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REPORT NO. RS-TR-70-6

RAPID HEATING AND LOADING OF 7075 – T6 ALUMINUM ALLOY SHEET

by

John H. Honeycutt

May 1970

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28 May 1970 Report No. RS-TR-70-6

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by

John H. Honeycutt

DA Project No. 1T062105A328
AMC Management Structure Code No. 5025.11.29400

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Abstract

The purpose of this report is to make available to the design engineer tensile property data on 7075-T6 aluminum, in the longitudinal and transverse directions, under conditions of rapid heating and loading.

The tensile property data reported are: ultimate tensile stress, ultimate yield stress (at 0.2-percent offset), elastic modulus, percent total elongation, and percent uniform elongation. These tensile properties were determined at strain rates of 0.0047, 0.0201, and 0.0266 in./in./sec and at temperatures from room temperature (78°F) to 700°F at 100° intervals, excluding 100° and 200°F. The time required to reach test temperature was, in most cases, less than 10 seconds.

Primary consideration is given to ultimate tensile and yield properties. Other tensile property data reported are secondary and should be used for design criteria only after consideration has been given to the methods used for obtaining and reducing these data.

The strength properties of the test material increased with an increase in strain rate from 300° to 700°F with one exception at 500°F on the transverse specimens. However, from room temperature to 300°F, the strength properties showed almost no change with respect to strain rate except for a point at room temperature on the longitudinal specimens.

Acknowledgement

The efforts of Malcolm Bumbalough in assembling the apparatus and modifying the electronics to provide accurate data and of Keith Bates in aiding in the reduction of data are gratefully acknowledged.

Contents

Illustrations

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1. Introduction

Four aluminum alloys were selected for tensile property evaluation at various strain rates and temperatures; they are 2014-0, 2024-T3, 7075-T6, and 5052-H34. At this time, only the 5052-H34 and the 7075-T6 alloys have been evaluated.[1]

The controlling factor for the strain rates to be used is the test equipment now on hand. These strain rates are 0.0047, 0.0201, and 0.0266 in./in./sec. The strain rates are not constant and are an average of the strain rates for each test condition.

The temperature for this investigation ranged from room temperature (78°F) to 700°F at 100° intervals, excluding 100° and 200°F. The test samples were resistance heated and the temperature was manually controlled by visually monitoring a thermocouple output. The time required to reach test temperature was approximately 10 seconds for all specimens.

To record the test, an X-Y recorder was employed at the slower strain rate (0.0047 in./in./sec). At the other two strain rates (0.0201 and 0.0266 in./in./sec), an oscilloscope with a Polaroid camera was used to record the test data. The reason for the instrumentation change was that the X-Y recorder slew rate is 20 in./sec and the loading rate of the specimens at the two faster strain rates is greater than 20 in./sec, which is too fast for the recorder.

Two specimens were required to establish a data point, if the data agreed within 10 percent. If the data did not agree within 10 percent, a third specimen was tested. The data used to plot the curves were averages of either two or three data points recorded.

Testing of the two other alloys is being held in abeyance until new test equipment is installed. This new equipment will provide a controlled strain and an increase in the strain differential.

2. Test Material

The 7075-T6 material used for this test was a sheet measuring 36 by 36 inches, 0.50 inch thick, which was furnished by the Reynolds Metals

[1] Honeycutt, J. H., Rapid Heating and Loading of 5052-H34 Aluminum Alloy Sheet, U. S. Army Missile Command, Redstone Arsenal, Alabama, Report No. RS-TR-69-2.

Company. No chemical composition was furnished. The test specimen configuration is shown in Figure 1.

3. Test Equipment

The test equipment used for tensile loading of the specimens was a Model TTD Instron universal testing machine with a full scale load capability of 20,000 pounds. Specimens were resistance-heated by use of a Marquardt TM9 power controller.

The recorder instrument used for the slower strain rate (0.0047 in./in./sec) was a Model 2D Mosley X-Y recorder. A Tektronix Model 502A dual-beam oscilloscope with Polaroid camera attached was used to record data at the two faster strain rates (0.0201 and 0.0266 in./in./sec).

The temperature of the specimen was controlled manually during observation of the temperature recorder. The temperature recorder monitored a chromel-alumel thermocouple, which was attached to the center of the gage length of the specimen by percussive welding.

The specimen strain was measured with a clip-on type extensometer over the 2-inch gage length of the specimen (Figure 2).

A block diagram of the test setup and associated instrumentation is shown in Figure 3.

4. Data Measurement

The specimen load was measured with an Instron load cell. This is an electronically calibrated strain-gage type cell with load ranges of 500, 1000, 2000, 5000, 10,000, and 20,000 pounds.

Strain measurements were made with the clip-on type extensometer. This extensometer consists of a 0.5-inch wide by 3-inch long piece of spring steel with appropriate clamps fastened to each end (Figure 2). There are two strain gages mounted on both the tension and compression side of the spring. The extensometer bridge network and physical arrangement of the gages are shown in Figure 4. This bridge arrangement is such that strain signals in R_1 and R_3 are additive in one direction and those of R_2 and R_4 are additive in the other direction, thus producing four times the electrical output of a single strain gage.

The strain rate for each test condition was measured with the second beam on the oscilloscope indicating strain only. A pulse generator caused the second beam to be displayed on the oscilloscope at a predetermined time interval of 15, 30, 60, or 100 milliseconds.

The strain rate beam sweep is shown in the upper part of Figure 5.

The strain rate reported for each condition was calculated from the load-strain curves at that condition. The strain rate was calculated over the portion of the curve from zero strain to the 0.2-percent offset yield point and is the average strain rate for each individual test sample (Figure 5).

In all cases the strain rate showed a definite increase after the specimen reached its proportional limit. This increase was a result of some of the cross-head movement being taken up by the elastic deformation of the test machine parts such as the load cell, pull rods, jaws, universal joints, and specimen shoulders.

Temperature measurements were read directly from a temperature meter, which is calibrated in degrees Fahrenheit. The meter w driven by a chromel-alumel thermocouple welded to the center of the gage le... of the specimen. The temperature was manually controlled because of the slow response to temperature change of the automatic temperature controller.

The percent total elongation of each specimen was measured by use of a Riehle percent gage for a 2-inch gage length. In some instances, the specimens that were run at other than room temperature arced upon fracture, causing the ends of the fractured part of the specimen to melt (Figure 6). Because of the arcing and consequent melting of the material, it was not possible to measure the percent total elongation with a consistent degree of accuracy.

The uniform elongation measurements were taken from the recorded data of the calibrated extensometer. Figure 7 shows a typical curve from which the uniform elongation was calculated.

The angle of fracture of each specimen was measured with an adjustable protractor. A fracture perpendicular to the load axis was considered a fracture angle of 0 degree.

5. Test Procedure

Specimens oriented in both the longitudinal and transverse directions were evaluated. The longitudinal specimens were tested first. The test was started at the slower strain rate (0.0047 in./in./sec) and at each strain rate specimens were tested at 700°, 600°, 500°, 400°, and 300°F, and at room temperature. At each temperature, only two specimens were tested if the tensile data agreed within 10 percent. If the tensile data did not agree within 10 percent, a third specimen was tested. The average tensile data from the two or three specimens were then used as the data point to construct all curves.

At the beginning of each test, all specimens were marked and measured, and their areas calculated and recorded.

Before the beginning of each test period, a sample specimen was mounted in the test machine and the temperature gradients were checked. When necessary, adjustments were made to keep the temperature gradients within 10°F or less over the gage length of the specimen. Periodic checks were made as required during the test period to maintain this minimum temperature gradient (Figure 8).

A specimen was clamped in the machine and a thermocouple percussively welded to the center of its gage length. The thermocouple was used to control and measure the temperature of the specimen. Next, the calibrated extensometer was clipped on the specimen and the specimen brought up to the desired temperature within 10 seconds or less. At this time, the load was applied to the specimen and the load-strain curve was recorded on the oscilloscope for the two faster strain rates (0.0266 and 0.0201 in./in./sec) and on the Mosley X-Y recorder at the slower strain rate (0.0047 in./in./sec).

During the test, the temperature was manually controlled by observation of the temperature meter. Manual control of the specimen temperature was held within ±10°F throughout the specimen test cycle.

The ultimate strength and 0.2-percent offset yield were determined from each calibrated load-strain curve. Modulus of elasticity was measured from the slope of the elastic portion of the load-strain curves (Figure 5). Total elongation was measured by use of a Riehle percent gage and the angle of fracture was measured with a protractor.

The strain rate for each test was calculated from the timing information on the oscilloscope trace as recorded on the load-strain curve (upper trace on the load-strain curve, Figure 5). As shown in this figure, the strain rate is 0.026 in./in./sec from zero strain to the 0.2-percent offset yield load on the strain axis. From this point, 2 centimeters out on the strain axis, the strain rate increases to 0.046 in./in./sec. The reasons for the lower strain rate are that pull rods, universal joints, load cell, and specimen shoulders have some elastic deformation that takes up some of the movement of the crosshead, which travels at a constant rate. The strain rates reported here are average rates taken from the start of loading to the 0.2-percent offset yield strength.

In each test for uniform elongation, the extensometer was left on the sample until failure. From the data plotted on the X-Y recorder, the uniform elongation was calculated by use of the recorded values of strain from the calibrated extensometer (Figure 7).

6. Test Results

The results of these tests are shown in Tables I through VI. The curves representing the average tabulated values are shown in Figures 9 through 24. The data points of each curve are an average of either two or three specimens as shown in the tabulated data.

a. Ultimate Tensile Properties

Ultimate tensile properties decrease moderately with an increase in temperature up to 300°F. However, past 300°F, the strength properties decrease sharply to 700°F.

The strain rates appear to have almost no effect on the stress values. This is particularly true for the transverse curves from room temperature to 300°F for all strain rates. Also the 0.0201-in./in./sec strain rate is erratic and shows stress levels different from the 0.0266 strain rate only between 500° and 700°F.

The general trend for both the longitudinal and transverse directions is approximately the same.

b. Yield Properties (at 0.2-Percent Offset)

The 0.2-percent offset yield curves for both longitudinal and transverse data show approximately the same trends as the ultimate tensile curve. However, the 0.0201-in./in./sec longitudinal curve shows a stress value below that of the ultimate curve at room temperature. This is probably due to the construction of the modulus line for this particular point. This low point represents an error of approximately 8 percent.

c. Elastic Modulus

The elastic modulus curves show a decrease in modulus with an increase in temperature up to 500°F, above which the modulus increases with an increase in temperature. However, the 0.0201- and 0.0047-in./in./sec longitudinal curves show a decreasing modulus value from room temperature to 700°F.

At the faster strain rate, the transverse and longitudinal specimens have comparable modulus values at corresponding temperatures. The intermediate strain rate of the longitudinal specimens as compared to the transverse specimens show higher modulus values at room temperature and 200°F; lower modulus values at 500°, 600°, and 700°F; and at 300° and 400°F, the modulus values are the same. At the slower strain rate, the longitudinal and transverse specimens exhibit approximately the same modulus values at corresponding temperatures, except at 700°F. At 700°F, the transverse specimen shows an increase in modulus of 56 percent compared to the longitudinal specimen.

d. Total Elongation

Both the longitudinal and transverse total elongation curves show the same trends with respect to temperature. That is, there is little change in elongation from room temperature to 550°F. However, from 550° to 700°F, there is a pronounced increase in total elongation for both longitudinal and transverse curves at all strain rates.

The average increase in total elongation in this temperature range is 213 and 150 percent for the longitudinal and transverse specimens, respectively.

e. Uniform Elongation

Uniform elongation is considered to be the elongation of the specimen that occurs before any decrease in load is observed on the recorded data. It is therefore the usable elongation in design. The trend of uniform elongation in relation to temperature is just the reverse of that exhibited by total elongation, decreasing with increasing temperature. In the design of missiles, this type of data can be extremely important where low factors of safety inherent in "one-shot" hardware are used.

The longitudinal and transverse curves are erratic at all strain rates. However, the longitudinal and transverse curves of the intermediate strain rate of 0.0201 in./in./sec show more uniformity than the curves of the other two strain rates of 0.0266 and 0.0047 in./in./sec.

f. Angle of Fracture

The angle of fracture for this material was 0 degrees in most cases. Only on two occasions was the average angle of fracture value over 5 degrees. These values were 6.5 degrees at 300°F and 6 degrees at 600°F for the longitudinal and transverse specimens, respectively, at a strain rate of 0.0266 in./in./sec.

No effort has been made to analyze the angle of fracture data by crystallographic or other means; they are reported simply as a matter of interest.

g. Stress-Strain

The stress-strain curves for all strain rates show decrease in stress with increasing temperature. The effect of increased strain rate shows an increase in stress level at corresponding temperatures for both the longitudinal and transverse specimens.

7. Conclusions

All properties evaluated in this test followed previously established trends with respect to temperature and strain rate. The trend established for uniform elongation shows a decrease in elongation with an increase in temperature.

Strain rates used for test conditions were not differentiated sufficiently to establish unquestionable trends with respect to strain rates in most cases. The ultimate yield and total elongation longitudinal curves are examples of this condition.

For design of missiles, the uniform elongation may be of significant importance and considerably more quantitative data concerning this parameter should be generated before they are used as design criteria.

TABLE I. TENSILE PROPERTIES OF 7075-T6 ALUMINUM SHEET (LONGITUDINAL SPECIMEN, 20 in./min)

Spec No.	Spec Area	Temp (°F)	Strain Rate (in./in./sec)	Ult Load (lb)	Ult Stress (psi)	Yield, 2-Percent Offset (lb)	Yield Stress (psi)	Elastic Modulus (× 10^6 psi)	Elong, Total (%)	Elong, Uniform (%)	Angle of Fracture (deg)
1	0.0260	700	0.0258	334	12,846	309	11,885	21.4	25.0	3.3	0
2	0.0255	700	0.0258	304	11,919	287	11,264	21.0	31.0	3.0	0
Av			0.0258	319	12,383	298	11.575	21.2	28.0	3.2	0
4*	0.0257	600	0.0250	518	20,744	501	19,494	15.5	11.0	3.2	0
5	0.0262	600	0.0283	523	19,955	503	19,192	15.2	12.0	3.2	0
Av			0.0267	521	20,050	502	19,343	15.4	11.5	3.2	0
6	0.0256	500	0.0250	895	34,960	872	34,023	15.2	6.0	2.9	0
7	0.0256	500	0.0266	835	32,617	812	31,704	15.5	7.0	2.8	0
Av			0.0258	865	33,789	842	32,864	15.4	6.5	2.8	0
8	0.0256	400	0.0275	1327	51,849	1281	50,250	15.5	10.0	6.0	5.0
9	0.0256	400	0.0308	1300	50,807	1281	48,462	15.5	10.0	5.0	0
Av			0.0292	1314	51,328	1281	49,356	15.5	10.0	5.5	2.5
10	0.0255	300	0.0241	1740	68,269	1641	64,346	14.7	11.0	7.0	7.0
11	0.0255	300	0.0283	1748	68,331	1654	64,869	14.2	10.0	7.0	6.0
Av			0.0262	1744	68,300	1648	64,608	14.5	10.5	7.0	6.5
12	0.0255	RT	0.0275	2025	79,412	1845	72,346	15.0	11.0	10.0	0
13	0.0258	RT	0.0266	2010	81,436	1914	74,197	15.4	11.0	10.0	7.0
Av			0.0271	2018	80,424	1880	73,272	15.2	11.0	10.0	3.5
Average strain rate			0.0268								

*Specimen No. 3 omitted. Expansion control failed to work properly.

TABLE II. TENSILE PROPERTIES OF 7075-T6 ALUMINUM SHEET (TRANSVERSE SPECIMEN, 20 in./min)

Spec No.	Spec Area	Temp (°F)	Strain rate (in./in./sec)	Ult Load (lb)	Ult Stress (psi)	Yield, 2-Percent Offset (lb)	Yield Stress (psi)	Elastic Modulus ($\times 10^6$ psi)	Elong, Total (%)	Elong, Uniform (%)	Angle of Fracture (deg)
1	0.0257	700	0.0267	364	14,163	339	13,191	20.3	28.0	3.6	5.0
2	0.0256	700	0.0225	359	14,025	342	13,373	21.7	29.0	3.2	0.0
Av			0.0246	362	14,106	340	13,282	21.0	28.5	3.4	2.5
3	0.0256	600	0.0208	576	22,506	546	21,364	18.1	12.0	2.9	5.0
4	0.0256	600	0.0267	569	22,226	538	21,000	18.1	12.0	3.0	7.0
Av			0.0238	572	22,366	542	21,182	18.1	12.0	2.95	6.0
5	0.0256	500	0.0300	912	35,641	882	34,470	12.3	11.0	3.6	7.0
6	0.0256	500	0.0267	989	38,633	942	36,812	13.5	10.0	3.6	0.0
Av			0.0283	950	37,137	912	35,641	12.9	10.5	3.6	3.5
7	0.0255	400	0.0267	1315	51,582	1225	48,056	15.2	9.0	4.40	0
8	0.0255	400	0.0250	1385	54,325	1315	51,582	14.2	8.0	3.70	0
Av			0.0258	1350	52,954	1270	49,819	14.7	8.5	4.05	0
9	0.0255	300	0.0292	1814	71,146	1661	65,131	13.5	10.0	7.60	0
10	0.0255	300	0.0292	1781	69,839	1628	63,823	13.8	10.0	7.20	0
Av			0.0292	1798	70,492	1642	64,477	13.65	10.0	7.40	0
11	0.0255	RT	0.0267	2081	81,609	1801	70,623	15.6	11.0	10.20	0
12	0.0255	RT	0.0267	2058	81,871	1814	71,141	16.0	11.0	10.20	0
Av			0.0267	2084	81,740	1808	70,882	15.8	11.0	10.20	0
Average strain rate			0.0264								

TABLE III. TENSILE PROPERTIES OF 7075-T6 ALUMINUM SHEET (LONGITUDINAL SPECIMEN, 10 in./min)

Spec No.	Spec Area	Temp (°F)	Strain Rate (in./in./sec)	Ult Load (lb)	Ult Stress (psi)	Yield, 2-Percent Offset (lb)	Yield Stress (psi)	Elastic Modulus (× 10^6 psi)	Elong, Total (%)	Elong, Uniform (%)	Angle of Fracture (deg)
1	0.0263	700	0.0250	270	10,266	270	10,266	8.6	23.0	0.5	0
2	0.0262	700	0.0200	270	10,305	270	10,305	9.9	22.0	0.5	0
Av			0.0225	270	10,286	270	10,286	9.3	22.5	0.5	0
4	0.0262	600	0.0241	446	17,022	446	17,022	10.4	12.0	0.5	0
5	0.0262	600	0.0175	424	16,183	424	16,183	10.5	12.0	0.6	0
Av			0.0208	435	16,603	435	16,603	10.45	12.0	0.55	0
6	0.0262	500	0.0166	836	32,154	824	31,692	9.7	8.0	1.0	0
7	0.0260	500	0.0158	826	31,783	808	30,149	10.0	8.0	1.0	0
Av			0.0162	828	31,969	816	30,921	9.9	8.0	1.0	0
8	0.0258	400	0.0208	1288	49,349	1216	46,590	12.8	8.0	1.0	0
9	0.0261	400	0.0241	1229	47,636	1156	44,806	11.8	9.0	3.0	0
Av			0.0225	1259	48,493	1186	45,698	12.3	8.5	2.0	0
10	0.0258	300	0.0216	1744	67,597	1640	63,566	13.6	9.0	2.0	0
11	0.0259	300	0.0225	1744	67,335	1643	63,436	12.8	10.0	2.0	0
Av			0.0221	1744	67,466	1642	63,501	13.2	9.5	2.0	0
12	0.0255	RT	0.0208	2197	86,157	1761	69,059	16.2	12.0	10.0	0
13	0.0255	RT	0.0200	2235	85,632	1734	66,460	16.7	11.0	10.0	0
Av.			0.0204	2216	85,895	1748	67,760	16.3	11.5	10.0	0
Average strain rate			0.0208								

TABLE IV. TENSILE PROPERTIES OF 7075-T6 ALUMINUM SHEET (TRANSVERSE SPECIMEN, 10 in./min)

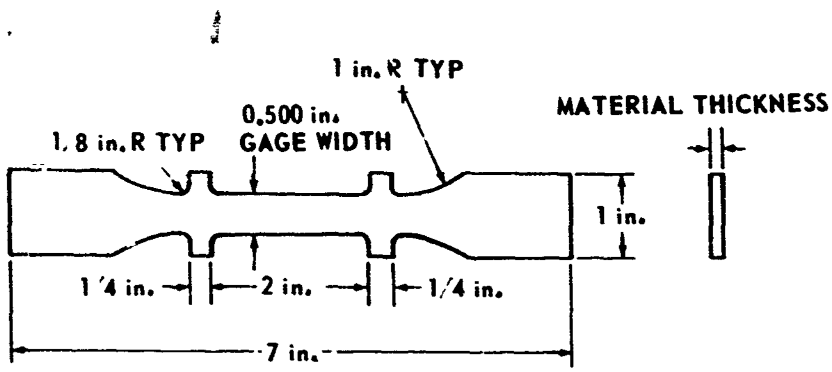
Spec No.	Spec Area	Temp (°F)	Strain Rate (in./in./sec)	Ult Load (lb)	Ult Stress (psi)	Yield, 2-Percent Offset (lb)	Yield Stress (psi)	Elastic Modulus ($\times 10^6$ psi)	Elong, Total (%)	Elong, Uniform (%)	Angle of Fracture (deg)
1	0.0257	700	0.0183	306	11,907	306	11,907	20.3	28.0	0.83	0
2	0.0256	700	0.0217	306	11,971	306	11,971	13.0	30.0	0.76	5.0
Av			0.0200	306	11,939	306	11,939	16.65	29.0	0.80	2.5
3	0.0256	600	0.0208	496	19,375	481	18,788	17.2	14.0	0.46	0
4	0.0256	600	0.0192	524	20,484	509	19,896	16.3	14.0	0.46	0
Av			0.0200	510	19,930	495	19,342	16.75	14.0	0.46	0
5	0.0256	500	0.0200	992	38,763	956	37,332	12.5	8.0	1.8	5.0
6	0.0256	500	0.0200	1046	40,845	966	37,723	13.0	12.0	2.2	0
Av			0.0200	1019	39,804	961	37,527	12.75	10.0	2.0	2.5
7	0.0256	400	0.0192	1327	51,849	1217	47,550	12.9	10.0	4.8	0
8	0.0256	400	0.0200	1354	52,891	1234	48,201	12.8	11.0	4.8	6.0
Av			0.0196	1340	52,370	1226	47,876	12.85	10.5	4.8	3.0
9	0.0256	300	0.0192	1774	69,305	1557	60,838	12.6	11.0	7.2	0
10	0.0254	300	0.0175	1781	70,114	1567	61,711	12.6	13.0	8.4	0
Av			0.0183	1778	69,710	1562	61,274	12.6	12.0	7.8	0
11	0.0255	RT	0.0183	2041	80,040	1754	68,793	13.7	11.0	10.1	0
12	0.0256	RT	0.0175	2081	81,289	1768	69,045	13.1	11.0	10.2	0
Av			0.0178	2061	80,664	1761	68,919	13.4	11.0	10.15	0
Average strain rate			0.0193								

TABLE V. TENSILE PROPERTIES OF 7075-T6 ALUMINUM SHEET (LONGITUDINAL SPECIMEN, 1 AND 2 in./min)

Spec No.	Spec Area	Temp (°F)	Strain Rate (in./in./sec)	Ult Load (lb)	Ult Stress (psi)	Yield, 2-Percent Offset (lb)	Yield Stress (psi)	Elastic Modulus ($\times 10^6$ psi)	Elong, Total (%)	Elong, Uniform (%)	Angle of Fracture (deg)
1	0.0263	700	0.0050	220	8365	220	8365	5.4	19.6	0.79	0
2	0.0262	700	0.0017	225	8588	225	8588	4.9	21.0	0.88	0
Av			0.00485	223	8477	223	8477	5.15	20.3	0.84	0
3	0.0258	600	0.0039	380	14,729	380	14,729	5.2	12.0	0.68	0
4	0.0262	600	0.0039	371	14,160	371	14,160	6.8	7.0	0.76	0
Av			0.0039	376	14,444	376	14,444	6.0	9.5	0.72	0
5	0.0263	500	0.0033	770	29,278	765	29,087	6.8	7.0	0.81	3
6	0.0263	500	0.0032	732	27,833	727	27,643	6.8	7.0	0.90	3
Av			0.0033	751	28,556	746	28,365	6.8	7.0	0.86	3
7	0.0265	400	0.0056	1202	45,358	1180	44,528	8.1	9.0	3.0	0
8	0.0258	400	0.0059	1140	44,186	1120	43,411	7.9	8.0	2.0	0
Av			0.0058	1171	44,772	1150	43,970	8.0	8.5	3.0	0
9	0.0257	300	0.0050	1624	63,191	1616	62,879	8.7	7.0	2.0	0
10	0.0265	300	0.0050	1720	64,906	1696	66,250	8.8	8.0	4.0	0
Av			0.0050					8.8	7.5	3.0	0
11	0.0260	RT	0.0050	2064	79,385	1920	73,846	9.6	11.0	9.0	0
12	0.0258	RT	0.0050	2040	79,070	1900	73,643	9.6	11.0	10.0	0
Av			0.0050	2052	79,228	1910	73,745	9.6	11.0	9.5	0
Average strain rate			0.00464								

TABLE VI. TENSILE PROPERTIES OF 7075-T6 ALUMINUM SHEET (TRANSVERSE SPECIMEN, 1 in./min)

Spec No.	Spec Area	Temp (°F)	Strain Rate (in./in./sec)	Ult Load (lb)	Ult Stress (psi)	Yield, 2-Percent Offset (lb)	Yield Stress (psi)	Elastic Modulus ($\times 10^6$ psi)	Elong, Total (%)	Elong, Uniform (%)	Angle of Fracture (deg)
1	0.0258	700	0.00483	233	9031	233	9031	8.2	28.0	0.40	0
2	0.0259	700	0.00475	230	8891	230	8891	8.2	31.0	0.34	0
Av			0.00479	232	8961	232	8961	8.2	29.5	0.37	0
3	0.0256	600	0.00383	429	16,758	427	16,680	6.3	14.0	0.74	0
4	0.0256	600	0.00617	437	16,928	406	15,728	6.2	18.0	0.62	0
Av			0.00500	433	16,843	416	16,204	6.15	16.0	0.78	0
5	0.0256	500	0.00533	826	32,266	802	31,328	6.5	9.5	2.6	0
6	0.0256	500	0.00517	862	32,672	838	32,734	6.9	9.5	2.5	0
Av			0.00525	839	32,969	820	32,031	6.7	9.5	2.55	0
7	0.0255	400	0.00467	1250	49,020	1170	45,882	7.8	13.0	6.6	0
8	0.0255	100	0.00458	1260	49,412	1198	46,980	8.2	13.0	4.5	0
Av			0.00462	1255	49,216	1184	46,431	8.0	13.0	5.55	0
9	0.0255	300	0.00383	1744	68,392	1616	63,373	8.9	12.0	6.7	0
10	0.0255	300	0.00383	1688	66,196	1576	61,804	8.7	12.0	6.9	0
Av			0.00383	1716	67,294	1596	62,588	8.8	12.0	6.8	0
11	0.0258	RT	0.00517	2120	82,171	1896	73,468	9.5	11.5	10.2	0
12	0.0258	RT	0.00492	2112	81,860	1872	72,588	9.5	11.5	10.4	0
Av			0.00504	2116	82,056	1884	73,023	9.5	11.5	10.3	0
Average strain rate			0.00476								



The thickness of machined specimens within the reduced section shall be uniform within 0.010 inch.

The ends of reduced section shall not differ in width by more than 0.002 inch. There may be a gradual taper in width from the ends to the center, but the width at either end shall not be more than 0.005 inch greater than the width at the center.

FIGURE 1. DIAGRAM OF TENSILE SPECIMEN

FIGURE 2. CLIP-ON EXTENSOMETER AND TEST SPECIMEN

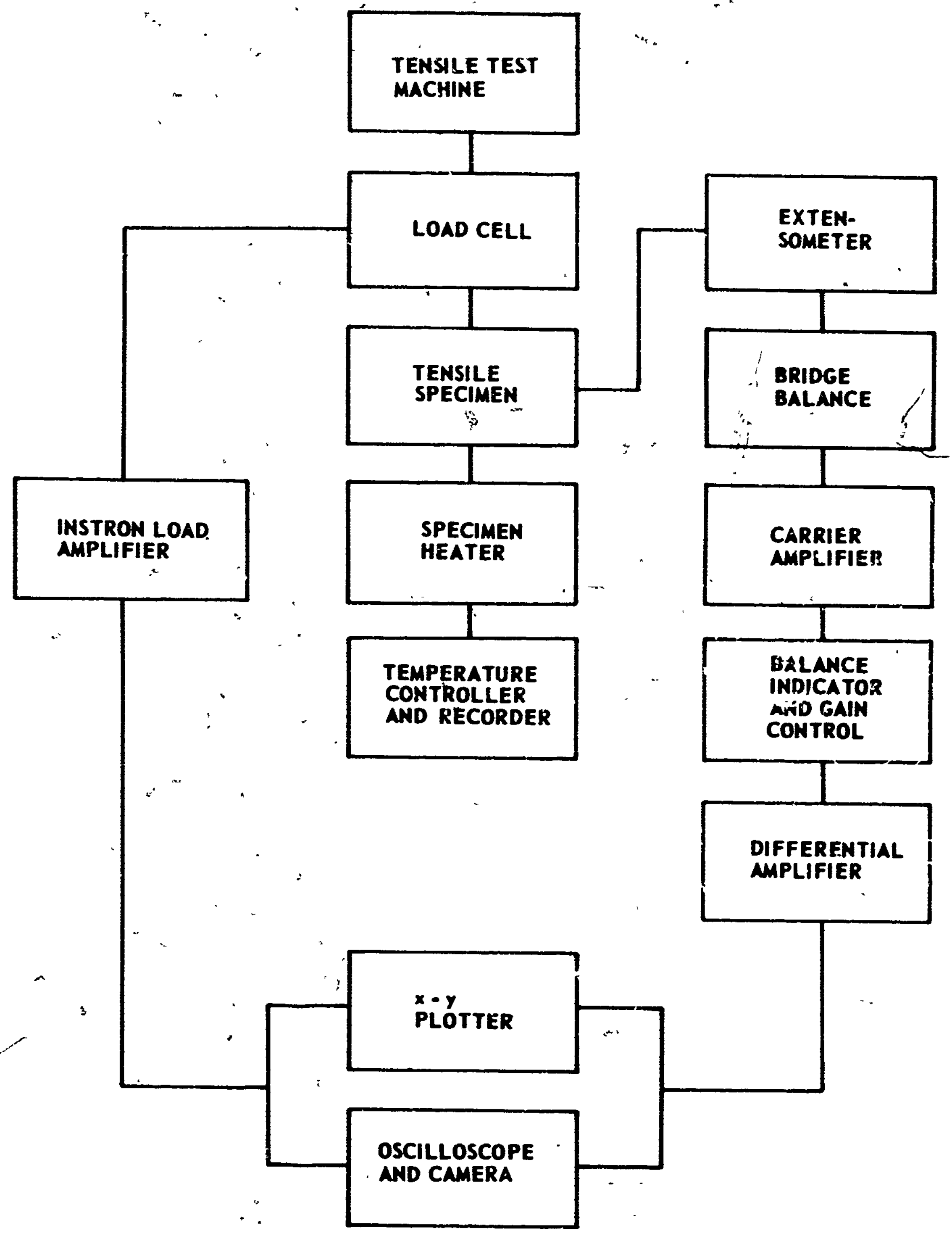


FIGURE 3. FUNCTIONAL DIAGRAM OF TEST SETUP

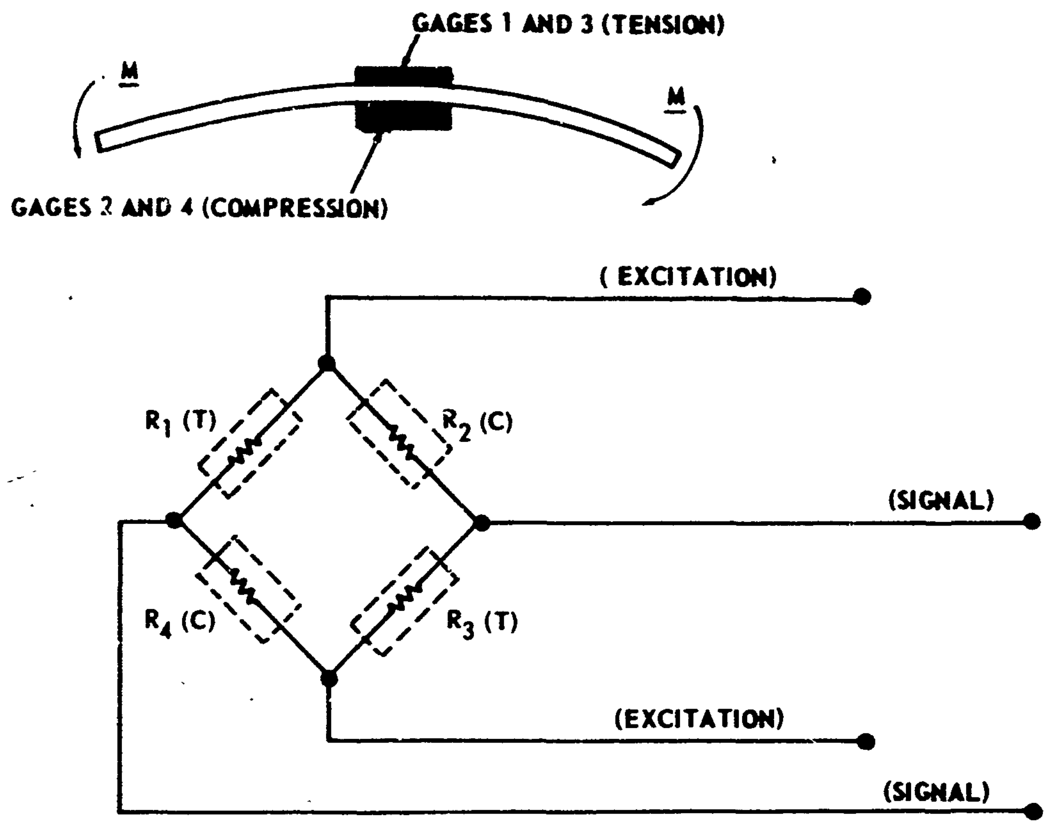


FIGURE 4. EXTENSOMETER PHYSICAL ARRANGEMENT AND BRIDGE NETWORK

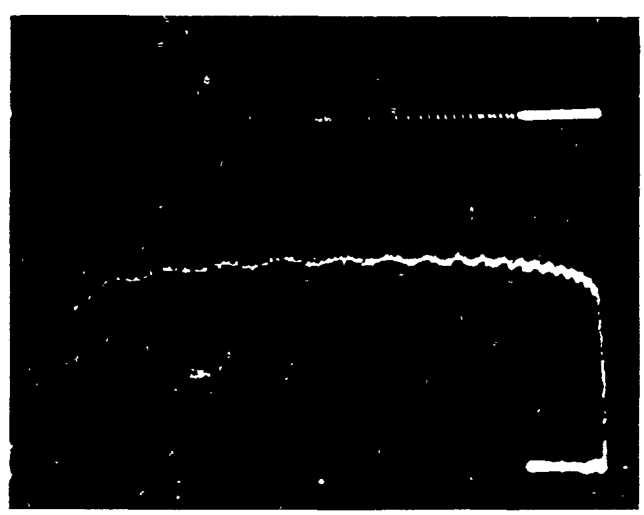


FIGURE 5. TYPICAL LOAD-STRAIN CURVE

FIGURE 6. ARCING CONDITION SHOWN BY 500°F TEST SPECIMEN

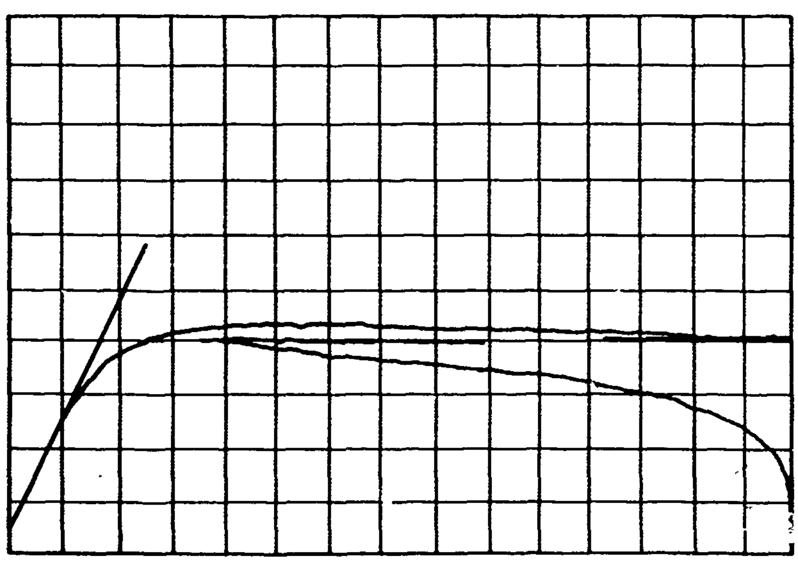


FIGURE 7. TYPICAL LOAD-STRAIN CURVE SHOWING UNIFORM ELONGATION DATA

FIGURE 8. TEMPERATURE GRADIENT CHECKOUT

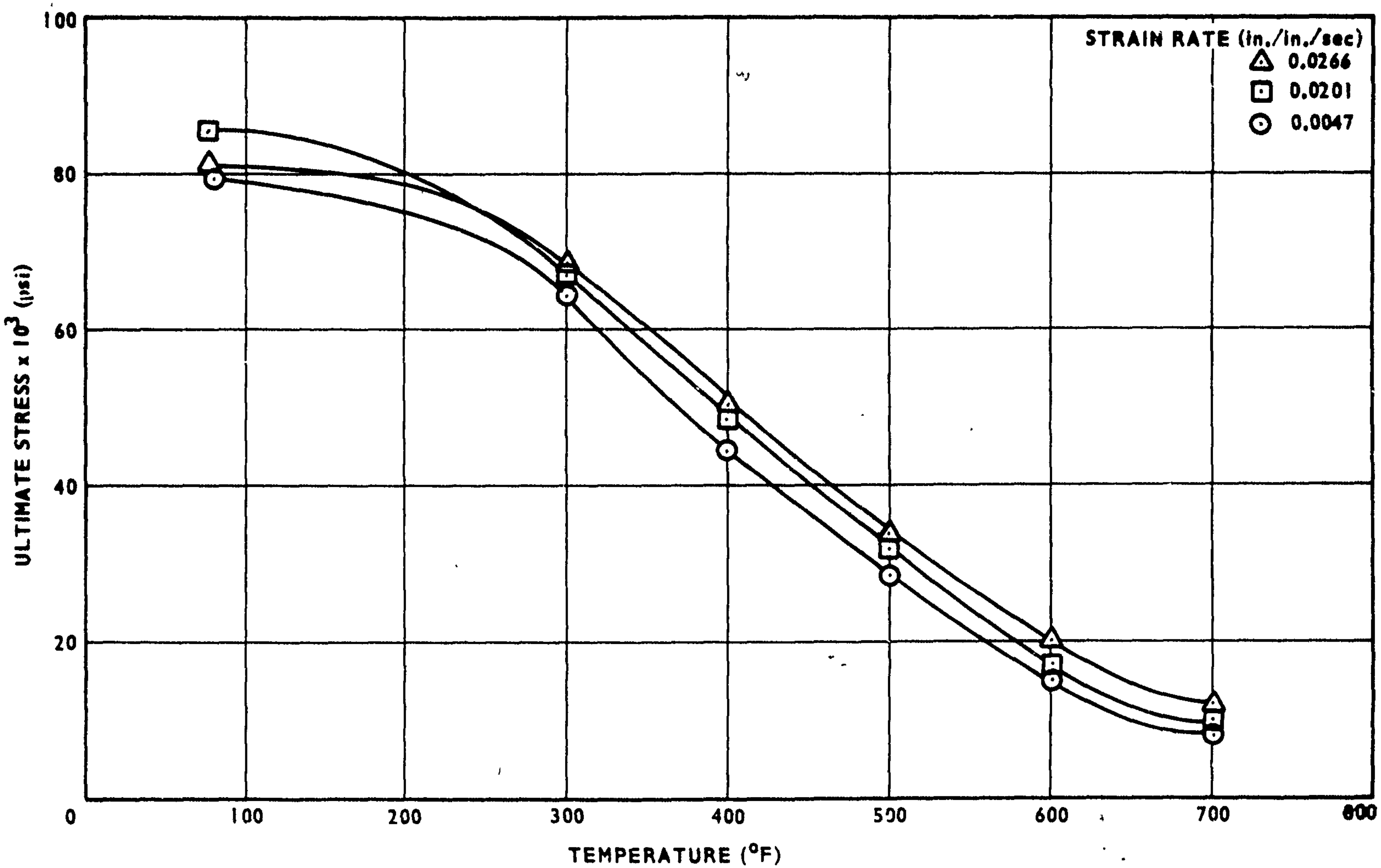


FIGURE 9. ULTIMATE STRESS-TEMPERATURE CURVES, LONGITUDINAL SPECIMEN

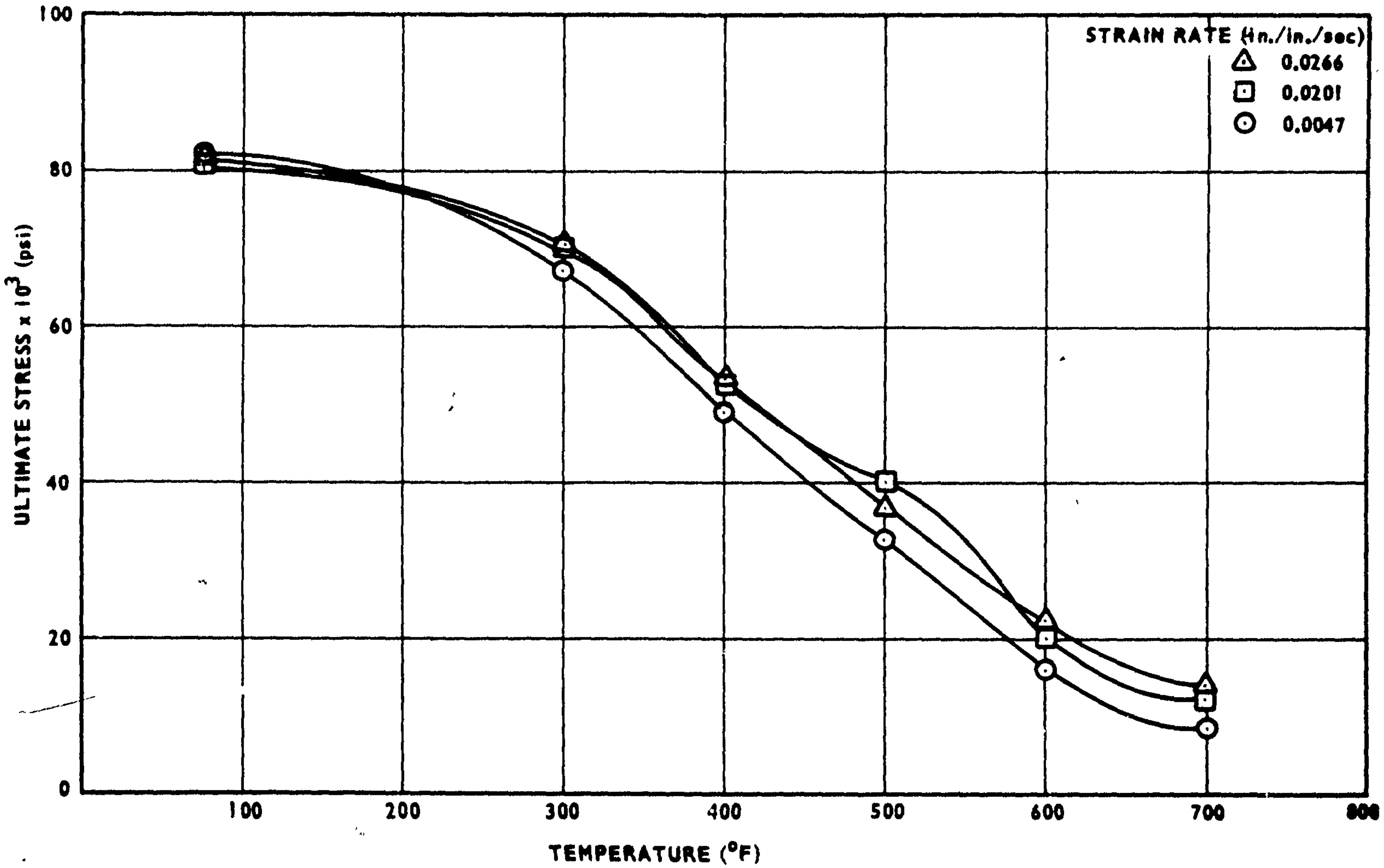


FIGURE 10. ULTIMATE STRESS-TEMPERATURE CURVES, TRANSVERSE SPECIMEN

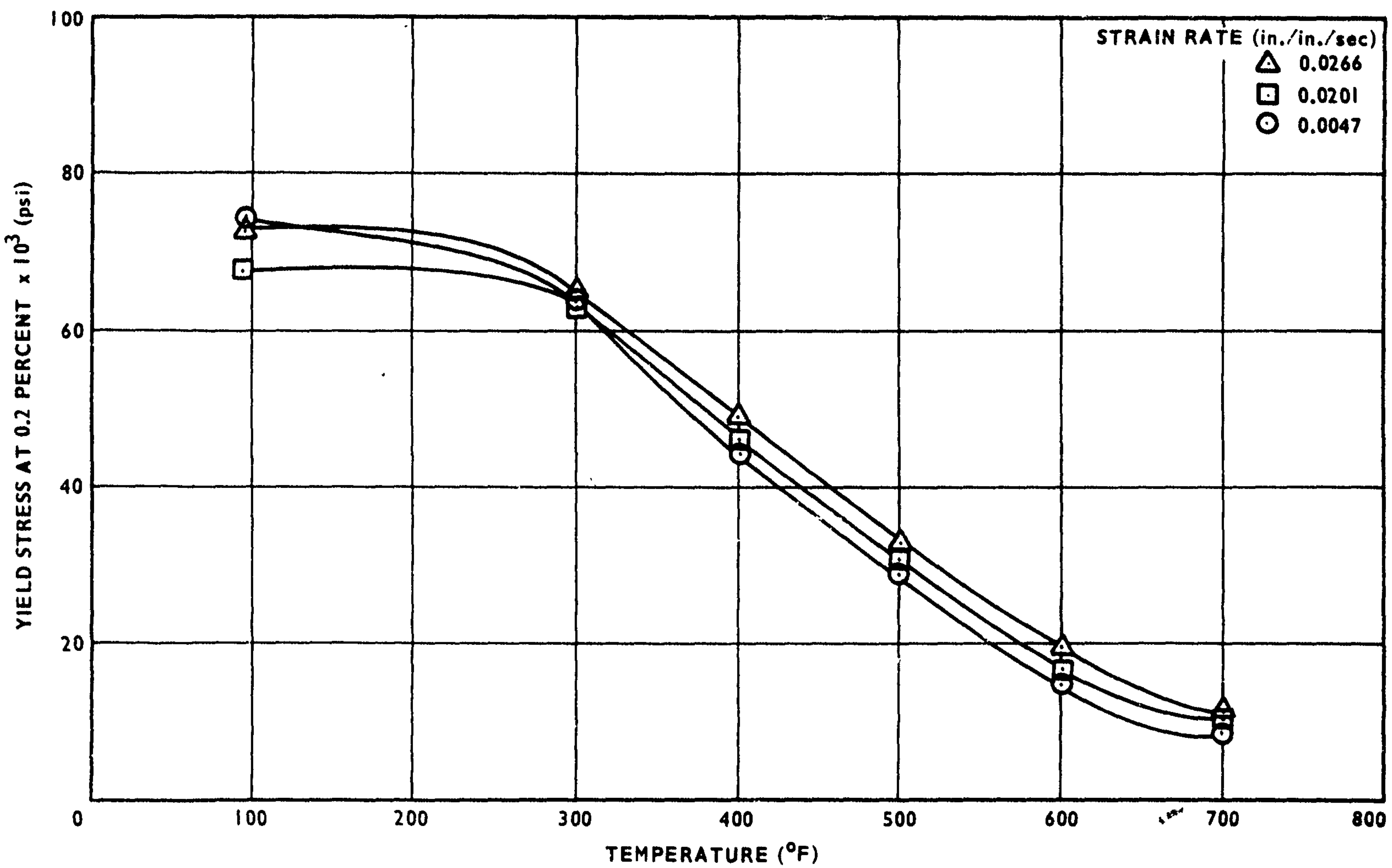


FIGURE 11. YIELD STRESS-TEMPERATURE CURVES, LONGITUDINAL SPECIMEN

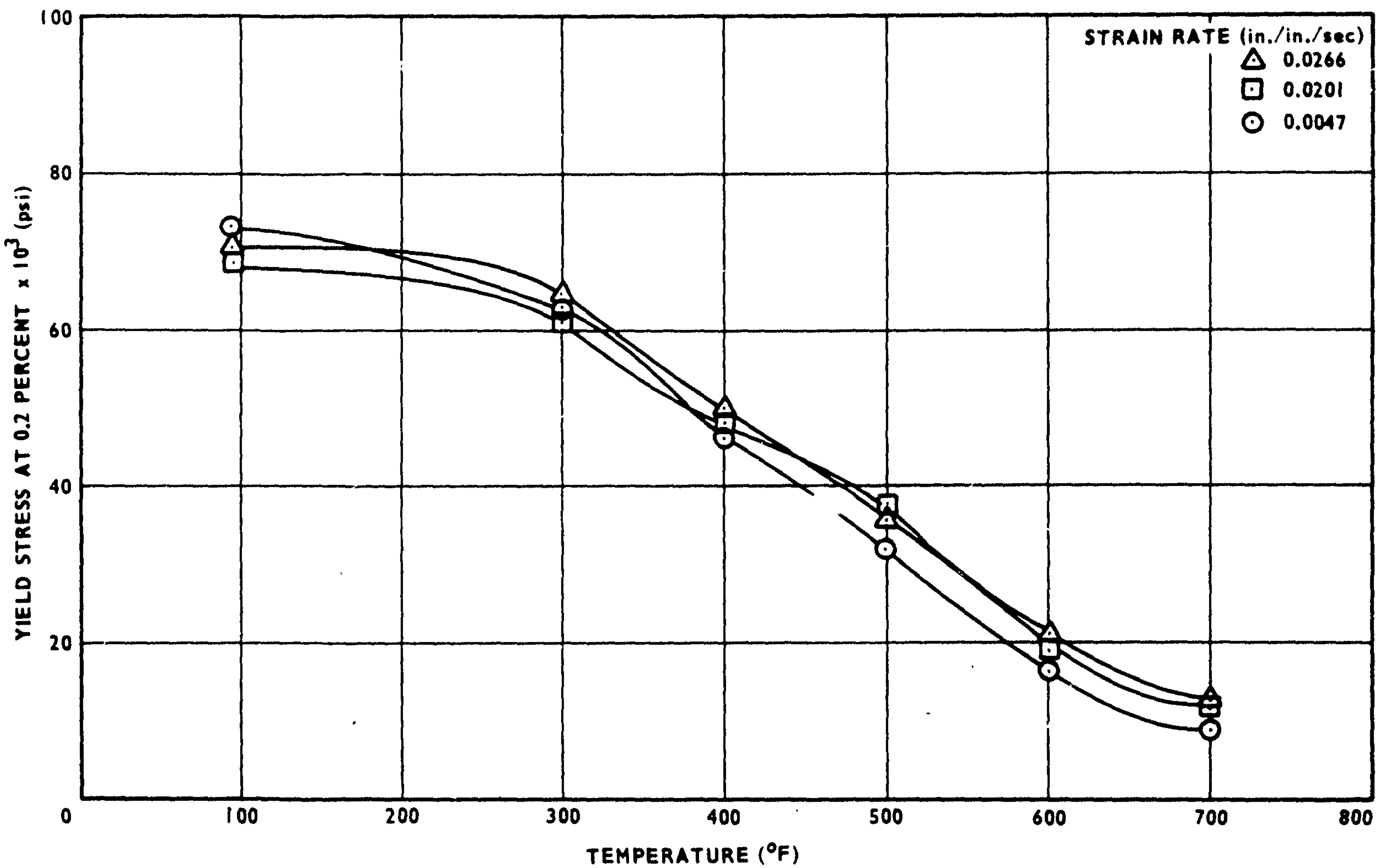


FIGURE 12. YIELD STRESS-TEMPERATURE CURVES, TRANSVERSE SPECIMEN

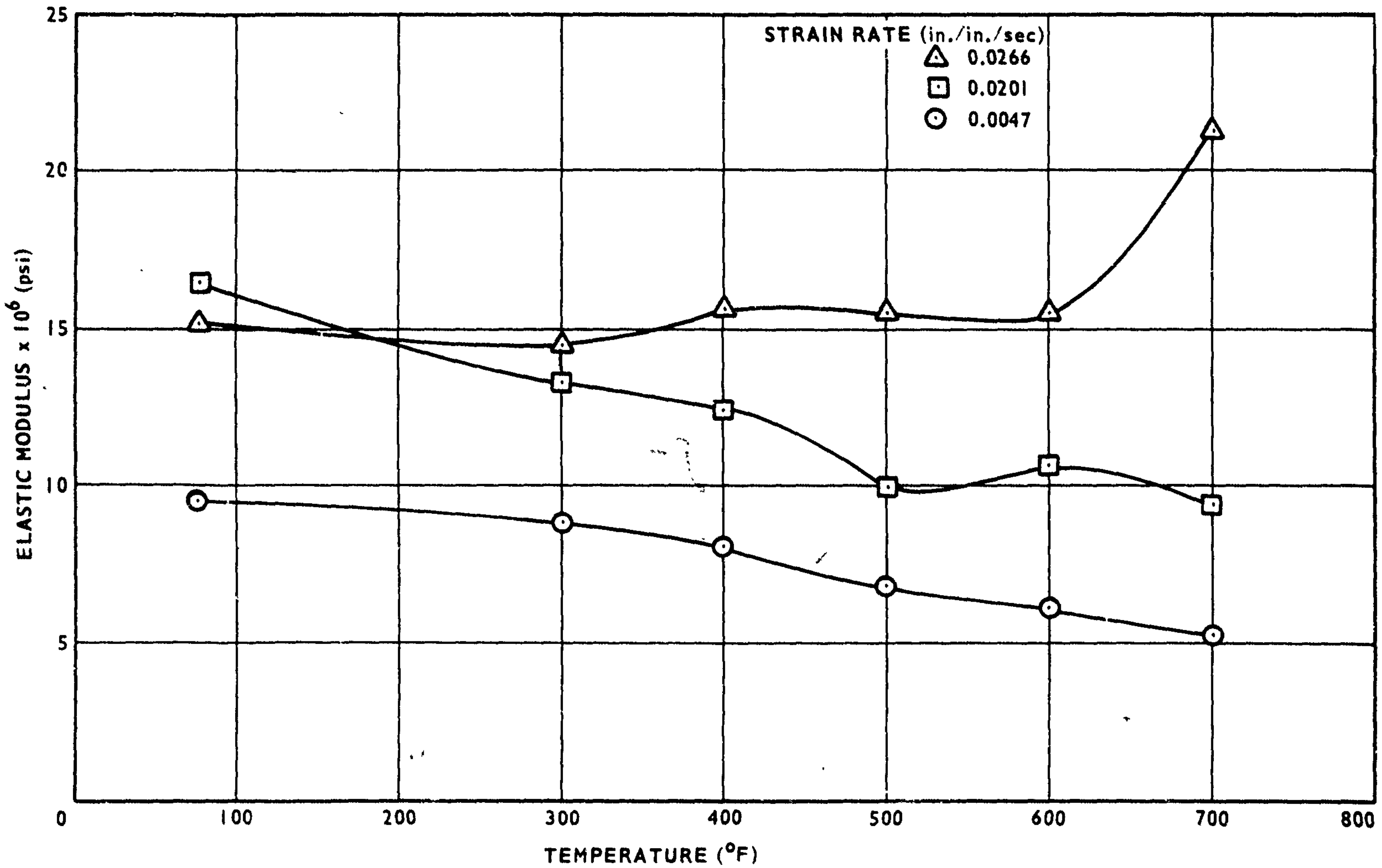


FIGURE 13. ELASTIC MODULUS-TEMPERATURE CURVES, LONGITUDINAL SPECIMEN

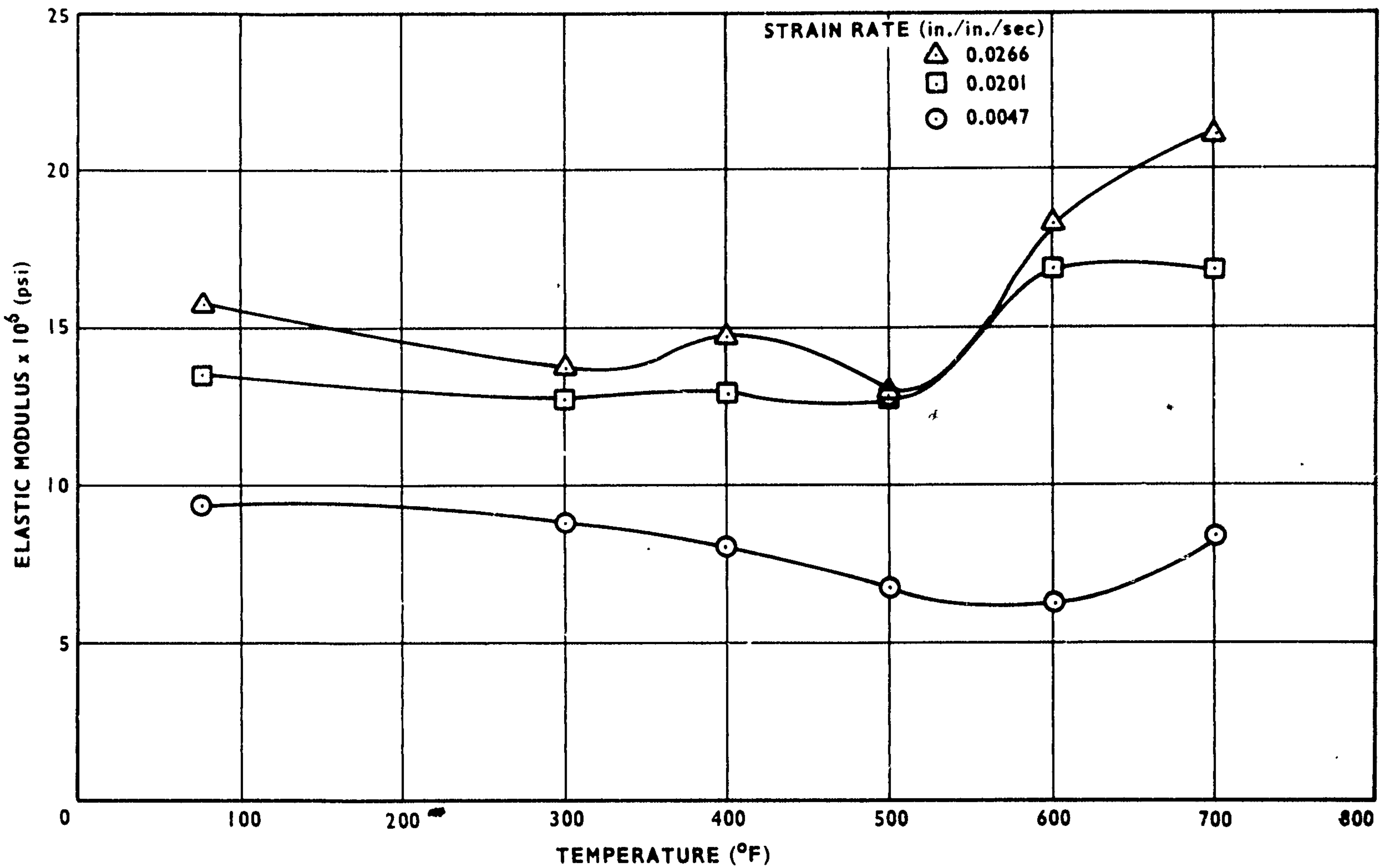


FIGURE 14. ELASTIC MODULUS-TEMPERATURE CURVES, TRANSVERSE SPECIMEN

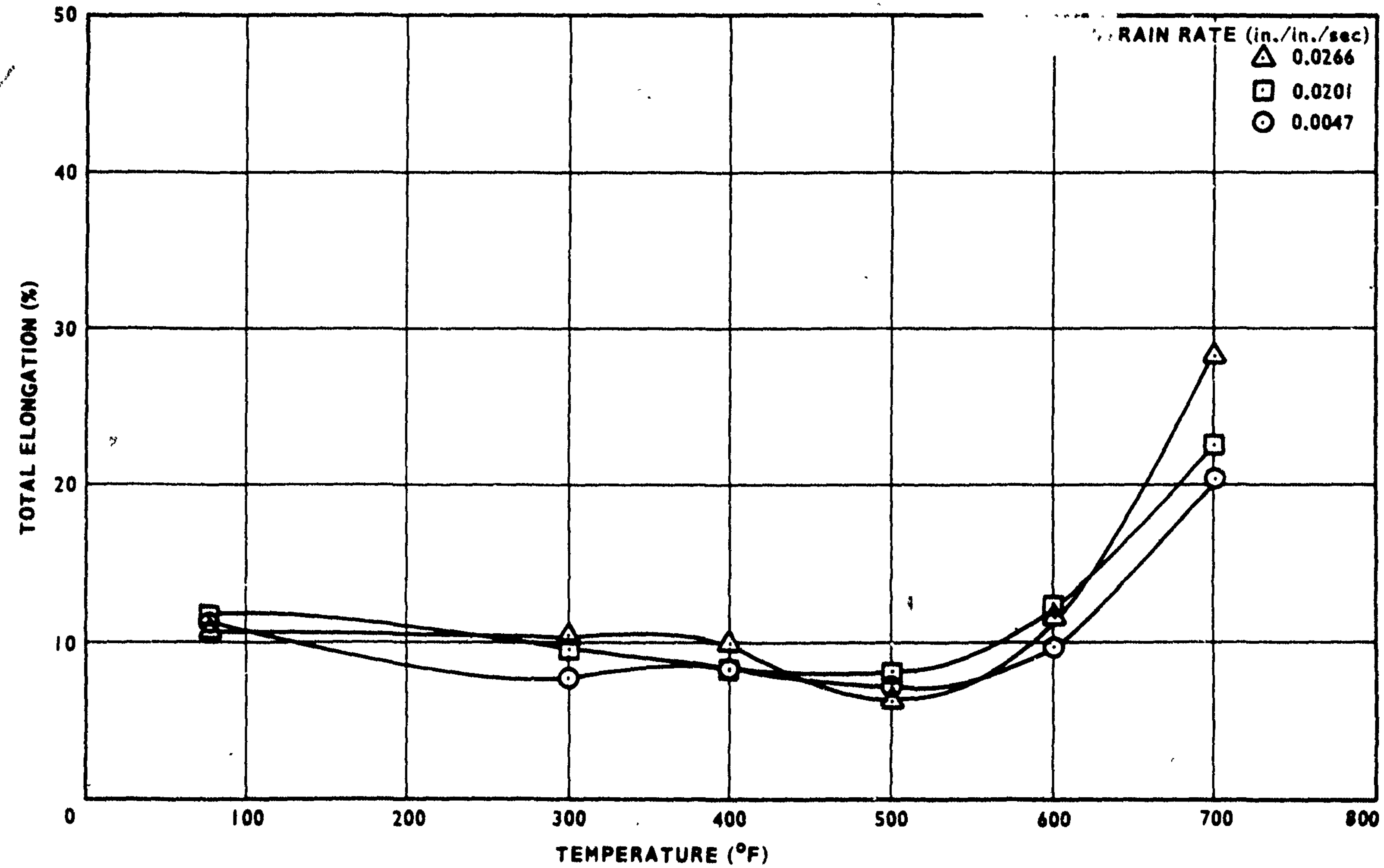


FIGURE 15. TOTAL ELONGATION-TEMPERATURE CURVES, LONGITUDINAL SPECIMEN

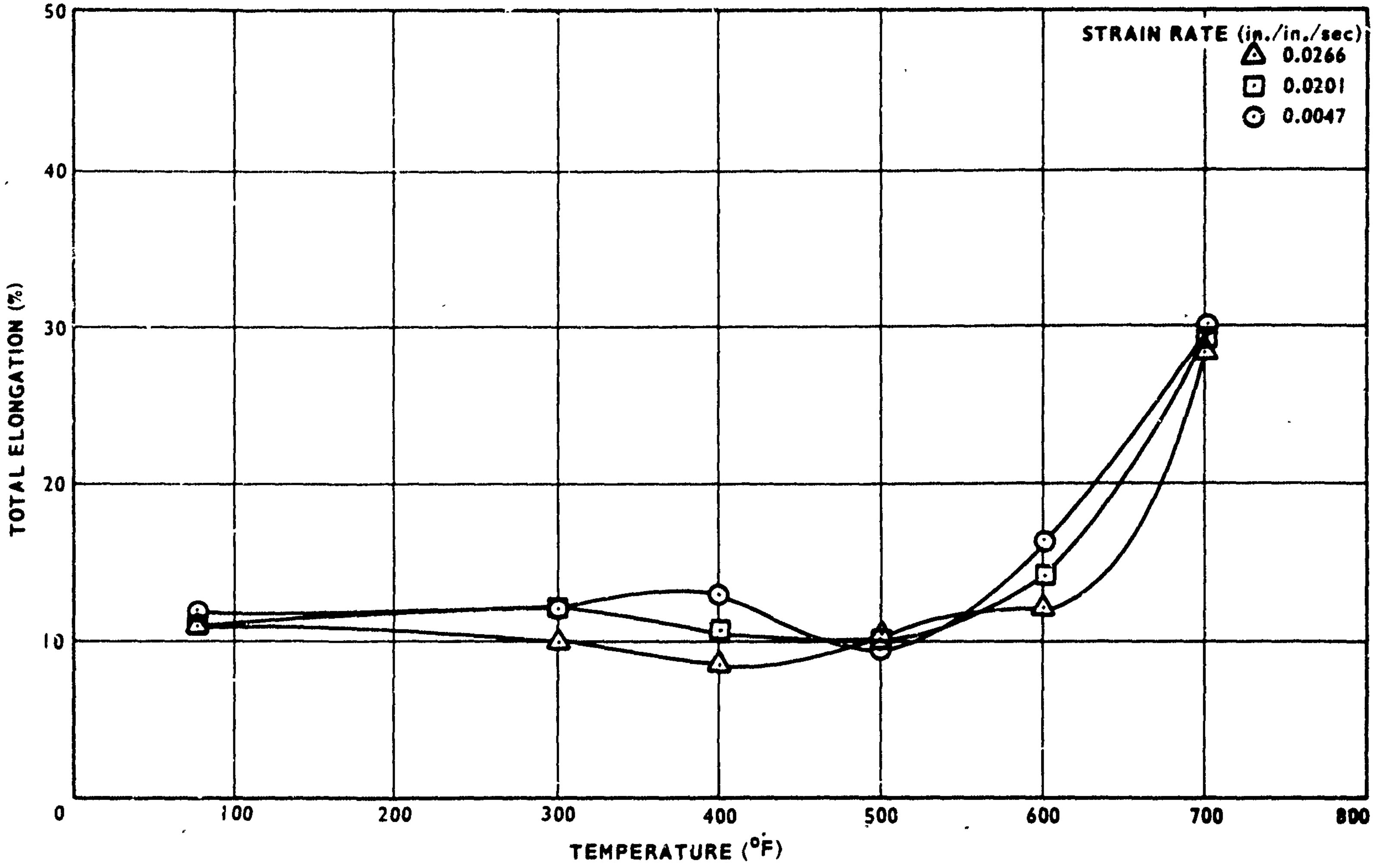


FIGURE 16. TOTAL ELONGATION-TEMPERATURE CURVES, TRANSVERSE SPECIMEN

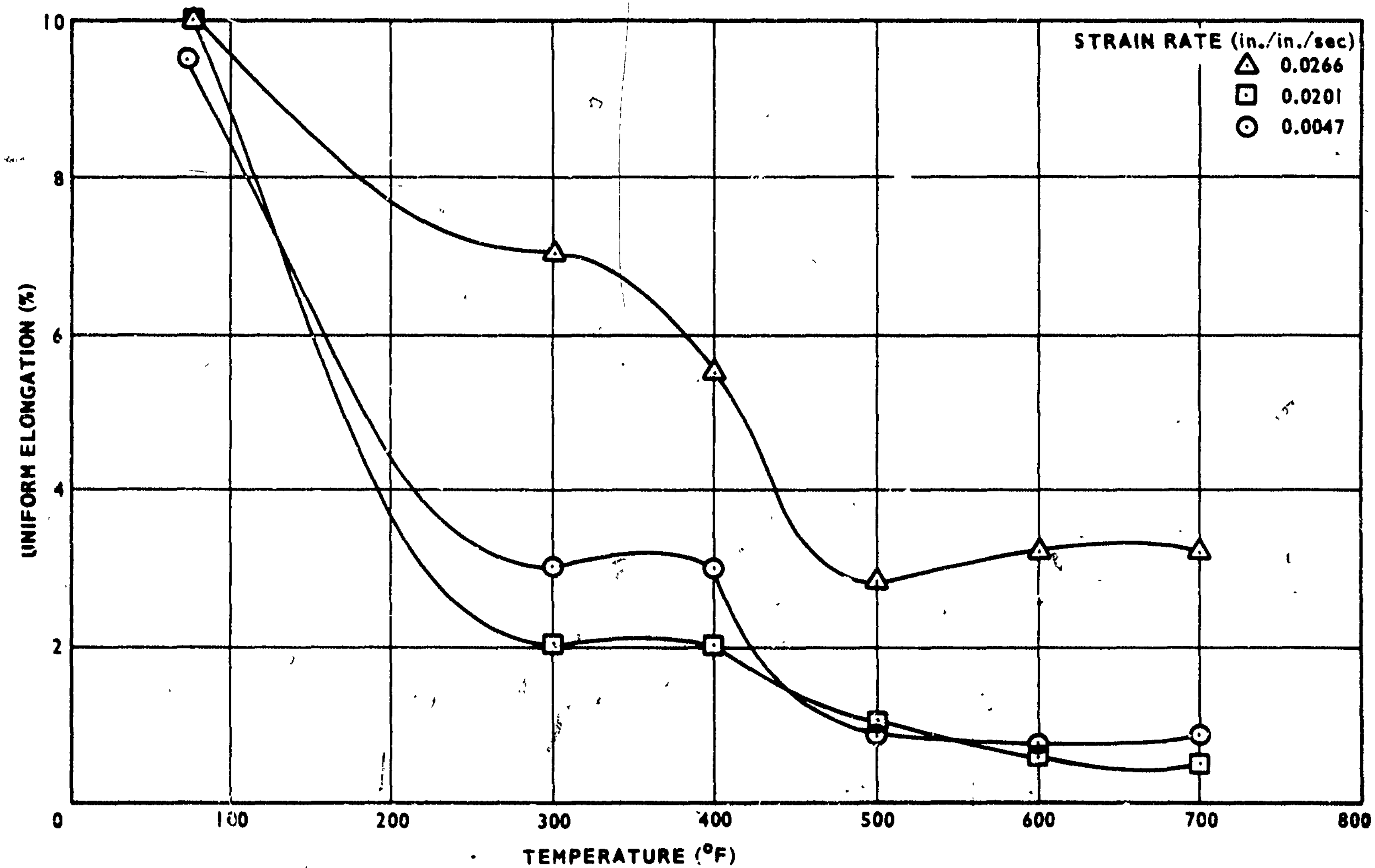


FIGURE 17. UNIFORM ELONGATION-TEMPERATURE CURVES, LONGITUDINAL SPECIMEN

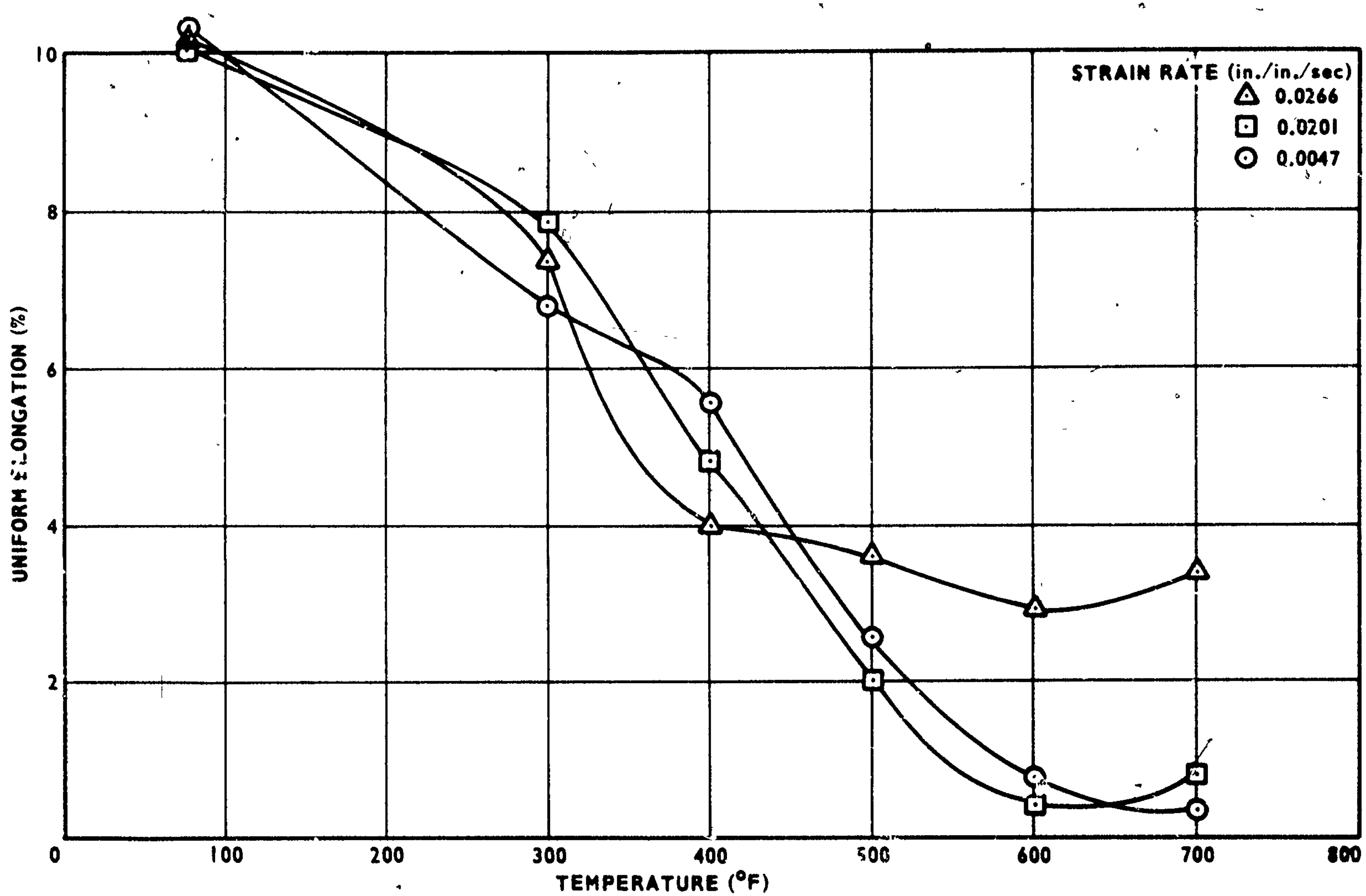


FIGURE 18. UNIFORM ELONGATION-TEMPERATURE CURVES, TRANSVERSE SPECIMEN

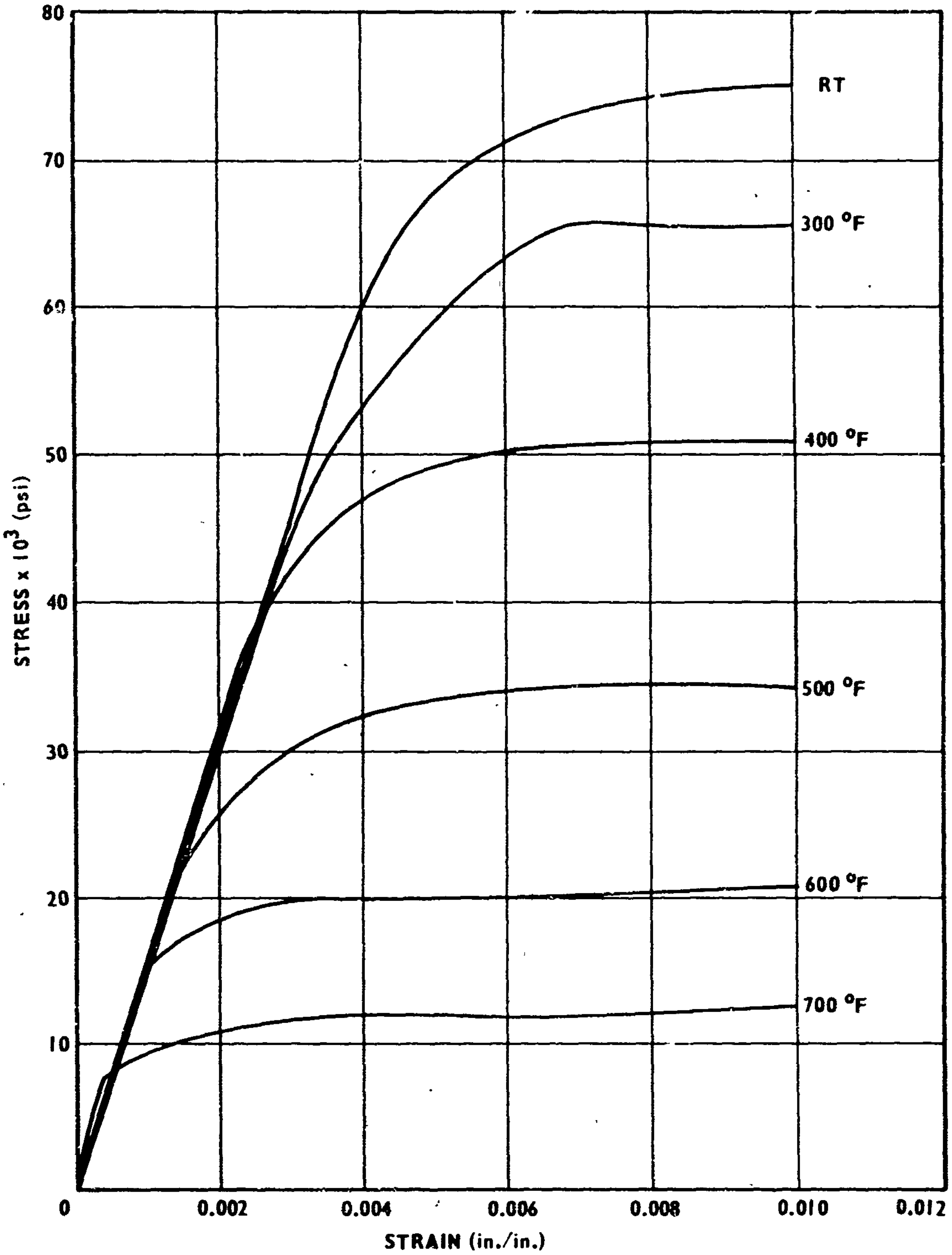


FIGURE 19. STRESS-STRAIN CURVES, LONGITUDINAL SPECIMEN, 0.0266-in./in./sec STRAIN RATE

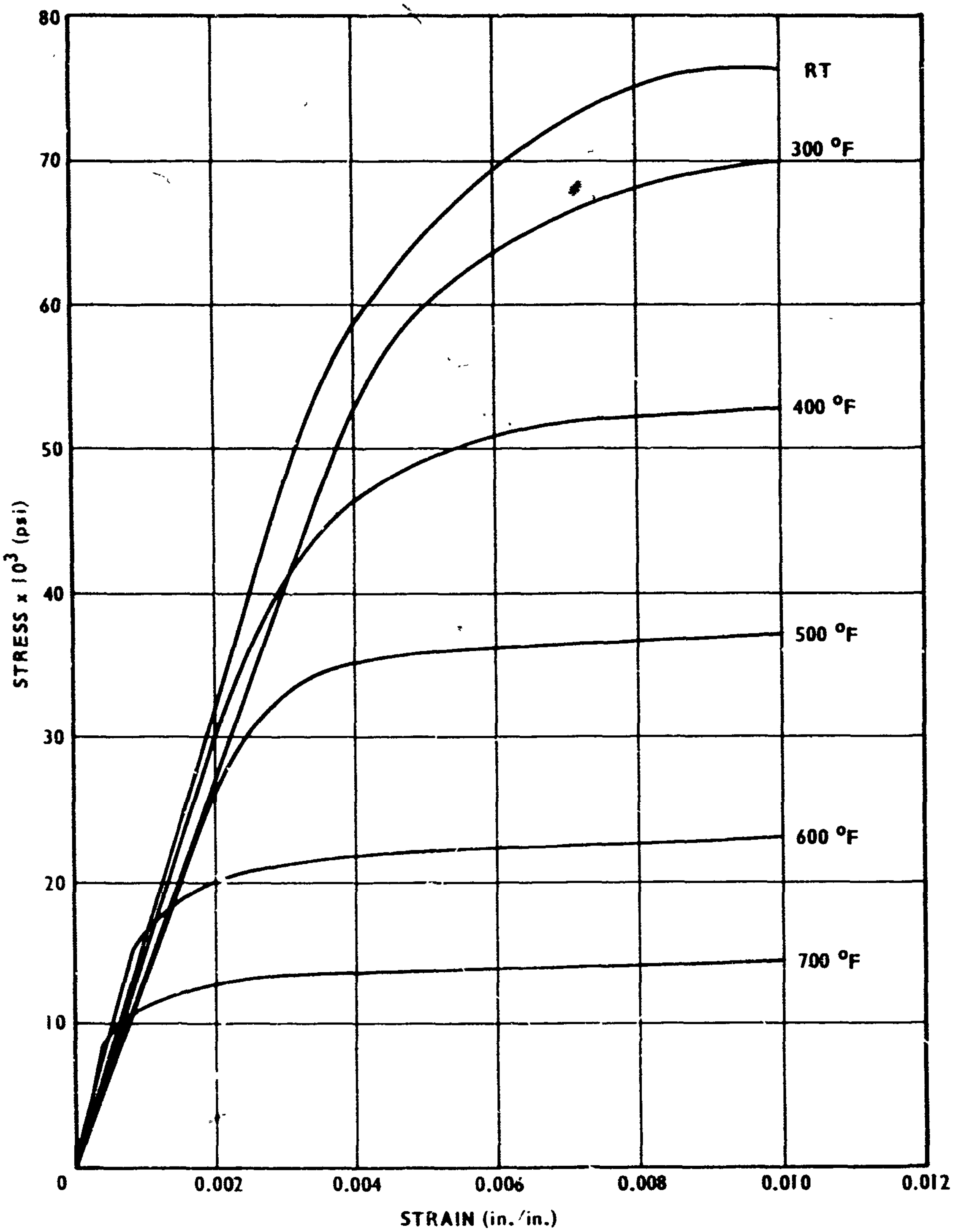


FIGURE 20. STRESS-STRAIN CURVES, TRANSVERSE SPECIMEN, 0.0266-in./in./sec STRAIN RATE

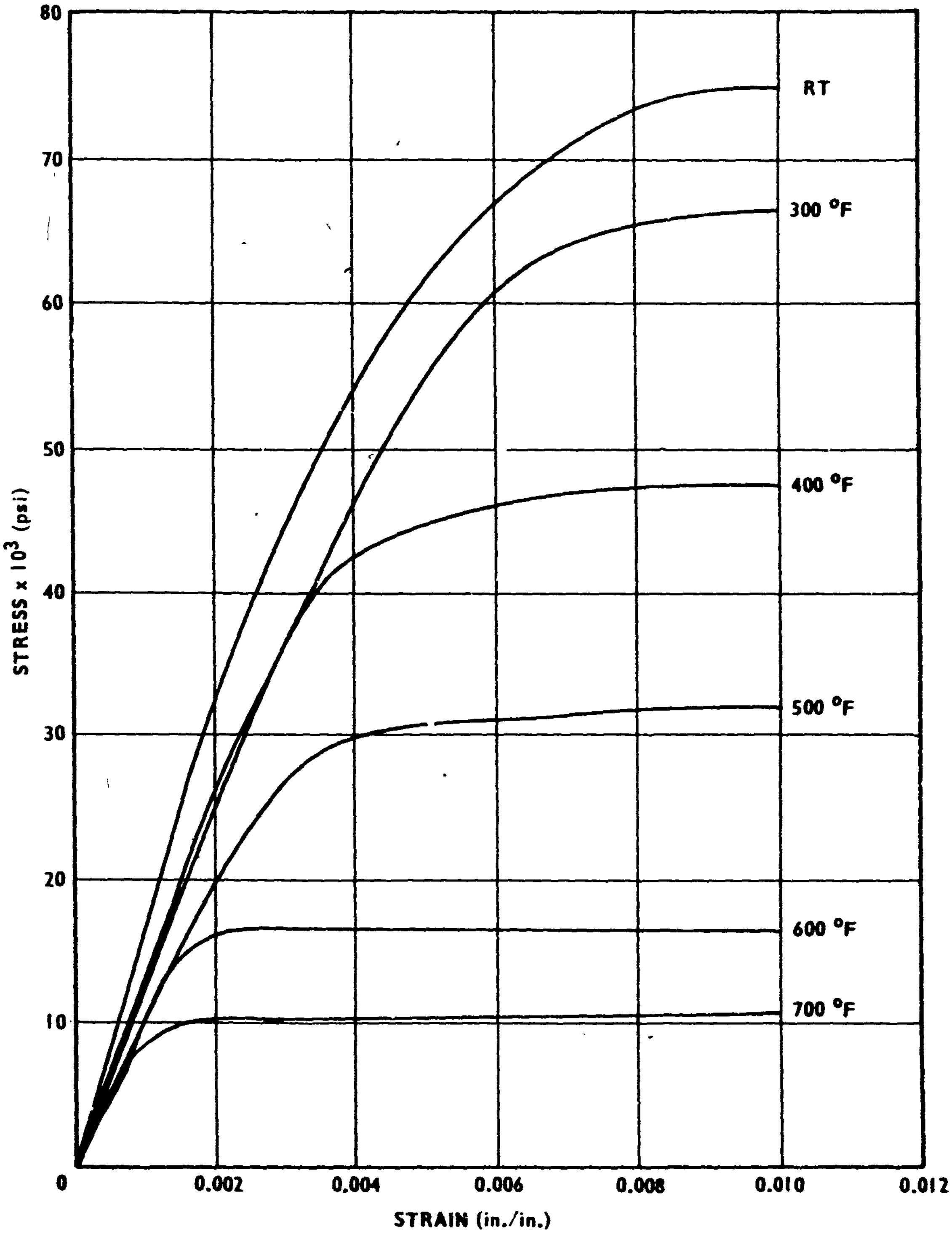


FIGURE 21. STRESS-STRAIN CURVES, LONGITUDINAL SPECIMEN, 0.0201-in./in./sec STRAIN RATE

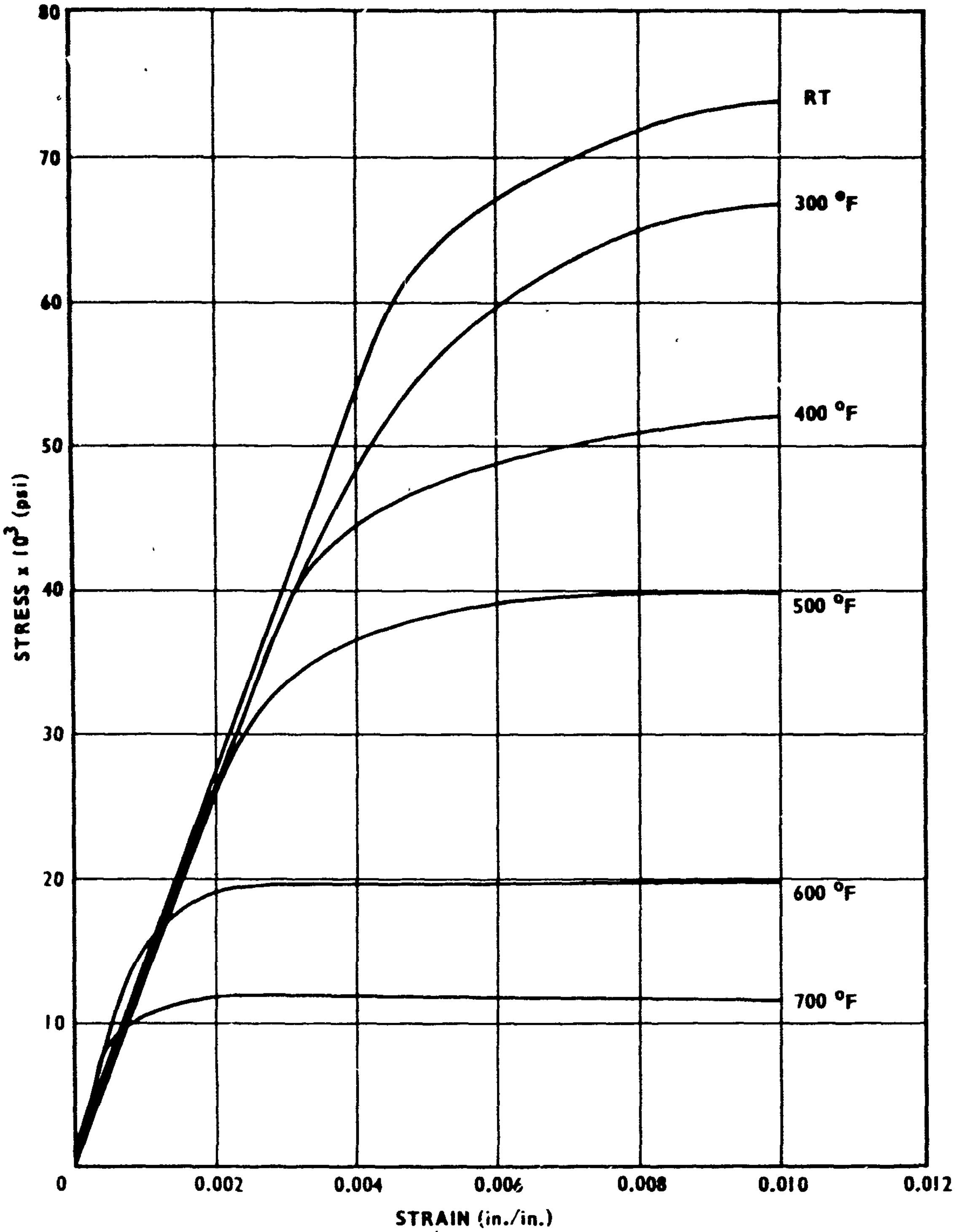


FIGURE 22. STRESS-STRAIN CURVES, TRANSVERSE SPECIMEN, 0.0201-in./in./sec STRAIN RATE

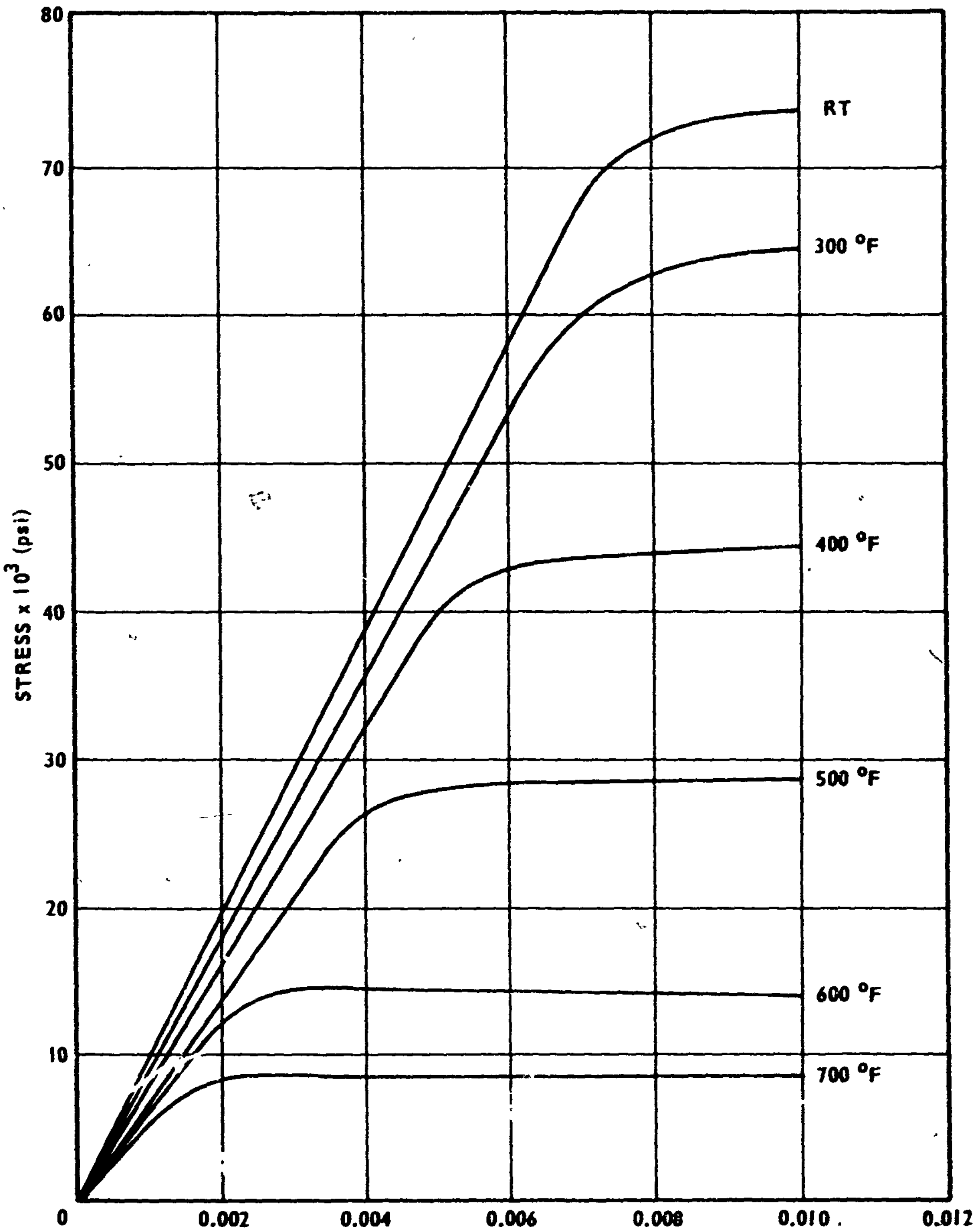


FIGURE 23. STRESS-STRAIN CURVES, LONGITUDINAL SPECIMEN, 0.0047-in./in./sec STRAIN RATE

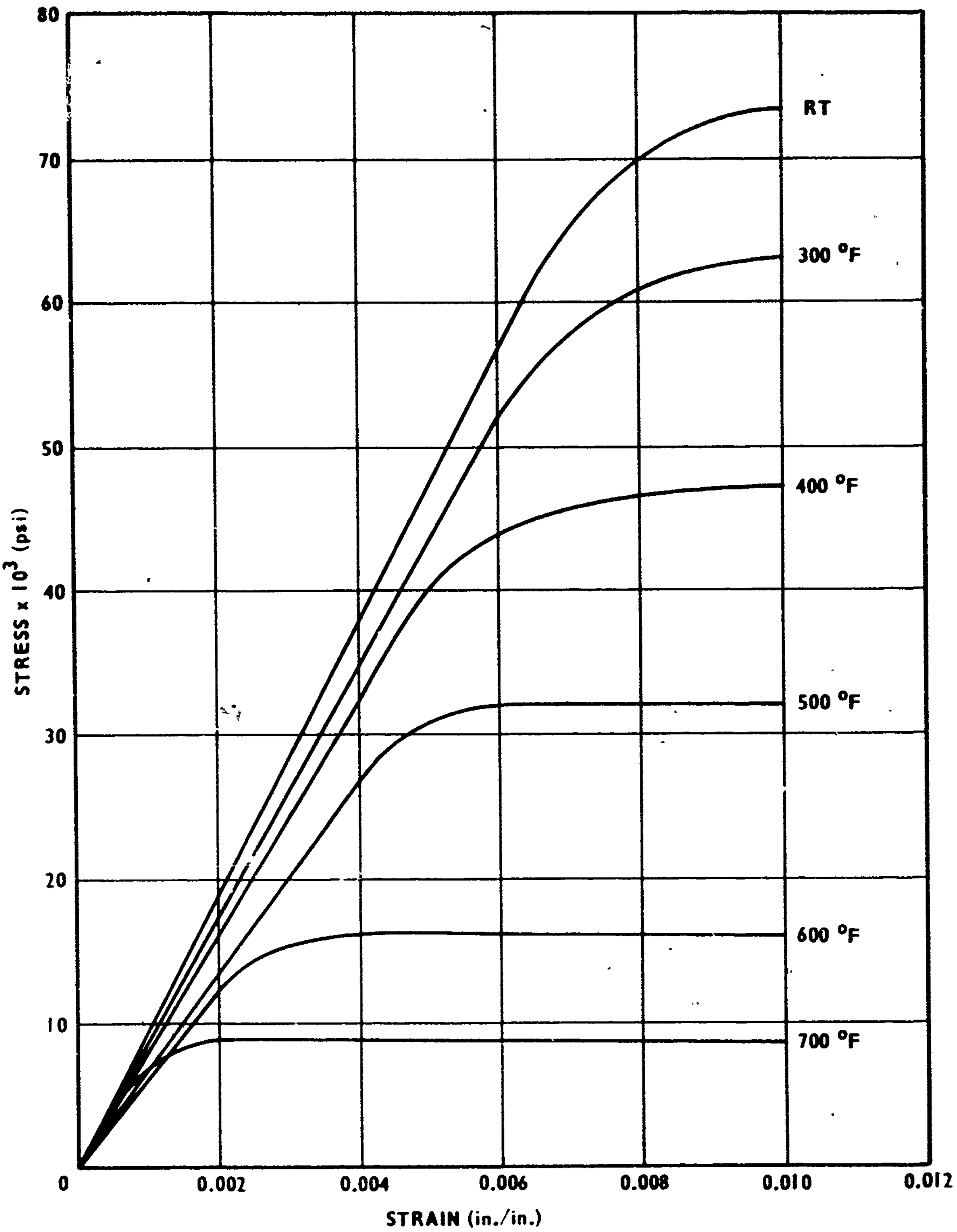


FIGURE 24. STRESS-STRAIN CURVES, TRANSVERSE SPECIMEN, 0.0047-in./in./sec STRAIN RATE

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DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author): Structures and Mechanics Laboratory, Research and Engineering Directorate, U. S. Army Missile Command, Redstone Arsenal, Alabama 35809	2a. REPORT SECURITY CLASSIFICATION: Unclassified 2b. GROUP: NA

3. REPORT TITLE

RAPID HEATING AND LOADING OF 7075-T6 ALUMINUM ALLC SHEET

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Technical Report

5. AUTHOR(S) (First name, middle initial, last name)

John H. Honeycutt

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO. OF REFS
28 May 1970	42	1

8a. CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. (DA) 1T062105A328	RS-TR-70-6
c. AMC Management Structure Code No. 5025.11.29400	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	AD________

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
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13. ABSTRACT

The purpose of this report is to make available to the design engineer tensile property data on 7075-T6 aluminum, in the longitudinal and transverse directions, under conditions of rapid heating and loading.

The tensile property data reported are: ultimate tensile stress, ultimate yield stress (at 0.2-percent offset), elastic modulus, percent total elongation, and percent uniform elongation. These tensile properties were determined at strain rates of 0.0047, 0.0201, and 0.0266 in./in./sec and at temperatures from room temperature (78°F) to 700°F at 100° intervals, excluding 100° and 200°F. The time required to reach test temperature was, in most cases, less than 10 seconds.

Primary consideration is given to ultimate tensile and yield properties. Other tensile property data reported are secondary and should be used for design criteria only after consideration has been given to the methods used for obtaining and reducing these data.

The strength properties of the test material increased with an increase in strain rate from 300° to 700°F with one exception at 500°F on the transverse specimens. However, from room temperature to 300°F, the strength properties showed almost no change with respect to strain rate except for a point at room temperature on the longitudinal specimens.

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
7075-T6 aluminum						
Tensile property data						
Rapid heating and loading						
Tensile stress						
Yield stress						
Elastic modulus						
Elongation						

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