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FINAL REPORT

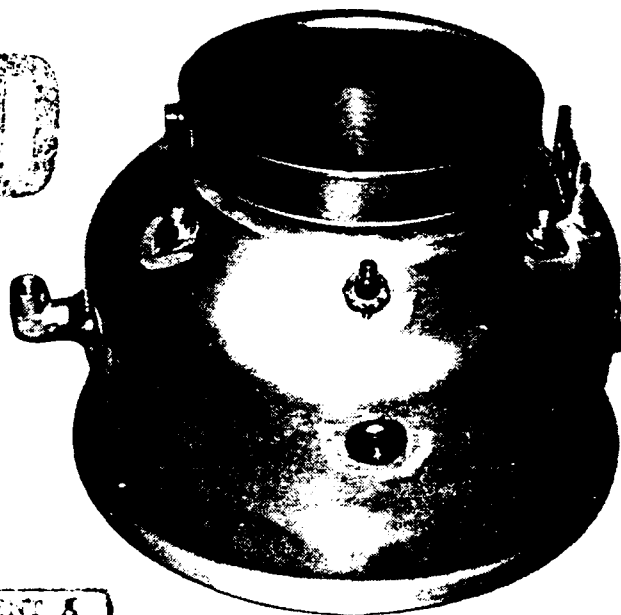
INDUSTRIAL MODERNIZATION INCENTIVE PROGRAM (IMIP)

PHASE II

SEPTEMBER, 1989 - MARCH, 1991

SUNDSTRAND'S PRECISION METAL FORMING CELL

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Sundstrand Power Systems

Division of Sundstrand Corporation



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SUNDSTRAND POWER SYSTEMS WAS SUCCESSFUL IN UTILIZING AND DEVELOPING ~~AND~~ ADVANCED MANUFACTURING MACHINE TOOLS AND TECHNIQUES IN FABRICATING COMBUSTOR HOUSING ASSEMBLYS. TECHNOLOGYS DEVELOPED WERE: FLOW FORMING AND LASER MACHINING AND WELDING. SIGNIFICANT REDUCTIONS IN COST AND LEADTIME, WITH INCREASED CONTROL ON QUALITY.

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FINAL REPORT

IMIP PHASE II

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Prepared By:

R.C. Barbier

Richard C. Barbier

Approved By:

Jay Fernandes

Jay F. Fernandes

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1.0 SUMMARY AND CONCLUSIONS

1.1 BACKGROUND

At this time all sheet metal component details from Sundstrand Power Systems (SPS) are purchased from outside vendor sources. In this present situation product costs are high, quality issues are difficult to resolve, and the ability to meet delivery schedules is at the mercy of many different suppliers. In addition, the combustor assembly housings have sustained in-field fatigue failures caused by high loading under high temperature conditions.

A Precision Metal Forming Cell became the subject of an Industrial Modernization Incentives Program (IMIP) funded by the Department of the Air Force. The Phase I study funded under contract F41608-86-C-0746, was completed in October, 1987. Initial studies in Phase I indicated that the combustor housing could be fabricated as a one-piece design, using Hastelloy X material, thereby producing a stronger and more reliable product. Further, the Phase I study indicated that the use of flow forming could produce the one-piece design at a significant savings.

The IMIP Phase II study, funded under contract F41608-89-C-1458, was complete by March 31, 1991. The Phase II study under the direction of Rich Barbier, reference Section 2.0 (Phase II Management Plan), is complete and this report provides the results of the Phase II study.

1.2 OBJECTIVES

The objectives of the IMIP Phase II study were to:

1. Perform engineering analyses necessary to evaluate the new one-piece design and material selection, reference Section 3.0.
2. Evaluate, test, and develop flow forming technology in support of combustor housing fabrication, reference Section 4.0.
3. Evaluate, test, and develop laser welding and machining technology in support of combustor housing fabrication and assembly, reference Section 5.0.
4. Develop an Implementation Plan for the Precision Metal Forming Cell, reference Section 6.0.
5. Confirm and update the Cost/Benefit Analysis of implementing the new facility, reference Section 7.0.

1.3 RESULTS

The IMIP Phase II study has verified that the one-piece combustor housing design fabricated from Hastelloy X material using flow forming and deep draw operations will produce a stronger more durable unit to that which is currently being used.

The use of laser cutting and welding to fabricate the combustor housing assembly does not have any adverse effects on the Hastelloy X material.

The implementation of a Precision Metal Forming Cell at Sundstrand, in San Diego, will show a cost savings for the combustor housing assembly on military programs of \$5,167,200 over a five year period once Sundstrand starts fabrication of production units. This equates to an Investment Return Rate (IRR) to the D.O.D. of 12.8% on projected contract with SPS thru 1995.

REFERENCE APPENDIX "C" DISCOUNTED CASH FLOW MODEL

1.4 RECOMMENDATIONS AND CONCLUSIONS

Sundstrand recommends that all combustor housing assemblies be produced using the new one-piece design using flow forming and laser technology.

Sundstrand plans to implement the new Precision Metal Forming Cell, reference Section 6.0.

Any cost risk associated with the implementation of the new facility is minimal due to the conservative approach taken by Sundstrand in the Cost/Benefit Analysis, reference Section 8.0.

2.0 PHASE II MANAGEMENT PLAN

2.1 PROGRAM MANAGEMENT

Sundstrand Power Systems (SPS) utilized Program Office concepts to structure and coordinate the diverse activities that were performed as part of its IMIP project, and to manage the resources required to perform those activities. This included management of both internal (SPS) resources and any outside (subcontractor) resources which were utilized to assist SPS in this effort.

2..1.1 Program Management Organization

SPS established a management organization for the execution of the IMIP Phase II project. It is composed of a Project Management Review Board, a Program Manager, and a Project Engineer as shown in Figure 2-1.

2..1.1.1 IMIP Management Review Board

The Management Review Board is composed of the General Manager, Directors from Finance, Operations, Engineering, and Quality Assurance. They participated in periodic reviews of the IMIP project to ensure the contractual, financial, and technological goals of SPS and the Air Force Logistics Command were met. The Management Review Board was assisted by the Technical Review Board, as required.

2.1.1.2 IMIP Program Manager

Bob Goddard was selected to continue the IMIP Phase II project as Program Manager. Mr. Goddard had overall responsibility for the project and reported directly to the IMIP Management Review Board.

2.1.1.3 IMIP Project Engineer

Rich Barbier was selected as the IMIP Phase II Project Engineer. Reporting directly to the Program Manager, Mr. Barbier was responsible for the planning and coordination of the personnel resources required for the project; supervising field work; obtaining time, expense, and progress reports from the IMIP project team members; and preparing periodic project management reports for the IMIP Review Board and the government. The Project Engineer was also responsible for reviewing all project deliverables; reviewing work at the completion of each task; developing and maintaining the detailed Program Master Plan and Schedule; maintaining communications with appropriate management to ensure a sufficient understanding of current project matters; coordinating and managing the efforts of all subcontractors; and identifying important issues or problems and resolving them promptly.

2.2 IMIP TEAM

The IMIP Project Team were key personnel selected to report to the Project Engineer and to be responsible to the Project Engineer as a focal point for all IMIP related activities within their area of responsibility, reference Figure 2-2.

2.3 PROGRAM STATUS SURVEILLANCE

Based on the program personnel (as identified above) and the technical approach, a program plan and schedule were developed along with a Work Breakdown Structure (WBS) to control and monitor the status of the project throughout planned effort. Figure 2-3 shows the Summary Project Schedule. Figures 2-4 and 2-4A show the WBS and the hours used within each area. Note that the hours shown in Figure 2-4 reflect the hours through March 10, 1991.

INDUSTRIAL MODERNIZATION INCENTIVES PROGRAM

Organization Plan

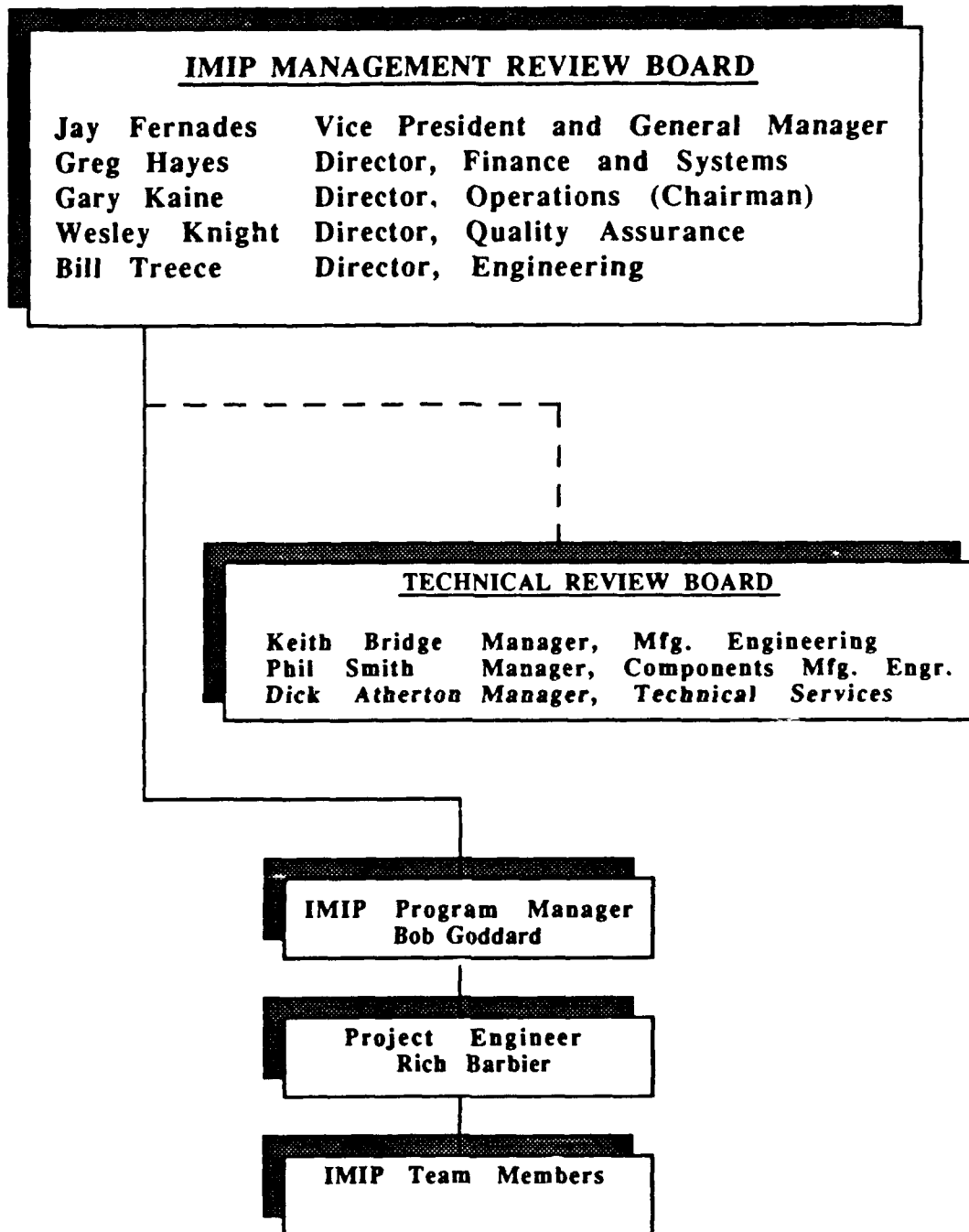


Figure 2-1 Program Management Organization

IMIP TEAM
Program Team

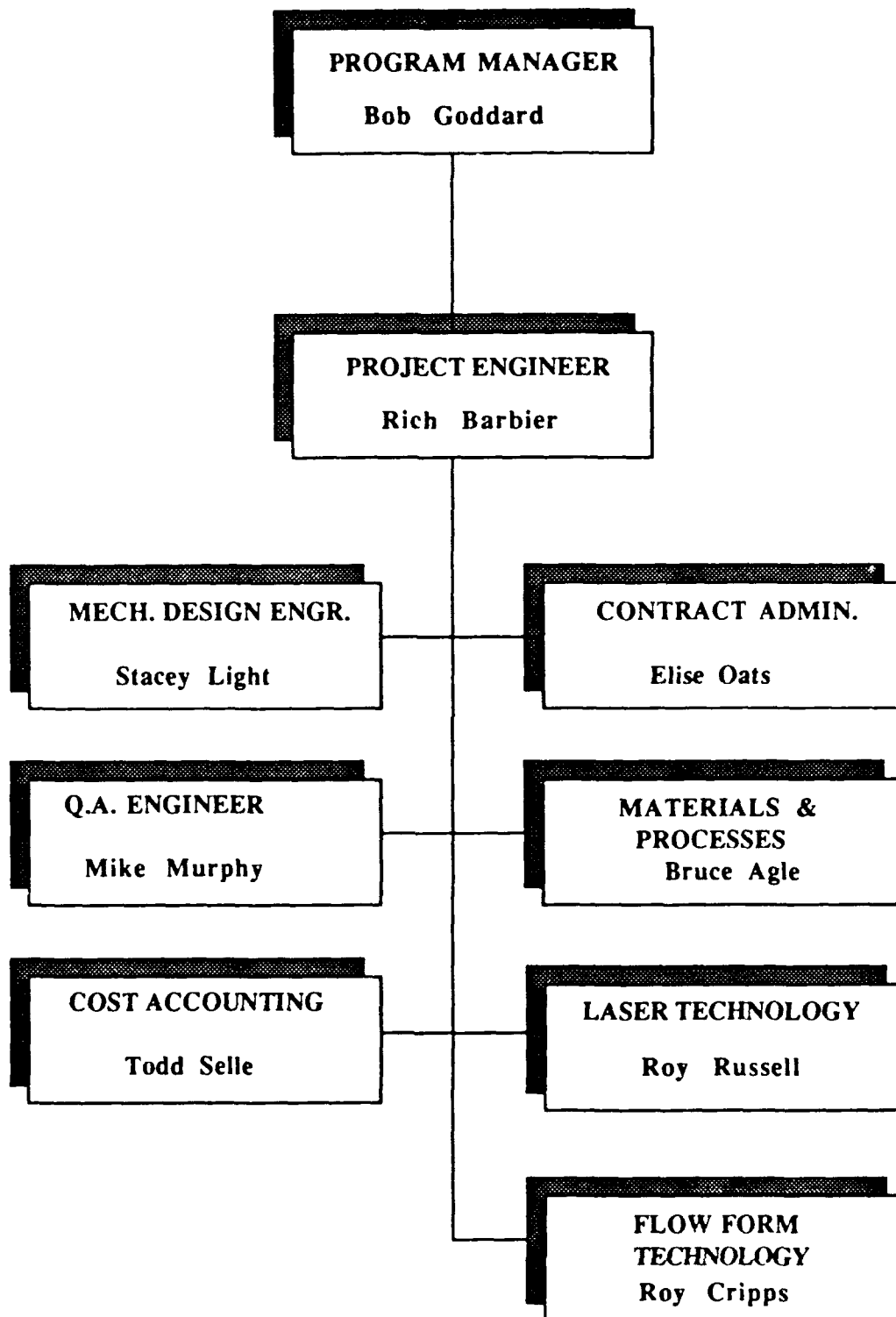


Figure 2-2 IMIP Project Team

IMIP PHASE II PRECISION METAL FORMING CELL - MASTER PROGRAM SCHEDULE S. O. S00827

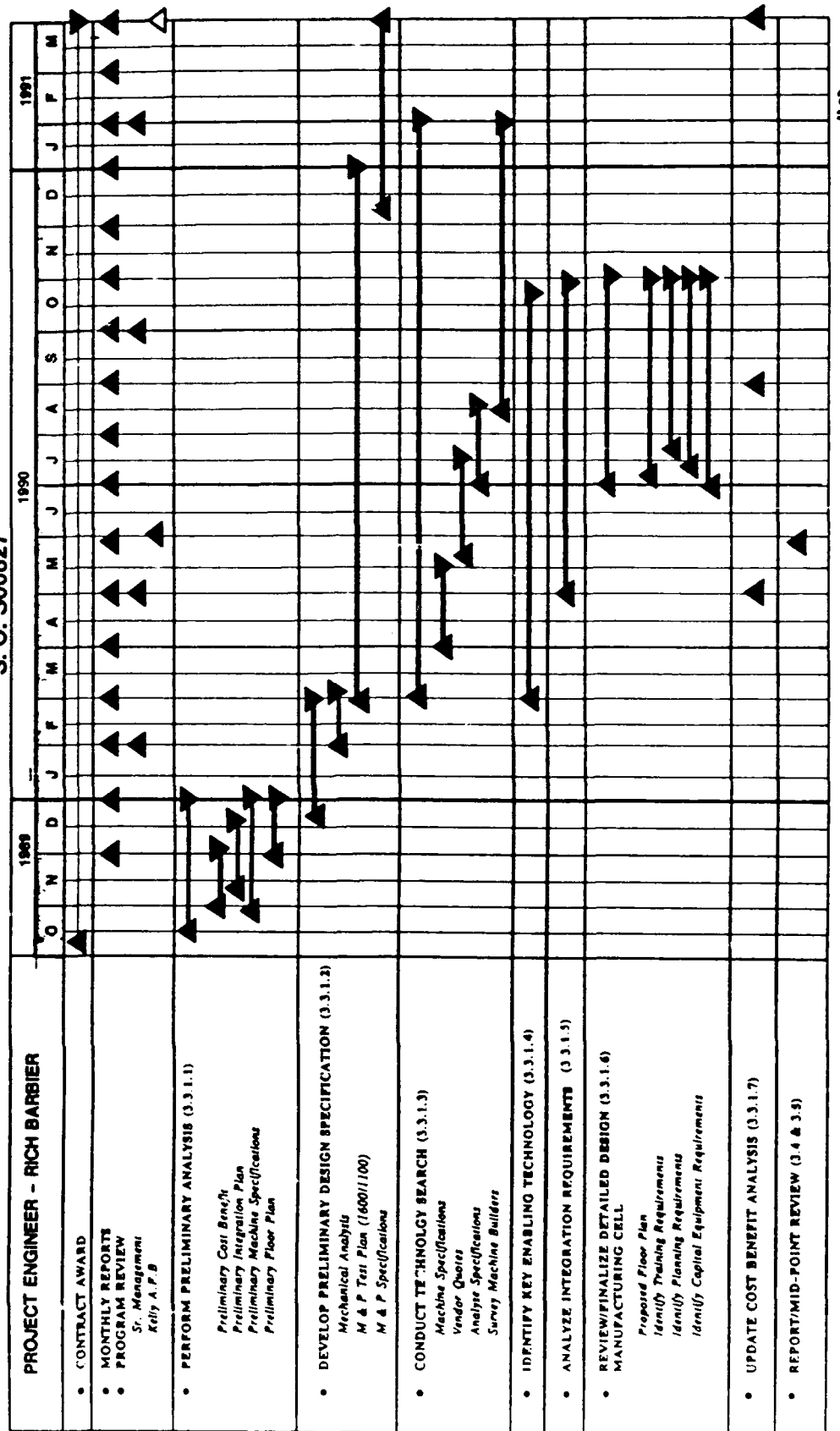


Figure 2-3A IMIP Phase II Master Program Schedule

IMIP PHASE II PRECISION METAL FORMING CELL - MASTER PROGRAM SCHEDULE

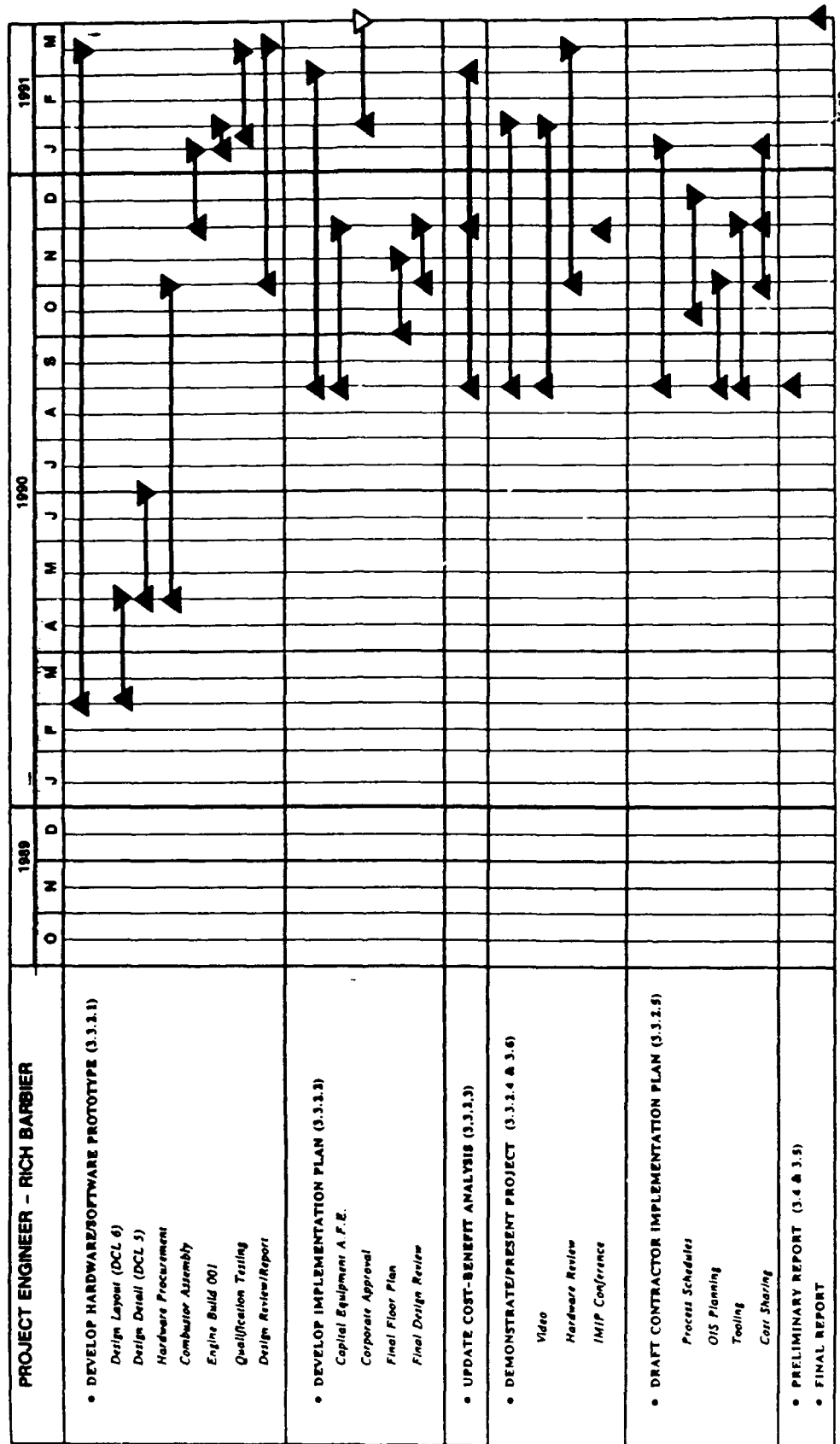


Figure 2-3B IMIP Phase II Master Program Schedule

Work Breakdown Structure

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IMIP Phase II A

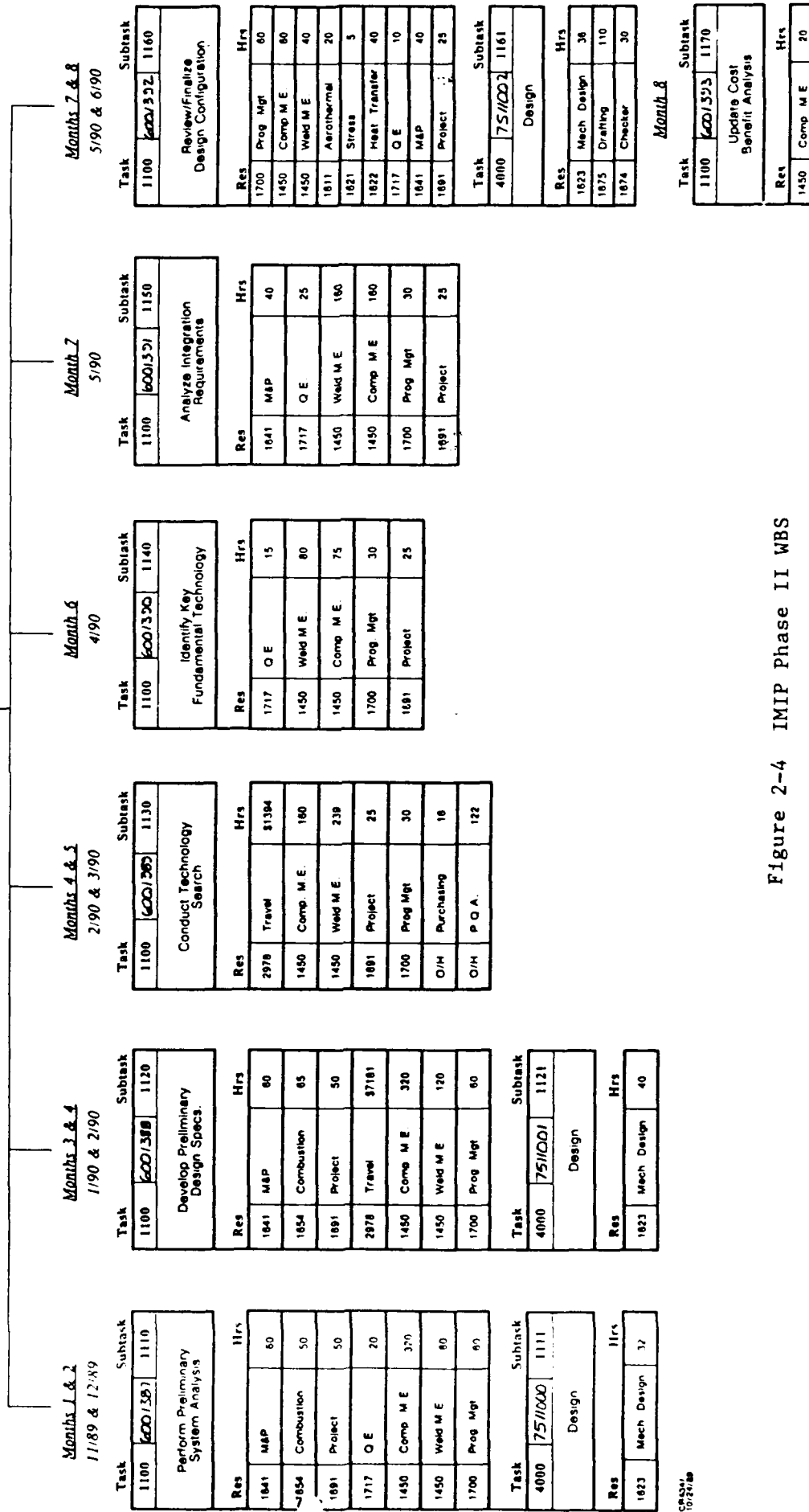


Figure 2-4 IMIP Phase II WBS

Work Breakdown Structure

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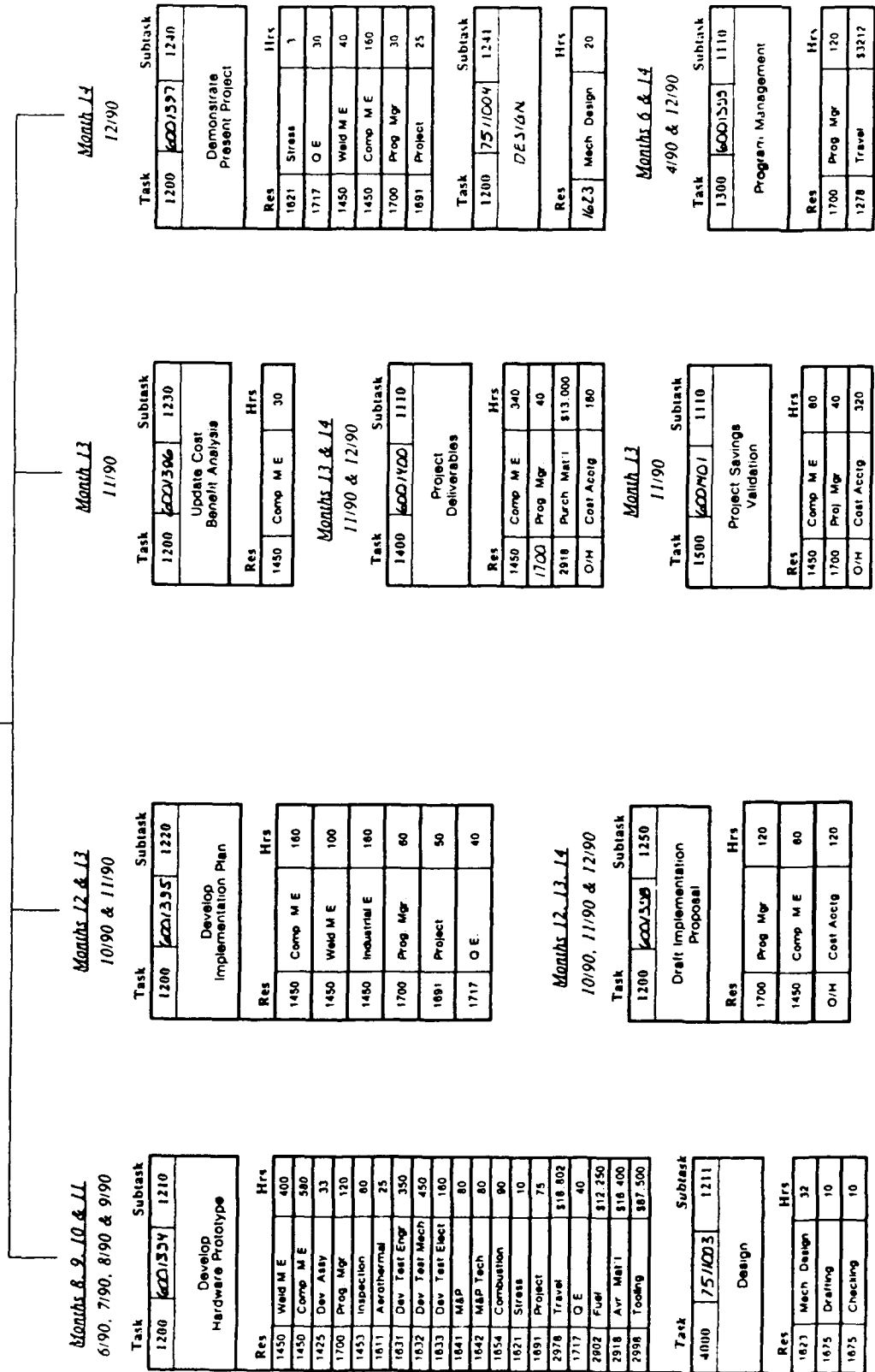


Figure 2-4A IMIP Phase II WBS

3.0 DESIGN

3.1 PROBLEM

The T-62T-40 style combustor housing currently in service in the KC-135 and JFS APU's is subject to early cracking and or non-repairable distortion due to high cycle fatigue, especially in the KC-135 application. Therefore, it was necessary to design a housing that gives a marked increase in structural integrity, without compromising weight and/or cost.

3.2 DESIGN CONCEPT

The existing design is shown in Figure 3-1, the new design is shown in Figure 3-2.

3.2.1 OUTER CASE

The new design incorporates a one-piece outer case with integral V-band flange at the housing inlet. The thicknesses are in general .028-.036 along the outer diameter and .040-.048 in the dome region.

3.2.2 DIFFUSER

The new diffuser is also a one-piece design at a thickness of .038-.046 with an integral V-band flange at one end.

3.2.3 BOSSES, ETC.

All of the bosses, except for the igniter, have been designed to eliminate separate sheet metal doublers and incorporate integral soleplate doublers per the latest Sundstrand design criteria. The bosses on the O.D. of the case are made from bar stock designed to be produced from a numerical control lathe operation. The 6 fuel manifold bosses have been changed to machine investment castings so that they conform to the conical dome shape. The igniter boss still maintains a sheet metal doubler so that the height of the boss from the start nozzle can be set at assembly.

3.2.4 JOINT DESIGN

All joints are designed for brazing, although laser welding was developed under the IMIP Program as a means of reducing cost and increasing durability of the housing assembly, see Section 4.0.

3.3 ANALYSIS

There were three engineering analyses completed in support of the new design: TRR-0892 (Stress Analysis), TRR-0919 (Thermal Analysis), and TRR-0935 (Dimensional Analysis).

3.3.1 STRESS ANALYSIS (TRR-0892)

To achieve the required increase in structural integrity, two outer combustor housing materials were considered, SS 321 and Hastelloy X (the current inner diffuser wall material). The final combustor housing configuration was selected

based on both pressure and thermal effects (reference TRR-0919 and TRR-00935). Pressure loading determined the final configuration, but thermal effects established material choice, based on component stress levels and life cycle fatigue requirements.

3.3.1.1 CONFIGURATION SELECTION

To investigate the relative merits between the proposed combustor housing configurations, 3D Finite Element (FE) models were created. Each FE model consisted of a 45 degree sector, with the following boundary and load conditions, refer to Figure 3-3 for model idealization.

Boundary Conditions:

- (a) The combustor housing outer flange was constrained in the axial direction only, allowing the housing to move radially.
- (b) Symmetrical boundary constraints were applied to the sector.
- (c) The inner diffuser wall was constrained radially at the nozzle interface to prevent the diffuser wall from distorting unrealistically.

Load Conditions:

- (a) Maximum pressure load condition taken from the KC-135 cycle desk, Cold Day (-40 degrees F) Sea Level = 90 psia for 75.3 psig.

3.3.1.2 RESULTS

The maximum equivalent stress levels for the proposed new combustor housing configurations, based on pressure loading only are given in Table I, together with the current design. Figures 3-4, 3-5, and 3-6 indicate the location of the maximum equivalent stress for the conical, vertical, and current dome configurations, respectively. A vertical dome design in SS 321 is not given in Table I, due to the increase in wall thickness required to reduce the stress levels below the current configuration level. Based on Table I results, the conical dome combustor housing was chosen.

3.3.1.3 MATERIAL SELECTION

To investigate material selection, the combined effects of pressure and temperature at various engine conditions were applied to the final combustor configuration, reference Table II.

Applied Load Conditions:

- (a) Standard Day, Sea Level
T amb = 59 degrees F; EGT = 1300 degrees F
Pressure = 57.0 psig

- (b) Hot Day, Sea Level
T amb = 130 degrees F; EGT = 1300 degrees F
Pressure = 48.4 psig
- (c) Cold Day, Sea Level
T amb = -40 degrees F; EGT = 1300 degrees F
Pressure = 75.3 psig

3.3.1.4 RESULTS

Figures 3-7, 3-8, and 3-9 represent the equivalent, bending and hoop stress for the conical dome configuration with a SS 321 outer casing, for the Standard Day load condition. Figure 3-10 represents the thermal distribution applied to the FE model for this condition.

Figures 3-11 thru 3-21 represent the equivalent stresses for an all Hastelloy X combustor housing assembly.

3.3.2 THERMAL ANALYSIS (TRR-0919)

The thermal analysis of the KC 135 combustor housing has been completed using the ANSYS model created for the stress analysis. Three conditions were analyzed:

- (a) T amb = 59 degrees F; EGT = 1300 degrees F (Standard Day)
- (b) T amb = 130 degrees F; EGT = 1300 degrees F (Hot Day)
- (c) T amb = -40 degrees F; EGT = 1300 degrees F (Cold Day)

3.3.2.1 RESULTS

Figure 3-22 shows the results of the analysis for the 59 degree day condition. The outer casing is running slightly above compressor discharge temperature at the outer diameter. The maximum temperature of the outer casing is 1095 degrees at the braze joint with the diffuser. The diffuser temperature varies from 852 to 1300 degrees F. Also shown in Figure 3-22 are the combustor liner temperatures obtained from thermal paint results and the compressor discharge air temperature distribution. Figures 3-23 and 3-24 show the temperatures for the 130°F and -40°F conditions, respectively.

3.4 CONCLUSIONS

3.4.1 An all Hastelloy X combustor assembly is best because it reduces the high stress levels produced by the large variation in thermal expansion rates between Hastelloy X and Stainless Steel 321. Maximum stress levels for the all Hastelloy X combustor are below the minimum yield strength of the material and therefore, permanent deformation of the casing will not be an issue. A summary of stress levels for an all Hastelloy X assembly is shown in Table III.

3.4.2 A change to an all Hastelloy X combustor housing will standardize present combustor designs.

3.4.3 The new combustor housing exceeds the component pressure test requirement of twice maximum pressure at twice the operating temperature without rupture, as required in MIL-P-85573, paragraph 4.5.4.1.

3.4.4 The inner diffuser wall of 0.04 inches in Hastelloy X prevents bucking of the diffuser cone under all applied load conditions.

3.4.5 Life cycle fatigue life for the combustor has been calculated to exceed 50,000 cycles even with a stress concentration factor of 3.

3.4.6 High Cycle Fatigue (HCF) is dependent on the alternating stress level produced by an external forcing function acting on the housing. If the magnitude of the forcing function is unknown, HCF life cannot be accurately evaluated. However, based on KC-135 in-service results, combustor outer casings with a minimum material thickness of .025 inches (in the dome region) have not shown signs of HCF failure. Therefore, the new combustor configuration with a dome thickness of .040 inches will increase component life significantly.

* F.S. = Factor of Safety

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* * * *

Table I
Combustor Housing Maximum Equivalent Stress
Pressure Load only

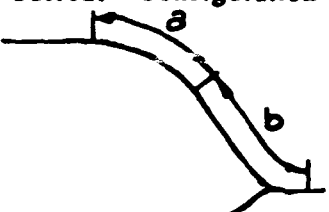
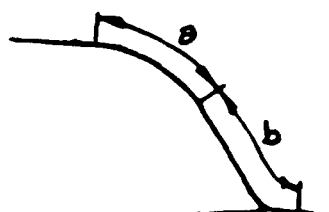
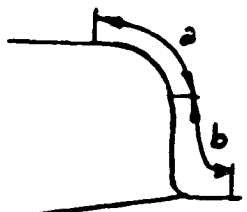
Combustor Configuration	Maximum Thickness Inches	Minimum Weight Pounds	Maximum Applied Pressure	Maximum Stress psi
Current Configuration 	$a = .023$ $b = .023$	4.11	75.3	36,500
Concical 	$a = .028$ $b = .040$	4.91	75.3	17,775
Vertical 	$a = .023$ $b = .080$	6.20	75.3	37,500

Table II
Standard Day Stress Levels - Outer Casing

* Factor of Safety

Stress Component	Max. Stress (psi)	Temp. (°F)	Minimum Yield (psi)	Minimum Ultimate (psi)	* F.S. Yield	* F.S. Ultimate
Equivalent	43,002	1060	18,000	46,000	0.42	1.07
Bending	-46,683	1060	18,000	46,000	0.39	0.99
Hoop	-45,067	1060	18,000	46,000	0.40	1.02

Table III
All Hastelloy X Combustor Stress Summary

* Factor of Safety

Load Condition	Temp. °F	Max. Stress Levels (psi)			Min. Yield (psi)	Min. Ultimate (psi)	* P.S Yield (Equiv)	* P.S Ultimate (Equiv)
		Equivalent	Bending	Hoop				
Standard Day	773	18571	9588	18009	37,800	91,350	2.04	4.92
Hot Day	909	16306	9127	15665	37,350	88,200	2.29	5.41
Cold Day	709	22997	9292	22727	38,700	94,500	1.68	4.11

- PARTS LIST**
- 167180-1 Manifold Bracket
 - 163241-1 Exhaust Flange
 - 163211-1 Drain Elbow
 - 162910-3 Outer Case
 - 162909-1 Exhaust Diffuser
 - 162908-2 Igniter Doubler
 - 162907-1 Drain Boss Doubler
 - 162906-1 Tube Ftg. Doubler (6)
 - 162905-1 Forward Flange
 - 100645-1 Tube Ftg. (6)
 - 100643-1 Inj. Nut Disc
 - 100642-1 Pin Nut Disc (4)
 - 49265-1 Ign. Plug Boss
 - 24003-0 Fitting (2)
 - 163737-2 Hex Nut Pin (4)
 - 163737-4 Inj. Nut

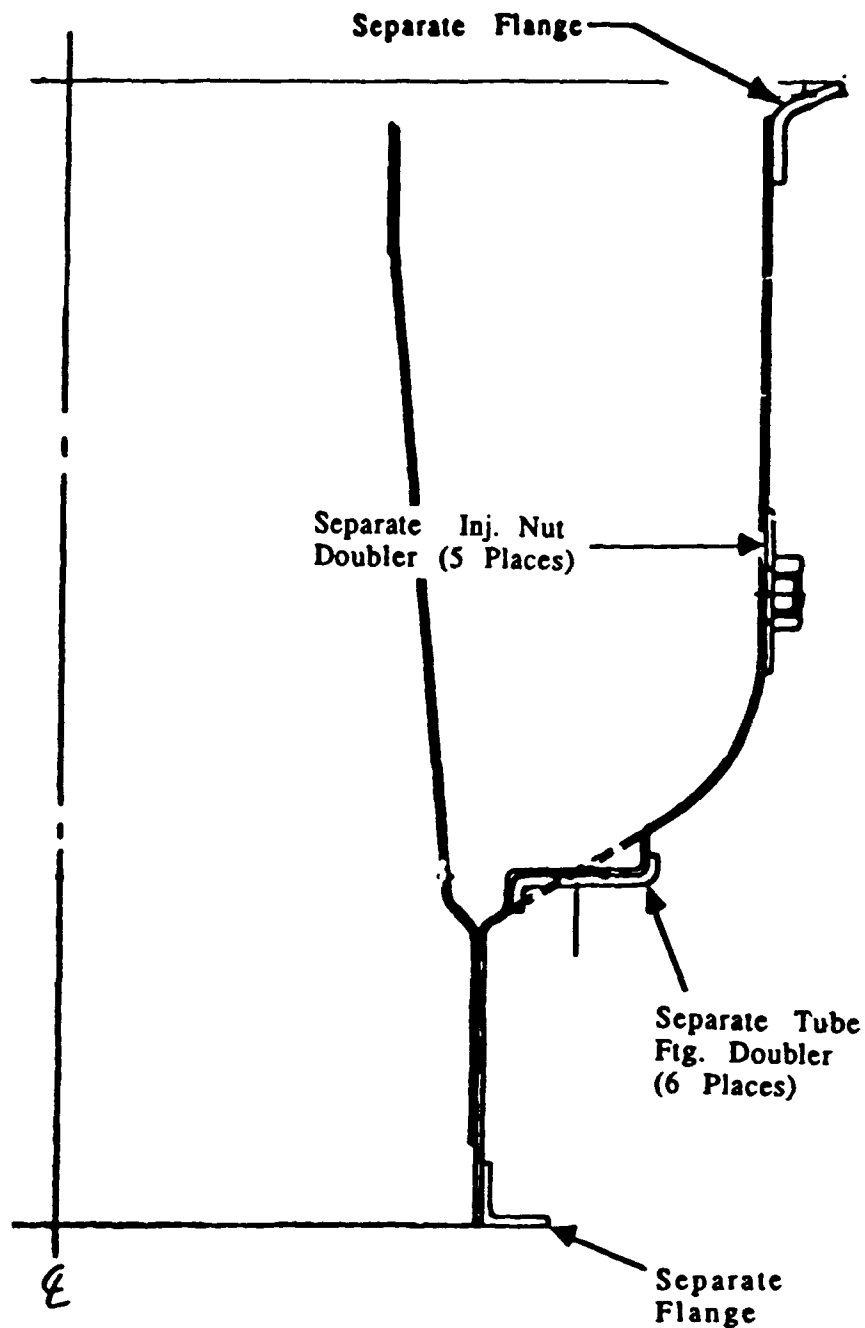


Figure 3-1 Existing Combustor Design

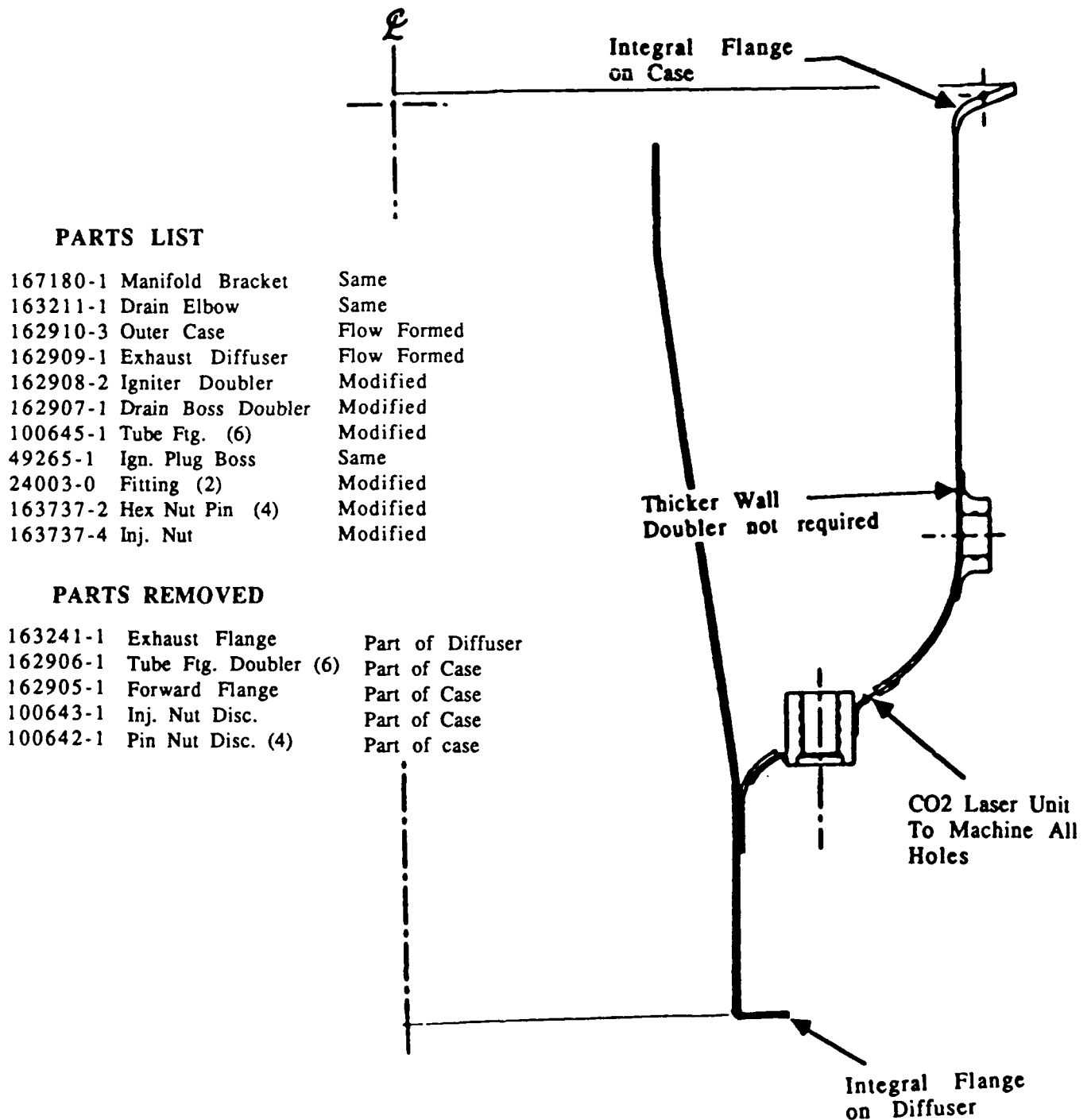


Figure 3-2 New Combustor Design

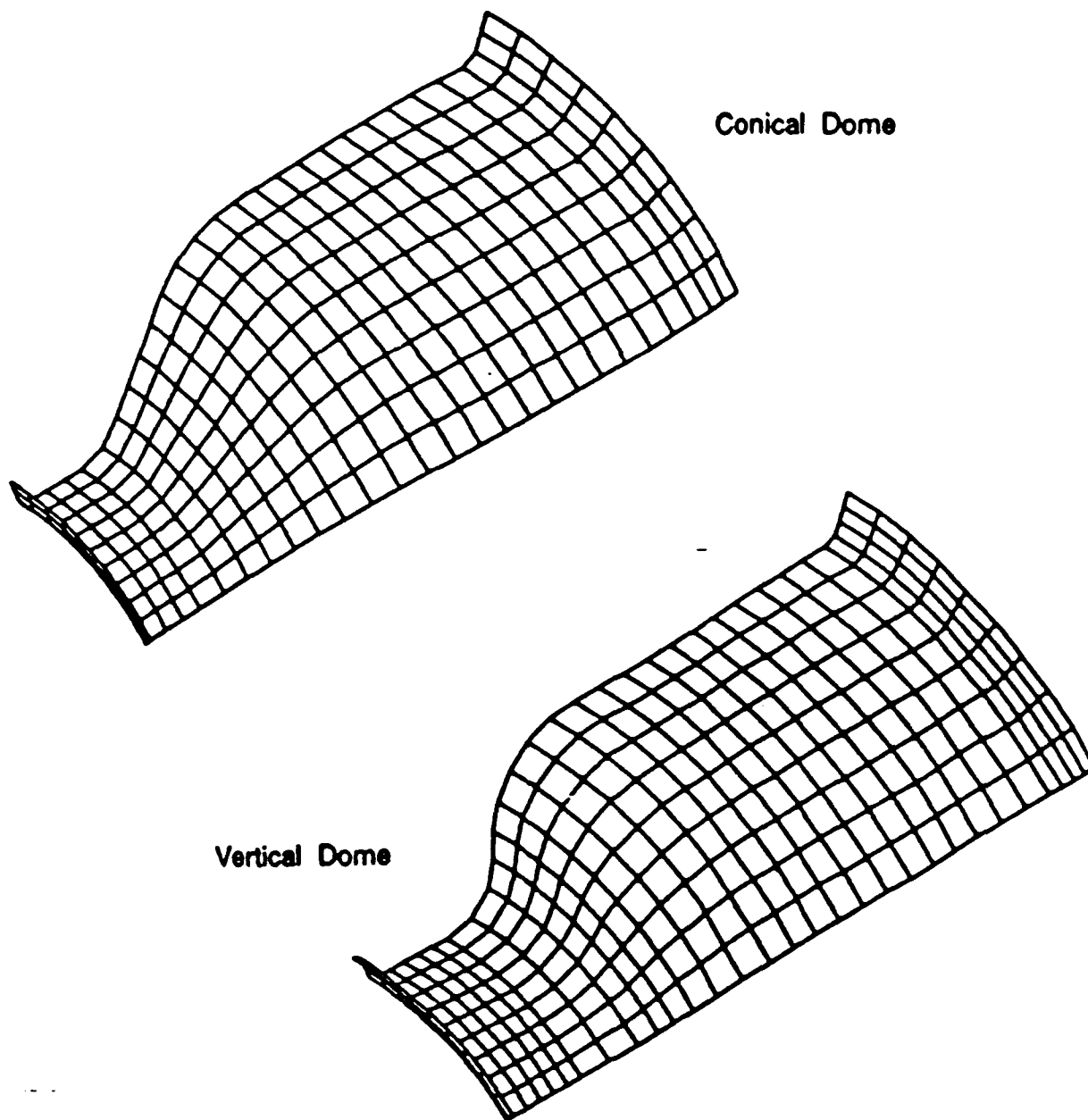


Figure 3-3 F.E. Model Idealization (a) Conical Dome (b) Vertical Dome

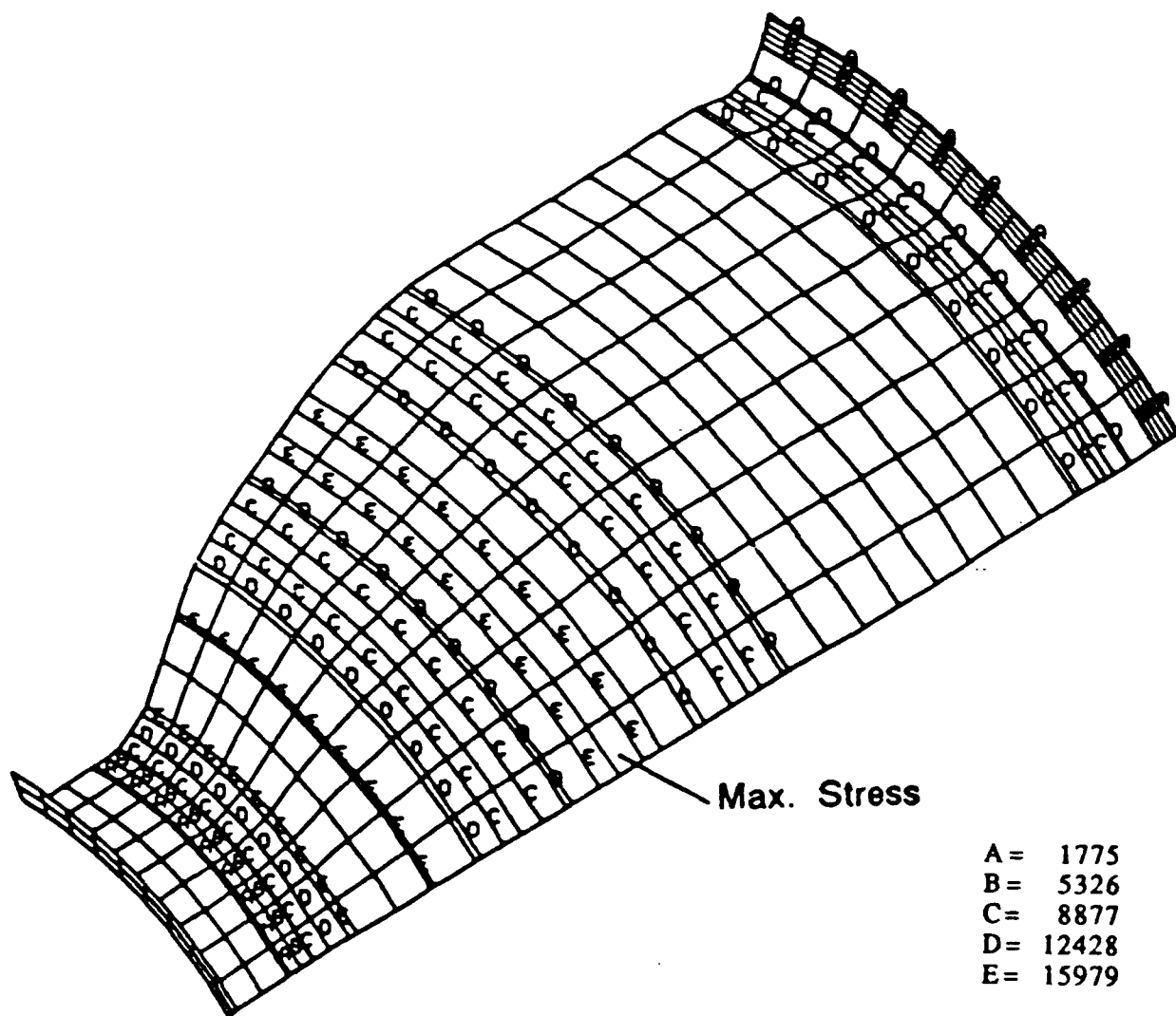


Figure 3-4 Maximum Equivalent Stress - Concial Dome - Pressure Load Only

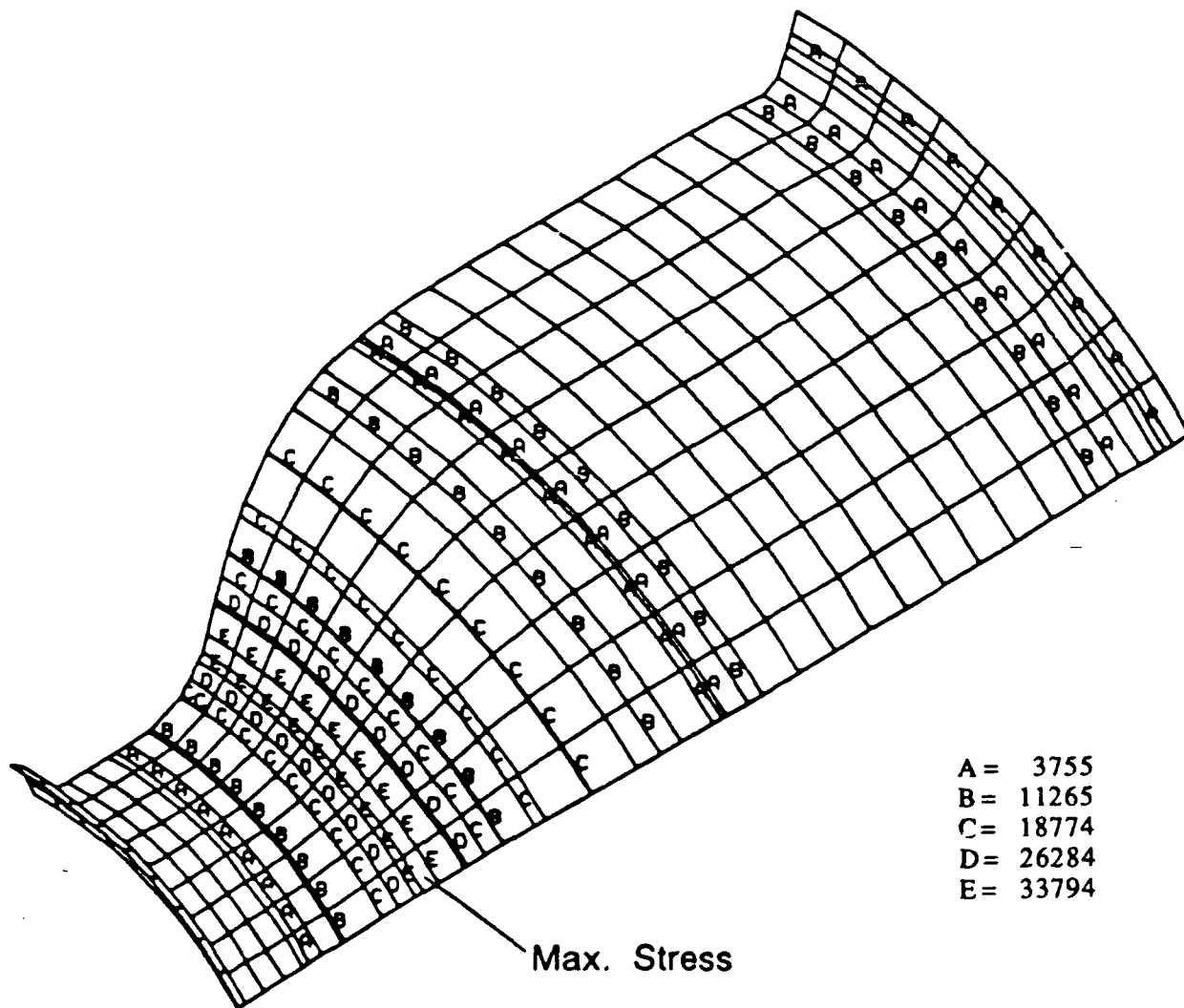


Figure 3-5 Maximum Equivalent Stress - Vertical Dome - Pressure Load Only

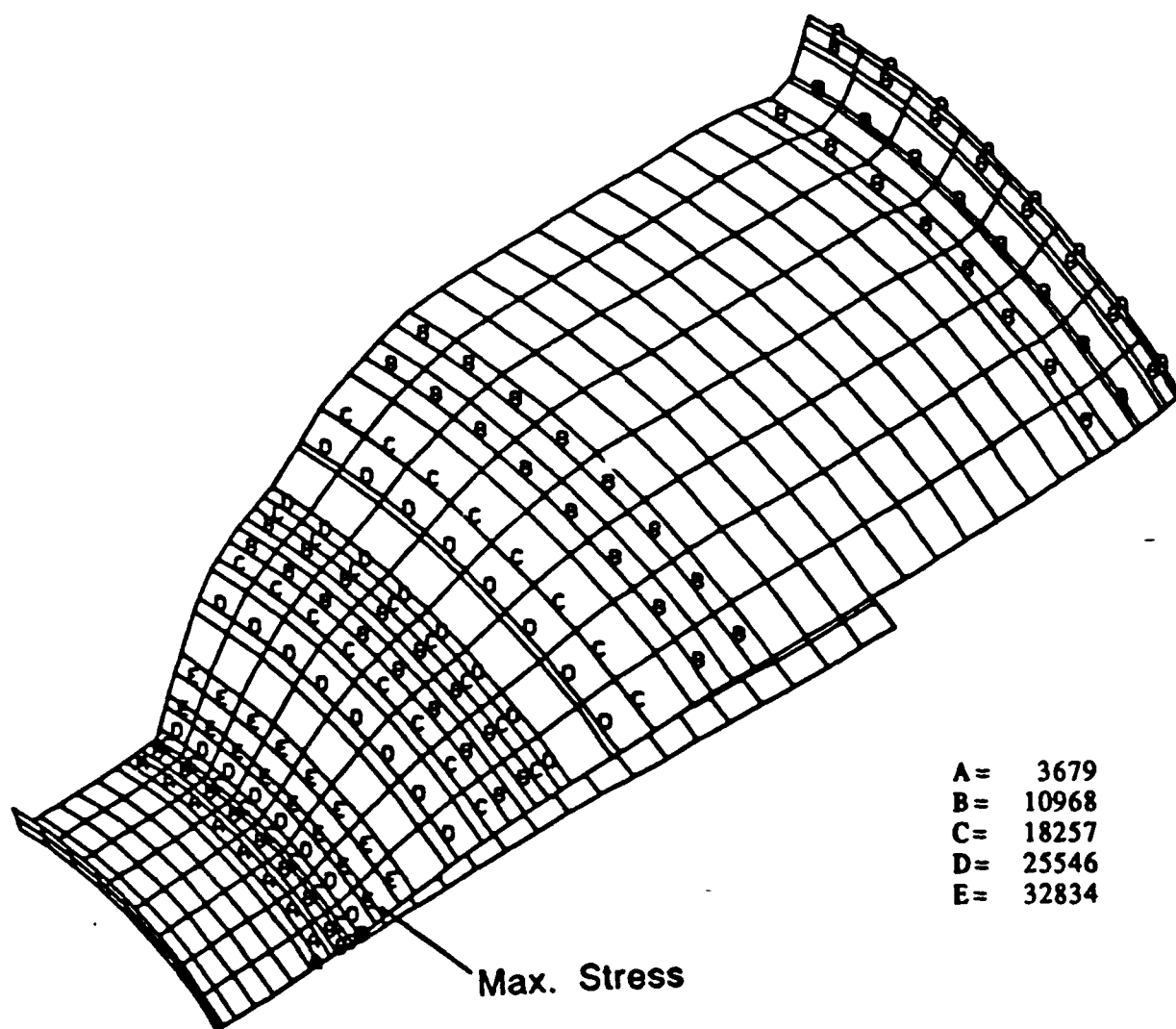


Figure 3-6 Maximum Equivalent Stress - Current Configuration
Pressure Load Only

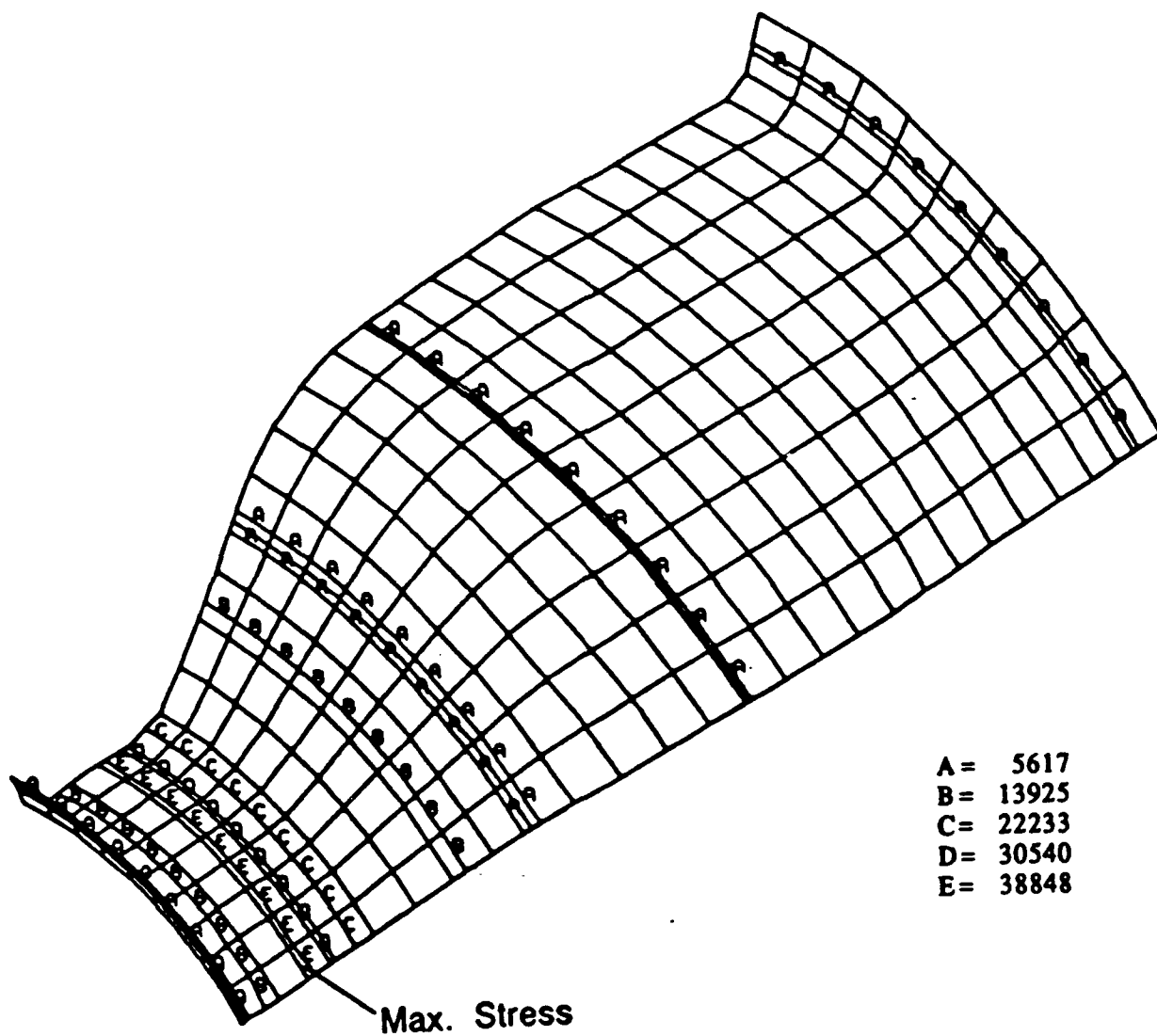


Figure 3-7 Maximum Equivalent Stress - Standard Day Load
Concial Dome in SS 321

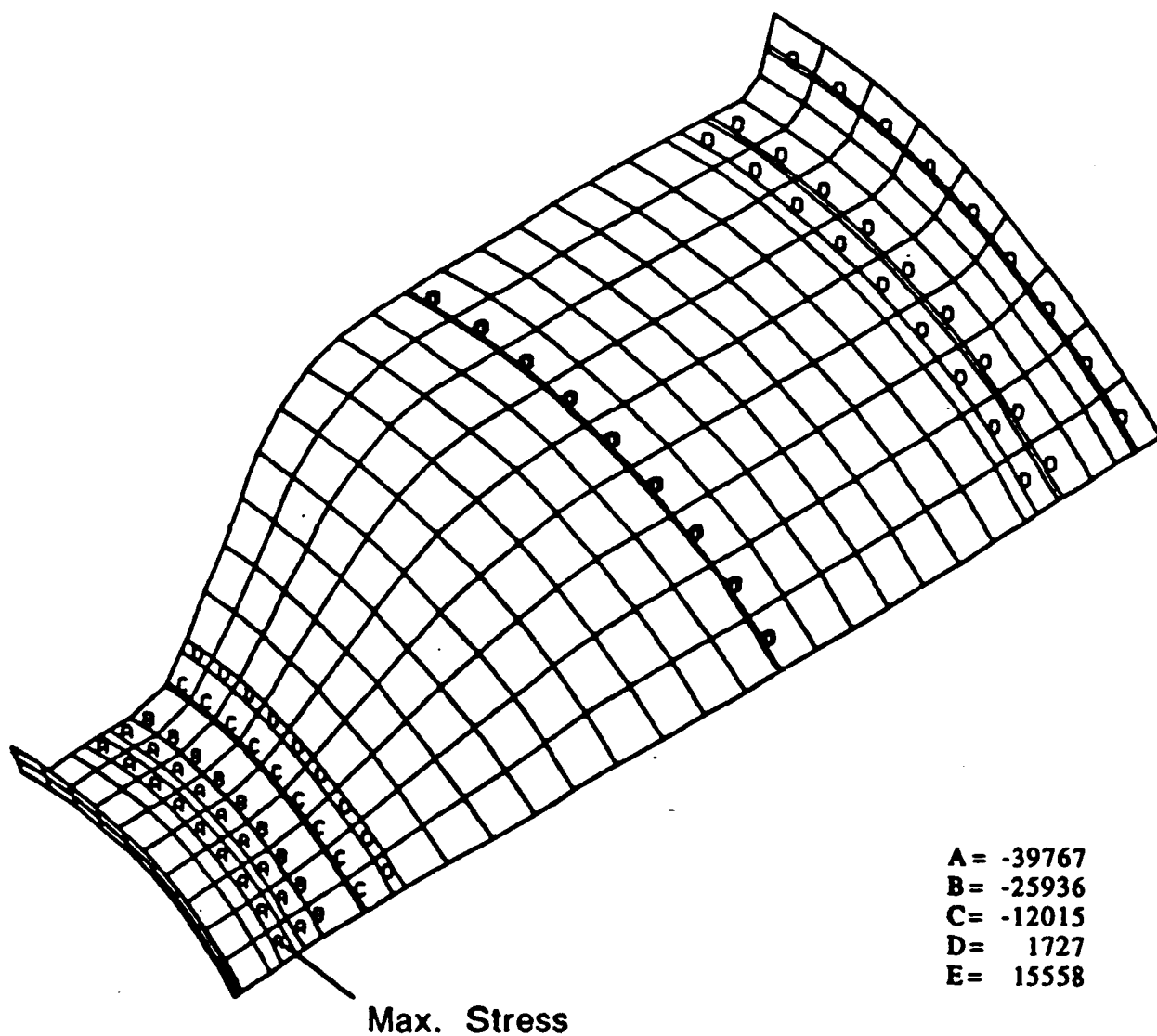


Figure 3-8 Maximum Bending Stress - Standard Day Load
Concial Dome in SS 321

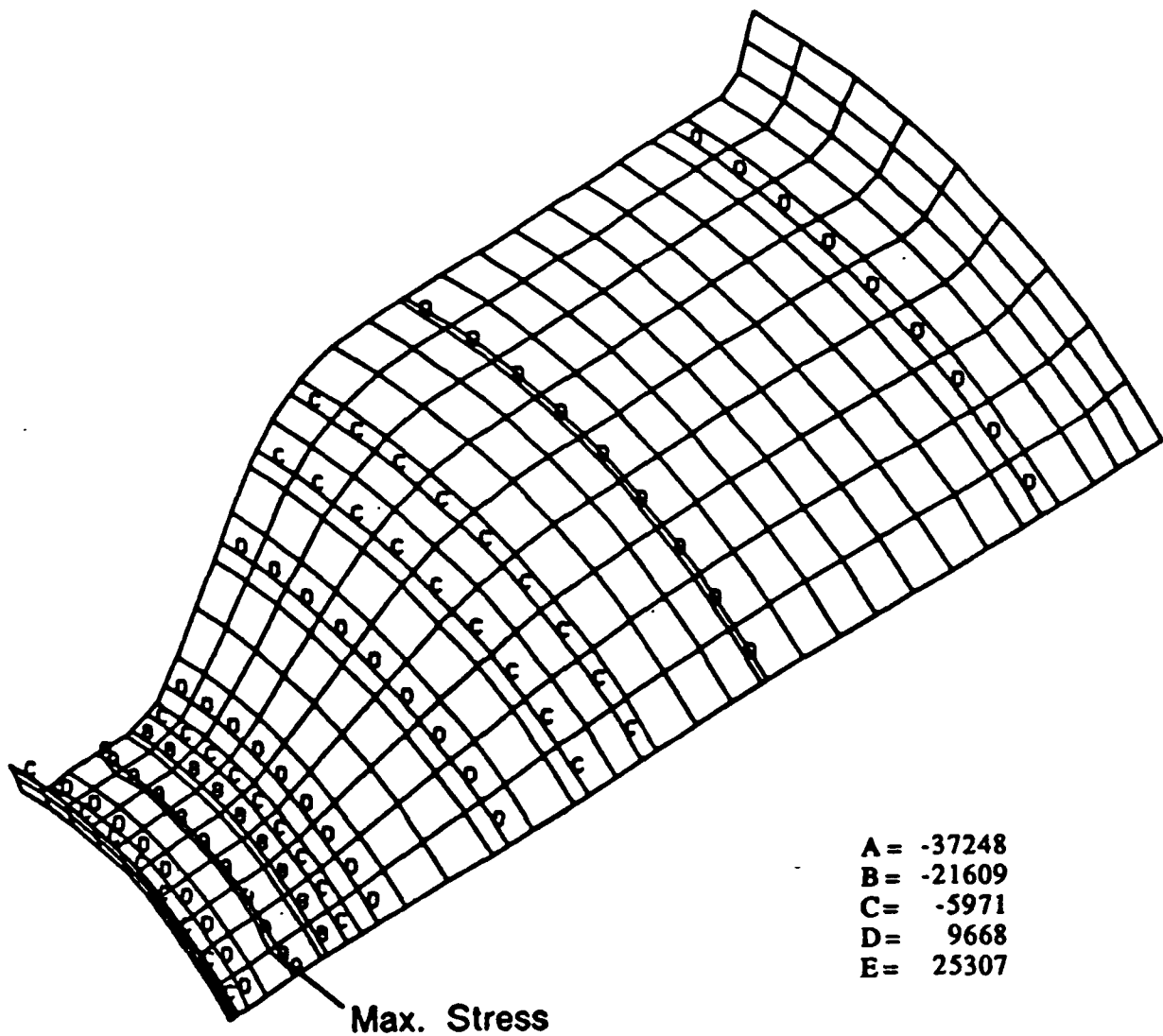


Figure 3-9 Maximum Hoop Stress - Standard Day Load Condition
Concial Dome in SS 321

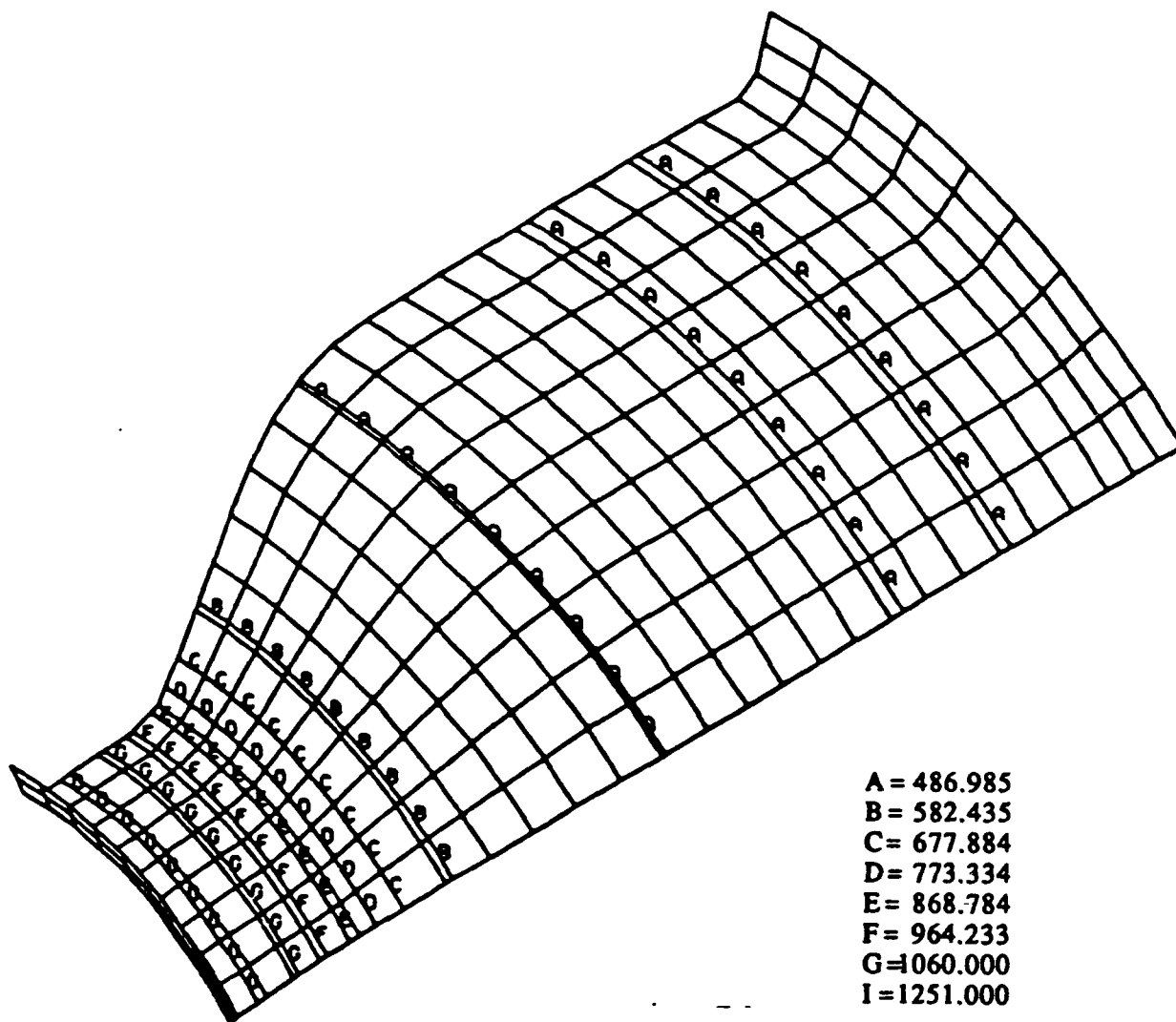


Figure 3-10 Temperature Distribution - Standard Day Load Condition

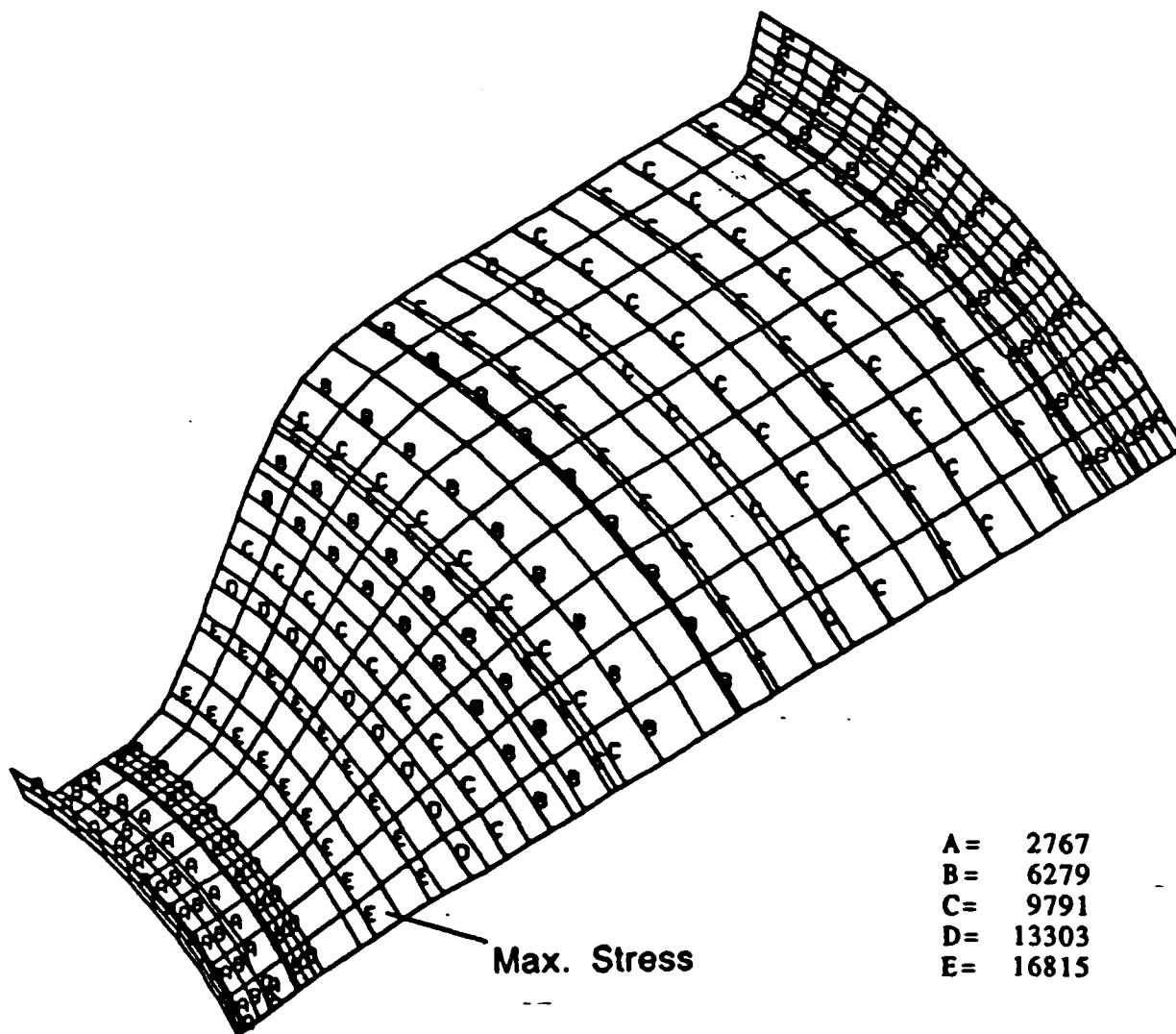


Figure 3-11 Maximum Equivalent Stress - Standard Day Load Condition
All Hastelloy X Combustor

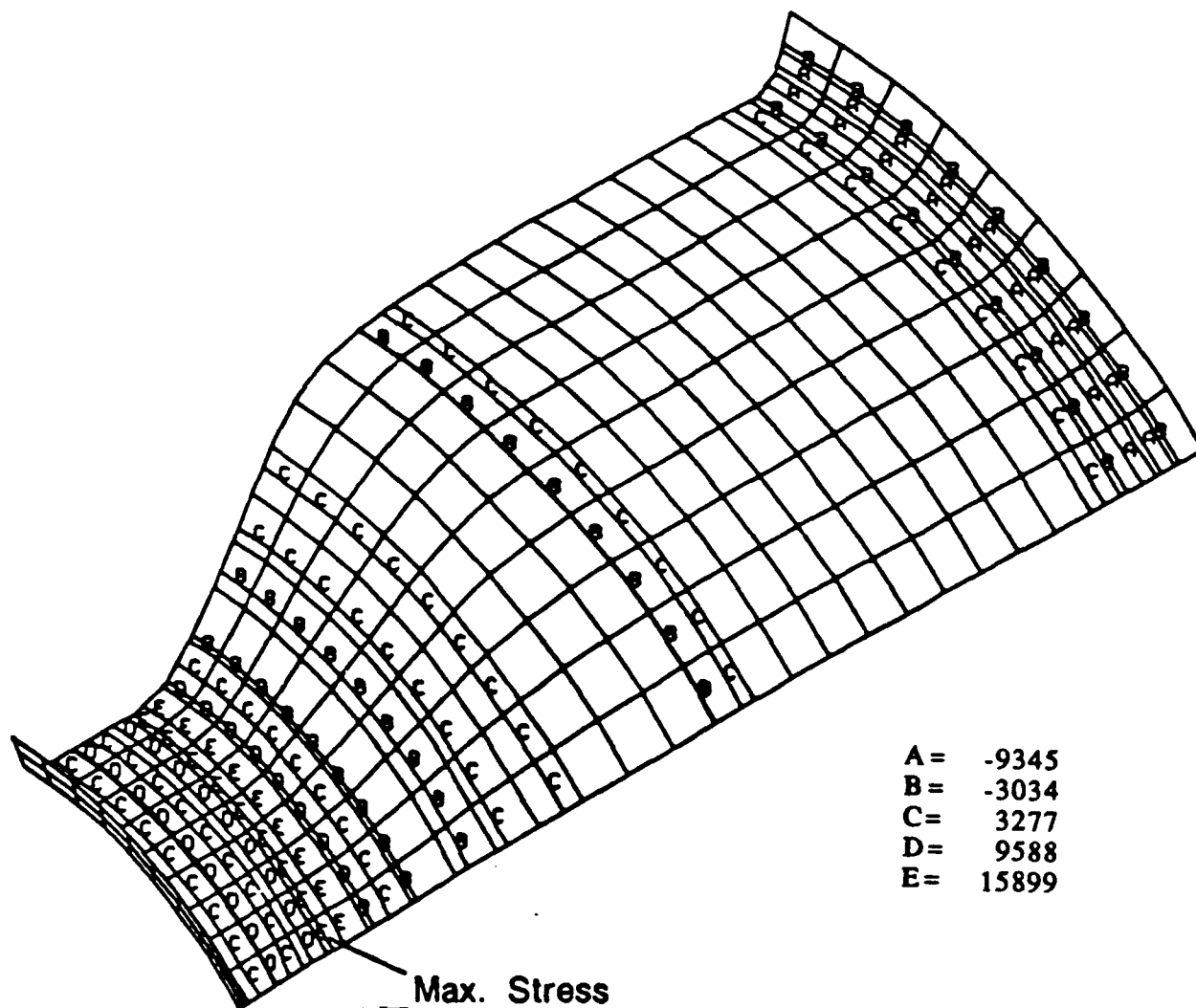


Figure 3-12 Maximum Bending Stress - Standard Day Load Condition
All Hastelloy X Combustor

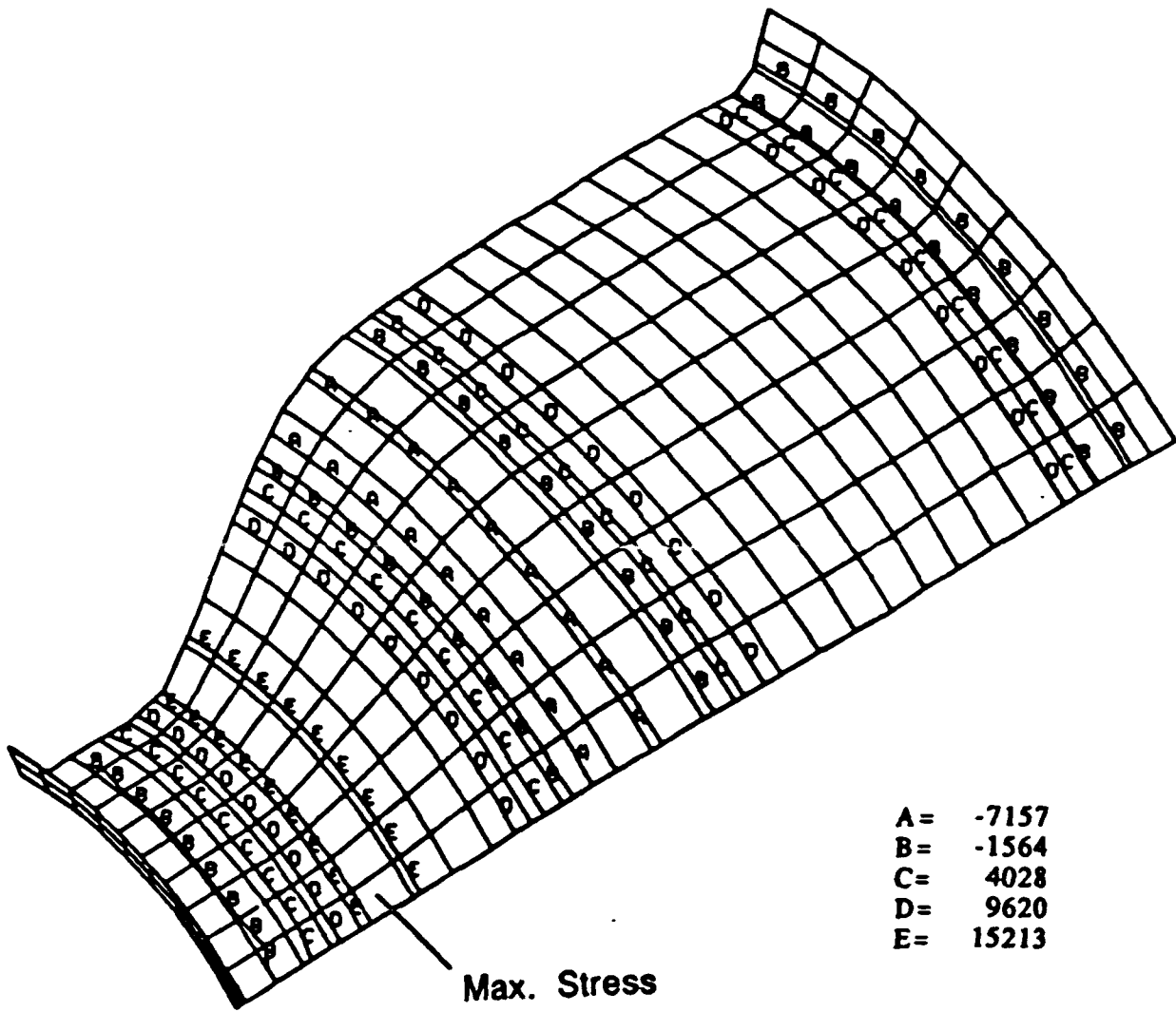


Figure 3-13 Maximum Hoop Stress - Standard Day Load Condition
All Hastelloy X Combustor

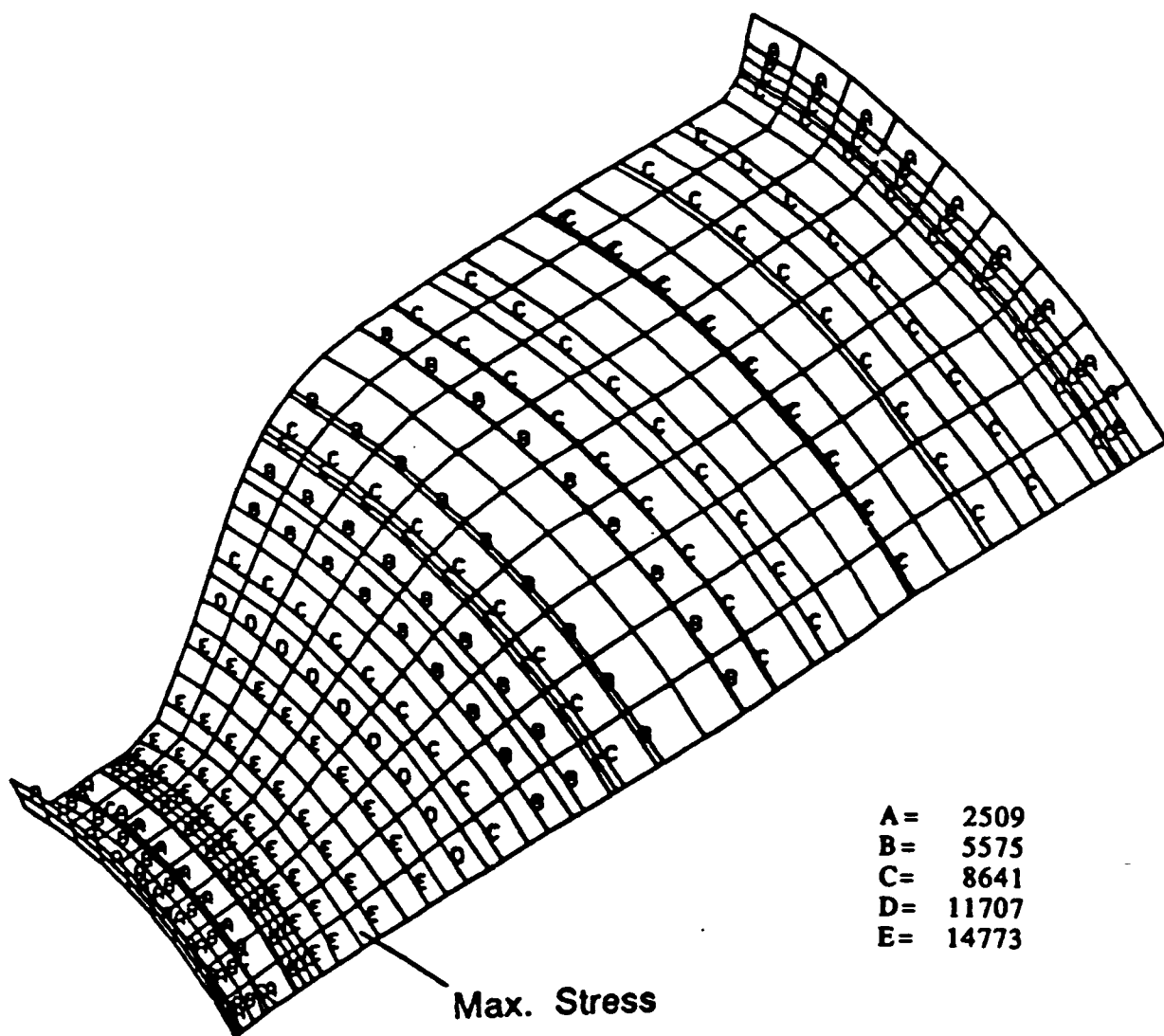


Figure 3-14 Maximum Equivalent Stress - Hot Day Load Condition
All Hastelloy X Combustor

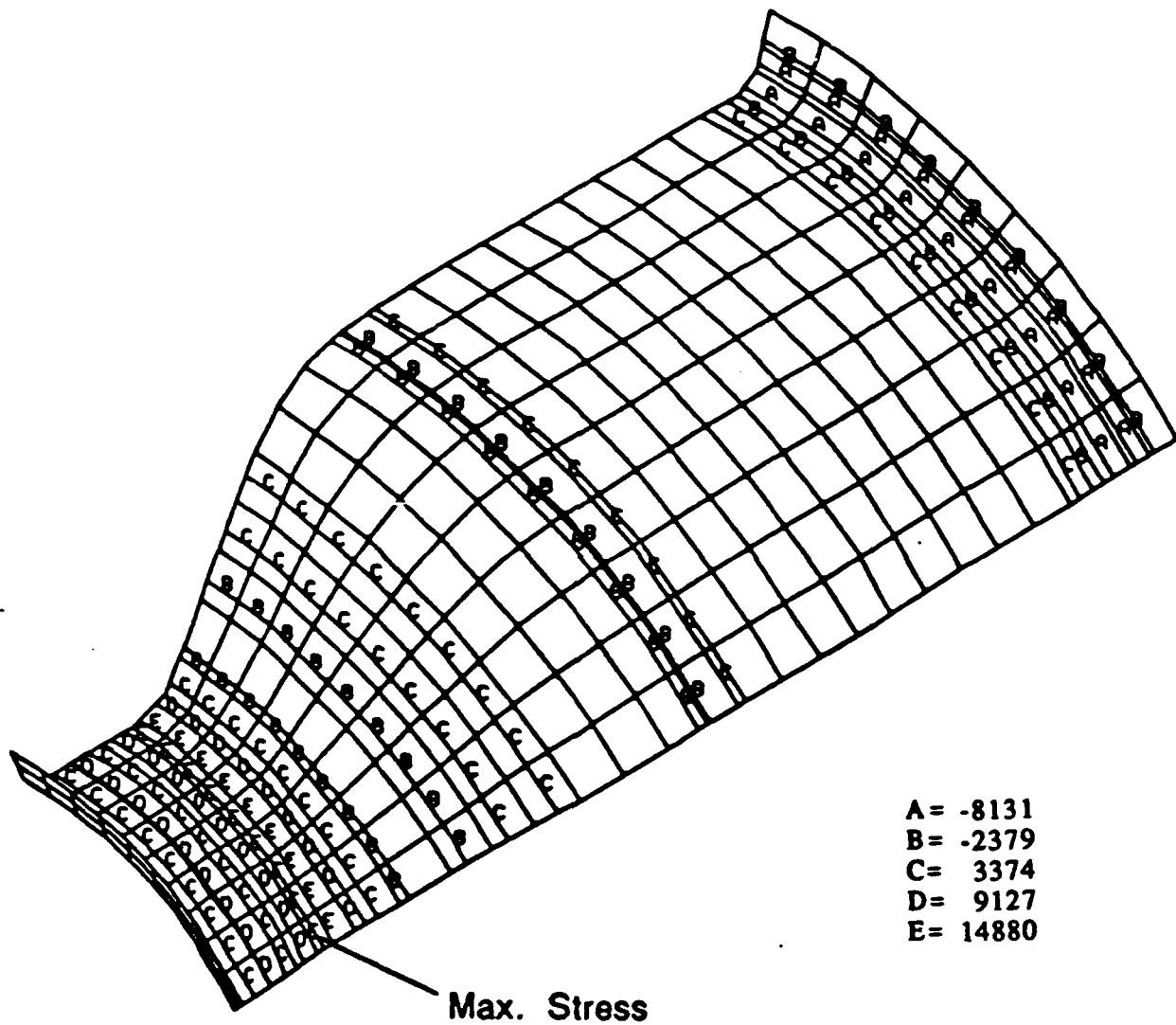


Figure 3-15 Maximum Bending Stress - Hot Day Load Condition
All Hastelloy X Combustor

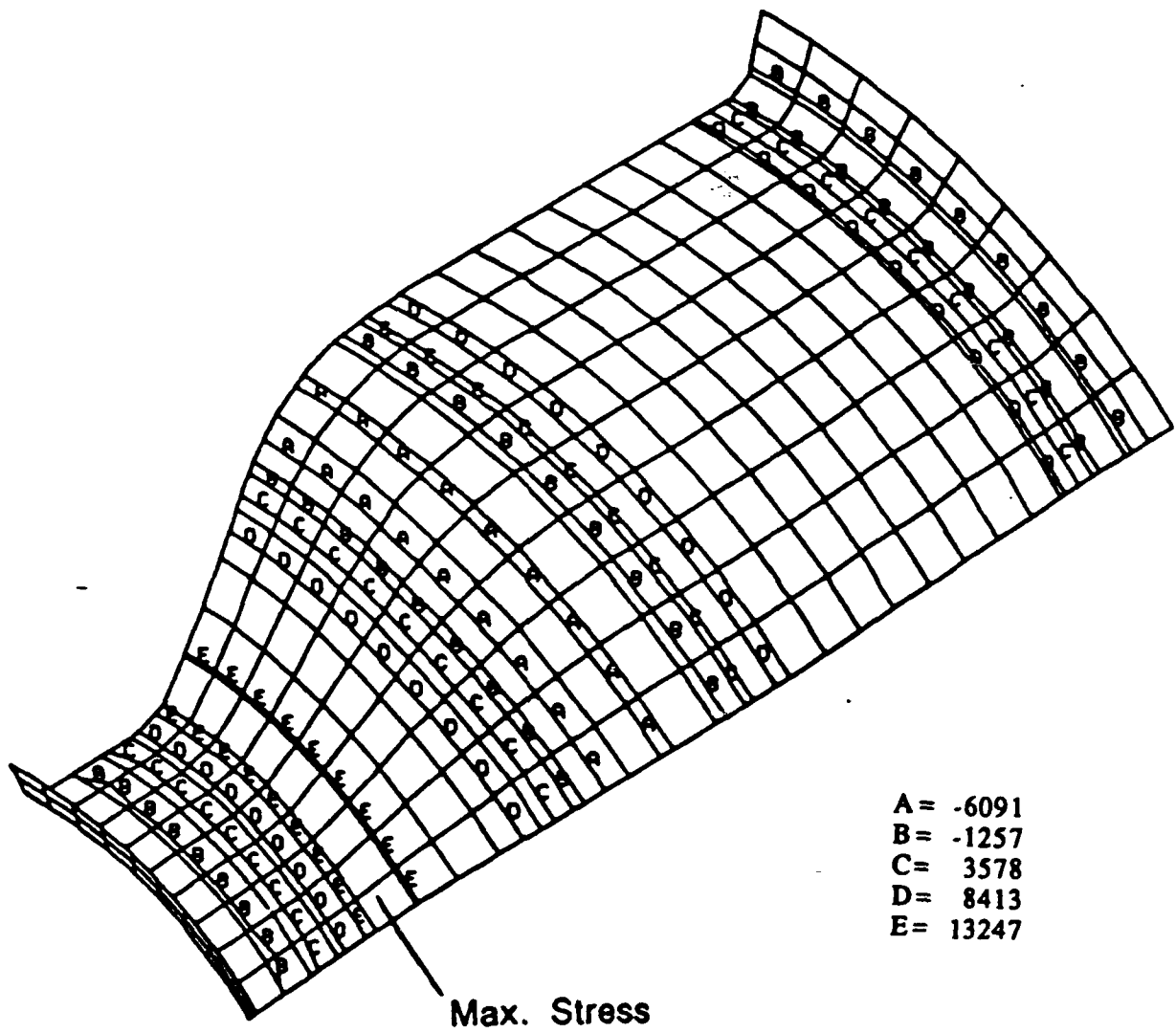


Figure 3-16 Maximum Hoop Stress - Hot Day Load Condition
All Hastelloy X Combustor

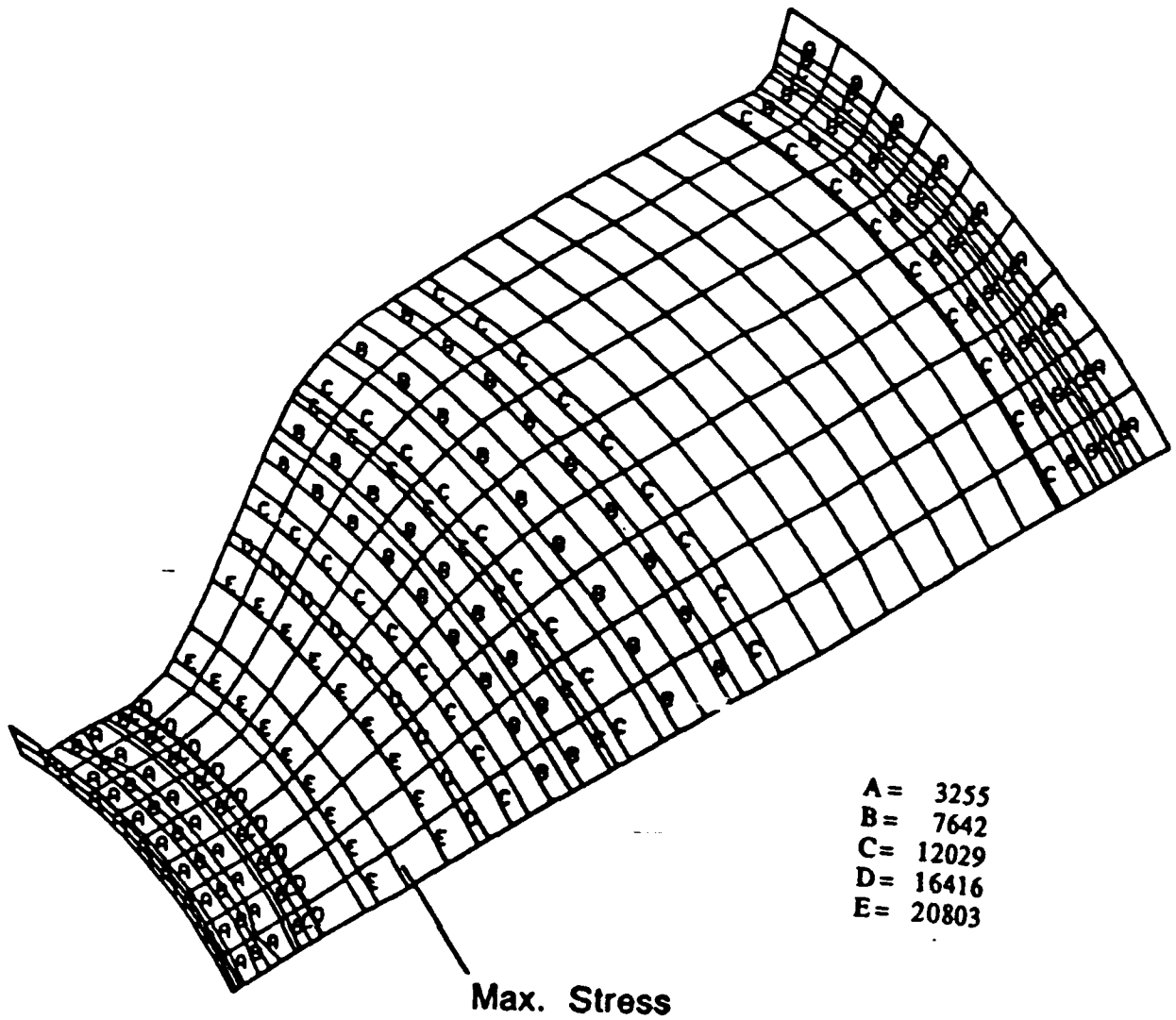


Figure 3-17 Maximum Equivalent Stress - Cold Day Load Condition
All Hastelloy X Combustor

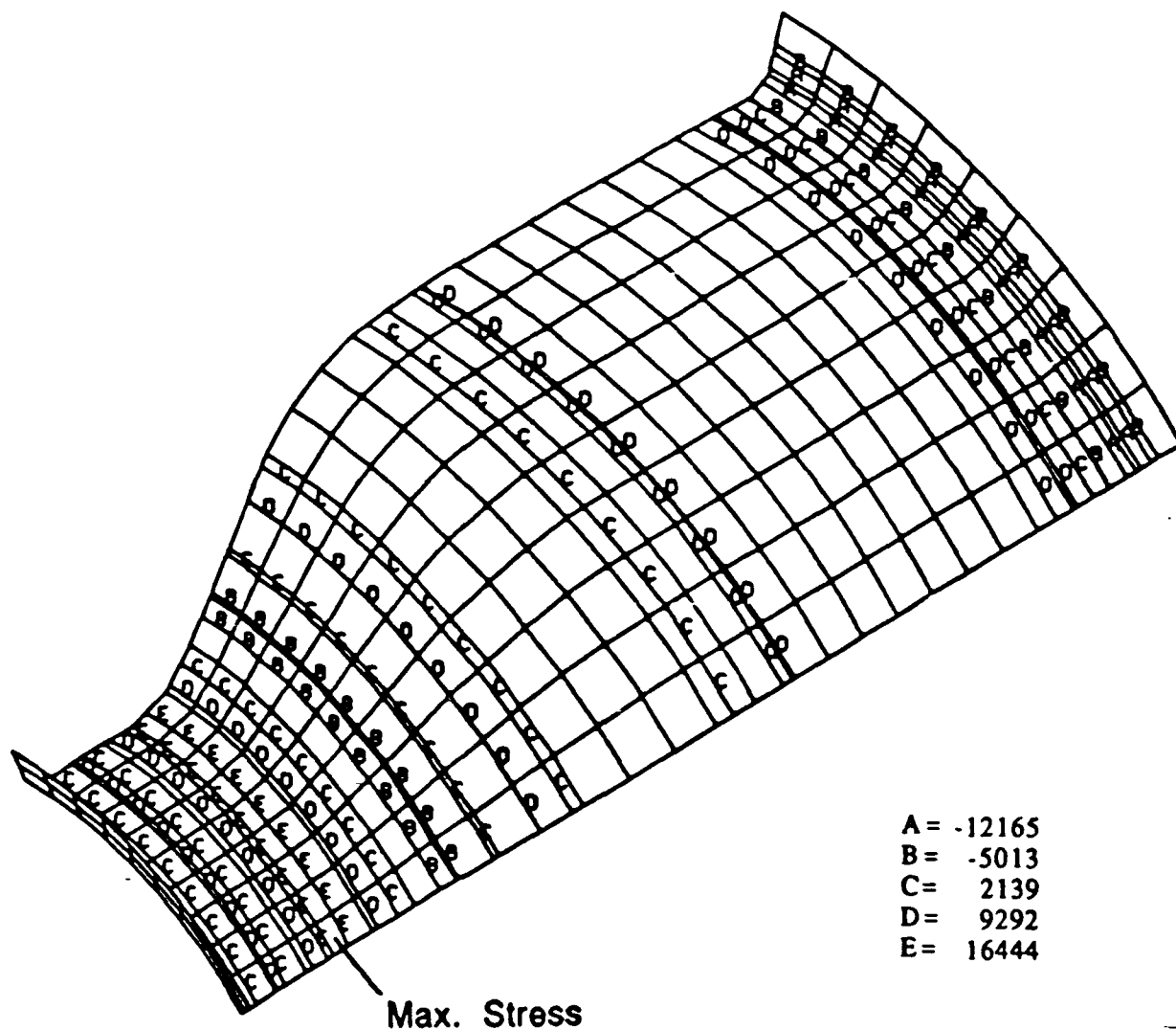


Figure 3-18 Maximum Bending Stress - Cold Day Load Condition
All Hastelloy X Combustor

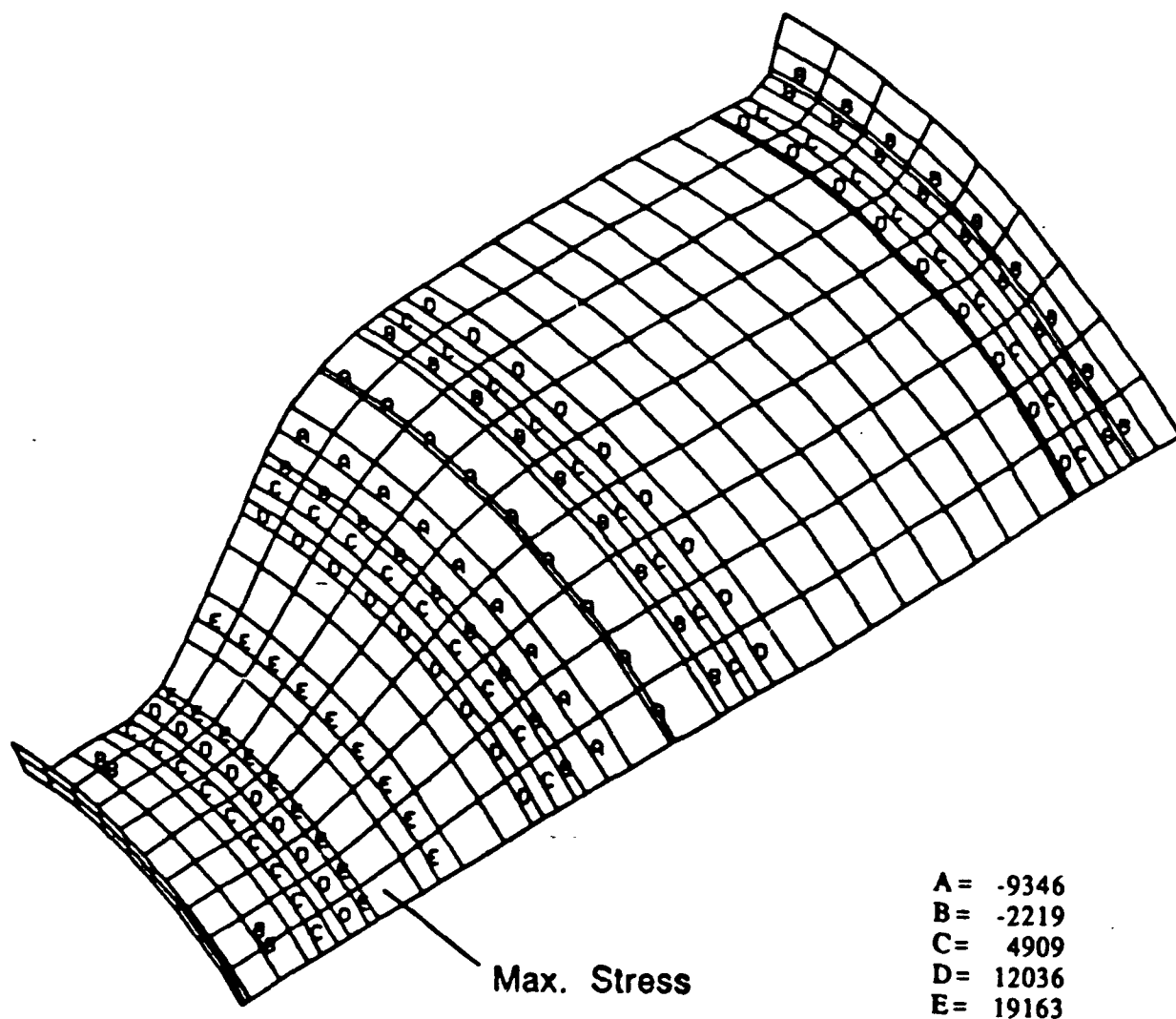


Figure 3-19 Maximum Hoop Stress - Cold Day Load Condition
All Hastelloy X Combustor

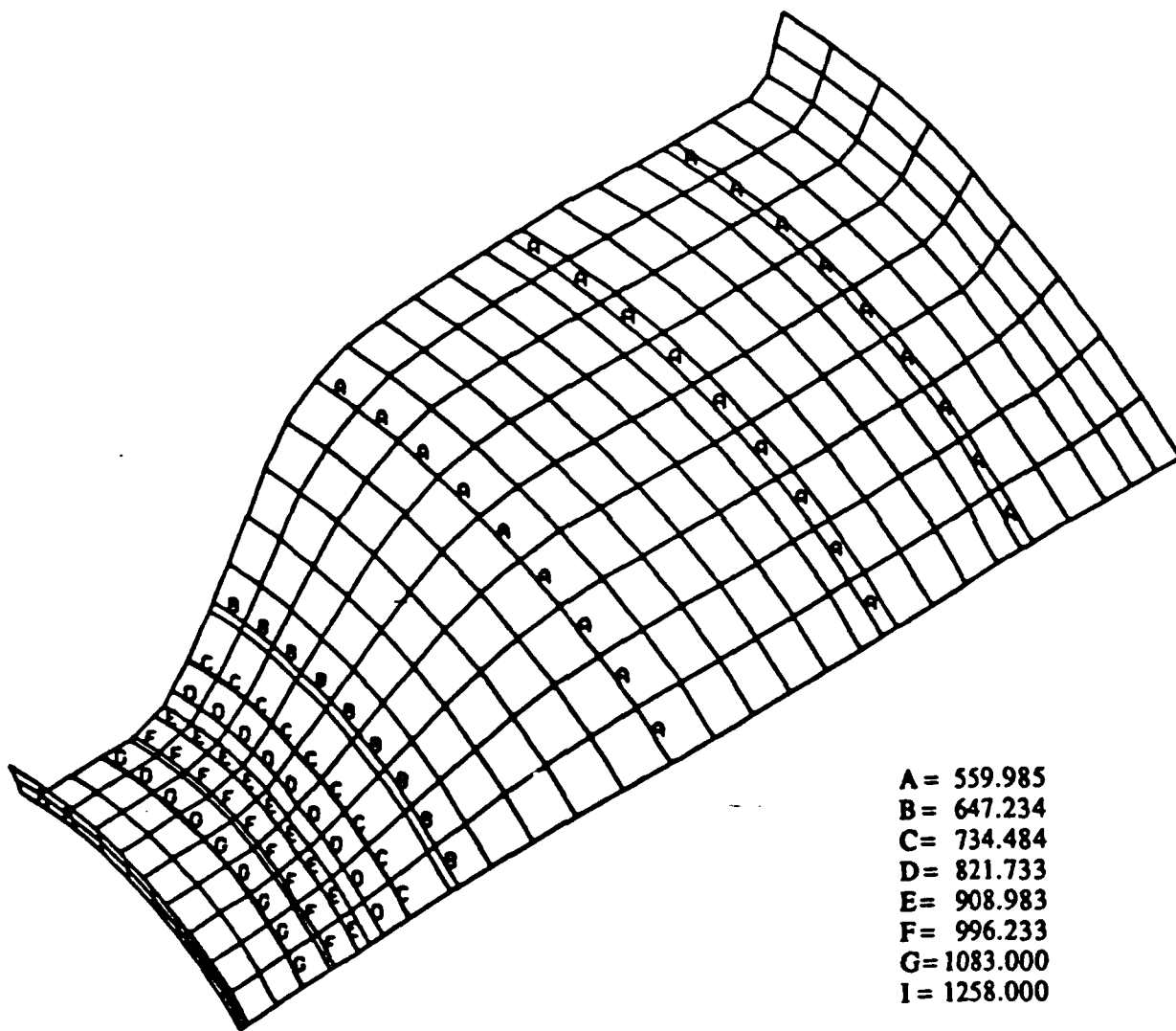


Figure 3-20 Temperature Distribution - Hot Day Load Condition
All Hastelloy X Combustor

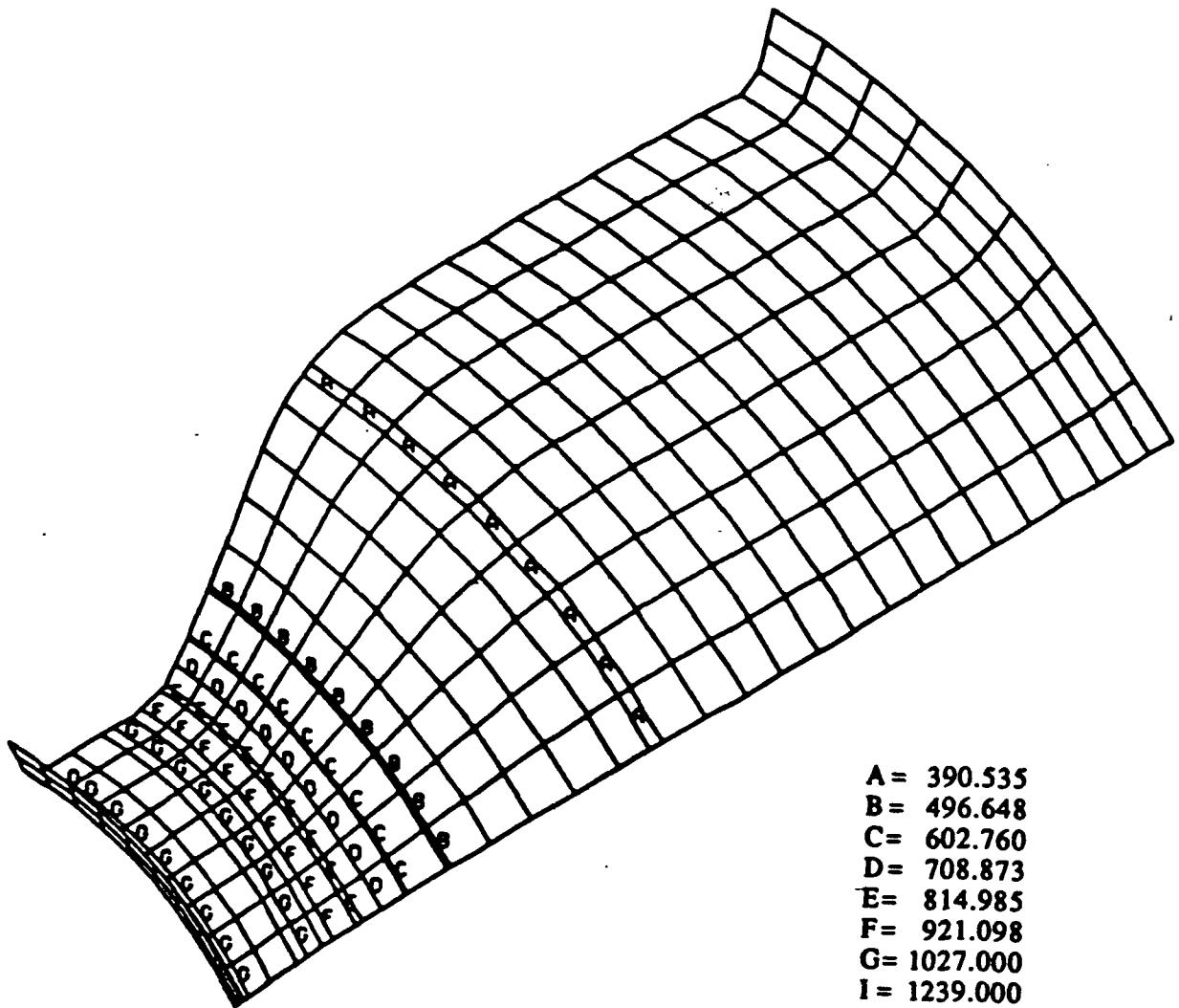


Figure 3-21 Temperature Distribution - Cold Day Load Condition
All Hastelloy X Combustor

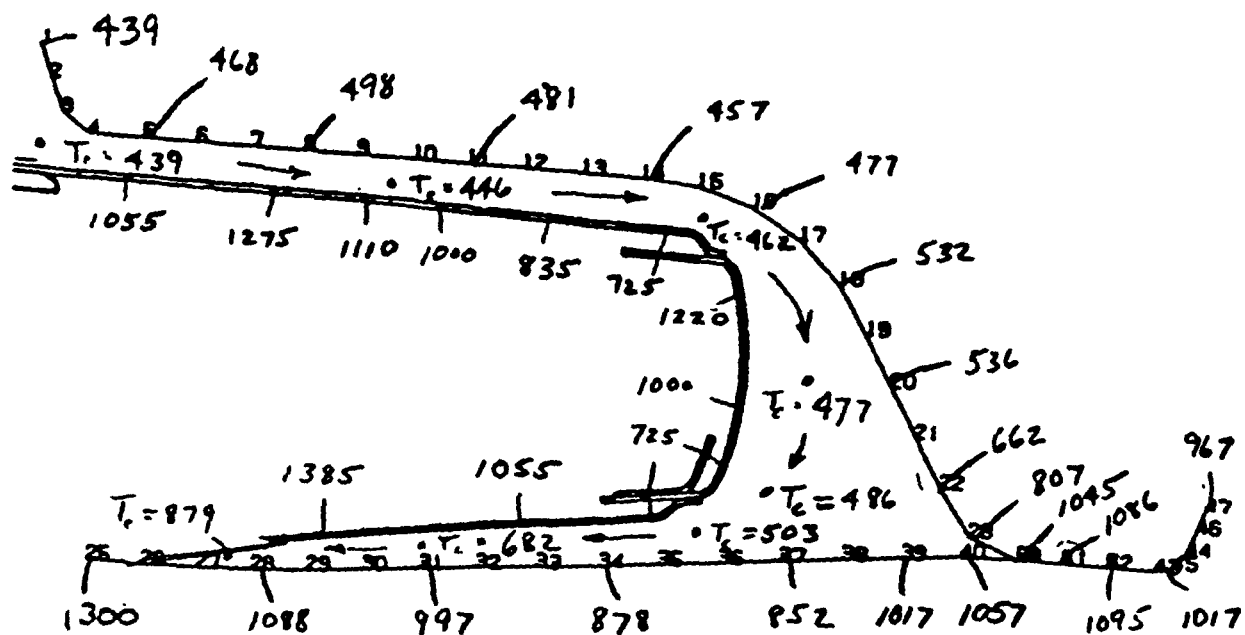


Figure 3-22 Thermal Analysis For Standard Day

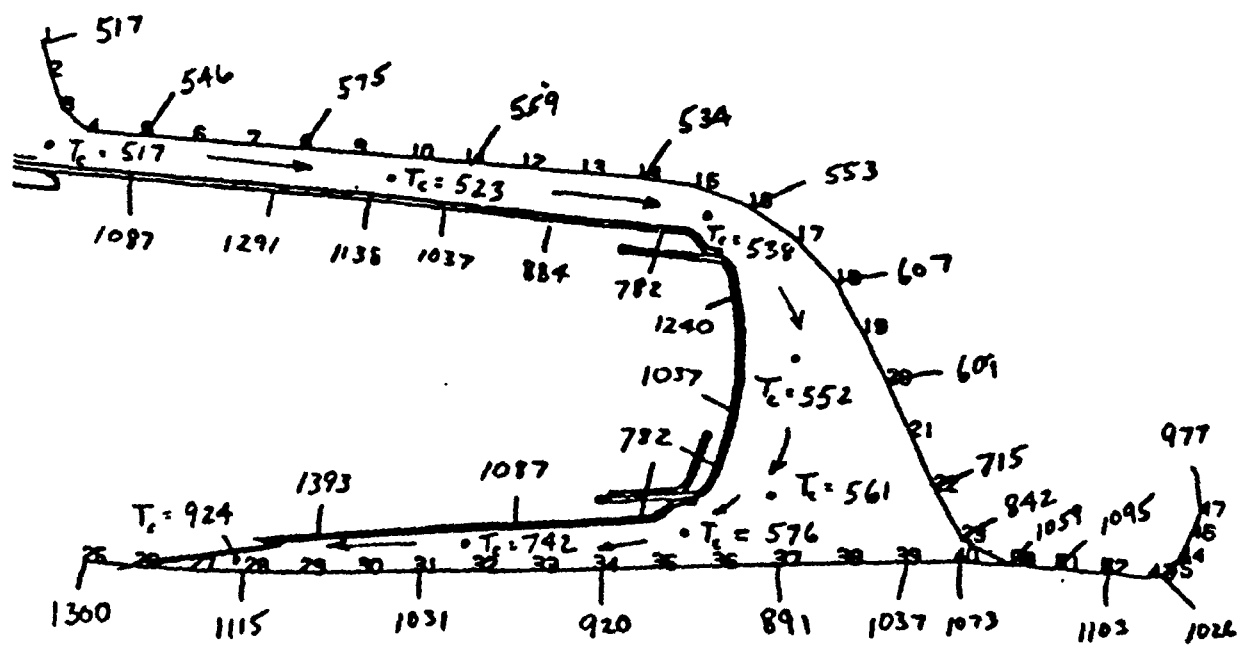


Figure 3-23 Thermal Analysis For Hot Day

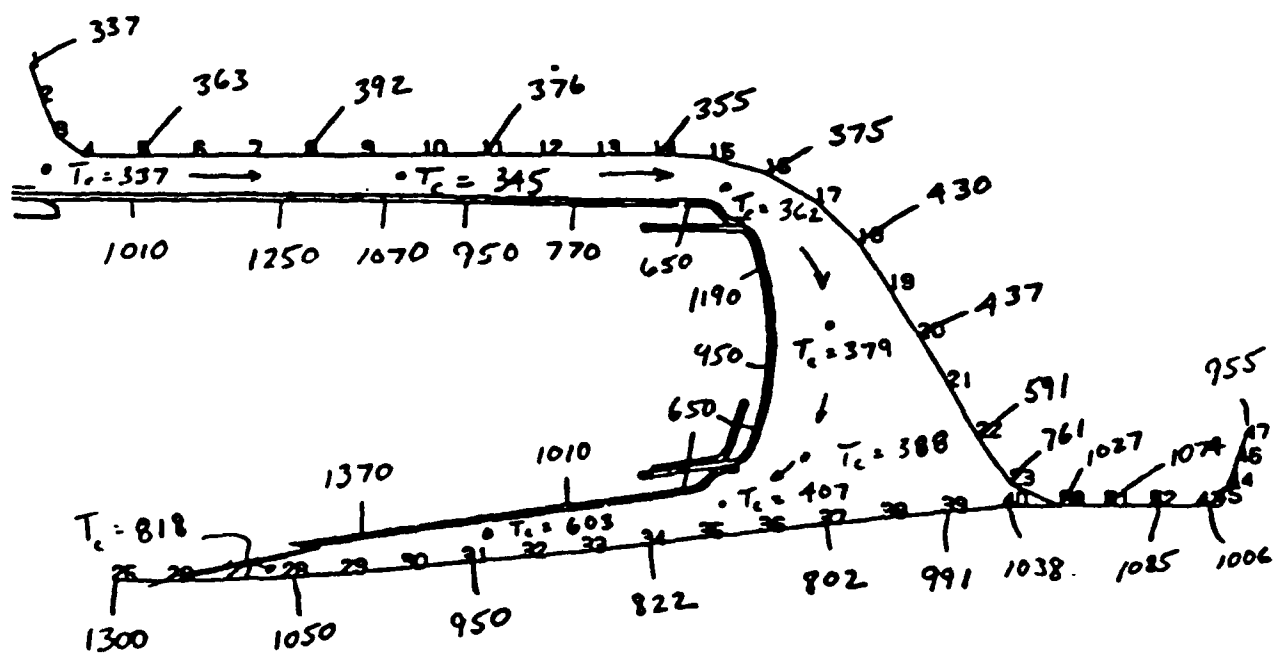


Figure 3-24 Thermal Analysis For Cold Day

4.0 FLOW FORM TECHNOLOGY

4.1 TECHNICAL APPROACH

The approach to flow forming consists of (1) the actual development of mechanically forming material to the combustor housing configuration and (2) evaluate the effects of flow forming on the mechanical properties of the material selected for use.

4.1.1 FLOW FORMING, WHAT IS IT?

Flow forming, also known as flow turning, hydro spinning, power spinning, shear spinning, and roll forming is a cold extrusion method of metal working. In this process a piece of metal takes the shape of a hardened steel rotating mandrel by virtue of extrusion under the action of forming rollers. Parts are produced which are round in cross section, but which may be straight-sided, cones, contoured cones, cylindrical shaped parts, or combinations of the above. The wall thickness is predetermined by mathematical equation varying and is closely controlled. Wall thicknesses can vary along the shape of the part to provide material where needed to meet strength or design requirements.

Flow forming is often confused with spinning. There is, however a very basic difference in conventional spinning and flow forming, even if spinning machines of today are equipped with tracer control and hydraulics. Spinning utilizes a relatively thin piece of starting material and produces the shape of the finished part from a larger diameter starting blank than the largest diameter of the finished part. This is very similar to deep drawing. No reduction of the wall thickness is contemplated, but is often experienced and is very difficult to control.

4.2 FLOW FORMING DEVELOPMENT

The new housing design is a one piece configuration with varying wall thicknesses to minimize the use of reinforcing doublers using Hastelloy X material. The manufacturing goal was to fabricate this new design from start to finish using flow forming techniques, thereby minimizing fabrication time and costs.

4.2.1 EXISTING CAPABILITY

A team was formed to survey the industry and determine if 100% flow forming capability existed. There are several manufacturers that do flow forming, but none have formed Hastelloy X material to the demanding configuration of the Sundstrand combustor housing. All forming houses refused to bid on manufacturing housings to the new one-piece design, except Precision Metal Forming Industries (PMF). PMF proposed to manufacture housings to the one-piece design, but would achieve the final configuration thru a combination of deep draw and flow forming, reference Section 4.3.

4.2.2 FORMING DEVELOPMENT

An initial set of housings were fabricated using the combination method proposed by PMF. These housings were sent to Engineering Materials and Processes for analysis and evaluation, reference Section 4.4. Some cracks and laps were discovered in these units. After modifications to the forming process, PMF was able to fabricate combustor housings without discrepancies.

4.2.3 UNIT/ASSEMBLY WEIGHT ANALYSIS

A weight analysis was performed comparing the existing housing assembly design to the new one-piece design. In addition, actual weighing of both designs was accomplished.

Results of analysis and actual testing were very close. The existing design contains more separate parts and has thinner wall thicknesses. The new proposed one-piece design contains fewer parts, but heavier wall thicknesses. The final weight between the two designs is almost the same. At worst, the new design is 2 ounces heavier. Both designs use brazing as a means of metal joining. When laser welding is incorporated, the new design will be a fraction lighter.

4.3 DETAIL FABRICATION

4.3.1 HOUSINGS IN SUPPORT OF PHASE II DEVELOPMENT

The housings manufactured in support of the IMIP Phase II development were fabricated by means of a combination of both deep draw and flow forming operations as discussed above in Section 4.2. The steps used in the forming process are shown in Figure 4-3-1.

- STEP 1 Start with a sheet of Hastelloy X material .090 inches thick with a 16.5 inch diameter.
- STEP 2 Make the initial deep draw shape using a 100 - 300 ton hydraulic press.
- STEP 3 It was established during the metallurgical evaluation, Section 4.4, that an annealing operation needed to be accomplished before the second draw operation to prevent material cracks.
- STEP 4 The second draw operation increased the cylindrical wall thickness to .095 inches and established the initial shape required for flow forming.
- STEP 5 The flow forming operation was accomplished using a Cincinnati Flow Turn Lathe. This operation established the basic length of the housing and the critical wall thicknesses.
- STEP 6 Another annealing operation was added to prepare the material for the final two sizing operations.
- STEP 7 This operation is accomplished using the 100 - 300 ton press to form the reverse curve of the housing. The material is cold formed between two dies.
- STEP 8 This is the last forming operation. This sizing operation again uses two dies to form the final shape of the combustor housing.
- STEP 9 This operation uses a conventional engine lathe to trim the forward flange and to cut off the unused portion of the housing at the exhaust end.

4.3.1.1 LASER MACHINING

The housing is sent to Laser Industries after all forming is complete for cutting openings in the combustor housing and final trimming. The openings are for the various ports required in the combustor design.

4.3.1.2 MISCELLANEOUS PARTS

All bosses were fabricated by outside vendors. This will not change from the existing design, except that the bosses have much smaller attach flanges and are coined or formed to the housing contour for direct attachment since most doublers have been eliminated. Figure 4-3-2 shows the various finished parts of the new housing design prior to assembly. The conical shaped part is the diffuser. Figure 4-3-3 shows the completed combustor housing assembly.

4.3.2 FINAL FORMING METHOD PLANNED FOR COMBUSTOR FABRICATION

The planned Precision Metal Forming cell will be a complete stand alone facility capable of fabricating major combustor housing details from sheet stock ready for major assembly.

The sequence of operations used to fabricate the Phase II units are discussed in Section 4.3.1. The sequence of operations that will be employed in the new Precision Metal Forming Cell will further enhance manufacturing technology.

4.3.2.1 COMBUSTOR HOUSINGS AND DIFFUSERS

Raw sheet stock will be sheared square and blanked to round discs as in Section 4.3.1. The flow form lathe (BOKO 3D 55/CNC-R3.1, see Section 6.0 in equipment selection) is capable of flow forming a complete housing or diffuser from a flat blank, thereby eliminating the pre-form operation and post flow turn final sizing, see Figures 4-3-4 and 4-3-5. BOKO has successfully demonstrated this machine tool capability. After the details have been flow turned complete, a functional gauge will be used to inspect dimensions and track any deviation using statistical process control.

Laser machining will be accomplished on our Lumonics Custom Modle laser center. Laser machining parameters have been developed, reference Section 5.0.

The laser unit will trim the housing and diffuser to length and trim the outside diameter of the flange. All holes are to be laser drilled for positioning of all subsequent bosses.

The machine specification and selection included a successful demonstration of laser welding all joints.

Laser welding does promise to show significant savings in the future, however we will have to develop in this technology. All bosses will be procured from outside vendors with numerical controlled lathes. Bosses will be "coined" or formed to match the outside contour of the flow formed housing.

Subsequent assembly will utilize assembly fixtures to locate all details in position. Resistance welding will be used to attach details in place. All joints will be loaded with braze alloy and brazed in our vacuum furnace. Final qualification and adjustments are then accomplished. Major assemblies are then ready for engine build.

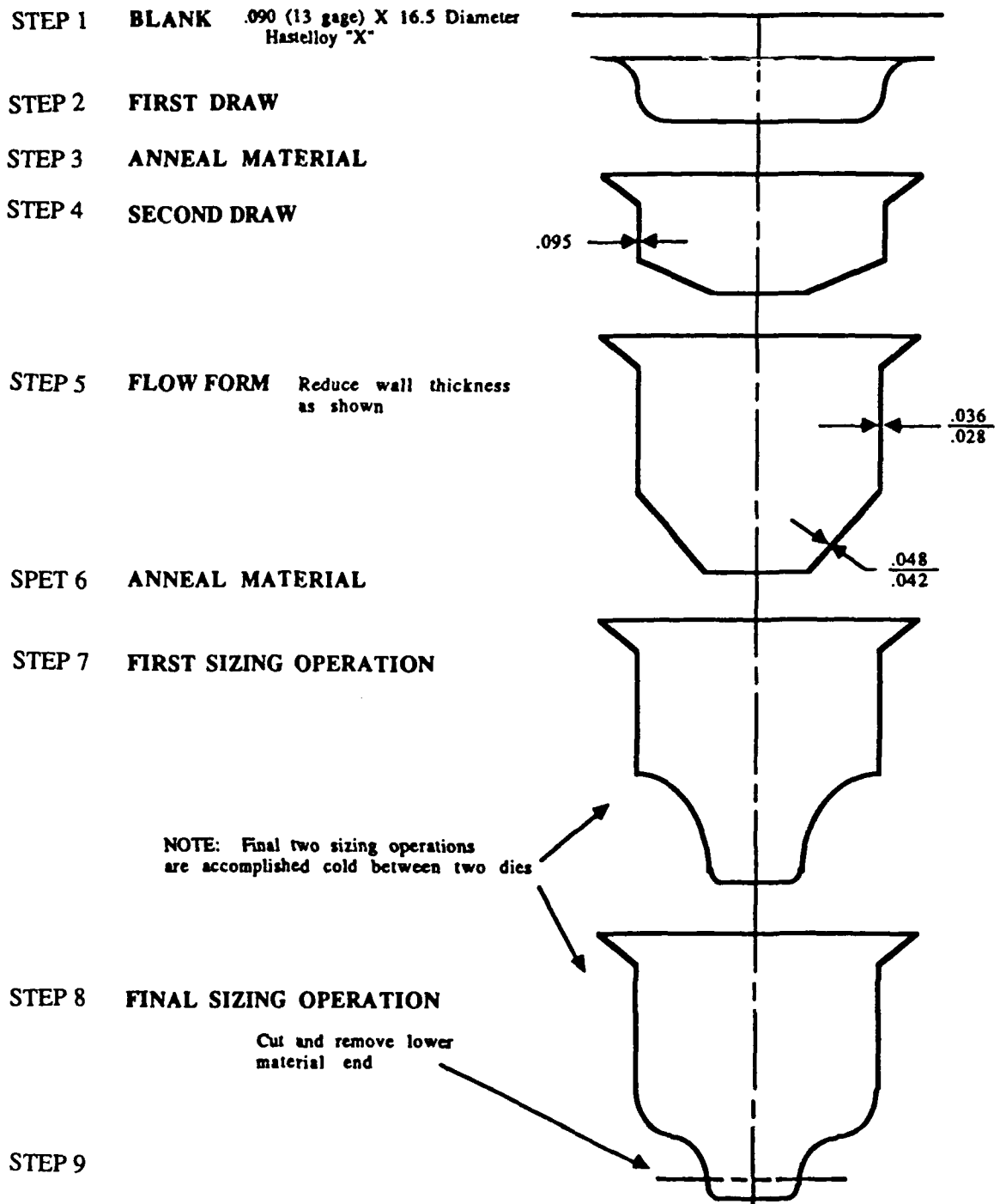


Figure 4-3-1 Forming Operations For Housing

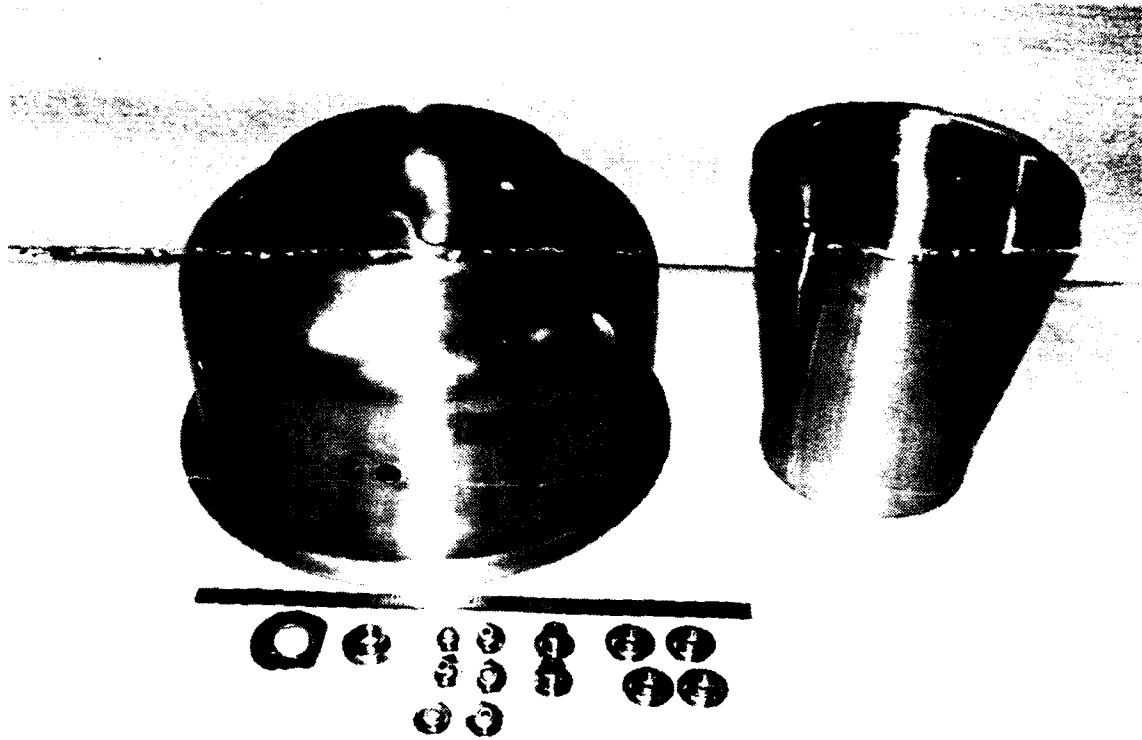


Figure 4-3-2 Basic Housing Parts



Figure 4-3-3 Complete Combustor Assembly

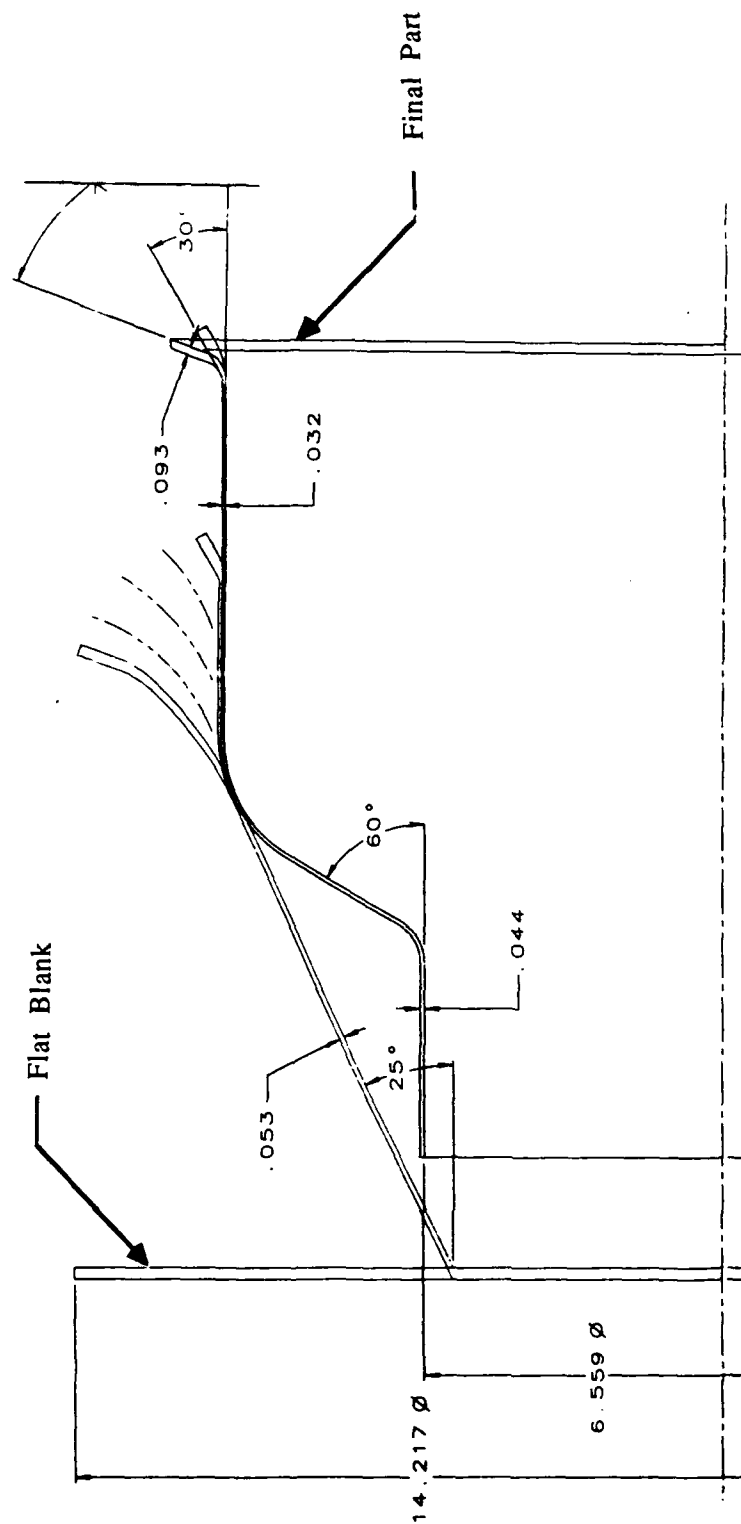


Figure 4-3-4 Housing Is Flow Formed In One Programmed Continuous Operation From A Flat Blank

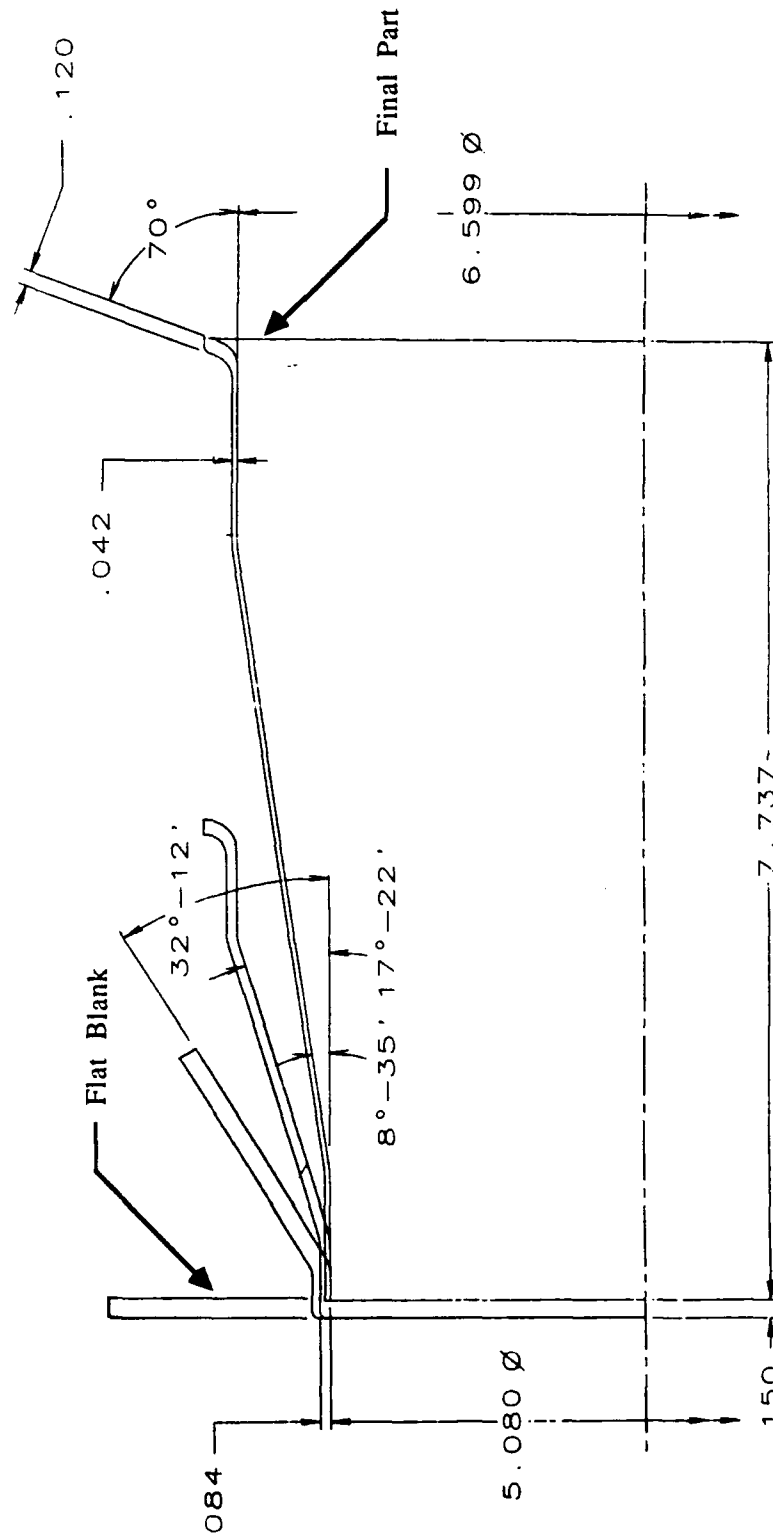


Figure 4-3-5 Diffuser Is Flow Formed In One Programmed Continuous Operation From A Flat Blank

4.4 METALLURGICAL EVALUATION

A metallurgical evaluation was initiated to determine the effects of flow forming on the mechanical properties of the Hastelloy X combustor case. The evaluation consisted of a metallographic examination and mechanical property analysis of a combustor case to the requirements of the Hastelloy X material specification AMS 5536.

4.4.1 EFFECTS OF BRAZING ON FLOW FORMED HASTELLOY X COMBUSTOR HOUSINGS

The material properties of the flow formed combustor after being exposed to a AMI 915 braze cycle were compared to the material specification AMS 5536. Evaluating the material properties after brazing will reflect the condition of the material in service. This testing included:

1. Metallographic Examination
2. Tensile
3. Stress Rupture
4. Bend
5. Chemical Composition

4.4.1.1 METALLOGRAPHIC EXAMINATION

AMS 5536 requires that sheet material under 0.125 inches thick have a grain size of ASTM No. 4 or finer. The microstructure of the as-received flow formed combustor housing varied from a grain size of ASTM No. 3 with a significant amount of deformation in the annealing twins near the exhaust end of the combustor housing (Area A, Figures 4-4-2 and 4-4-3) to ASTM No. 1.5 with very little deformation in the annealing twin in the flange of the case (Area B, Figures 4-4-2 and 4-4-4). Grain growth in the flange is to be expected because the material in the flange was annealed twice at 215 degrees F without being cold worked during the drawing and flow forming operations.

After being exposed to the braze cycle the material near the exhaust end recrystallized to an ASTM No. 5.5 grain size (Figures 4-4-3 and 4-4-5). Recrystallization indicates the material had greater than 6% cold work (ref., Universal Cyclops vendor information literature). There was no noticeable change in the microstructure of the Hastelloy X material in the flange (Figures 4-4-4 and 4-4-6).

4.4.1.2 TENSILE

The tensile properties conformed to the requirements of AMS 5536 (Figure 4-4-2 and Table I). One of the specimens was under the low limit for tensile strength and elongation but results of a retest of a specimen taken from an identical area was satisfactory.

4.4.1.3 STRESS RUPTURE

The stress rupture test results conformed to the requirements of AMS 5536 (Figure 4-4-2 and Table II).

4.4.1.5 CHEMICAL COMPOSITION

Quantitative spectrographic analysis verified that the material met the requirements of AMS 5536.

4.4.2 FLOW FORMED COMBUSTOR HOUSING SURFACE QUALITY

During the development of the formed combustor housing, penetrant indications were observed on 50% of the initial run of twenty-four housings. The housing is formed from a 0.909 inch wall thickness to 0.032 inch wall thickness in some areas. The indications were evaluated to determine the type of discontinuity.

The forming operation was broken up into two steps with an anneal operation in between. This increased the material ductility and eliminated the cracking and laps.

4.4.2.1 VISUAL EXAMINATION

Visual examination revealed that the indications were confined to two areas of the housing. One area was a 0.5 inch band which was near the middle of the 11 inch I.D. and extended around 2/3 of the circumference (Figure 4-4-7). These indications were perpendicular to the axis of the housing. The second location was the radius (Figure 4-4-7). These locations were parallel to the axis of the housing.

4.4.2.2 SEM EXAMINATION

SEM examination revealed that the indications on the radius were identified as cracks (Figure 4-4-8). One of the cracks was broken open for examination. The length of this crack was .050 inches and the depth was .008 inches (Figure 4-4-9).

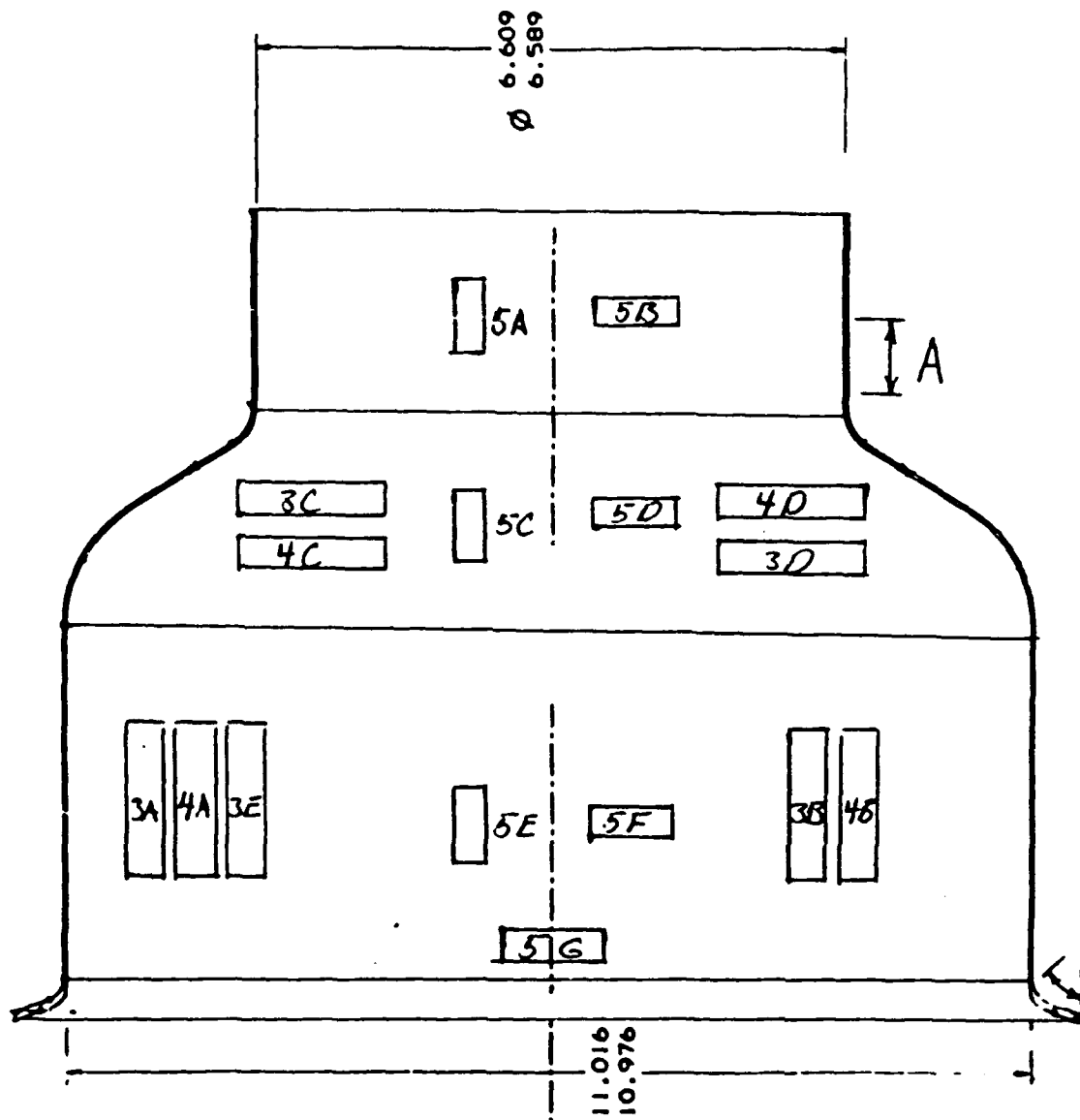
The indications in the 0.5 inch band were also examined on the SEM. The indications were identified as laps (Figure 4-4-10).

4.4.2.3 METALLOGRAPHIC EXAMINATION

Metallographic examination of the indications in the 0.5 inch band confirmed that the indications were in fact laps which were .005 inches deep (Figure 4-4-11). No material abnormalities were noted which would have contributed to the formation of the laps or cracks.

4.4.3 CONCLUSIONS AND RECOMMENDATIONS

After modifying the forming operation to include two annealing operations the surface cracks and laps were eliminated. The material near the exhaust end of the combustor housing had cold worked over 6%. This was traced to two sizing operations (Figure 4-3-1). These sizing operations are done after the final anneal and affect only the exhaust end of the combustor housing. Exposure to an AMI 915 braze cycle stress relieves the material via recrystallization. No distortion occurred after brazing, therefore, no anneal was recommended after the sizing operations since the braze cycle anneals the material.



3"X" - Tensile Specimens
4"X" - Stress Rupture Specimens

Figure 4-4-2 A sample cross section of the combustor case illustrating the location of the mechanical property test specimens and the location of the metallographic examination (Areas A and B).

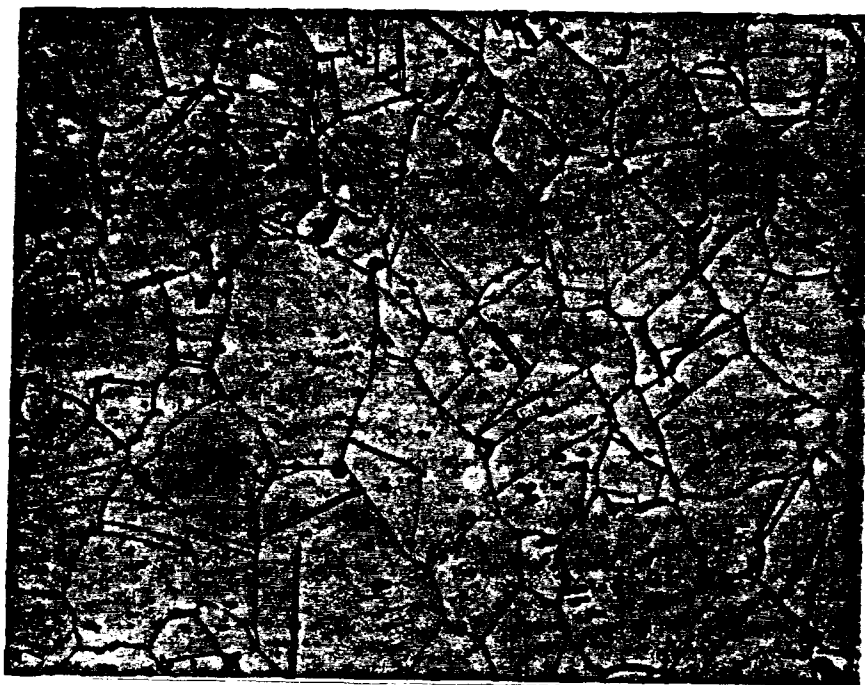


Figure 4-4-3 Metallographic cross section taken from area A (Figure 2) of the flow formed combustor case in the as-received condition. Grain size is ASTM No. 3.0. Mt. No. 90-557, Mag: 100X, Etchant: Electrolytic, 10% Oxalic Acid



Figure 4-4-4 Metallographic cross section taken from area B (Figure 2) of the flow formed combustor case in the as-received condition. Grain size is ASTM No. 1.5. Mt. No. 90-562, Mag: 100X, Etchant: Electrolytic, 10% Oxalic Acid

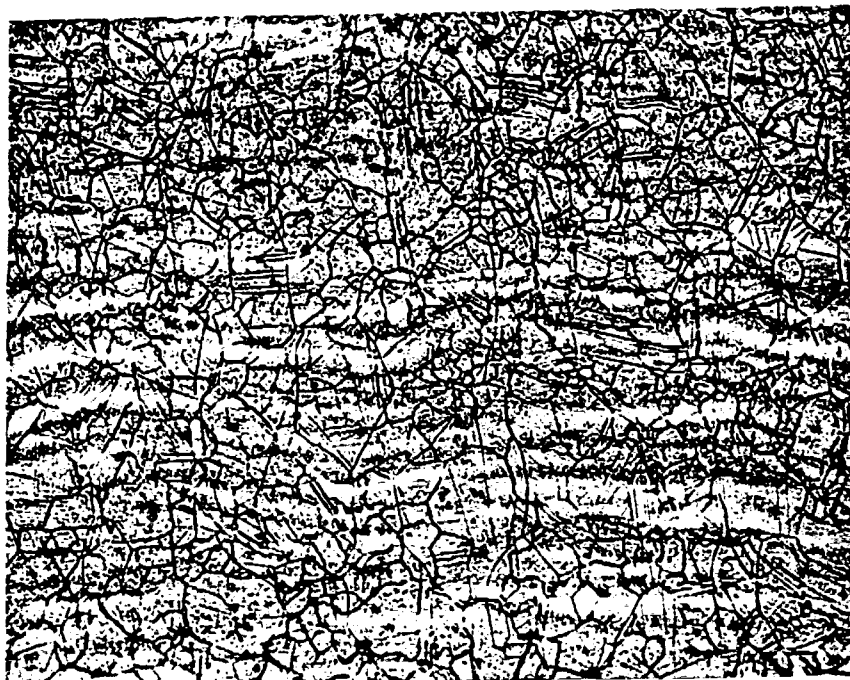


Figure 4-4-5 Metallographic cross section taken from area A (Figure 2) of the flow formed combustor case after being exposed to an AMI 915 braze cycle. Grain size is ASTM No. 5.5. Mt. No. 90-582, Mag: 100X, Etchant: Electrolytic, 10% Oxalic Acid

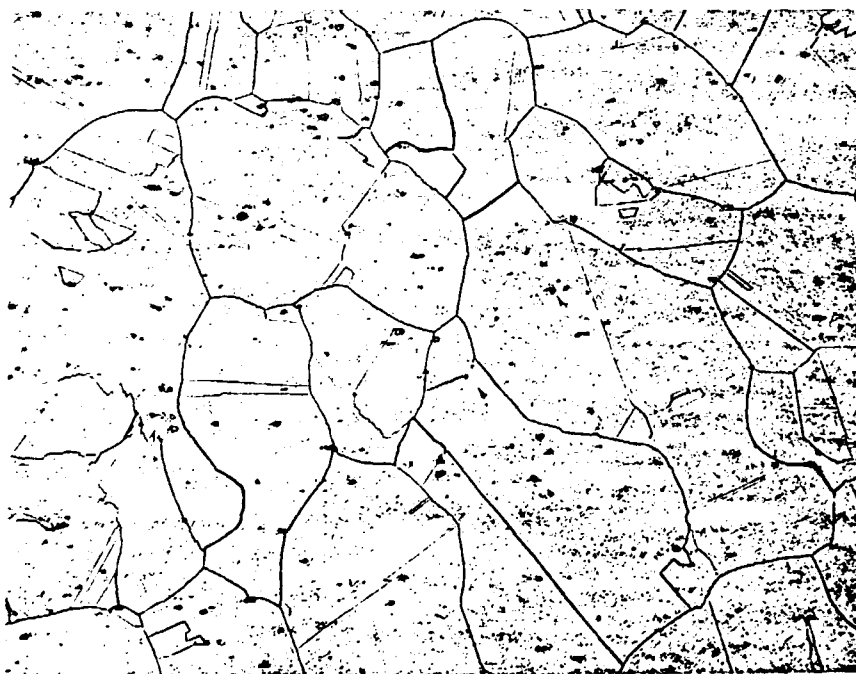


Figure 4-4-6 Metallographic cross section taken from area B (Figure 2) of the flow formed combustor case after being exposed to an AMI 915 braze cycle. Grain size is ASTM No. 1.5. Mt. No. 90-583, Mag: 100X, Etchant: Electrolytic, 10% Oxalic Acid

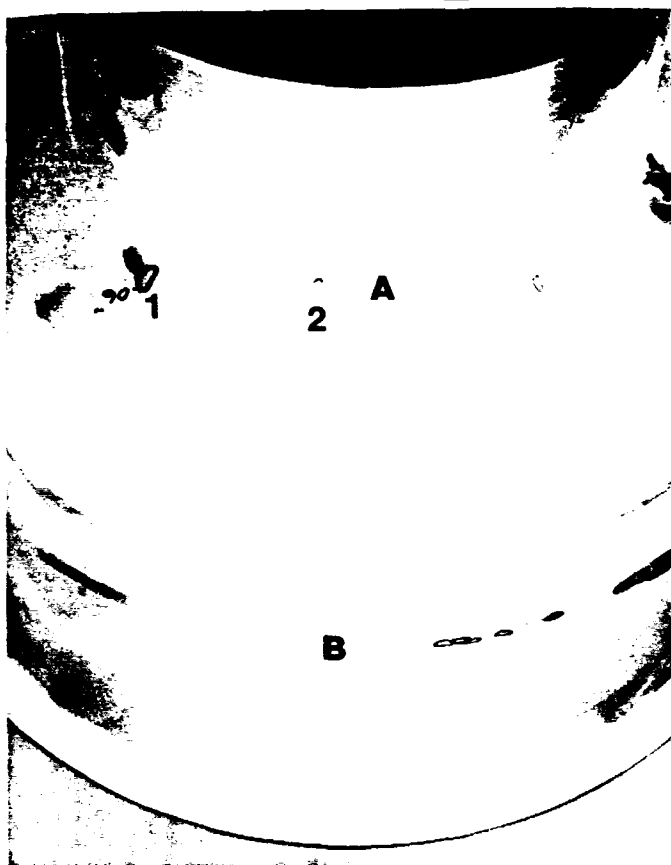


Figure 4-4-7 Overall view of combustor case documenting the location of the penetrant indications. Indications were located either in the radius (Area A) or in a 0.5" band (Area B). Mag: 0.67x

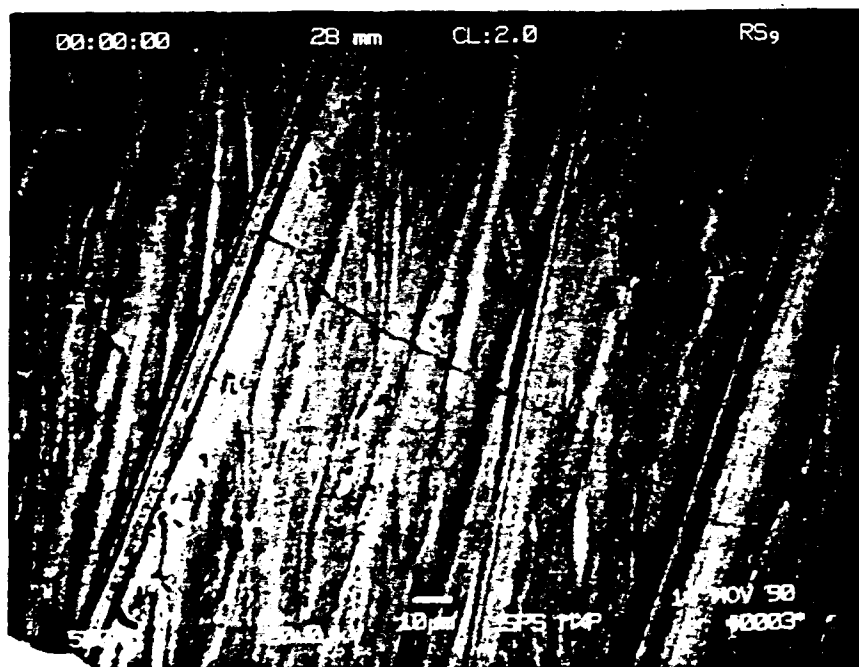


Figure 4-4-8 SEM photograph documenting the crack A1, Figure 7. This crack was parallel to the axis of the combustor case. Mag: 500x



Figure 4-4-9 SEM photograph documenting the crack A2, Figure 7, which was broken open for SEM examination. The depth of the crack was .008" and the length was .005" (arrows). Mag: 40x

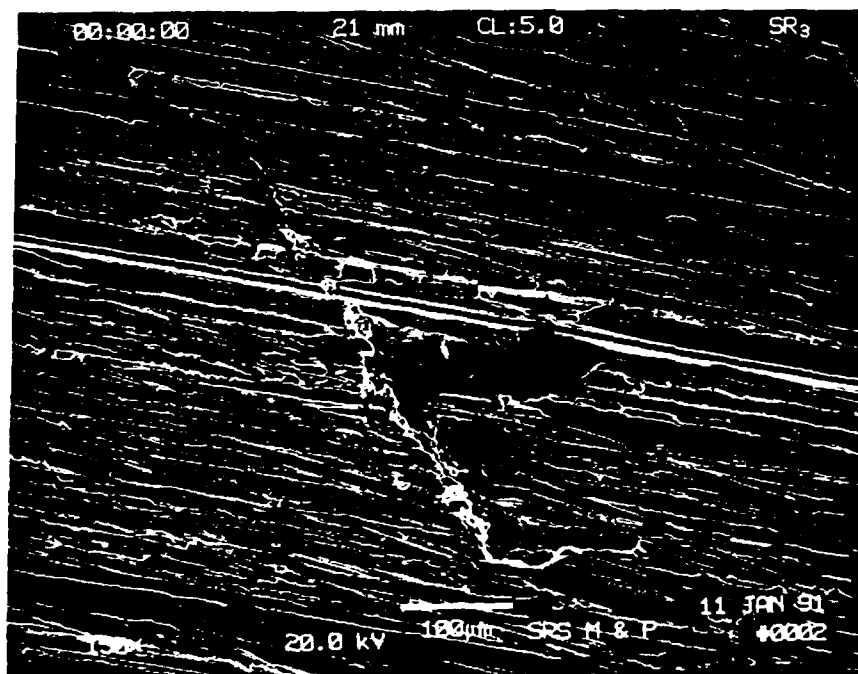


Figure 4-4-10 SEM photograph documenting a typical indication (arrows) in Area B of Figure 7. Mag: 150x



Figure 4-4-11 Metallographic cross section of the indication in Figure 10 verifying that the indication was a lap. The depth of this lap was .005". Mt. No. 91-610, Mag: 200x.

TABLE I. TENSILE RESULTS FOR THE FLOW FORMED COMBUSTOR CASE

<u>Location</u>	<u>Specimen I.D.</u> <u>(Fig. 2)</u>	<u>Yield Str.</u> <u>(0.2%, ksi)</u>	<u>Tensile Str.</u> <u>(ksi)</u>	<u>Elongation</u> <u>(% in 4D)</u>
11" I.D.	3A	48.1	103.6	32.0
	3B	48.0	105.3	41.0
	3E	46.2	108.0	42.0
11"I.D. to 6.6" I.D. Transition	3C	50.4	115.8	41.0
	3D	55.6	110.8	44.0
AMS 5536 Minimum Requirements		45.0	105.0	35.0

TABLE II. STRESS RUPTURE RESULTS FOR THE FLOW FORMED COMBUSTOR CASE

<u>Location</u>	<u>Specimen I.D.</u> <u>(Fig. 2)</u>	<u>Test Temp.</u> <u>(F)</u>	<u>Stress</u> <u>(ksi)</u>	<u>Hrs. to</u> <u>Fracture</u>	<u>Elongation</u> <u>(% in 4D)</u>
11" I.D.	4A	1500	22.0	43.7	59.0
	4B	1500	20.0	44.6	35.0
11"I.D. to 6.6" I.D. Transition	4C	1500	18.0	44.5	105.0
	4D	1500	20.0	45.6	86.0
AMS 5536 Minimum Requirements		1500	16.0	24.0	8.0

4.5 TEST VALIDATION/QUALIFICATION

The qualification of the flow formed combustor assembly for the T-62T-40LC-2 APU is hereafter referred to as "the unit". The new unit developed under the IMIP project is nearly identical to the current configuration and is interchangeable, but a qualification test was necessary due to the slight differences in shape, metal thickness (one piece design), and material properties. The new unit is expected to be superior as a result of the one piece construction, controlled metal thickness, and fewer number of parts. The unit was tested in conjunction with qualification test of the APU. See Figure 4-5-1, showing the combustor housing installed.

4.5.1 TEST REQUIREMENTS

This test will qualify the Turbine Wheel, Nozzle, Containment Ring Extension, and the Combustor Housing.

4.5.1.1 TEST FACILITY REQUIREMENTS

4.5.1.1.1 FUEL

Fuel used during the Qualification Test shall be JP-4. Samples verifying the specific gravity shall be recorded during the 500 start inspection intervals.

4.5.1.1.2 OIL

Oil conforming to MIL-L-7808 shall be used throughout the test. The oil shall be changed during each 500 start inspection interval.

4.5.1.1.3 STARTING

APU starting shall be accomplished using a hydraulic start cart P/N PC75763 designed to simulate the aircraft hydraulic start system.

4.5.1.1.4 LOAD ABSORPTION

The facility bleed ducting shall include a 2-1/2 inch valve, downstream of the customer valve, which will be in the full open position to create a fixed bleed system back pressure. A water dynamometer will be used to apply shaft loading.

4.5.1.1.5 APU INSTALLATION

The APU will be tested in one of the Development Test Facilities located at 4400 Ruffin Road, San Diego, CA. Mounting on the test stand shall be accomplished using facility mounts, which attach to the APU gearbox, and a single support of the powerhead at the six (6) o'clock position.

The APU exhaust shall be directed through the facility exhaust ducting.

The fuel pressure from the facility system shall be regulated to maintain an APU fuel pump inlet pressure of 5 psig to 40 psig.

The APU oil will be directed through a facility oil cooler utilizing the "TO COOLER" and the "FROM COOLER" ports on the gearbox.

The APU will be tested with the inlet air muff installed. Prevailing test cell environment air will be drawn into the muff and consumed at approximately three hundred six (306) ppm.

Facility shop air at 70 psig and 90 psig will be ducted into the APU/facility exhaust ducting in accordance with the Test Duty Cycle. This air is intended to reduce the turbine wheel bulk temperature to simulate a cold start for each cycle.

A Systems and Controls Engineering/facility load cycle controller will provide for automated start and run operation for Cycles A and B. This load cycle also controls the shop air ON and OFF. An interlock function is programmed into the load cycle to prevent APU restarting until a complete thermal cycle is completed.

Load absorption shall be accomplished by directing the load compressor discharge air via facility ducting through a customer start control valve. Bleed and bypass operation will be controlled by the ESCU.

4.5.1.2 TEST DUTY CYCLES

The Qualification Test shall consist of the following cycles:

CYCLE A Start and run for two (2) minutes at 1200 °F EGT NORMAL MODE. Add a 20 HP shaft load and run for twenty-five minutes in GEN ONLY MODE. Remove shaft load and continue running to GEN ONLY MODE for eighteen (18) minutes.

Stop and wait until EGT is ≤ 300 °F (AIR OFF). Turn air on until EGT is ≤ 100 °F.

CYCLE B Start and run for fifteen (15) minutes NORMAL MODE.

Stop and wait until EGT is ≤ 300 °F (AIR OFF). Turn air on until EGT is ≤ 100 °F.

CYCLE C Start and run in EWO (1300°F EGT) for forty-five (45) minutes.

Stop and wait until EGT is ≤ 300 °F (AIR OFF). Turn air on until EGT is ≤ 100 °F.

A graphic display of the above cycles is shown in Figure 4-5-2.

Currently, we are required to provide the following service life per the BMA SOCD 458-50065:

HOURS	1010
EWO	25
STARTS	750

This qualification test plan will demonstrate:

HOURS	1035
EWO	27
STARTS	2052

The APU hourmeter and event (start) counter shall be used to document the starts and operating hours during this qualification test.

Cycles A and B will be controlled by an automatic load cycler. Cycle C will be controlled manually.

4.5.1.2.1 ENGINE INSPECTION

Periodic inspections will be performed at approximately 250 start intervals. The inspections will include visual inspection of each part being qualified.

4.5.1.2.2 CONDITIONS REQUIRING SHUTDOWN

The mandatory limits are those limits which would normally cause the engine to shut down on its own protective circuits. Operation in excess of these limits shall be cause for immediate shutdown of the test unit and determination of the cause for failure of the automatic shutdown.

The discretionary limits are those limits which rely on the observation of the Test Operator to initiate an engine shutdown should the engine operation exceed any of the specified limits. The Test Operator shall shut down the unit unless the Test Engineer is available for immediate consultation. These limits may be exceeded at the instruction of the Test Engineer within the limits of reasonable engineering practice.

The following are the limits of operation to be observed during all phases of testing:

- a) Evidence of fuel or air leak.
- b) Abnormal noise, smoking, or exhaust flame.
- c) Vibration in excess of 5 Gs at rotor frequency when operating under pneumatic load and/or shaft load. Vibration in excess of 10 Gs at rotor frequency when operating under no pneumatic load (IGV's closed) nor shaft load.
- d)* Oil pressure below 18 psig at 100 percent speed.
- e)* Oil sump temperature exceeds 275 °F.
- f) Surge at any time during operation or acceleration.
- g) Exhaust gas temperature that exceeds 1320 °F for more than 10 seconds.
- h) Measurable oil consumption exceeds 20 cc/Hr as measured at the reduction gearbox oil vent.

- i) Speed variation at constant load exceeds 0.5 percent. Speed variation during on/off load transient exceeds 2 percent.

* Mandatory shutdown

4.5.1.3 INSTRUMENTATION

All instrumentation shall be inspected and certified to be within calibration. Development Test Engineering shall be responsible for meeting these requirements. The data requirements intervals are listed in Table I.

4.5.2 TEST RESULTS

The combustor housing assembly of the new proposed design and configuration underwent all test conditions without any indication of any material or design weaknesses. Testing validated the design and analyses covered in Sections 3.0, 4.0, and 5.0 of this report.

Duty cycles were run continuously 24 hours per day. Occasional interruptions were made for inspection, troubleshooting, and facility maintenance. The test duty cycle involved three different operating cycles separated by identical cool down cycles, reference Section 4.5.1.2. One C (EWO) cycle was run for every 28 A and B cycles (one C cycle for each 57 total cycles). The A and B cycles were executed automatically through the use of a "load cyler box". After the EGT cooled to 100 °F, the cooling air was automatically turned off and the load cyler initiated another start. The C cycles were run at convenient times and were initiated manually but runs automatically once initiated.

A summary of significant events is shown in Figure 4-5-3.

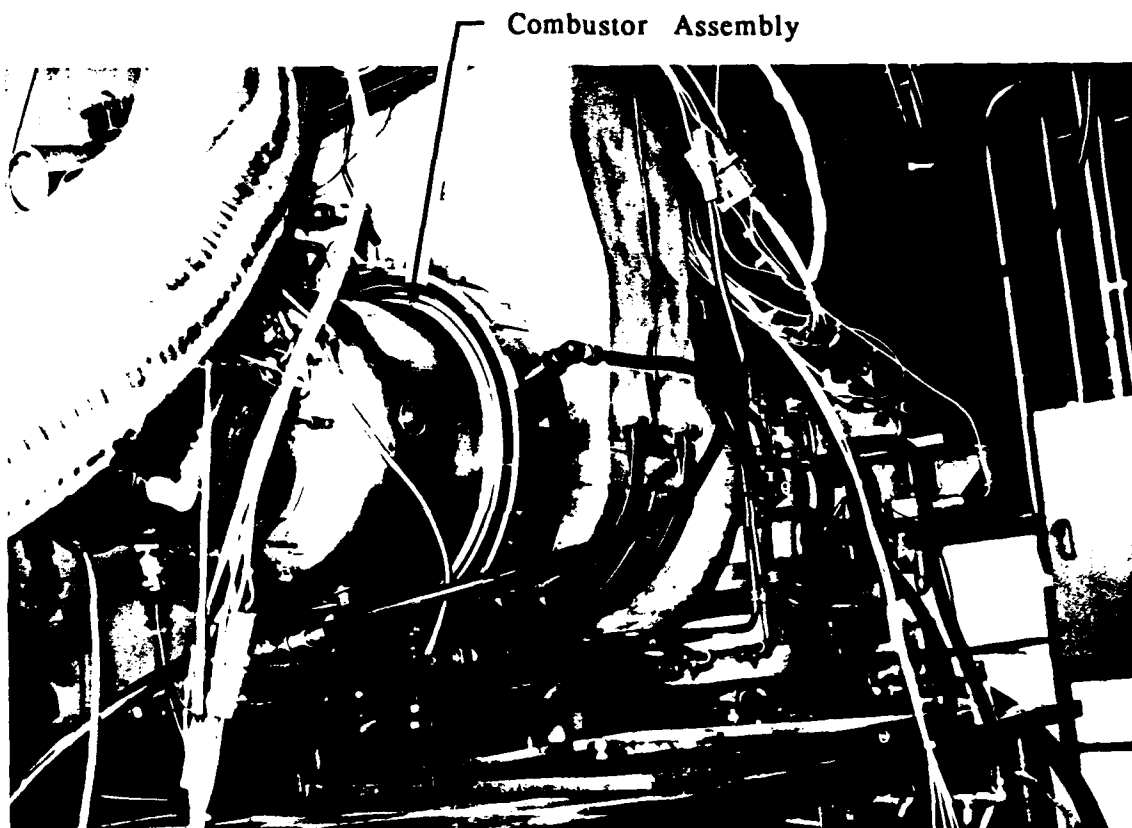


Figure 4-5-1 Test Set-up

KC-135R IR&D ENDURANCE TESTS
SIGNIFICANT EVENT SUMMARY

DATE	EVENT	CYCLE	HOURS	EVENTS
01/24/91	START COATED TURBINE WHEEL TEST ON APU 850568	0	0.0	0
02/06/91	REMOVE APU 850568 (NOTE: ENGINE USING 200-300 CC/HR OIL)	275	144.1	327
02/07/91	INSTALL APU 001 W/ BORELESS TURBINE WHEEL	0	0.0	0
02/08/91	HYDRAULIC STARTER SHAFT SHEARED APU 001	3	1.0	5
02/13/91	REMOVED APU 001 DUE TO HIGH VIBES	122	59.8	125
02/21/91	INSTALL COATED TURBINE WHEEL APU 850568	275	144.1	327
02/27/91	INSTALLED NEW PURGE ORIFICE AND START NOZZLE	431	223.7	501
03/04/91	REMOVE APU 850568	514	226.5	585
03/05/91	INSTALL APU 001 W/ RESRETCHED TIEBOLT,	122	59.8	125
03/16/91	END OF BORELESS T/W TEST APU 001 (201 A, 209 B, 7 C CYCLES)	417	208.9	434

Note: A SINGLE HAST-X COMBUSTOR WAS USED FOR TESTING ON BOTH ENGINES AND ACCUMULATED A COMBINED RUNTIME OF 435.4 HRS/1019 EVENTS

Figure 4-5-3 Summary Of Significant Test Events

5.0 LASER TECHNOLOGY

5.1 TECHNICAL APPROACH

Current combustor housings are brazed assemblies which require about 10 hours/ combustor to assemble. A flow formed combustor minimizes labor by reducing the number of components and is estimated to require 5.2 hours per combustor. Labor required to assemble a combustor would be reduced even further by laser welding which is estimated to require 2.3 hours per combustor.

Before laser welding can be considered for combustor applications specific process parameters have to be developed and evaluated. The laser weld joints must be as strong in shear as the .040 inch Hastelloy X base metal in tension and have a fatigue life comparable to the current brazed joint design.

5.2 LASER WELD PARAMETERS AND JOINT DESIGN

5.2.1 Tensile Test Procedure

Panels were assembled in a joint design which simulates a boss welded to the combustor case (Figure 5-14) and a diffuser welded to the combustor case (Figure 5-15). To evaluate the effects of weld types, fusion zone width, and gap width on the weld joint design, panels were welded together using two weld types, two fusion zone widths (.040 inch and .080 inch), and two gap widths (.006 inch and .010 inch). Tensile specimens were machined from these panels and tested per ASTM E8 (Figure 5-1).

The variables evaluated by the tensile testing were:

Weld Joint Design: Three piece lap joint using Hastelloy X and 347 CRES.
Two piece lap joint using Hastelloy X to Hastelloy X.

Weld Types: 90 Degree Fillet (Figures 5-16 and 5-17)
Seam Weld (Figures 5-18 and 5-19)

Fusion Zone Width: 1 or 2 times the base metal thickness (.040 inch or .080 inch)

Gap Width: .006 inch and .010 inch

A Trump 1500 Watt CO 2 laser was selected for the test program. This laser simulates the type of laser which would be purchased through the IMIP program. The fusion zone widths to be evaluated were one and two times the base metal thickness (.040 inch and .080 inch). Linear welds were made on panels of Hastelloy X to Hastelloy X and Hastelloy X to 347 CRES using various laser settings. The laser parameters which resulted in a .040 inch fusion zone at the interface of the .040 inch panels were:

Power: 1500 Watts

Focal Length: 3.75 inches

Focus: 1/3 down from maximum height

Backup gas: Helium, 85 psi both sides

Travel Speed: 40 inches per minute

Pulse Setting: Continuous Wave, 95% Power, 5 khz

To achieve a fusion zone width of .080 inch two passes .040 inch apart were used.

5.2.2 TENSILE RESULTS

Results of room temperature tests appear in Table I. All of the fractures occurred outside the weld. The three piece joint design typically failed just outside the heat affected zone while the two piece joint design typically failed away from the weld (Figure 5-1).

5.2.3 HIGH CYCLE FATIGUE (HCF) TEST PROCEDURE

Panels for HCF testing of the two piece lap joint design were identical to the tensile panels (Figure 5-15). The panels for the HCF testing of the three piece lap joint were modified by reducing the 347 CRES strip from 1.5 inches to 0.75 inch to fit within the gauge section and adding a laser weld in the center (Figure 5-20).

One weld type, a 45 degree fillet, was added to the HCF testing. In the 45 degree fillet weld (Figure 5-21) the weld beam impacts the base metal at a 40 degree angle vs. a 90 degree angle for the seam and 90 degree fillet welds (Figures 5-16 and 5-18). The fusion zone width was held constant at .040 inch, and the gap widths were .006 inch and .010 inch.

The variables evaluated by the HCF testing were:

Weld Joint Design: Three piece lap joint using Hastelloy X and 347 CRES.
Two piece lap joint using Hastelloy X to Hastelloy X.

Weld Types: 45 Degree Fillet (Figure 5-20)
90 Degree Fillet (Figures 5-16 and 5-17)
Seam Weld (Figures 5-18 and 5-19)

Fusion Zone Width: .040 inch

Gap Width: .006 inch and .010 inch

HCF specimens were machined from these welded panels and tested (Figure 5-10). The test parameters were:

Specimen Type: Cantilever Bend

Mode: Full reversal

Temperature: Ambient

R Ratio: -1

Frequency: 30 Hz

Cycles to Failure: 5×10^5 - 10^7

5.2.4 HCF RESULTS

The results appear in Figures 5-7, 5-8, 5-22, 5-23, and Tables II and III.

Three Piece Lap Joint, .006 inch Gap Width: The 45 degree fillet welds had the best HCF properties (Figure 5-7). The 45 degree fillet weld had a concave fillet vs. the 90 degree fillet welds which had a convex weld (Figures 5-16 and 5-21). The concave fillet was more effective at minimizing the stress concentration at the weld than the convex fillet.

Two Piece Lab Joint, .006 inch Gap Width: There was no difference in the HCF properties between the 90 degree fillet weld and the seam weld (Figure 5-8). The 90 degree fillet weld was expected to have better HCF properties because the fillet would minimize the stress concentration, but this was not the case.

Three Piece Lap Joint, .010 inch Gap Width: There was no significant difference between the fatigue strength of the 45 degree fillet weld and the 90 degree fillet weld (Figure 5-22). The fatigue strength of the .010 inch gap width 90 degree fillet weld specimens increased compared to the .006 inch gap width specimens (Figures 5-7 and 5-22).

Two Piece Lap Joint, .010 inch Gap Width: The 90 degree fillet weld specimens had a higher fatigue strength than the seam weld specimens (33 ksi vs. 23 ksi at 10 to the 6th. cycles, Figure 5-23). The gap width has a minimal affect on the fatigue strength of the 90 degree fillet weld specimens (32 vs. 32 ksi fatigue strength at 10 to the 6th. cycles, Figures 5-8 and 5-23). However, the .010 inch gap width resulted in a 30% reduction in fatigue life for the seam weld specimens (33 vs. 23 ksi fatigue strength at 10 to the 6th. cycles, Figures 5-8 and 5-23).

5.3 EFFECTS OF RECAST LAYER ON HIGH CYCLE FATIGUE

One aspect of IMIP is to reduce cost by the use of laser technology in the fabrication of sheet metal components. Laser trimming and cutting are two ways to reduce cost.

The main concern is that the recast layer may have an adverse effect on high cycle fatigue (HCF) life. The current practice for laser machined combustor cases is to allow .002 inch max. recast layer with no microcracks. The following evaluation was initiated to quantify the effects of the depth of recast layer on HCF properties of laser machined sheet metal components.

5.3.1 PROCEDURE

In order to establish the laser parameters, single cuts were made in Hastelloy X sheets varying the travel speed, flow through gas pressure, and wave mode. A 1000 Watt Mazak Laser was used in this study.

To achieve .006 inch of recast layer both travel speed and flow through gas pressure had to be reduced. After numerous attempts it was decided to keep the travel speed and mode constant, and modify the back-up gas pressure to achieve the various depths of recast layer.

The laser parameters were:

Power: 1050 Watts

Travel Speed: 1 inch per minute

Pulse Setting: Continuous wave

Back-up Gas Pressure: 30 psi - .006 inch recast layer
 60 psi - .004 inch recast layer
 120 psi - .0025 inch recast layer
 160 psi - .001 inch recast layer

To minimize material variation effects, all of the HCF specimens were machined from the same sheet of Hastelloy X. The specimen geometry is shown in Figure 5-25.

The depth of recast layer was not consistent along the length of the gauge region (Figure 5-25). One of the reasons that cantilever bending HCF specimens were selected was to maximize the area of constant stress (the entire gauge region is under constant stress) thus minimizing the effects of the recast layer being inconsistent. Cantilever bending HCF specimens are also the best specimen geometry for simulating the loading of the combustor case.

The specimens were deburred. Another batch of specimens were machined on an end mill and tested as a baseline without being polished.

The test parameters were:

Specimen Type: Cantilever Bend

Mode: Full reversal

Temperature: Ambient

R Ratio: -1

Frequency: 30 Hz

Cycles to Failure: $5 \times 10^5 - 10^7$

5.3.2 Results

The results appear in Figures 5-11, 5-26, 5-27, and Table IV. There was a direct relationship between the depth of recast layer and the endurance limit. Based on limited data, the difference in the endurance limit between a machined surface and .0025 inch thick recast layer is 8 ksi or 20% reduction in the endurance limit (38 ksi vs. 30 ksi, Figures 5-9 and 5-10). The difference between a .0025 inch recast layer and .006 inch was minimal (Figures 5-10 and 5-11).

A metallographic examination of the gauge section of one HCF specimen representing each depth of recast layer revealed that there were no microcracks, even in the specimens with .006 inch of recast layer. There was evidence of carbide precipitation at the grain boundaries adjacent to the recast layer (Figure 5-12).

5.4 HIGH CYCLE FATIGUE PROPERTIES OF AMS 4777 AND AMI 915 BRAZE JOINTS

The current combustors are brazed assemblies. Two nickel base braze alloys used at Sundstrand Power Systems are AMS 4777 and AMI 915. Some combustors have failed in the field because a high cycle fatigue crack has originated in the braze fillet. Determining which braze alloy has the best HCF properties is key to improving the life of combustors.

The AMS 4777 alloy will be evaluated in the as-brazed condition and the AMI 915 alloy will be evaluated in the as-brazed condition and also after a diffusion heat treatment. The diffusion heat treatment would improve toughness which may improve HCF properties. The diffusion heat treatment may also be weld repairable which would reduce combustor housing repair costs.

5.4.1 PROCEDURE

Panels of .040 inches thick Hastelloy X were resistance spot welded to a 0.75 inches strip of 347 CRES to simulate a boss being brazed to the Hastelloy X combustor case (Figure 5-20). The material was from the same sheet of Hastelloy X cut perpendicular to the grain flow. These panels were brazed using the AMS 4777 and AMI 915 braze alloys. HCF specimens were machined from these panels and tested.

The test parameters were:

Specimen Type: Cantilever Band

Mode: Full reversal

Temperature: Ambient

R Ratio: -1

Frequency: 30 Hz

Cycle to Failure: 5×10^5 - 10^7

5.4.2 RESULTS

Results appear in Figure 5-7 and Table V. Most of the fatigue origins were adjacent to the braze fillet (Figure 5-2). The endurance limit of the brazed specimens varied from 36 ksi for the AMS 4777 specimens (Figure 5-5) to 33 ksi for the AMI 915 specimens (Figures 5-6 and 5-7). The lower fatigue limit of the AMI 915 specimens is the result of grain growth in the base metal due to the higher brazing temperatures (Figures 5-28 and 5-29).

5.5 EFFECTS OF BRAZING TEMPERATURES ON 347 CRES

The current braze alloy, AMI 915, requires a brazing temperature of 2100°F or 50°F above the maximum recommended annealing temperature of 347 CRES (1800-2050°F). These temperatures may affect performance by causing grain growth and reducing tensile strength, especially in thin (.040 inches) sheet.

The braze cycles selected for evaluation were AMS 4777 and AMI 915. Both of these braze alloys are nickel base and are commonly used in combustor applications. The braze cycle for AMS 4777 is 1950F for 7 minutes and the braze cycle for AMI 915 is 2100F for 9 minutes. The panels will be exposed to each braze cycle twice to simulate a worst base scenario.

The recommended annealing temperature for 347 CRES is 1800-2020°F. Exposing the thin (.040 inches thick) 347 CRES sheet stock to temperatures above 1900F may have an adverse affect on mechanical properties.

5.5.1 PROCEDURE

A 36 inches x 6 inches x .040 inches sheet of 347 CRES per AMS 5512 was divided into 3 segments. One segment was tensile tested in the as-received condition, one segment was exposed to two AMS 4777 braze cycles (195°F for 14 min.) and one segment was exposed to two AMI 915 braze cycles (2100°F for 18 min.). Tensile specimens were machined from the panels in the longitudinal and transverse directions and tested per ASTM E8 (Figure 5-30).

Metallographic cross sections were made of the forementioned panels in the longitudinal and transverse directions. Grain size was measured per ASTM E112.

5.5.2 RESULTS

Results appear in Figure 5-13 and Table VI. The effect of the braze cycle is most noticeable in the yield strength. There was a reduction of 5 ksi in the yield strength between the as-received specimens and the specimens exposed to the AMS 4777 braze cycles. There was a 9 ksi reduction in yield strength between the as-received specimens and the specimens exposed to the AMI 915 braze cycles.

The main effect of the braze cycles on the microstructure of the panels was grain growth. The grain size increased from ASTM No. 10 in the as-received material, to ASTM No. 9 after exposure to the AMS 4777 braze cycles, to ASTM No. 6 after exposure to the AMI 915 braze cycles (Figures 31-33). There is a direct correlation between the reduction in yield strength and the increase in grain size (Figure 5-13 and Table VI).

5.6 CONCLUSIONS

A fusion zone width equal to or greater than the base metal thickness results in a weld joint which is stronger than the base metal regardless of the weld joint design, weld type, or gap width (Figure 5-1 and Table I).

The brazed specimens had higher endurance limits than the welded specimens. The endurance limit for the brazed specimens varied from 33-36 ksi compared to 22-26 for the welded specimens (three piece lap joint, .006 inches gap width, Figures 5-2 - 5-7). If the welded specimens are exposed to the AMI 915 braze temperatures (2100F for 9 min.) the endurance limit may be reduced even further by grain growth in the base metal.

For a three piece lap joint with a .006 inch gap width the 45 degree fillet weld has the best HCF properties (Figure 5-7).

For a two piece lap joint with a .006 inch gap width, a seam weld and a 90 degree fillet weld have equivalent HCF properties (Figure 5-8).

Based on limited data, increasing the depth of recast layer from 0.0 (a machined surface) to .0025 inch of recast layer (our current standard is .002 inches) would result in an 8 ksi or 20% reduction in the endurance limit (28 ksi vs. 21 ksi, Figures 5-9 and 5-10). Increasing the depth of recast layer from .0025 inch to .006 inch had a minimal effect on the endurance limit (Figures 5-10 and 5-11).

Laser machining causes carbide precipitation at the grain boundaries adjacent to the recast layer. The effect of carbide precipitation in the grain boundaries of the Hastelloy X would be to reduce elongation by up to 50% and low cycle fatigue strength by up to 25% (ref. Superalloys 1988 Symposium Proceedings). The volume of material affected by the carbide precipitation is small (.012 inch thick layer, Figure 5-12), therefore the overall effect on the low cycle fatigue life of the combustor case is negligible.

The AMS 4777 brazed specimens has a 3 ksi or 8% higher endurance limit than the AMI 915 brazed specimens (36 ksi vs. 33 ksi, Figure 5-7). This was attributed to grain growth due to the higher brazing temperatures of the AMI 915.

The braze cycles caused grain growth which resulted in lower tensile properties for the specimens exposed to the braze temperatures (Figure 5-13).

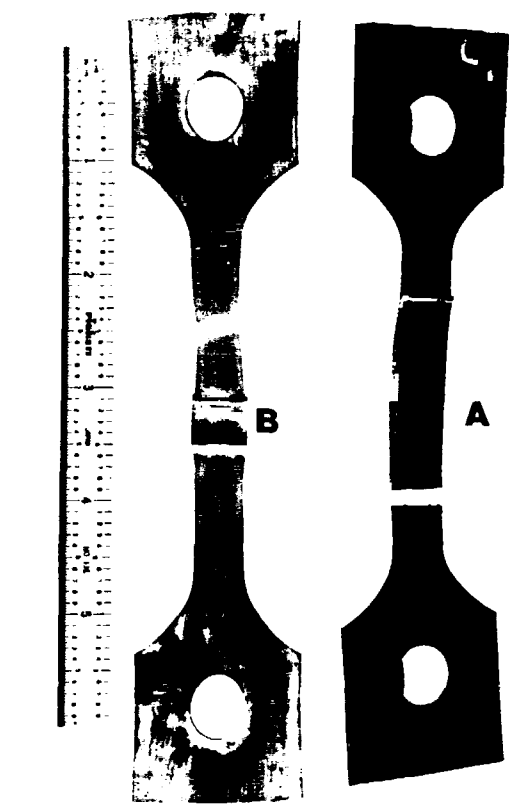


Figure 1. Typical tensile fracture. The fractures occurred adjacent to the weld in the heat affected zone in the three piece joint design (A), and away from the weld in the two piece joint design (B).

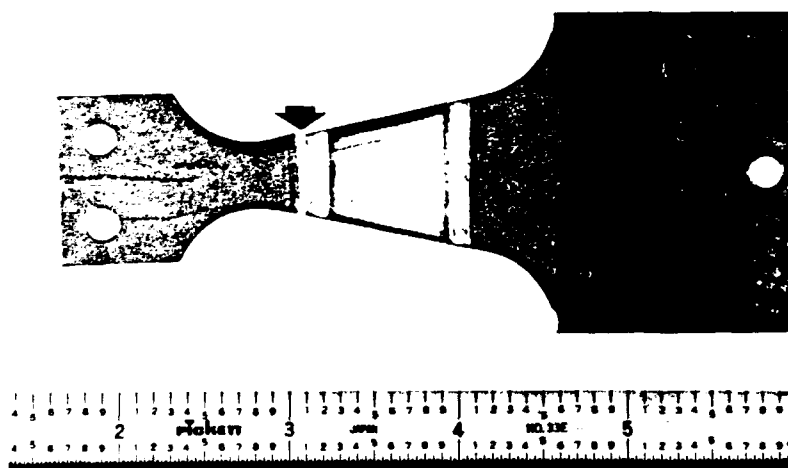


Figure 2. Typical brazed cantilever bending HCF specimen. Failures occurred just outside the braze fillet (arrow).

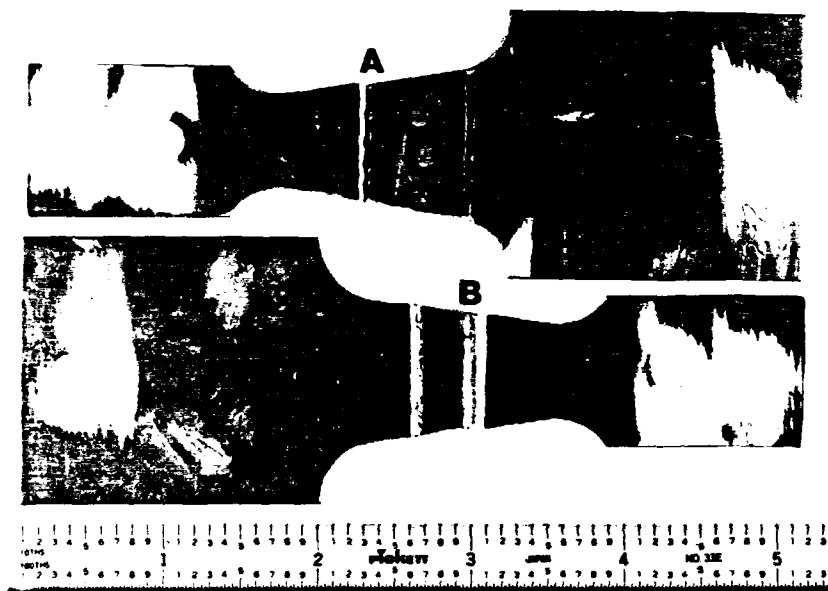


Figure 3. Typical Laser Welded HCF specimens after testing. Specimen A is a three piece joint design (0.75" wide CRES strip) and specimen B is a two piece joint design. The failures occurred just outside the weld in the heat affected zone.

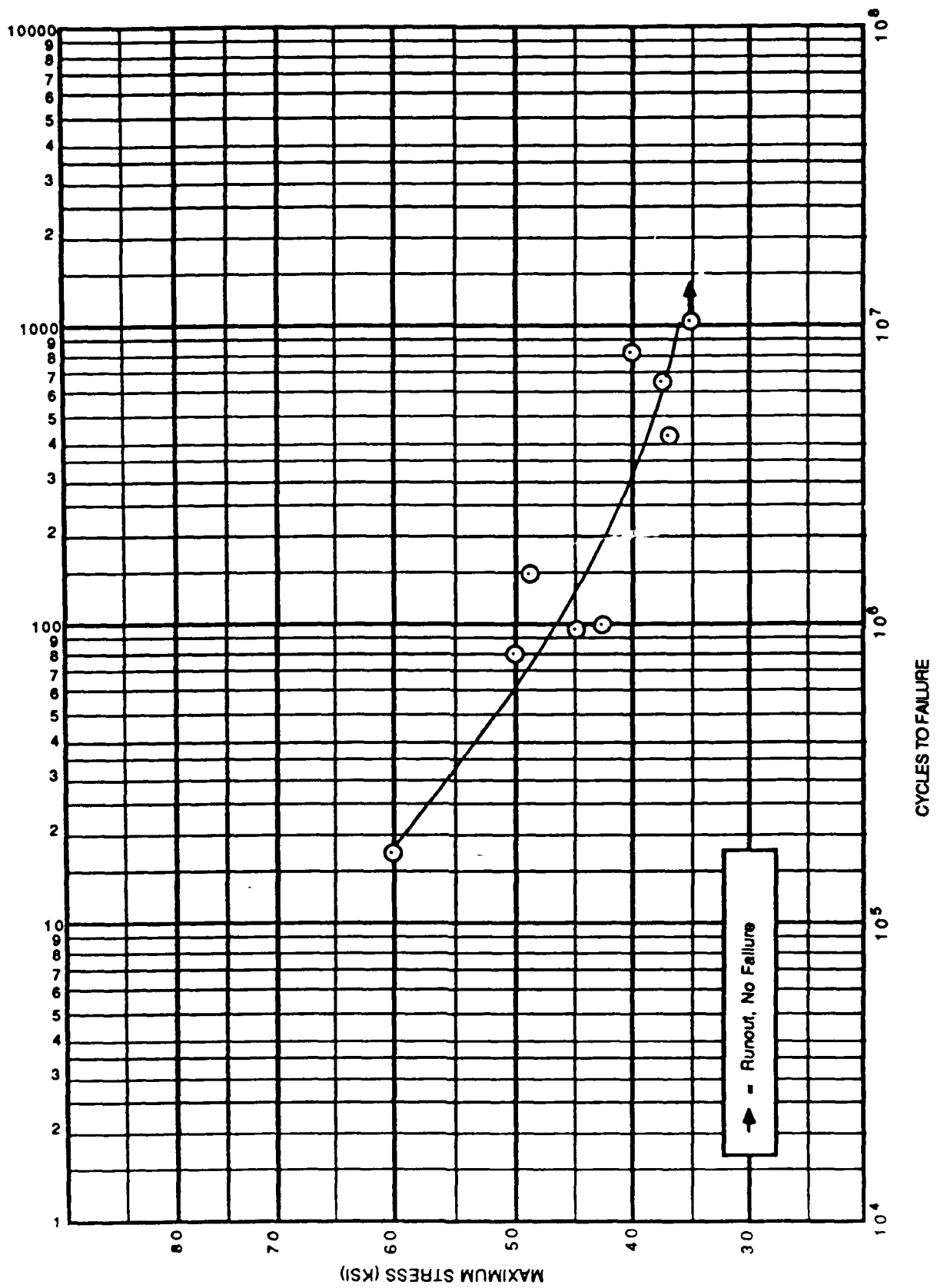
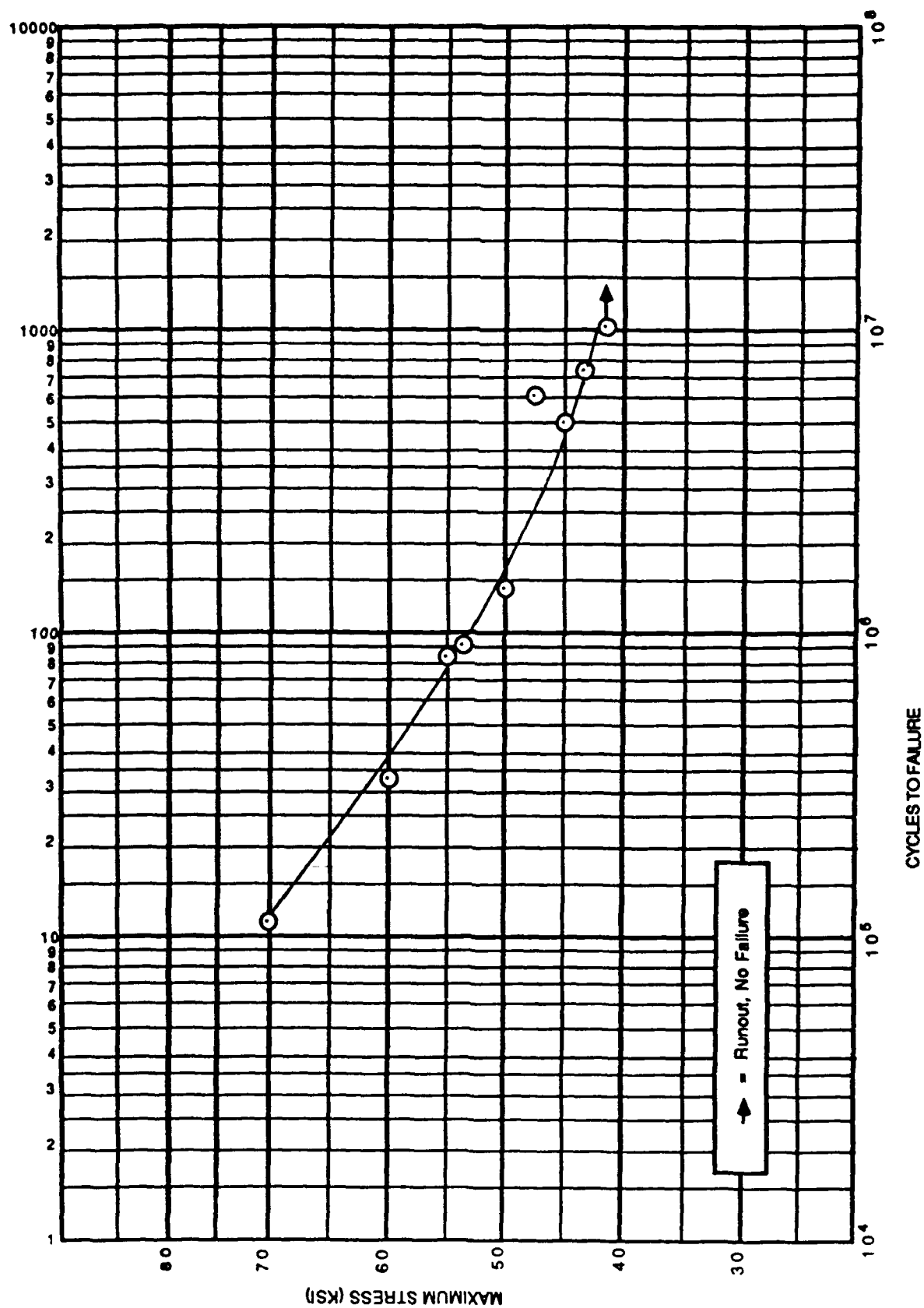
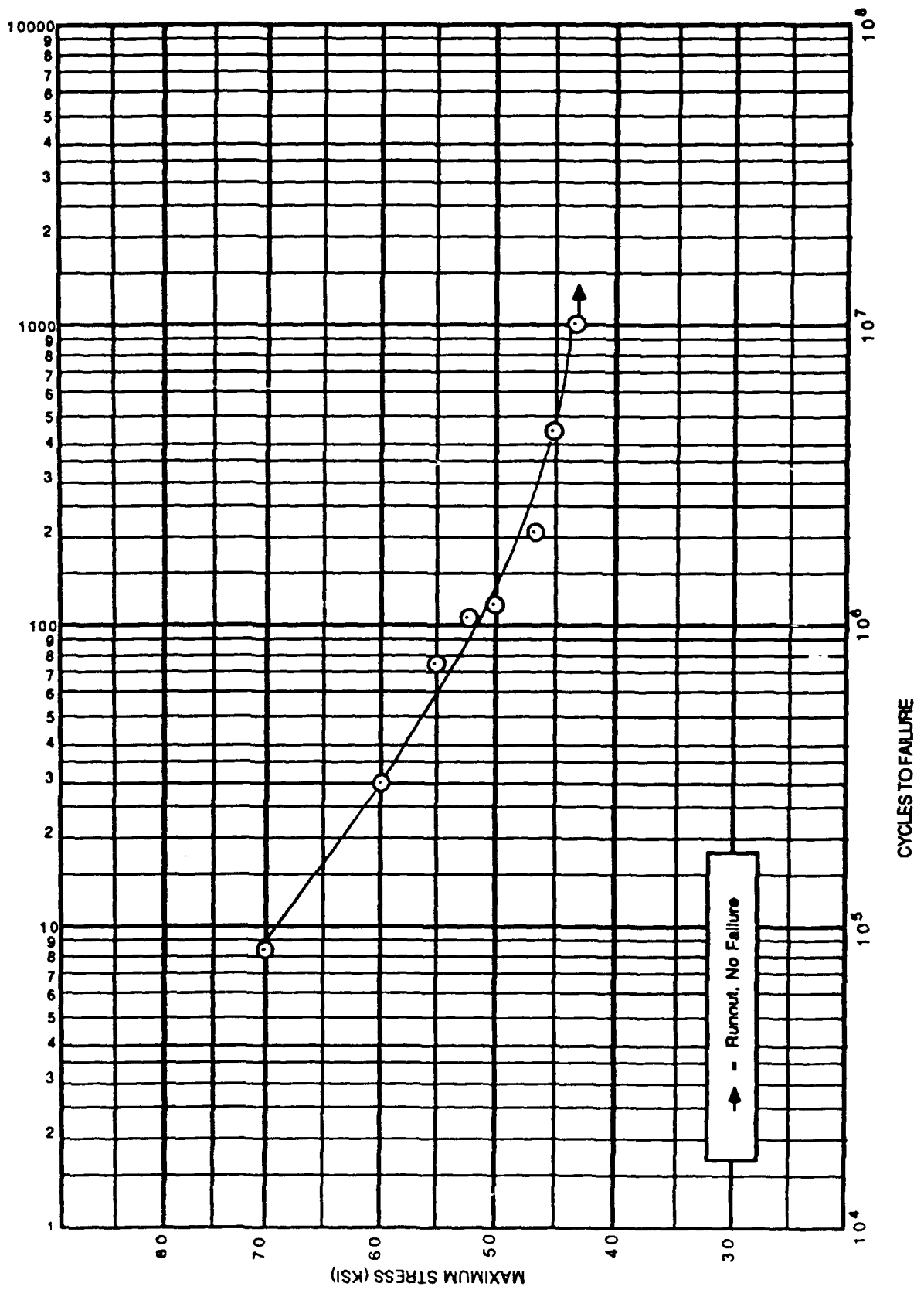


Figure 4. High Cycle Fatigue Results For Specimens Brazed With AMS 4777





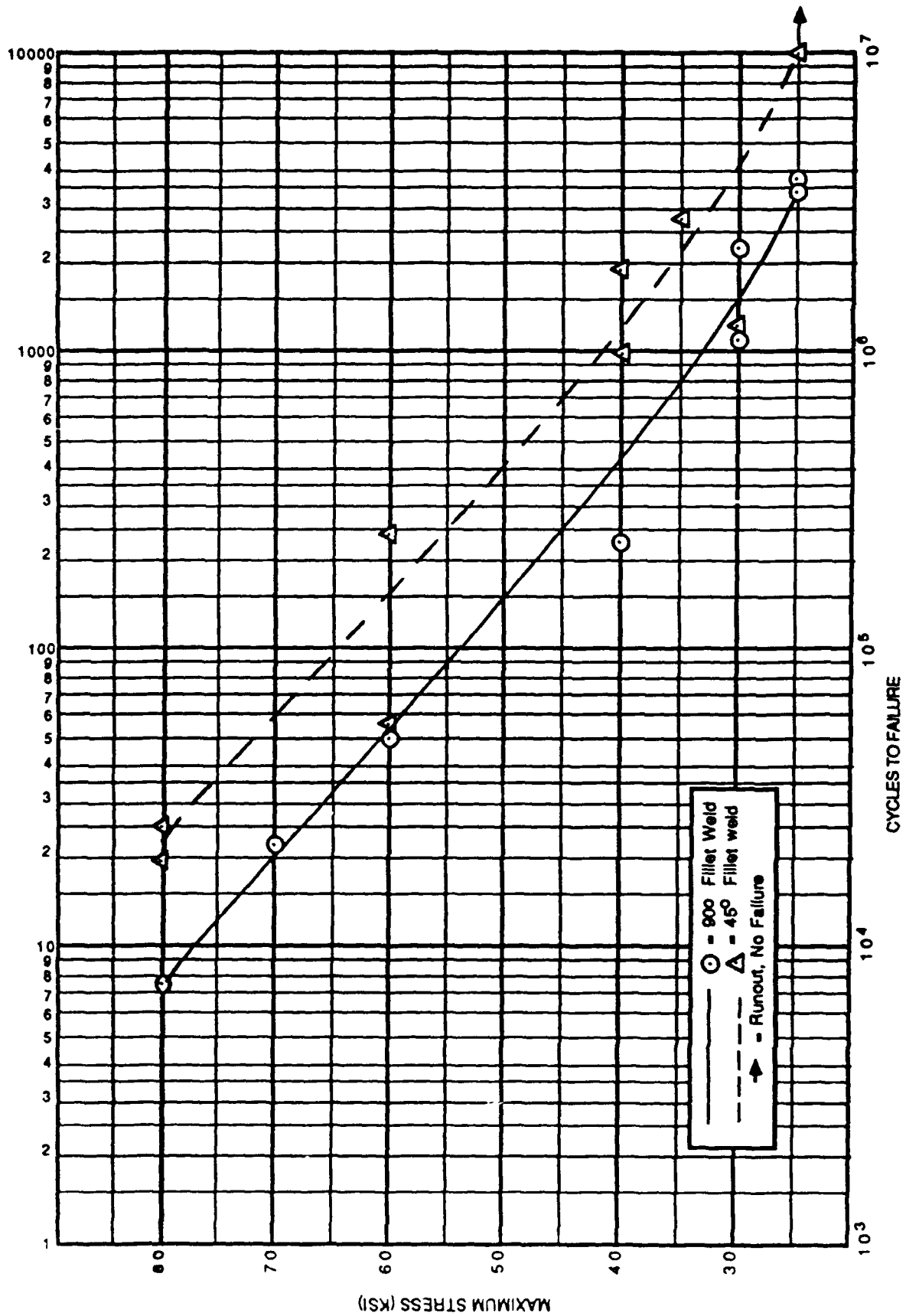


Figure 7. High Cycle Fatigue Results For Laser Welded Three Piece Lap Joint Specimens, .006 Gap Width

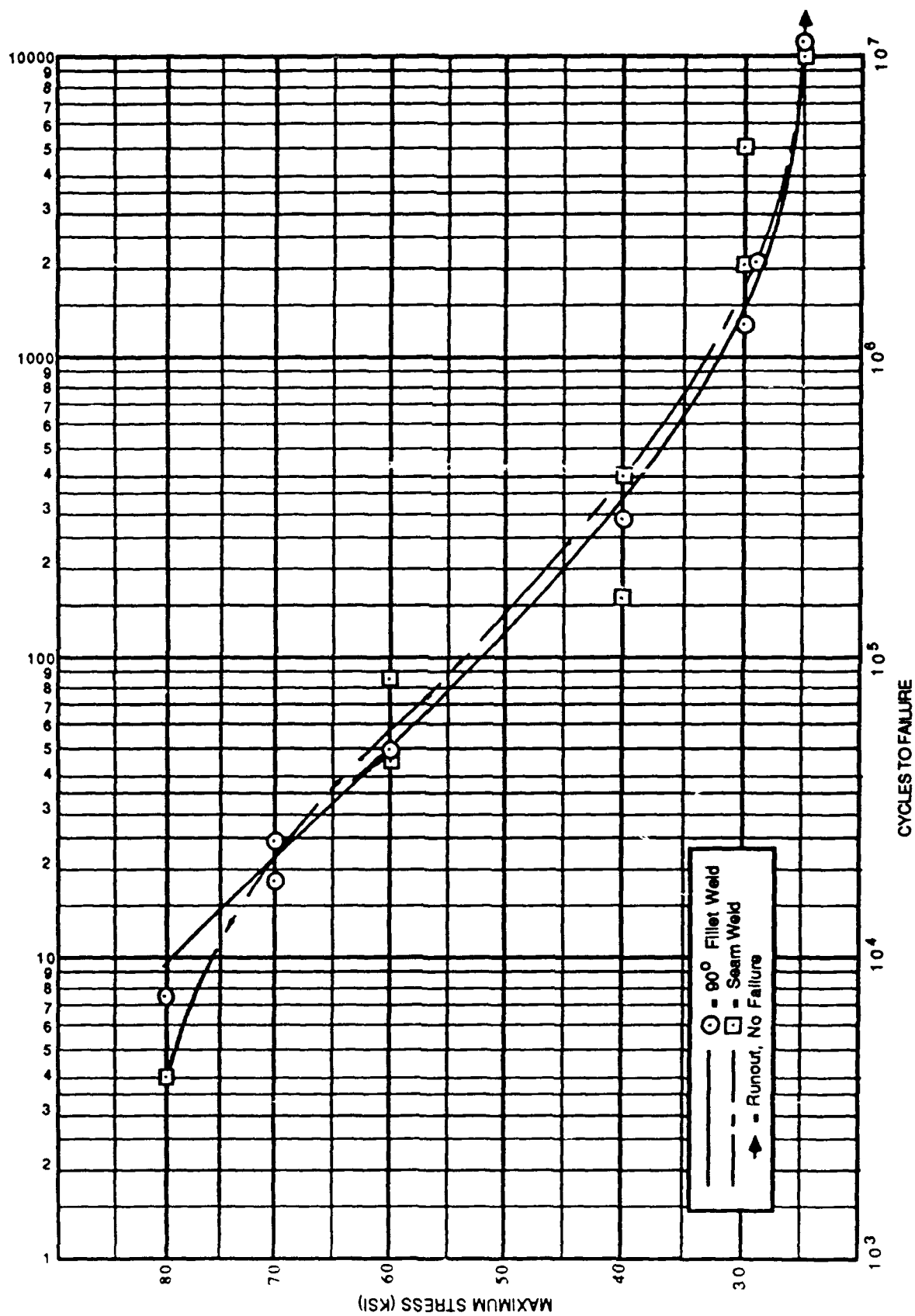


Figure 8. High Cycle Fatigue Results For Laser Welded Two Piece Lap Joint Specimens, .006 Gap Width

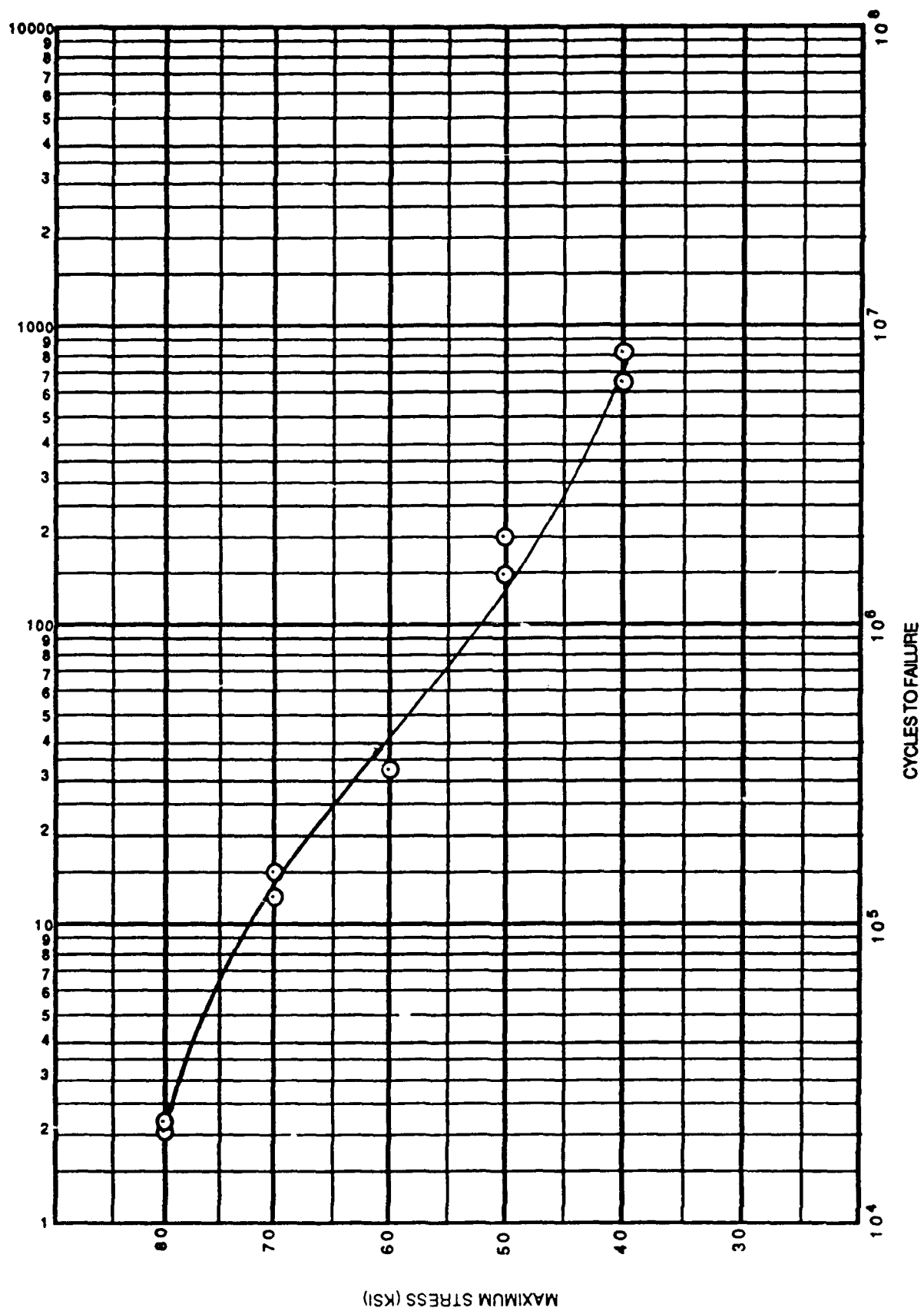


Figure 9. High Cycle Fatigue Results For Machined Specimens

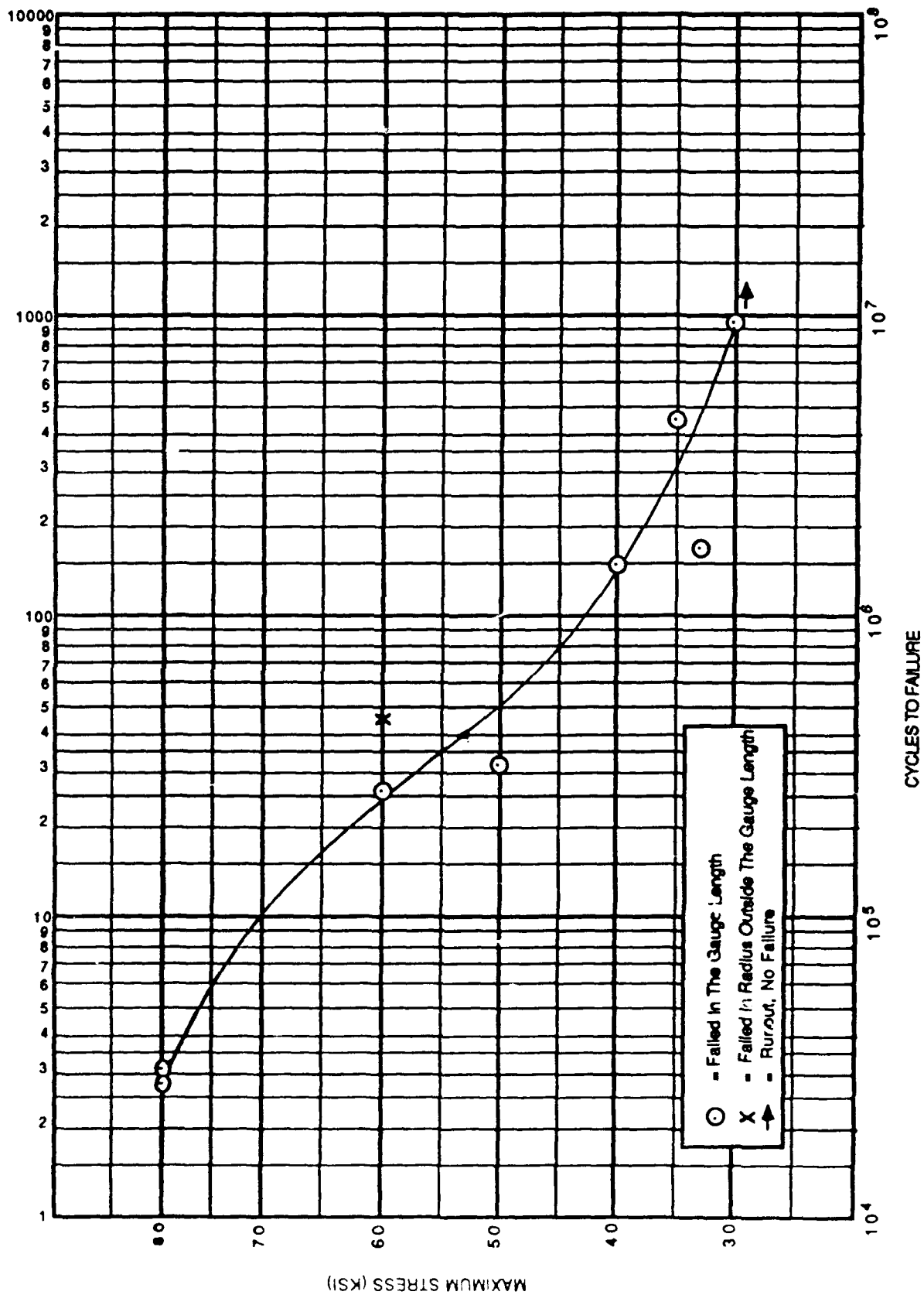


Figure 10. High Cycle Fatigue Results For Specimens With .0025" Recast Layer

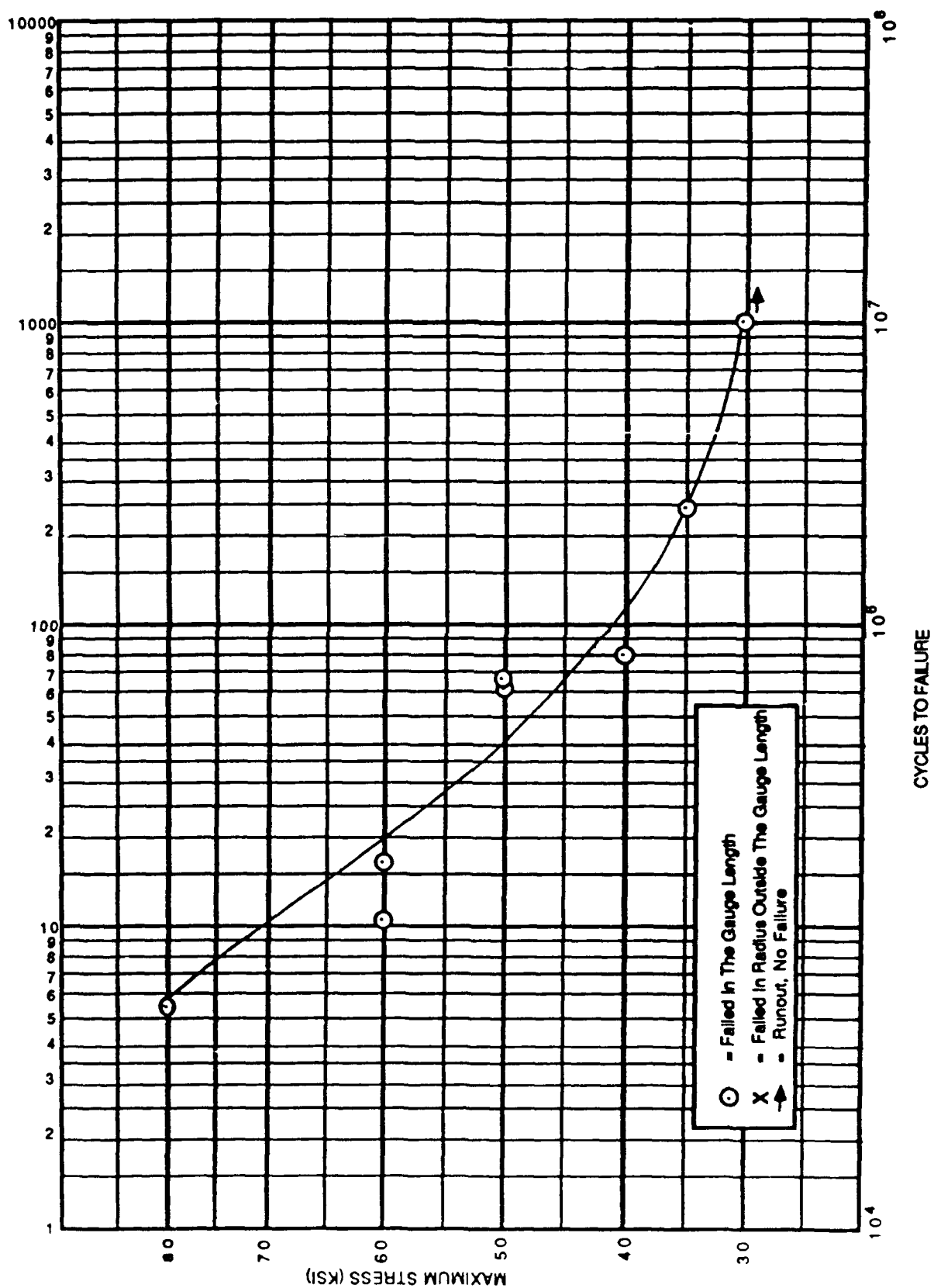


Figure 11. High Cycle Fatigue Results For Specimens With .006" Recast Layer



Figure 12. Metallographic cross section of a Hastelloy X laser machined surface showing a .012" thick region of carbide precipitation adjacent to the recast layer (arrows). Mt. No. 90-505, Mag: 125X, Etchant: Electrolytic, 10% Oxalic Acid.

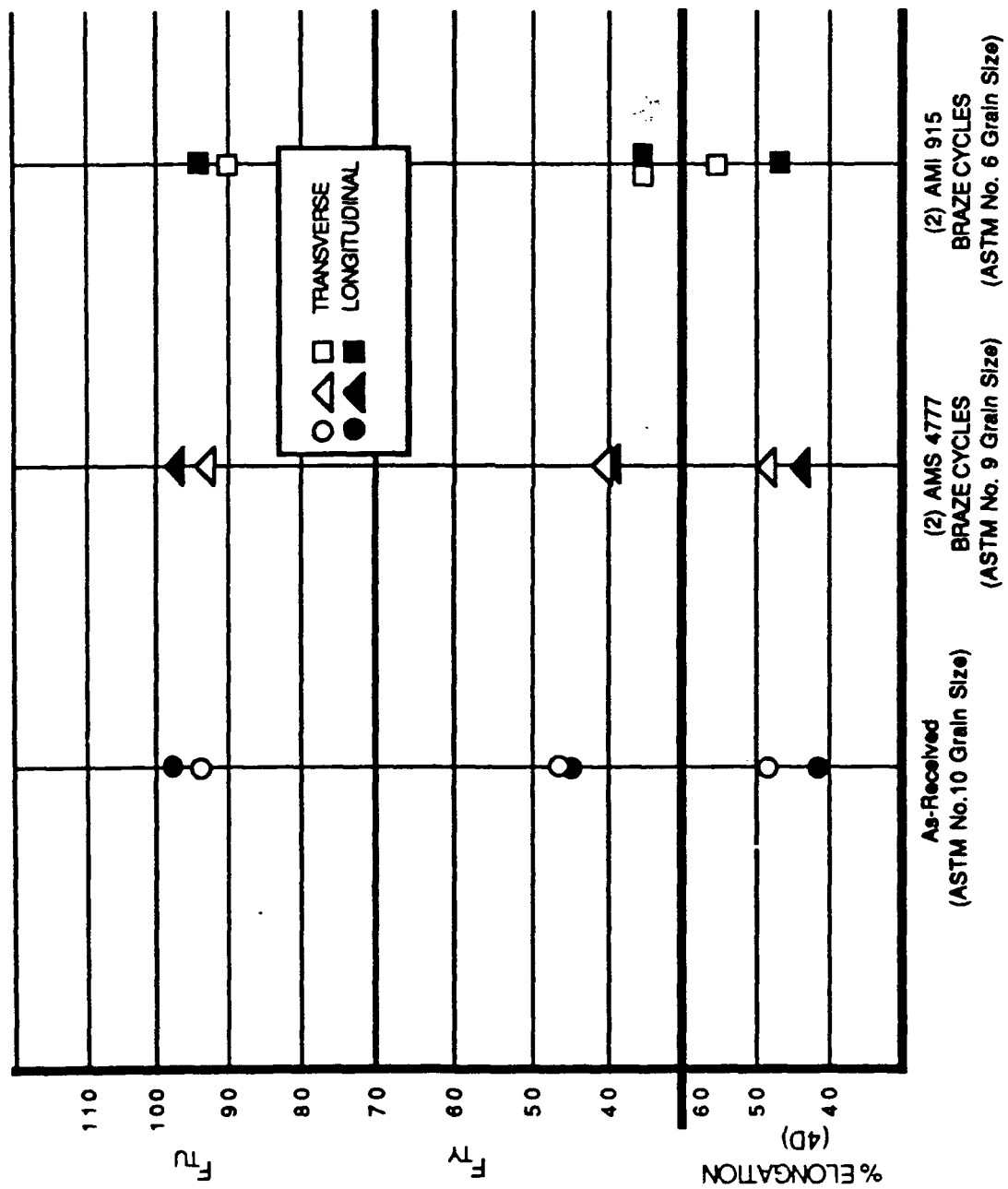


Figure 13. Tensile Results For 347 CRES Exposed To Braze Cycles

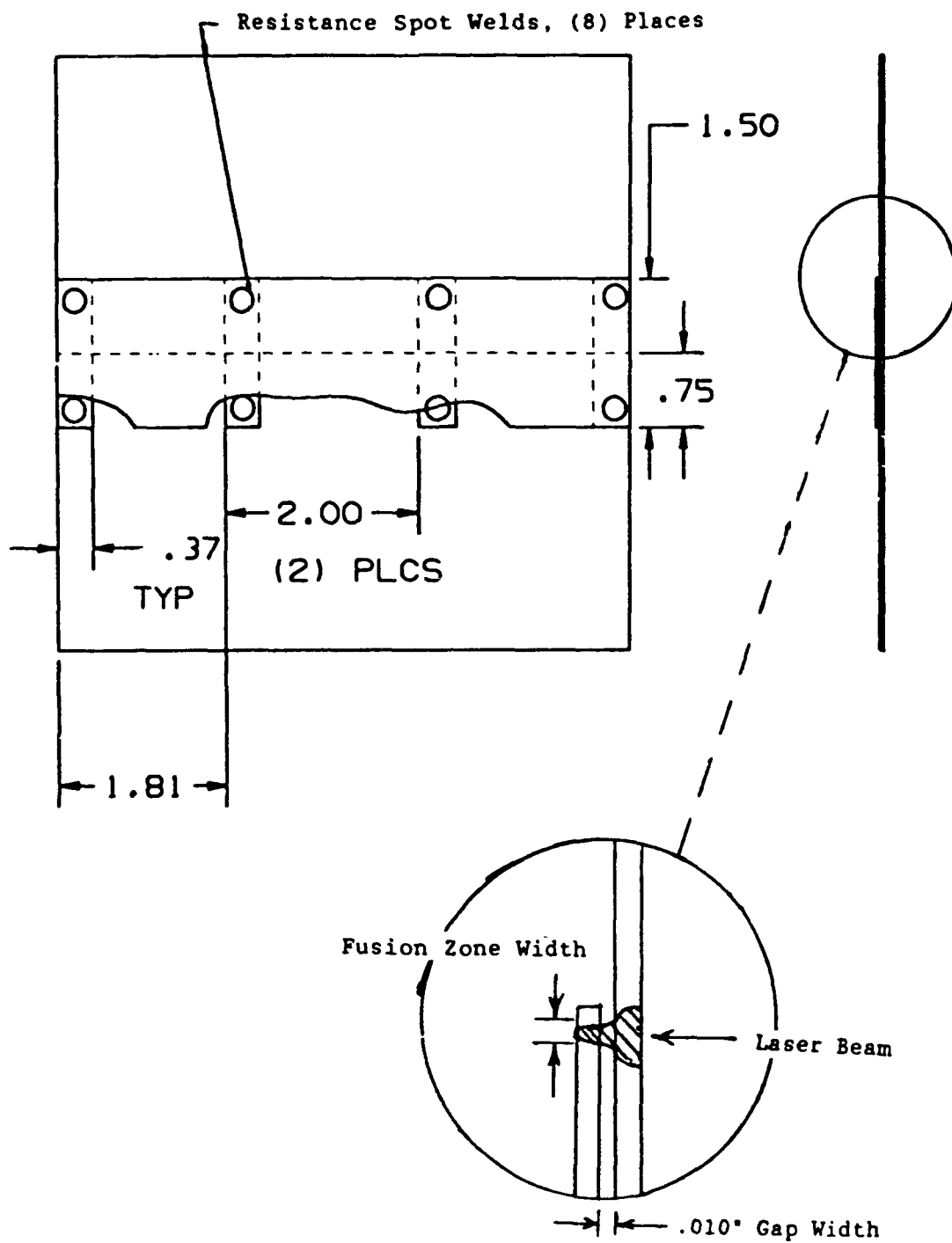


Figure 14. Typical Three Piece Panel Assembly
for Tensile Specimens

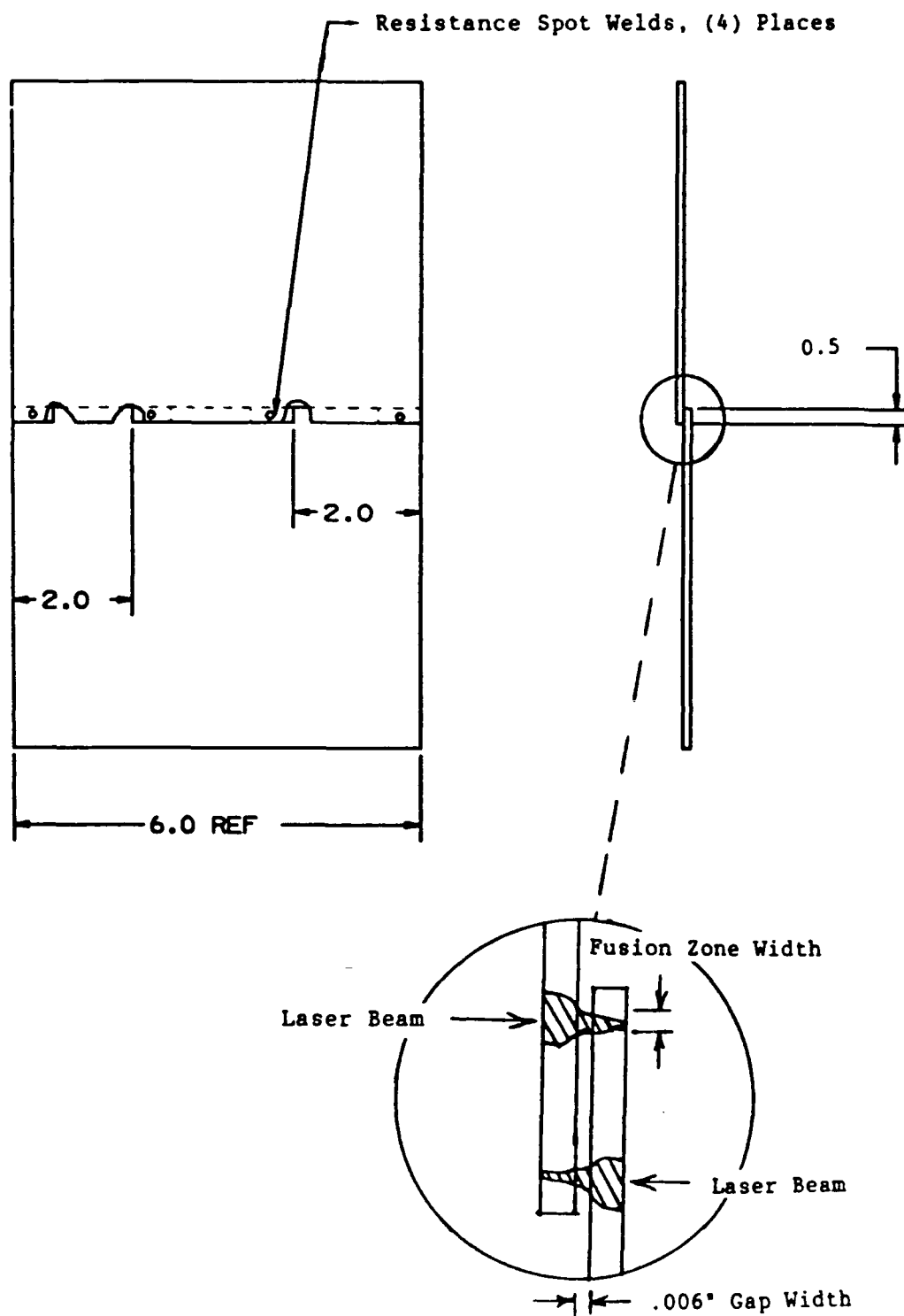


Figure 15. Typical Two Piece Panel Assembly
for Tensile and HCF Specimens

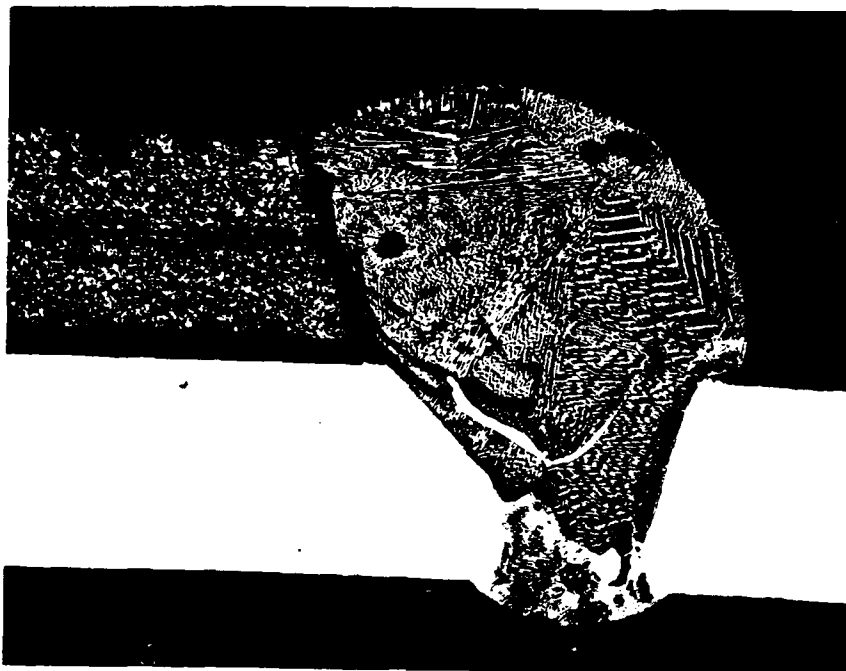


Figure 16. Metallographic cross section of a typical 90° fillet weld of .040" 347 CRES (top) to .040" Hastelloy X. The weld fillets were convex. Mt. No. 90-515, Mag: 26X, Etchant: Glyceregia



Figure 17. Metallographic cross section of a typical 90° fillet weld of .040" Hastelloy X to .040" Hastelloy X. The weld fillets were slightly convex. Mt. No. 90-515, Mag: 26X, Etchant: Glyceregia

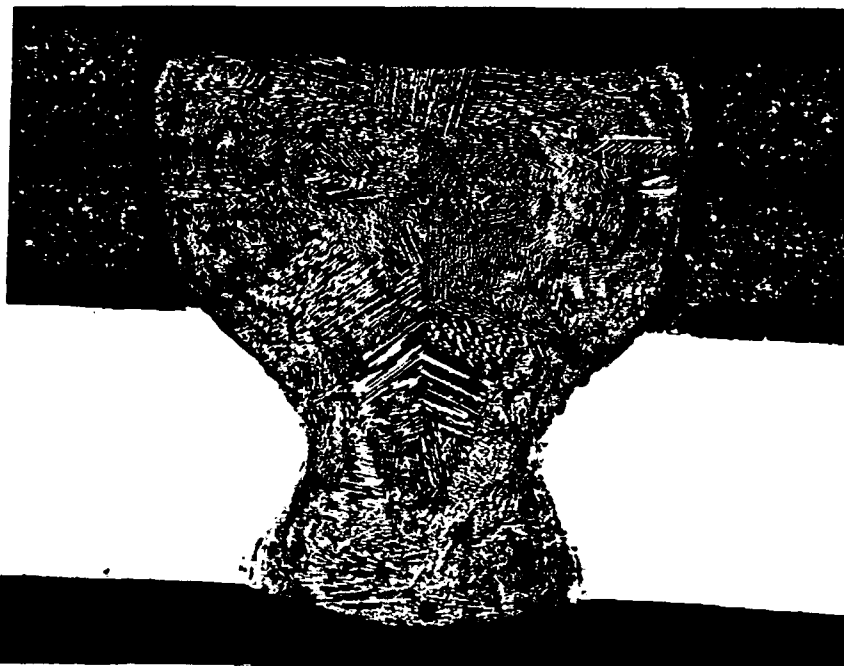


Figure 18. Metallographic cross section of a seam weld of .040" 347 CRES (top) to .040" Hastelloy X. Mt. No. 90-516, Mag: 32X, Etchant: Glyceregia



Figure 19. Metallographic cross section of a seam weld of .040" Hastelloy X to .040" Hastelloy X. Mt. No. 90-516, Mag: 32X, Etchant: Glyceregia

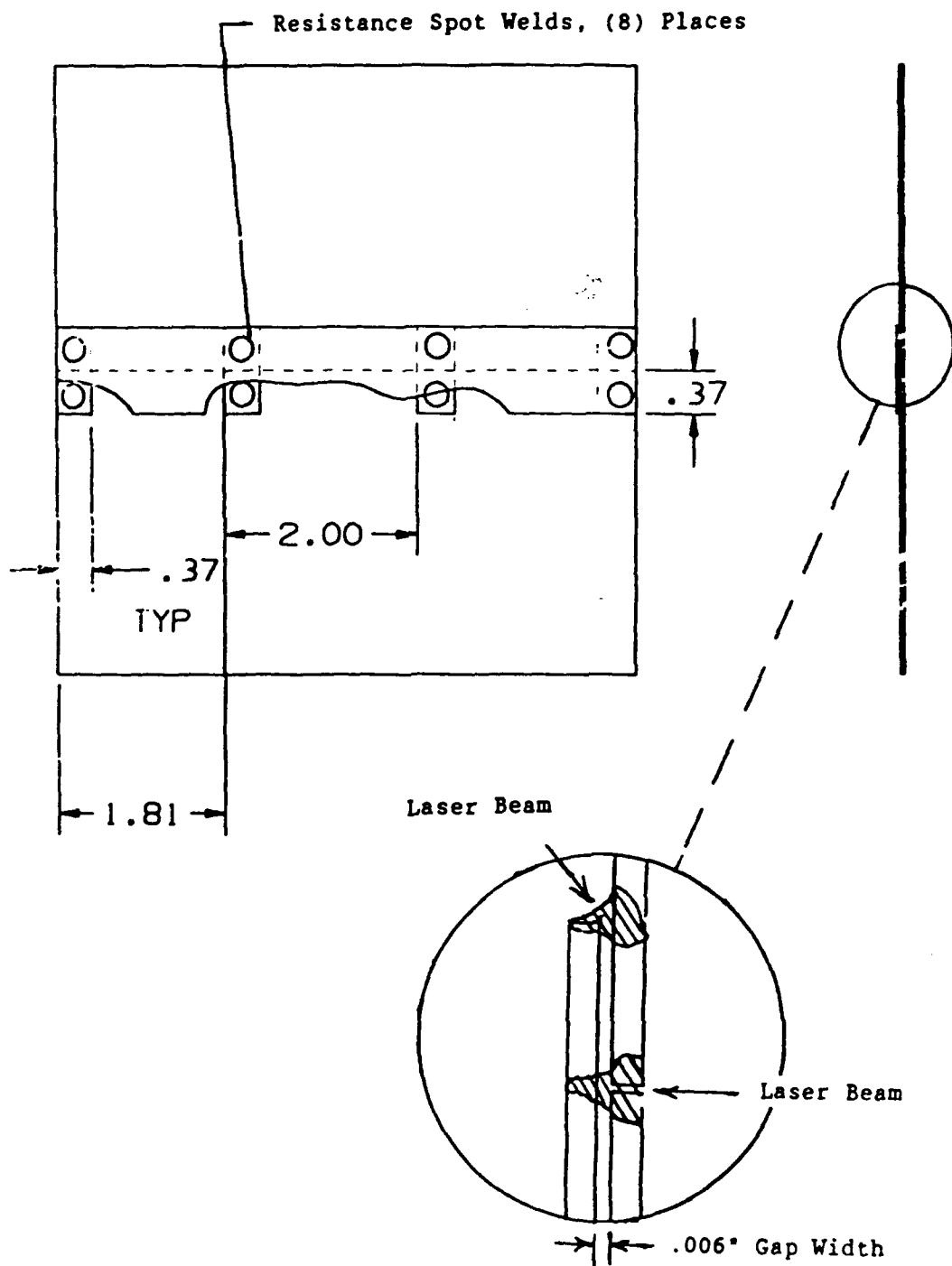


Figure 20. Typical Three Piece Panel Assembly
for HCF Specimens



Figure 21. Metallographic cross section of a 45° fillet weld of .040" 347 CRES (top) to .040" Hastelloy X. The weld fillets were concave vs. convex (see Figure 16). Mt. No. 90-516, Mag: 32X, Etchant: Glyceregia

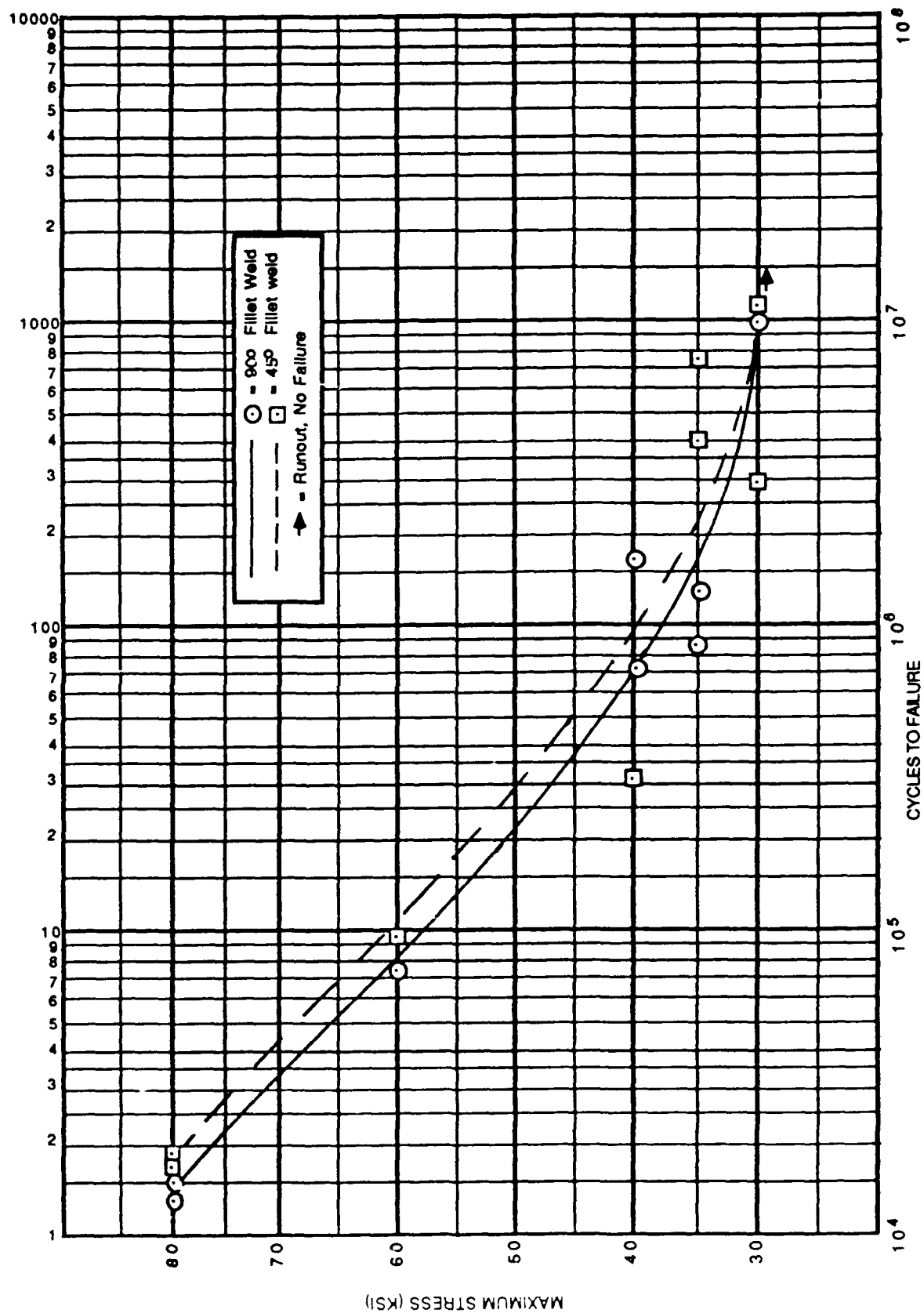


Figure 22. High Cycle Fatigue Results For Laser Welded Three Piece Lap Joint Specimens, .010 Gap Width

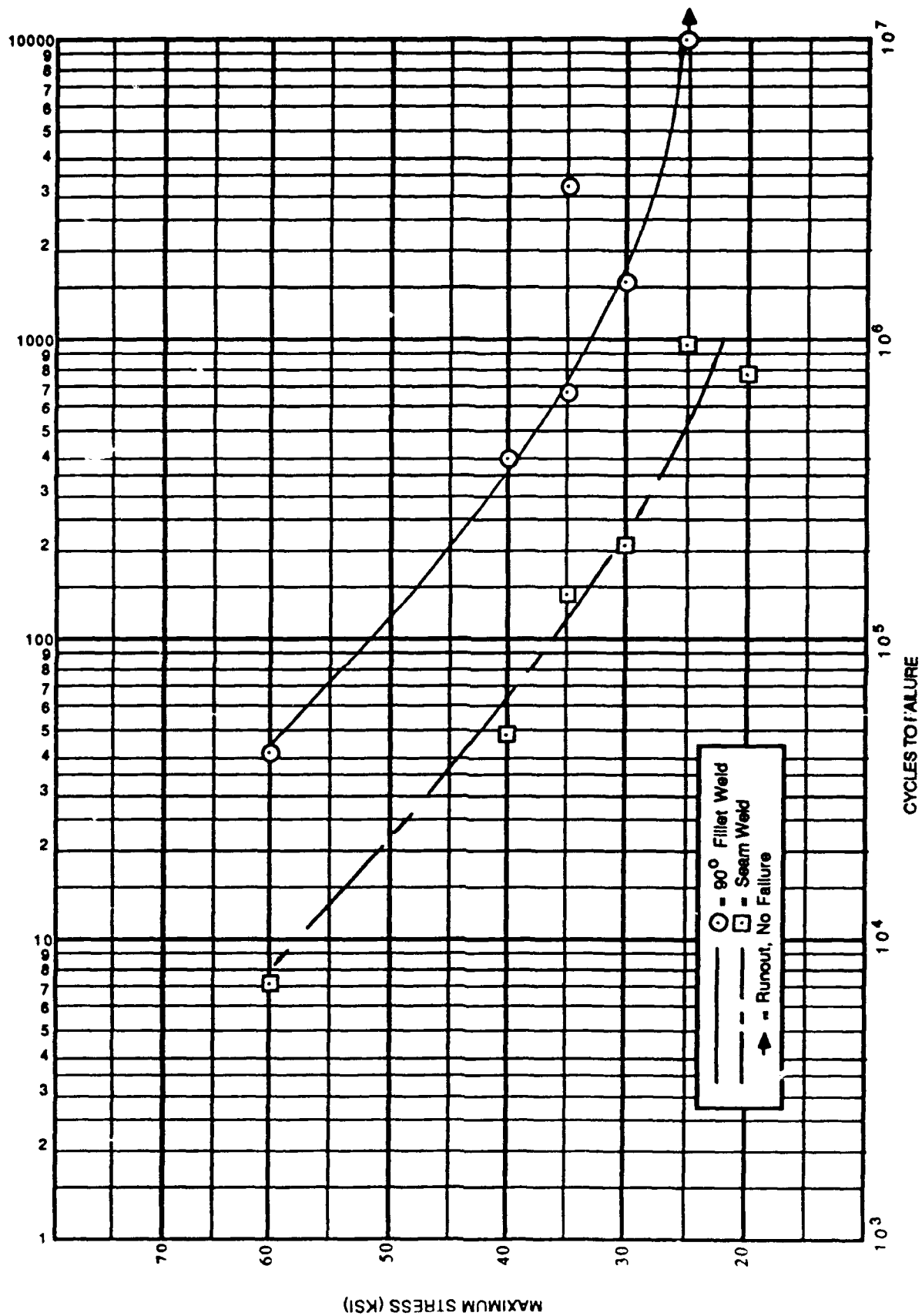


Figure 23. High Cycle Fatigue Results For Laser Welded Two Piece Lap Joint Specimens, .010 Gap Width

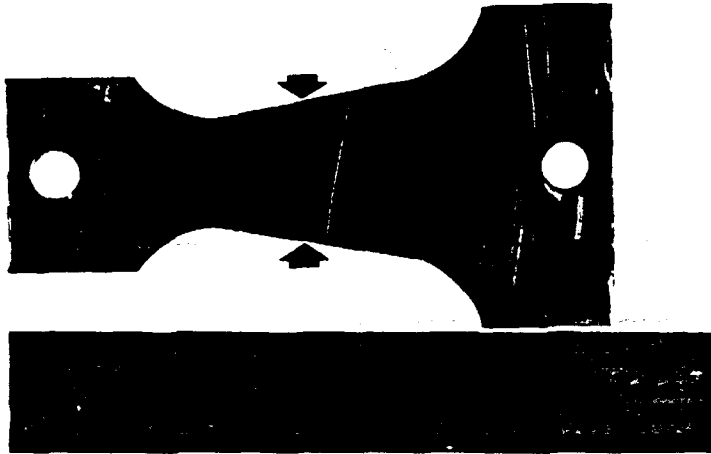


Figure 24. Typical cantilever bending HCF specimen which has been laser machined. The constant stress gauge section is 0.5" long. The dark areas adjacent to the edges of the specimen (arrows) is oxidation cause by the heat generated during laser machining.



Figure 25. Metallographic cross section of a Hastelloy X laser machined surface showing recast layer variability. The recast layer of adjacent areas varies form .0005" to .0044" (arrows). Mt. No. 90-477, Mag: 100X, Etchant: Glyceregia

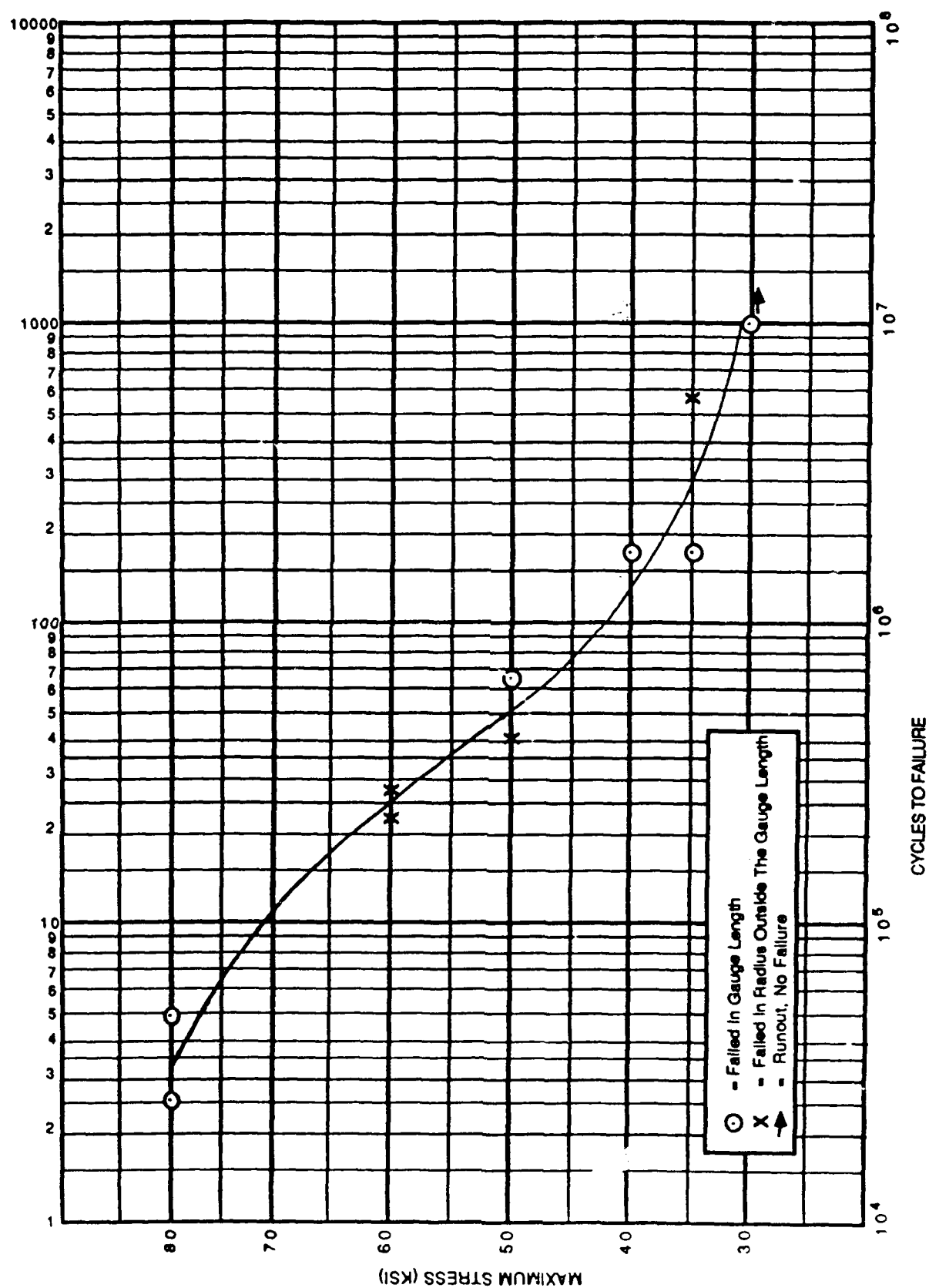


Figure 26. High Cycle Fatigue Results For Specimens With .001" Recast Layer

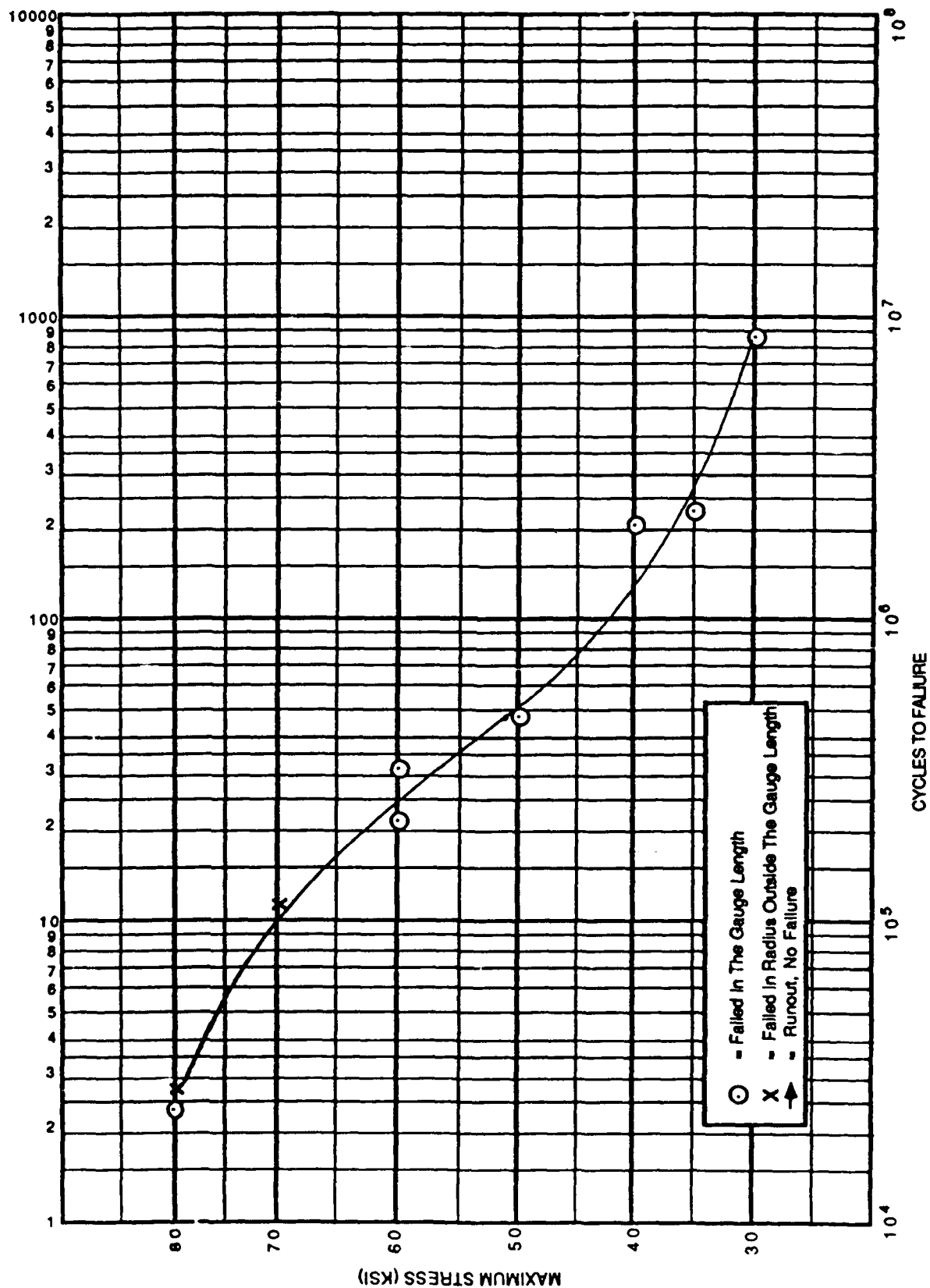


Figure 27. High Cycle Fatigue Results For Specimens With .004\"/>

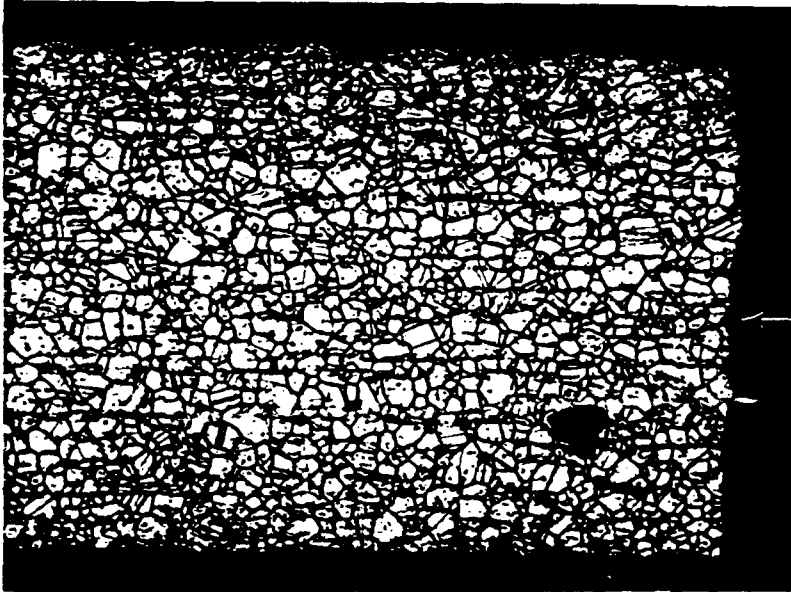


Figure 28. Metallographic cross section of a failed AMS 4777 brazed cantilever bending HCF specimen. The arrow indicates the fracture surface. Grain size is ASTM No. 6.0 through the entire cross section which can be compared to the AMI 915-HT brazed specimen (Figure 29). Mt. No. 91-673, Mag: 64X, Etchant: Electrolytic, 10% Oxalic Acid

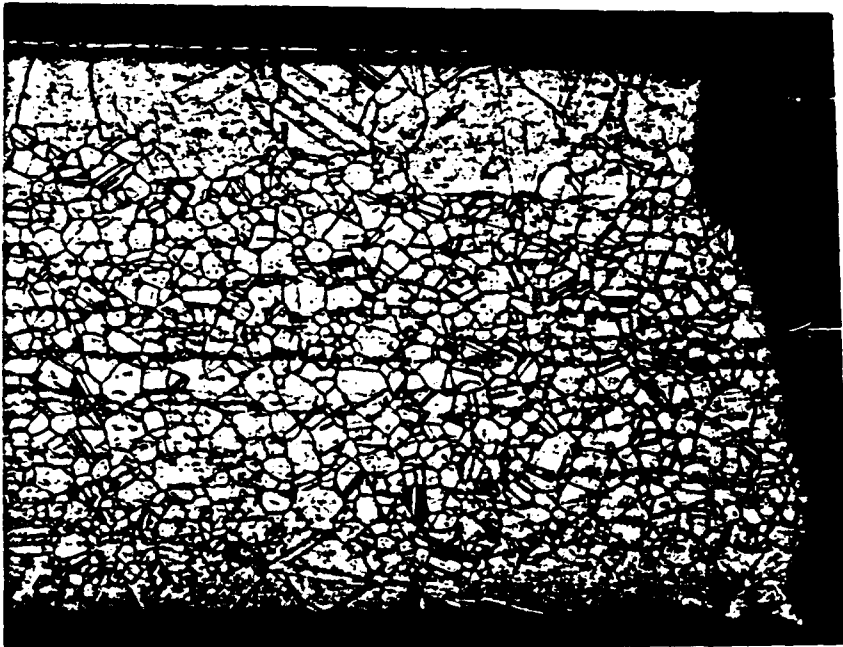


Figure 29. Metallographic cross section of a failed AMI 915-HT brazed cantilever bending HCF specimen. The arrow indicates the fracture surface. Grain size is ASTM No. 5.5 on the interior and 2.5 on the exterior surfaces. This can be compared to the AMS 4777 brazed specimen which had an ASTM 6.0 grain size throughout (Figure 28). Mt. No. 91-672, Mag: 64X, Etchant: Electrolytic, 10% Oxalic Acid

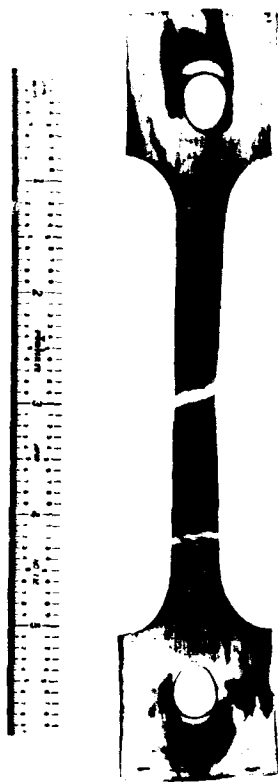


Figure 30. Typical tensile specimen. Tensile specimens were pulled in both the longitudinal and transverse directions.

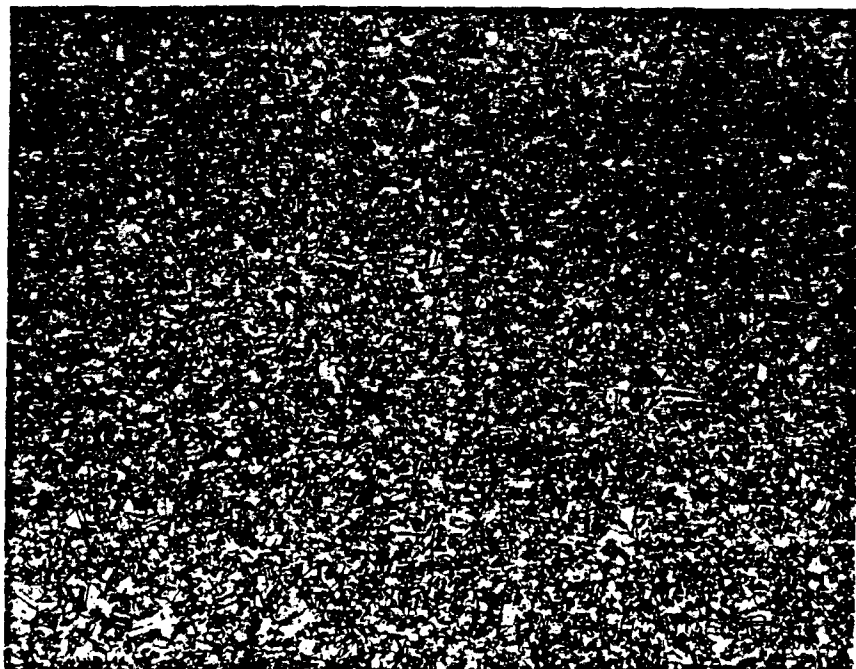


Figure 31. Metallographic cross section of the as-received 347 CRES sheet. Grain size is ASTM No. 10. Mt. No. 90-576, Mag: 100X, Etchant: Electrolytic, 10% Oxalic Acid

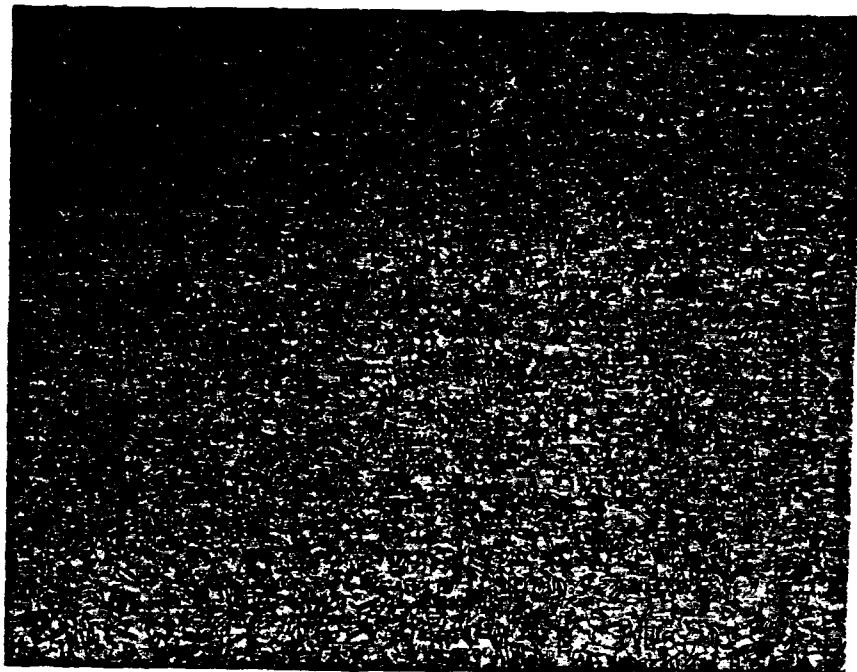


Figure 32. Metallographic cross section of the 347 CRES sheet exposed to (2) AMS 4777 braze cycles. Grain size is ASTM No. 9.0. Mt. No. 90-580, Mag: 100X, Etchant: Electrolytic, 10% Oxalic Acid

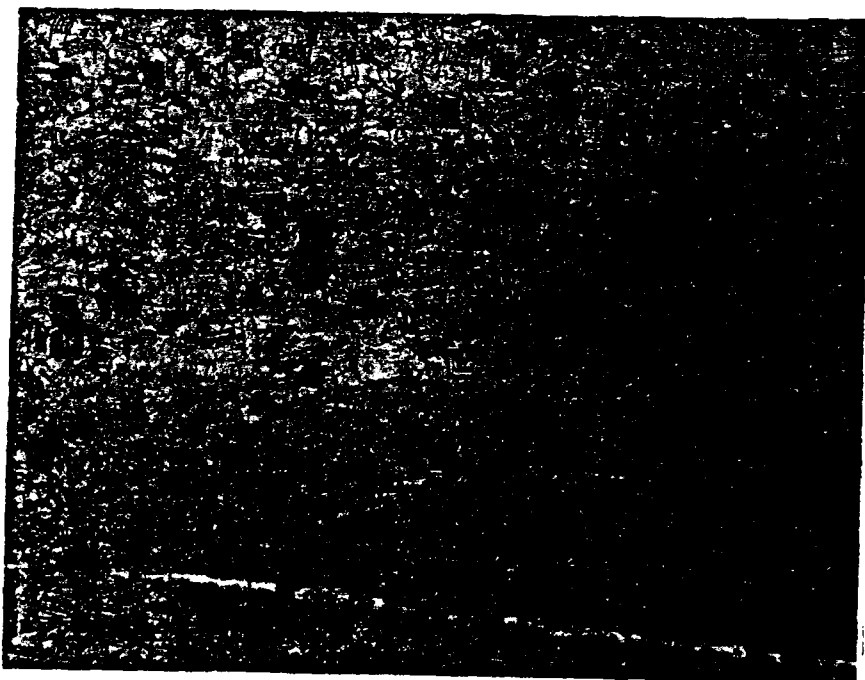


Figure 33. Metallographic cross section of the 347 CRES sheet exposed to (2) AMI 915 braze cycles. Grain size is ASTM No. 6.0. Mt. N Etchant: Electrolytic, 10% Oxalic Acid

TABLE I. TENSILE RESULTS FOR LASER WELDED SPECIMENS

<u>Weld Joint Design/Weld Type</u>	<u>Fusion Zone Width (inch)</u>	<u>Gap Width (inch)</u>	Average ¹ Yield Str.	Average ¹ Tensile Str.
			<u>(0.2%, ksi)</u>	<u>(ksi)</u>
Three Piece Lap Joint/Fillet	.040	.006	35.1	94.2
	.040	.010	37.2	92.4
Three Piece Lap Joint/Seam Weld	.040	.006	35.8	87.4
	.040	.010	33.1	87.4
	.080	.006	40.6	94.9
	.080	.010	37.2	92.4
Two Piece Lap Joint/Fillet	.040	.006	59.0	115.9
	.040	.010	59.0	118.6
Two Piece Lap Joint/Seam Weld	.040	.006	56.1	115.6
	.040	.010	56.7	115.0
	.080	.006	55.3	114.0
	.080	.010	57.6	118.4

1. Average value from four tensile specimens.

**TABLE II. HIGH CYCLE FATIGUE RESULTS FOR LASER WELDED
SPECIMENS, .006" GAP WIDTH**

<u>Weld Joint Design/Weld Type</u>	<u>Maximum Stress (ksi)</u>	<u>Fatigue Life (cycles)</u>
Two Piece Lap Joint/90° Fillet	80	8,200
	70	18,300
	70	24,100
	60	47,200
	40	291,300
	30	1,352,300
	30	2,140,600
	25	>10,000,000
Two Piece Lap Joint/Seam Weld	80	4,100
	60	43,900
	60	84,000
	40	153,200
	40	393,300
	30	2,178,400
	30	4,930,900
	25	>10,000,000
Three Piece Lap Joint/45° Fillet	80	20,200
	80	26,300
	60	61,800
	60	239,100
	40	949,500
	40	1,971,900 (1)
	35	2,769,400
	30	1,214,700
Three Piece Lap Joint/90° Fillet	80	7,400
	70	23,900
	60	50,800
	40	253,000
	30	1,075,500
	30	3,295,600
	25	3,543,500
	25	3,742,900

(1) Failed in parent metal away from weld joint.

TABLE III. HIGH CYCLE FATIGUE RESULTS FOR LASER WELDED
SPECIMENS, .010" GAP WIDTH

<u>Weld Joint Design/Weld Type</u>	<u>Maximum Stress (ksi)</u>	<u>Fatigue Life (cycles)</u>
Two Piece Lap Joint/90° Fillet	60	42,300
	40	395,200
	35	676,800
	35	3,337,100 (1)
	30	1,568,700
	25	>10,000,000
Two Piece Lap Joint/Seam Weld	60	7,300
	40	48,700
	35	136,900
	30	210,200
	25	939,600
	20	770,900
Three Piece Lap Joint/45° Fillet	80	17,100
	80	17,900
	60	96,200
	40	319,200
	35	4,191,000
	35	7,652,400
	30	2,962,400
	30	>10,000,000
Three Piece Lap Joint/90° Fillet	80	13,800
	80	15,000
	60	74,900
	40	711,000
	40	1,732,200
	35	833,300
	35	1,311,800
	30	>10,000,000

(1) Failed in parent metal away from weld joint.

TABLE IV. HIGH CYCLE FATIGUE RESULTS FOR RECAST LAYER SPECIMENS

<u>Recast Layer Depth</u> <u>(inches)</u>	<u>Maximum Stress</u> <u>(ksi)</u>	<u>Fatigue Life</u> <u>(cycles)</u>
Machined	80	20,800
	80	22,200
	70	132,400
	70	147,400
	60	352,900
	50	1,540,100
	50	2,013,800
	40	6,232,500
	40	8,506,800
.001	80	24,700
	80	47,900
	60	222,200 (1)
	60	268,700 (1)
	50	395,400 (1)
	50	699,000
	40	1,675,500
	35	1,706,000
	35	5,415,600 (1)
	30	>10,000,000
.0025	80	28,800
	80	32,800
	60	270,900
	60	496,700 (1)
	50	378,600
	40	1,481,100
	35	4,301,400
	33	1,714,400
	30	>10,000,000
.004	80	24,300
	80	28,600 (1)
	70	108,600 (1)
	60	217,900
	60	307,700
	50	477,400
	40	2,073,200
	35	2,219,900
	30	8,975,700
.006	80	51,600
	60	99,400
	60	165,900
	50	600,200
	50	673,500
	40	772,100
	35	2,367,100
	30	>10,000,000

(1) Failed in the radius outside the gauge length.

TABLE V. HIGH CYCLE FATIGUE RESULTS FOR BRAZED SPECIMENS

<u>Braze Joint Design/Braze Alloy</u>	<u>Maximum Stress (ksi)</u>	<u>Fatigue Life (cycles)</u>
Three Piece Lap Joint/AMS 4777	60	171,000
	50	804,000
	47	1,581,000
	45	973,000
	43	1,017,000
	40	8,171,000
	37	4,247,000
	37	6,565,000
	35	>10,000,000
Three Piece Lap Joint/AMI 915	60	123,000
	50	344,000
	45	816,000
	43	907,000
	40	1,302,000
	37	6,225,000
	35	4,993,000
	33	7,597,000
	32	>10,000,000
	30	>10,000,000
Three Piece Lap Joint/AMI 915-HT	60	84,000
	50	309,000
	45	742,000
	43	1,120,000
	40	1,404,000
	37	2,295,000
	35	4,586,000
	33	>10,000,000

TABLE VI. TENSILE RESULTS FOR THE 347 CRES SHEET
EXPOSED TO BRAZE CYCLES

<u>Heat Treatment</u>	<u>Orientation</u>	<u>Tensile Strength</u> <u>(ksi)¹</u>	<u>Yield Strength</u> <u>(ksi)¹</u>	<u>Elongation</u> <u>(4D)¹</u>
As-Recieved	L	96.8	45.0	41.5
	T	94.0	46.1	47.8
Two AMS 4777 Braze Cycles	L	97.0	39.7	43.8
	T	92.3	40.4	48.8
Two AMI 915 Braze Cycles	L	92.8	35.8	46.3
	T	89.8	36.3	53.8

1. Average value from four specimens.

6.0 IMPLEMENTATION PLAN

6.1 PRIMARY OBJECTIVE

The new one-piece combustor housing design is complete. At present all detail parts are purchased items manufactured by vendors to Sundstrand engineering drawings. These parts are assembled in-house at Sundstrand.

The primary objective of the IMIP Phase II project was to establish the necessary equipment, facility requirements, engineering specifications, and implementation plan for the Sundstrand Precision Metal Forming Cell. This new facility will have the capability to fabricate all sheet metal parts in support of the flow formed combustor housing assemblies. A detailed "Make or Buy" list is shown in Figure 6-1.

6.2 CAPITAL EQUIPMENT REQUIREMENTS AND SELECTION

A list of equipment for the Precision Metal Forming Cell is shown in Figure 6-2. This is the equipment required to support the planned flow forming and laser welding method of manufacturing.

6.2.1 FLOW FORMING LATHE

The procurement specification for this equipment requires a minimum of two roller heads with a capability of forming a .375 inch thick Hastelloy "X" blank, down to a thickness of .020 inches. The lathe shall be capable of forming angles and Radii of .030 inches.

This lathe is considered a medium heavy machine which requires special cylindrical components with high accuracy. Machine range shall be from 2 inches through 24 inches in diameter and a length capacity of 49 inches (forward) and 98 inches (reverse). The machine shall have spindle rotation of 35 to 875 rpm and a feed rate of 0.4 to 38 inches per minute.

Requests for quotations were sent to all flow form lathe producers. A team was formed to review and compare actual performance against quoted capabilities to support final selection.

The only quotations received were from Bohner and Kiale GmbH & Co. (BOKO) and Autospin, Inc. (Leifeld). The price of this equipment includes a complete set of formal drawings, wiring diagrams, schematics, training for SPS personnel, and all operating, repair, etc. manuals.

The BOKO unit was selected, reference Figure 6-3. The main reasons are they have more experience, and appear to be better capable of meeting all contract requirements. However, each supplier was asked to produce a part similar to the housing in design shape and thickness using 100% flow forming. Final selection was based primarily on their ability to fabricate the part. Both suppliers, Leifeld and BOKO, are sure that they can produce the part. This is a step in the right direction as neither supplier thought they could do this a few months ago. Leifeld refused to compete with BOKO. The only way they would fabricate a part was for Sundstrand to contract with them to build the necessary tooling and would guarantee that Sundstrand would select them if they were successful in fabricating the part using 100% flow forming.

BOKO did fabricate a part similar to the housing configuration from a flat sheet of Hastelloy X thru completion using 100% flow forming without any annealing operations. As stated above, training is part of the contract with BOKO and Sundstrand expects this to be a successful operation with minimum time once the equipment is installed.

6.2.2 CO2 LASER UNIT

The procurement specification for this unit requires the unit to be a computer controlled 1500 watt CO2 fast axial pulsed laser which can be used for welding, drilling, and cutting.

The CO2 laser shall have the capability to weld, drill, and cut high temperature nickel alloys. A weld depth penetration of .150 inches is required. It shall be capable of making holes from .010 inches to 10.0 inches in diameter with hole entrance angles of 10 degrees. It shall be able to cut material from .250 to .500 inches thick. The laser shall be capable of computer programmable power settings. The price of the laser unit like the flow forming lathe will include drawings, wiring diagrams, schematics, training for SPS personnel, etc.

A request for quote was sent to eight laser manufacturers and laser machine builders. They are:

S.E. Huffman Corp.
Clover, SC 29710

Rofin Sinar Laser
Vista, CA 92084

Trumpf Industrial Lasers
Laguna Hills, CA 92653

Lumonics Laser Systems
Pleasanton, CA 94588

Coherent General
San Diego, CA 92128

Raycon Corporation
Ann Arbor, MI 48105

Amada Laser Systems
Buena Park, CA 90621

Utilase
Detroit, MI 48205

Only Amada Laser Systems did not respond. SPS employed Mr. Belforte, an expert in industrial technology, to review and aid SPS in equipment and supplier selection. Referenced vendor quotations are in Appendix A.

Review covered material penetration per kilowatt of power, beam mode quality, fixturing, end piece production, and quality. Of the bids received and reviewed, Trumpf Industrial, Lumonics Lasers, and Raycon Corporation are the most promising. A visit to each was accomplished and the final selection went with Lumonics, reference Figure 6-4. The primary feature with this unit is that it has an enclosed section where the laser process is in operation. The work table slides from side to side allowing set or removal operations to occur in parallel with the laser operation.

6.2.3 HYDRAULIC SHEER

Shears must have a minimum capacity to accept 6 foot wide material with a thickness up to 3/16 inches. It must be able to shear 32' SS (100,000 psi), 347 SS (105,000 psi), and Hastelloy X (113, 000 psi). It was also requested that each supplier state their maximum and minimum capability for each material to determine equipment safety factors. Machines shall be wired for 440 volt, 3 phase, 60 cycle, with only one current supply for all functions.

The RFQ included Operator Manuals, Programmer Manuals, Electrical Wiring and Schematic Diagrams, plus Service, Maintenance, and Repair Manuals. Each supplier was asked to supply SPS personnel training.

Request for specifics on design for features such as squaring material with the blade, number of hold downs, positioning accuracy, repeatability, etc., be provided.

RFQ's were sent to 6 sources of equipment. They were:

Cincinnati Alhambra, CA 91801	Niagara Brea, CA 92621	Darley Essa International Santa Fe Springs, CA 90670
U.S. Amada, Ltd Buena Park, CA 90621	Wysong and Miles Co. Escondido, CA 92025	Pacific Press & Shear Co. Anaheim, CA 92805-5651

Summary of Quotations are as follows:

ITEM	CINCINNATI	AMADA	DARLRY	NIAGARA	PACIFIC/HTC	WYSONG
Type	Hydraulic	Mechanical	Swing Arm	Hydraulic	Hydraulic	Mechanical
Thickness X Long	1/4 X 6'	1/4 X 6'	.156 x 6'	1/4 x 10'	1/4 X 10'	.156 X 6'
Base Cost \$	42,540	45,000	30,543	33,347	29,900	37,000
Light Beam	920	STD	STD	STD	STD	1,150
Extra Knives	2,390	1,010	2,600	2,600	910	1,600
Total Price	49,063	50,000 Est.		36,000 Est.	39,000 Est.	35,300
	39,700					
Hold Downs	8	9	10	12	13	11

Of the 6 vendors listed above, the Niagara Spartan SP1/4-10 was selected. This shear qualified to the Machine Tool Matrix and was within the cost budget planned for this unit. This shear has all of the features required for a precision sheet metal facility. It has an adjustable power operated rake angle, thus the operator will be able to adjust the angle at the cutting blade to minimize distortions of the finished work and allow the shear to cut to its maximum capacity.

The variable blade clearance adjustment is accomplished by means of two levers at the rear of the shear and will allow the shear to cut different thicknesses with a minimum of burrs. Both of these features will provide this shear the versatility required to accommodate the different thicknesses and materials used in SPS sheet metal products.

The underdrive feature of this shear enhances its ability to resist shearing forces without the need for heavy side frames and special foundations. This shear can be mounted on any solid floor and has built-in leveling screws.

The front-operated power package (push button controlled with digital indicator display) will provide the accuracy and repeatability required. This package has a built-in shock absorber to cushion impact loads as the operator slides the sheet into position.

Niagara Machine and Tool Works are a leading manufacturer of hydraulic shears and have designed and built this shear using years of experience and knowledge.

6.2.4 100 TON HYDRAULIC PRESS

This shall be an Open Gap Hydraulic Guided Press, with a capacity of 100 Tons, stroke minimum of 8 inches, open height 20 inches minimum, and shut height of 8 inches. The press shall have light curtain with interlocking guards. Ram platen size, front to back and side to side shall be 12 inches minimum.

Electrical cabinets are to meet or exceed N.E.M.A. standards. All electrical and electronics must conform to all Federal, California State, and San Diego local codes, laws, and regulations. All electronics to be protected by dust free enclosures.

All price quotes shall include Operator's, Programmer's, Service, Maintenance, and Repair manuals plus training.

RFQ's were sent to 6 sources of equipment. They were:

Cincinnati Alhambra, CA 91801	Niagara Brea, CA 92621	Komatsu Ltd. Santa Fe Springs, CA 90670
U.S. Amada, Ltd Buena Park, CA 90621	Greenerd Press Escondido, CA 92025	Pacific Press & Shear Co. Anaheim, CA 92805-5651

Summary of quotations is as follows:

ITEM	CINCINNATI	KOMATSU	PACIFIC	GREENERD
BASE PRICE	71,191	59,879	43,500	197,000
INSTALLATION	3,500	4,540	4,000	STD.
LIGHT CURTAIN	3,800	8,000	4,500	STD.
AUTO LUBE	STD.	1,800	STD.	STD.
DIE CUSHION	STD.	10,000	5,000	STD.
TOTAL	80,400	84,719	57,000	197,000
STROKE	8	18	12	18
OPENING	15	24	20	32
THROAT	14	12	30	?
MOTOR hp	20	20	30	?
WEIGHT lbs	16,000	12,000	20,000	36,000

The Pacific HTC Model CFP100G, 100 ton guided C-frame hydraulic press was selected for its rugged construction along with the ability to handle a variety of work. This press will be ordered with a 23 inch open height that will allow for the tallest parts and a 18 inch stroke to run dies as small as 5 inches. With an automatic lubrication system, this press will permit a minimum of maintenance. The 100 ton force is available throughout the stroke and the ram has 3 traveling speeds. Approach speed of 318 inches per minute, forming speed of 162 inches per minute, and a return speed of 330 inches per minute.

6.2.5 400 TON HYDRAULIC PRESS

The 400 ton press will be used for the flow preform blank and for final sizing after forming. The requirements for this are the same as the 100 ton press except for a larger capacity and working load. This press will be purchased with a 3.5 to 4.0 foot stroke.

Pacific HTC offers a 400 ton press and Sundstrand can save money by a purchase of both the 100 ton and 400 ton presses. A final selection has not been made at this time because detail requirements for this press have not been completed.

6.2.6 WORK STATIONS AND MISCELLANEOUS EQUIPMENT

6.2.6.1 SHOP STOOLS

The shop stools selected are the type of shop stool used throughout SPS. Since this is an item that has undergone some recent procurement activity, it has been established that United provides the best stool for the money. Our price for a United D42L stool without casters and with a cloth seat and back is \$100.00 each. 16 stools are required, therefore the total is \$1,600.00 plus tax and shipping = \$2,000.00

6.2.6.2 WORK BENCHES

The work benches selected are the type most used in SPS's manufacturing areas. They are 3 feet deep by 8 feet long with a wood maple top. There are two types selected, one with a set of drawers on the right side under the working area and a closed compartment on the left. The second type table is designed with a set of drawers on the left side only. These work benches will be used as an addition to the first type of bench and are planned to be set up at a 90 degree angle to the other, see Figure 7-2 for facility layout. The Stanley/VIDMAR line has been used in the past because of their versatility and durability and these are the units planned for this facility.

6.2.6.3 TOOL CABINETS

Two tool cabinets are planned. One in support of the CO2 laser unit and one in support of the flow form lathe. These cabinets are approximately 3 X 3 X 5 feet high with drawers of varying sizes to accommodate small tooling. Again, Stanley/VIDMAR type was selected because this type is presently used in the factory and most desirable by both shop foremen and technicians.

6.2.6.4 TOOL RACKS

Tool racks planned are to accommodate the tooling in support of the presses and the flow form lathe. These racks are of a heavy duty type that comes in 10 foot sections with 5 shelves and are 12 feet high. The shelves are adjustable on 4 inch centers and are adaptable to add-ons if required. Two units are selected making the rack 40 inches deep by 20 feet long by 12 feet high. SPS has just recently purchased some for our High Bay area and they cost about \$1,500 for the two units.

6.2.6.5 TD 40136 TANGENT PRESS

This machine will form the major forming operations of the housing until the flow forming equipment is up and operational. It will also serve as a back-up unit throughout the life of the sheet metal facility. It is a four cylinder press that has reverse drawing capability and will allow coil feed. A Tangent press is the same as a Lagan press.

6.2.6.6 TD 40137 CIRCLE SHEER

This shear will be used to cut a disc out of a flat sheet, a necessary operation to control the forming of some parts. There are several off the shelf units on the market. One of the better makes is ARYMA.

6.3 IMPLEMENTATION PLAN

6.3.1 FACILITY

The area planned for the Precision Metal forming Cell is located at the south end of Sundstrand's Ruffin Road Facility as shown in Figure 6-5. This area is an open area with a temporary roof used for storage. It is planned to close in and complete this area to meet the requirements for the new sheet metal cell.

The new area is being sized to accommodate the planned equipment in support of the IMIP flow forming cell plus additional equipment that would allow Sundstrand to fabricate all sheet metal parts now under contract and planned future needs, reference Figure 6-6. Note, these additional items located in the facility that are not listed in Figure 6-2.

6.3.2 EQUIPMENT

A detailed plan for the procurement, installation, and facility build is shown in Figure 6-7. The down payment for all equipment listed is planned for 1991. The facility construction is also planned for 1991. Receipt of equipment and their installation is planned for 1992, such that the facility and equipment will be capable of delivering production units by mid 1992.

6.3.3 MANAGEMENT

The Precision Metal Forming Cell operation will be integrated into Sundstrand's existing management structure. As shown in Figure 6-8, the Director of Operations report to the Vice President and General Manager. In turn, as shown in Figure 6-9, the Manager of Components Manufacturing, report to the Director of Operations. Finally, the new facility operation is the responsibility of the Supervisor of Production, Sheet Metal Components, as shown in Figure 6-10. He in turn report to the Manager of Components Manufacturing.

6.4 FOLLOW-ON ACTIVITIES

This new facility will provide Sundstrand the capability to produce our products at a significant savings. Some additional benefits will be in support of future programs both in shortened lead times for existing hardware and reduced time for development of new hardware.

As mentioned in Section 6.3 above, with the addition of more capital equipment (less than \$1,000,000), all sheet metal parts can be fabricated in-house with higher quality and at a reduced cost.

PART	PREVIOUS DESIGN		NEW DESIGN		
	MAKE	BUY	MAKE	BUY	
167180-1		X	X		
163241-1		X	X		Part of Diffuser
163211-1		X		X	
162910-3		X	X		
162909-1		X	X		
162908-2		X	X		
162907-1		X	X		
162906-1		X	X		Part of Case
162905-1		X	X		Part of Case
100645-1		X		X	
100643-1		X			Part of Case
100642-1		X			Part of Case
49265-1		X		X	
24003-0		X		X	
163737-2		X		X	
163737-4		X		X	
COMBUSTOR ASSEMBLY	X		X		

Figure 6-1 Make Or Buy Plan

ITEM	\$	\$
	1991	1992
FLOW FORM LATHE	675,000	1,575,000
CO2 LASER UNIT	75,000	675,000
HYDRAULIC PRESS 100 TONS	6,000	54,000
SHEAR	5,000	45,000
TANGENT PRESS	40,000	360,000
CIRCLE SHEAR		70,000
HYDRAULIC PRESS 400 TONS		225,000
EQUIPMENT INSTALLATION		50,000
TOOL CABINET 3' X 3' X 5' HIGH (2)		1,500
TOOL RACK 42" X 20' X 15' HIGH		1,500
WORK BENCH (20)		14,000
SHOP STOOLS (16)		1,000
FACILITY	150,000	
CONTINGENCY 5%	47,550	153,600
TOTAL	998,550	3,225,600

Figure 6-2 Capital Equipment, Precision Metal Forming Cell

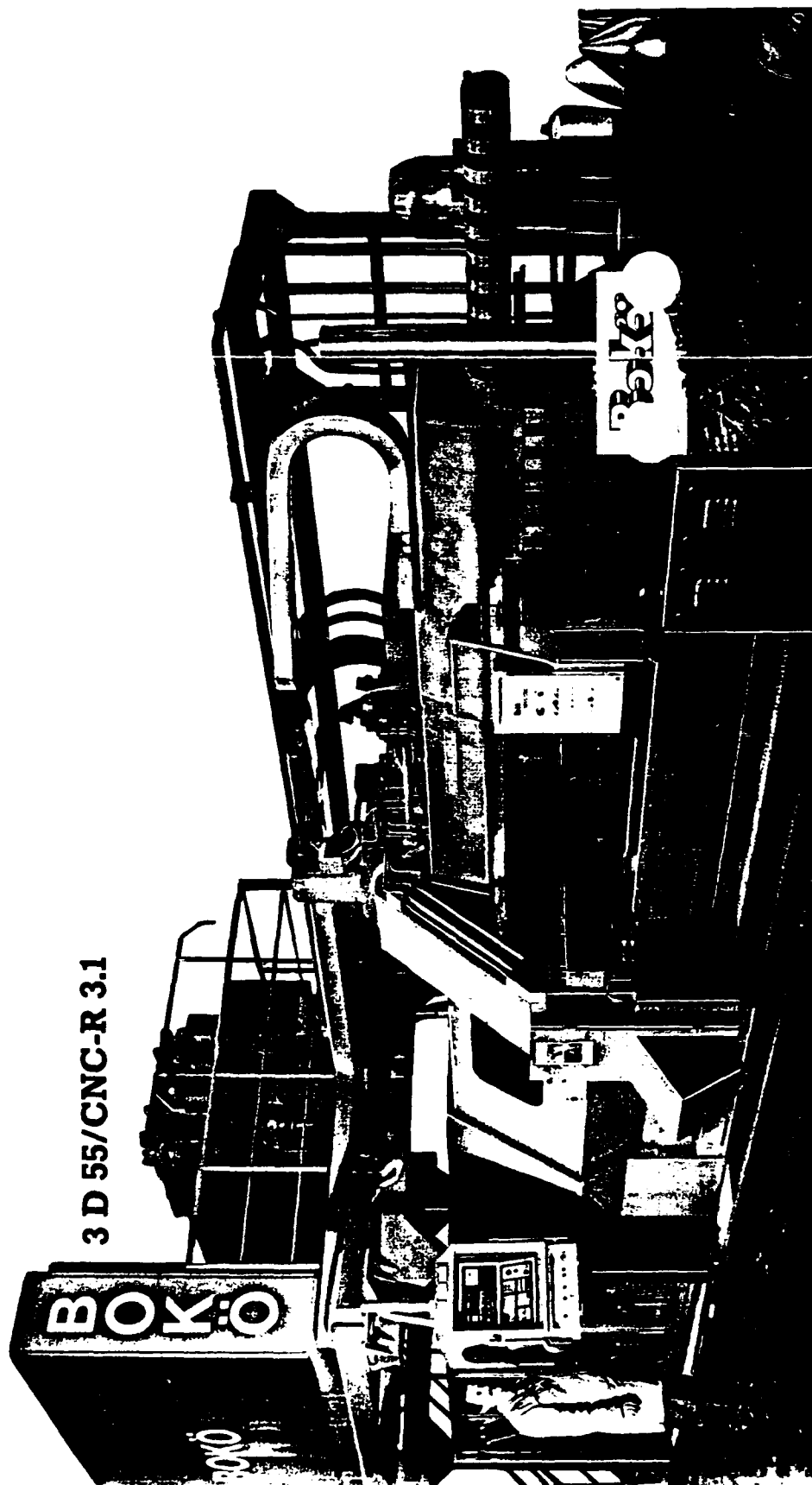


Figure 6-3 Flow Form Lathe

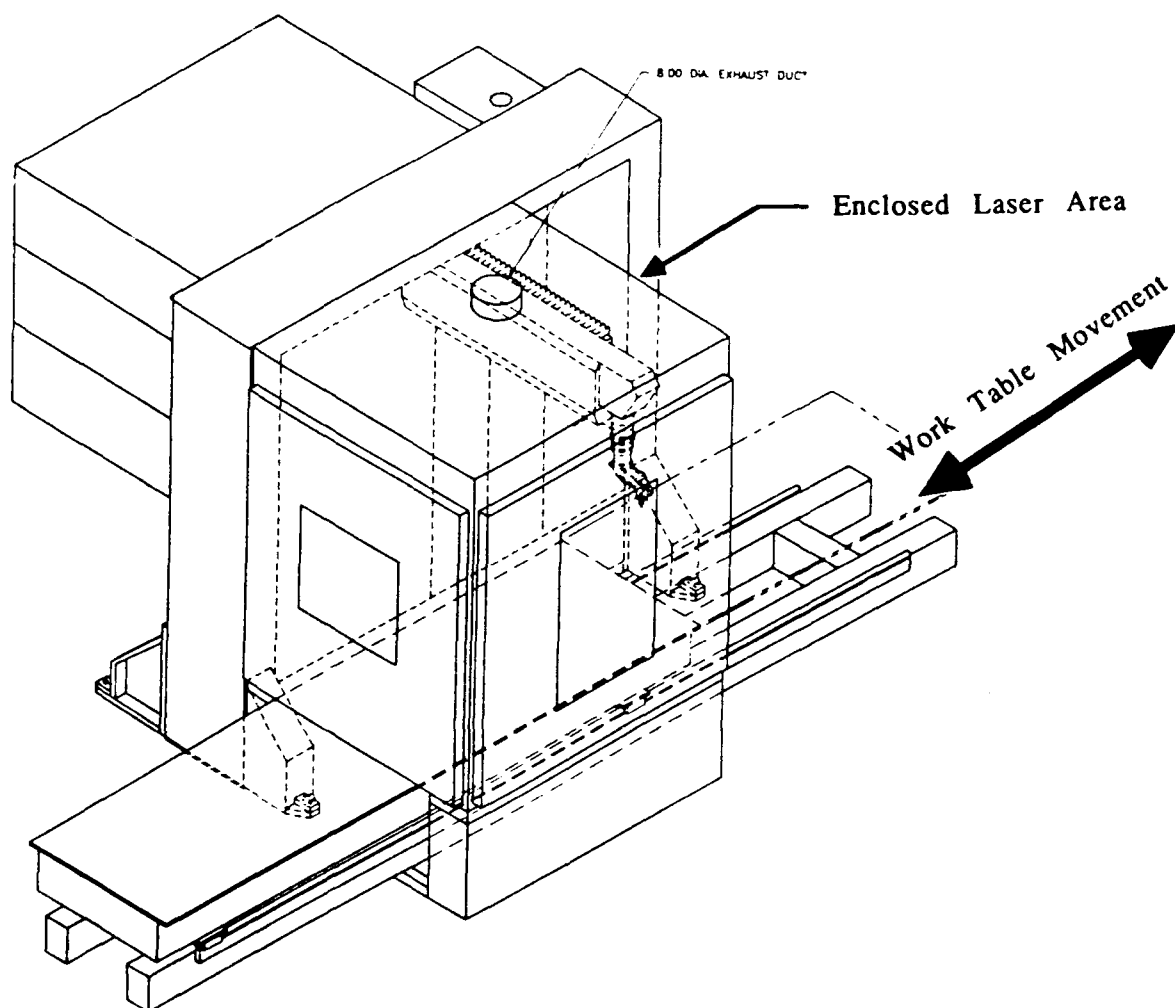


Figure 6-4 CO2 Laser Unit

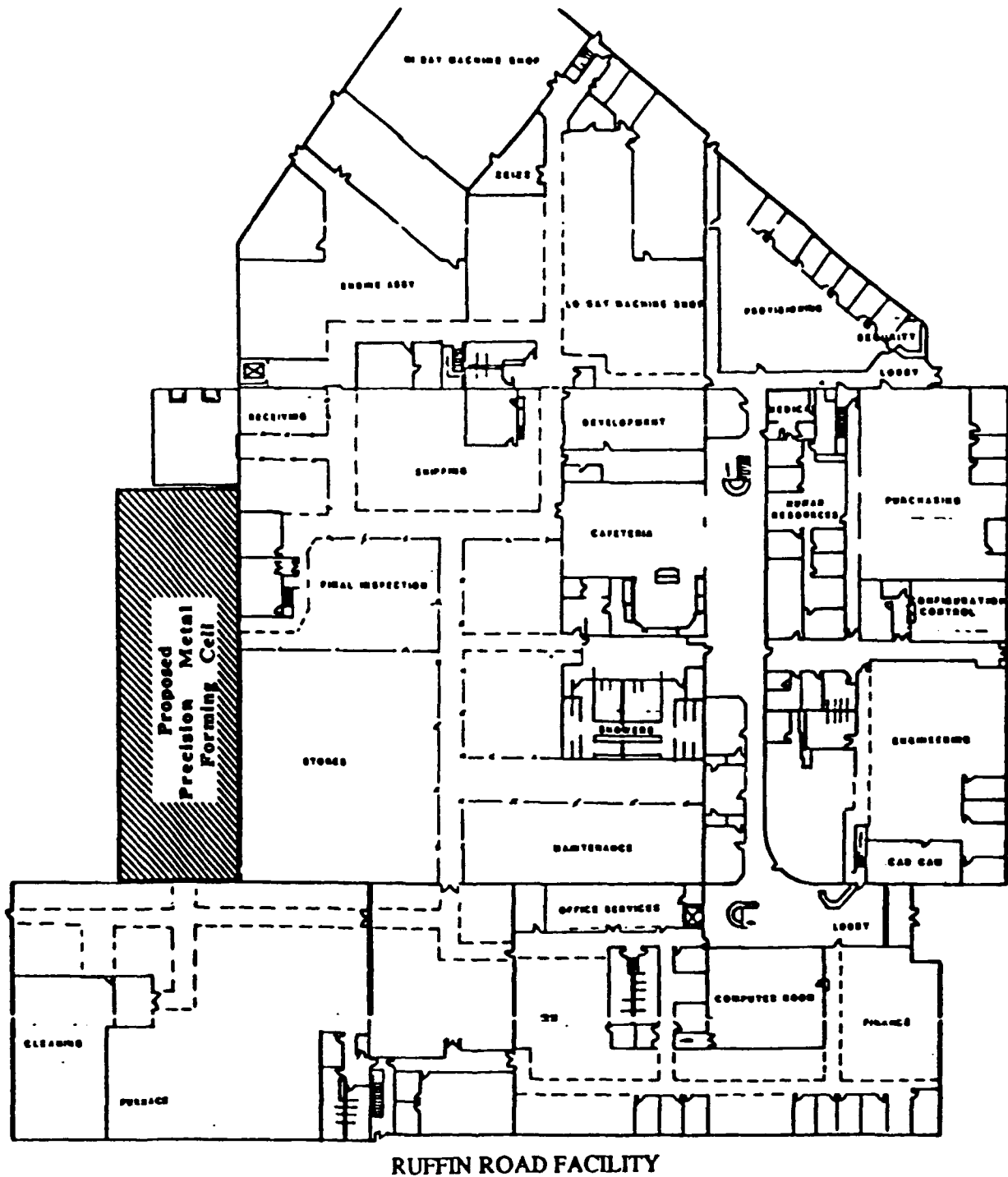


Figure 6-5 Location Of The Precision Metal Forming Cell

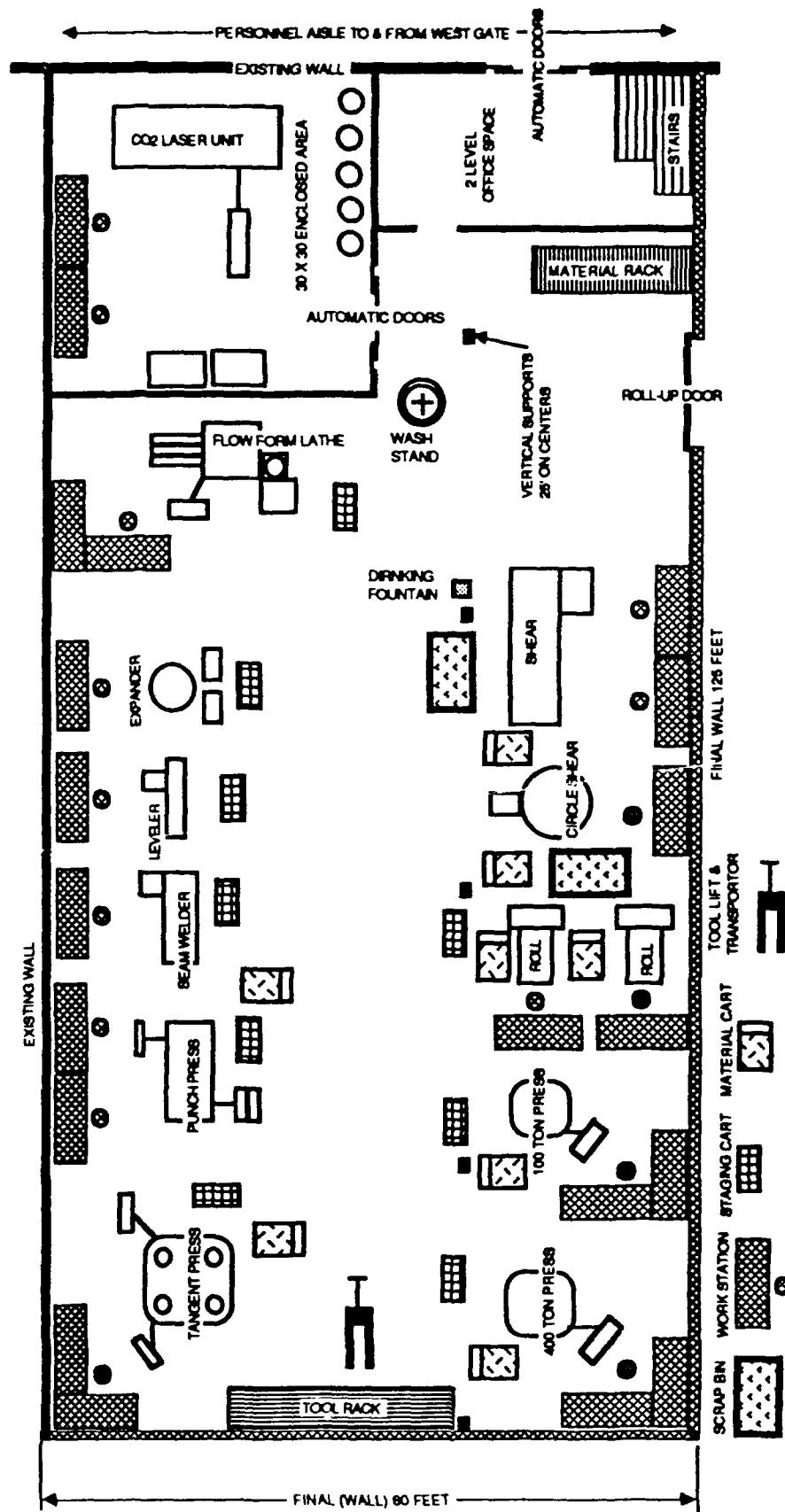


Figure 6-6 Precision Metal Forming Cell Layout

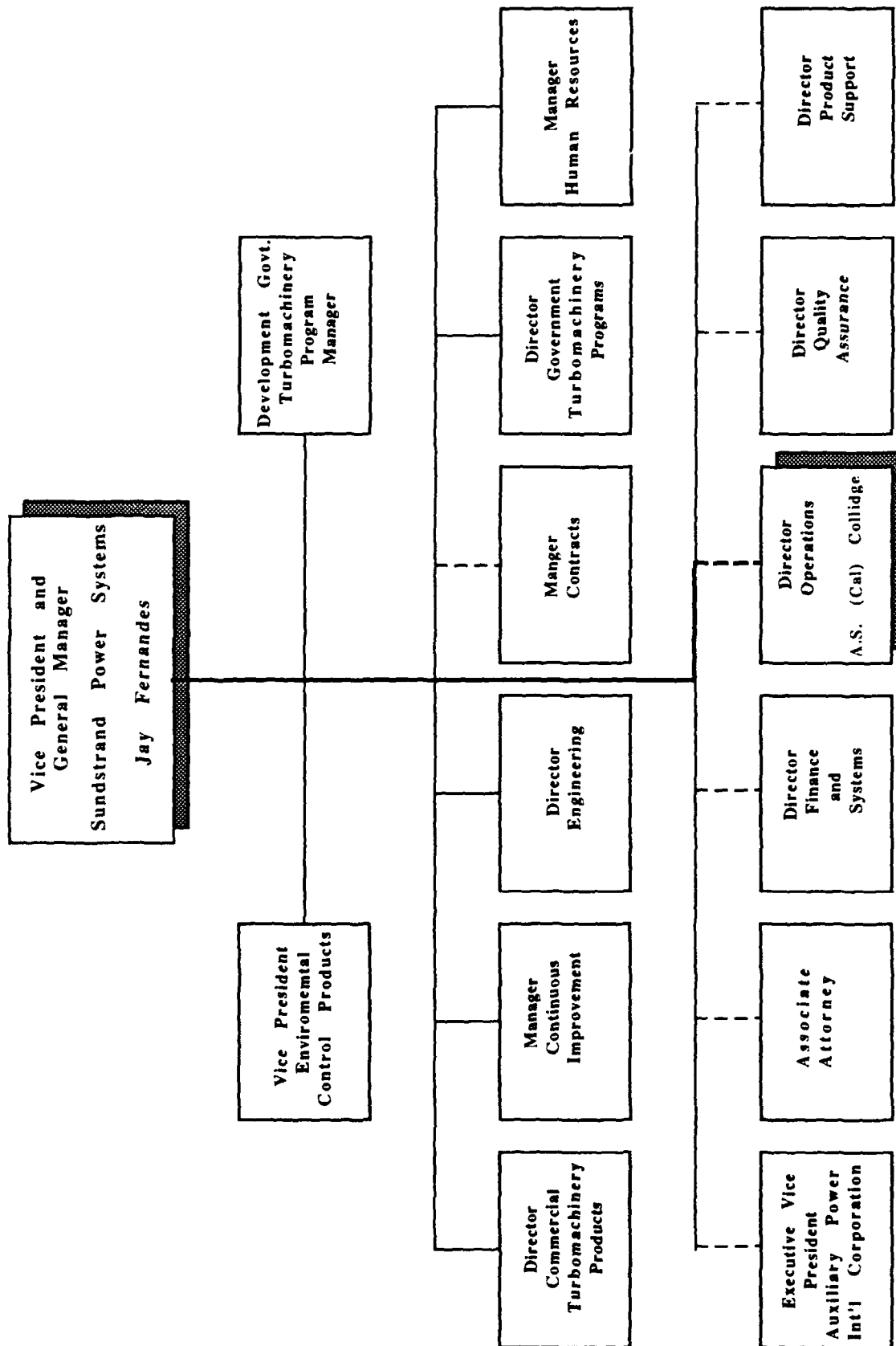


Figure 6-8 Sundstrand Power Systems Management Plan
Precision Metal Forming Cell

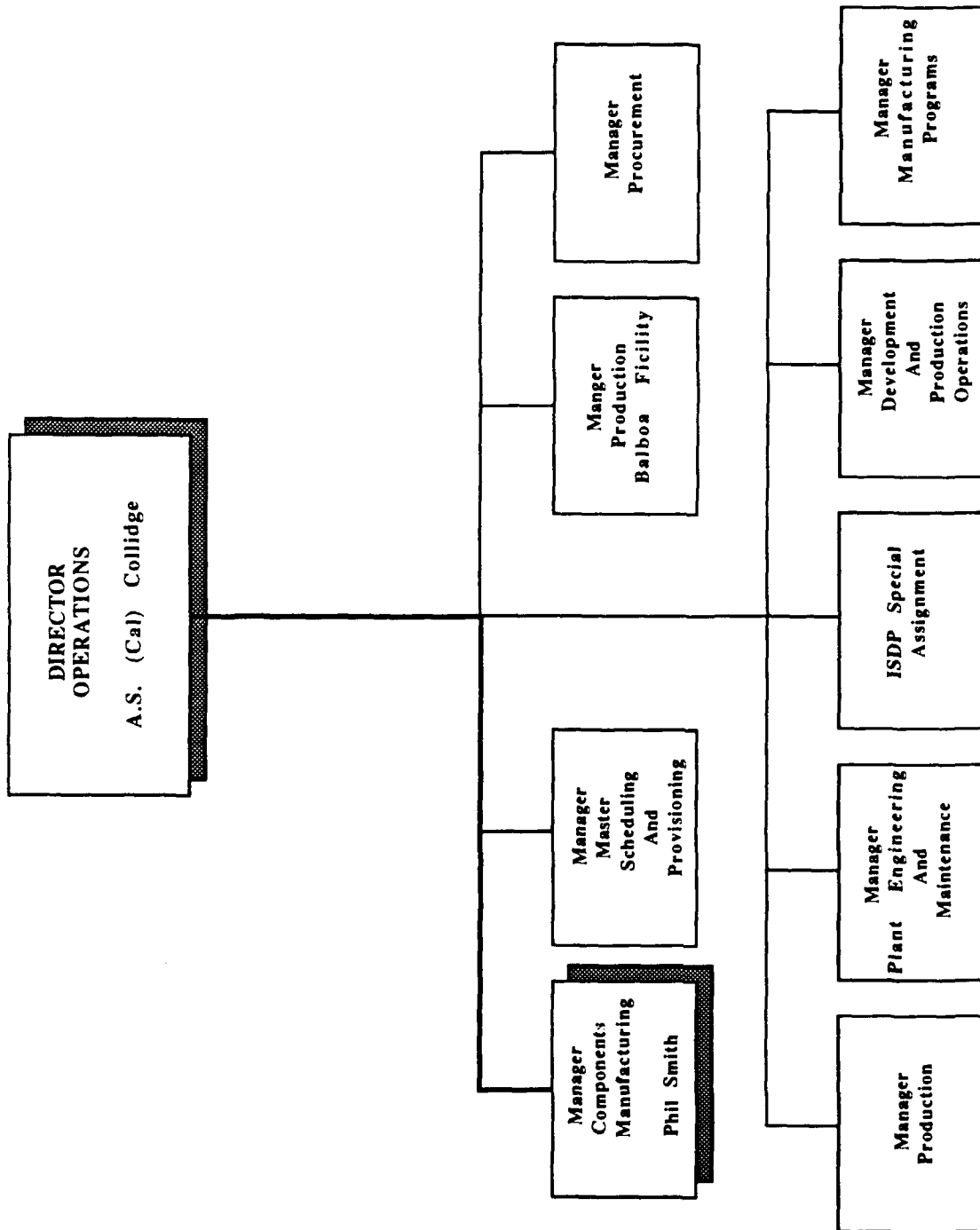


Figure 6-9 Operations Organization - Precision Metal Forming Cell

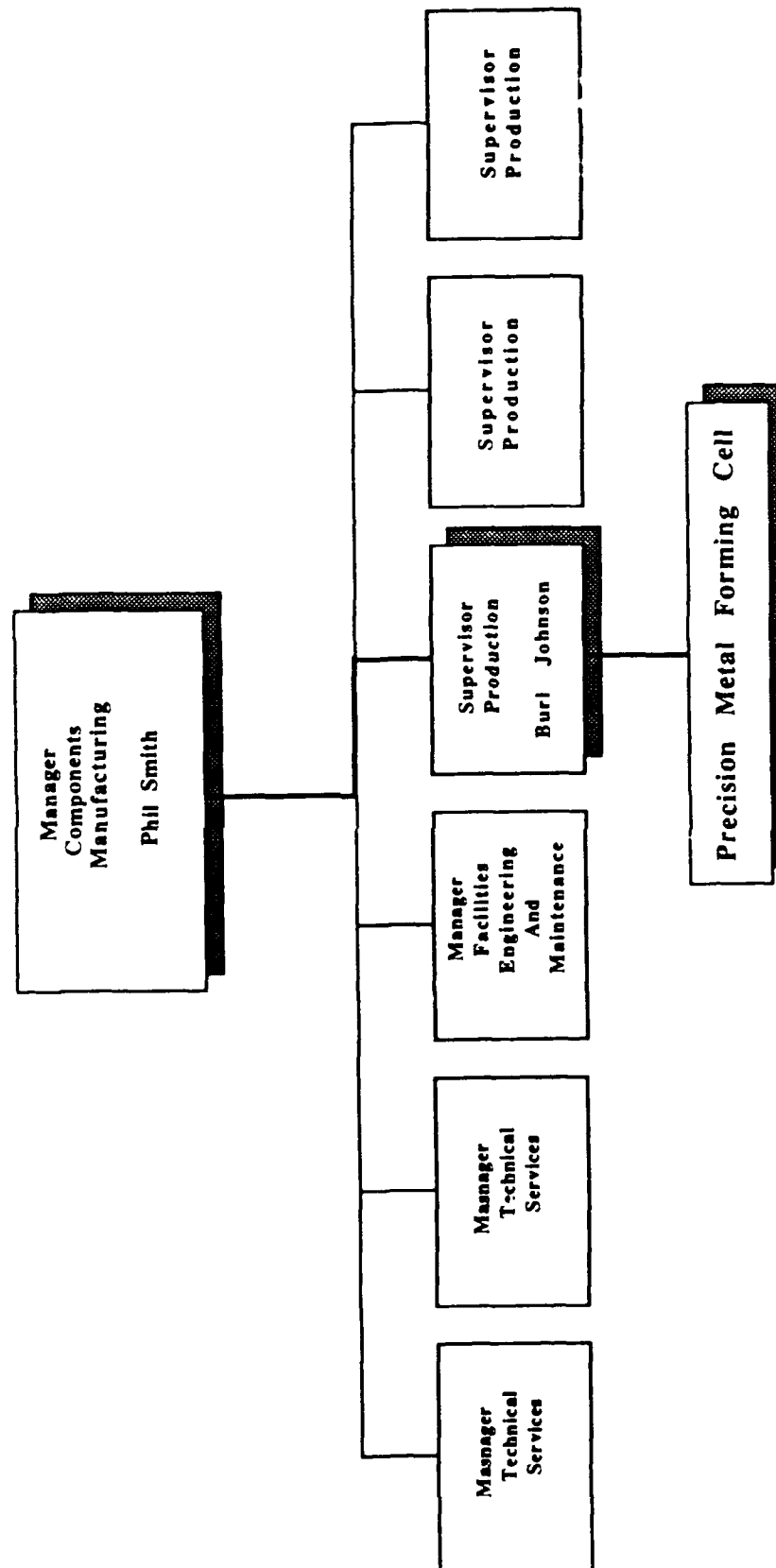


Figure 6-10 Components Manufacturing Organization
Precision Metal Forming Cell

7.0 COST BENEFIT ANALYSIS

7.1 COST ANALYSIS APPROACH

The basic approach used for the cost analysis update was not the approach used during Phase I. A complete new baseline had to be established due to the many changes in Sundstrand's financial structure since August of 1987, when the Phase I analysis was completed. The Phase I approach was essentially a "grass roots" estimate which would take considerable time and many more hours than planned in the Phase II budget.

The approach used consisted of two parts. First, the Task Node Tree developed in Phase I was updated and was used as the primary guide for developing the cost estimate for nonrecurring effort, see Appendix A.

Second, the primary and recurring task estimate was based upon a detailed analysis of the combustor assemblies as reconfigured. The direct manhours and direct material dollars were estimated and compared to the "AS IS" resulting in the delta direct manhours and dollars per unit. These costs were multiplied by the number of production units planned for the base, year 1990. Sundstrand's 1990 forward pricing rates were applied and distributed in accordance with existing ratios to establish the total cost "TO BE" for the base year.

The base year was then projected through 1998, based upon planned and forecasted production deliveries with the appropriate inflation factors applied, see Figure 7-1. The spike in Commercial units for 1992 is due to the one time retro fit of the 737 with the APS 2000. This helps compensate for the dip planned in Military units that same year. Since the overall production delivery rates are rather consistent, it was determined that the 1990 forward rate ratios would be also fairly consistent.

Finally, the nonrecurring labor and capital equipment planned for this project were added to the forecast in the years that those expenses are expected to occur.

7.2 COST BENEFIT SUMMARY

The cost benefit was established for Commercial and Military projects based upon planned and forecasted production deliveries. Only the capital equipment identified in the Phase II plan (flow form and laser weld equipment, military portion) was applied to the Military cost savings. Both the flow form and laser weld equipment (commercial portion) plus the additional capital equipment required for the complete metal forming cell were applied to the Commercial cost savings.

The total accumulated savings forecasted through 1998 are \$8,916,450. Commercial savings projected are \$4,075,476. Military savings projected are \$4,840,974. The savings on the Military side are to be shared between the Air Force and Sundstrand on a 50/50 basis. A summary of the projected savings are shown in Figure 7-2.

7.3 RETURN ON INVESTMENT

The government has invested a total of \$1,671,647 in the IMIP Phase I and Phase II funded studies. It is projected that with the implementation of the flow forming and laser welding equipment the government will see a savings of \$2,420,487 over the next seven years. This equates to an average of 20.69% per year return on investment.

Sundstrand Power Systems plans a capital investment of \$4,224,150 with a projected savings of \$6,495,963 in combustor housing costs for both Commercial and Military programs over the next seven years. This equates to an average of 21.97% per year return on investment.

THE SAVINGS LISTED ABOVE ARE THOSE SAVINGS REALIZED OVER AND ABOVE THE COST OF THE CAPITAL INVESTMENT.

7.4 GROUND RULES AND ASSUMPTIONS

7.4.1 All combustor housing assemblies will be of the new configuration in time to support all deliveries planned for 1992.

7.4.2 Configurations other than that used for KC-135 and T-40 assemblies will be accomplished in order of priority based upon production delivery rates. The highest number of deliveries being first.

7.4.3 Flow form and laser weld equipment will be placed on order (contract) in time to support mid 1992 deliveries.

7.4.4 A 10% down payment will be made with each equipment order and all will occur in 1991.

7.4.5 The T-40 and KC-135 combustor housing assemblies will be used as the basis for the detailed cost analysis to determine the direct labor and material dollar impact due to the flow form design.

7.4.6 The cost impact between Q.C. and P.Q.E. will be a wash between the existing and planned configurations.

7.4.7 The cost impact within the Finance departments will be a wash between the existing and planned configurations.

7.4.8 All capital equipment other than that specified in the IMIP Phase I and II plan will be charged against the Commercial Programs only.

7.4.9 The ratios between department functions will remain steady through 1998.

7.4.10 Inflation will occur at a rate of 5% per year through 1998.

7.5 BASELINE DEVELOPMENT

The Price Waterhouse software program ACBG was used to establish the "AS IS" baseline. Reference IMIP Phase II Book 4, User Documentation (located at Sundstrand).

7.5.1 To use the ACBG program it necessary to have a TECHMOD Serial Port Security Key installed in the 9 pin Serial Port located on the aft side of the computer. The key consists of a 25 pin connector assembly attached to an adaptor harness with a 25 pin connector to a 9 pin connector.

Note: If the security key is not already installed onto computer, the key will be stored in the Users Documentation Manual, IMIP Phase II Book 4.

7.5.2 Program call up is: \IMIP\DCF\ACBG\REV. (all caps must be used). The program will request: "YOUR ACCOUNT PLEASE", which is "TECHMOD" (caps).

ENTER PASSWORD "PW" (for Price Waterhouse)

2-1

COMPANY CODE STC Sundstrand Turbomach Corporation - Phase I

SPS Sundstrand Power Systems - Phase II

7.5.3 Once into the ACBG\REV program, a new company SPS was created the same as STC with updated revisions. First the Cost Centers and their expenditures were updated to reflect today's financial structure and expenditures for the period of January 1, 1990 through August 30, 1990. Data was obtained from the Budget Variance Report, etc. See Figure 7-4, Basic 18 Cost Elements. This report specifies the cost element and from which report the data was obtained. See APPENDIX B for detailed cost data by Cost Center for all Cost Centers.

7.5.4 After completion of the Cost Center update was completed, a "Ao" Report was requested from the ACBG\REV program. This report summarizes the Cost Center data in the basic Cost Elements, see Figure 7-5, for above expenditure period. This was then extended through the end of 1990, giving us our "AS IS" Base Year.

7.5.5 The "AS IS" and the "TO BE" baseline data were entered into a Lotus Spread Sheet (IMIP-2). The "TO BE" baseline was created by performing a detailed analysis of the T-40 and KC-135 Combustor Housing Assemblies. This analysis was performed by Manufacturing Engineering and the results are shown in Figure 7-6. This analysis provided the change in Direct Labor hours and Direct Material dollars between the existing configuration and the new. Using Sundstrand's Forward Pricing Rates, shown in Figure 7-7, the cost data was entered into the IMIP-2 Cost Benefit Analysis and provided the "TO BE" baseline data. Math for the generation of the "TO BE" baseline and extension through 1998 is shown in Section 7.8.1.2.

7.6 NODE TREE UPDATE

7.6.1 The Task Node Tree established in IMIP Phase I study was updated and distributed to all departments affected for comment. All comments were collected and incorporated into its final form shown in APPENDIX A.

7.6.2 The final Node Tree was distributed to all functions affected and used as a guide to determine nonrecurring expenditures required to implement the new Precision Metal Forming Cell. Per Ground Rules and Assumptions all nonrecurring tasks will be complete by the end of 1992. These costs were added into the Cost Benefit Analysis Spread Sheet. Only two departments could identify any significant impact and they were Manufacturing Engineering and ILS. These costs were added to the Direct Nontouch Labor in 1992. Back-up data for this is located in the IMIP Phase II Book 2, located at Sundstrand.

7.7 UNIT DELIVERY FORECAST

7.7.1 The basis for Unit Delivery Forecast was the October Plan generated by all Program Offices. The Commercial Data was reviewed by Mr. Rich Pozzi on 8-14-90 and was modified to reflect the SAAB and APS 3000 programs and a forecast of the APS 2000 program out years. Using the above data, a Mean Data Curve was generated establishing the final projected Unit Delivery Forecast, see Figure 7-1. Reference IMIP Phase II Book 2 for detailed back-up data.

7.8 DETAILED COST ANALYSIS

7.8.1 LOTUS INPUT FORMULAS

All worksheet math is recorded in detail in the IMIP Phase II Reference Book 2, in Section "Impact Rational". A summary is provided in the following sections.

7.8.1.1 BASIC DISTRIBUTION

The basic distribution of dollars was based upon the existing ratios between basic elements of the base year, reference Figure 7-2. It was assumed that these ratios will remain constant for the period of this analysis. They are:

Direct Labor Burden	\$	RATIO
Indirect Touch Labor	454,976	.83333
Indirect Nontouch Labor (.1737)	2,850,984	.52222
Rework Labor	319,232	.05847
Maintenance (.1737)	21,917	.00401
Supplies (.1737)	75,803	.01388
Tooling	394,374	.07224
Facilities (.1737)	113,367	.02077
Utilities	995,296	.18231
Miscellaneous (.1737)	<u>233,433</u>	<u>.04277</u>
TOTAL	5,459,382	1.00000
Material Burden		
Indirect Nontouch Labor (.8263)	13,562,280	.58885
Outside Services	5,394,690	.23423
Maintenance (.8263)	104,262	.00453
Supplies	360,601	.01566
Information Systems	175,686	.00763
Facilities (.826)	539,291	.02342
Travel	1,784,250	.07747
Miscellaneous (.8363)	<u>1,110,453</u>	<u>.04821</u>
TOTAL	23,031,513	1.00000

7.8.1.2 BASE YEAR EXTENSION

The base year was extended through 1997 based upon the production/delivery rates and inflation forecast. The APS 2000 Combustor Housing costs are 2.3 times the cost of the other housings, therefore an adjustment to the quantity delivered was added to compensate for both cost of the APS 2000 and to provide a proper mix between Military and Commercial savings. The above rates and factors used, are shown below:

	1990	1991	1992	1993	
Delivery Rate	936	818	808	943	
APS 2000 Adjustment to Prod.	9	127	343	193	
Inflation Rate	1.0	1.0500	1.1025	1.1576	
Extension Factor	1.0	1.0500	1.3428	1.3916	
	1994	1995	1996	1997	1998
Delivery Rate	780	740	700	660	620
APS 2000 Adjustment to Prod.	136	136	136	136	136
Inflation Rate	1.2155	1.2763	1.3401	1.4071	1.4775
Extension Factor	1.1666	1.1561	1.1572	1.1361	1.1507

For example the Extension Factor for the year 1992 = 1.3428. This is obtained by establishing a ratio between the Base Year (1990) and the year 1992 for the number of production or planned delivery units for that year. To neutralize the expensive APS 2000 Housings which costs 2.3 times as much as the other units, an Adjustment Factor was added.

The Adjustment Factor is established by obtaining the number of APS 2000 units planned for a given year and multiplying by the cost factor of 2.3 - the number of APS 2000 housings in the total year. Using 1992, the total number of Production Units = 808. Of the 808 total units, 264 are APS 2000 units. Therefore, $264 \times 2.3 = 607$. Since there are 264 APS 2000 units already in the 808 count, 264 is removed from the 607 above to give the total Adjustment Factor = 343.

Since the Adjustment Factor for 1990 (calculated the same way) = 9, the total number of production units for 1990 is $936 + 9$ or 945. Comparing the total number of production units for 1992 ($808 + 343$ or 1151) to 1990 (945), the Extension Factor becomes $1151/945 = 1.2180$. By adding the inflation rate of 5% per year ($1992 = 1.1025$) the final Extension Factor = $1.2180 \times 1.1025 = 1.3428$.

For 1993 the Extension Factor = $943 + 193/(936 + 9) \times 1.1576 = 1.3916$.

7.8.1.3 COMMERCIAL AND MILITARY SPLIT

The split in savings, cost of capital equipment and depreciation of that equipment between Commercial and Military projects was based upon their ratio of delivered units each year. The ratios used for this analysis are:

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Commercial	.1852	.3471	.6202	.4129	.4377	.4860	.5343	.5872	.6195
Military	.8148	.6529	.3798	.5871	.5623	.5140	.4657	.4128	.3805

Results of this split between Commercial and Military projects is shown in Figure 7-2.

7.8.1.4 CAPITAL EQUIPMENT

The split in capital equipment as been separated into two categories: That which is shared between Commercial and Military projects and that which was applied to the Commercial projects only, reference Figure 7-3.

This is a direct input into the Cost Work Sheet, reference Figure 7-2. Note, the down payment for the capital equipment is in 1991. The balance will occur in 1992 when the equipment is received. The new facility has been estimated to cost \$150,000. To insure that all costs have been considered, a 5% contingency was also added for 1991 and 1992. Sundstrand's planned expenditure schedule is shown in Figure 7-8.

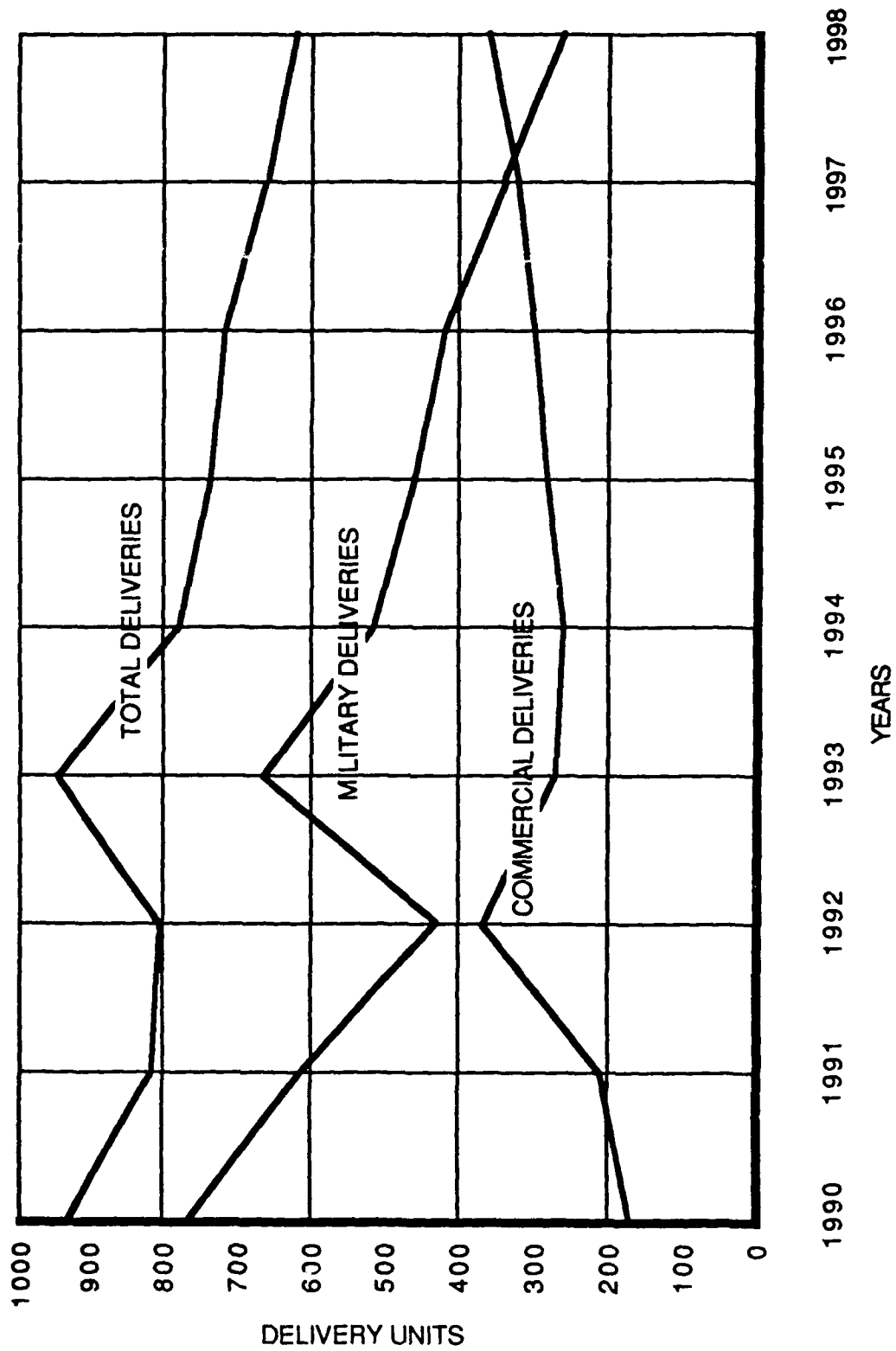


Figure 7-1 Production Delivery Forecast

COST ELEMENT	BASE YR										TOTAL
	1990	1991	1992	1993	1994	1995	1996	1997	1998		
SUMMARY											
PROJECT TOTAL	89,880,432	94,374,454	120,376,863	125,077,609	104,854,512	103,910,767	104,009,636	102,113,159	103,425,413	858,142,413	
"TO BE"	88,706,506	94,409,454	119,706,995	123,443,974	103,485,010	102,553,592	102,651,169	100,779,462	102,074,577	849,104,234	
POT SAV PROJ SUB TOTAL	1,173,926	0	669,867	1,633,635	1,369,502	1,357,175	1,358,467	1,333,697	1,350,836	9,073,178	
G & A	262,138	0	149,581	364,791	305,810	303,057	303,346	297,814	301,642	2,026,041	
POT SAV PROJ SUB TOTAL	1,436,063	0	819,449	1,998,425	1,675,311	1,660,233	1,661,812	1,631,511	1,652,478	11,099,219	
COMMERCIAL SAVINGS											
FLOW FORM EQUIPMENT	0	0	508,222	825,150	733,284	806,873	887,906	958,023	1,023,710	5,743,168	
EQUIPMENT DEPRICATION	0	(260,325)	(1,395,450)	0	0	0	0	0	0	(1,655,775)	
ADDITIONAL CELL EQUIP	0	0	84,498	56,255	59,633	66,214	72,795	80,002	84,402	503,799	
EQUIPMENT DEPRICATION	0	(248,550)	(975,600)	0	0	0	0	0	0	(1,224,150)	
COST OF MONEY	0	(43,254)	(146,433)	79,645	72,123	78,938	86,385	92,958	98,915	319,277	
TOTAL COMMERCIAL SAVINGS	0	(552,129)	(1,869,169)	1,016,643	920,635	1,007,619	1,102,680	1,186,577	1,262,621	4,075,476	
MILITARY SAVINGS											
FLOW FORM EQUIPMENT	0	0	311,227	1,173,276	942,027	853,360	773,906	673,488	628,768	5,356,051	
EQUIPMENT DEPRICATION	0	(489,675)	(854,550)	0	0	0	0	0	0	(1,344,225)	
COST OF MONEY	0	0	51,745	79,988	76,609	70,029	63,448	56,241	51,840	449,901	
TOTAL MILITARY SAVINGS	0	(41,622)	(41,784)	106,527	86,584	78,488	71,175	62,027	57,852	379,247	
TOTAL POTENTIAL SAVINGS	0	(531,297)	(533,363)	1,359,791	1,105,221	1,001,876	908,529	791,756	738,460	4,840,974	
TOTAL POTENTIAL SAVINGS	0	(1,083,427)	(2,402,531)	2,376,434	2,025,856	2,009,495	2,011,209	1,978,333	2,001,081	8,916,450	

RETURN ON INVESTMENT BASED UPON A 50-50 SHARE ON MILITARY PROGRAM SAVINGS
 AIR FORCE SAVINGS = 2,420,487 WITH AN INVESTMENT OF 1,671,647 THE IRR OVER THE SEVEN YEARS ABOVE = 20.69 %
 SUNSTRAND SAVINGS = 6,495,963 WITH AN INVESTMENT OF 4,224,150 THE IRR OVER THE SEVEN YEARS ABOVE = 21.97 %

Figure 7-2 Summary, Projected Cost Savings

ITEM	\$ 1991	\$ 1992	\$ TOTAL
* FLOW FORM LATHE	675,000	1,575,000	2,250,000
* CO2 LASER UNIT	75,000	675,000	750,000
HYDRAULIC PRESS 100 TONS	6,000	54,000	60,000
SHEAR	5,000	45,000	50,000
TANGENT PRESS	40,000	360,000	400,000
CIRCLE SHEAR		70,000	70,000
HYDRAULIC PRESS 400 TONS		225,000	225,000
EQUIPMENT INSTALLATION		50,000	50,000
TOOL CABINET 3' X 3' X 5' HIGH (2)		1,500	1,500
TOOL RACK 42" X 20' X 15' HIGH		1,500	1,500
WORK BENCH (20)		14,000	14,000
SHOP STOOLS (16)		1,000	1,000
FACILITY	150,000		150,000
CONTINGENCY 5%	47,550	153,600	201,150
TOTAL	998,550	3,225,600	4,224,150

* Equipment identified in IMIP Phase II plan chagred
against military contracts.

Figure 7-3 Listing Of Capital Equipment Planned In
Support Of The Precision Metal Forming Cell

Cost Element	Data Source
Direct Touch Labor	Budget Variance Report
Indirect Touch Labor	Budget Variance Report
Direct Nontouch Labor	Budget Variance Report
Indirect Nontouch Labor	Budget Variance Report
Rework Labor	Quality Assurance Report
Outside Services	Budget Variance Report
Maintenance	Budget Variance Report
Scrap	Quality Assurance Report
Supplies	Budget Variance Report
Information Systems	Budget Variance Report
Equipment	Budget Variance Report
Tooling	Budget Variance Report
Facilities	Budget Variance Report
Utilities	Budget Variance Report
Material	P. O. Commit Report
Travel	Budget Variance Report
Miscellaneous	Budget Variance Report

Figure 7-4 Sundstrand Basic Cost Elements

SUNDSTRAND POWER SYSTEMS		Ao REPORT	
ALL COST CENTERS SELECTED			
-----		-----	
Included Cost Elements:		Costs	Costs
-----		6 Month Base Year	12 Month Base Year
DIRECT TOUCH LABOR		2,977,923	5,955,846
INDIRECT TOUCH LABOR		227,488	454,976
DIRECT NONTOUCH LABOR		7,836,297	15,672,594
INDIRECT NONTOUCH LABOR		8,206,632	16,413,264
REWORK LABOR		159,616	319,232
OUTSIDE SERVICES		2,697,345	5,394,690
MAINTENANCE		63,090	126,180
SCRAP		732,300	1,464,600
INVENTORY CARRYING COST		NOT USED	NOT USED
SUPPLIES		218,202	436,404
INFORMATION SYSTEMS		87,843	175,686
EQUIPMENT		2,007,984	4,015,968
TOOLING		197,187	394,374
FACILITIES		326,329	652,658
UTILITIES		497,648	995,296
MATERIAL		17,140,264	34,280,528
TRAVEL		892,125	1,784,250
MISCELLANEOUS		671,943	1,343,886
		-----	-----
TOTAL:		44,940,216	89,880,432

Figure 7-5 Ao Report

160007 (T40-8) 161637 (KC-135)
Combustor Assembly Cost Analysis

PART NUMBER/NAME	CURRENT	PROPOSED	COMMENTS
167180-1 MANIFOLD BRKT.	\$ 15.99	\$ 15.99	SAME
163214-1 EXHAUST FLANGE	\$ 70.99	0	PART OF DIFFUSER
163211-1 DRAIN ELBOW	\$ 18.04	\$ 18.04	SAME
162910-3 OUTER CASE	\$352.25	\$ 45.00	FLOW FORMED
162909-1 EXHAUST DIFFUSER	\$126.48	\$ 25.00	FLOW FORMED
162908-2 IGNITER DOUBLER	\$ 15.05	\$ 1.50	MODIFIED
162907-1 DRAIN BOSS DOUBLER	\$ 9.89	\$ 3.00	MODIFIED
162906-1 TUBE FTG. DBLR. (6)	\$ 63.72	\$ 0	PART OF OUTER CASE
162905-1 FORWARD FLANGE	\$ 46.36	\$ 0	PART OF OUTER CASE
100645-1 TUBE FTG. (6)	\$ 25.32	\$ 95.70	MODIFIED
100643-1 INJ. NUT DISC.	\$ 2.60	\$ 0	PART OF OUTER CASE
100642-1 PIN NUT DISC (4)	\$ 13.00	\$ 0	PART OF CASE
49265-1 IGN. PLUG BOSS	\$ 3.54	\$ 3.54	SAME
24003-0 FITTING (2)	\$ 53.82	\$ 8.40	MODIFIED
163737-2 HEX NUT PIN (4)	\$ 12.28	\$ 14.16	MODIFIED
163737-4 INJ. NUT	\$ 3.29	\$ 4.40	MODIFIED
TOTAL MATERIAL	\$832.62	\$234.73	SAVINGS = \$597.89

IN-HOUSE FABRICATION

162910-3	OUTER CASE	0.00	.40 HRS.
162909-1	EXHAUST DIFFUSER	0.00	.20 HRS.
162908-2	IGNITER DOUBLER	0.00	.04 HRS.
162907-1	DRAIN BOSS DOUBLER	0.00	.08 HRS.
COMBUSTOR ASSEMBLY		10.34 HRS	5.20 HRS
TOTAL FAB. HOURS		10.34	5.92
			SAVINGS = 4.42 HRS.

Figure 7-6 Unit Cost Analysis

ITEM	1990	1991	ITEM	1990
Material	15.74%	16.50%	G & A	22.8%
Scrap	4.00%	4.00%	Treasury	8.5%
Manufacturing Burden	\$14.28 \$89.72	\$14.99 \$94.21		
Engineering Burden	\$22.27 \$27.04	\$23.38 \$28.39		

Figure 7-7 Forward Pricing Rates

[illegible]

8.0 COST/SAVINGS RISK ANALYSIS

The Cost/Benefit Analysis in Section 7.0 was accomplished by taking a very conservative approach to projected savings. The elements of risk associated with the implementation of the Precision Metal Forming Cell are:

1. Projected sales or number of units planned for delivery
2. Cost of capital equipment/facilities
3. Part fabrication costs
4. Material costs
5. Recurring/Nonrecurring effort is support of the new facility
6. Other costs

8.1 PROJECTED SALES

The projected sales shown in Section 7.0, Figure 7-1, are based upon firm sales, near term sales, and likely sales thru 1998. This projection shows a continuous reduction in sales, which is a worst case scenario. Once the new facility is in place, it is expected that sales will increase due to a reduction in product cost and the ability to expand Sundstrand's product base.

8.2 COST OF CAPITAL EQUIPMENT/FACILITIES

All costs for capital equipment were from actual quotes or estimates based upon the highest quotes of similar equipment. Experience shows that minor costs will occur for items inadvertently overlooked. Therefore, a percent contingency factor (\$201,150) was added. It is expected that another 2 to 3 percent can be obtained during negotiations for the procurement of the equipment. Costs associated with the building of the facility are well known and it is expected that the economy in 1991 will not change enough to drive costs above that estimated.

8.3 PART FABRICATION COSTS

Manhours and run times used in the development of unit costs were based upon actuals obtained from our vendors now fabricating the combustor components for the IMIP study. As discussed in Section 4.0, there are 9 steps in just the forming of the combustor housing. The cost analysis was based on using this same procedure in house. Once the flow form lathe is operational and technique demonstrated by BOKO is in place, housing costs will greatly decrease. Assembly costs decrease due to the one-piece housing design, which has fewer parts. Estimated assembly times were multiplied by 2 to be conservative, even then a significant reduction can be achieved. In addition, when laser welding is incorporated assembly times will be just a fraction of that experienced with brazing.

8.4 MATERIAL COSTS

With the incorporation of the new facility, materials will be mostly limited to raw materials or minor parts presently being fabricated. Both of these costs are well known and a 5 percent inflation factor per year was added. This is higher than being experienced today or projected by economists.

8.5 RECURRING/NONRECURRING SUPPORT COSTS

These are costs associated with new tooling and Manufacturing Engineering support for start-up of the new facility and on going facility support. Tooling already exists to support housings fabricated using the method used to fabricate the housings for the IMIP study. Very little tooling will be required for the new flow form lathe. Manhours estimated to develop planning, etc in support of fabrication of parts in-house was increase by 30 percent to allow for unanticipated tasks. No reduction in Manufacturing Engineering support was taken due to fewer parts being procured. It was assumed that the additional liaison support would equal the required support for existing procurement of parts. Experience shows this to be a conservative assumption.

8.6 OTHER COSTS

There are other costs savings which can be realized, such as the reduction in material handling and material stores which were not incorporated into the cost/benefit analysis. Material handling costs will be reduced due to the reduction in parts with the new one-piece design. In addition, once the new facility is in operation, Sundstrand will no longer carry the large inventory presently required to support production assembly schedules. It is planned to produce the flow formed parts on a "just in time" basis.

8.7 RISK ANALYSIS SUMMARY

With the conservative approach taken in the Cost/Benefit analysis, as stated in Sections 8.1 thru 8.6, it is Sundstrand's position that there is very little or no risk associated with achieving the projected cost savings. In fact, it is expected that both the government and Sundstrand will experience greater savings than projected.

**SUNDSTRAND POWER SYSTEMS IMIP
NODE TREE FOR PHASE III**
(NODES IMPACTED ARE HIGHLIGHTED IN BOLD TYPE)

Revision: A August 7, 1990

A 1 MARKET AND SELL PRODUCT**A 2 ADMINISTRATE COMPANY****A 21 Perform Financial Planning and Analysis****A 22 Perform General Accounting****A 221 MANAGE ASSETS****A2211 Account For Cash/Marketable Securities/Prepaid Items****A2212 Manage Accounts Receivable****A2213 Manage Notes Receivable****A2214 Account For Plant Property and Equipment****A2215 Account For Long Term Investments/Receivables****A 222 MANAGE LIABILITIES****A2221 Manage Accounts Payable****A2222 Account For Notes Payable****A2223 Account For Taxes Payable****A2224 Account For Accruals****A2225 Provide Payroll Processing****A 223 MANAGE COSTS****A2231 Account For Standard/Product Costs****A2232 Control Inventory Costs****A2233 Generate Rate Information****A2234 Perform Labor Audit Procedures****A 224 PREPARE FINANCIAL STATEMENTS/REPORTS****A2241 Generate Company Balance Sheet/Income****A2242 Generate Product Income Statement****A2243 Analyze and Report On Operating Various****A23 Manage Programs****A 231 PLAN AND CONTROL PRODUCT ORDERS AND DELIVERIES****A 232 ENSURE CUSTOMER AND TECHNICAL REQUIREMENTS ARE MET****A 233 PLAN PROGRAM BOOKINGS AND REVENUE****A 234 DEVELOP AND MONITOR PROGRAM BUDGETS****A 235 ADMINISTER CONTRACT****A2351 Interpret Customer Requirements As Contractulized To Sales Order****A2352 Interpret Contract Law & Government Regulations****A2353 Conduct Formal Interface With Customer Status & Program Updates****A2354 Ensure All CDRL's Are Met****A2355 Analyze & Incorporate Contract Revisions/Addenda****A 236 MANAGE PROGRAM TEAM**

A24 Provide Information Services

A 241 PROVIDE INFORMATION RESOURCE MANAGEMENT (IRM)

A2411 Provide Business System Applications

A24111 Provide Financial Systems

A24112 Provide Manufacturing Systems

A241121 Provide Systems Analysis

A241122 Provide Systems Development

A241123 Provide Systems Implementation Support

A241124 Provide Systems Training To User

A24113 Provide Payroll-Personnel System

A2412 Provide Office Automation

A2413 Operate Information Center

A2414 Provide Telecommunications

A2415 Provide System Security

A 242 PROVIDE TECHNICAL SYSTEMS MANAGEMENT

A2421 Provide CAD System & Support (Commercial only)

A2422 Provide CAE System & Support

A 2423 Provide CAM System & Support

A2424 Provide CAP System & Support

A2425 Provide CIM System & Integrate DEC with CINCOM Mfg. System

A243 OPERATE HOST DEC COMPUTER NETWORK

A25 Manage Human Resources

A26 Provide Facilities/Equipment Engineering & Maintenance

A 261 Provide Facilities Design & Engineering

A 262 Perform Equipment Engineering

A 263 Perform Facilities Maintenance

A 264 Perform General Equipment Maintenance

A3 ENGINEER PRODUCT

A4 MANUFACTURE PRODUCT

A 41 Perform Manufacturing/Industrial Engineering

A411 PERFORM SUPPLIER TECHNICAL LIAISON

A412 PERFORM INDUSTRIAL ENGINEERING

A4121 Conduct Work Measurement Analysis

A4122 Analyze Manpower Requirements

A4123 Analyze Potential Applications of New Technologies

A413 PERFORM ASSEMBLY & MANUFACTURING ENGINEERING

A4131 Prepare Process Planning To Accomplish Assy & Mfg. Ops.

A4132 Create Photo Planning to Assist Assembly Operations

A4133 Determine Perishable Tools & Hardware to Support Mach. Ops

A4134 Program CNC Operations

A4135 Provide Welding Engineering Data & Process

A4136 Perform Shop Floor Liaison

A414 PERFORM TEST MANUFACTURING ENGINEERING

A415 PERFORM TRAINING FOR SHOP FLOOR & ENGR PERSONNEL

A 4 2

Plan Schedule and Control Production

A 4 2 1 CREATE MASTER SCHEDULE

A 4 2 1 1 Review Production Unit Forecast

A 4 2 1 2 Coordinate With Program Management

A 4 2 1 3 Refine Production Unit Forecast Into Master Schedule

A 4 2 2 DETERMINE REQUIREMENTS & RELEASE ORDERS

A 4 2 2 1 Determine & Analyze Production & Material Requirements

A 4 2 2 2 Release Purchase Requisitions

A 4 2 2 3 Release Work Orders

A 4 2 3 CONTROL SHOP FLOOR

A 4 2 3 1 Schedule Daily Build Activity

A 4 2 3 1 1 Determine Priorities & Release W/O's For Kitting

A 4 2 3 1 2 Determine Available Material

A 4 2 3 1 3 Provide Work Assignments & Routing To Mechs.

A 4 2 3 2 Supervise Mechanics, Test tech, & Material Movers

A 4 2 3 3 Resolve Inventory/Work Order Discrepancies

A 4 2 3 3 1 Research Various Quality, Inventory, History, Req's

A 4 2 3 3 2 Interface With Involved Individuals

A 4 2 3 3 3 Determine Inventory Adjustments/Resolutions

A 4 2 3 3 4 Resolve Work Order Problems

A 4 2 3 4 Expedite Material

A 4 2 3 4 1 Prioritize Parts According To Shortages & Need

A 4 2 3 4 2 Analyze Past-Due MRP Req'mts & Up-Date

A 4 2 3 4 3 Ensure Parts Are Located & Issued To Floor

A 4 2 3 5 Monitor Production Line & Paper Flow

A 4 3 Engineer Quality

A 4 3 1 ASSURE QUALITY OF OUTSIDE PRODUCED HARDWARE

A 4 3 1 1 Monitor Vendors & Assure Quality Compliance

A 4 3 1 1 1 Survey Vendor For Acceptable Quality Standards

A 4 3 1 1 2 Rate Vendor Performance & Update Vendor Rating

A 4 3 1 1 3 Audit Vendors For Compliance To Specifications

A 4 3 1 1 4 Conduct Vendor Source Inspection

A 4 3 1 2 Review & Approve All Special Processes

A 4 3 1 3 Determine Purchase Order Quality Requirements

A 4 3 1 4 Prepare Detail Check Charts For Receiving Inspection

A 4 3 1 5 Conduct Receiving Inspection

A 4 3 1 5 1 Conduct Mech. Insp. on Outside Hardware & Tools

A 4 3 1 5 2 Conduct Electrical Inspection

A 4 3 1 5 3 Inspect Raw Material

A 4 3 2 ASSURE QUALITY OF IN-HOUSE PRODUCT

A 4 3 2 1 Review Contracts & S.O's. For Specific Customer's QA Specs.

A 4 3 2 2 Review Production & Test Instruct. For Compliance To Specs.

A 4 3 2 2 1 Review Assembly Instructions

A 4 3 2 2 2 Review Manufacturing Instructions

A 4 3 2 2 3 Review Test Instructions

A 4323 Support Problem Investigations**A 433 ASSURE OVERALL PRODUCT QUALITY****A 4331 Perform Calibration****A 43311 Calibrate Tooling & Gages****A 43312 Calibrate Test Cells****A 43313 Calibrate Electrical Test Equipment****A 4332 Maintain Records****A 4333 Support MRB****A 434 AUDIT PRODUCT & SYSTEM QUALITY****A 4341 Perform Product Audits Of Power Systems With Customer****A 4342 Perform Random Product Audits****A 4343 Audit Internal System & Procedures****A 44 Provide Tooling (Production, Development, ILS)****A 441 Produce, Coordinate & Monitor Tool Design & Tool Fab Orders****A 442 Design Tool (Outside Sources)****A 443 Fabricate Tools (Outside Sources)****A 444 Maintain Tool (Jigs/Fix, Etc.)****A 4441 Write & Issue Tool Repair Orders****A 4442 Move Tools To Repair Shop & Return Tools To Production****A 4443 Repair Tools (Outside Vendors)****A 45 Control Material****A 451 PROCURE MATERIAL****A 4511 Establish Suppliers****A 45111 Determine Potential Vendors****A 45112 Request Vendor Qualification****A 45113 Verify Qualifications & Place On Approved List****A 4512 Write/Issue Purchase Orders****A 45121 Receive Requisition & Drawing****A 451211 Review Dwg. Package for latest Rev.****A 451212 Obtain Engr. Specs., Etc.****A 451213 Develop Lot Buy vs. Immediate Need****A 45122 Prepare & Send RFQ****A 45123 Receive & Evaluate Responses to RFQ****A 451231 Perform Cost/Price Analysis****A 451232 Evaluate Delivery Schedules****A 451233 Check Supplier Is On Approved List****A 4513 Maintain/Monitor P.O. and Delivery Schedule****A 45131 Issue Engineering Changes To Supplier****A 45132 Expedite Late Deliverables****A 45133 Create & Issue P.O. Revisions****A 452 RECEIVE MATERIAL****A 4521 Verify Packing Ship quantity****A 4522 Generate Receiver Ticket****A 45221 Input Data Into CINCOM System****A 45222 Send Receiver Ticket/Packing Slip to Matl Mover****A 45223 Revise CINCOM Status From Dock To Stock**

- A4523 Move Production Parts To Receiving Inspection
- A4524 Move Office Supplies/Non Production Parts

A453 STORE & ISSUE PARTS

A454 MAINTAIN & CONTROL MATERIAL DOCUMENTATION

- A4541 Record Material Transactions In Computer
- A4542 Analyze Physical Inventory
- A4543 Reconcile & Close Work Orders
 - A45431 Receive completed Work Order Document
 - A45432 Analyze & Reconcile Work Order Variance
 - A45433 Refer Variance To Production Control
 - A45434 Close work Order/Update Computer

A455 HANDLE MATERIAL BETWEEN PLANTS & DEPARTMENTS

A456 PACKAGE & SHIP PRODUCT

A 46 Produce Product

A461 FABRICATE COMPONENTS

- A4611 Assemble Sheet Metal Products
 - A46111 Assemble Sheet Metal Components
 - A461111 Assemble Into Fixtures
 - A461112 Trim & Drill Assembly
 - A461113 Pressure Test/Flow Test Assembly
 - A461114 Expand Sheet Metal Assemblies
 - A462215 Check & Adjust Assy's To Qual Reqmts
 - A46112 Weld Sheet Metal Details
 - A461121 Spot Tack Assemblies
 - A461122 Roll Weld Assemblies
 - A461123 Fusion Weld Assemblies
 - A461124 Laser Weld Assemblies
 - A46113 Braze Sheet Metal Details
 - A46114 Inspect Sheet Metal
 - A461141 Measure Dimensions, Verify To Reqmts
 - A461142 Perform In-Process Inspection
 - A461143 Perform Nondestructive Testing
 - A4611431 Conduct Dye Penetrant Inspec
 - A4611432 Conduct Mag. Particle Inspec
 - A4611433 Conduct Eddie Current Inspec
 - A46115 Move & Store Material Within Department
 - A461151 Store Material In Current Dept
 - A461152 Store Fixtures & Tools
 - A461153 Store & Inventory Perishable Tools
 - A46116 Maintain Equipment Within Department
- A4612 Manufacture Machine components
- A4613 Overhaul Sheet Metal & Machine Components

A462 ASSEMBLE PRODUCT

A463 TEST PRODUCT

A464 PREPARE PRODUCTION FOR OVERHAUL

A465 PREFORM OUTSIDE VENDOR PROCESSING

A 5 SUPPORT PRODUCT**A 51 Prod Technical Publications****A 52 Provide Technical Training****A 53 Depot Support Provisioning Requirements****A 54 Provide Techfld Support, FRACAS****A 541 DET SUPT PROVISING RQMTS****A 542 ASES LKLY CAUSES OF PROB****A 543 EVAL ADEQCY CUST INSTLIN****A 5431 Travel to Customer****A 5432 Visual Exam APU/Instl Intrf****A 5433 Review Stack-up Tolerances****A 544 ANSWER TECHNICAL QUESTIONS****A 545 DEV RESL & IMP RECMD CHG****A 55 Provide Product Services****A 551 PROV PRODUCT SERVICES PLNG****A 5511 Co-Or Review Of Contracts****A 5512 Provide Business Perfmnd Report****A 5513 Budget For Warranty Repair/Replace****A 5514 Monitor Department Procedures****A 5515 Provide I/P To Inventory Plan****A 552 SUPPORT BUSINESS DEVELOPMENT****A 5521 Support After Sales Promo.****A 5522 Provide Input Into Sales Forecast****A 5523 Provide Repair Center Interface****A 5524 Administer Third Party Support****A 5525 Coordinate Product Support Agrmnts.****A 553 PROVIDE INTRM CONTRACT SUPPORT****A 554 PROVIDE REPAIR SERVICES****A 5541 Disposition Product For Repair****A 5542 Book & Bill Repair Order****A 55421 Prepare & Issue Repair Orders****A 55422 Prepare Cost Estimate To Repair****A 55423 Prepare Final Cost Of Repair****A 5543 Repair APU's In Field****A 5544 Repair Fuel Controls In Field****A 5545 Repair Electronic's In Field****A 555 PROVIDE PARTS SERVICE****A 5551 Provide Parts Info Services****A 5552 Administrate Parts Sales****A 5553 Maintain Commercial Price Lists****A 5554 Prepare Parts Proposals****A 56 Plan & Support Return/Phase-Out****A 57 Perform Integrated Logistics Support****A 571 PERFORM LOGISTICS SUPPORT ANALYSIS (LSA)****A 5711 Prepare LSA Record (LSAR)****A 57111 LSA-015 Sequential Task Description****A 57112 LAS-060 LSA Control Number Master File****A 57113 LSA-061 Parts Master File****A 572 PERFORM LIFE CYCLE COST****A 573 PERFORM DESIGN TO COSTS****A 574 PROVIDE RELIABILITY SUPPORT****A 5741 Perform Failure Modes Effects & Critical Analysis (FMECA)****A 5742 Perform Reliability Predictions****A 5743 Perform Reliability Modeling**

- A5744 Establish Reliability Apportionment
- A5745 Preform Failure Report, Anal & Corr Action System (FRACAS)
- A5746 Provide Supplier & Subcontractor Rel Control
- A5747 Provide Reliability Test Planning & Reporting
- A5748 Perform Reliability Design Analysis
- A5749 Provide Critical Items Control
- A575 PERFORM MAINTAINABILITY
 - A5751 Perform Maintainability Predictions
 - A5752 Perform Human Factors Engineering
 - A5753 Perform Safety Hazard Analysis
- A576 PROVIDE EQUIPMENT SUPPORT
 - A5761 Prepare Support Equipment Recommendation Data (SERD)
 - A5762 Provide Support Equipment Hardware
- A577 PERFORM PROVISIONING
 - A5771 Prepare LSR & Data Records
- A578 PROVIDE PUBLICATIONS SUPPORT
 - A5781 Prepare IPR
 - A5782 Prepare IPC
 - A5783 Prepare RPSTL
 - A5784 Provide Maintenance Support
 - 57841 Perform Corrective Maintenance
 - 57842 Perform Preventative Maintenance

APPENDIX B

JUNDRAND POWER SYSTEMS

MASTER COST CENTER LIST
ALL COST CENTERS SELECTED

DATA FOR JANUARY 1, 1990 THRU JUNE 30, 1990
"AS IS"

COST CENTER: 006 OPERATIONS ADMINISTRATION HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	475.097	
INDLBR	INDIRECT NONTouch LBR	A	SV	291.188	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	89.564	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	316	
MATL	MATERIALS	E	V	866	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	675	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	38.040	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	40	
UTILITY	UTILITIES	A	SV	7.017	
MISC	MISC	A	V	3.607	
TRAVET	TRAVEL & ENTERTAINMENT	E	V	4.134	
Total Assigned Cost:				910.544	

COST CENTER: 007 MANUFACTURING ADMINISTRATI HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	297.319	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	0	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	531	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	94	
TOOLS	TOOLING	A	V	125	
FACIL	FACILITIES	A	V	12	
UTILITY	UTILITIES	A	SV	1.016	
MISC	MISC	A	V	0	
TRAVET	TRAVEL & ENTERTAINMENT	E	V	1.308	
Total Assigned Cost:				300.405	

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

APPENDIX B

SUNDSTRAND POWER SYSTEMS

MASTER COST CENTER LIST
ALL COST CENTERS SELECTED

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COST CENTER: 009

QUALITY CONTROL

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	109.767	
DNFDLB	DIRECT NONTouch LBR	A	V	37.789	
INDLBR	INDIRECT NONTouch LBR	A	SV	56.836	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	11.628	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	32	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	257	
OUTINF	OUTSIDE INFO SYS	A	SF	46	
EQUIP	EQUIPMENT	A	V	6.868	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILITY	UTILITIES	A	SV	602	
MISC	MISC	A	V	22	
TRAVET	TRAVEL & ENTERTAINMENT	E	V	4.223	

Total Assigned Cost:

228.072

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COST CENTER: 010

PROCUREMENT QUALITY ASSURA HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	463.110	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	341.860	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	753	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	5.975	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILITY	UTILITIES	A	SV	5.386	
MISC	MISC	A	V	7.317	
TRAVET	TRAVEL & ENTERTAINMENT	E	V	40.368	

Total Assigned Cost:

864.769

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MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 011

QUALITY ASSURANCE

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	238.992	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	39.255	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAF	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	7.205	
OUTINF	OUTSIDE INFO SYS	A	SF	2.212	
EQUIP	EQUIPMENT	A	V	4.484	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	3.694	
MISC	MISC	A	V	4.683	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	11.917	

Total Assigned Cost:

312.442

COST CENTER: 012A

QUALITY SYSTEMS ADMIN

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	145.467	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	5.442	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAF	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	0	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	182	
MISC	MISC	A	V	0	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	0	

Total Assigned Cost:

151.091

COST CENTER: 013

COMBUSTER ASSEMBLY

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	325.571	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	0	
REWORK	REWORK LBR	A	V	6.213	
OUTSER	OUTSIDE SERVICES	A	V	14.118	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	33.641	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	85.679	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	141	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	139.987	
TOOLS	TOOLING	A	V	87.824	
FACIL	FACILITIES	A	V	7.648	
UTILTY	UTILITIES	A	SV	170	
MISC	MISC	A	V	0	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	105	

Total Assigned Cost:

701.097

COST CENTER: 014

FACILITIES ADMIN

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	117.721	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	38.540	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	63.914	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	63	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	29.645	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	61.053	
UTILTY	UTILITIES	A	SV	348	
MISC	MISC	A	V	4.513	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	1.065	

Total Assigned Cost:

316.862

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 015

PRODUCTION TEST

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	163.182	
IFRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	0	
REWORK	REWORK LBR	A	V	18.426	
OUTSER	OUTSIDE SERVICES	A	V	10.189	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	254.108	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	7	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	91.754	
TOOLS	TOOLING	A	V	5.250	
FACIL	FACILITIES	A	V	3.192	
UTILTY	UTILITIES	A	SV	0	
MISC	MISC	A	V	0	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	0	
Total Assigned Cost:				546.108	

COST CENTER: 016

FUEL CONTROL ASSEMBLY

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	90.255	
IFRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	0	
REWORK	REWORK LBR	A	V	955	
OUTSER	OUTSIDE SERVICES	A	V	1.118	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	13.181	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	6.631	
TOOLS	TOOLING	A	V	188	
FACIL	FACILITIES	A	V	88	
UTILTY	UTILITIES	A	SV	0	
MISC	MISC	A	V	0	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	0	
Total Assigned Cost:				112.416	

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 018

TRAFFIC/SHIPPING/RECEIVING HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTOUCH LBR	A	V	504.877	
INDLBR	INDIRECT NONTOUCH LBR	A	SV	0	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	6.918	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	801	
MATL	MATERIALS	E	V	2.622	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	1.728	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	6.804	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	423	
MISC	MISC	A	V	5.793	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	0	

Total Assigned Cost:

531.966

COST CENTER: 019

PLANT ENGRG/MAINTENANCE

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTOUCH LBR	A	V	0	
INDLBR	INDIRECT NONTOUCH LBR	A	SV	333.840	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	0	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	18.573	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	13.202	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	17.631	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	2.840	
UTILTY	UTILITIES	A	SV	883	
MISC	MISC	A	V	88	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	0	

Total Assigned Cost:

387.057

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 020

OPERATIONS ADMIN

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	18,560	
INDLBR	INDIRECT NONTouch LBR	A	SV	224,392	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	914	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	5,509	
OUTINF	OUTSIDE INFO SYS	.	SF	0	
EQUIP	EQUIPMENT	A	V	4,920	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	794	
MISC	MISC	A	V	2,135	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	12,599	

Total Assigned Cost:

269,823

COST CENTER: 021

PURCHASING

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	669,800	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	56,995	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	732	
MATL	MATERIALS	E	V	26,211	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	4,595	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	109,898	
TOOLS	TOOLING	A	V	26,211	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	18,116	
MISC	MISC	A	V	7,575	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	33,336	

Total Assigned Cost:

953,469

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 022

MATERIAL MANAGEMENT

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	374.337	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	5.683	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIF	EQUIPMENT	A	V	14.708	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	1.773	
MISC	MISC	A	V	0	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	2.127	

Total Assigned Cost:

398.628

COST CENTER: 023

PRODUCTION & INVENTORY CON HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	336.497	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	3.694	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	1.053	
OUTINF	OUTSIDE INFO SYS	A	SF	2.623	
EQUIP	EQUIPMENT	A	V	4.798	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	1.976	
MISC	MISC	A	V	7.025	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	3.793	

Total Assigned Cost:

361.459

COST CENTER: 025

DEVELOPMENT ASSEMBLY

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	320.410	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTOUCH LBR	A	V	0	
INDLBR	INDIRECT NONTOUCH LBR	A	SV	0	
REWORK	REWORK LBR	A	V	2.177	
OUTSER	OUTSIDE SERVICES	A	V	0	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	1.358	
SCRAP	SCRAP	A	V	30.024	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	6.306	
TOOLS	TOOLING	A	V	2.115	
FACIL	FACILITIES	A	V	288	
UTILTY	UTILITIES	A	SV	0	
MISC	MISC	A	V	0	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	0	

Total Assigned Cost:

362.678

COST CENTER: 026

MANUFACTURING ENGINEERING

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTOUCH LBR	A	V	1,122.020	
INDLBR	INDIRECT NONTOUCH LBR	A	SV	54.707	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	473.306	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	15.380	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	1.489	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	1.481	
TOOLS	TOOLING	A	V	7.061	
FACIL	FACILITIES	A	V	3.359	
UTLTY	UTILITIES	A	SV	9.884	
MISC	MISC	A	V	4,666	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	45.056	

Total Assigned Cost:

1,738.409

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 027

PRODUCTION ASSEMBLY

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	606.541	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	0	
REWORK	REWORK LBR	A	V	13.009	
OUTSER	OUTSIDE SERVICES	A	V	3,919	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	50.041	
SCRAP	SCRAP	A	V	179,414	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	4,139	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	32,582	
TOOLS	TOOLING	A	V	37,459	
FACIL	FACILITIES	A	V	172	
UTILTY	UTILITIES	A	SV	0	
MISC	MISC	A	V	0	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	70	

Total Assigned Cost:

927,346

COST CENTER: 028

QUALITY CONTROL INSPECTION HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	1,034.981	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	0	
REWORK	REWORK LBR	A	V	8.815	
OUTSER	OUTSIDE SERVICES	A	V	1,335	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	4,927	
SCRAP	SCRAP	A	V	121,562	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	116,988	
TOOLS	TOOLING	A	V	1,251	
FACIL	FACILITIES	A	V	1,162	
UTILTY	UTILITIES	A	SV	0	
MISC	MISC	A	V	341	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	202	

Total Assigned Cost:

1,291,564

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 029

RUFFIN OCCUPANCY

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	0	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	1.907	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	97	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	259	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	342.440	
TOOLS	TOOLING	A	V	89	
FACIL	FACILITIES	A	V	196.374	
UTILTY	UTILITIES	A	SV	239.089	
MISC	MISC	A	V	239.494	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	218.430	

Total Assigned Cost:

1,238,179

COST CENTER: 078

IMPELLER CELL

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	436.983	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	0	
REWORK	REWORK LBR	A	V	3.505	
OUTSER	OUTSIDE SERVICES	A	V	351	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	48.332	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	7.500	
EQUIP	EQUIPMENT	A	V	399.897	
TOOLS	TOOLING	A	V	27.641	
FACIL	FACILITIES	A	V	1,620	
UTILTY	UTILITIES	A	SV	106	
MISC	MISC	A	V	0	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	0	

Total Assigned Cost:

925,935

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 258

ADVANCED TECHNOLOGY ENGR

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTOUCH LBR	A	V	0	
INDLBR	INDIRECT NONTOUCH LBR	A	SV	56.605	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	0	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	3.166	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	0	
MISC	MISC	A	V	0	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	6.744	
Total Assigned Cost:				66.515	

COST CENTER: 259

TECHNONLGY DEVELOPMENT4

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTOUCH LBR	A	V	215.020	
INDLBR	INDIRECT NONTOUCH LBR	A	SV	0	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	0	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	362	
OUTINF	OUTSIDE INFO SYS	A	SF	562	
EQUIP	EQUIPMENT	A	V	0	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	1.595	
MISC	MISC	A	V	1,425	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	7.119	
Total Assigned Cost:				226.083	

COST CENTER: 260

ENGINEERING ADMINISTRATION HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	129.362	
INDLBR	INDIRECT NONTouch LBR	A	SV	24.183	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	0	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	17.511	
OUTINF	OUTSIDE INFO SYS	A	SF	1.962	
EQUIP	EQUIPMENT	A	V	31.718	
TOOLS	TOOLING	A	V	1.031	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	3.294	
MISC	MISC	A	V	4.192	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	43.591	

Total Assigned Cost:

256.844

COST CENTER: 261

AEROTHERMAL ENGINEERING

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	245.367	
INDLBR	INDIRECT NONTouch LBR	A	SV	0	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	0	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	1.020	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	12	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	981	
UTILTY	UTILITIES	A	SV	1,860	
MISC	MISC	A	V	0	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	7.302	

Total Assigned Cost:

256.542

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 262

MECHANICAL DESIGN & ANALYS HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	406.397	
INDLBR	INDIRECT NONTouch LBR	A	S'	0	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	275.783	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	654	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	508	
TOOLS	TOOLING	A	V	148	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	3,317	
MISC	MISC	A	V	1,200	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	15,593	

Total Assigned Cost:

703,600

COST CENTER: 263

DEVELOPMENT TEST ENGINEERI HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	858.331	
INDLBR	INDIRECT NONTouch LBR	A	SV	813	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	209.088	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	89	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	2,121	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	210.888	
TOOLS	TOOLING	A	V	17	
FACIL	FACILITIES	A	V	45,557	
UTILTY	UTILITIES	A	SV	0	
MISC	MISC	A	V	1,155	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	0	

Total Assigned Cost:

1,328,059

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 264

MATERIALS AND PROCESSES

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	222.547	
INDLBR	INDIRECT NONTouch LBR	A	SV	3.391	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	676	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	16.256	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	3.242	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	22.678	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	1.221	
MISC	MISC	A	V	835	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	6.799	

Total Assigned Cost:

277.645

COST CENTER: 266

SYSTEMS & CONTROLS ENGINEE HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	9.986	
INDLBR	INDIRECT NONTouch LBR	A	SV	31.385	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	216	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	150	
MATL	MATERIALS	E	V	72	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	4.590	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	35.086	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	3.372	
MISC	MISC	A	V	2.414	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	9.626	

Total Assigned Cost:

96.897

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 267

MECHANICAL DRAFTING

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTOUCH LBR	A	V	213.554	
INDLBR	INDIRECT NONTOUCH LBR	A	SV	182.963	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	517.240	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	306	
MATL	MATERIALS	E	V	2.244	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	2.691	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	5.720	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	1.358	
MISC	MISC	A	V	108	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	9.333	

Total Assigned Cost:

935.517

COST CENTER: 268

COMMERCIAL PROJECTS

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTOUCH LBR	A	V	522.696	
INDLBR	INDIRECT NONTOUCH LBR	A	SV	464.529	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	2.306	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	2.288	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	8.550	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	5.497	
MISC	MISC	A	V	1,175	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	10,531	

Total Assigned Cost:

1,017,572

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 270

PROGRAM MANAGEMENT

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IFRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	934.002	
INDLBR	INDIRECT NONTouch LBR	A	SV	272.052	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	2.008	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	2.784	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	966	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	8.295	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	10.953	
MISC	MISC	A	V	11.252	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	70.893	

Total Assigned Cost:

1,313.205

COST CENTER: 271

QUALITY ENGINEERING

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IFRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	146.520	
INDLBR	INDIRECT NONTouch LBR	A	SV	9.162	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	285.975	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	12	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	2.509	
MISC	MISC	A	V	18.884	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	5.986	

Total Assigned Cost:

469.048

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 273

I.L.S. ENGINEERING

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	736.044	
INDLBR	INDIRECT NONTouch LBR	A	SV	63.788	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	261	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	16.129	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	2.738	
OUTINF	OUTSIDE INFO SYS	A	SF	65	
EQUIP	EQUIPMENT	A	V	22.884	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	4.332	
MISC	MISC	A	V	1.876	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	0	

Total Assigned Cost:

848,117

COST CENTER: 274

I.L.S. SUPPORT SYSTEMS

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	302.023	
INDLBR	INDIRECT NONTouch LBR	A	SV	41.895	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	21.565	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	5.660	
OUTINF	OUTSIDE INFO SYS	A	SF	5.632	
EQUIP	EQUIPMENT	A	V	21.138	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	3.843	
MISC	MISC	A	V	177	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	5.817	

Total Assigned Cost:

407.750

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 275

ILS PROJECT ENGINEERING

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	21,419	
INDLBR	INDIRECT NONTouch LBR	A	SV	0	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	101	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	0	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	2,867	
MISC	MISC	A	V	21,666	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	2,658	

Total Assigned Cost:

48,711

COST CENTER: 278A

T46/47 SERVICE ENGINEERING HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	272,111	
INDLBR	INDIRECT NONTouch LBR	A	SV	0	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	126	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	1,465	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	54	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	6,439	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	7,572	
MISC	MISC	A	V	901	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	1,837	

Total Assigned Cost:

290,505

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 279A

GPS & T40 SERVICE ENGINEER HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	311,597	
INDLBR	INDIRECT NONTouch LBR	A	SV	0	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	1,528	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	261	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	316	
OUTINF	OUTSIDE INFO SYS	A	SF	16,381	
EQUIP	EQUIPMENT	A	V	0	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	7,764	
MISC	MISC	A	V	2,629	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	47,835	

Total Assigned Cost:

388,311

COST CENTER: 391

ADMIN SERVICES

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	108,737	
INDLBR	INDIRECT NONTouch LBR	A	SV	0	
REWORK	REWORK LBR	A	V	106,516	
OUTSER	OUTSIDE SERVICES	A	V	1,087	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	82,697	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	141,900	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	18,771	
MISC	MISC	A	V	9,242	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	2,102	

Total Assigned Cost:

471,052

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 392

FINANCE & ADMINISTRATION

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	107.001	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	0	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	50	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	0	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	709	
MISC	MISC	A	V	475	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	553	

Total Assigned Cost:

108.788

COST CENTER: 789

PROV & INV PLANNING

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	40.076	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	0	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	0	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	0	
MISC	MISC	A	V	0	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	3.207	

Total Assigned Cost:

43.283

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 790

PRODUCT SUPPORT ADMINISTRATION HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	326.725	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	39	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	2.360	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	2.694	
TOOLS	TOOLING	A	V	732	
FACIL	FACILITIES	A	V	0	
UTILITY	UTILITIES	A	SV	5.627	
MISC	MISC	A	V	5,148	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	54.375	

Total Assigned Cost:

397,700

COST CENTER: 792

SUPPORT ADMINISTRATION

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	519.221	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	48.385	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	5,669	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	5,558	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	16,132	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILITY	UTILITIES	A	SV	8,919	
MISC	MISC	A	V	5,771	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	48.446	

Total Assigned Cost:

658,101

COST CENTER: 793A

COMMERCIAL/INTERNTL MARKET HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IFRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTOUCH LBR	A	V	0	
INDLBR	INDIRECT NONTOUCH LBR	A	SV	367.906	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	141	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	590	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	1.293	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	7.549	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	7.270	
MISC	MISC	A	V	0	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	80.704	
Total Assigned Cost:				465.453	

COST CENTER: 795

REPAIR ADMINISTRATION

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IFRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTOUCH LBR	A	V	0	
INDLBR	INDIRECT NONTOUCH LBR	A	SV	31.515	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	0	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	0	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	5	
MISC	MISC	A	V	0	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	0	
Total Assigned Cost:				31.520	

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 796

MARKETING SERVICES

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	99.704	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	61.131	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	130	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	10.154	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	332	
MISC	MISC	A	V	34,729	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	2,387	
Total Assigned Cost:				208,567	

COST CENTER: 797

FIELD SERVICE

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	43.243	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	94	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	146	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	242	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	219	
MISC	MISC	A	V	260	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	0	
Total Assigned Cost:				44,204	

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 933

HUMAN RESOURCES

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IFRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	278,855	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	52,041	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	42	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	2,277	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	3,079	
TOOLS	TOOLING	A	V	45	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	11,157	
MISC	MISC	A	V	142,585	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	8,175	

Total Assigned Cost:

498,256

COST CENTER: 939A

FINANCIAL

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IFRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	747,461	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	1,356	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	14,855	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	8,056	
MISC	MISC	A	V	97,738	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	10,872	

Total Assigned Cost:

880,338

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 941A

INFO RESOURCE MNGMN

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IFRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	326.142	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	75.022	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	1.572	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	31.897	
OUTINF	OUTSIDE INFO SYS	A	SF	49.907	
EQUIP	EQUIPMENT	A	V	41.786	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	76.473	
MISC	MISC	A	V	217	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	3,720	

Total Assigned Cost:

606.736

COST CENTER: 969A

CONTRACTS-COMMERCIAL

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IFRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNPDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	270.056	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	2,745	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	569	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	0	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	2,793	
MISC	MISC	A	V	7,562	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	29,272	

Total Assigned Cost:

312.997

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 970A

PROGRAM MANAGEMENT

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	22,241	
INDLBR	INDIRECT NONTouch LBR	A	SV	142,644	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	2,138	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	1,689	
OUTINF	OUTSIDE INFO SYS	A	SF	951	
EQUIP	EQUIPMENT	A	V	1,917	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	2,281	
MISC	MISC	A	V	155	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	8,292	

Total Assigned Cost:

182,308

COST CENTER: 971A

COMMERCIAL CONTRACTS

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	73,339	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	0	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	0	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	0	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	0	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	0	
UTILTY	UTILITIES	A	SV	46	
MISC	MISC	A	V	1,700	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	7,872	

Total Assigned Cost:

82,957

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

COST CENTER: 985

SECURITY

HIERARCHY CODE:

Cost Elements

CODE	DESCRIPTION	STATUS	COST TYPE	AMOUNT	CODE
DIRLBR	DIRECT TOUCH LABOR	A	V	0	
IPRDLB	INDIRECT TOUCH LABOR	A	V	0	
DNFDLB	DIRECT NONTouch LBR	A	V	0	
INDLBR	INDIRECT NONTouch LBR	A	SV	156.953	
REWORK	REWORK LBR	A	V	0	
OUTSER	OUTSIDE SERVICES	A	V	2.183	
OUTMNT	OUTSD MAINT SERV & MAT'L	A	SV	0	
MATL	MATERIALS	E	V	1.972	
SCRAP	SCRAP	A	V	0	
ICC	INVENTORY CARRY'G COST	A	V	0	
SUPPLY	SUPPLIES & PERISH TOOLS	A	V	3.780	
OUTINF	OUTSIDE INFO SYS	A	SF	0	
EQUIP	EQUIPMENT	A	V	8.651	
TOOLS	TOOLING	A	V	0	
FACIL	FACILITIES	A	V	1.943	
UTILTY	UTILITIES	A	SV	2.177	
MISC	MISC	A	V	9.213	
TRA/ET	TRAVEL & ENTERTAINMENT	E	V	1.751	
Total Assigned Cost:				188.623	

MASTER COST CENTER LIST

ALL COST CENTERS SELECTED

APPENDIX C

DISCOUNTED CASH FLOW MODEL

Year:	1991	1992	1993	1994	1995	1996	1997
	1	2	3	4	5	6	7
SECTION I. CORE DATA							
1 Contractor Investment	998.6	3,225.6	0.0	0.0	0.0	0.0	0.0
Cumulative Total	998.6	4,224.2	4,224.2	4,224.2	4,224.2	4,224.2	4,224.2
2 Contractor Expenses	0.0	16.5	16.5	0.0	0.0	0.0	0.0
Cumulative Total	0.0	16.5	33.0	33.0	33.0	33.0	33.0
3 DoD/Government Funding	1,671.0	0.0	0.0	0.0	0.0	0.0	0.0
Cumulative Total	1,671.0	1,671.0	1,671.0	1,671.0	1,671.0	1,671.0	1,671.0
4 Savings Available to DoD	0.0	0.0	1,359.8	1,105.2	1,001.9	908.5	791.8
Cumulative Total	0.0	0.0	1,359.8	2,465.0	3,466.9	4,375.4	5,167.2
SECTION II. INCREMENTAL CASH FLOWS							
5 Productivity Savings Reward	0.0	0.0	679.9	552.6	500.9	454.3	395.9
Cumulative Total	0.0	0.0	679.9	1,232.5	1,733.4	2,187.7	2,583.6
6 Cost of Money (CAS 414) 13.00%	0.0	0.0	251.7	480.5	434.7	389.0	343.2
7 CAS 409 Depreciation	0.0	0.0	352.0	352.0	352.0	352.0	352.0
8 Profit Effect	0.0	0.0	825.2	732.3	806.9	887.9	958.0
9 Subtotal: DoD Cash Flows to Contractor	0.0	0.0	2,108.7	2,117.4	2,094.6	2,083.2	2,049.1
10 Salvage Value	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11 Contractor Before-Tax Cash Flow	(998.6)	(3,242.1)	2,092.2	2,117.4	2,094.6	2,083.2	2,049.1
SECTION III. TAX CALCULATIONS							
12 ACRS Depreciation	0.0	0.0	401.3	401.3	401.3	401.3	401.3
13 Contractor Taxable Income	0.0	(16.5)	1,691.0	1,716.1	1,693.3	1,681.9	1,647.8
14 Contractor Income Tax 38%	0.0	6.3	(642.6)	(652.1)	(643.4)	(639.1)	(626.2)
15 Investment Tax Credit 10%	0.0	0.0	422.4	0.0	0.0	0.0	0.0
16 Contractor After-Tax Cash Flow	(998.6)	(3,235.8)	1,872.1	1,465.3	1,451.1	1,444.0	1,422.9
Cumulative Total	(998.6)	(4,234.4)	(2,362.3)	(897.0)	554.1	1,998.2	3,421.1
SECTION IV. SUMMARY							
17 DoD Program Benefit (Without Incentive)	(1,671.0)	0.0	1,359.8	1,105.2	1,001.9	908.5	791.8
Cumulative Total	\$3,496.2	(1,671.0)	(311.2)	794.0	1,795.9	2,704.4	3,496.2
18 DoD Program Benefit (With Incentive)	(1,671.0)	0.0	679.9	552.6	500.9	454.3	395.9
Cumulative Total	\$912.6	(1,671.0)	(991.1)	(438.5)	62.4	516.7	912.6
19 DoD Payback Period	4.9 years						
20 DoD Rate of Return	12.8%						
21 Government Benefit	(1,671.0)	(6.3)	900.0	1,204.7	1,144.4	1,093.4	1,022.1
Cumulative Total	(1,671.0)	(1,677.3)	(777.2)	427.5	1,571.9	2,665.3	3,687.3
22 Government Payback Period	3.6 years						
23 Government Rate of Return	36.5%						
24 Contractor Internal Rate of Return							
Without Incentive	12.5%						
With Incentive	22.4%						
25 Contractor Payback Period	4.6 years						
MODEL INPUTS:							
Year	1991	1992	1993	1994	1995	1996	1997
Contractor Investment	998.6	3,225.6	0.0	0.0	0.0	0.0	0.0
Contractor Expenses	0.0	16.5	16.5	0.0	0.0	0.0	0.0
DoD/Government Funding	1,671.0	0.0	0.0	0.0	0.0	0.0	0.0
Savings Available to DoD	0.0	0.0	1,359.8	1,105.2	1,001.9	908.5	791.8
Productivity Savings Reward	0.0	0.0	679.9	552.6	500.9	454.3	395.9
Profit Effect	0.0	0.0	825.2	732.3	806.9	887.9	958.0
Salvage Value	0.0	0.0	0.0	0.0	0.0	0.0	0.0

CAS 414 Rate 0.1300

CAS 409 Depreciation:

 Depreciation Method 1

 (1: Straight Line; 2: Sum-of-Years; 3: Sum-of-Years/Half-Year;

 4: 150% Declining Balance; 5: 150% DB, Switch to St Line)

 Asset Service Life (years) 12

 Year Placed into Service 3

ACRS Depreciation:

 Depreciation Method 2

 (1: Standard ACRS Tables; 2: Straight Line)

 Asset Class (Service Life) 10

 (3: 3-yr; 5: 5-yr; 10: 10-yr)

 Year Placed into Service 3

Contractor Tax Rate 0.38

Investment Tax Credit Rate 0.10

Completed Contract - Tax Lag 0 years (0 implies no lag)

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