TAYLOR

FINAL ORAL REPORT

THERMAL-STRUCTURAL DESIGN STUDY OF AN AIRFRAME-INTEGRATED SCRAMJET

CONTRACT NAS 1-13984

PRESENTED AT

NASA

LANGLEY RESEARCH CENTER

JULY 13, 1978

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AIRESEARCH MANUFACTURING COMPANY
OF CALIFORNIA

S 27662

#234046

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PROGRAM OBJECTIVES

- COOLED STRUCTURES ASSEMBLY
- SUBSYSTEMS
- AIRCRAFT INTERFACE

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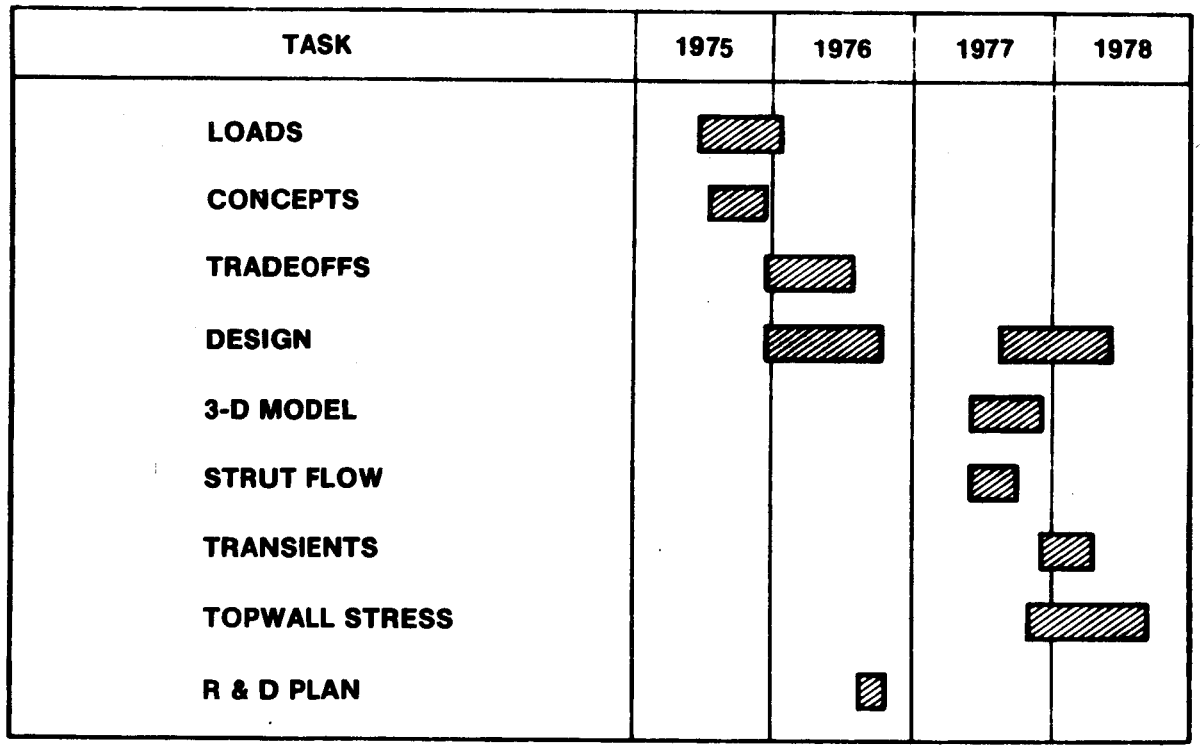
PROGRAM SCHEDULE



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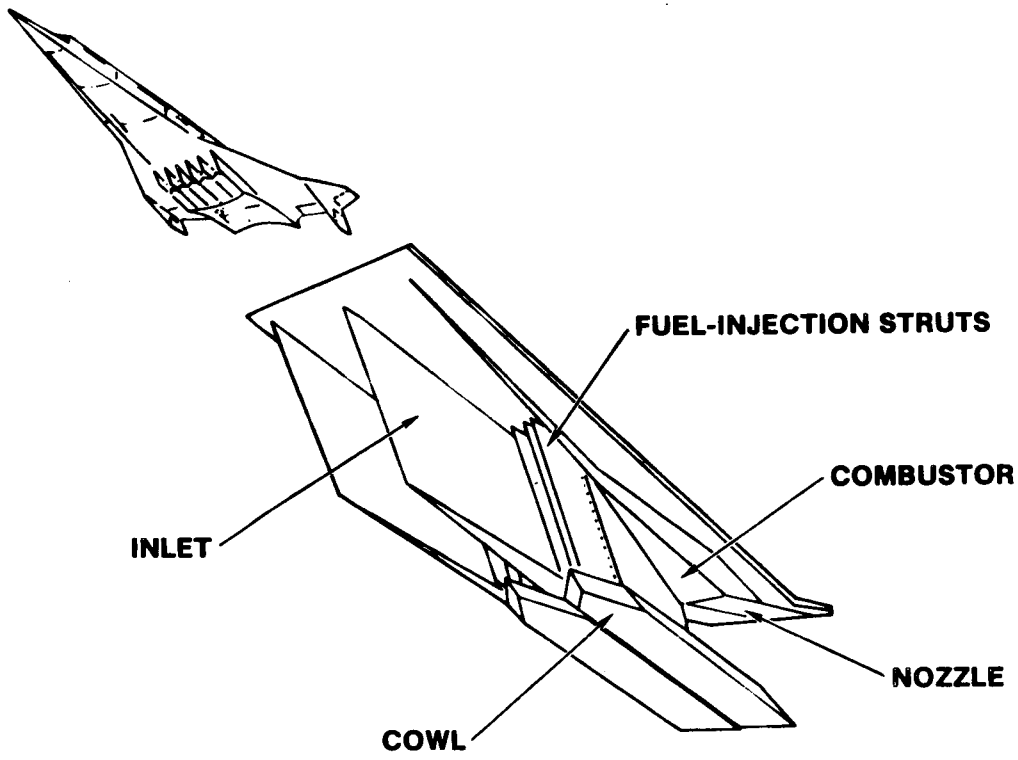
SCRAMJET



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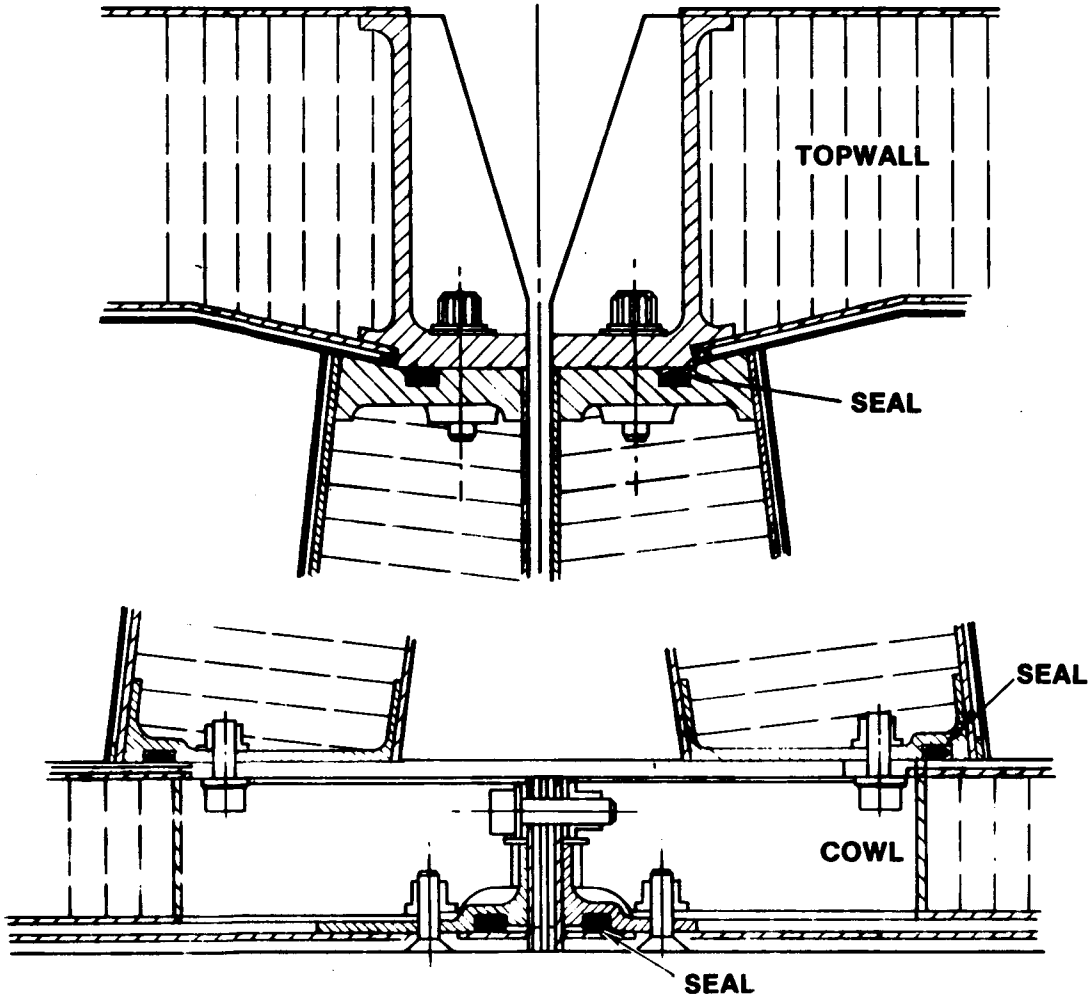
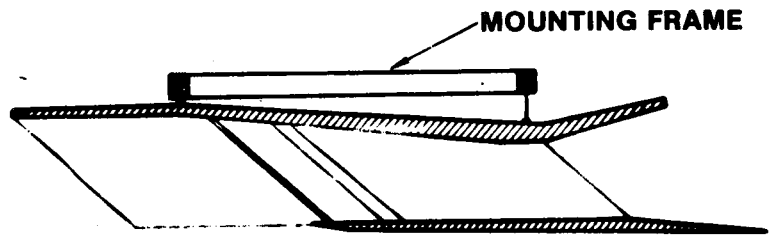
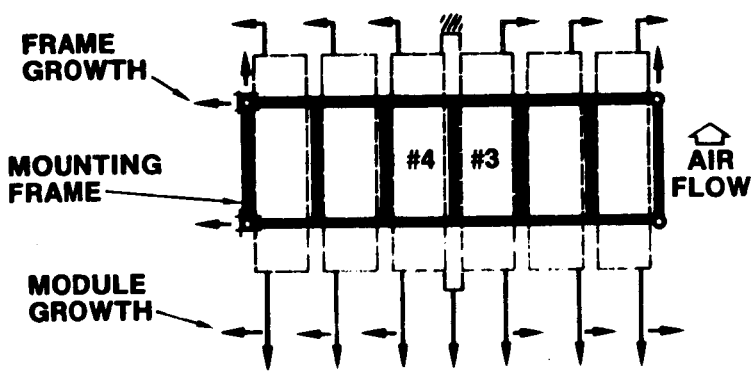
PANEL ASSEMBLY



S 27659

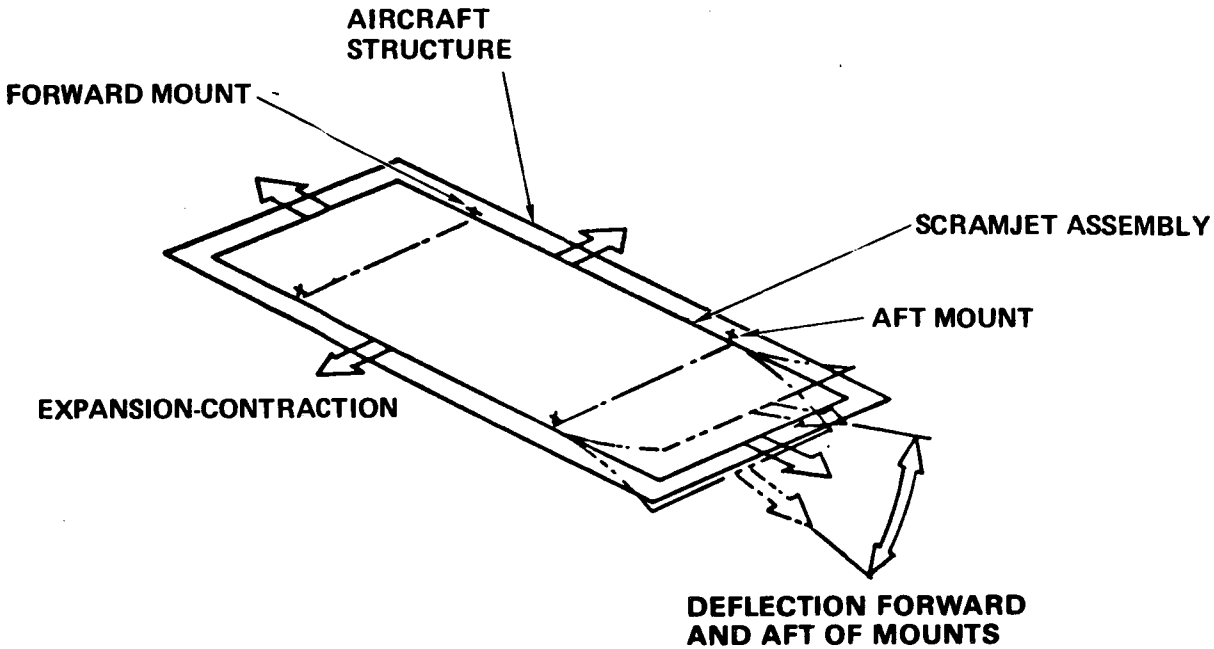
ENGINE MOUNTING





S 27666

SCRAMJET/VEHICLE SEALING



S-13967

DESIGN CONDITIONS

• LIFE	100 HRS, 1000 CYCLES
• DEFLECTIONS	< 5% AREA, 0.4°
• METAL TEMP	< 1600°F
• HYDROGEN	
INLET	1000 PSIA, 100°R
OUTLET	750 PSIA, 1600°R
COOLANT ϕ	< 1.0

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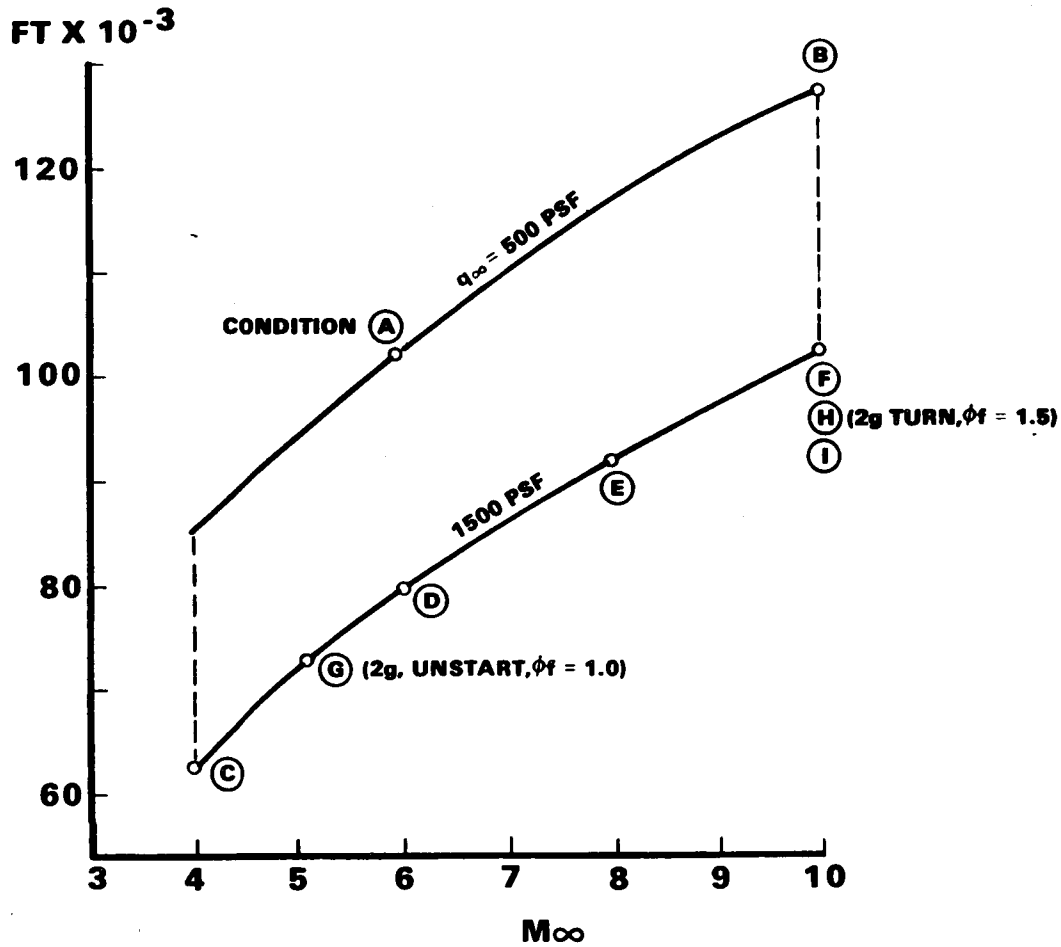
ALTITUDE - MACH NUMBER



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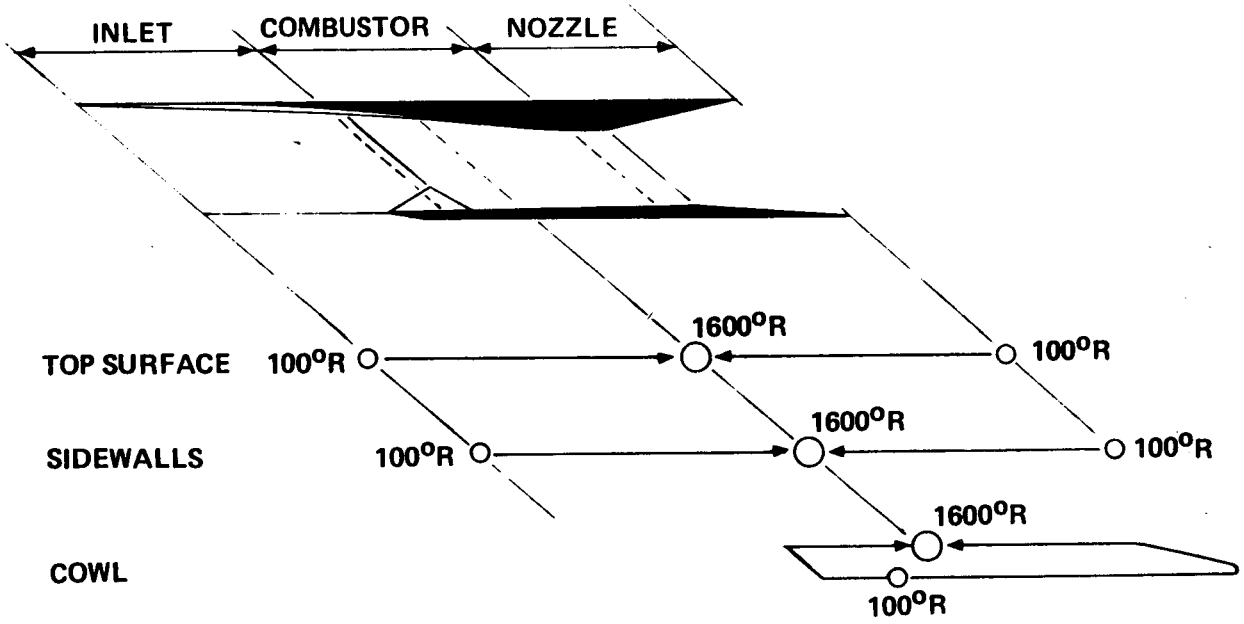
ENGINE FLOW ROUTING



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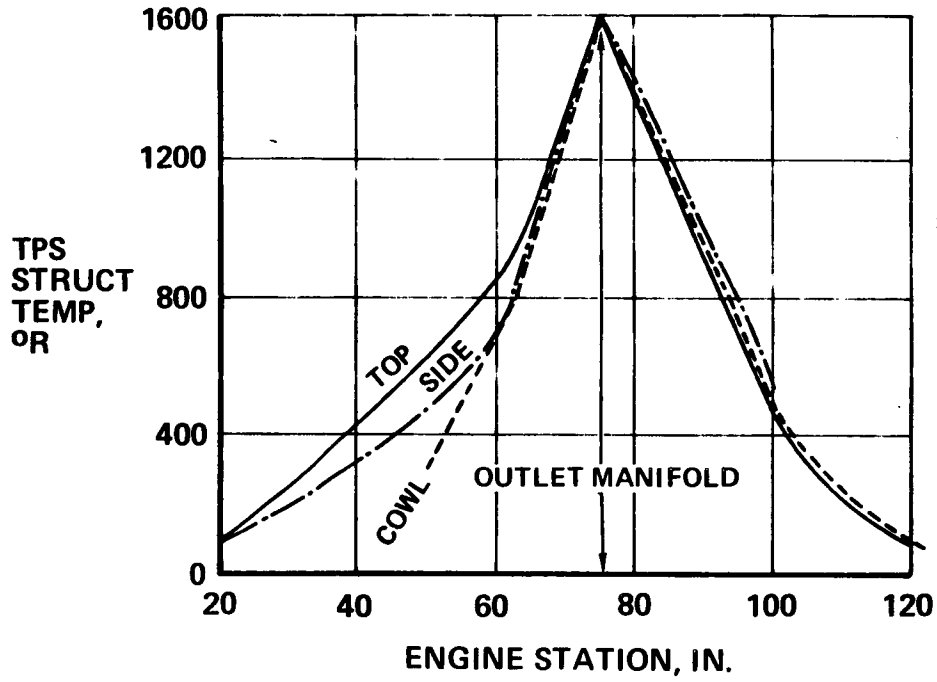
OUTLET MANIFOLD LOCATION

SIDEWALL SHUNT DESIGN

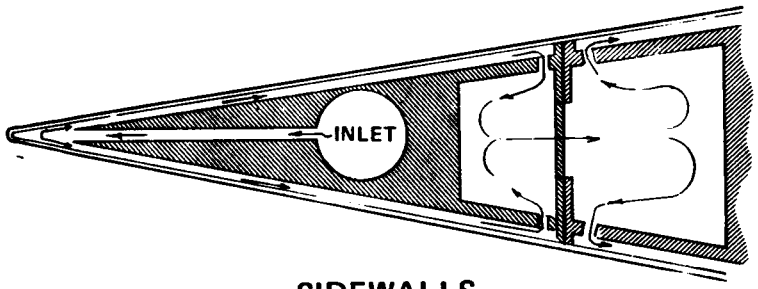


MINIMIZE:

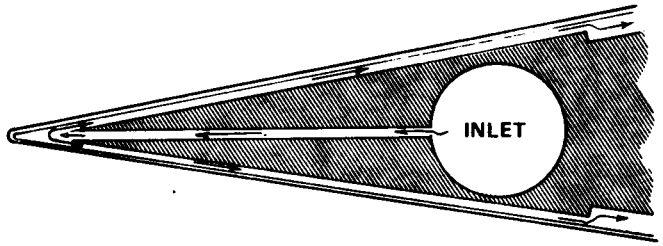
- COOLANT RATE
- COOLANT ΔP
- TPS ΔT
- INTERPANEL ΔT

S-27765

LEADING-EDGE FLOW ROUTING



SIDEWALLS



STRUTS

- ENTIRE FLOW COOLS LEADING-EDGE

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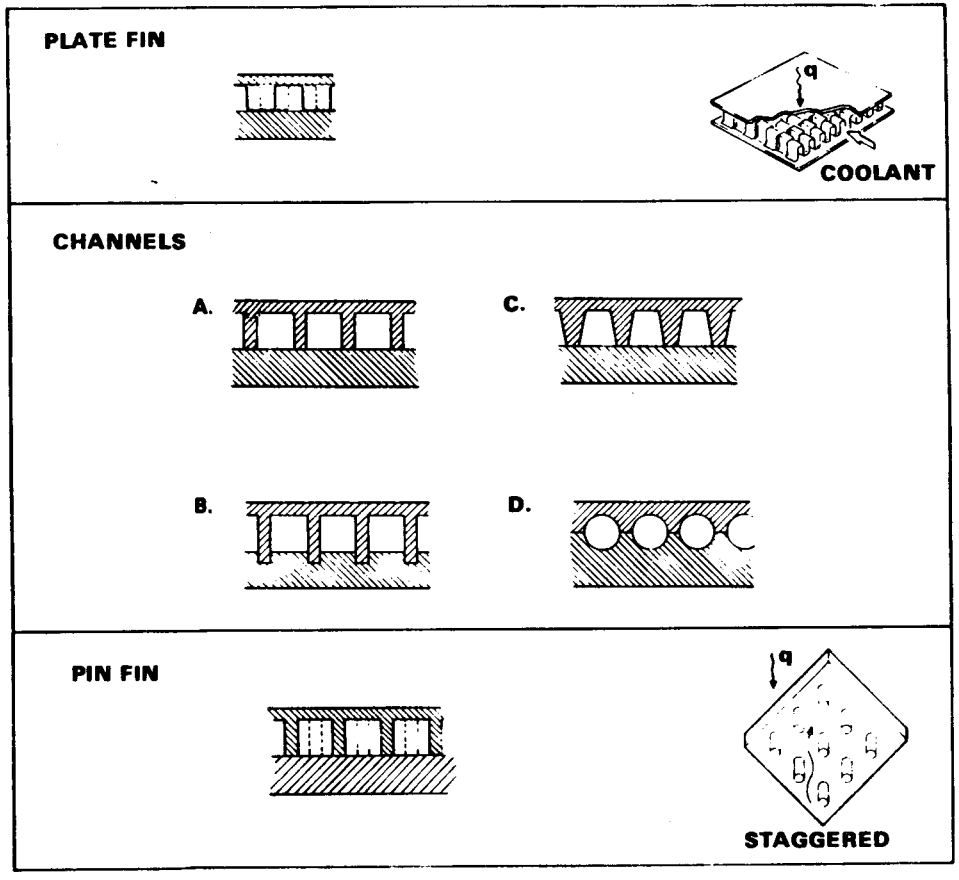
CANDIDATE CONFIGURATIONS



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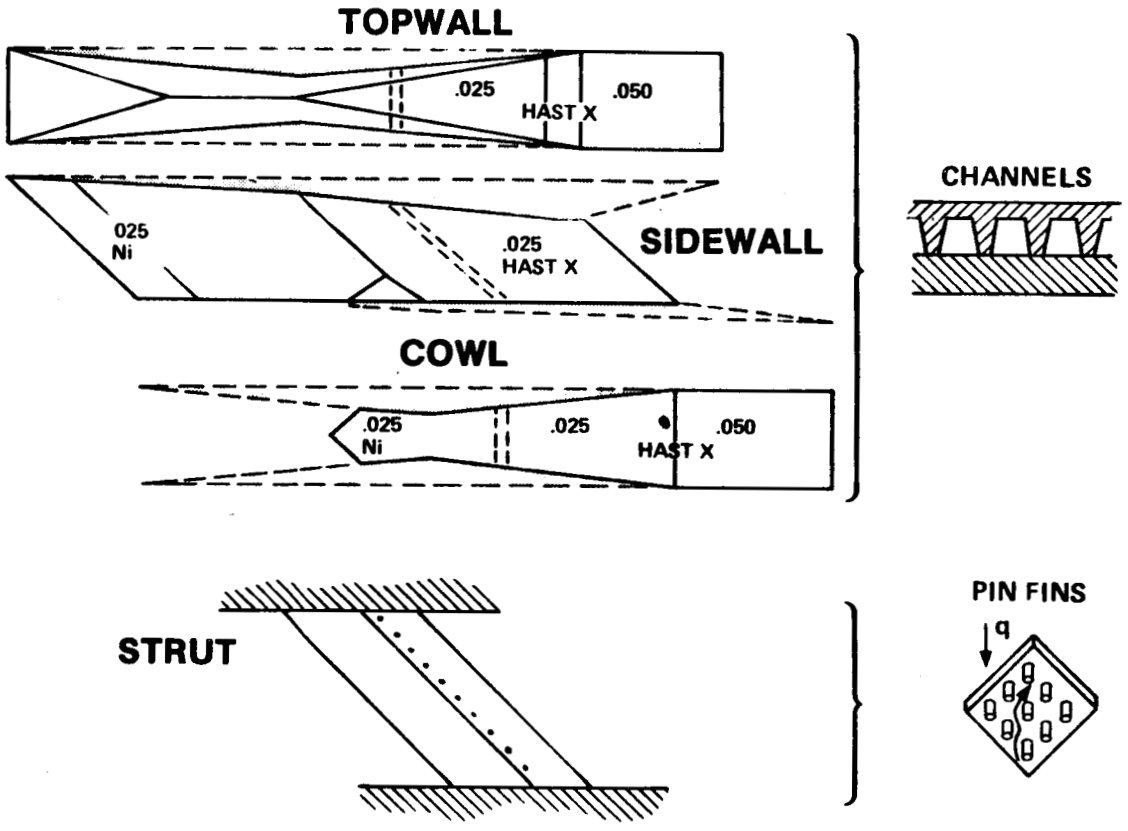
TPS PASSAGE SELECTION



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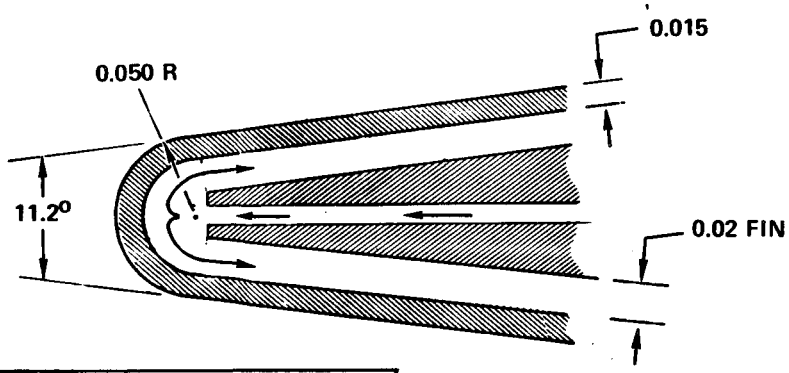
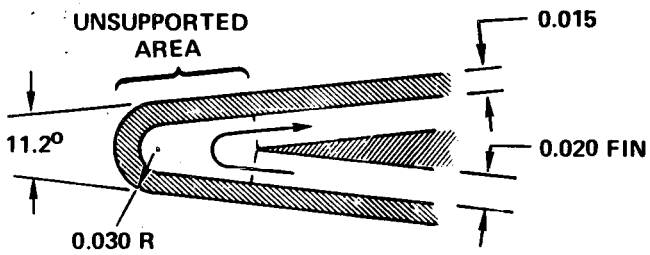
LEADING EDGE DESIGNS



DIRECT IMPINGEMENT



INDIRECT IMPINGEMENT

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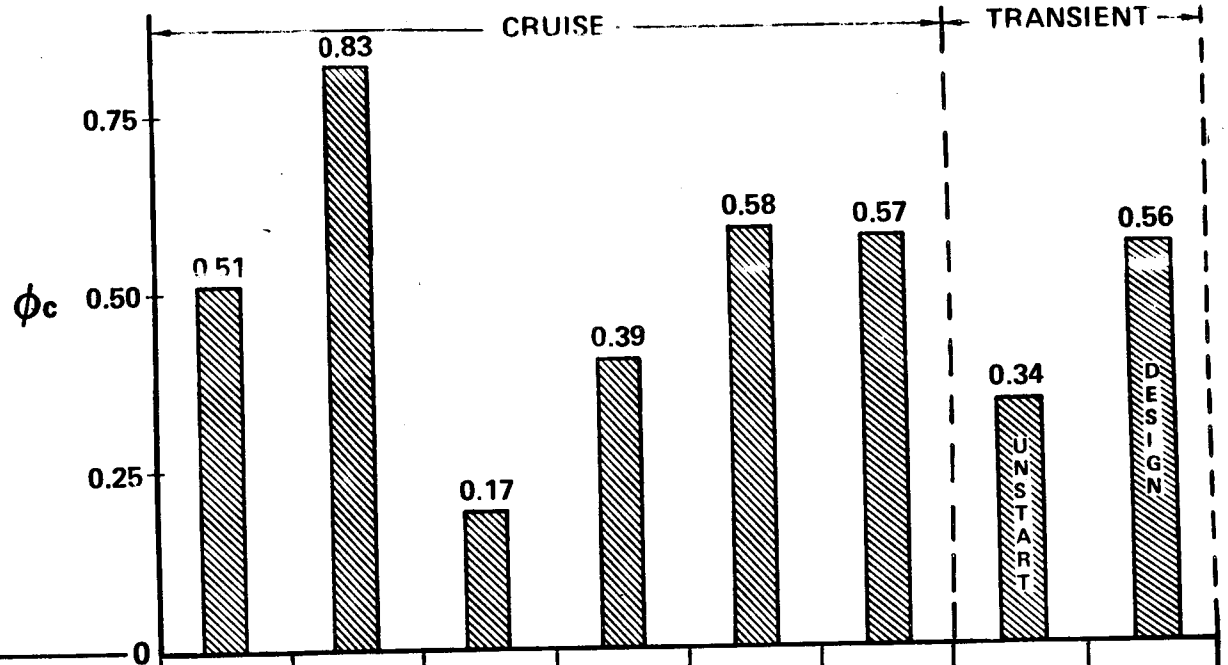
ENGINE COOLING PERFORMANCE



CONDITION	A	B	C	D	E	F	G	H
MACH NO.	6	10	4	6	8	10	5.1	10
ϕ_f	1.0	1.5	1.0	1.0	1.0	1.5	1.0	1.5

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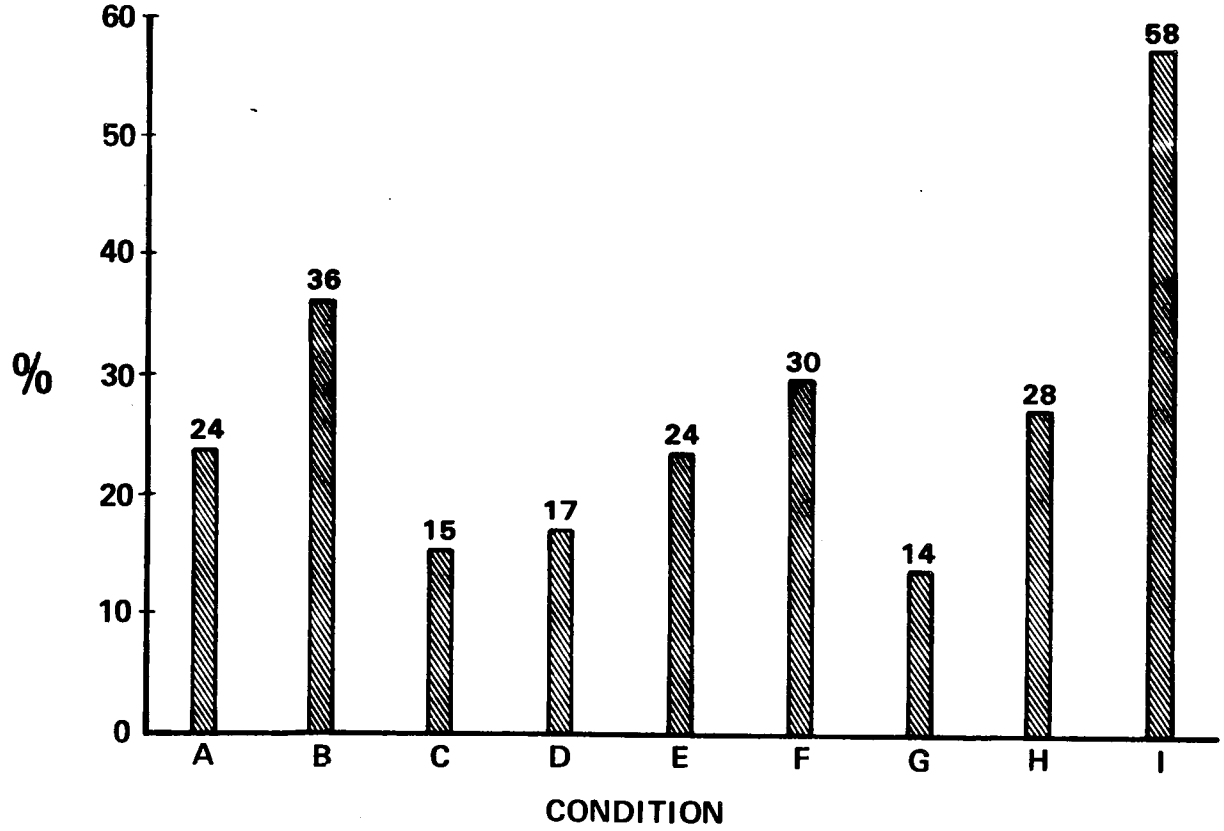
FORWARD/TOTAL HEAT LOAD



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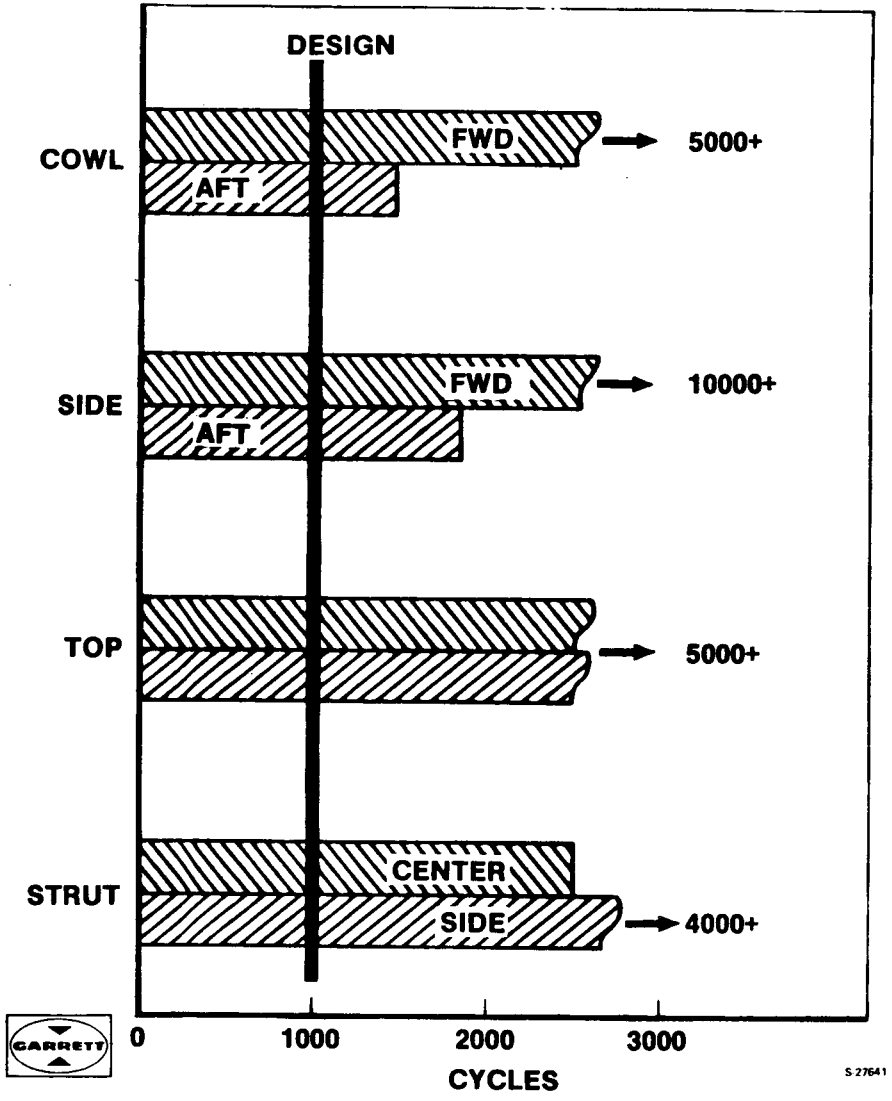
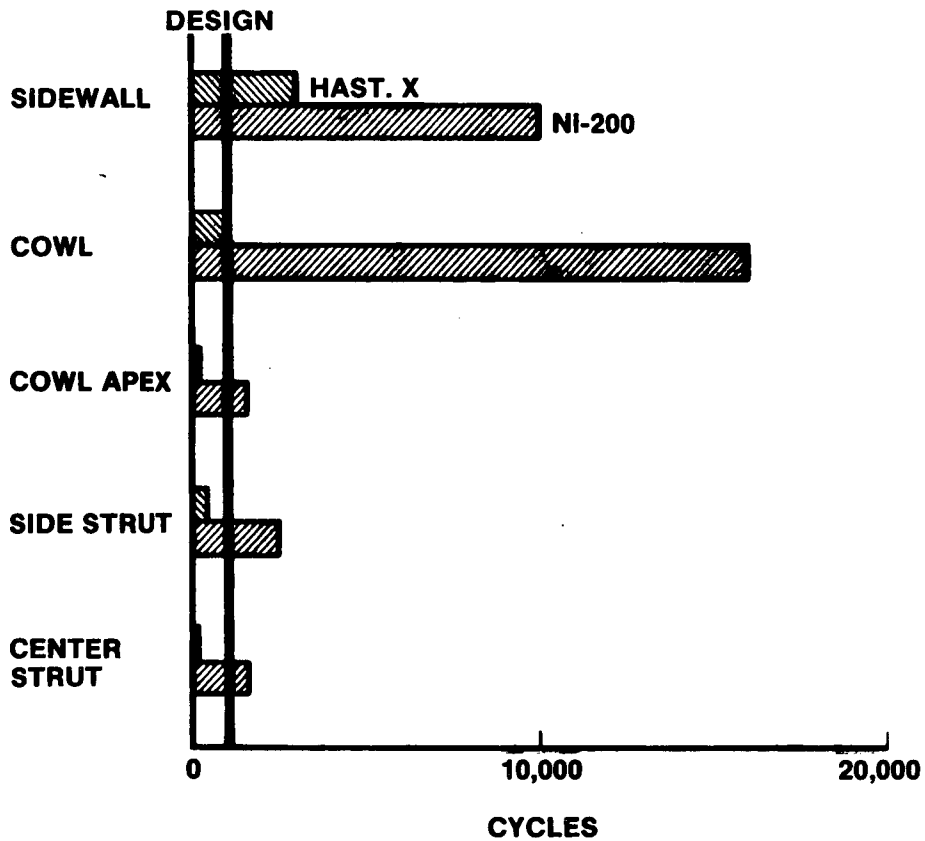
TPS CYCLE LIFE
STEADY STATE



LEADING EDGE CYCLE LIFE



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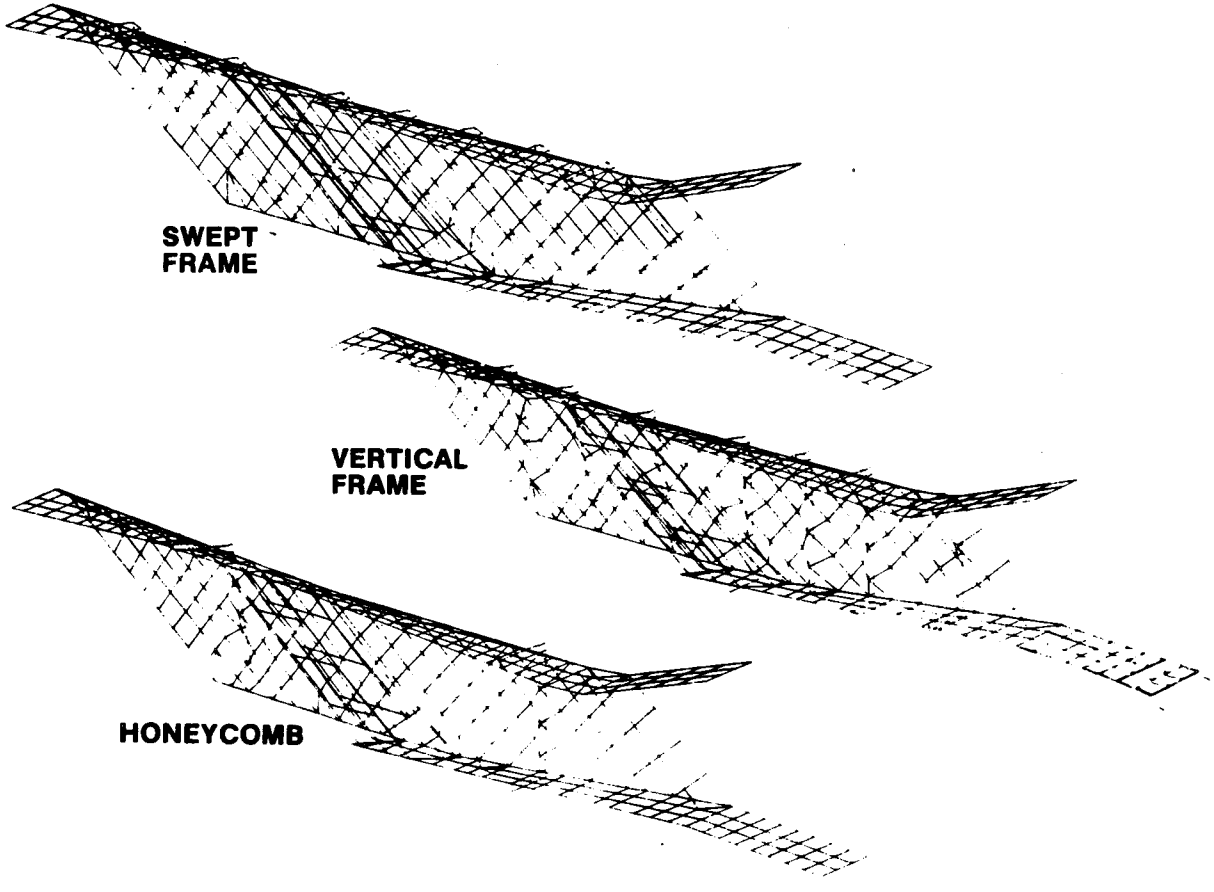
FINITE ELEMENT MODELS



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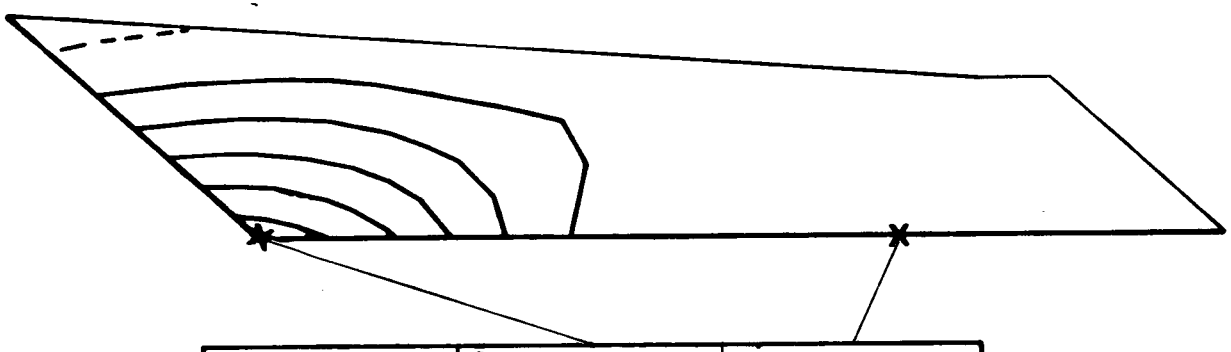
SIDEWALL DISPLACEMENTS

MAXIMUM PRESSURE LOAD



STRUCTURE	DISPLACEMENT, IN.	COMPARATIVE STRESS, KSI
SWEPT BEAM	2.29	68
VERTICAL BEAM	1.08	86
HONEYCOMB (SHOWN)	0.23	58

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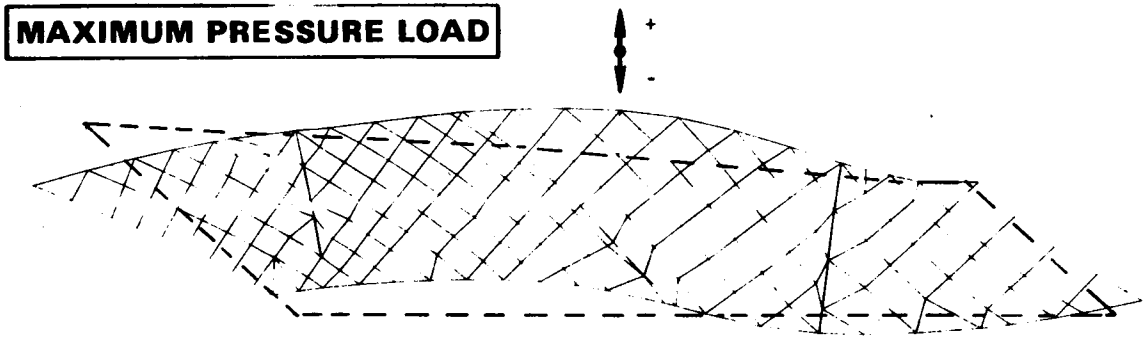
SIDEWALL DISTORTED GEOMETRY

MAXIMUM PRESSURE LOAD



STRUCTURE	VERTICAL DISPLACEMENT, IN.					
	LE TOP	LE BOTTOM	MID TOPWALL	MID COWL	TE TOP	TE BOTTOM
SWEPT BEAM	+ .005	+ .300	+ .110	0	-.092	- .108
VERTICAL BEAM	- .154	+ .146	+ .150	+ .164	0	+ .005
HONEYCOMB (SHOWN)	- .172	+ .051	+ .127	+ .091	0	+ .036

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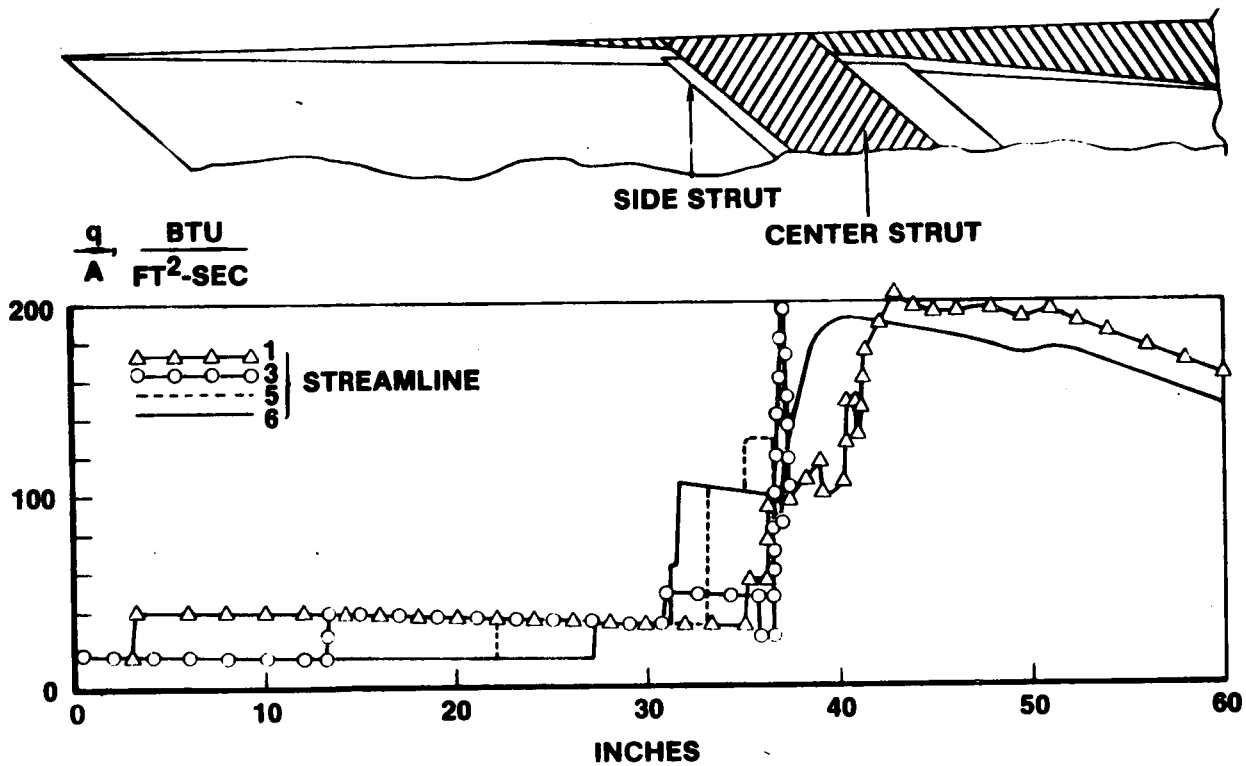
TOPWALL
2-D THERMAL ANALYSIS



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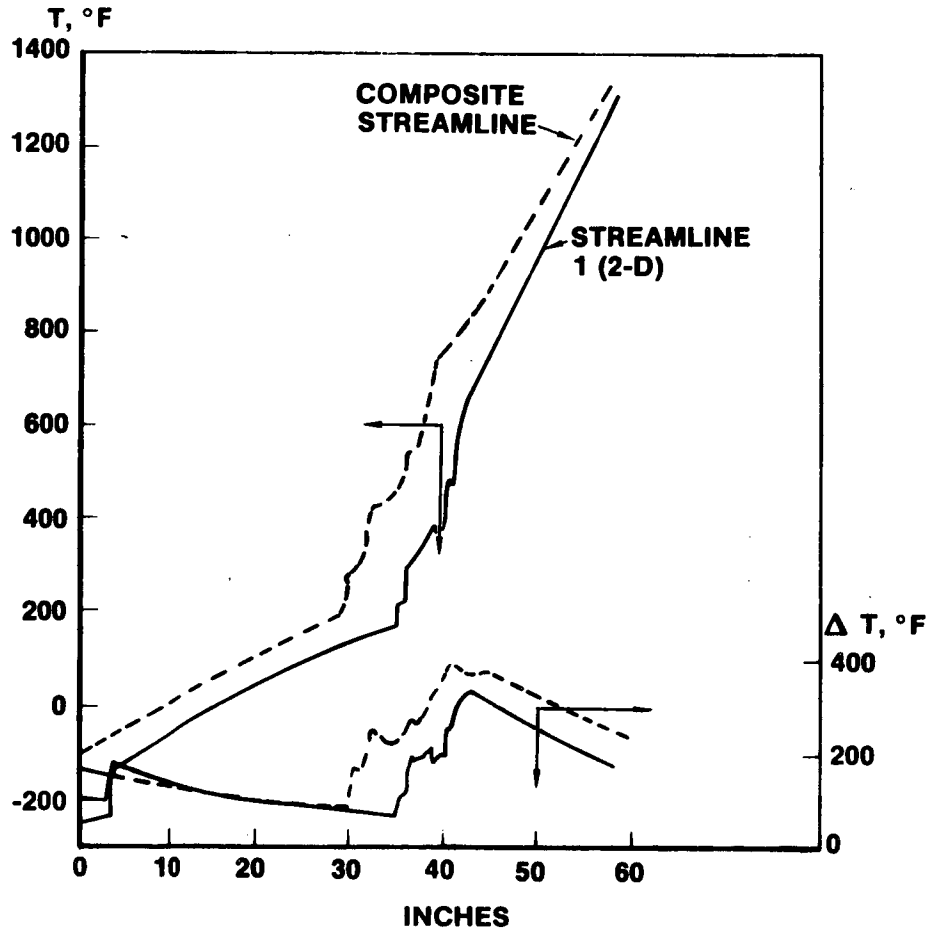
TOPWALL 2-D TEMPERATURE



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TOPWALL
2-D THERMAL STRESS

STA	LOCATION	°F	STRESS, KSI	YIELD, KSI	CREEP, KSI
41	COLD FACE	169	45	43	—
25	HOT FACE	31	-49	45	—
55	HOT FACE	1000	21	34	—
58	HOT FACE	1100	7	32	35

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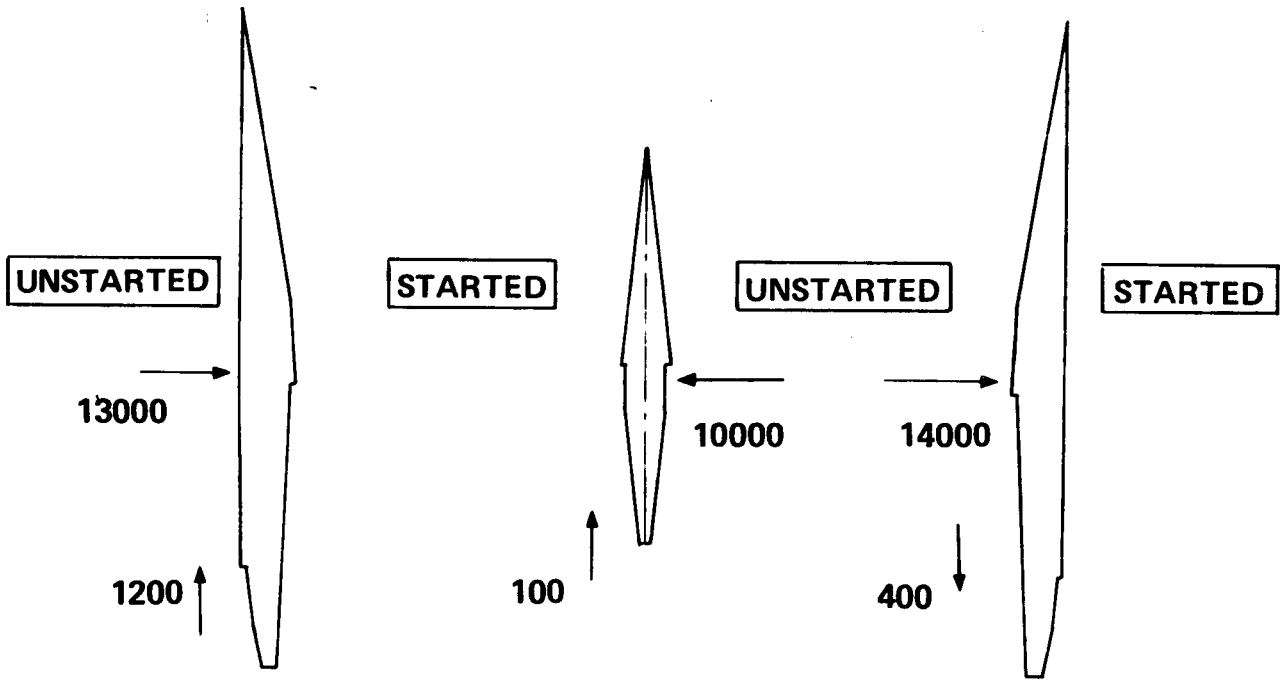
STRUT LOADS (LB)



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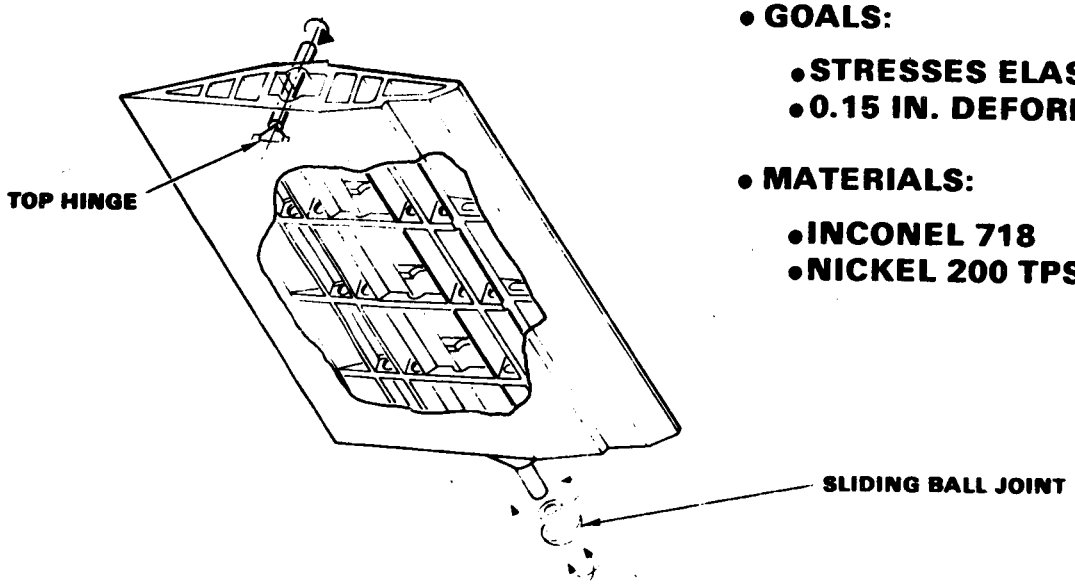
STRUT STRUCTURAL DESIGN



- METHOD:
  - 3-MODEL
- DESIGN:
  - 0.080-IN. WALLS
  - 0.125-IN. RIBS AND WEBS
- GOALS:
  - STRESSES ELASTIC
  - 0.15 IN. DEFORMATION
- MATERIALS:
  - INCONEL 718
  - NICKEL 200 TPS

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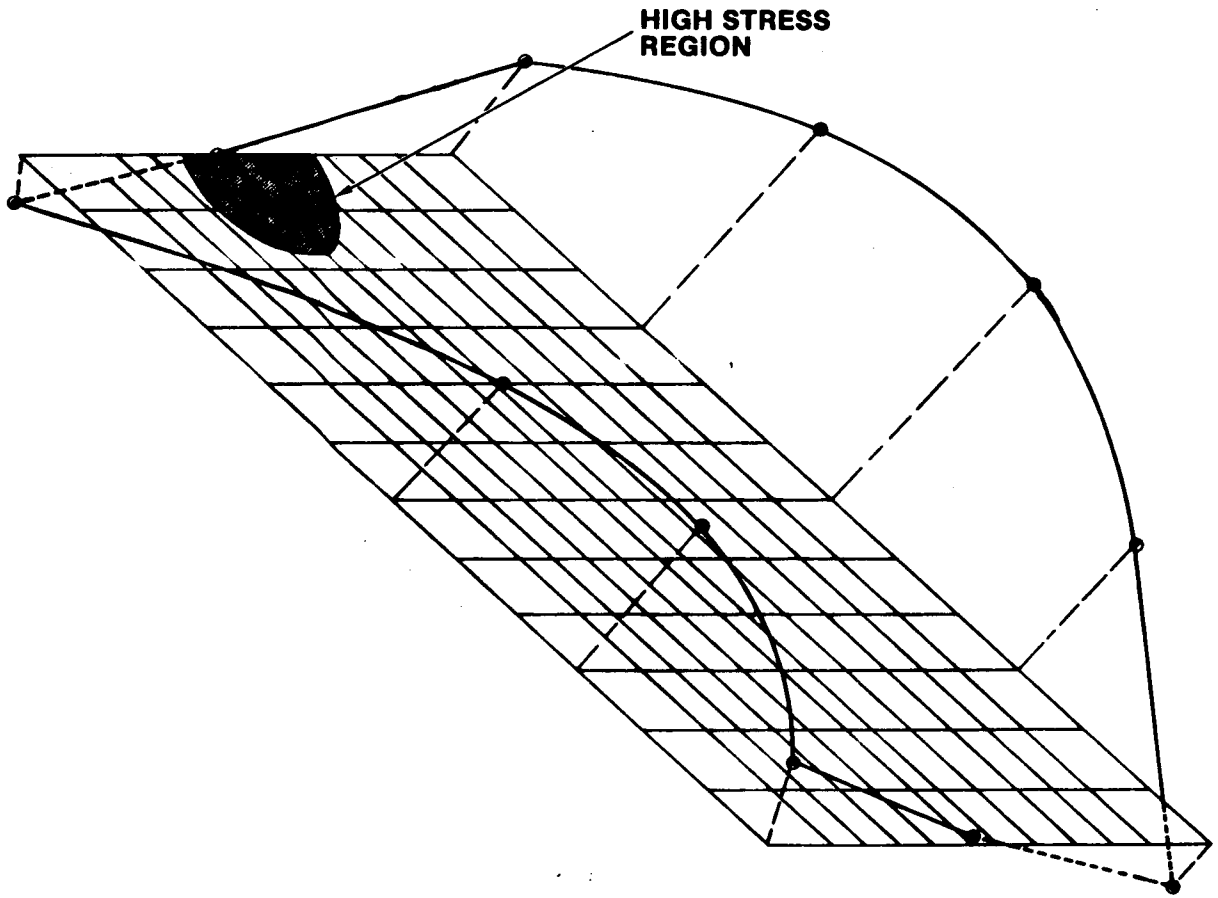
STRUT DISPLACEMENTS



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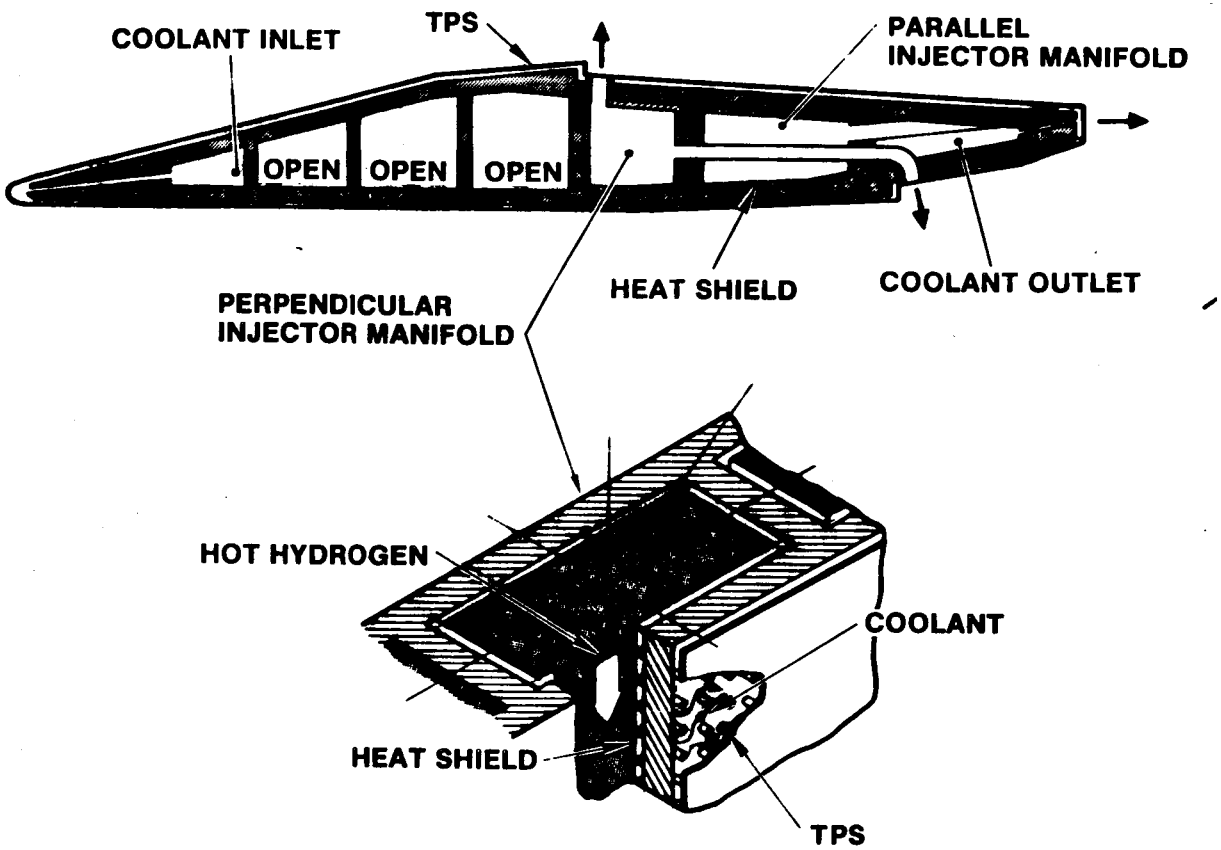
SIDE STRUT



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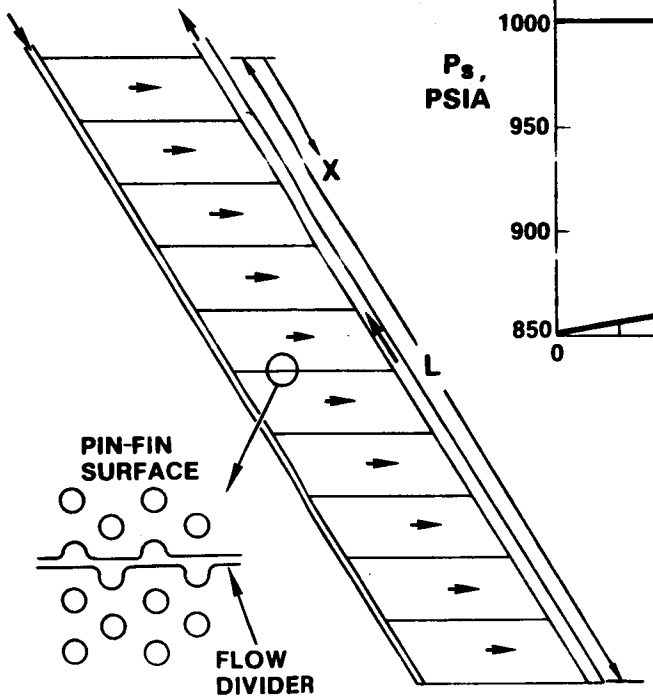
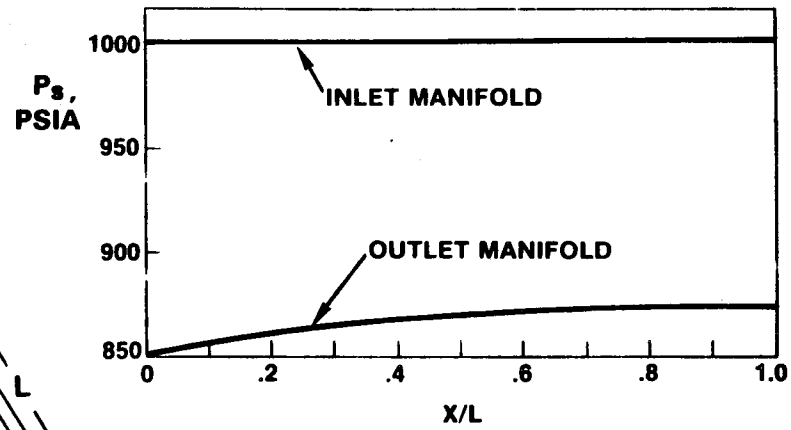
STRUT COOLANT MANIFOLDS





MALDISTRIBUTION	
SIDE STRUT	11%
CENTER STRUT	6%

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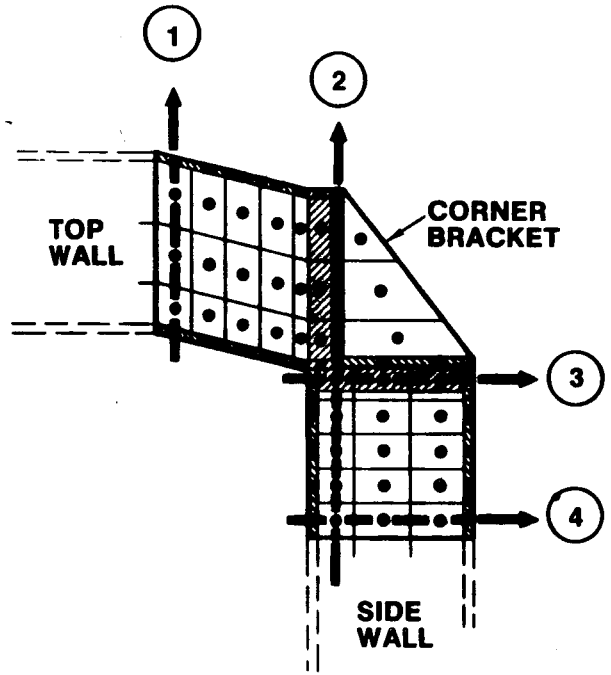
HONEYCOMB
TRANSIENT ANALYSIS CASES



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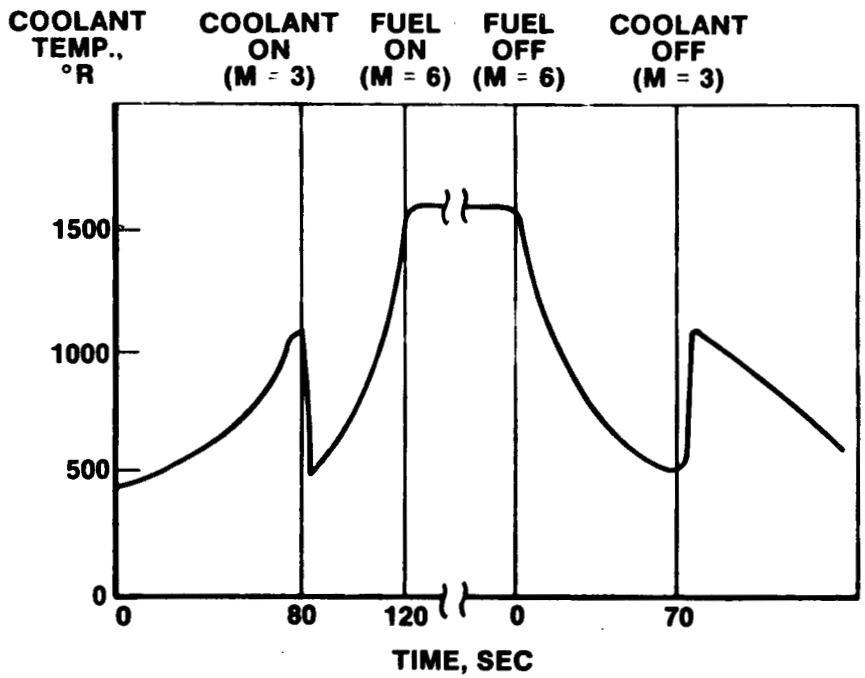
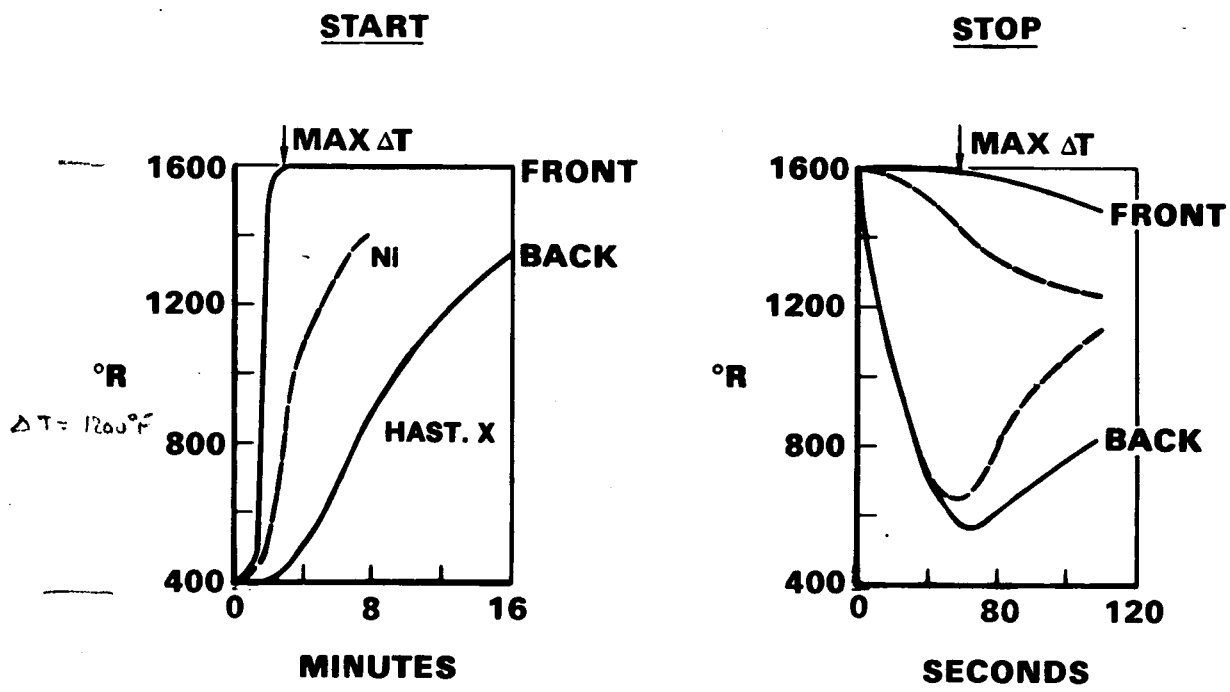
COOLANT OUTLET TRANSIENT



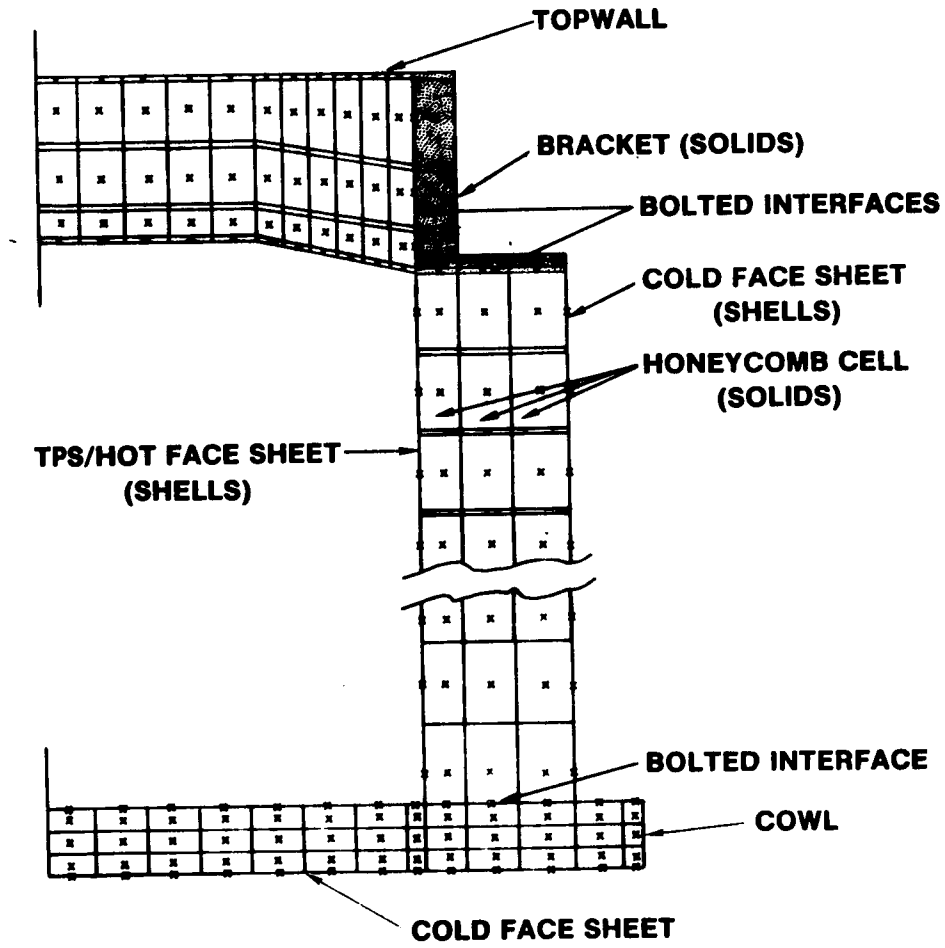
S-27658

TPS/HONEYCOMB TEMPERATURE HISTORY ④



S-27650

TRANSIENT STRESS ANALYSIS MODEL



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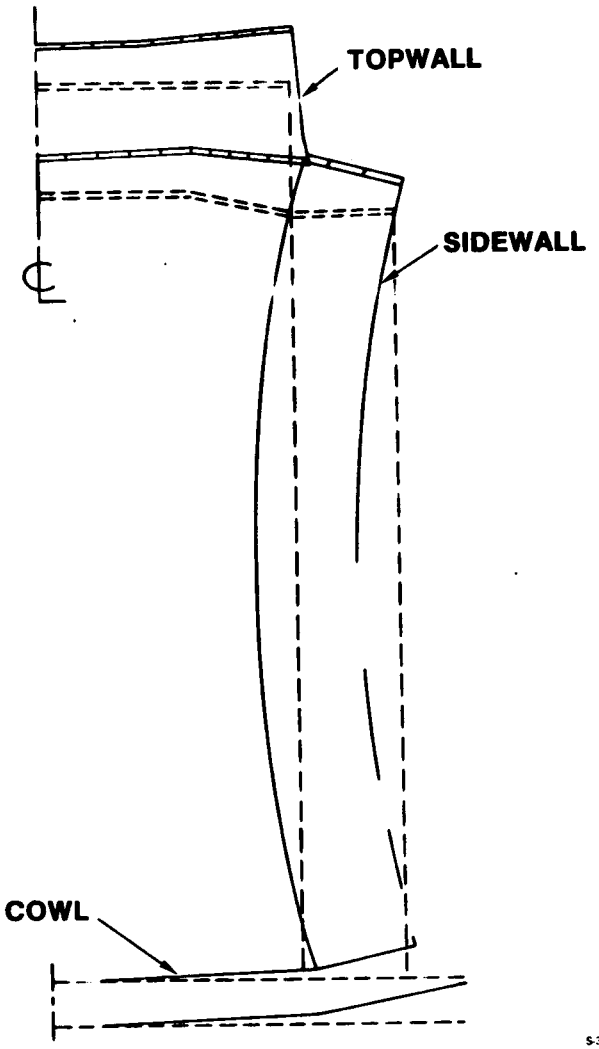
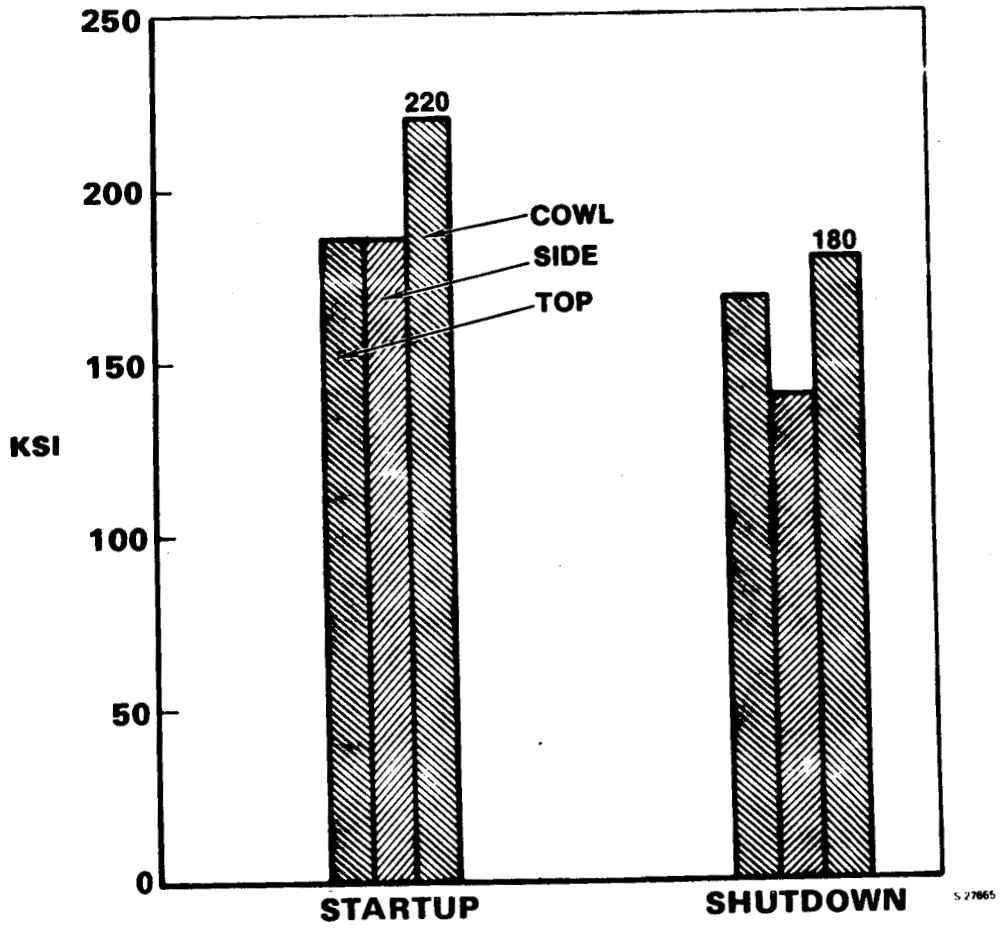
TRANSIENT DISTORTIONS



S-37639

PEAK THERMAL STRESSES (ELASTIC)



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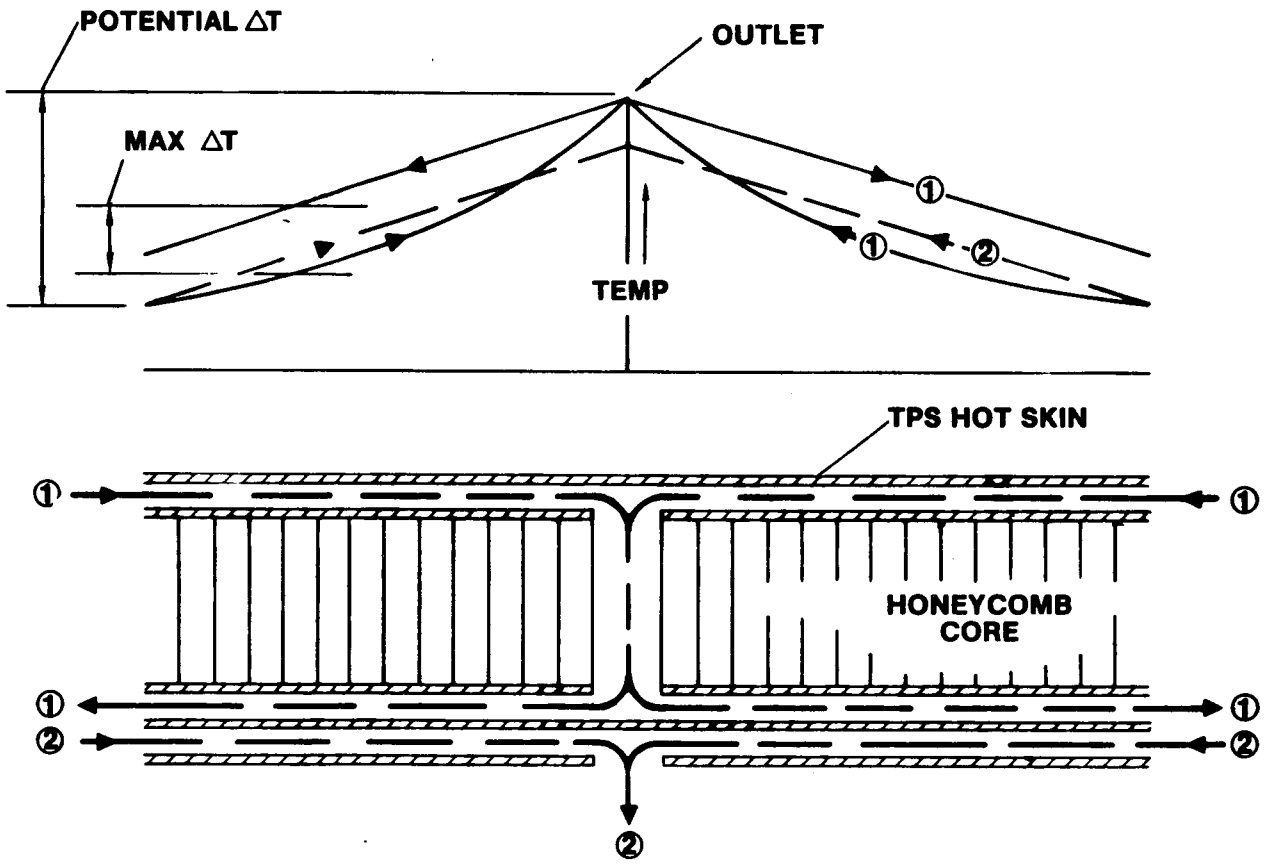
2-PASS TPS/STRUCTURE



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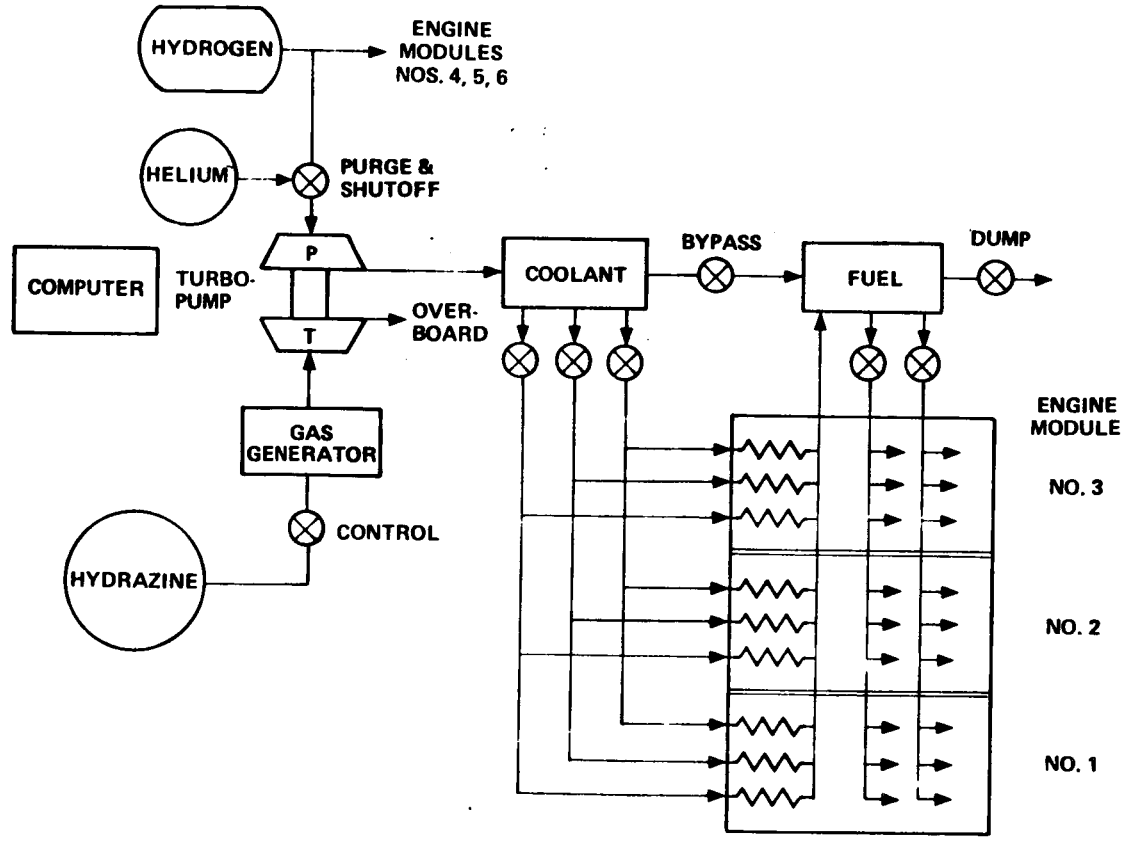
ENGINE FUEL SYSTEM



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ENGINE WEIGHT (LB)
6 MODULES @ 14.4 x 18 IN.

ITEM	SWEPT BEAM	VERT BEAM	HONEY-COMB
STRUCTURE	3050	3020	2940
TPS & MANIFOLDS	1400	1400	1400
HONEYCOMB	640	640	830
BEAMS & CLIPS	380	340	70
L.E., T.E., STRUTS	640	640	640
MOUNTING	140		
FUEL SYSTEM	540		
PLUMBING	300		
INSTRUMENTATION			
	980		
TOTAL	4030	4000	3920

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SUMMARY
THERMAL-STRUCTURAL DESIGN

- TPS
  - FLOW ROUTING
  - CONFIGURATION
  - MATERIALS
- STRUCTURE
  - BEAMS
  - ALL-HONEYCOMB
- STRUTS
  - STRUCTURE
  - MANIFOLDS
- LONG RANGE PLANNING

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CRITICAL DESIGN AREAS

- LOCAL
  - LEADING EDGES
  - STRUTS
  - INTEGRAL MANIFOLDS
  - HONEYCOMB ΔT
- ASSEMBLY
  - COWL FROM STRUTS TO APEX
  - PANEL-TO-PANEL ATTACHMENT
  - SEALS

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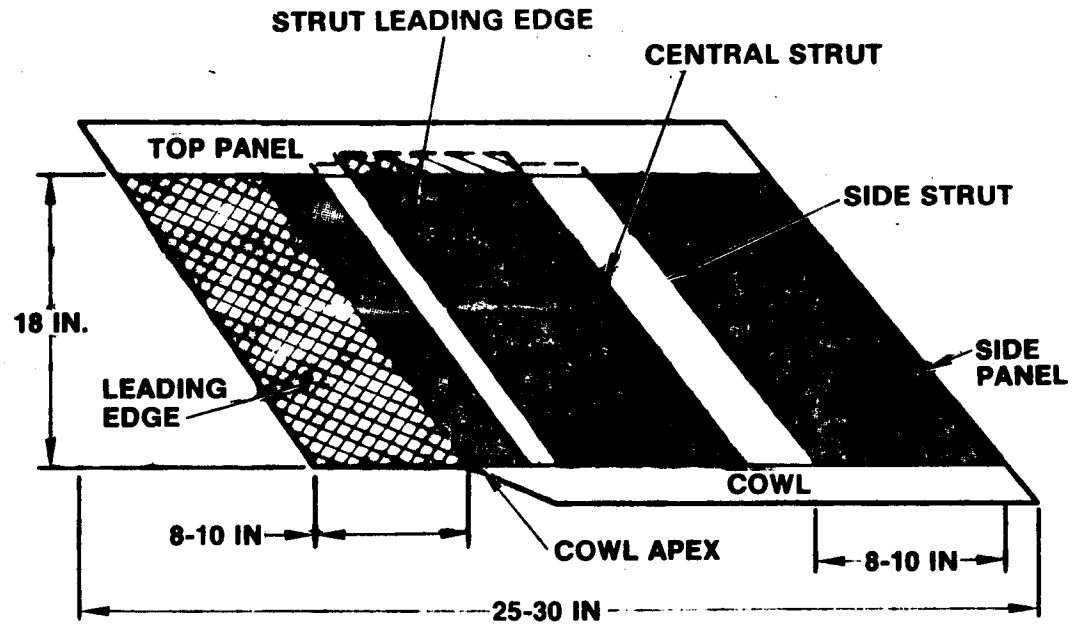
CRITICAL SECTION TESTING



S-27763

SUMMARY
ENGINE SUBSYSTEMS

- FUEL SUBSYSTEM
  - CONCEPT
  - SIZING
- INSTALLATION
  - INTERFACE
  - SUPPORT FRAME
  - SEALING
  - THERMAL GROWTH

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DESIGN DATA REQUIREMENTS

- ENGINE UNSTART
  - PRESSURES
    - VERTICAL
    - HORIZONTAL
    - SYMMETRY
  - MODULE-MODULE
    - INTERACTION
    - PROPAGATION
  - DYNAMICS
    - PROPAGATION
    - BUZZ
- HEAT FLUX DISTRIBUTION
  - COMBUSTION
  - SHOCKS
  - CORNERS
  - BLUNTING
  - AIRCRAFT INTEGRATION

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CONCLUSIONS

- TRANSIENTS GOVERN DESIGN
- DESIGN SOLUTIONS IDENTIFIED
- DESIGN OBJECTIVES FEASIBLE

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RECOMMENDATIONS

- SELECTIVE ANALYSIS

  MECHANICAL JOINTS
  TRANSIENTS

- FABRICATION DEVELOPMENT

  MANIFOLDS
  MECHANICAL JOINTS
  COMPONENTS

- TEST

  TRANSIENT
  LOW CYCLE FATIGUE
  H_2 COMPATIBILITY

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