

Tony

MATERIAL: A1SI 440C

DRM: 19.01-R1
DATE: 16 AUGUST 1971
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AEROJET NUCLEAR SYSTEMS COMPANY
MATERIALS DATA RELEASE

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NOTE: SUPERSEDES DRM 19.01, DATED 11-4-70

WORK STATEMENT REFERENCE: M 19, LINES 1-4

SYMBOLS USED:

- n = EFFECTIVE SAMPLE SIZE
- f = EFFECTIVE DEGREES OF FREEDOM FOR COMBINED STANDARD DEVIATION
- k = 99/95 TOLERANCE LIMIT FACTOR
- ~~df = DEGREES OF FREEDOM FOR WITHIN-GROUP VARIANCE.~~

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APPROVAL

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RELIABILITY: A. S. B...

CLASSIFICATION:

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PER M. Kerow

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MATERIAL AISI-440C FORM BAR CONDITION QUENCHED & TEMPERED

SPECIFICATIONS AMS 5630

PROPERTY COMPRESSIVE YIELD STRENGTH, KSI

TEMP	NO. OF OBSERVATIONS	NO. OF LOTS	VARIANCE		COMBINED (s_T^2)	m	f	MEAN VALUE (\bar{x})	STAND DEV. (s_T)	k	DESIGN ALLOWABLE ($\bar{x} - ks_T$)	dF	DATA CATEGORY	SOURCE REFERENCE
			WITHIN- LOT	* LOT-TO- LOT										
-423	9	2	127.3	6.5	133.8	7.7	9.3	437	11.6	3.99	391	14	C	(2)
RT	9	2	127.3	38.3	165.6	4.9	5.3	267	12.9	4.99	203	14	C	(2)

* POOLED OVER BOTH TEMPERATURES

MATERIAL AISI-440C FORM BAR CONDITION QUENCHED & TEMPERED

SPECIFICATIONS AMS 563C

PROPERTY COMPRESSIVE ELASTIC MODULUS, KSI x 10⁻⁶

TEMP	NO. OF OBSERVATIONS	NO. OF LOTS	WITHIN- [*] LOT	VARIANCE LOT-TO-LOT	COMBINED (s _T ²)	n	f	MEAN VALUE (x̄)	STAND DEV. (s _T)	k	99/95 LIMITS		dF	DATA CATEGORY	SOURCE REFERENCE
											LOWER (x̄ - ks _T)	UPPER (x̄ + ks _T)			
-423	9	2	0.844	0	0.844	9	14	30.1	0.92	3.59	26.8	33.4	14	C	(2)
RT	9	2	0.844	0	0.844	9	14	31.2	0.92	3.59	27.9	34.5	14	C	(2)

* POOLED OVER BOTH TEMPERATURES

MATERIAL AISI-440C FORM BAR CONDITION QUENCHED & TEMPERED

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SPECIFICATIONS AMS 5630

PROPERTY POISSON'S RATIO

TEMP	NO. OF OBSERVATIONS	NO. OF LOTS	WITHIN-LOT *	VARIANCE LOT-TO-LOT **	COMBINED (s_T^2)	m	f	MEAN VALUE (\bar{x})	STAND DEV. (s_T)	k	99/95 LIMITS		dF	DATA CATEGORY	SOURCE REFERENCE
											LOWER	UPPER			
											$(\bar{x} \pm ks_T)$				
-423	4	1**	.000213	.000028	.000241	6.8	7.6	0.268	.015	4.26	.205	.331	11	C	(2)
RT	10	2	.000213	.000028	.000241	6.8	7.6	0.278	.015	4.26	.215	.341	11	C	(2)

* POOLED OVER BOTH TEMPERATURES

** VALID DATA UNAVAILABLE FOR ONE OF THE LOTS. LOT TO LOT VARIABILITY AT -423°F ASSUMED TO BE THE SAME AS FOR RT.

MATERIAL AISI-44C FORM BAR CONDITION QUENCHED & TEMPERED

SPECIFICATIONS AMS 5630

PROPERTY HARDNESS, ROCKWELL "C"

TEMP	NO. OF OBSERVATIONS	NO. OF LOTS	WITHIN LOT VARIANCE	m	f	MEAN VALUE (\bar{x})	STAND DEV. (s)	k	99/95 LIMITS		DATA CATEGORY	SOURCE REFERENCE
									LOWER ($\bar{x} \pm ks_T$)	UPPER		
-320 & * RT	8 **	2	0.83	8	7	58	0.9	4.35	54	62	C	(2)

* NO SIGNIFICANT DIFFERENCE BY TEMPERATURE OR LOT

** EACH OBSERVATION IS AN AVERAGE OF 5 READINGS ON THE SAME SPECIMEN.

MATERIAL AISI-440C FORM BAR CONDITION QUENCHED & TEMPERED

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SPECIFICATIONS AMS 5630

PROPERTY DENSITY, LBS/IN³

TEMP °F	TYPICAL VALUE	UNCERTAINTY RANGE	DATA CATEGORY	REFERENCE
-423	.28	± 5%	C	(4)
RT	.28	± 5%	D	(5)

NOTE: TAKEN FROM PREVIOUS DRM 19.01, DATED 11-4-70.

I. TEST DESCRIPTION

AISI 440C annealed bar stock*per AMS 5630 was obtained from two Universal Cyclops heats, H-16540-K2 (Heat "H") and B-18683-K1 (Heat "B") and was heat-treated as follows: (Ref. 1)

- a. Solution anneal @ 1900°F, 1 hr., oil quench
- b. Temper @ 350°F, 2 hrs., air cool to RT
- c. Quench in LN₂, hold 0.5 hr., warm to RT
- d. Temper (per Step b)
- e. Quench (per Step c)
- f. Temper (per Step b).

Specimens 1/2 in. square by 1 in. long^{4x} were prepared from the heat-treated material. Testing was conducted for compressive yield strength, compressive modulus and Poisson's ratio according to the following matrix showing the number of specimens.

	Heat H	Heat B
-423°F	5	5
RT	5	5

In addition, hardness measurements were made on two specimens from each heat at both room temperature and -320°F.

* 2 1/2" and 1 1/2" diameter for Heats H and B respectively.

** Reduced to 1/4" square x 1" long for compressive yield strength testing at -423°F.

II. DATA ANALYSIS

The test data (Ref. 2) and averages and standard deviations of each group are shown in Table 1.

The Poisson's ratio results for Heat H at -423°F were extremely erratic, exhibiting a high variability which was not consistent with that of the other groups. Since this excessive variability was considered to be a testing anomaly rather than a true measure of the material property, the data for the entire group were excluded from the analysis.

Analysis of variance showed that for all properties lot-to-lot variance was either non-existent or small relative to within-lot variation. Use of the Bartlett-Box test showed that within-group variances were homogeneous for the two temperatures and therefore pooling of these variances was justified.

Calculation of design allowables followed the method of Reference 3, Paragraph 5.4.5.4, in which the estimates of lot-to-lot variance and within-lot variances are combined.

The computer program SATT on the GE Mark II computer was used to perform the calculations leading to the 99/95 design allowables. For modulus, Poisson's ratio and hardness, both upper and lower 99/95 limits are furnished to be used at the discretion of the designer.

In the case of Poisson's ratio where the -423°F data for Heat H were eliminated, the lot-to-lot variation observed in the room temperature data was assumed to apply at both temperatures.

Although the test matrix was designed to furnish "A" data, the test failures prevented the realization of this goal. A maximum of 14 degrees of freedom were available to estimate the within-group variance, instead of the 15 required for "A" data. The present data for modulus and yield strength can probably be upgraded to "A" with the testing of one or more additional specimens from the same lots. The data are currently categorized as "C".

For hardness, no significant differences were found either for temperatures or lots. Accordingly all data were pooled both for mean and variance.

No new density measurements were made and therefore the density information from the previous DRM is repeated in this revision. Room temperature density was obtained from Reference (4) and the density at -423°F was estimated from the characteristics of similar stainless steels. (Ref. (5)).

AISI 440C BAR MECHANICAL PROPERTIES DATA

	POISSON'S RATIO *		COMPRESSIVE YIELD STRENGTH, KSI		COMPRESSIVE MODULUS, KSI $\times 10^{-6}$		HARDNESS (R _C) **	
	-423°F	RT	-423	RT	-423	RT	-320°F	RT
HEAT B-18683-K1	.241	.294	458.2	269.2	30.6	30.8	58.3	57.8
	.273	.289	441.9	262.8	29.0	31.0	58.6	57.6
	.283	.298	435.5	237.2	29.0	30.5		
	.274	.272	430.6	273.3	31.2	32.9		
	(a)	.266	438.7	(b)	30.1	(c)		
\bar{x}	.268	.284	441.0	260.6	30.0	31.3	58.4	57.7
n	4	5	5	4	5	4	2	2
s	.0185	.0140	10.5	16.2	0.98	1.09	0.2	0.1
HEAT 1-16540-K2	.276	.257	428.1	269.2	31.0	32.4	57.7	58.2
	.360	.268	429.7	260.5	30.1	29.7	59.4	56.3
	.301	.269	430.9	289.0	30.5	31.1		
	.374	.289	441.7	273.3	29.8	31.1		
	(b)	(c) .268	(b)	269.0	(b)	31.2		
\bar{x}	.328	.270	432.6	272.2	30.4	31.1	58.6	57.2
n	4	5	4	5	4	5	2	2
s	.0466	.0152	6.2	10.5	0.52	0.96	1.3	1.3

NOTES: * EACH FIGURE IS THE AVERAGE OF 4 DETERMINATIONS, EACH AT A DIFFERENT STRESS (12, 14, 16 AND 18 ksi)

** EACH FIGURE IS THE AVERAGE OF 5 READINGS MADE ON A SINGLE SPECIMEN.

(a) STRAIN GAGE FAILURE

(b) SPECIMEN FAILURE

(c) DATA NOT USED IN ANALYSIS BECAUSE OF EXTREME VARIABILITY.

III. REFERENCES

1. Laboratory Work Request #14289, ANSC to ALRC
(IDO #961089, dated 3-29-71).
2. Materials Memorandum N8130:0110 from A. J. Giannuzzi to
M. S. Lev, dated 13 August 1971, Subject: AISI 440C Mechanical
Properties.
3. NERVA Program Procedure R-101-NRP-503 "Statistical Analysis
of Material Test Data"
- * 4. Republic Stainless Steels
- * 5. Cryogenic Materials Data Handbook (Revised), Vol. 1,
Section B, AFML-TOR-64-280, August 1968

* References cited in original DRM dated 11-4-70.