Al
4.6 Zn
1.4 Mg
0.5 Mn
0.1 Zr
0.1 Cr
0.03 Ti

X7005

1. GENERAL
X7005 is a wrought, age-hardenable aluminum-zinc-magnesium alloy developed recently for use in large structures where post-braze solution heat treatment is impractical. This high strength aluminum alloy has a high melting range and can be readily brazed, soldered or welded. Its high mechanical properties are maintained after brazing or welding without the need for solution heat treatment. The low quench sensitivity of this alloy requires only a moderate rate of cooling from brazing or soldering temperatures. Thus, severe distortions are avoided.
X7005 exhibits good corrosion and stress-corrosion cracking resistance, good mechanical properties at room and cryogenic temperatures and its fracture toughness appears to be excellent, (1)(2).
The alloy is considered to be experimental, at present, except for extrusions made by the producer.

1.01 Commercial Designation
X7005.

1.02 Alternate Designation
None.

1.03 Specifications
None.

1.04 Composition
Table 1.04.

TABLE 1.04

Source	Alcoa (1)	
	Percent	
	Min	Max
Chromium	0.06	0.20
Copper	-	0.10
Iron	-	0.35
Magnesium	1.0	1.8
Manganese	0.20	0.70
Silicon .	-	0.35
Titanium	0.01	0.06
Zinc	4.2	5.0
Zirconium	0.06	0.20
Others Each	-	0.05
Total	-	0.15
Aluminum	Balance	

1.05 Heat Treatment
1.051 Anneal (O temper): Heat to 650 to 750F, hold several hours, furnace cool at 50F per hour to about 400F, air cool.
1.0511 Stabilizing anneal: Heat to 450F, hold 4 to 6 hours subsequent to full anneal treatment and air or furnace cool.
1.052 Thermal treatment: Optimum strength and resistance to stress-corrosion cracking are obtained by a thermal treatment resulting in the T53 or T63 temper. This thermal treatment practice was developed by Alcoa and is proprietary. Requests for licensing and disclosure of this practice should be directed to Alcoa, (1).
1.053 Brazing temperatures are sufficiently high to cause solution treatment during brazing of the alloy, and the alloy is relatively insensitive to rate of cooling from the braze temperature. Thus many assemblies can be air cooled after brazing and then artificially aged or natural aged to high strengths.

1.054 Temper designations for the alloy, Table 1.054.

TABLE 1.054

Source	(1)
Alloy	X7005
Temper	Description
F	As fabricated
O	Annealed
W	Solution heat treated
T6	Solution heat treat + artificial age by producer
T62	Solution heat treat + artificial age by user
T53(a)	Artificially aged following an elevated temperature fabricating process by producer
T63	Solution heat treat + artificial age by producer

(a) For extrusions and tubing

1.06 Hardness

1.07 Forms and Conditions Available
1.071 Sheet (O, F and T6 tempers).
1.072 Plate (O, F, T6 and T63 tempers).
1.073 Extrusions and tubing (O, T53, T6 and T63 tempers).

1.08 Melting and Casting Practice

1.09 Special Considerations
1.091 Thick sections, stressed in the short-transverse direction, are susceptible to stress-corrosion cracking at stresses as low as 25 percent of F_{ty}. Stress corrosion cracking resistance in the longitudinal and long-transverse directions, however, is of a high order for material stressed up to 75 percent of F_{ty}, (1).
1.092 Forming of alloy products in an artificially aged temper may produce residual stresses that can cause stress corrosion cracking, particularly if a sustained tension load is super-imposed upon the residual tension stress. It is recommended that when severe forming operations are required, that the alloy be formed in the O or W temper and then given the appropriate thermal treatment, (1).
1.093 In fillet-welded joints, residual welding stresses exerting tension across the edge of a plate may cause stress-corrosion cracking in the edges. Care should be taken in the design of such joints, (1).

2. PHYSICAL AND CHEMICAL PROPERTIES

2.01 Thermal Properties
2.011 Melting range. 1125 to 1195F, (1).
2.012 Phase changes
2.0121 Time-temperature-transformation diagrams
2.013 Thermal conductivity
O temper. 96.8 Btu ft per (hr sq ft F),
T63 temper. 87.1 Btu ft per (hr sq ft F), (1).
2.014 Thermal expansion
Fig. 2.014.
2.015 Specific heat
2.016 Thermal diffusivity

2.02 Other Physical Properties
2.021 Density. 0.101 lb per cu in; 2.8 gr per cu cm, (1).
2.022 Electrical properties
2.0221 Electrical conductivity at RT.
O temper, 43% IACS,
T63 temper, 38% IACS, (1).
2.023 Magnetic properties
The alloy is nonmagnetic, (1).
2.024 Emissivity
2.025 Damping capacity

Al
4.6 Zn
1.4 Mg
0.5 Mn
0.1 Zr
0.1 Cr
0.03 Ti

X7005

2.03 Chemical Properties

2.031 General. In the aged tempers, the corrosion resistance of X7005 is comparable to that of 6061 and 5000 series of aluminum alloys and is superior to that of the 7000 series alloys such as 7075-T6 and 7079-T6. Susceptibility to exfoliation has been observed in the F and in the W tempers only, and it is recommended that the final product should receive a thermal treatment during or after fabrication to eliminate this characteristic, (1)(2).

2.032 Preliminary studies indicate that the corrosion resistance of brazed specimens, artificially aged after brazing, is good. Specimens naturally aged after brazing exhibit a slight reduction in corrosion resistance.

2.033 X7005 is anodic to the recommended brazing filler alloys and to most other aluminum alloys. Thus it generally will preferentially corrode to protect the filler metal and the dissimilar metal to which it is joined, when exposed to environments conducive to galvanic corrosion, (2).

2.034 Resistance to stress corrosion cracking of aged material is good when alloy is stressed up to 75 percent of F_{ty} in the longitudinal and transverse directions. Thick sections stressed in the short-transverse direction are susceptible to stress corrosion cracking at stresses as low as 25 percent of F_{ty}. (See also Section 1.09). Optimum strengths and stress corrosion crack resistance are obtained by a thermal treatment resulting in the T53 or T63 temper.

2.035 Preliminary studies on butt-welded T6 and T63 sheet and plate indicate that little problem with stress corrosion cracking is expected in these joints. In good electrolytes such as sea water, however, severe selective attack may occur in the heat affected zone adjacent to the weld. This can be avoided by post-weld aging joints, which are welded in the W or T63 temper, using the T63 aging practice.

2.04 Nuclear Properties

3. MECHANICAL PROPERTIES

3.01 Specified Mechanical Properties

3.011 AMS Specifications.
None.

3.012 Producer's tentative typical and expected minimum design properties of sheet, plate and extrusions, Table 3.012.

3.0213 Effect of long time aging at 250F on tensile properties of sheet, Fig. 3.0213.

3.0214 Effect of aging time at room temperature on tensile properties of sheet, Table 3.0214.

TABLE 3.0214

Source	(1)(2)		
Alloy	X7005		
Form	0.063 inch sheet		
Condition	Heated 1090F, 10 min, AC + natural age at RT		
Aging time	F_{tu}, ksi	F_{ty}, ksi	e(2 in), percent
None	28	12	26
3 days	42	21	22
1 week	45	24	22
1 month	49	27	21
3 months	52	30	21
6 months	54	32	21
to T63	52	44	13

3.022 Compression

3.0221 Compressive yield strength, see Table 3.012.

3.023 Impact

3.024 Bending.
Cold bend tests have indicated that the bend properties of plate and sheet in the T63 temper are similar to 6061-T6 bend properties.

3.0241 Suggested bend radii for plate and sheet in O and T63 tempers, Table 3.0241.

TABLE 3.0241

Source	(1)	
Alloy	X7005	
Form	Plate, sheet	
Condition	O	T63
Thickness - in	Approx. radii for 90° cold bend	
0.064	1/2 - 1 1/2t	1-2t
0.125	1- 1 1/2t	1 1/2-2 1/2t
0.187	1- 2t	2-3t
0.250	1- 2t	2 1/2-3 1/2t
0.375	2- 3t	3-4t
0.500	2- 3t	3-4t

TABLE 3.012

Source	Alcoa (1)						
Alloy	X7005						
Form	Extrusions				Sheet, plate		Extrusions
Condition	O	T53	T6	T63, T6351	T6	T63, T6351	T53
Thickness - in	-				≤ 0.250	0.250-3.00	-
	Typical				Minimum		Minimum
F_{tu}, -ksi, L	28	60	54	54	47	47	50
T	28	60	54	54	47	47	46
F_{ty}, -ksi, L	12	53	46	46	38	38	44
T	12	53	46	46	38	38	40
F_{cy}, -ksi L	-	-	-	-	39	38	42
T	-	-	-	-	39	40	42
F_{su}, -ksi	17	32	32	32	29	27	27
F_{bru}, -ksi							
e/D = 1.5	-	-	-	-	70	70	70
e/D = 2.0	-	-	-	-	91	91	90
F_{bry}, -ksi							
e/D = 1.5	-	-	-	-	53	53	57
e/D = 2.0	-	-	-	-	61	61	70
e(2 in or 4D) -percent	20	15	12	12	7	7	10

3.02 Mechanical Properties at Room Temperature

3.021 Tension. See also Table 3.012.

3.0211 Effect of natural aging on tensile properties of sheet and plate, Fig. 3.0211.

3.0212 Effect of natural aging on tensile properties of extrusions, Fig. 3.0212.

3.025 Torsion and shear

3.0251 Shear ultimate strength, see Table 3.012.

3.026 Bearing

3.0261 Bearing ultimate and yield strengths, see Table 3.012.

3.027 Stress concentration. See Section 3.037.

3.0271 Notch properties

Al
4.6 Zn
1.4 Mg
0.5 Mn
0.1 Zr
0.1 Cr
0.03 Ti

X7005

3.0272 Fracture toughness
3.028 Combined properties

3.03 Mechanical Properties at Various Temperatures
3.031 Tension
3.0311 Stress-strain diagrams
3.0312 Effect of low temperatures on tensile properties of sheet, Fig. 3.0312.
3.032 Compression
3.033 Impact
3.034 Bending
3.035 Torsion and shear
3.036 Bearing
3.037 Stress concentration
3.0371 Notch properties
3.03711 Effect of low temperature on sharp notch strength of sheet and extrusions, Fig. 3.03711.
3.03712 Effect of low temperature on notch-strength-ratio for sheet and extrusions, Fig. 3.03712.
3.03713 Effect of low temperature on tear strength of sheet and extrusions, Fig. 3.03713.
3.03714 Results of tear tests on T6 sheet and T53 extrusions at room temperature and low temperatures, Table 3.03714.

TABLE 3.03714

Source			(1)			
Alloy			X7005			
Test			Tear tests (a)			
Form			0.063 in. T6 sheet and T53 extrusions			
			Energy required to			
Temp	Temper	Dir	Initiate a crack	propagate a crack	Total energy	Unit propagation energy
F			in-lb	in-lb	in-lb	in-lb/in^2
RT	T6	L	29	83	112	1290
RT	T6	T	36	82	118	1275
RT	T53	L	67	104	171	1040
RT	T53	T	64	84	148	840
-112	T53	L	40	59	99	590
-112	T53	T	40	37	77	375
-320	T53	L	27	59	86	590
-320	T53	T	28	37	65	375

(a) For tear test specimen used. See Fig. 3.03713.

3.0372 Fracture toughness
3.038 Combined properties

3.04 Creep and Creep Rupture Properties

3.05 Fatigue Properties
3.051 S-N curves for smooth and notched extrusions in various conditions, Fig. 3.051.
3.052 S-N flexural fatigue curve for sheet, Fig. 3.052.

3.06 Elastic Properties
3.061 Poisson's ratio
3.062 Modulus of elasticity
3.0621 Young's modulus. $E = 10.3 \times 10^3$ ksi, (1).
3.0622 Compression modulus. $E_c = 10.5 \times 10^3$ ksi, (1).
3.0623 Modulus of rigidity. $G = 3.9 \times 10^3$ ksi, (1).

4. FABRICATION

4.01 Formability
4.011 General. Formability of the alloy in the T63 temper is reported to be similar to that of 6061-T6 as evaluated from 90° cold bend tests (see Section 3.024). Forming of artificially aged products may produce residual stresses that can cause stress corrosion cracking (see Section 1.092). Thus it is recommended that when severe forming is required the alloy should be formed in the O (annealed) or W (solution heat treated) temper and then given the appropriate thermal treatment. If severe forming is applied to material in the W Condition, it should be accomplished within 12 hours after solution heat treatment, (1).

4.012 Suggested bend radii for plate and sheet in O and T63 temper, see Table 3.0241.

4.02 Machining and Grinding
4.021 Machinability of this alloy is good. For high production work, high speed steel or preferably carbide-tipped cutting tools are recommended. Single point cutting tools of high speed steel should be ground 20 to 50 degree top rake, 10 to 20 degree side rake, 8 to 10 degree front and side clearance angles. High speeds and fine to medium feeds should be used. For rough lathe turning, cutting speeds of 500 to 1000 sfpm, feeds of 0.007 to 0.030 inch and depths of cut up to 0.25 inch can be employed. Cutting speeds of 600 to 1000 sfpm, feeds of 0.0002 to 0.010 inch and depth of cut of 0.002 to 0.010 inch can be used for finish lathe turning. In shaping, boring and planing operations a cutting speed equal to the maximum travel of the ram can be attained. The alloy can be cut dry, but a cutting fluid is recomended for good cooling and lubrication. Soluble oils are satisfactory for many operations. Carbon oils or kerosene mixed with lard oil, usually in equal parts, are also satisfactory. For heavy cuts and slow feeds, pure lard oil gives good results.
Cutting edges of tools should be kept sharp and free from grinding scratches, (2).

4.03 Welding
4.031 General. This alloy can be readily welded, brazed or soldered, and will maintain high mechanical properties after welding or brazing without post-weld (or post-braze) solution heat treatment.
4.032 Fusion welding. Weldability by TIG and MIG fusion processes is excellent if X5180 filler wire is employed.
After welding, the alloy will naturally age in several weeks to produce a stronger weld joint than any of the non-heat treatable aluminum alloys. Artificial aging, after welding, will further improve the weld strength, particularly the yield strength.
Welding procedures, joint preparation, machine settings and other welding variables are the same for X7005 as for other aluminum alloys. Precleaning procedures are the same as those employed for the other heat treatable alloys, (1).
4.0321 Average tensile strength (bead on) of butt-welded sheet joints, Table 4.0321.

TABLE 4.0321

Source	(1)	
Alloy	X7005 (X 5180 filler)	
Form	Butt-welded sheet joints	
Condition	T6 (before welding)	
	Postweld aged to T63	Natural age (3 months)
F_{tu}, -ksi	51	49
F_{ty}, -ksi	41	28
e(2 in) -percent	9	10.8
e(10 in) -percent	8.5	8.7

4.0322 The presence of zinc as a constituent in X7005 and in the filler metals requires that precautions be taken to provide adequate ventilation during shop or field welding operations.
4.033 Resistance welding. The alloy can be successfully spot, or stud welded by using machine schedules similar to those established for 7075 or X7106 alloys.
4.034 Brazing. The alloy is suitable for brazing by all brazing methods; furnace, dip, torch and the new vacuum fluxless brazing technique. It has good brazing characteristics, and high strength after brazing is obtained by natural or artificial aging. Brazing temperatures employed are sufficiently high to effect solution heat treatment during brazing. This alloy is relatively insensitive to rate of quenching. Thus many assemblies may be air cooled from brazing temperatures, (1)(2).

Al
4.6 Zn
1.4 Mg
0.5 Mn
0.1 Zr
0.1 Cr
0.03 Ti

X7005

Typical properties of sheet, air cooled from brazing temperatures, see Table 3.0214.

4.0341 The melting range of 1125 to 1195F for this alloy enables brazing to be accomplished with standard fluxes and fillers. For "dip brazing" in the recommended range of 1080 to 1100F, Alcoa No. 34 flux permits easy flow and good wetting of filler metals. Alcoa No. 33 and No. 53 fluxes are satisfactory for "furnace brazing". Alcoa No. 716 or No. 718 filler wires are recommended, (2).

4.0342 The alloy can be successfully brazed up to a temperature of 1120F. However, brazing times and temperatures should be kept as low as possible to minimize silicon penetration from the filler and to prevent excessive grain growth in the alloy, (1).

4.0343 Precleaning methods used for other heat treatable aluminum alloys are satisfactory for X7005. After brazing, the brazed joint must be thoroughly cleaned to remove all flux residue. Hot running water will wash off the major portion of the residue, (1).

4.0344 Recommended fillers and temperatures for brazing, Table 4.0344.

TABLE 4.0344

Source	(1)	
Alloy	X7005	
Brazing X7005 to	Filler *	Temperature range for brazing
X7005	4047 (No. 718)	1080-1100F
3003 or 1100	4047 (No. 718)	
No. 23 or 24 Brazing sheet	4045 (No. 714) or 4047 (No. 718)**	
No. 21 or 22 Brazing sheet	4343 (No. 713)	1100-1120F
No. 11 or 12 Brazing sheet	4343 (No. 713)	

* Use No. 34 flux for dip brazing; No. 33 or 53 flux for furnace

** Use No. 718 where additional filler is required.

4.035 Soldering. This alloy may be easily furnace soldered with Alcoa 805 or 806 solders and a reactive zinc chloride flux. A solution of 50 to 70 percent 66A flux in normal propyl alcohol is satisfactory for furnace soldering in the temperature range of 750-850F, (1).

4.0351 Tensile properties of sheet, furnace soldered, air cooled and aged, Table 4.0351.

TABLE 4.0351

Source	(1)		
Alloy	X7005		
Condition	Furnace soldered at 750F, 1 min, AC + age		
Aging treatment	F_{tu}, (ksi)	F_{ty}, (ksi)	e(2 in), (percent)
None	35	16	21
1 week at RT	48	25	20
1 month at RT	53	29	20
2 months at RT	54	30	20

4.04 Heat Treatment

4.041 If severe forming is required, it should be accomplished within 12 hours after solution heat treatment, see Section 4.011.

4.05 Surface Treatment

4.051 Alumilite finishes, including alumilite "hard coatings" can be applied to X7005 without difficulty. The annealed (O) temper requires a higher formation voltage than T6 or T63 tempers. Chromic acid anodize coatings and chemical conversion films may also be applied, (1).

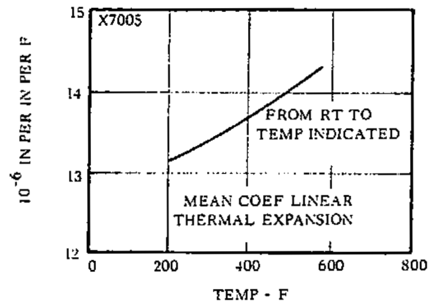


FIG. 2.014 THERMAL EXPANSION (1, p.3)

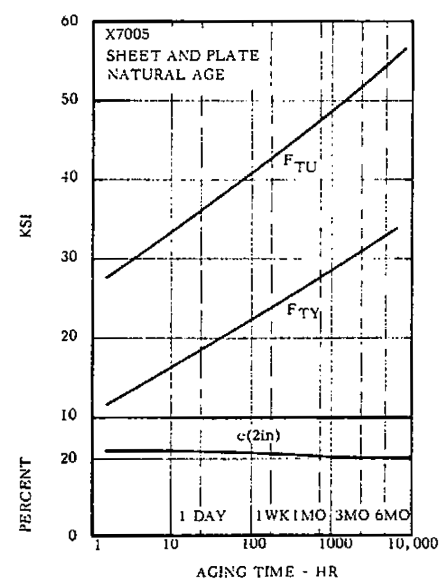


FIG. 3.0211 EFFECT OF NATURAL AGING ON TENSILE PROPERTIES OF SHEET AND PLATE (1)

	Al
4.6	Zn
1.4	Mg
0.5	Mn
0.1	Zr
0.1	Cr
0.03	Ti

X7005

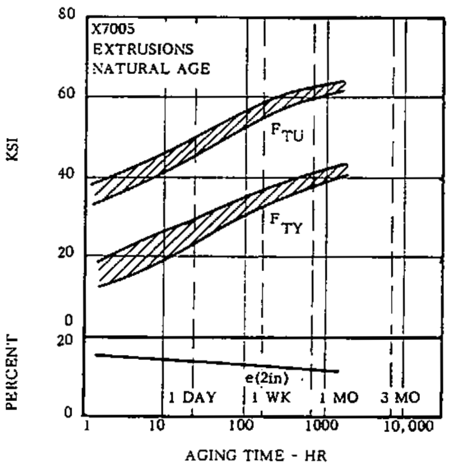


FIG. 3.0212 EFFECT OF NATURAL AGING ON TENSILE PROPERTIES OF EXTRUSIONS (1)

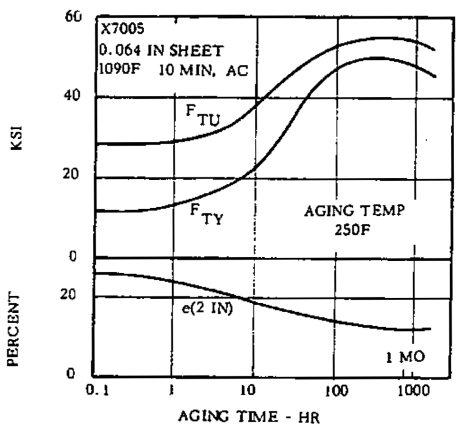


FIG. 3.0213 EFFECT OF LONG TIME AGING AT 250F ON TENSILE PROPERTIES OF SHEET (1)

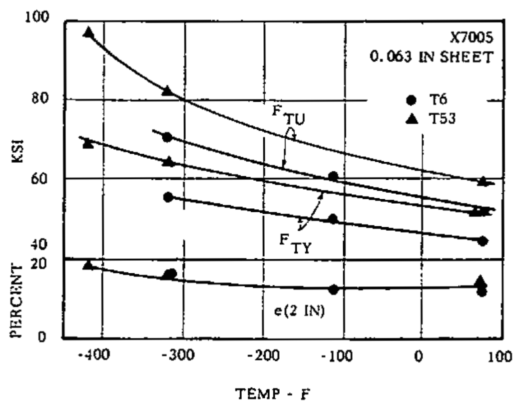


FIG. 3.0312 EFFECT OF LOW TEMPERATURES ON TENSILE PROPERTIES OF SHEET (4)(5)

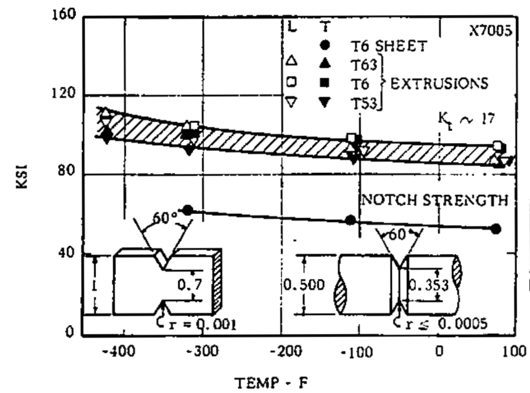


FIG. 3.03711 EFFECT OF LOW TEMPERATURE ON SHARP NOTCH STRENGTH OF SHEET AND EXTRUSIONS (1)(4)

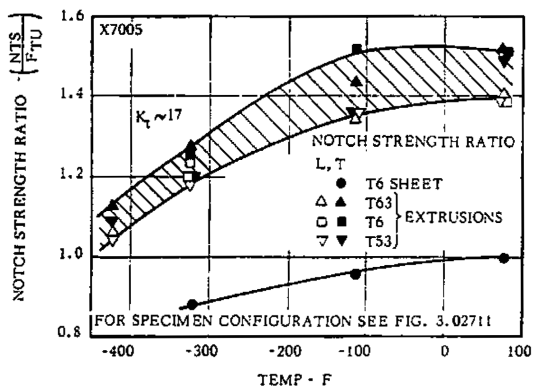


FIG. 3.03712 EFFECT OF LOW TEMPERATURE ON NOTCH STRENGTH RATIO FOR SHEET AND EXTRUSIONS (1)

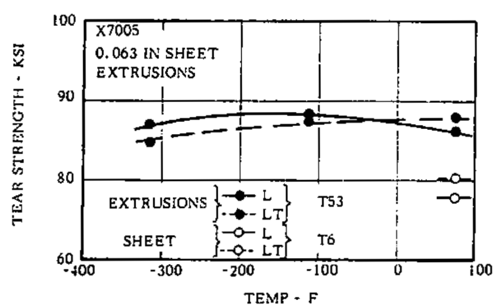
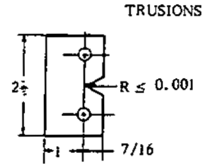


FIG. 3.03713 EFFECT OF LOW TEMPERATURES ON TEAR STRENGTH OF SHEET AND EXTRUSIONS (1)



	Al
4.6	Zn
1.4	Mg
0.5	Mn
0.1	Zr
0.1	Cr
0.03	Ti

X7005

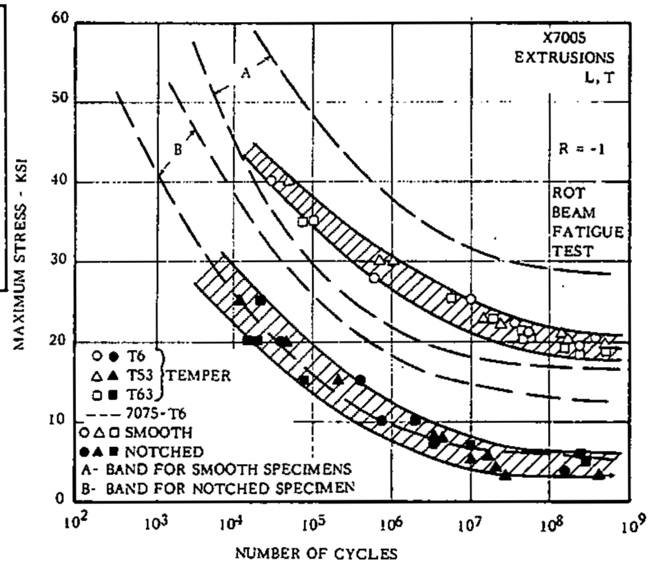


FIG. 3.051 S-N CURVE FOR SMOOTH AND NOTCHED EXTRUSION IN VARIOUS CONDITIONS (1)

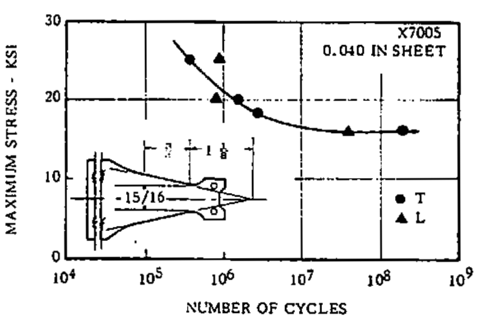


FIG. 3.052 S-N FLEXURAL FATIGUE CURVE FOR SHEET (1)

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