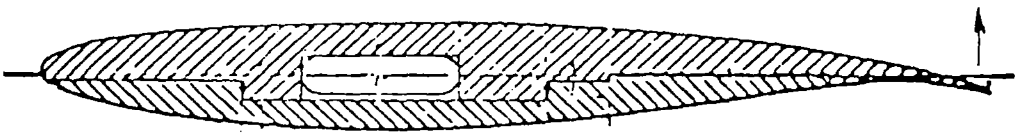
METALLIC ALLOY STABILITY STUDIES

George C. Firth
Lockheed-Georgia Company
Marietta, Georgia

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.

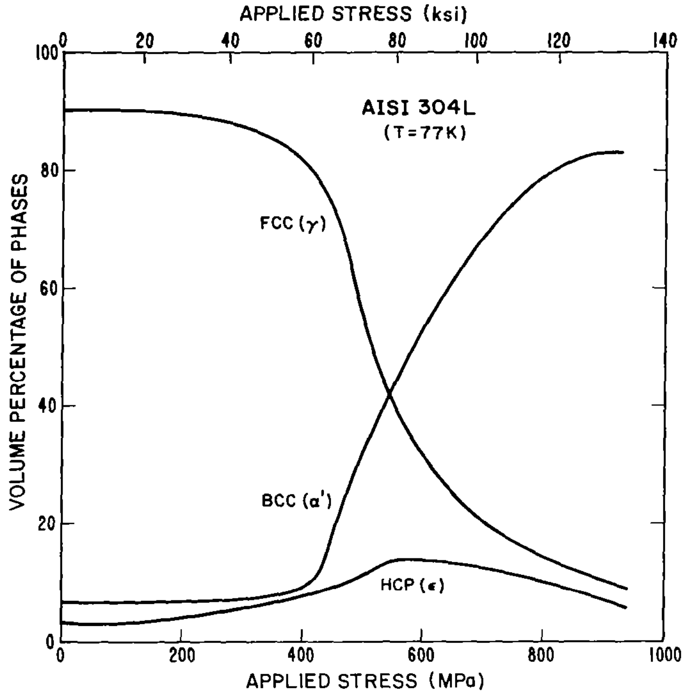
2-D AIRFOIL



DISTORTION MECHANISMS

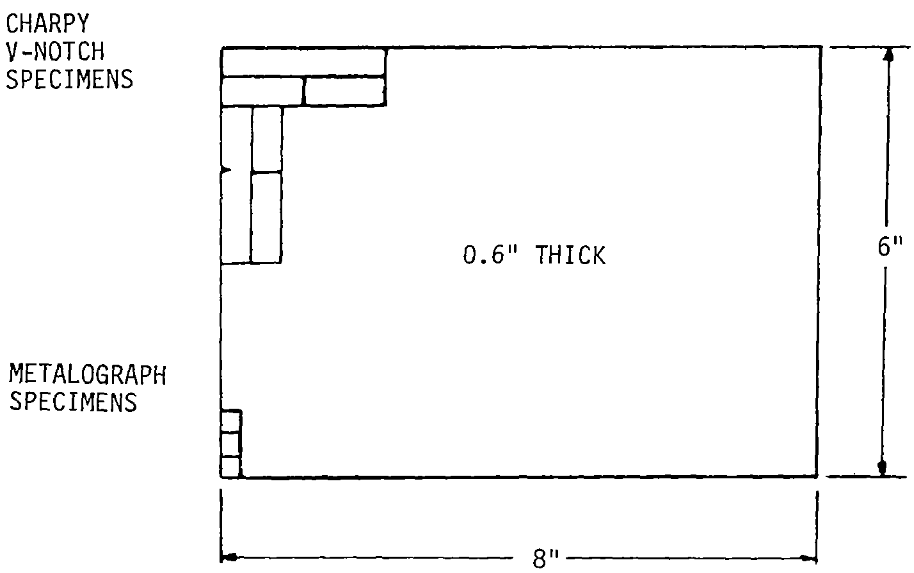
- METALLURGICAL TRANSFORMATION
  - AUSTENITIC TO MARTENSITIC (15-5 PH, 17-4 PH)
- REDISTRIBUTION OF FABRICATION STRESSES
  - INFLUENCED BY GRAIN SIZE

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

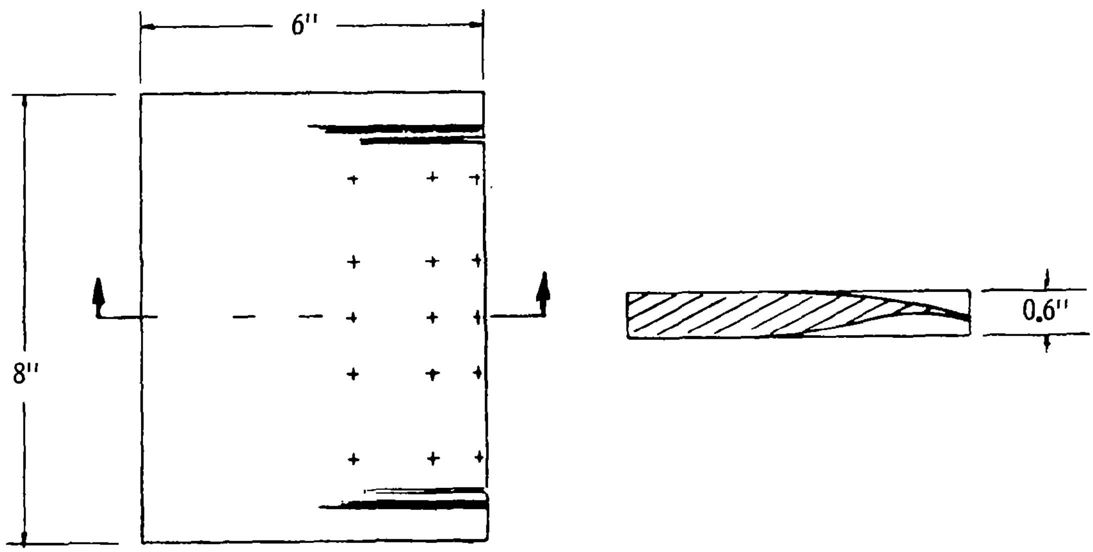


*From R. L. Tober, Materials for Cryogenic Wind Tunnel Testing, National Bureau of Standards, NBSIR 79-1624, 1980, p. 27.

BASIC DIMENSIONAL STABILITY SPECIMEN

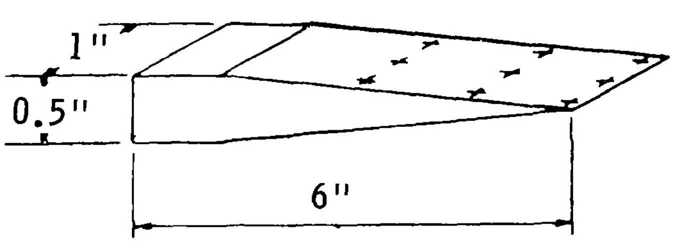


SIMULATED AIRFOIL
DIMENSIONAL STABILITY SPECIMEN



DIMENSIONAL STABILITY WEDGE

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



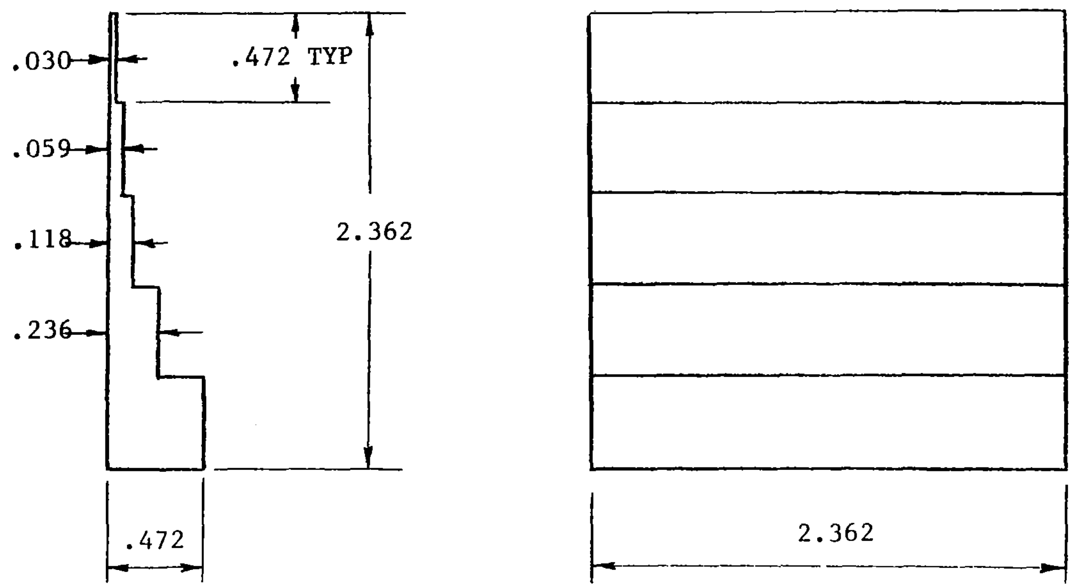
WARPING OF 2-D AIRFOILS OF VARIOUS MATERIALS AND DESIGNS

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

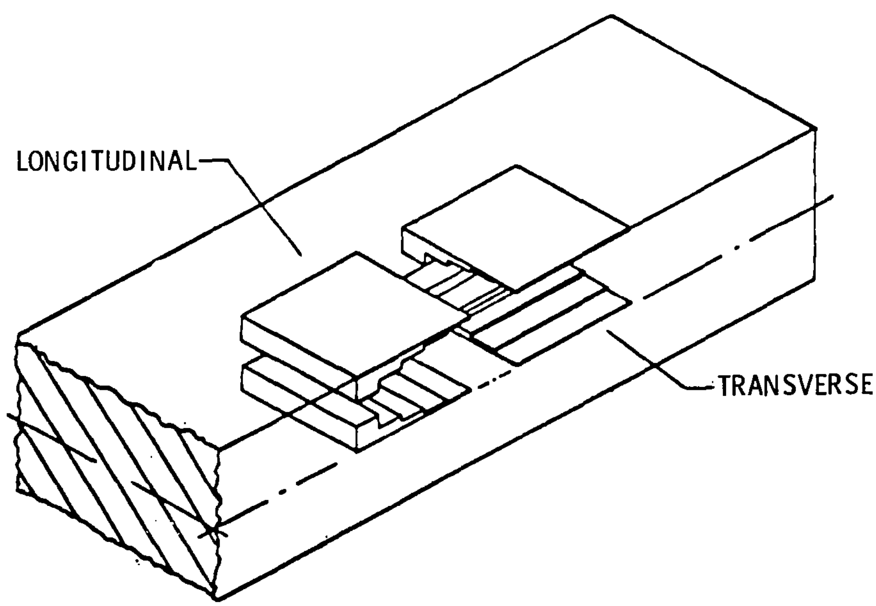
DISTORTION AFTER CRYO CYCLING

		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

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

CONCERNS & PROSPECTS

- 0 CORROSION
- 0 SENSITIVITY OF ALLOYS TO MANUFACTURING, FABRICATION & HEAT TREATMENT PROCEDURES
- 0 12 Ni STEELS & GRAIN REFINEMENT