METALLIC ALLOY STABILITY STUDIES

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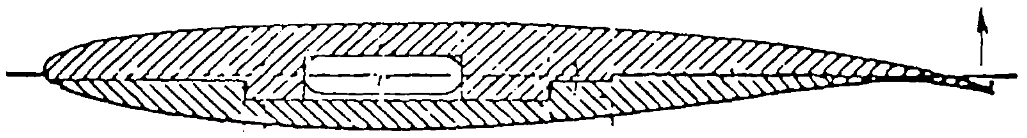
An investigation into the dimensional stability of candidate cryogenic wind tunnel model materials was initiated due to the distortion of an airfoil model during testing in the Langley 0.3-Meter Transonic Cryogenic Tunnel. Flat specimens of candidate materials were fabricated and cryo-cycled to assess relative dimensional stability. Existing 2-dimensional airfoil models as well as models in various stages of manufacture were also cryo-cycled. The tests indicate that 18 Ni maraging steel offers the greatest dimensional stability and that PH 13-8 Mo stainless steel is the most stable of the stainless steels. Testing of more sophisticated "stepped" specimens will provide a basis for more conclusive comparisons.

Dimensional stability is influenced primarily by metallurgical transformations (austenitic to martensitic) and manufacturing-induced stresses. These factors can be minimized by utilization of stable alloys, refinement of existing manufacturing techniques, and incorporation of new manufacturing technologies.

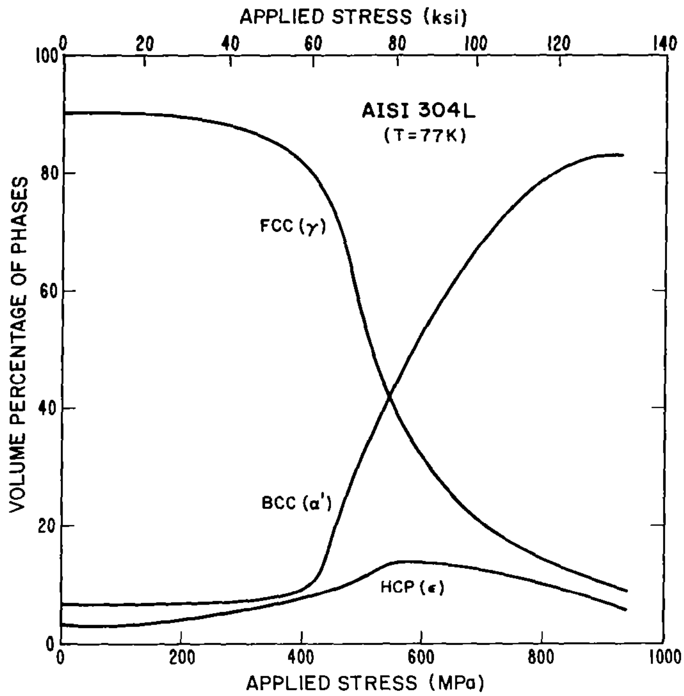
2-D AIRFOIL



DISTORTION MECHANISMS

- METALLURGICAL TRANSFORMATION
  - AUSTENITIC TO MARTENSITIC (15-5 PH, 17-4 PH)
- REDISTRIBUTION OF FABRICATION STRESSES
  - INFLUENCED BY GRAIN SIZE

STRESS EFFECTS ON MARTENSITIC PHASE TRANSFORMATION
IN AN ANSI 304L STAINLESS STEEL*

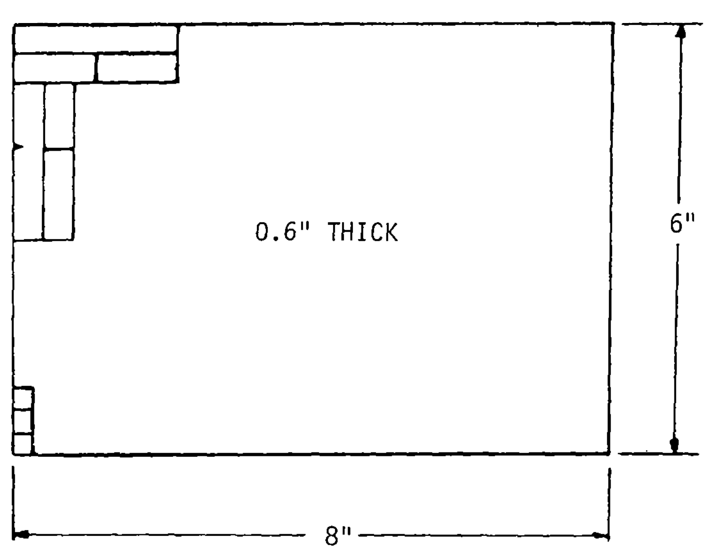


*From R. L. Tober, Materials for Cryogenic Wind Tunnel Testing, National Bureau of Standards, NBSIR 79-1624, 1980, p. 27.

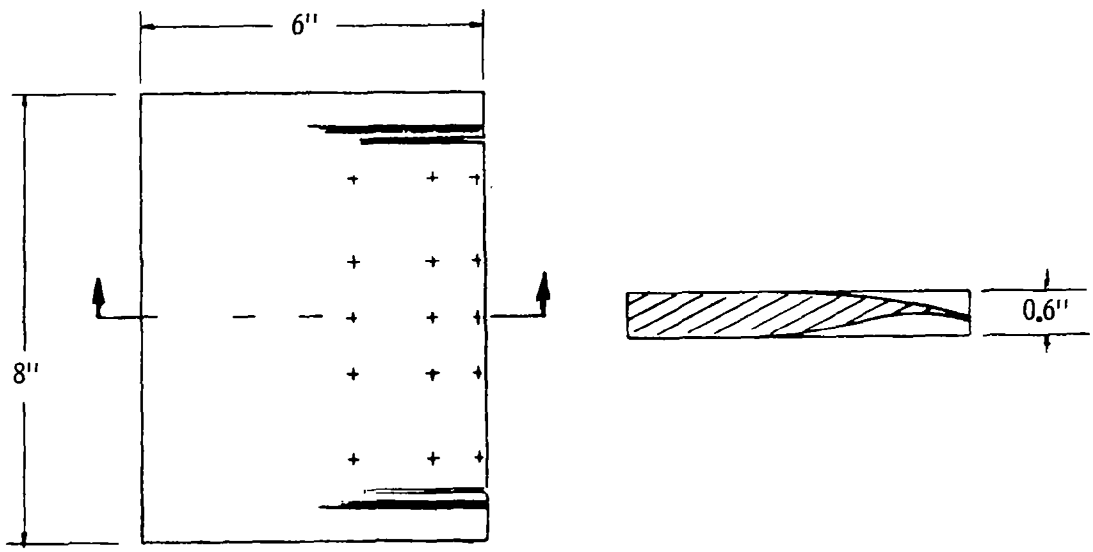
BASIC DIMENSIONAL STABILITY SPECIMEN

CHARPY
V-NOTCH
SPECIMENS

METALOGRAPH
SPECIMENS

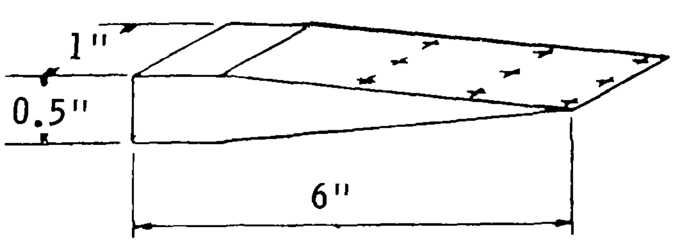


SIMULATED AIRFOIL
DIMENSIONAL STABILITY SPECIMEN



DIMENSIONAL STABILITY WEDGE

COMPARISON OF CONVENTIONAL MACHINING
(WORK INDUCED STRESSES)
vs WIRE ELECTRO-DISCHARGE MACHINING
(HEAT AFFECTED ZONE)



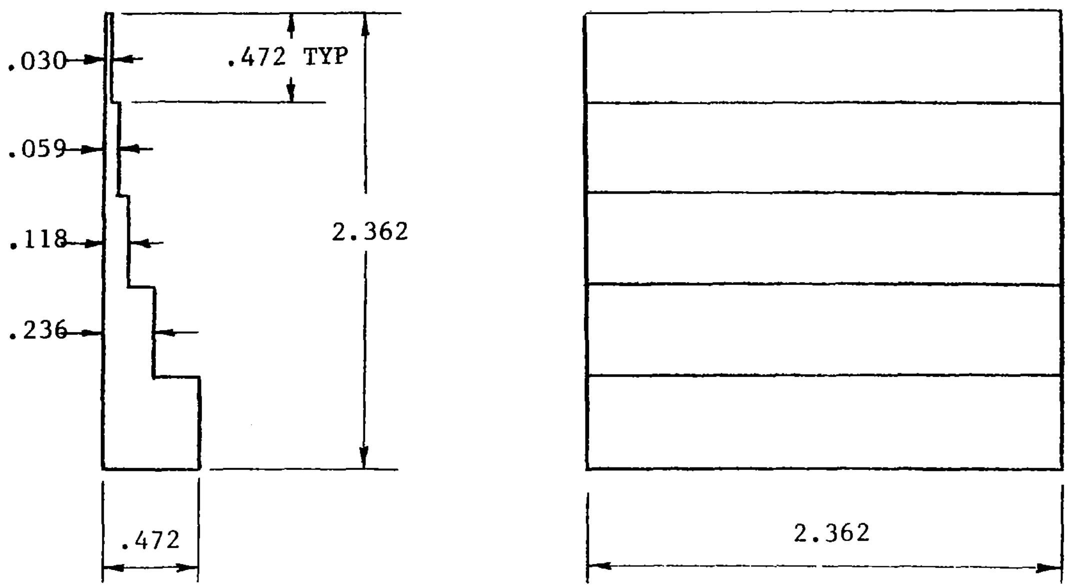
WARPING OF 2-D AIRFOILS OF VARIOUS MATERIALS AND DESIGNS

Airfoil, material, design	Deviation after three cryogenic cycles			
	Upper surface		Lower surface	
1027 airfoil, 347 stainless steel, brazed coverplate	high low total	+0.0008 -0.0016 0.0024	high low total	+0.0011 -0.0007 0.0018
0014 airfoil, 15-5 stainless steel, bonded coverplate	high low total	+0.0061 -0.0019 0.0080	high low total	+0.0020 -0.0071 0.0091
65-213 airfoil, 13-8 stainless steel, tongue and groove	high low total	+0.0011 -0.0005 0.0016	high low total	+0.0009 -0.0001 0.0010
5/8-in. by 5-in. by 8-in. sample, NITRONIC 40 stainless steel, tongue and groove	high low total	+0.0005 -0.0003 0.0008	high low total	+0.0000 -0.0005 0.0005

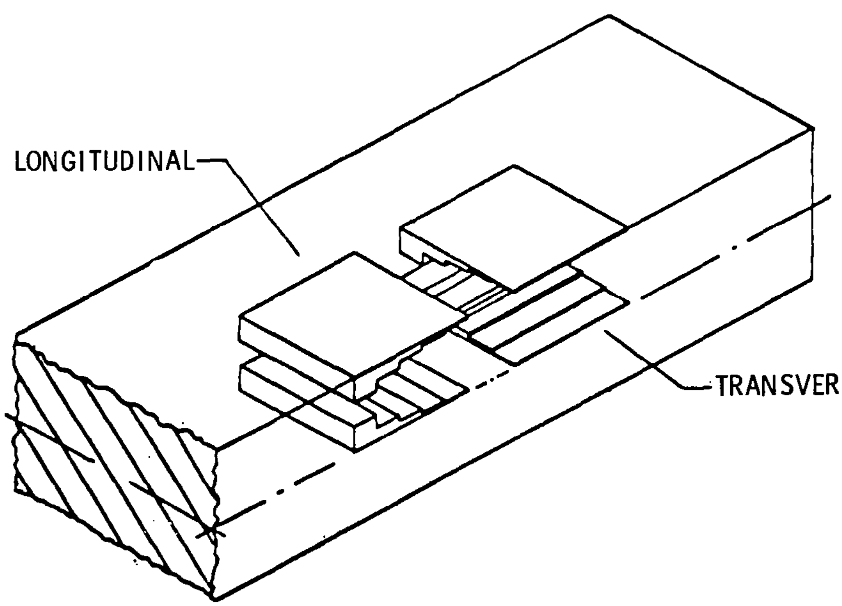
DISTORTION AFTER CRYO CYCLING

		Deviation from absolute flat	
		BEFORE	AFTER
NITRONIC 40 (TONGUE IN GROOVE) SIMULATED AIRFOIL	0019		
15-5 PH (H 1025) (E.B.W. COVER PLATE) 6% SUPERCRITICAL AIRFOIL	.0023		
*NITRONIC 40 FLAT SPECIMEN (BONDED COVER PLATE)	.0012	.0013	.0004
VASCOMAX 200 A	.0002	.0003	.0004
VASCOMAX 200 B	.0005	.0013	.0011
VASCOMAX 200 A (SIMULATED AIRFOIL)	.0010		
CUSTOM 450 (1 x 6)	.0009		
*ERROR IN MEASUREMENT SPECIMEN REPROCESSED	.0007		
12 Ni SPECIMENS (.23 x 3 x 3)	.001		

STEPPED DIMENSIONAL STABILITY SPECIMEN



SPECIMEN ORIENTATION



MATERIALS INVESTIGATED	FURTHER INVESTIGATIONS
NITRONIC 40	VASCOMAX 200 CVN
15-5 PH	PH 13-8 Mo
VASCOMAX 200 CVN	A-286
PH 13-8 Mo	9 Ni STEEL
347 STAINLESS STEEL	HP 9-4-20
CUSTOM 450	NITRONIC 40
2024 ALUMINUM	12 Ni STEELS
12 Ni STEELS	AF 1410
	300 SERIES STAINLESS STEEL
	5000 & 6000 SERIES ALUMINUM
	COPPER ALLOYS
	NICKEL ALLOYS

FABRICATION TECHNIQUES

A. FORGING

B. CASTING

C. POWDER METALLURGY

D. DIFFUSION BRAZING

E. DIFFUSION BONDING

F. SUPER PLASTIC FORMING

G. ELECTRO-DEPOSITING (PLATING)

H. EDM-GRINDING & CHEM-GRINDING

I. ELECTRO POLISHING

CONCLUSIONS

STABILITY

- O VASCOMAX 200 CVN
- O PH 13-8 Mo & A-286
- O AUSTENITIC STEELS (300 SERIES, NITRONIC 40)
- O DUAL PHASE ALLOYS (15-5 PH, AF 1410)

CONCERNS & PROSPECTS

- O CORROSION
- O SENSITIVITY OF ALLOYS TO MANUFACTURING, FABRICATION & HEAT TREATMENT PROCEDURES
- O 12 Ni STEELS & GRAIN REFINEMENT