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MECHANICAL PROPERTIES OF 17-4PH STEEL, HOMOGENIZED VERSUS AS RECEIVED CONDITION

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GENERAL DYNAMICS | FORT WORTH

TEST DATA MEMORANDUM

F-TDM NO. 3226
MODEL F-111
TEST NO. 30-3219

TEST: MECHANICAL PROPERTIES OF 17-4PH STEEL, HOMOGENIZED VERSUS AS RECEIVED CONDITION

OBJECT: To determine if a homogenizing heat treatment would improve the mechanical properties of 17-4PH steel sufficiently to require homogenization as a pre-requisite for the rework of the fuselage lugs on the wear and bearing pivot test component.

Test Specimens and Procedures:

The plate used for this test was from the same alloy heat as that used for the original lug and as the material proposed for the modified lug. Coupons for the tensile specimens, Figure 1 (FTJ 10940-1), were sawed from the plate according to the diagram in Figure 2 in order to sample the surface and center layers.

One piece of plate was retained "as received," or in the solution heat treated condition. The other piece was homogenized at 2150 F. for two hours and air cooled to room temperature (<90F). It was then solution heat treated at 1900 F. for 1/2 hour and air cooled. Both pieces of plates were now in the annealed condition. Nine tensile coupons were machined from each plate. Three specimens from each set of nine were aged for one hour at 900, 1000, and 1075 F., respectively. All of the specimens were then polished with emery paper to the proper diameter and were tested in a 120,000# capacity Baldwin Universal Test Machine equipped with an autographic load-strain recorder. In addition to the usual tensile properties, a proportional limit was calculated at .01% plastic strain per the Mil-Hdbk 5 definition.

Results and Discussion:

The tensile properties are recorded in Table I and are plotted as a function of aged condition in Figure 4.

The Armco Technical Data Manual states that homogenizing will "add materially to the ductility" of 17-4PH and their data indicate better than a 100% improvement. As measured by elongation, our results showed a negligible improvement from homogenizing. The percent reduction of area improved by 17% for the H900 condition after homogenizing but the same improvement could be achieved by using the H1000 condition. Homogenizing also improved the uniformity of ductility for each aging condition, but reduced the tensile strength from 2 to 3 percent.

BY
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DATE: 2-19-64

The modulus of elasticity was below the Armco valve but this variance was attributed to autographic plotting of the load-strain curve and to placing the modulus line on the curve.

Figure 4 shows that, as a function of aging condition, the ultimate and yield strengths decreased, whereas the elastic and proportional limits remained constant. The tensile properties did not reveal an obvious relationship to the thickness of the plate. Two middle and one surface position specimen had "volcanos" or projection discontinuities on the fracture surface. Metallurgical literature state that volcanos are evidence of localized weak spots attributed to inclusions in the alloy. The splits mentioned in Table I were the delta ferrite stringers present in 17-4PH steel. The sporadic appearance of fracture splits was considered to be evidence of an unevenly distributed delta ferrite phase.

The fine or coarse fracture texture and the shear lip size were indicative of the strength and ductility of an aging condition. Considered together with the specimen position in the plate, several fracture features account for the variations in tensile properties within the age condition groups.

Optical and electron microscopy was used to examine the microstructure of representative samples from the H900 and H1075 conditions. The panorama of the observed structures, Figure 3, shows that there was little, if any, difference between the homogenized and non-homogenized samples at each aged condition.

Conclusion:

For this particular heat of 17-4PH steel plate, the homogenizing treatment improved the ductility as measured by the reduction of area and reduced the spread in ductility data for each aged condition.

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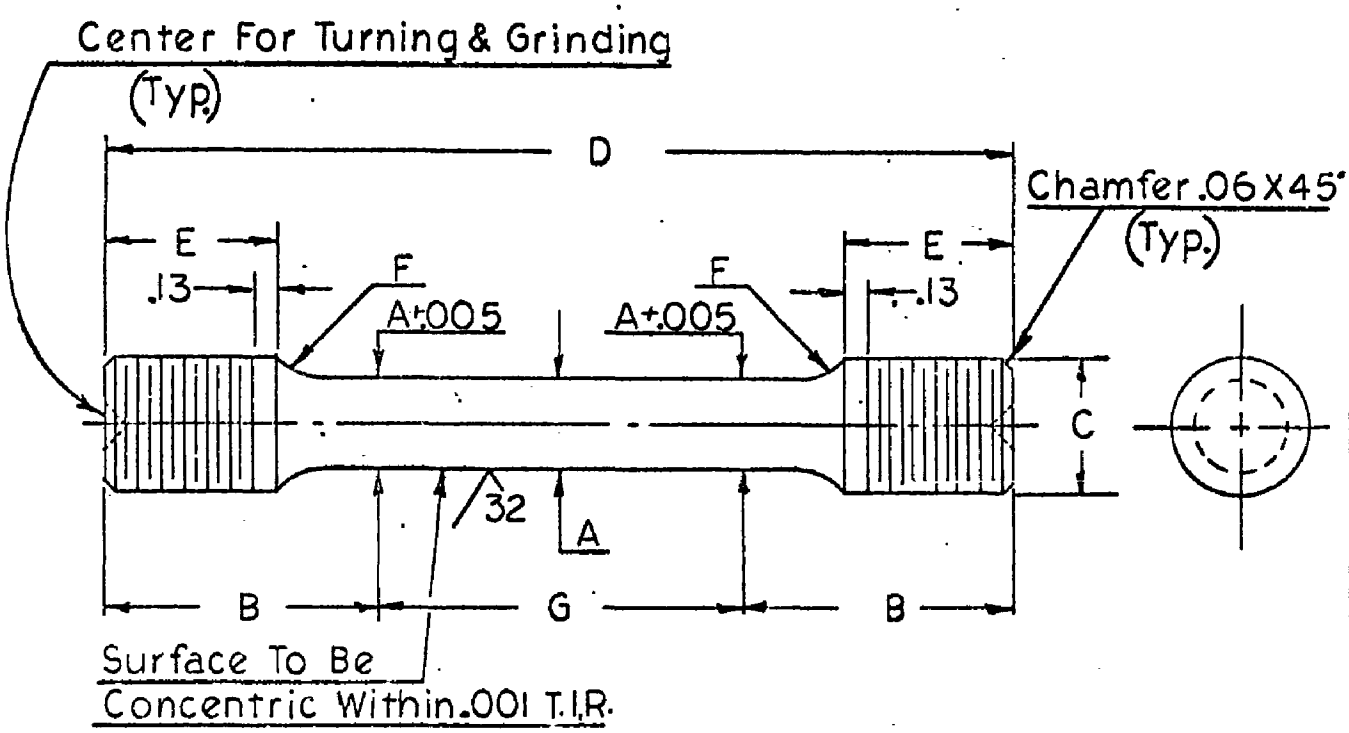
TABLE I

MECHANICAL PROPERTIES OF 17-4PH HOMOGENIZED VS NONHOMOGENIZED

SPEC. No.	CONDITION		Fty ksi	Ftu ksi	Ftu ksi	Elast.Lmt. ksi	e % in 2"	R/ %	E x(10)^6	FRACTURE TEXTURE AND CHARACTERISTICS	SPECIMEN POSITION IN PLATE
P5	H900	NonHomo	176.1	198.6	135.6	120.1	12.0	30.7	26.6	Fine, small shear lip	Bottom
P12			174.7	198.3	137.7	102.7	11.0	26.2	27.0	Fine, " " " , volcano *	Bottom
P7			174.4	197.3	132.0	117.1	14.0	30.2	26.1	Fine, " " "	Top
		Avg.	175.1	198.1	131.8	113.3	11.7	29.0	26.56		
H6	H900	Homo.	171.2	194.5	131.0	110.3	12.5	36.4	26.8	Fine, small shear lip	Bottom
H12			169.3	193.8	131.0	117.1	12.0	34.9	26.7	Fine, " " "	Bottom
H4			169.3	193.9	130.3	109.4	13.0	33.7	27.3	Fine, " " "	Top
		Avg.	170.3	194.1	130.8	112.4	12.8	35.0	26.95		
P3	H1000	NonHomo.	164.2	175.3	128.7	107.7	10.0	28.3	26.4	Coarse, large shear lip, volcano	Middle
P2			164.6	175.1	118.9	82.8	13.0	40.0	27.5	Coarse, " " " , splits **	Top
P8			166.4	176.9	121.8	100.2	13.0	38.2	28.2	Coarse, " " " , splits	Top
		Avg.	164.9	175.8	123.5	96.9	12.0	35.5	27.38		
H10	H1000	Homo.	159.3	168.8	125.2	117.7	13.0	45.5	27.1	Coarse, small shear lip, radial splits	Top
H3			160.6	172.2	127.3	109.8	14.0	44.3	26.9	Coarse, large shear lip, fine splits	Bottom
H5			160.9	170.9	126.4	107.4	13.0	43.3	27.4	Coarse, " " "	Middle
		Avg.	160.3	170.6	126.3	111.6	13.3	44.4	27.12		
P11	H1075	NonHomo.	159.0	166.1	125.8	100.7	13.0	44.1	27.3	Coarse, large shear lip, splits	Bottom
P4			157.1	164.6	118.6	95.0	13.0	42.7	27.0	Coarse, " " " , "	Middle
P6		Av	160.2	166.3	133.2	116.1	15.0	45.7	27.0	Coarse, " " , "	Bottom
		Avg.	158.8	165.7	125.9	104.6	13.7	44.2	27.21		
H9	H1075	Homo.	155.1	160.6	130.7	117.2	14.0	47.8	27.0	Coarse, large shear lip, five splits	Bottom
H8			154.9	160.4	127.7	108.1	14.0	47.4	27.2	Coarse, " " ", volcano	Middle
H1			155.8	161.6	130.5	118.0	14.0	48.2	26.8	Coarse, " " "	Top
		Avg.	155.2	160.9	129.6	114.4	14.0	47.8	26.97		
ARMCO	H925		171.0	178.0			5.0	5.4			
DATA	H955	Homo.	170.0	188.0			12.5	33.2			
62-1-2	H900		185.0	200.0			14.0	50.0	28.5		
	H1075		150.0	165.0			16.0	56.0			

* - projection discontinuity in the fracture
** - cracks perpendicular to the fracture surface



1. Unless otherwise specified tolerances are as follows:
   Linear dimensions - .xx ∠ .03 .xxx ∠ .010
   Angular ∠ 0° - 30'
2. Material to be as specified.
3. Grain direction to be longitudinal unless otherwise specified.

Dash No	A	B	C	D	E	F (Min)	G (Gage Length)
-1	.505±.010	1.50	3/4-10NC	5.00	1.00	.38	2.000 ±.005
-2	.357±.007	1.30	5/8-11NC	4.00	.88	.25	1.400 ±.005
-3	.252±.005	1.06	1/2-13NC	3.12	.75	.19	1.000 ±.005
-4	.200±.004	.85	5/16-24NF	2.50	.63	.13	.800 ±.005

DRAWN	K Cathey	DATE	TENSILE TEST SPECIMEN-ROUND
CHECKED	[illegible]	5/15/51	FTJ-10940
ENG.			Full Scale
PROJECT			FIGURE 1

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FORT WORTH DIVISION - FORT WORTH, TEXAS

ISSUED: REVISED:

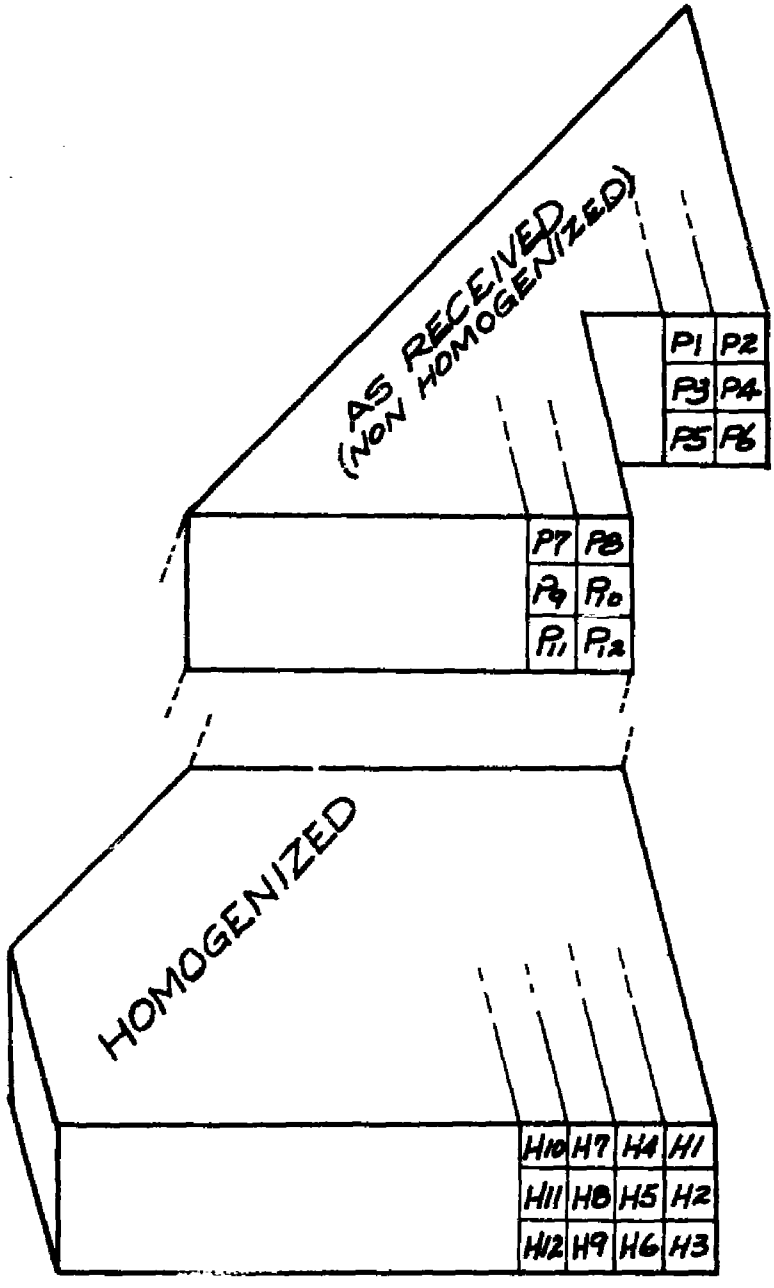

FIGURE 2

LOCATION OF SPECIMENS IN 17-4PH PLATE

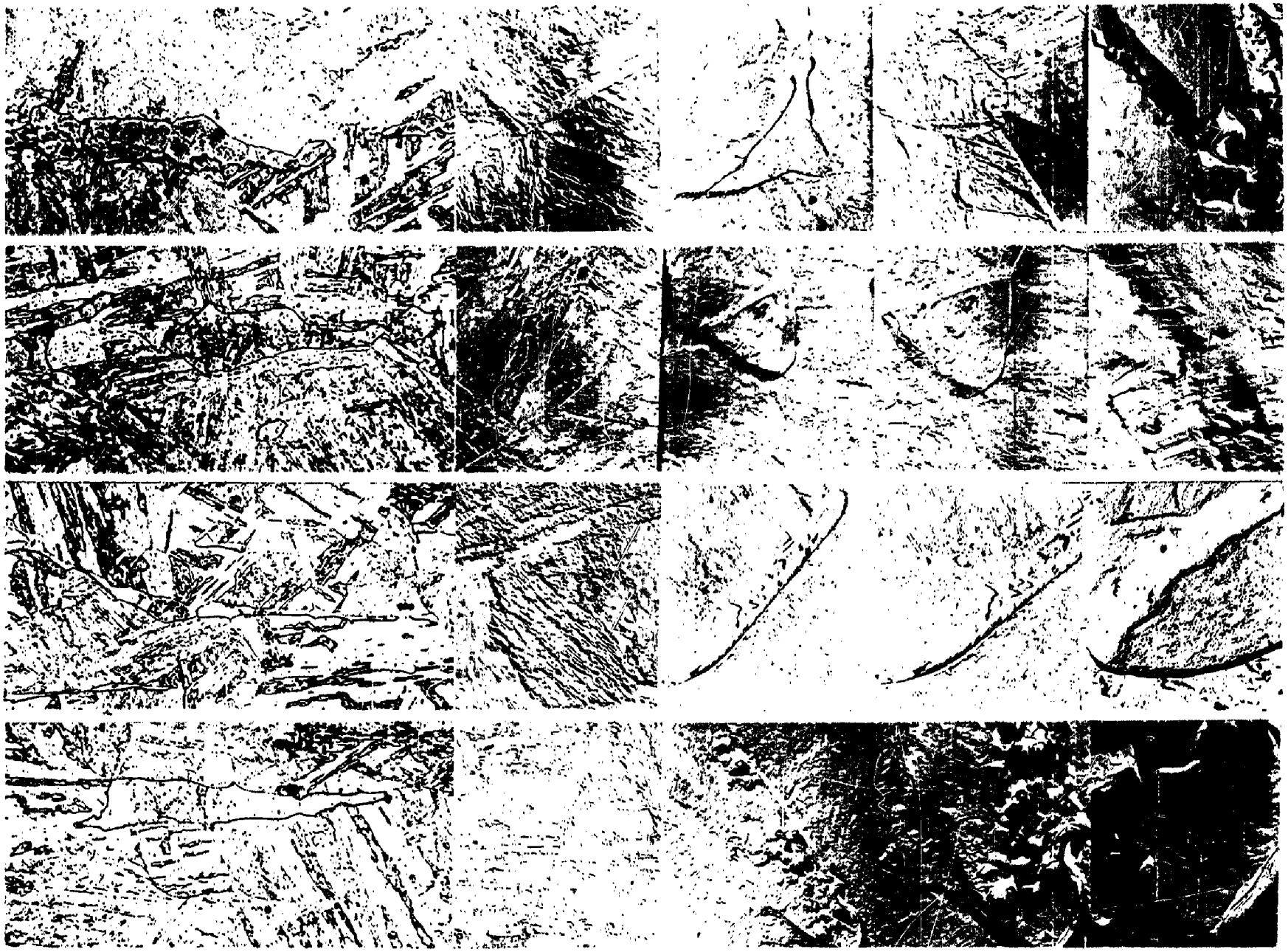

Figure 3. General structure and delta ferrite in precipitation hardening 17-4pH stainless steel

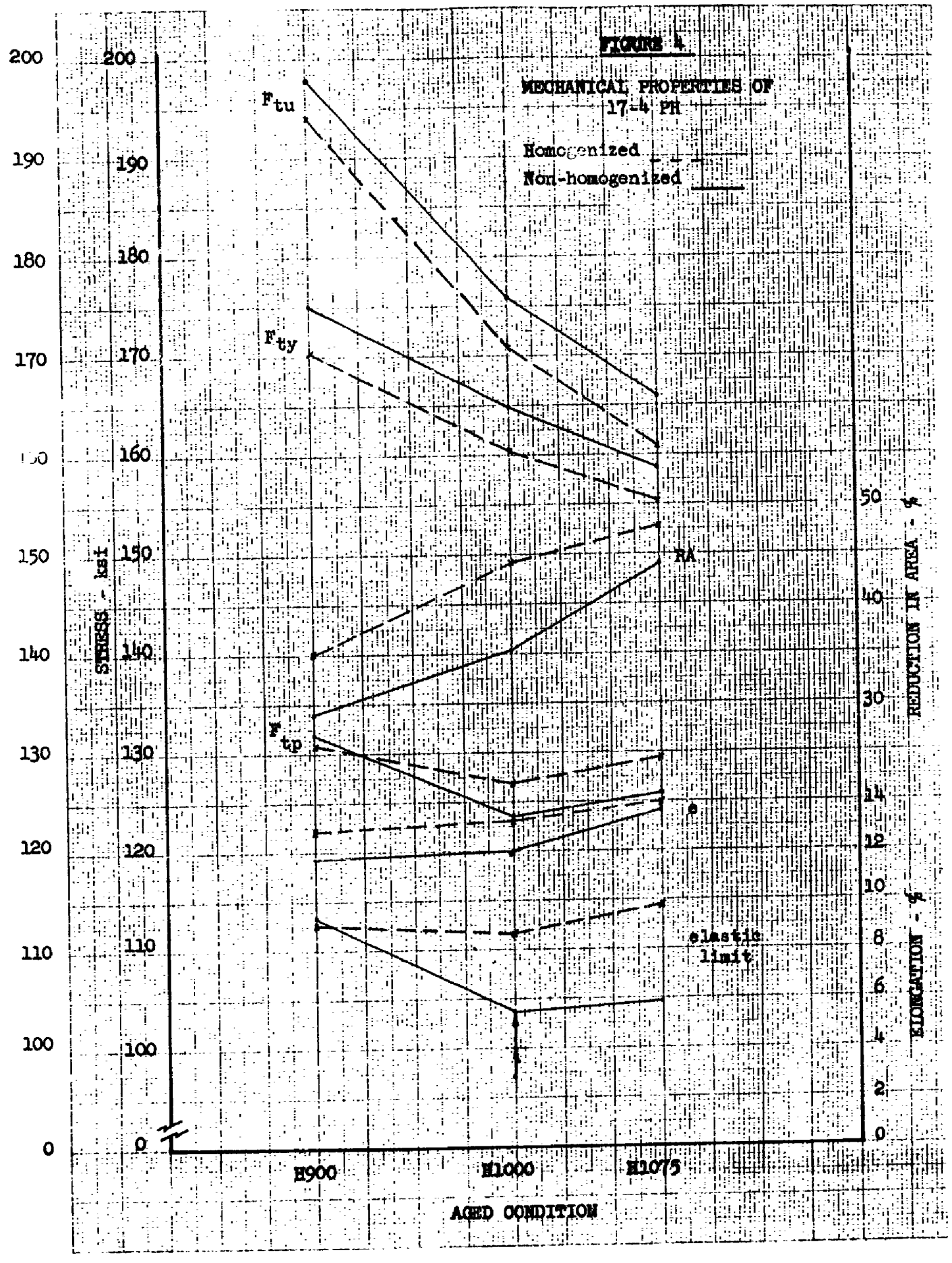
FIGURE 4
MECHANICAL PROPERTIES OF
17-4 PH
Homogenized
Non-homogenized
F_{tu}
F_{ty}
F_{tp}
RA
e
elastic limit
STRESS - ksi
REDUCTION IN AREA - %
ELONGATION - %
H900
H1000
H1075
AGED CONDITION

UNCLASSIFIED