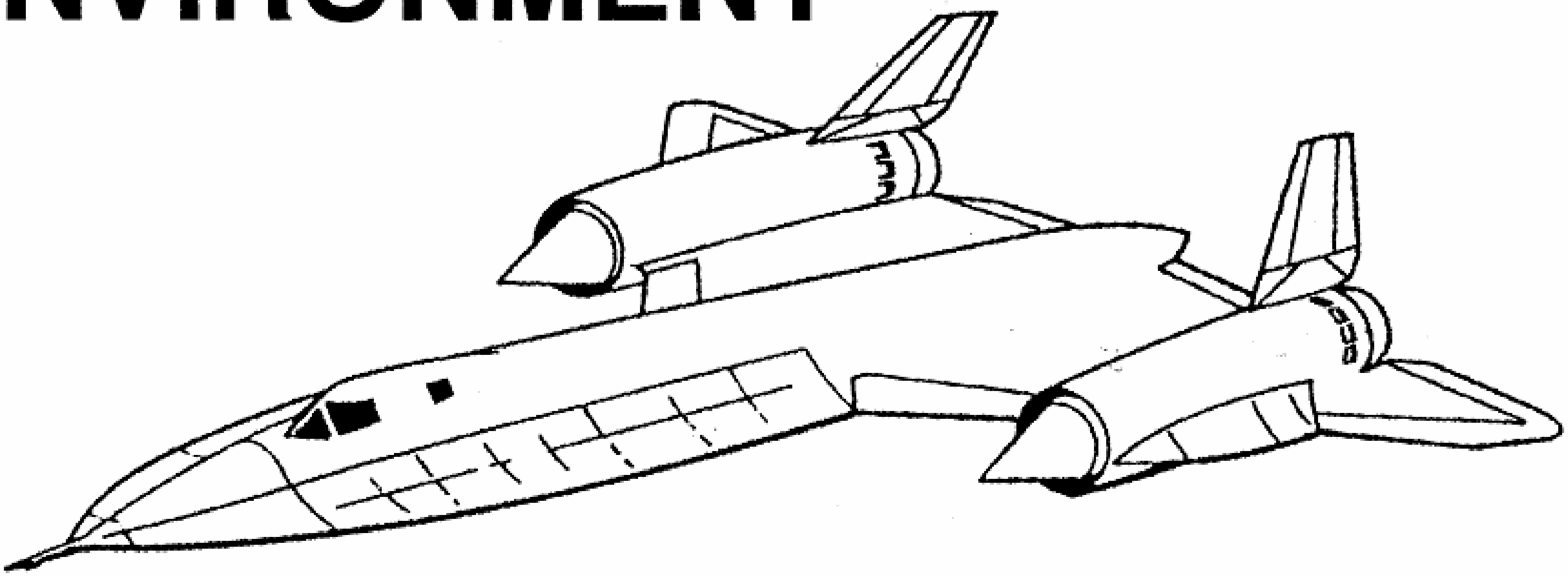
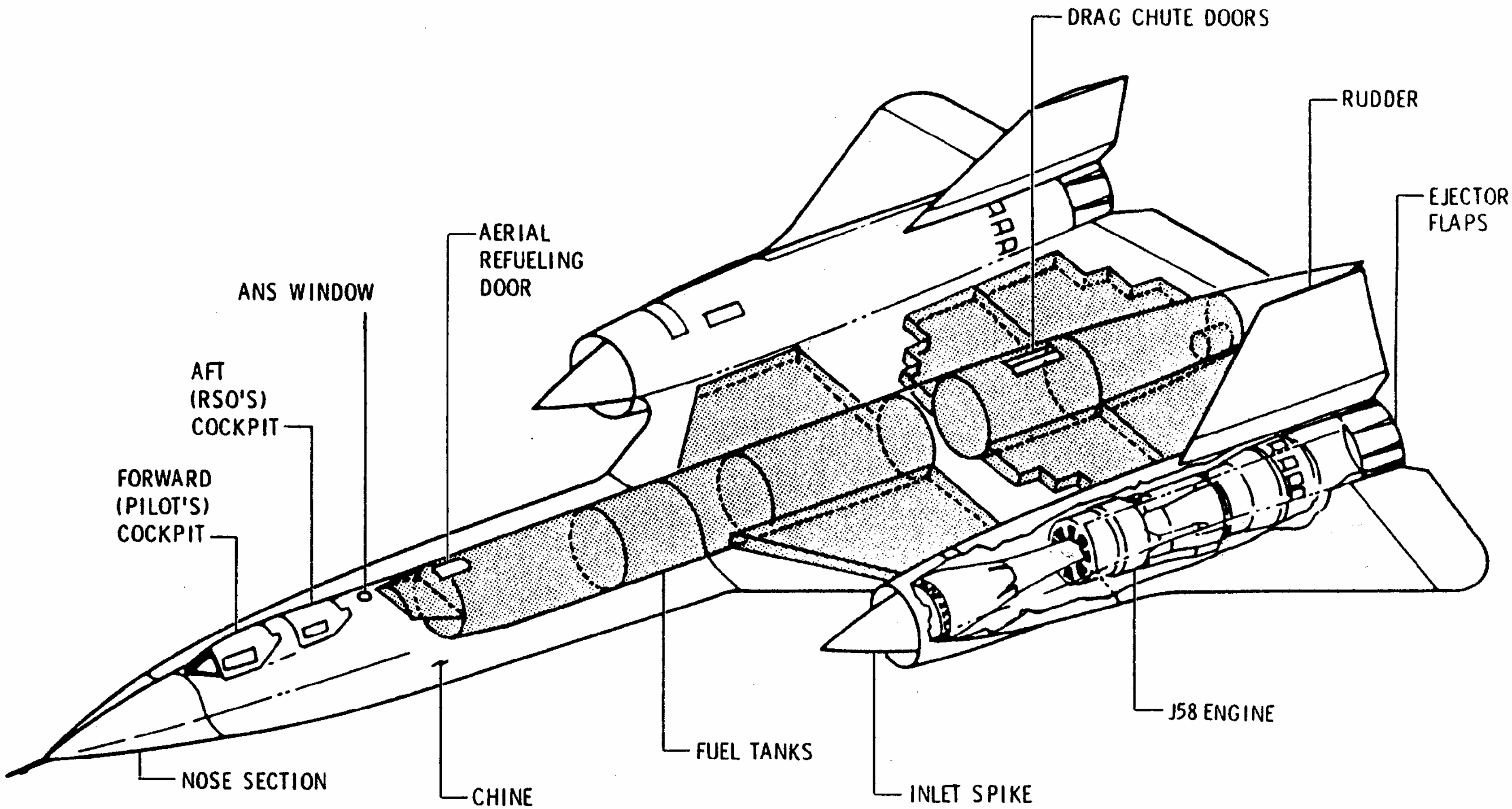
SR–71 THERMAL ENVIRONMENT



PETER V. LAW

GENERAL AIRCRAFT ARRANGEMENT



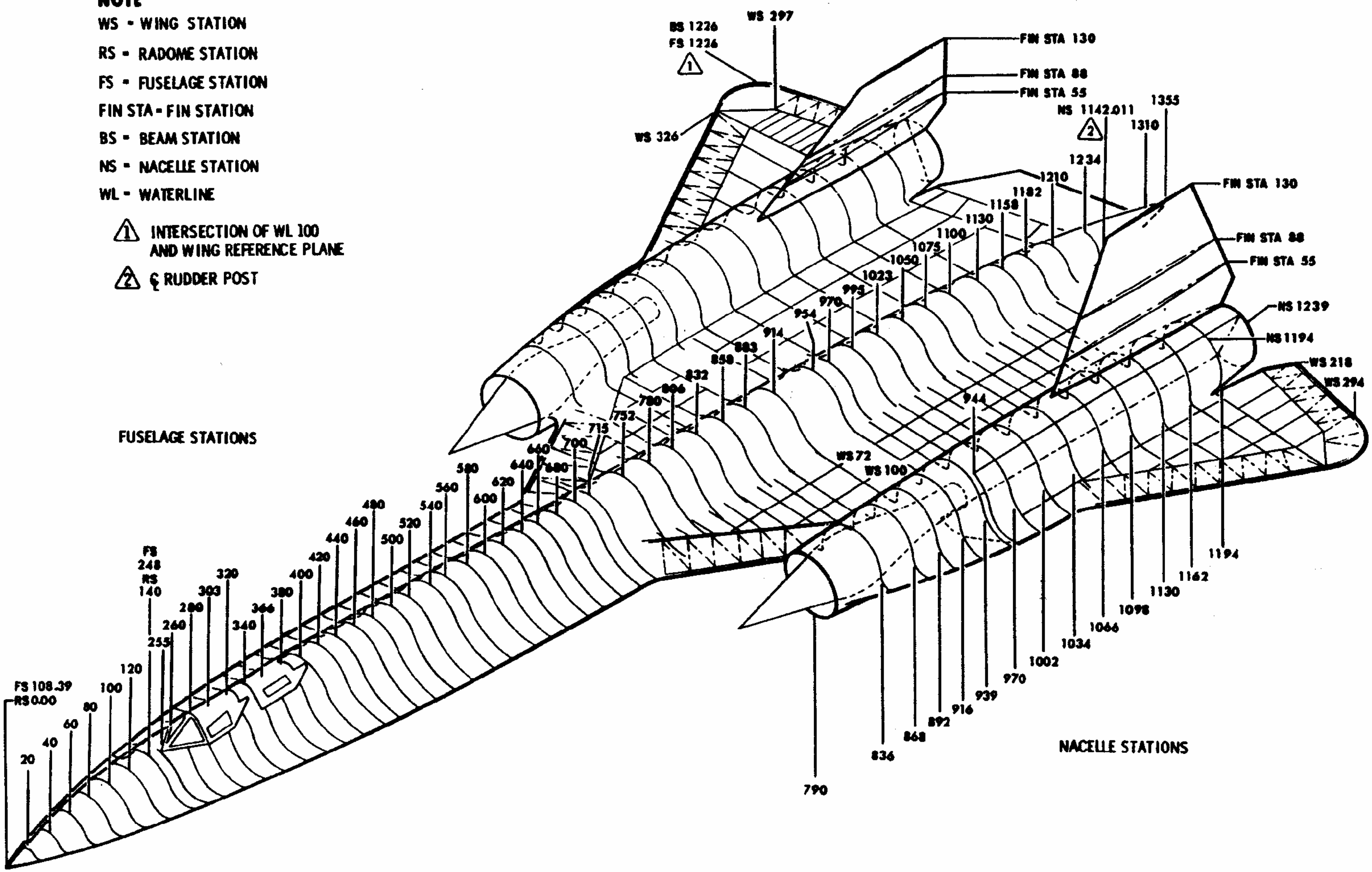
GENERAL STATION LOCATIONS

NOTE

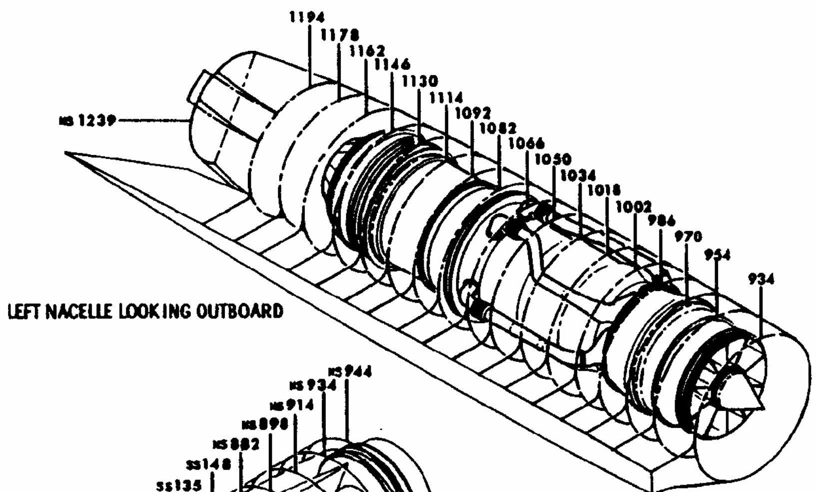
WS - WING STATION
RS - RADOME STATION
FS - FUSELAGE STATION
FIN STA - FIN STATION
BS - BEAM STATION
NS - NACELLE STATION
WL - WATERLINE

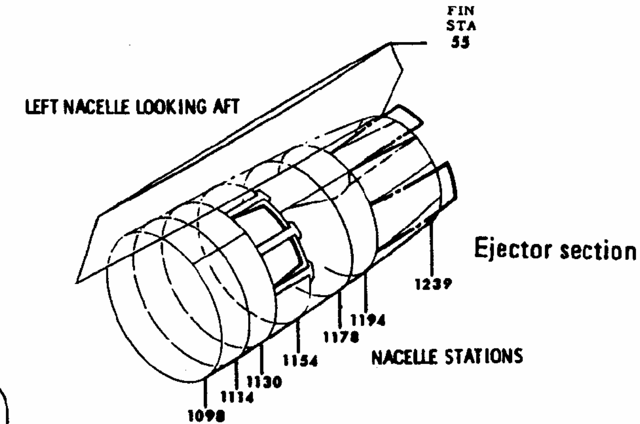
⚠1 INTERSECTION OF WL 100 AND WING REFERENCE PLANE

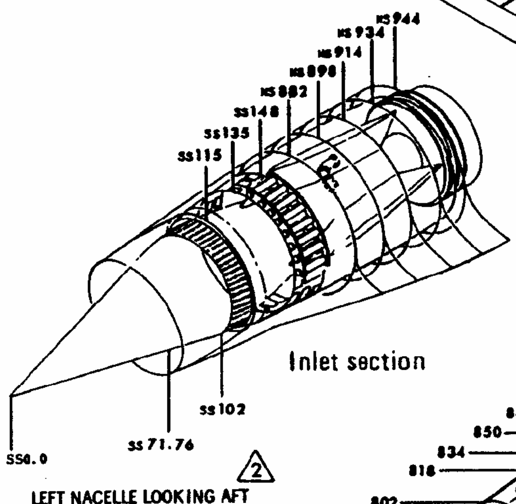
⚠2 ℄ RUDDER POST

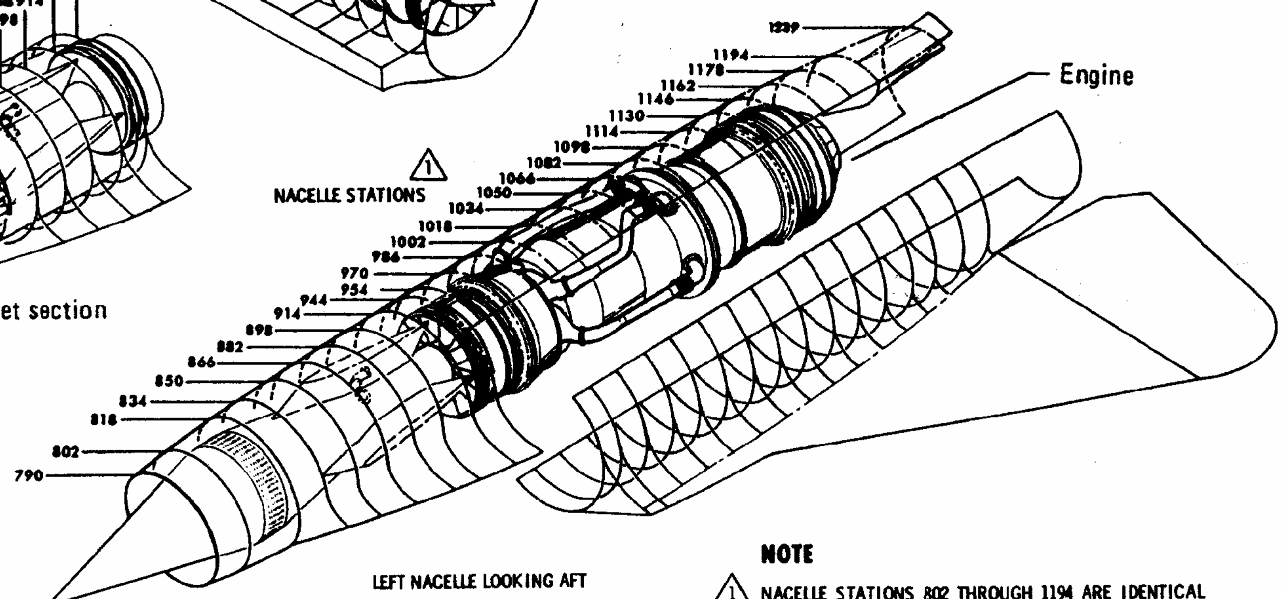


PROPULSION SYSTEM STATION LOCATIONS









NOTE

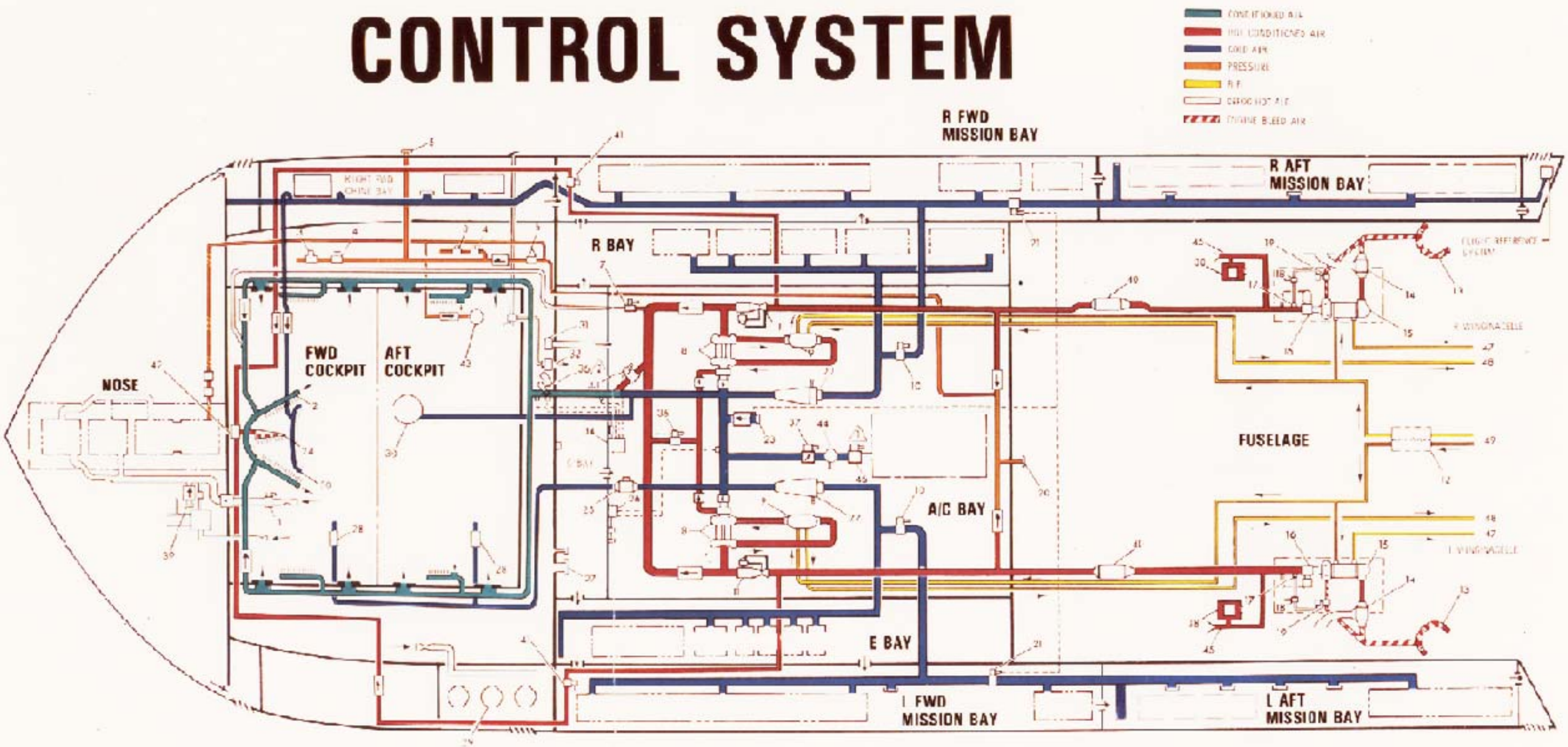
1. NACELLE STATIONS 802 THROUGH 1194 ARE IDENTICAL TO WING BEAM STATIONS, SIMILARLY NUMBERED, EXCEPT FOR NS944, NEAREST EQUIVALENT OF WHICH IS BS934 (NOT SHOWN)

2. SS - SPIKE STATION

THERMAL ENVIRONMENT

- THE SR-71 THERMAL ENVIRONMENT IS MUCH MORE SEVERE THAN MOST OPERATIONAL AIRCRAFT FLYING TODAY AND IN THE PAST.
- THE HEAT GENERATED BY THE HIGH SPEED (MACH 3+) RESULTS IN SKIN FRICTION HEATING AND IN STAGNATION TEMPERATURES OVER 800°F, DEPENDING UPON HIGH ALTITUDE AMBIENT TEMPERATURES.
- AERODYNAMIC HEATING RESULTS IN LEADING EDGE TEMPERATURES OF UP TO 800°F, EXTERNAL SURFACE TEMPERATURES ON THE FUSELAGE AND WINGS OF UP TO 640°F AND SURFACE AND STRUCTURAL TEMPERATURES IN THE ENGINE NACELLE OF OVER 1100°F.
- TYPICAL DESIGN TEMPERATURES DURING HIGH SPEED CRUISE FLIGHT (MACH 3+) ARE PRESENTED TO DOCUMENT THE SEVERE THERMAL ENVIRONMENT ENCOUNTERED FOR STEADY STATE STRUCTURAL DESIGN.

SR-71 ENVIRONMENTAL CONTROL SYSTEM



THERMAL ENVIRONMENT

- EFFECT OF THE SEVERE THERMAL ENVIRONMENT ON THE DESIGN OF THE VEHICLE
  - ALL THE MATERIALS HAD TO SUSTAIN STRENGTH AND LIFE DURING STEADY-STATE-OPERATION AT THE TEMPERATURES EXPECTED IN THE VARIOUS AREAS OF THE VEHICLE. SYSTEMS AND SYSTEM COMPONENTS HAD TO BE DESIGNED FOR STEADY-STATE-OPERATION IN THE ADVERSE THERMAL ENVIRONMENT. FLUIDS, LUBRICANTS AND SEALANTS ALSO HAD TO BE FOUND TO FUNCTION IN THESE SEVERE CONDITIONS.
- DESIGN DRIVERS
  - TO MAKE THE STRUCTURE, THE FUNCTIONAL SYSTEMS, AND THE MISSION EQUIPMENT LIVE IN THE EXTREME THERMAL ENVIRONMENTS, NEVER ENCOUNTERED BEFORE AS STEADY-STATE-OPERATING CONDITIONS FOR AN AIR VEHICLE, AND OPERATE RELIABLY FOR LONG PERIODS OF TIME WITH MINIMAL MAINTENANCE AND RELATIVELY LOW DEVELOPMENT RISK.
- SOLUTIONS TO THE THERMAL DESIGN CHALLENGES
  - FINDING SOLUTIONS TO THE DESIGN CHALLENGES WAS A THERMODYNAMICS DEPARTMENT DREAM OR NIGHTMARE, DEPENDING UPON HOW ONE LOOKED AT THE CONCERN TO BE ADDRESSED. THE CHALLENGES WERE MET AND SUCCESSFULLY OVERCOME. THE ENVIRONMENT OF EACH AREA IN THE VEHICLE WAS RELATIVELY EASY TO DETERMINE, BUT FINDING WAYS TO ALLOW EQUIPMENT TO LIVE WAS DIFFICULT.

THERMAL ENVIRONMENT

- GENERAL AREAS OF CONCERN
  - EXTERNAL THERMAL ENVIRONMENTS
    - ALL SURFACES; FUSELAGE, WING, NACELLE, AND CONTROL SURFACES
  - STRUCTURAL THERMAL ENVIRONMENTS
    - ALL STRUCTURE; BEAMS, LONGERONS, RINGS, MOUNTS, BRACKETS, SKINS, AND NACELLE STRUCTURAL ELEMENTS
  - INTERNAL THERMAL ENVIRONMENTS
    - CREW COMPARTMENTS, COOLED EQUIPMENT BAYS, UNCOOLED EQUIPMENT BAYS, FUEL TANKS, WHEEL WELLS, ENGINE COMPARTMENTS, AND DRAG CHUTE COMPARTMENT
  - SYSTEMS AND SYSTEM COMPONENT THERMAL ENVIRONMENTS
    - FUEL SYSTEM; TANKS, PUMPS, VALVES, LINES, HEAT SINK SYSTEM, AND ENGINE SUPPLY AND RETURN-BLEED HARDWARE; FUEL TANK SEALANT
    - HYDRAULIC SYSTEM; PUMPS, VALVES AND ACTUATORS
    - FUEL TANK INERTING SYSTEM; NITROGEN TANKS AND DISTRIBUTION HARDWARE
    - OXYGEN SYSTEM; BOTTLES, VALVES AND REGULATORS
    - ENVIRONMENTAL CONTROL SYSTEM; HARDWARE AND DUCTING
    - POWER GENERATION SYSTEM AND CONSTANT SPEED GEAR BOX SYSTEM
    - MAINTENANCE RECORDING SYSTEM
    - DIRECTIONAL GYRO PACKAGE COOLING

THERMAL ENVIRONMENT
SPECIFIC AREAS OF CONCERN

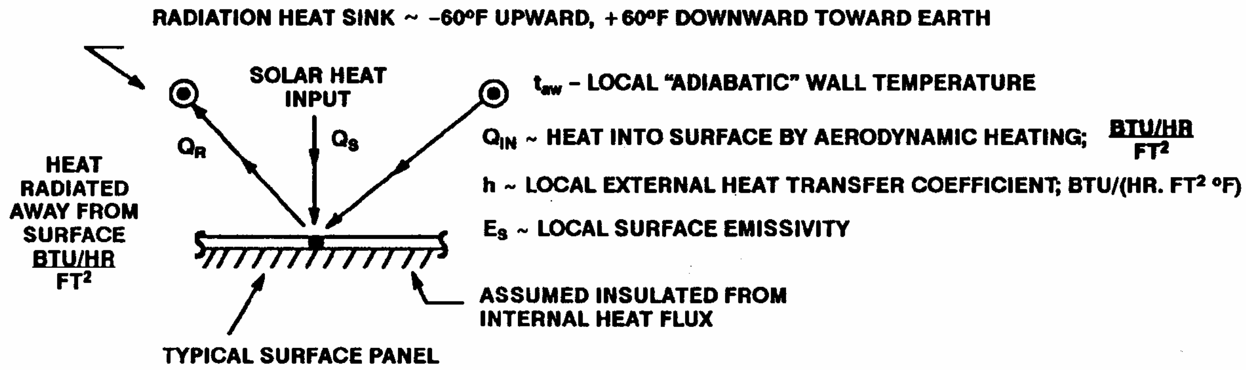
- **EXTERNAL AND INTERNAL ENVIRONMENT SUMMARY**

	DESIGN EXTERNAL ENVIRONMENT	INTERNAL (MAX DESIGN)
– FUSELAGE		
■ NOSE	570°F → 640°F	250°F
■ COCKPIT	510°F → 570°F	80°F
■ FUEL TANKS	500°F → 550°F	550°F
■ EQUIPMENT BAYS	525°F → 550°F	160°F
■ WHEEL WELLS	525°F → 550°F	NOSE: 160°F; MAIN: 400°F
– WINGS		
■ INBOARD	480°F → 640°F	550°F
■ OUTBOARD	510°F → 640°F	550°F
– NACELLE		
■ INLET SPIKE	800°F	800°F
■ INLET COWL	800°F	800°F
■ ENGINE COMPT	900°F +	900°F +
■ ENGINE & A.B.	900°F +	900°F +
■ EJECTOR NOZZLE	1000°F	1300°F
■ EXHAUST FLAPS	1100°F	1700°F
– CONTROL SURFACES		
■ HORIZONTAL	460°F → 550°F	550°F
■ VERTICAL	470°F → 640°F	640°F

06-JM-0045-03-26-91-CB

EXTERNAL THERMAL ENVIRONMENT

- EXTERNAL SURFACE TEMPERATURES – AREAS EFFECTIVELY INSULATED FROM HEAT SOURCES
  - METHODS TO DETERMINE RADIATION EQUILIBRIUM SURFACE TEMPERATURES (ABBREVIATED)
    - ■ TYPICAL THERMAL HEAT BALANCE



- ■ TYPICAL THERMAL ASSUMPTIONS:
  - AMBIENT CONDITIONS: 1959 ARDC STANDARD ATMOSPHERE
  - SOLAR HEAT LOADS: 0, 200, 400 BTU/HR. FT^2 NORMAL TO SURFACE
  - SURFACE EMISSIVITIES: 0.5 (UNPAINTED), 0.9 (BLACK AREAS)
  - SURFACE SOLAR ABSORPTIVITY: 0.6 (UNPAINTED), 0.93 (BLACK AREAS)
  - RADIATION HEAT SINK TEMPERATURES:
    - ✓ UPPER SURFACES: −60°F USED AS OUTER SPACE VALUE
    - ✓ LOWER SURFACE: +60°F USED AS EARTH SURFACE VALUE
    - ✓ NO RADIATION FROM OTHER SURFACE FOR "ACREAGE" PANELS

06-JM-0046-04-01-91-CB

EXTERNAL THERMAL ENVIRONMENT

(CONTINUED)

- **METHODS TO DETERMINE SURFACE TEMPERATURES (CONTINUED)**
  - **LOCAL ADIABATIC WALL TEMPERATURE: (TEMPERATURES IN °F)**

    $t_{aw} = t_a + 0.89\,(T_{RAM} - t_a)$ where t_a is ambient temperature ~°F, T_{RAM} is stagnation temperature ~°F

  - **LOCAL TURBULENT HEAT TRANSFER COEFFICIENT: (BTU/(HR.FT²°F))**

    $$h_\ell = 41.7\, C_f \, \frac{p_\ell \, V_\ell}{T_{ref}} \, (c_p)_{ref};$$

    c_p is specific heat at T_{ref} ~ $\frac{BTU/\#}{°F}$

    p_ℓ is local static pressure ~ PSFA

    V_ℓ is local velocity ~ feet/sec.

  - **LOCAL BOUNDARY LAYER REFERENCE TEMPERATURE: (TEMPERATURES IN R)**

    $T_{ref} = 0.5\, t_w + t_\ell\,(0.5 + 0.0394\, M_\ell^2)$ local static conditions

    where: t_w is wall temperature, t_ℓ is local static ambient temperature, M_ℓ is local Mach number

  - **LOCAL SKIN FRICTION COEFFICIENT**

    $$C_f = \frac{0.585\,\overline{C}_f}{0.557 + 2.(\overline{C}_f)^{1/2}} \quad ; \quad \overline{C}_f = \left[\frac{0.242}{\log_{10}(R_{e\,ref}\,\overline{C}_f)}\right]^2$$

    (iterative solution required)

  - **REFERENCE REYNOLDS NUMBER: (TEMPERATURES IN °R, V_ℓ is ft/sec, p_ℓ is PSFA)**

    $R_{e_{ref}} = 25{,}600.\, p_\ell \, V_\ell \;\; X\,(T_{ref} + 200.)\,/\,(T_{ref})^{2.5}$

    where: X is reference distance from leading edge parallel to fuselage centerline in feet

06-JM-0047-04-01-91-CB

EXTERNAL THERMAL ENVIRONMENT

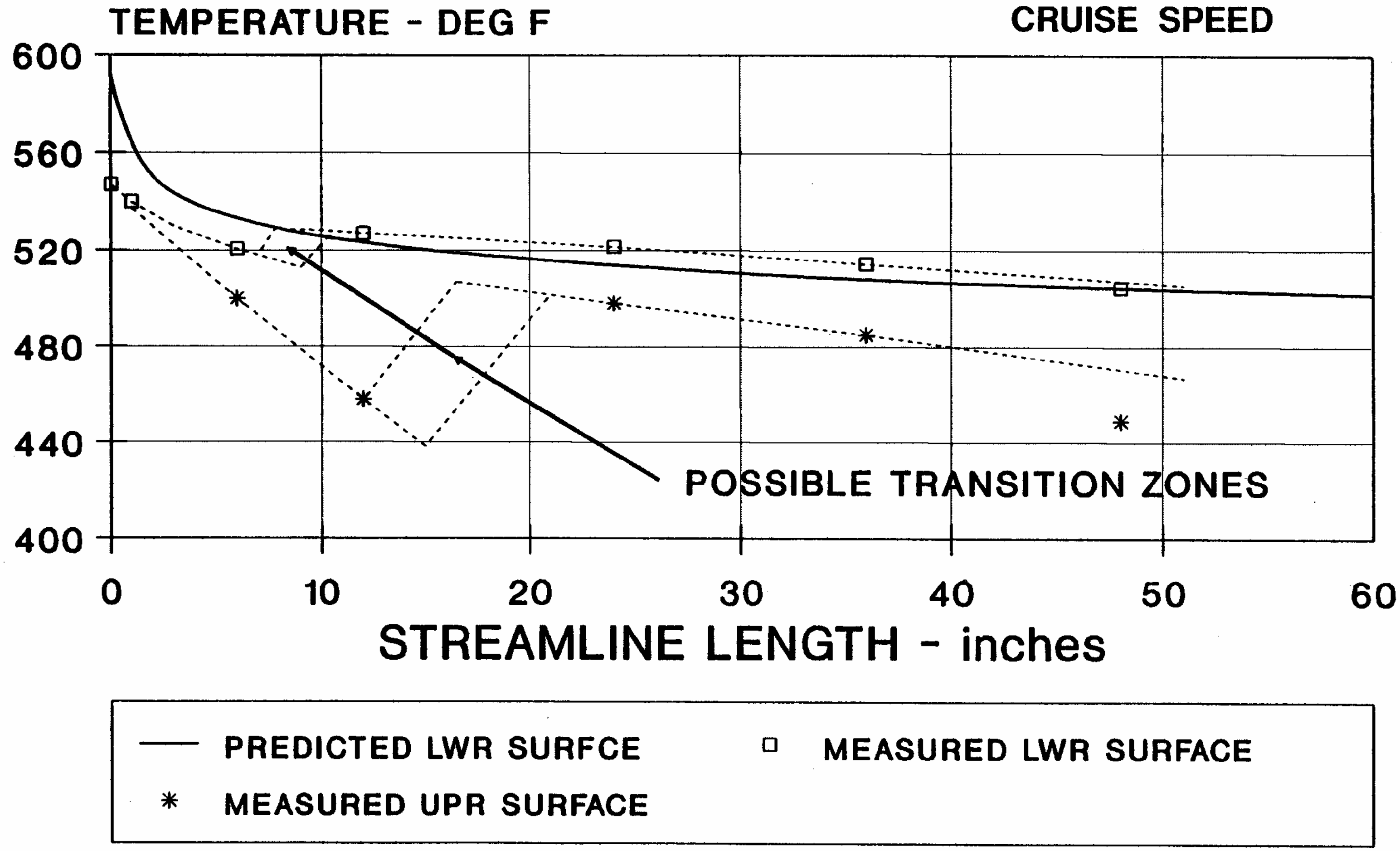
EXTERNAL SURFACE TEMPERATURES (CONTINUED)

- GENERAL TEMPERATURE TRENDS AT HIGH SPEED/HIGH ALTITUDE FOR "ACREAGE" SURFACES
  - 25°F INCREASE FOR EACH 0.1 INCREASE IN MACH NUMBER
  - 16°F INCREASE FOR EACH 10°F INCREASE IN AMBIENT TEMPERATURE (CONSTANT ALTITUDE AND SPEED)
  - 15°F INCREASE FOR EACH 5,000′ DECREASE IN ALTITUDE (CONSTANT SPEED AND AMBIENT TEMPERATURE)
  - 4°F INCREASE FOR EACH 10°F INCREASE IN RAM AIR TOTAL TEMPERATURE
  - 17°F INCREASE OF EACH 0.1 DECREASE IN EXTERNAL SURFACE EMISSIVITY
  - 40°F INCREASE FROM ZERO TO MAXIMUM SOLAR HEAT LOAD NORMAL TO SURFACE

- TEST DATA SHOWED THAT ACTUAL SURFACE TEMPERATURES WERE WITHIN ±20°F OF PREDICTED SURFACE VALUES EXCEPT IN THE FOLLOWING AREAS:
  - WHERE RAM AIR LEAKED INTO AN AREA THROUGH GAPS OR FROM NACELLE
  - WHERE RADIATION FROM NACELLE SURFACE BECAME AN INFLUENCE
  - WHERE SHOCKS FROM THE NACELLE CROSSED THE SURFACE WITH A LARGER THAN EXPECTED INFLUENCE ON LOCAL HEAT TRANSFER COEFFICIENTS AND LOCAL ADIABATIC WALL TEMPERATURES

- TEST DATA INDICATED WHAT INCREMENTS HAD TO BE ADDED TO COMPUTED VALUES TO OBTAIN TEMPERATURES IN OTHER FLIGHT REGIMES AT THE VARIOUS LOCATIONS WHERE LEAKAGE AND SHOCK INTERFERENCE OCCURRED, SUCH AS ALONG THE INBOARD EDGE OF THE NACELLE, IN THE VERTICAL STUB FIN AREA, AND AT THE INBOARD WING CONNECTION TO THE NACELLE.

FLIGHT MEASURED WING SURFACE TEMPERATURES



90210-A04

EXTERNAL THERMAL ENVIRONMENT

EXTERNAL SURFACE TEMPERATURES (CONTINUED)

- DETAILED AREAS OF CONCERN (FORE-TO-AFT)

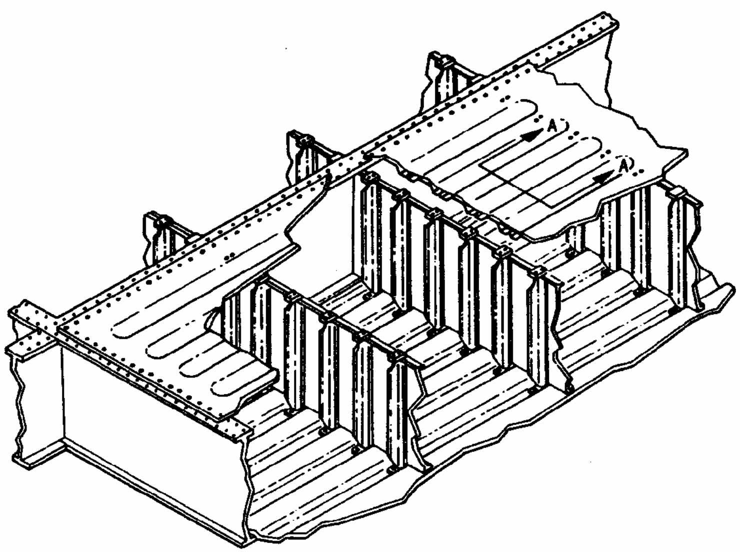
– NOSE PITOT BOOM	800°F	(STAINLESS STEEL)
– WINDSHIELD LEADING EDGE	640°F	
– WINDSHIELD AND CANOPY GLASS	600°F	
– NACELLE INLET SPIKE TIP	800°F	(STAINLESS STEEL TIP)
– ANTENNAE	450°F → 800°F	

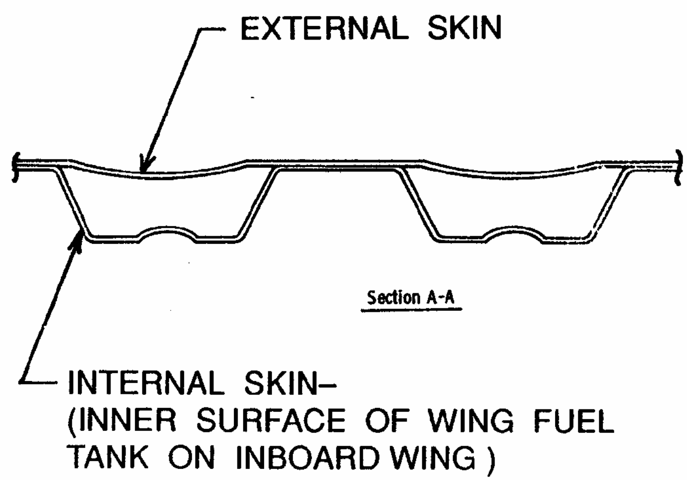
- DESIGN DRIVERS AT EACH AREA OF CONCERN
  - TEMPERATURES NEEDED TO DETERMINE PROPER MATERIAL SELECTION
  - TEMPERATURES AND MATERIALS DETERMINE WHAT TYPE OF INSULATION MATERIALS ARE NEEDED TO REDUCE HEAT INPUT TO LOW TEMPERATURE AREAS
  - EXTERNAL SOURCE TEMPERATURES NEEDED FOR TRANSIENT ANALYSIS OF CRITICAL BURIED PARTS, I.E., DIRECTIONAL GYROS, DRAG CHUTE, TIRES, AND REFUELING RECEPTACLE
  - EXTERNAL SOURCE TEMPERATURES NEEDED FOR TRANSIENT ANALYSIS OF HEAVY STRUCTURE, I.E., WING BEAMS, NACELLE/WING JOINTS, FUSELAGE LONGERONS, AND OTHER MASSIVE SUBSTRUCTURE ELEMENTS.

EXTERNAL THERMAL ENVIRONMENT

EXTERNAL SURFACE TEMPERATURES

- SPECIAL CONCERN ON WING SURFACES
  - PROBLEM WAS HOW TO ADDRESS DISTORTION OF THE WING SURFACE PANELS DUE TO DIFFERENCES IN THERMAL EXPANSION OF FAST HEATING SKIN PANELS AND SLOWER HEATING INTERNAL SUPPORT STRUCTURE.
  - SOLUTION WAS TO BUILD DOUBLE PANELS WITH FORE-TO-AFT CORRUGATIONS AS SHOWN BELOW. THEREFORE, DISTORTIONS WOULD BE IN A KNOWN DIRECTION AND WOULD NOT ADVERSELY EFFECT AIRFLOW PATTERN OVER WING AND SO LOADS WOULD BE DISTRIBUTED THROUGH KNOWN PATHS. PANELS ARE IN OUTBOARD AND INBOARD WING AREAS.





STRUCTURAL THERMAL ENVIRONMENT

- STRUCTURAL ELEMENTS WERE DESIGNED TO SUSTAIN LOADS DURING STEADY-STATE AND TRANSIENT APPLICATION OF EXTERNAL HEATING. THERMAL LAG WITH RESPECT TO TIME DEPENDED UPON HEAT PATHS AND HEATING MODES; I.E., EFFECTS OF INSULATION, CONDUCTION AND CONVECTION IN SOME AREAS, AND THE EFFECTS OF DIRECT RAM AIR CONVECTION AND ENGINE RADIATION IN OTHERS.
- WINGS AND FUSELAGE STRUCTURE HEATED SLOWLY WHILE ENGINE INLET SYSTEM, NACELLE, AND EXHAUST SYSTEM HEATED QUICKLY.
- AREAS WHERE STRUCTURAL THERMAL GRADIENTS, STEADY-STATE AND TRANSIENT, WERE INVESTIGATED:

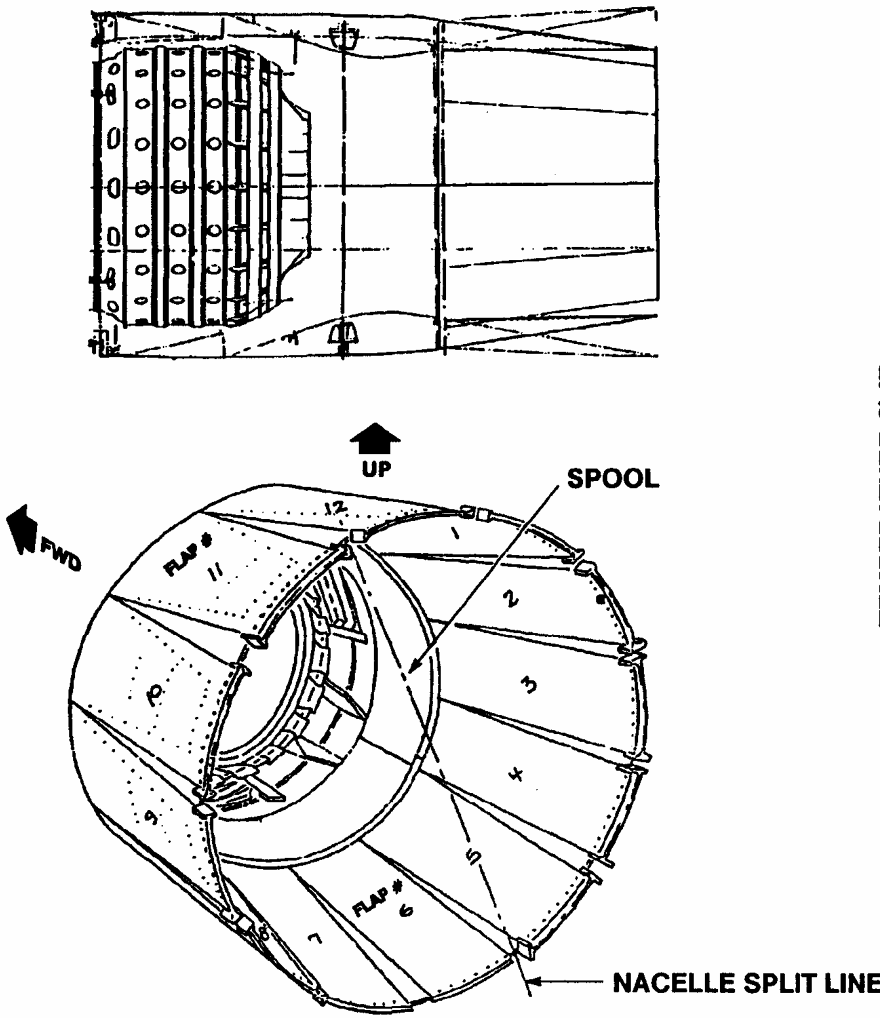
<u>NOSE AND FUSELAGE</u>
- NOSE UNCOOLED STRUCTURE
- NOSE COOLED STRUCTURE
- PRESSURIZED COCKPIT
- CANOPY STRUCTURE
- FUSELAGE LONGERONS
- FUSELAGE FUEL TANKS
- WHEEL MOUNT STRUCTURE
- FLIGHT CONTROLS MIXER

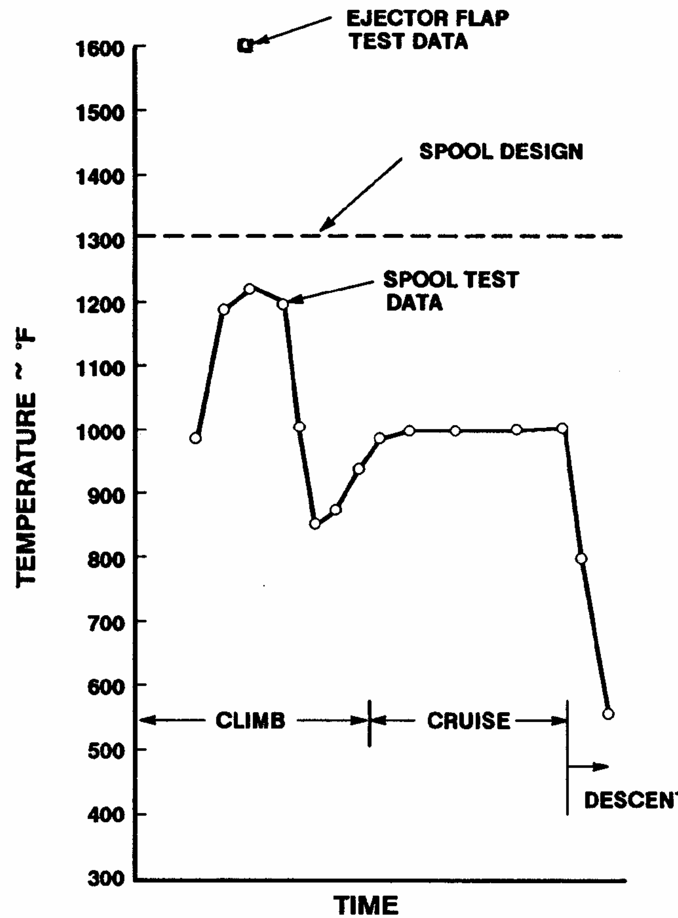
<u>WINGS</u>
- MAIN WING BEAMS
- WING/NACELLE INTERFACE
- OUTBOARD WING STRUCTURE
- WING FUEL TANKS
- WHEEL MOUNT STRUCTURE

<u>CONTROL SURFACES</u>
- VERTICAL POST STRUCTURE
- VERTICAL FIN STRUCTURE
- HORIZONTAL CONTROL STRUCTURE

<u>ENGINE SYSTEMS (HOTTEST)</u>
- INLET SPIKE STRUCTURE
- COWLING STRUCTURE
- AIR BYPASS DOOR STRUCTURE
- NACELLE RING STRUCTURE
- EJECTOR SPOOL MOUNTING
- SKIN DOOR STRUCTURE
- EXHAUST FLAP STRUCTURE
- VERTICAL TAIL MOUNT

ENGINE EJECTOR NOZZLE TEMPERATURE DATA





06-JM-0063-04-16-91-CM

INTERNAL THERMAL ENVIRONMENTS

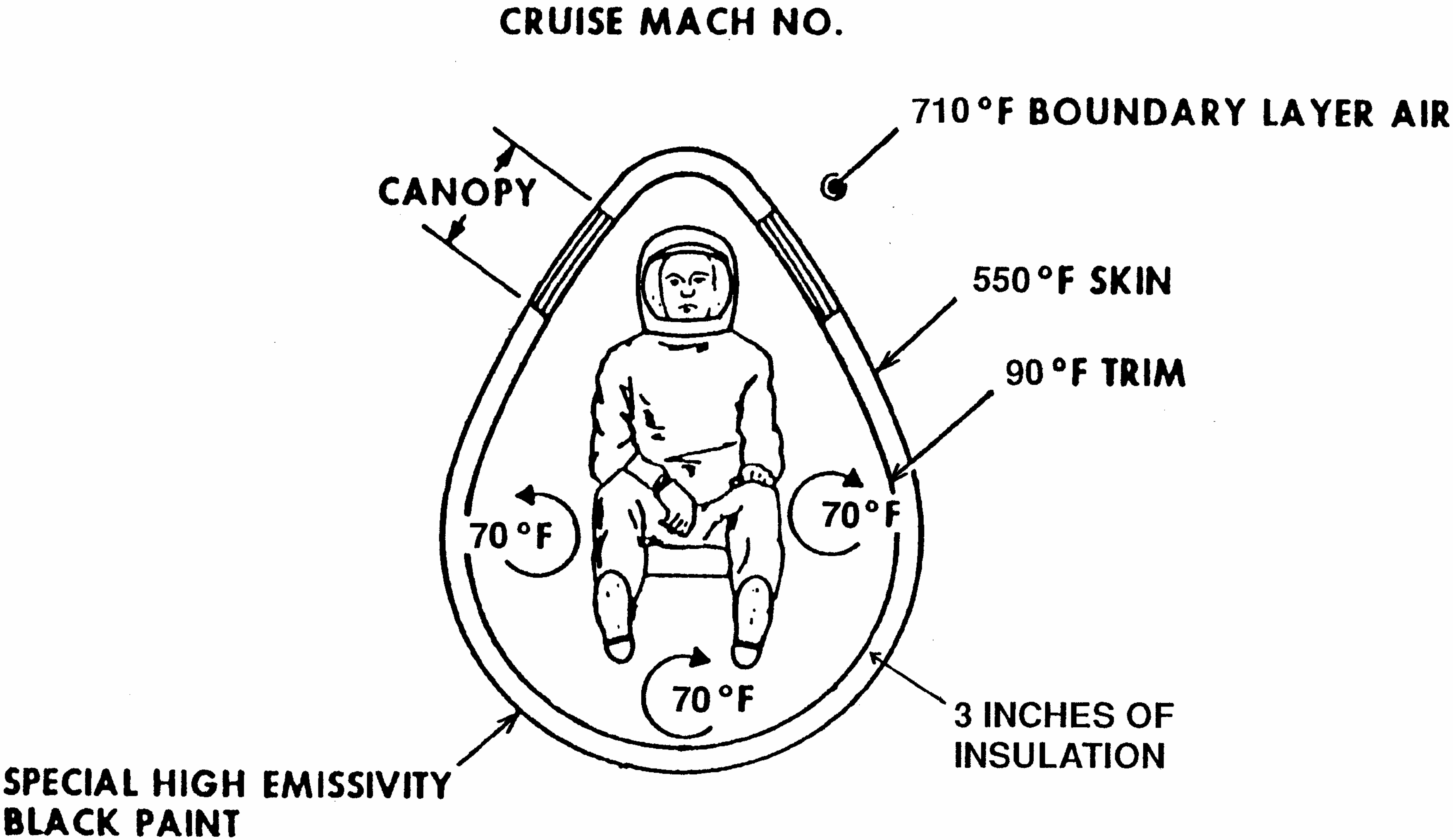
- INTERNAL THERMAL ENVIRONMENTS WERE ESTABLISHED TO SUSTAIN REQUIRED CREW AND EQUIPMENT OPERATING ENVIRONMENTS
  - CREW COMPARTMENT: INSULATED WITH 3″ OF FIBERGLASS INSULATION AND PROVIDED WITH COOLING/HEATING AIR TO PROVIDE A 70°F ENVIRONMENT FOR THE CREW AND COCKPIT EQUIPMENT, WITH DIRECT COOLING TO CREW SUITS FOR TRIM CONDITIONING AND FOR EMERGENCY CONDITIONS.
  - AVIONIC EQUIPMENT AND MISSION EQUIPMENT BAYS DESIGNED FOR MAXIMUM NORMAL OPERATION OF 160°F. COLD AIR (BETWEEN –30°F AND +45°F) SUPPLIED TO EQUIPMENT, AND EQUIPMENT EXHAUST AIR CASCADES FROM BAY-TO-BAY ON ITS WAY OUT OF THE AFT-MOST EQUIPMENT BAY. ACTUAL BAY TEMPERATURES VARY BETWEEN 50°F AND 140°F DEPENDING UPON LOCATION AND HEAT LOAD EXPENDED. DURING SINGLE ECS PACKAGE OPERATION, MISSION EQUIPMENT (AND ITS AIR SUPPLY) ARE SHUT DOWN AND BAY ENVIRONMENT IS ALLOWED TO RISE TO 200°F. PRIMARY AIR COOLING FLOW IS TO CREW COMPARTMENT AND FLIGHT CRITICAL EQUIPMENT.
  - UNCOOLED BAYS, WHERE MISCELLANEOUS EQUIPMENT LINES, WIRES, PIPES AND HOSES ARE LOCATED, ARE INFLUENCED DIRECTLY BY THE SURROUNDING STRUCTURAL TEMPERATURES AND BY THE TEMPERATURE OF ANY INCOMING LEAKAGE AIRFLOW, SUCH AS RAM FLOW OR NACELLE LEAKAGE AIRFLOW. UNCOOLED BAY ENVIRONMENTS RANGE FROM 450°F TO 800°F.

INTERNAL THERMAL ENVIRONMENTS

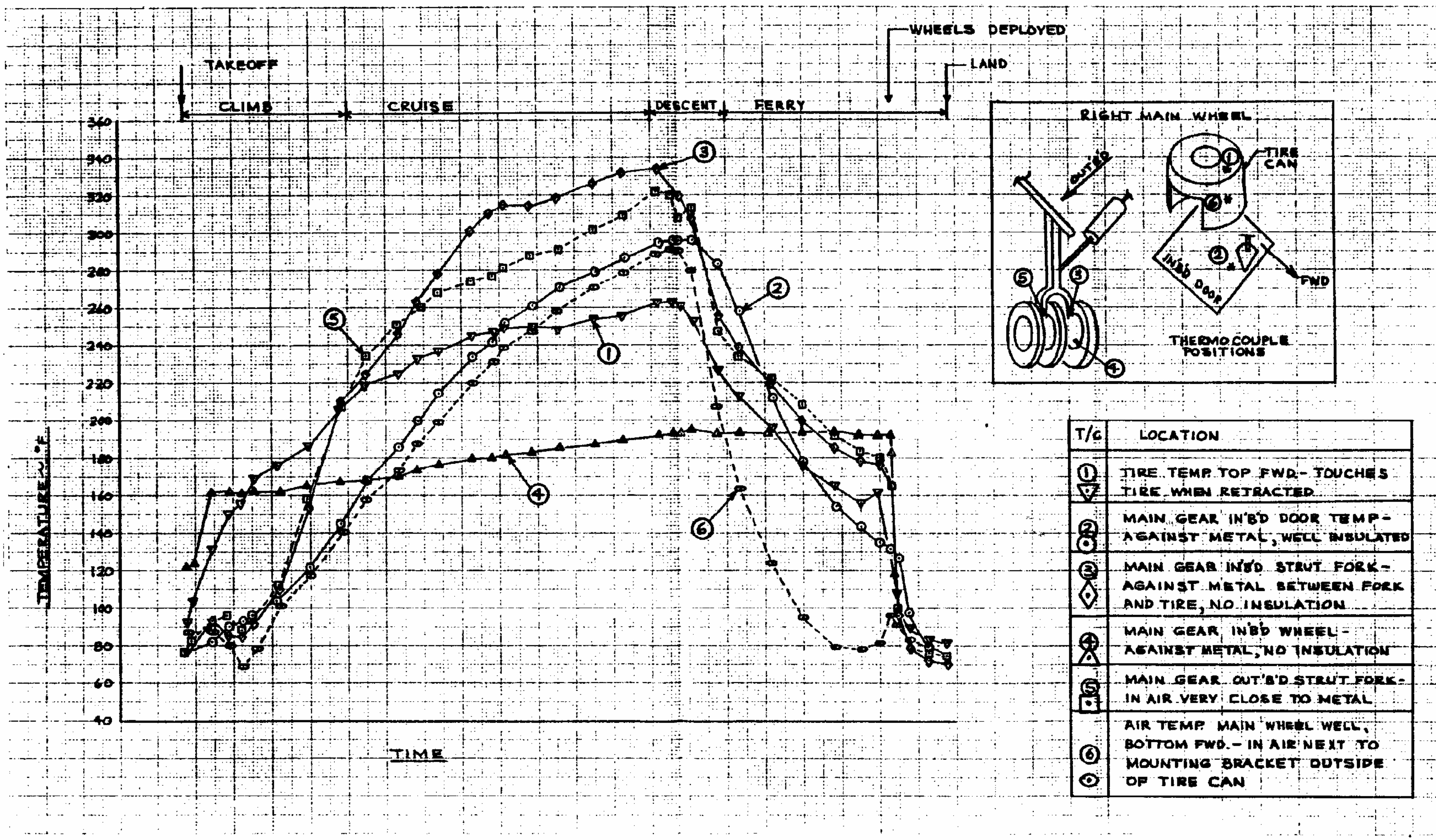
(CONTINUED)

- FUEL TANK INTERNAL ENVIRONMENT IS A BALANCE BETWEEN THE FUEL, THE FUEL VAPOR, THE NITROGEN INERTING GAS, AND THE SURROUNDING SKIN AND STRUCTURE. THE ENVIRONMENT OF TANKS CONTAINING FUEL IS FROM 70°F TO 200°F AND OF TANKS EMPTIED DURING FLIGHT, 450°F TO 600°F.
- NACELLE ENVIRONMENT IS FROM 800°F TO 1000°F DEPENDING UPON LOCATION.
- DRAG CHUTE COMPARTMENT IS SUBMERGED INTO THE LAST FUEL TANK TO BE USED AND IS, THEREFORE, KEPT COOL BY THE SLOW TRANSIENT TEMPERATURE RESPONSE OF THE FUEL; ENVIRONMENT IS 80°F TO 200°F.
- NOSE WHEEL WELL IS COOLED BY AIR EXHAUSTING FROM THE ENVIRONMENT CONTROL SYSTEM EQUIPMENT BAY ABOVE; ENVIRONMENT IS 50°F TO 140°F.
- MAIN WHEEL WELL COMPARTMENTS ARE COOLED BY CONVECTION AND RADIATION TO FUEL TANK BULKHEAD SURFACES AT THE FORWARD AND AFT ENDS OF THE TWO MAIN WHEEL WELLS. THE MAIN GEAR RETRACTS INTO AN INSULATED CAN WHICH COMPLETELY ENCLOSES THE WHEELS AND BRAKES AND ACTS TO PROTECT THE FORE AND AFT FUEL TANK BULKHEADS IN CASE OF A TIRE FAILURE. THIS INSULATED TIRE CAN HELPS TO SHIELD THE GEAR STRUCTURE AND THE TIRES FROM THE HOTTER SURFACES IN THE AREA. ENVIRONMENT OF THE MAIN WHEEL WELL SHOULD BE LESS THAN 550°F. TYPICAL MAIN GEAR TEMPERATURES ARE PRESENTED TO SHOW THE TRANSIENT RESPONSE ACTUALLY MEASURED DURING FLIGHT TESTS.

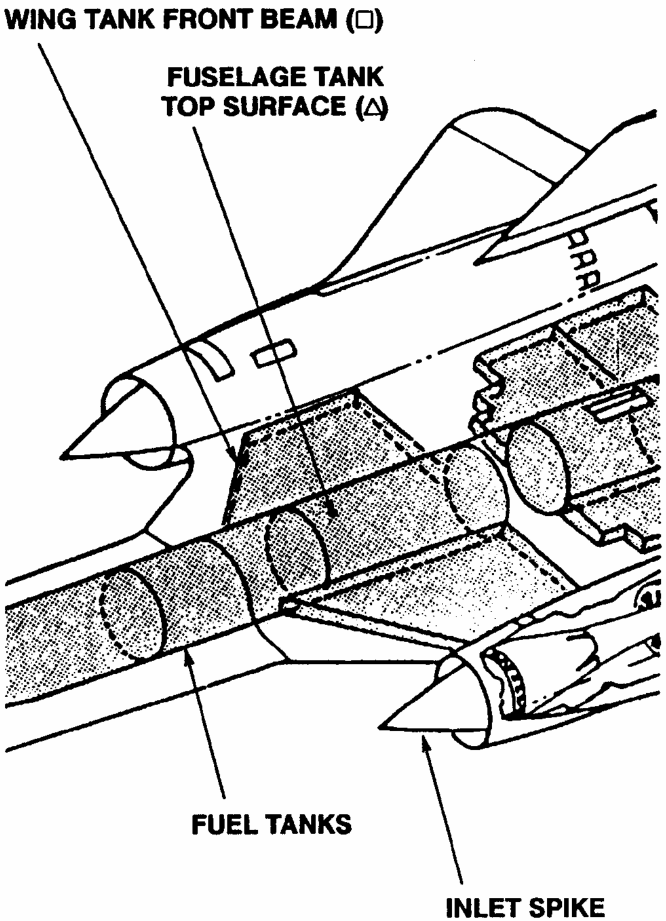
COCKPIT THERMAL ENVIRONMENT

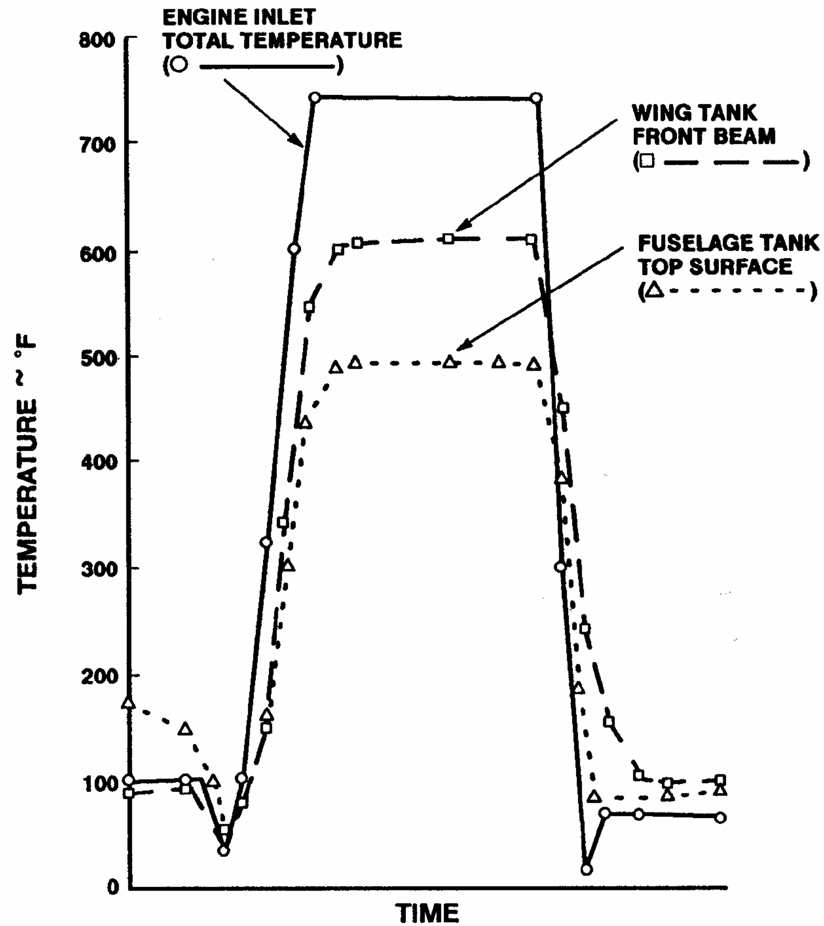


TIME HISTORY OF WHEEL WELL TEMPERATURES

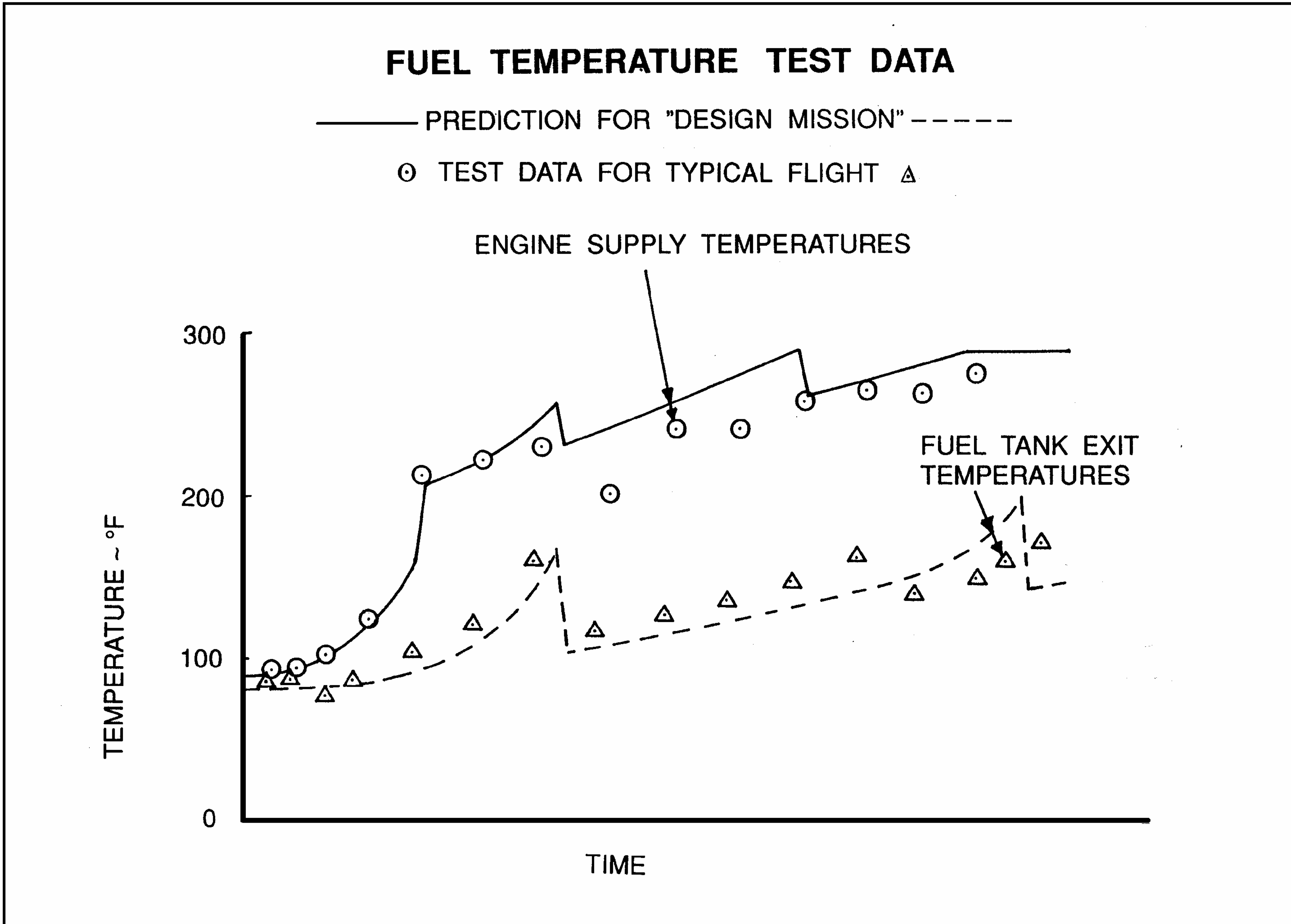


FUEL TANK SURFACE TEMPERATURE DATA





06-JM-0064-04-16-91-CM


FUEL TEMPERATURE TEST DATA
PREDICTION FOR "DESIGN MISSION"
TEST DATA FOR TYPICAL FLIGHT
ENGINE SUPPLY TEMPERATURES
FUEL TANK EXIT TEMPERATURES
300
200
100
0
TEMPERATURE ~ °F
TIME

SYSTEMS THERMAL ENVIRONMENT

- SYSTEM THERMAL ENVIRONMENTS WERE DETERMINED FOR EACH SPECIFIC SYSTEM:
  - <u>FUEL SYSTEM</u>: HARDWARE AND PLUMBING ARE CONTAINED IN ALL PREVIOUSLY DESCRIBED THERMAL ENVIRONMENTS FROM 80°F TO 1000°F. FUEL TANK SEALANT WAS EVENTUALLY DEVELOPED TO TAKE 630°F NEAR NACELLE/WING JUNCTION NEAR LEADING EDGE OF FUEL TANK #3. FUEL TANK TRANSIENTS PROVIDED HEAT SINK FOR ALL VEHICLE SYSTEMS.
  - <u>HYDRAULIC SYSTEM</u>: HARDWARE AND PLUMBING ARE CONTAINED IN MOST HIGH TEMPERATURE ENVIRONMENTS FROM 500°F TO 1000°F; HYDRAULIC FLUID IN LINES UP TO 680°F, BUT FLUID COOLED BY FUEL HEAT SINK SYSTEM TO 550°F OR LESS.
  - <u>FUEL TANK INERTING SYSTEM</u>: LIQUID NITROGEN DEWARS AND PRESSURE REGULATING SYSTEM IN NOSE WHEEL WELL IN A 50°F TO 100°F AMBIENT ENVIRONMENT; DISTRIBUTION SYSTEM IN FUSELAGE FUEL TANKS IN 500°F TO 550°F ENVIRONMENT
  - <u>OXYGEN SYSTEM</u>: LIQUID OXYGEN DEWARS AND CONTROL HARDWARE IN BAY NEXT TO COCKPIT UTILIZE CONTROLLED EXIT AIR FROM COCKPIT FOR COOLING; 50°F TO 160°F AMBIENT ENVIRONMENT FOR EQUIPMENT.
  - <u>ENVIRONMENTAL CONTROL SYSTEM</u>: EQUIPMENT SPREAD THROUGHOUT VEHICLE IN ALL PREVIOUSLY DESCRIBED ENVIRONMENTS FROM 80°F TO 1000°F WITH ENGINE BLEED AIR DUCTING AND COMPONENTS SEEING UP TO 1200°F IN NACELLE.

SYSTEMS THERMAL ENVIRONMENT

- POWER GENERATION AND GEAR BOX SYSTEM (CSD): EQUIPMENT IN NACELLE IN AN 800°F+ ENVIRONMENT; OIL IN CSD SYSTEM COOLED TO 330°F WITH FUEL IN HEAT SINK SYSTEM LOOP.
- MAINTENANCE RECORDING SYSTEM: TAPE RECORDING EQUIPMENT LOCATED IN BAY WITH ENVIRONMENT OF UP TO 140°F; SENSORS LOCATED THROUGHOUT VEHICLE IN ALL PREVIOUSLY DESCRIBED ENVIRONMENTS FROM 80°F TO 1000°F.
- DIRECTIONAL GYRO PACKAGES: TWO LOCATED IN FUEL TANKS, WITH ENVIRONMENTS OF UP TO 550°F. PACKAGES ARE COOLED EXTERNALLY WITH FUEL FROM THE HEAT SINK SYSTEM CIRCULATING AROUND THE EXTERNAL CASE, WHILE THE INTERNAL COOLING AROUND THE ACTUAL GYROSCOPE IS ACCOMPLISHED BY THE USE OF A "CHICKEN FAT" (STEARIC ACID) HEAT SINK PACKED IN A SEALED CONTAINER. THIS CONCEPT UTILIZES THE HEAT OF FUSION, WHILE MELTING BETWEEN 150°F AND 160°F, IF THE GYROS OR THE FUEL COOLING SYSTEM TEMPERATURES EXCEED 150°F FOR SHORT PERIODS OF TIME.
- OTHER SYSTEMS CONTAINED IN THE DESCRIBED ENVIRONMENTS ARE DESIGNED TO OPERATE RELIABLY IN THEIR SPECIFIC ENVIRONMENTS.
- FACT OF INTEREST: DUE TO THE OPERATIONAL ENVIRONMENT IN WHICH THE SR-71 FLIES (ABOVE 800°F), THE AIRCRAFT GROWS ABOUT 2.5 INCHES IN LENGTH FROM THE TIME IT TAKES OFF UNTIL IT REACHES MAXIMUM SPEED, AND BY THE TIME IT LANDS IT HAS RETURNED TO ITS ORIGINAL LENGTH. THIS IS DUE TO THERMAL EXPANSION OF THE MATERIALS

SR-71 THERMAL ENVIRONMENT SUMMARY

- ENVIRONMENTS WHERE ESTABLISHED FOR ALL AREAS OF THE VEHICLE
- MATERIALS WERE SELECTED AND SYSTEMS, COMPONENTS, AND FLUIDS IDENTIFIED
- TESTS WERE RUN ON MOST SYSTEMS AND STRUCTURES AT TEMPERATURE
- FLIGHT TEST UNDERTAKEN TO VERIFY ENVIRONMENTS AND EQUIPMENT OPERATION
- VEHICLE VERY SUCCESSFUL AT OPERATING IN THE SEVERE THERMAL ENVIRONMENT
- VEHICLE STILL THE FASTEST AIRCRAFT FLYING AFTER 29 YEARS