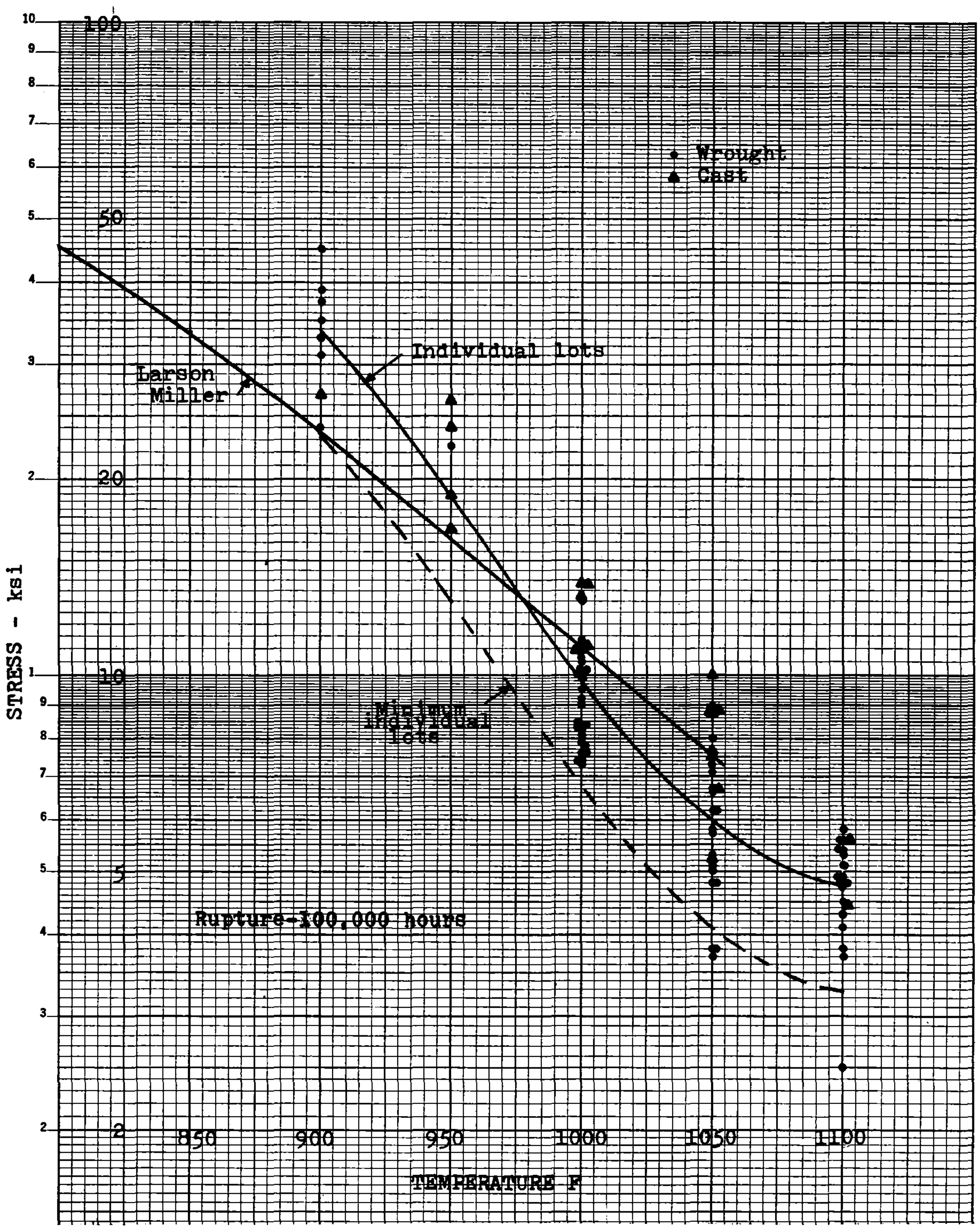


Fig. 27c. Variation of rupture strength of 1 1/4 Cr - 1/2 Mo - Si steel with temperature.

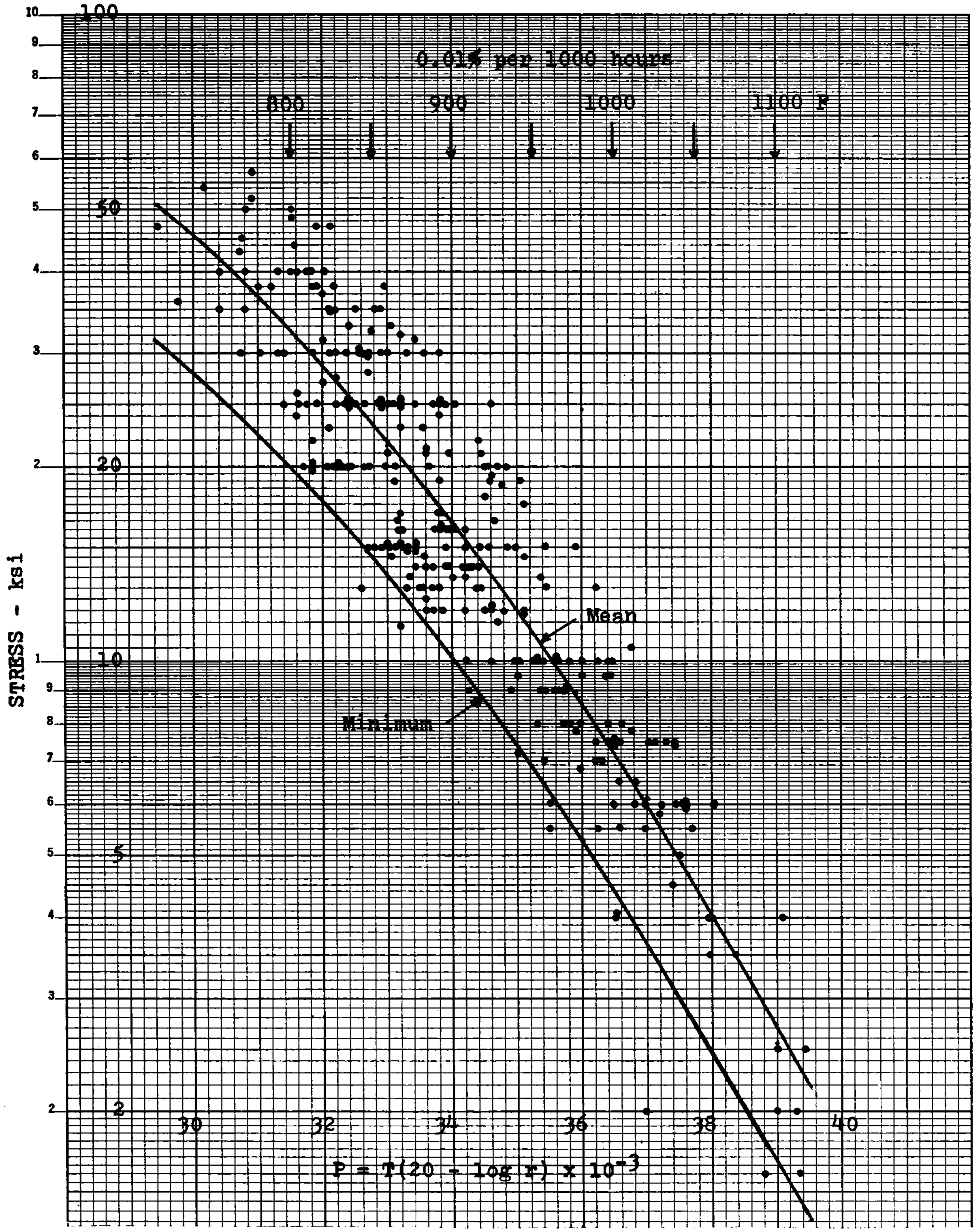


Fig. 28a. Variation of Larson - Miller creep rate parameter with stress for wrought 1 1/4 Cr - 1/2 Mo - Si steel.

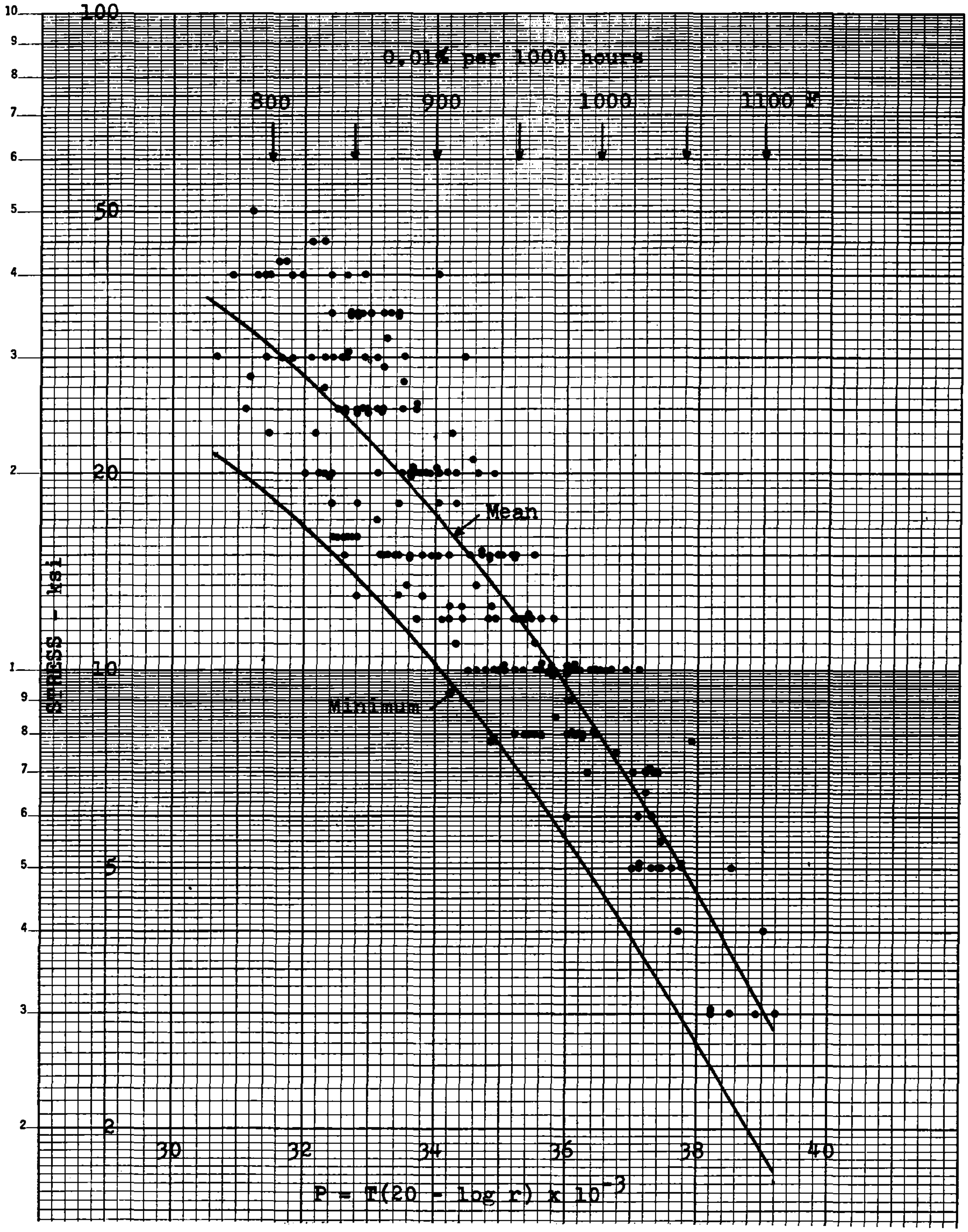


Fig. 28b. Variation of Larson - Miller creep rate parameter with stress for cast 1 1/4 Cr - 1/2 Mo - Si steel.

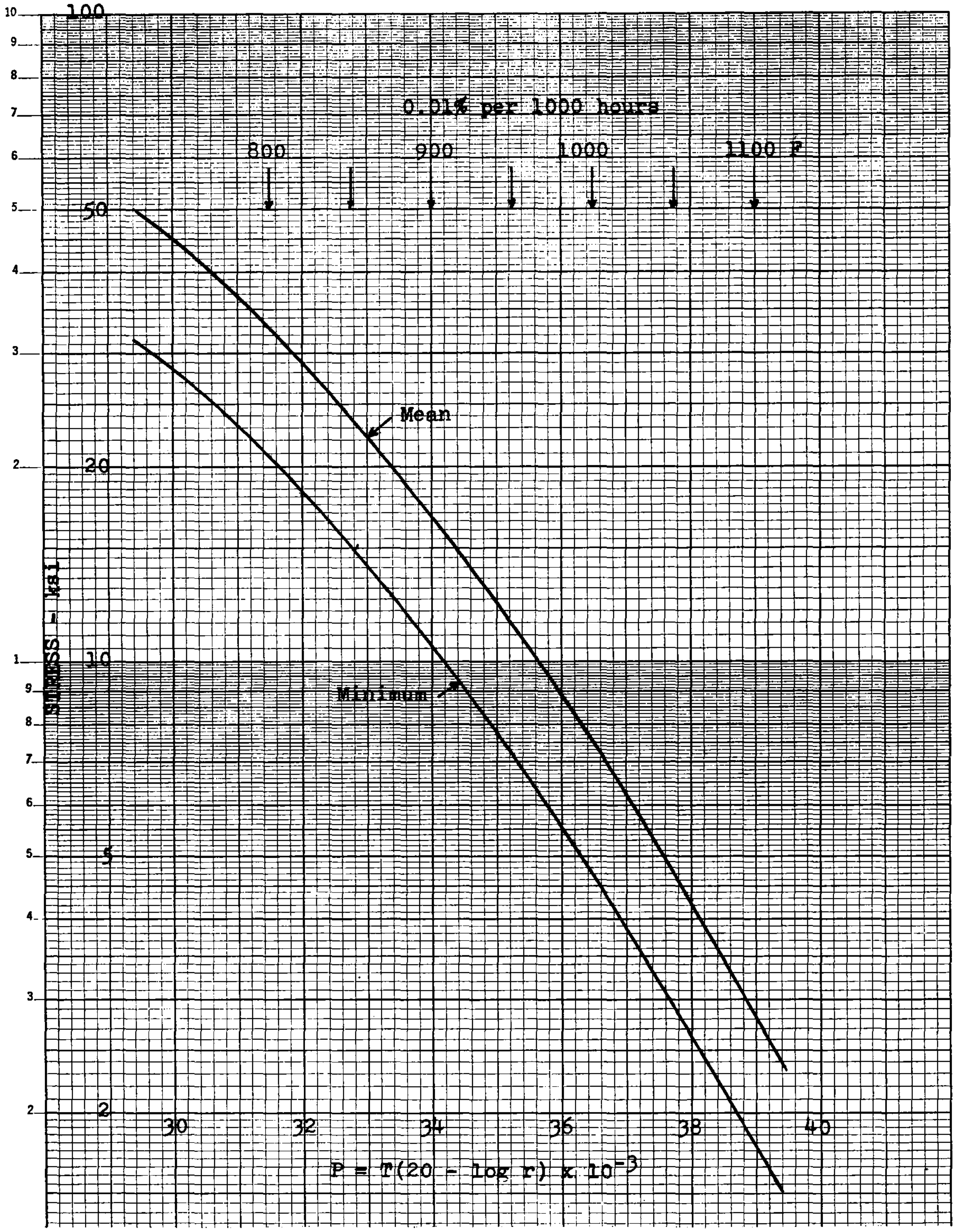


Fig. 28c. Variation of Larson - Miller creep rate parameter with stress for wrought and cast 1 1/4 Cr - 1/2 Mo - Si steel.

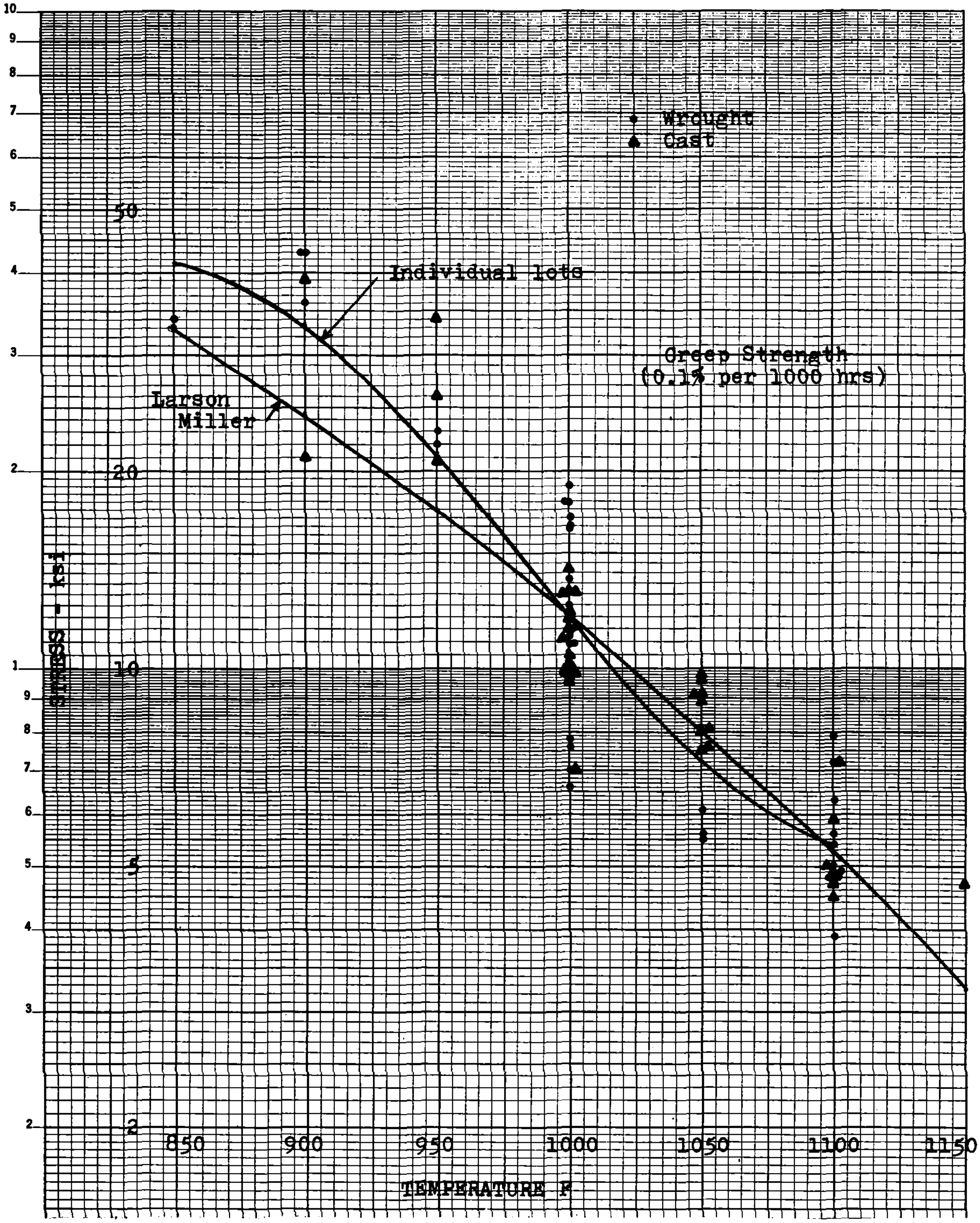


Fig. 29a. Variation of creep strength of 1 1/4 Cr - 1/2 Mo - Si steel with temperature.

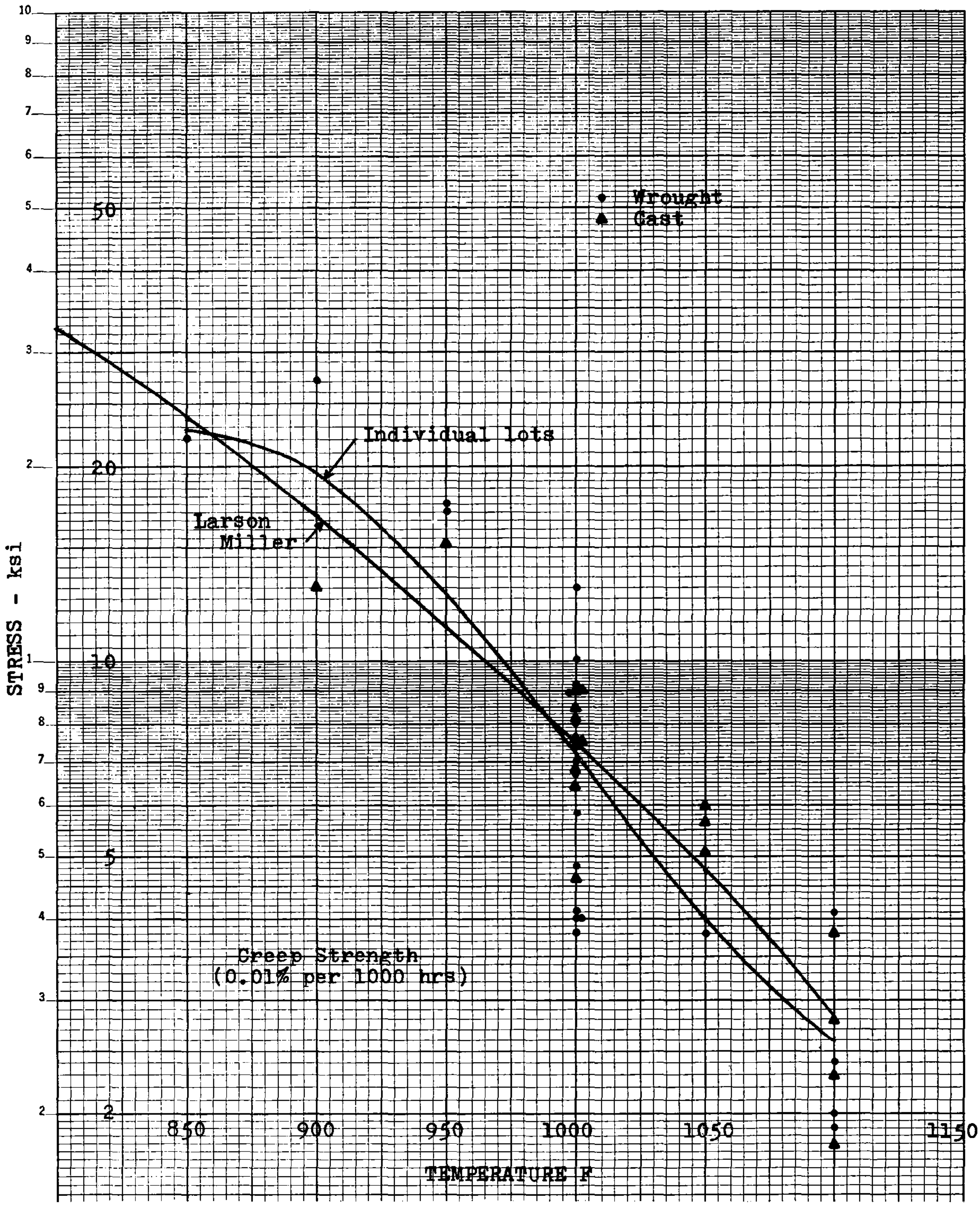


Fig. 29b. Variation of creep strength of 1 1/4 Cr - 1/2 Mo - Si steel with temperature.

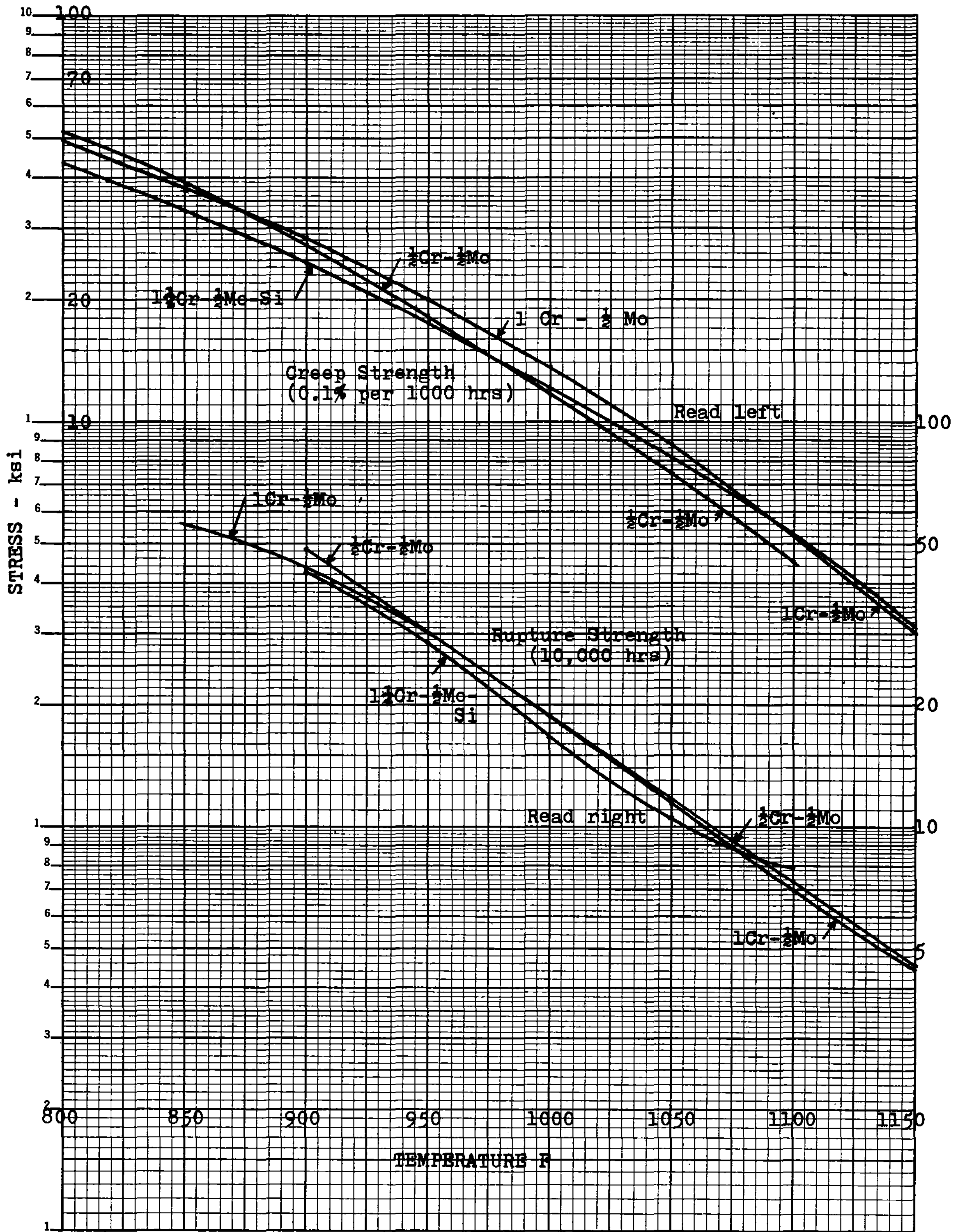


Fig. 30a. Comparison of mean creep and rupture strengths of 1/2 Cr-1/2 Mo, 1 Cr - 1/2 Mo, and 1 1/4 Cr - 1/2 Mo - Si steels

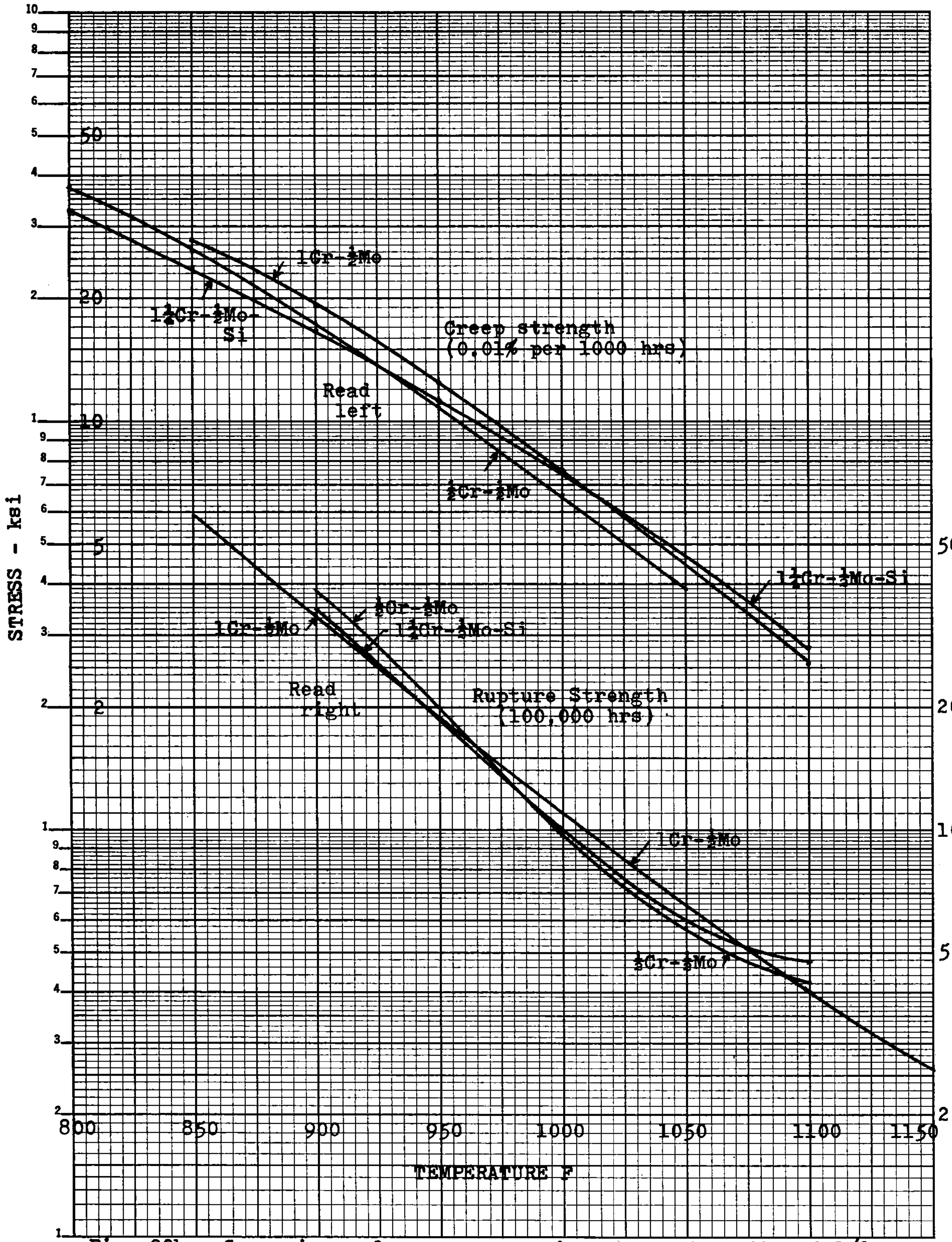


Fig. 30b. Comparison of mean creep and rupture strengths of 1/2 Cr - 1/2 Mo, 1 Cr - 1/2 Mo, and 1 1/4 Cr - 1/2 Mo - Si steels.

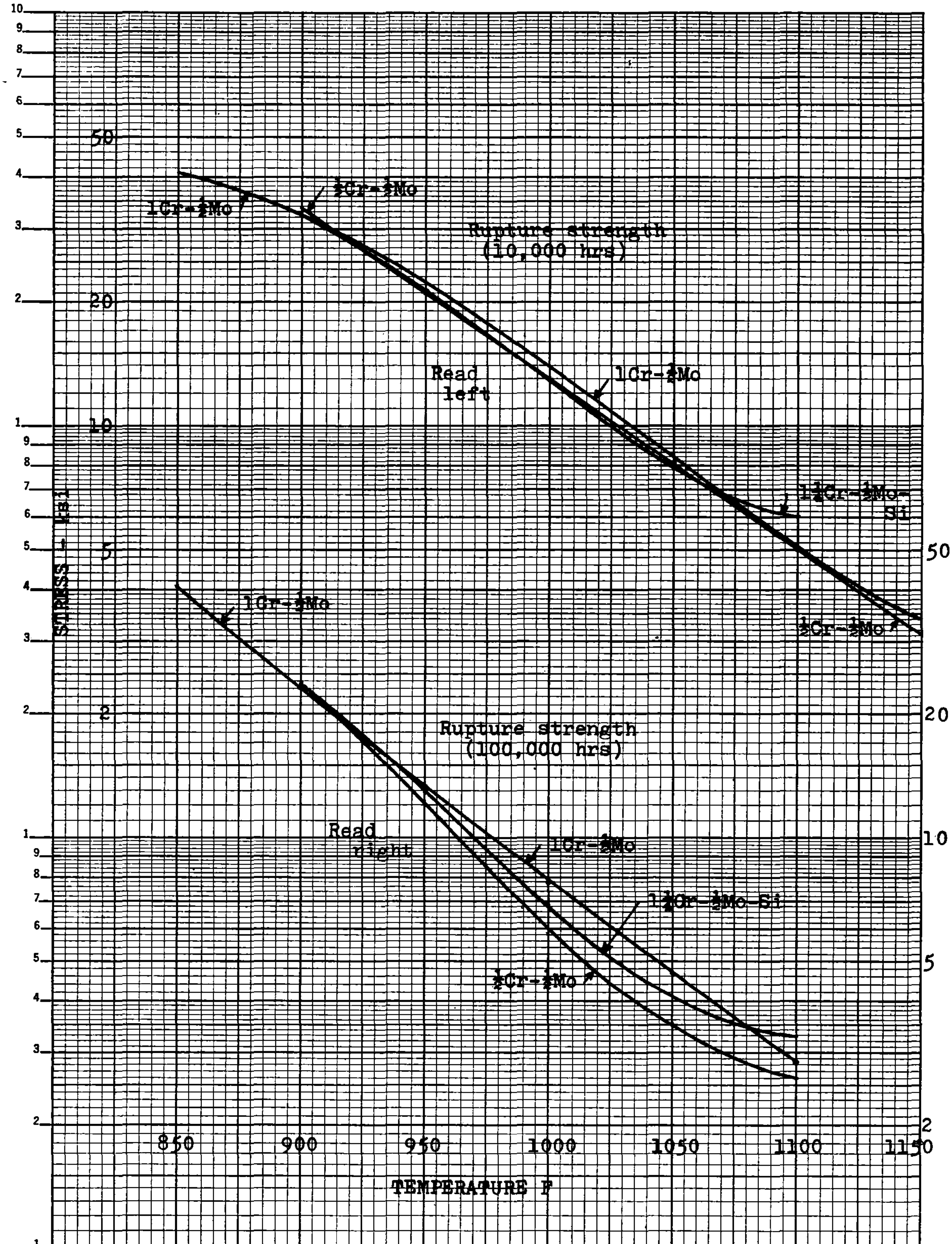


Fig. 31a. Comparison of minimum creep and rupture strengths of 1/2 Cr - 1/2 Mo, 1 Cr - 1/2 Mo, 1 1/4 Cr - 1/2 Mo - Si steels.

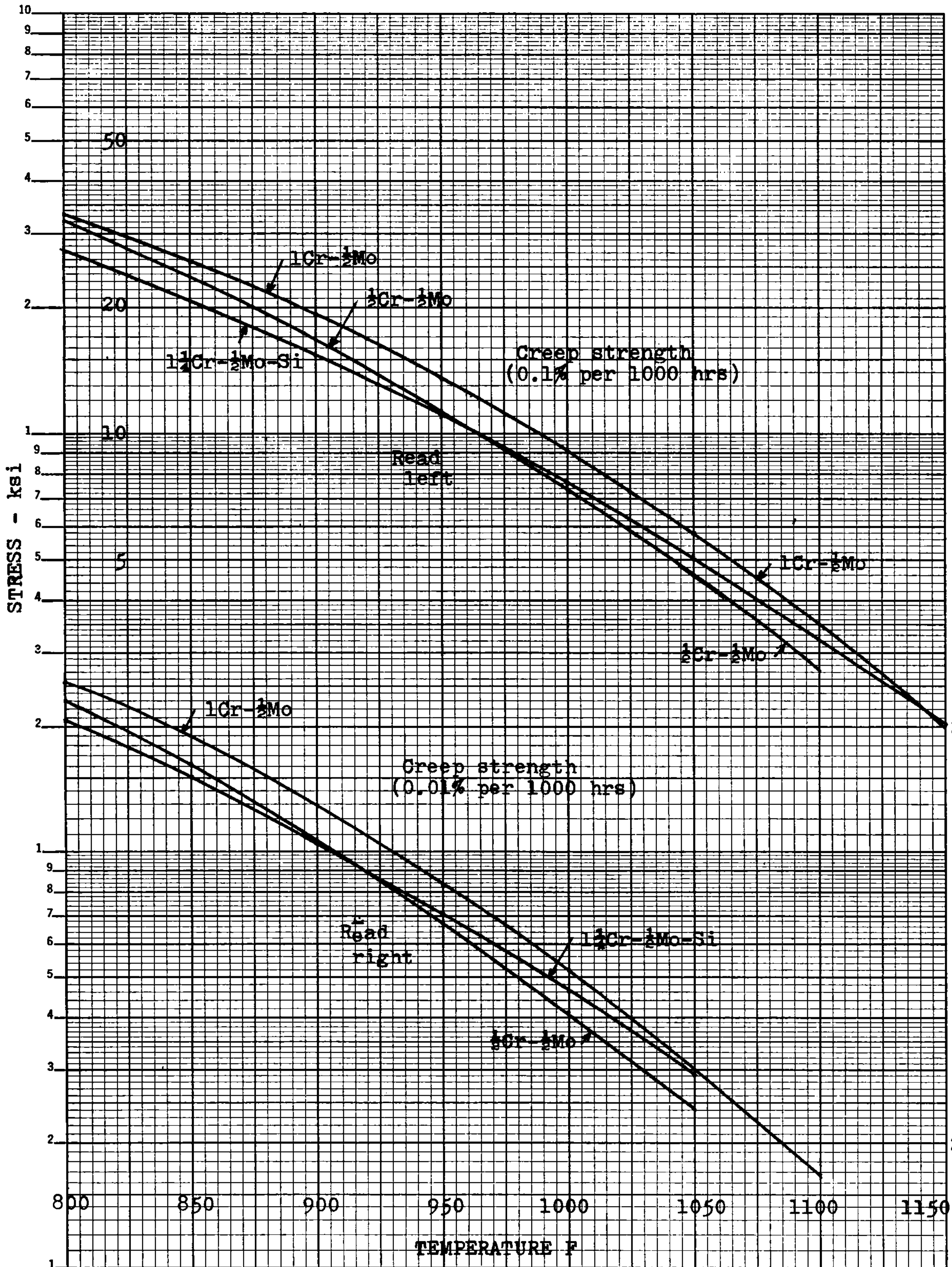


Fig. 31b. Comparison of minimum creep and rupture strengths of 1/2 Cr - 1/2 Mo, 1 Cr - 1/2 Mo, and 1 1/4 Cr - 1/2 Mo - Si steels.