TWR-17591, Volume IV

Space Shuttle

Solid Rocket Motors
Thiokol Corporation

QM-8 FINAL PERFORMANCE EVALUATION REPORT - SEALS

June 1989

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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QM-8 FINAL PERFORMANCE EVALUATION REPORT (SEALS)

June 1989

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1.0 INTRODUCTION

The Space Shuttle Redesigned Solid Rocket Motor (RSRM) static test of Qualification Motor-8 (QM-8) was conducted 20 January 1989 at Morton Thiokol, Inc., Space Operations. The QM-8 test article (see Figure 1) was the fifth full-scale, full-duration test, and the third qualification motor to incorporate the redesigned case field joint and nozzle-to-case joint as illustrated in Figures 2 and 3, respectively. This was the second static test conducted in the T-97 test facility, which is equipped with actuators for inducing external side loads to a 360 degree External Tank (ET) attach ring during test motor operation, and permits heating/cooling of an entire motor. The QM-8 motor was cooled to a temperature which ensured that the maximum propellant mean bulk temperature (PMBT) of 40° F was achieved at firing. QM-8 was tested per Morton Thiokol, Inc. Test Plan CTP-0060, Revision D (see Reference 1).

This final report does not include all test results, but rather, addresses the performance of the metal case, field joints, and nozzle-to-case joint. It focuses on the involvement of the Structural Applications and Structural Design Groups with the QM-8 test which includes: assembly procedures of the field and nozzle-to-case joints, joint leak check results, structural test results, and post-test inspection evaluations.

The final test report which addresses all objectives is TWR-17591, Volume I (see Reference 2).

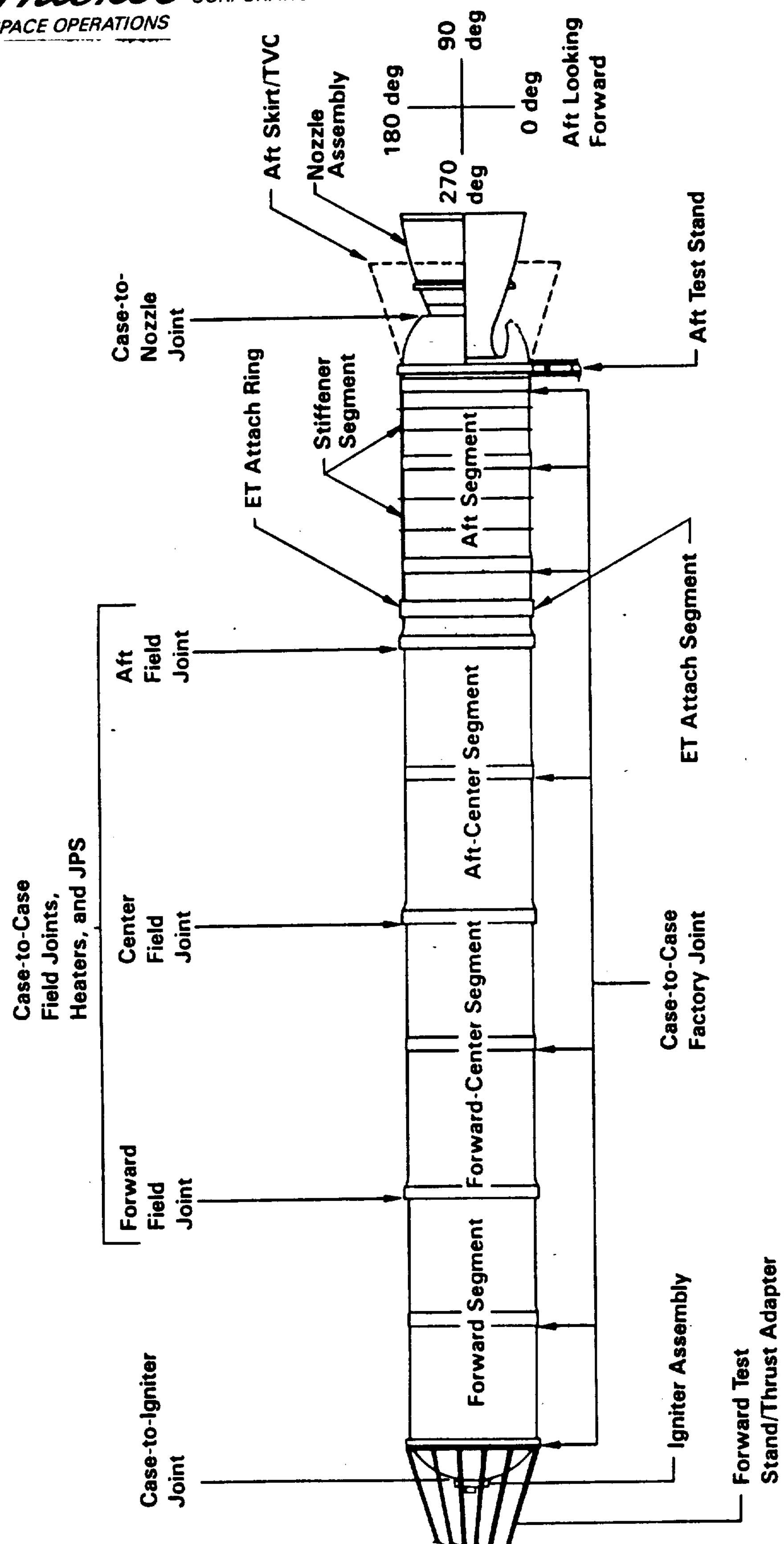

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Figure 1 QM-8 Test Article

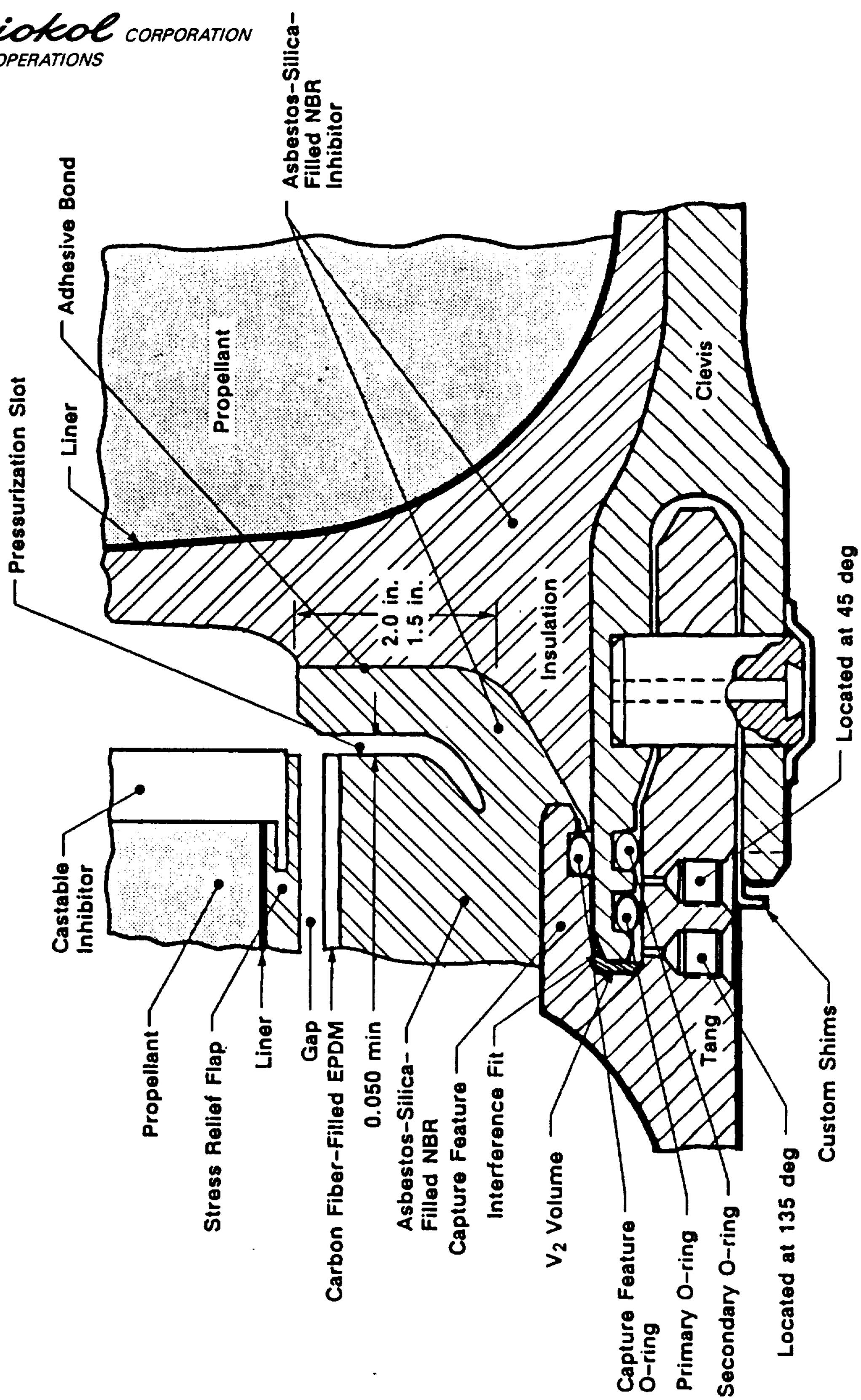


Figure 2 QM-8 Assembled Field Joint

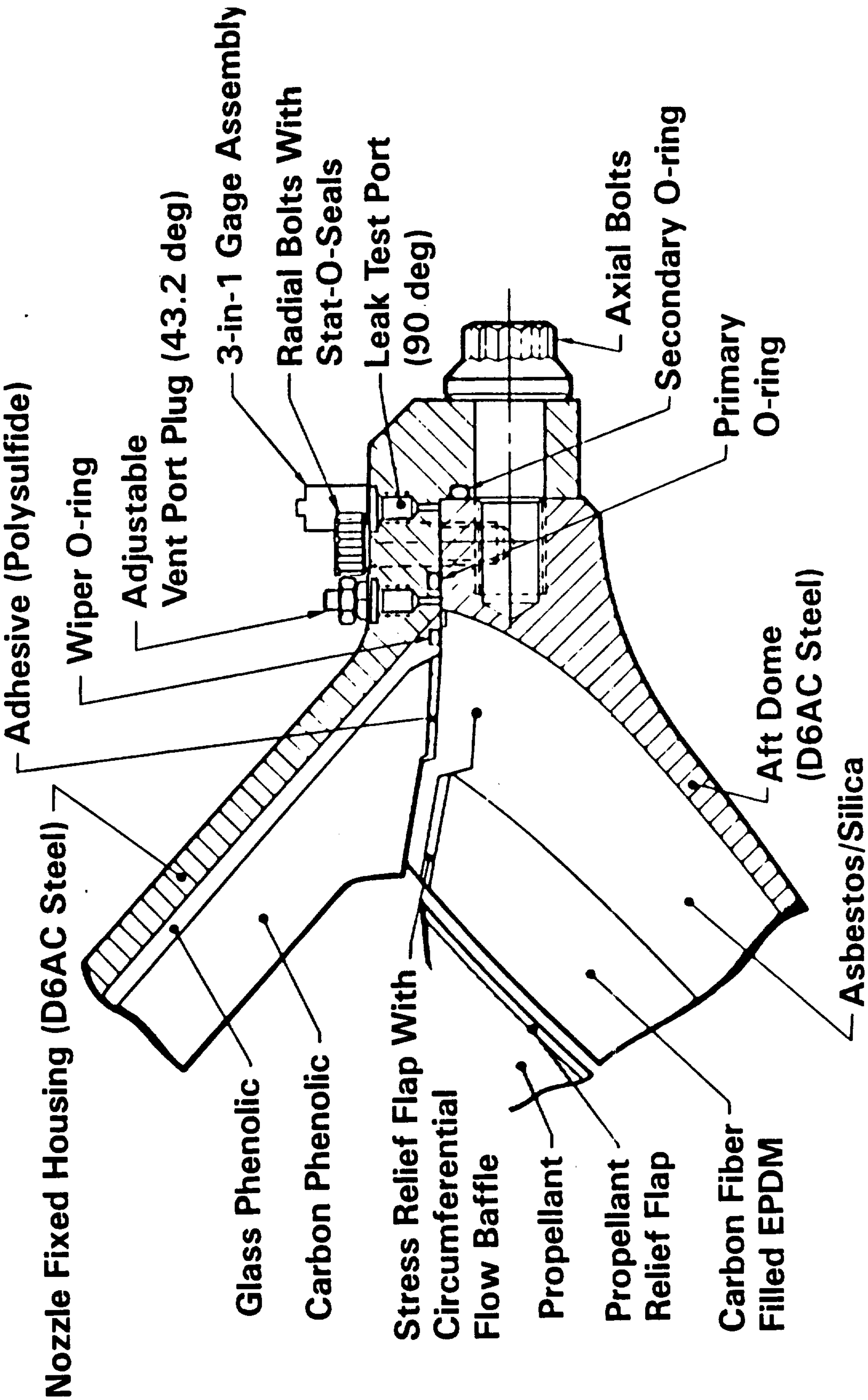


Figure 3 QM-8 Assembled Nozzle-to-Case Joint

2.0 SUMMARY AND CONCLUSIONS

2.1 Motor Performance per Instrumentation

The girth gage measurements from QM-8 field, factory, case, and nozzle-to-case joints compare closely to pretest predictions. The highest percentage differences were 8.5 percent on the FWD field joint, 6.9 percent on the CTR field joint, 10.6 percent on the FWD cylinder to cylinder factory joint, 5.7 percent on case segment (station 1411.5), and 19.6 percent on the nozzle-to-case joint girth gages. The overall maximum radial growth occured in the case membrane at station 931.5, and had a value of 0.271 inch. Several of the gage readings are questionable, or produced no data.

The biaxial gage measurements were not consistently comparable with pretest predictions which are discussed in more detail in the test results sections. The included tables can more clearly depict similarities and differences. The maximum stress experienced by the case membrane (stations 1196 and 1466) occured in the hoop direction, 270 degrees, at station 1466, and had a value of 145.1 KSI. In the aft field joint/ET region, a comparison between biaxial gage test data and predicted values can be found in TWR-19506 (Reference 3).

The QM-8 maximum head end pressure of 872.6 psia occurred in the forward dome at 0.656 seconds following motor ignition (see Table 31). The joint and heater temperatures ranged between 84.9 °F to 106.7 °F prior to ignition (see Table 32), well above the 75 °F minimum required.

The gap opening aft of the primary O-ring was measured with an LVDT via the 45 degree leak check port for the forward field joint. LVDTs were also used on the center and aft field joints, unfortunately the deflection data was not generated. The forward field joint Linear Variable Displacement Transformer (LVDT) measured a radial growth of 0.004 inch, which is the same as the pretest predictions.

The maximum axial growth was 1.06 inches between stations 527.0 to 1505.0 inches which is a typical value. (see Table 33) Negative values were experienced in the gages which spanned the joints. Evaluation of the placement of these gage locations which experienced negative values supports that these values are in error. In other words, the instrument measured a negative value but the joint did not go negative. The measurement was that of of instrument, and not the joint.

2.2 Motor Performance Per Disassembly Inspection

The detailed results of the post-test inspection of QM-8 can be found in Section 5.0. In summary, the most significant observations made from post-test inspection where:

- White colored material, which ran circumferentially, was found on the aft edge of the forward field joint capture feature O-ring at 169 degrees. More thin lines of the white colored material were found intermittently on the aft edge from 164 to 167 degrees. Also small thin lines of the white colored material were found on the capture feature metal-to-J-leg interface (aft of the capture feature groove on the tang J-leg) at intermittent degree locations. Lab analysis indicated the white material was Teflon tape adhesive. Teflon tape is used to mask the J-leg during grease application and O-ring installation processes.

- Inspection of the radial bolt Stat-O-Seals by the O-ring inspection team revealed that 35 of 100 had unacceptable flow line conditions which should have been rejected by Receiving Inspection. Drawing No. 1U75374 defines the Stat-O-Seals to be inspected per MIL-STD-413, which allows circumferential flow lines no greater than 0.180 inch in length. No radial flow marks are allowed.

  At the present time there is a Stat-O-Seal inspection test designed to qualify each inspector. This test was not in force at the time the QM-8 Stat-O-Seal inspection occurred.

- Inspection of the nose-to-forward end ring revealed one very small pressure path through the RTV of the joint interface at 355 degrees flowing circumferentially to 350 degrees before penetrating into the metal interface. The primary O-ring experienced no damage as a result of the pressure path. The RTV backfill of this joint was much better than the current application of RTV to this joint ("buttering application"). No soot or evidence of blow by was present past the primary O-ring.

Considering these case and seal observations were the most significant found, QM-8 represents the fifth successful assembly and firing of a full-scale capture feature RSRM in a horizontal configuration.

3.0 DISCUSSION

The following sections provide a discussion on the assembly of the field joints and nozzle-to-case joint. A summary of the QM-8 configuration follows:

- O Field Joints
  - o RSRM design with fluorocarbon O-rings
  - o No intentional flaws
  - o Joint protection system with heaters and weather seal installed
  - o Adjustable vent port plugs and vent valves installed
  - o LVDTs installed in leak check ports
- O Case-To-Nozzle Joint
  - o Axial and radial bolt configuration with fluorocarbon O-rings
  - o No intentional flaws
  - o Adjustable plug installed in vent port and a pressure transducer installed in the leak check port
  - o Temperature sensors of 105 °F, ± 5 °F
- O Side load actuators for inducing external side loads to the 360 degree external tank attach ring which follow the curves shown in Figures 4, 5, and 6.
- O Three stiffener rings installed on the aft segment
- O Weather seals installed on all factory joints

Strut Loads

Lift-off Simulation
QM-8

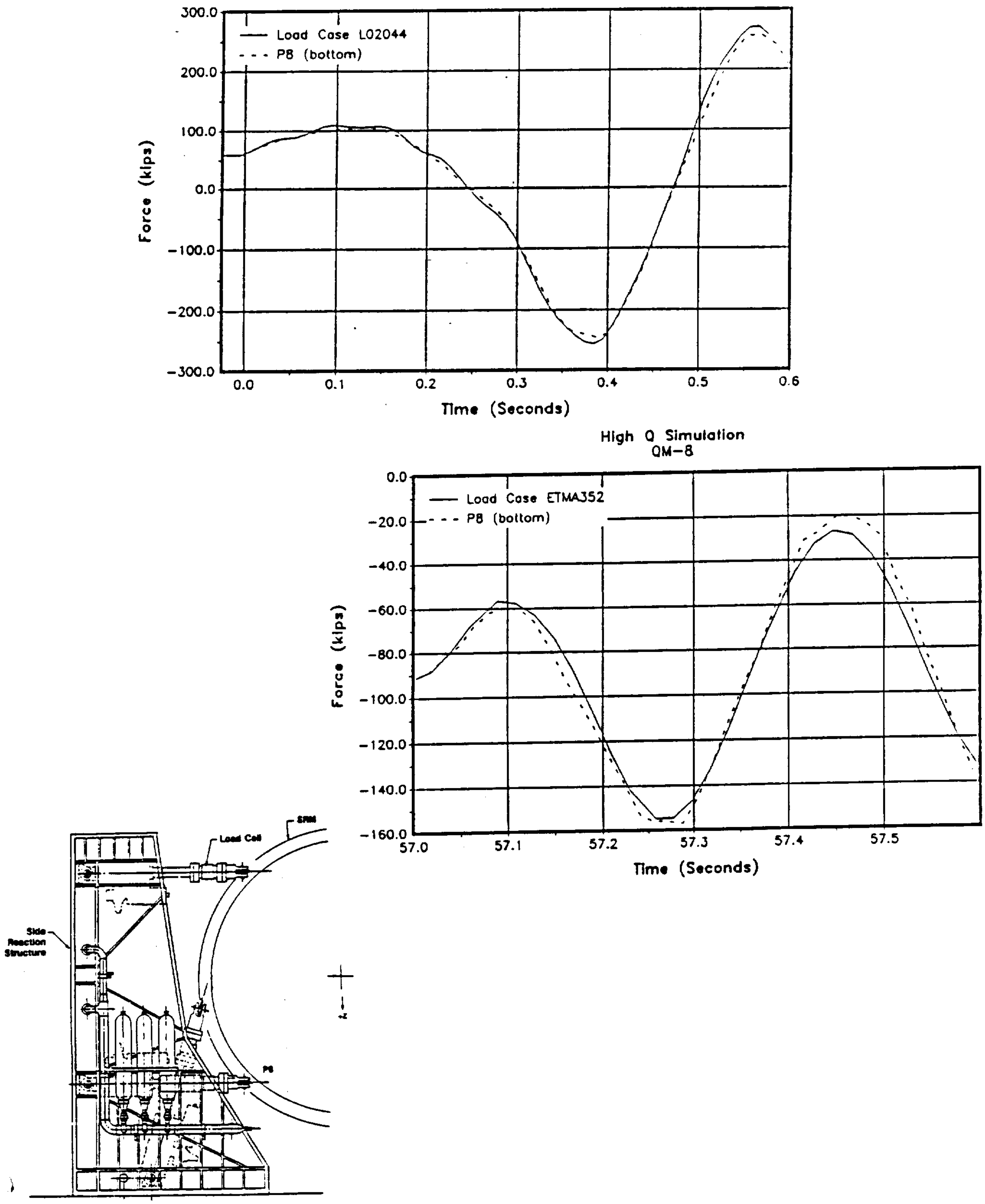
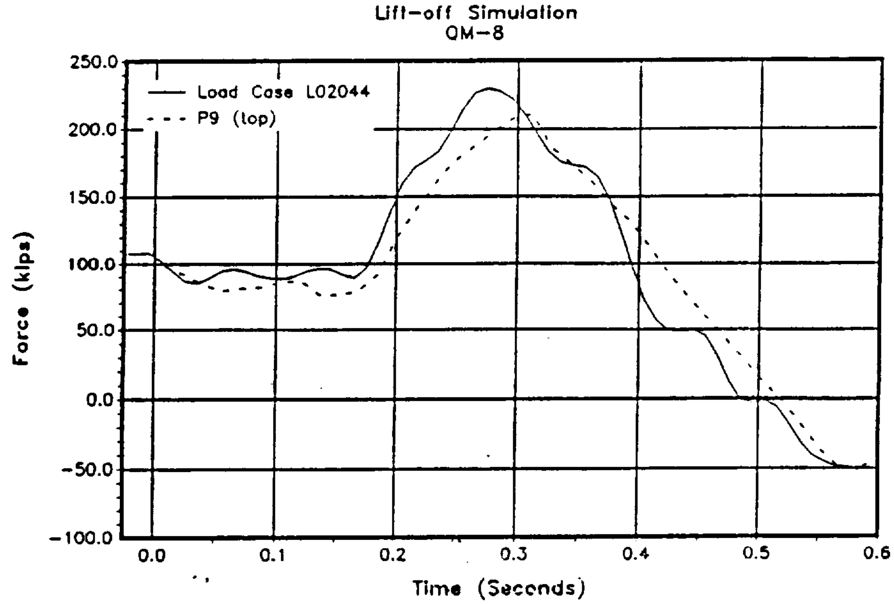
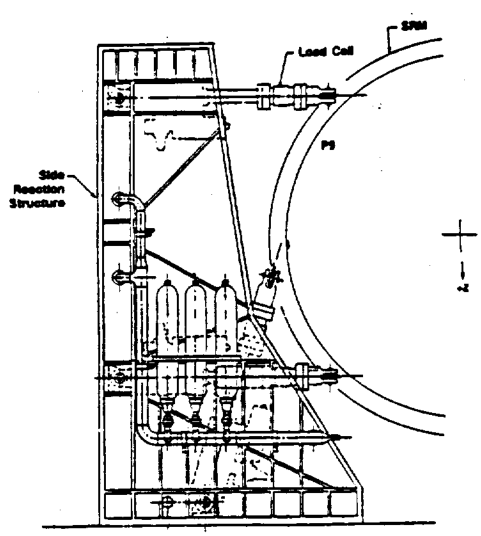


Figure 4 P-8 Strut Load Duty Cycle

Strut Loads





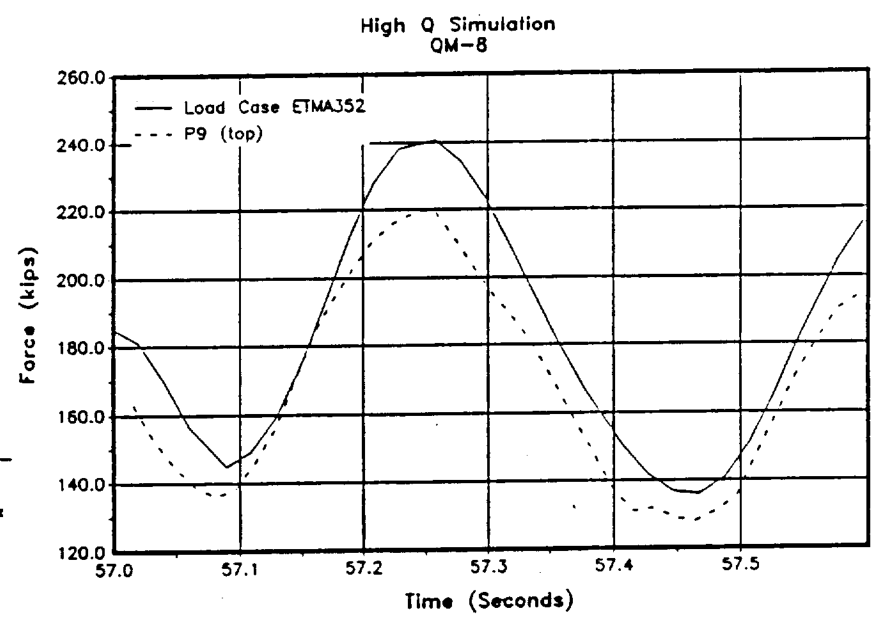


Figure 5 P-9 Strut Load Duty Cycle

3.1 Test Objectives

Test objectives, as outlined in CTP-0060, Revision D (see Reference 1) which apply to any structural or seal issue, are addressed here. Explanation of how each objective was met is discussed.

3.1.1 Structural

The test objectives from CTP-0060, Revision D regarding structural performance and the corresponding results are as follows:

"H. Certify that all RSRM seals, including adjustable vent port plug seals in the field joints, experience no erosion or blow-by throughout the static test" (Section 3.2.1.2, CTP-0060, Revision D).

Post-test inspection showed that no motor gas pressurization went past any primary seal and no erosion or heat effects were found (see Section 5.0). Objective H was met.

"J. Certify that the case field joint and nozzle-to-case joint seals, if pressurized, accommodate static test motor and side load induced structural deflections" (Section 3.2.1.2.1.a, CTP-0060, Revision D).

Post-test inspection of the field and nozzle-to-case joints showed that no motor gas pressurization went past the J-Leg or polysulfide insulation respectively (see Section 5.1.2). Objective J was met.

"K. Certify that the case field joint and nozzle-to-case joint seals, if pressurized, operate when PMBT is at 40° F" (Section 3.2.1.2.1.b, CTP-0050, Revision D).

No pressure was seen to any field or nozzle-to-case joint seal (see Section 5.1.2). Objective K was met.

"M. Certify that the nozzle-to-case joint O-ring temperature is maintained prior to static firing" (Section 3.2.1.2.1.f, CTP-0060, Revision D).

Temperature gages located on the nozzle-to-case joint heater gave a temperature range of 87.4 °F to 106.7 °F (see Section 4.7). Objective M was met.

"V. Certify that the ignition system seals, if pressurized, accommodate static test motor structural deflections" (Section 3.2.1.2.4.a, CTP-0060, Revision D).

Post-test inspection of the igniter joints (see Section 5.3) showed there was no blow by past any primary gasket seal. Objective V was met.

"X. Certify that the ignition system seals, if pressurized, operate when PMBT is at 40 °F" (Section 3.2.1.2.4.b, CTP-0060, Revision D).

Post-test inspection of igniter joints (see Section 5.3) showed there was no blow by past any primary gasket seal. Objective X was met.

"Z. Certify that the nozzle internal seals and the aft exit cone field joint seals, if pressurized, accommodate static-test motor structural deflections" (Section 3.2.1.2.5.a, CTP-0060, Revision D).

Post-test inspection of all internal nozzle seals, which includes the aft exit cone-to-forward exit cone field joint seals, (Section 5.4) showed there was no blow by past any primary O-ring. Objective Z was met.

"AA. Certify that the nozzle internal seals and the aft exit cone field joint seals, if pressurized, operate when PMBT is at 40 °F" (Section 3.2.1.2.5.b, CTP-0060, Revision D).

Post-test inspection of all internal nozzle seals, which includes the aft exit cone-to-forward exit cone field joint seals (see Section 5.4) showed there was no blow by past any primary O-ring. Objective AA was met.

"AD. Certify that the case is capable of containing the static-test internal pressure" (Section 3.2.1.3.a, CTP-0060, Revision D)

Post-test inspection of the QM-8 hardware (see Section 5.0) and structural evaluation from strain gage instrumentation (see Section 4.0) indicated no anomalous conditions. Objective AD was met.

"A. (Development Objective) Acquire engineering data for model validation."

Comparisons of test data to predicted model data show a close correlation except in the nozzle-to-case biaxial strain gages. Discrepancies in this joint are explained in Section 4.2.2.4.

3.1.2 Adjustable Vent Port Plug Installation Fixture

Figure 7 illustrates the components which make up the adjustable vent port plug. Figure 8 shows how the installation fixture is used to install the bottom section of the plug into the vent port. The qualification test objectives regarding the vent port plug installation fixture and how the objectives were met are discussed in this section.

"CQ. Certify the performance of the Adjustable Vent Port Plug Installation Tool as a means of installing, rotating, and torquing the bottom section of the adjustable vent port plug" (Section 3.2.1.1, CTP-0060, Revision D).

All bottom sections of the plugs were installed correctly with the installation tool. However, three bottom sections had to be replaced when the tool slipped causing raised metal on the bottom section. This problem was a result of inadequate training in the use of the tool, not the tool design (see Section 3.5). Objective CQ was met.

"CR. Certify that the installation fixture is efficient and does not require special and additional tooling" (Section 3.2.1.1, CTP-0060, Revision D).

No addition tooling was required to install the Adjustable Vent Port Plugs (see Section 3.5). Objective CR was met.

"CS. Certify that the use of the adjustable vent port plug installation tool does not affect the safe and reliable use and reusability of the RSRM" (Section 3.2.1.1, CTP-0060, Revision D).

Post-test inspection of the QM-8 field and nozzle-to-case joint vent ports revealed no anomalous conditions (see Section 5.0). Objective CS was met.

"CT. Certify that the tool allows for a threaded installation to the bottom section of the adjustable vent port plug" (Section 3.2.1.2.1, CTP-0060, Revision D).

There were no problems associated with the threaded installation to the bottom section of the adjustable vent port plug (see Section 3.5). Objective CT was met.

"CU. Certify that the interlocking allows for rotation and torquing of the bottom section of the adjustable vent port plug" (Section 3.2.1.2.2, CTP-0060, Revision D).

All bottom sections of the plugs were torqued correctly with the interlocking feature of the installation tool (see Section 3.5). Objective CU was met.

"CV. Certify the capability of interlocking the installed installation tool with the bottom section of the adjustable vent port plug, and the utilization of the notch in the bottom section of the adjustable vent port plug" (Section 3.2.1.2.2, CTP-0060, Revision D).

All bottom sections of the plugs were installed correctly with the installation tool. However, three bottom sections had to be replaced when the tool slipped, causing raised metal on the bottom section. This problem was a result of inadequate training in the use of the interlocking feature, not the tool design (see Section 3.5). Objective CV was met.

"CW. Certify that the tool is capable of applying a minimum torquing force of 70 inch pounds to the bottom section of the adjustable vent port plug" (Section 3.2.1.2.4, CTP-0060, Revision D).

The tool was capable of applying the minimum required torque of 70 inch pounds (see Section 3.5). Objective CW was met.

"CX. Demonstrate that the tool is capable of being transported to the work site" (Section 3.2.8, CTP-0060, Revision D).

The tool size and weight are acceptable (see Figure 8).

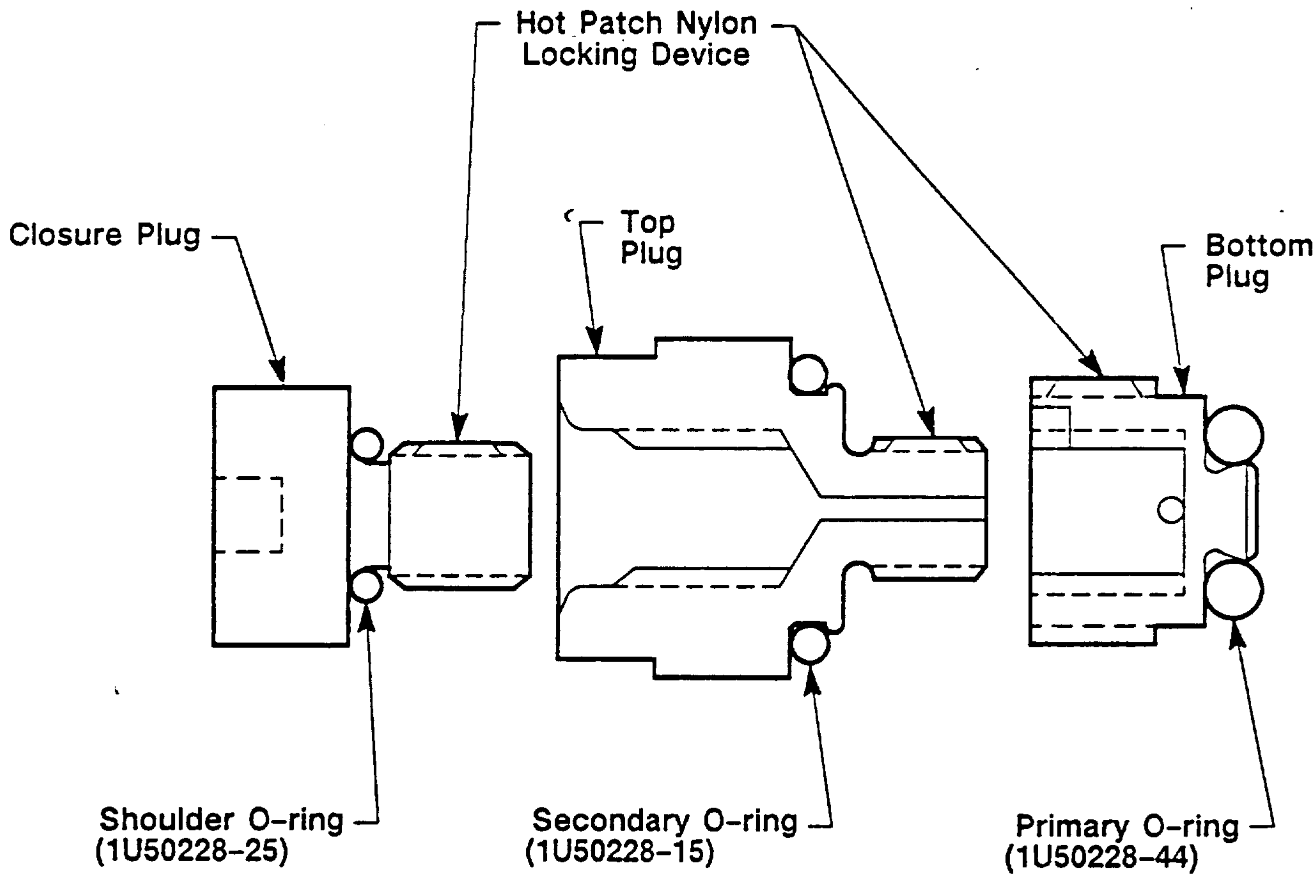


Figure 7 Adjustable Vent Port Plug

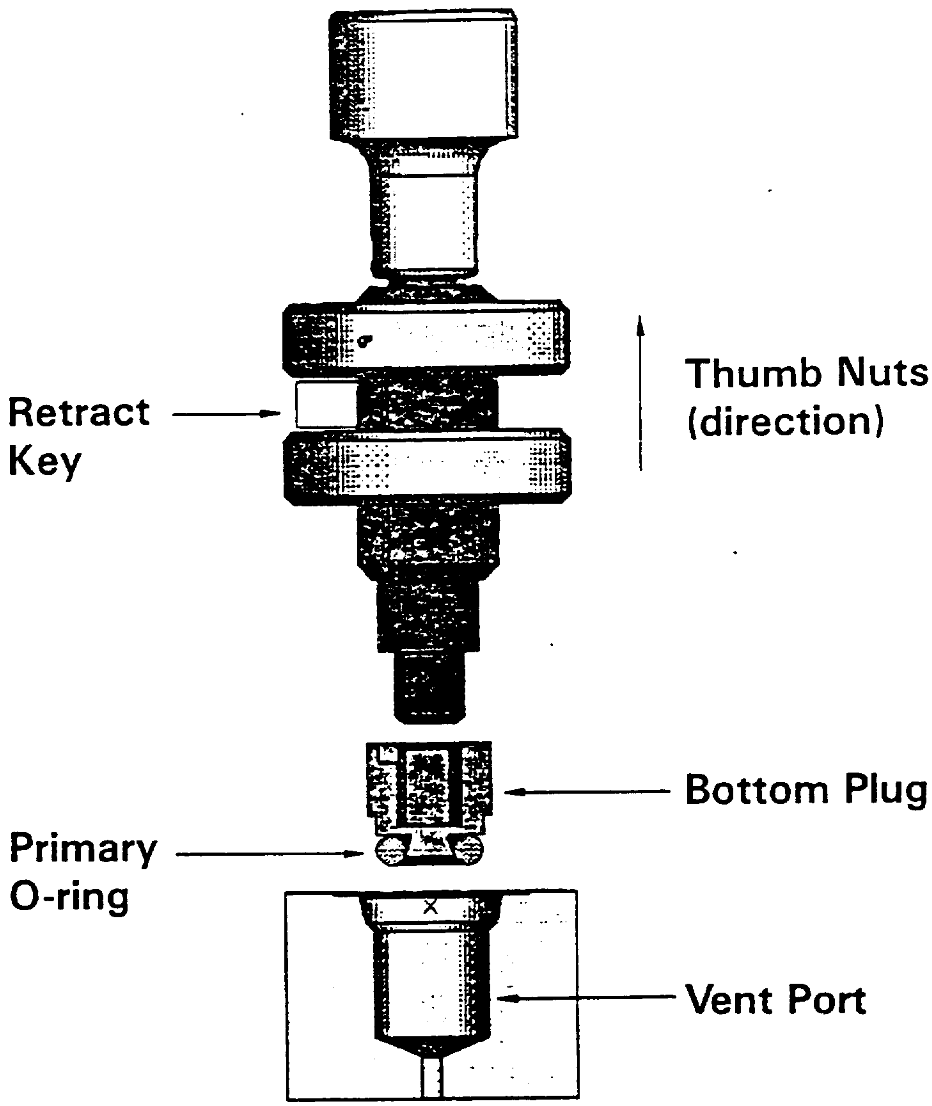


Figure 8 Bottom Plug Installation Setup

3.1.3 Leak Check

The qualification test objectives regarding leak test performance are as follows:

"I. Certify the verifiability of the RSRM seals (except for the nozzle-to-case joint primary seal, the factory joint primary seal, the fixed housing to aft end ring primary seal, the igniter dual seal plugs (5 places) and the operational pressure transducer (OPT) primary and secondary seals)" (Section 3.2.1.2, CTP-0060, Revision D).

"L. Certify that the case field joint and nozzle-to-case joint seal verification does not degrade the performance or integrity of the sealing system" (Section 3.2.1.2.1.c, CTP-0060, Revision D).

"M. Certify that the bore seals for the center field joints are verifiable in the proper direction" (Section 3.2.1.2.1.d, CTP-0060 Revision D).

"Y. Certify that the ignition system seal verification does not degrade the performance or integrity of the sealing system" (Section 3.2.1.2.4.c, CTP-0060, Revision D).

"AB. Certify that the nozzle internal seals and the aft exit cone field joint seals verification does not degrade the performance or integrity of the sealing system" (Section 3.2.1.2.5.c, CTP-0060, Revision D).

"AC. Certify that the bore seals for the nozzle are verifiable in the proper direction" (Section 3.2.1.2.5.e, CTP-0060, Revision D).

"BD. Certify the field joint, nozzle-to-case joint, and igniter-to-case joint leak test compatibility" (Section 3.2.1.8.1.1.b, CTP-0060, Revision D).

The following is a discussion of the test objectives and test results relating to leak testing, and evidence that the current specifications meet the requirements of the CEI Specification.

Objective I requires that all RSRM seals be verifiable, which, by definition in the CEI Specification, means that a leak test must be performed. The seals not meeting this requirement have been previously identified in Deviations RDW0526 and RDW0541 (see Reference 4). These seals include the nozzle-to-case joint primary seal, the factory joint primary seal, the fixed housing-to-aft end ring primary seal, the igniter dual seal plugs (five places) and the OPT primary and secondary seals. All leak tests were completed successfully. The leak test results are provided and discussed in Section 3.4. Objective I was met.

Objective L requires the certification that the case field joint and nozzle-to-case joint seal verification (leak test) does not degrade the performance or integrity of the sealing system. This is verified by post-test inspection. The completed inspections show no damage or degradation to the system (see Section 5.0). This objective was met.

Objective M requires the certification that the bore seals in the field joints are verifiable in the proper direction. These data are gathered during the leak test. When the primary-to-secondary seal cavity (V4) is pressurized to 1000 psig, the secondary seal is seated in the proper direction. It is already in that configuration because of assembly, but that is assured with pressure. The primary seal is moved into the "wrong" position. When the primary seal-to-capture feature O-ring cavity (V2) is subsequently pressurized to 100 psig, the primary seal is moved and seated in the proper sealing direction. This seal movement is evidenced by a pressure rise in the V4 volume, which is monitored by a pressure transducer during the test. The pressure rise must be a minimum of 0.5 psi. Table 1 contains the results of the final leak tests, showing the pressure rises recorded.

Based on above data, all field joint bore seals were seated and verified in the proper direction. Objective M was met.

TABLE 1
QM-8 CASE FIELD JOINT PRIMARY O-RING MOVEMENT

FIELD JOINT	*INITIAL PRESSURE (psig)	*FINAL PRESSURE (psig)
FORWARD	0.036	3.573
CENTER	0.059	3.982
AFT	0.063	3.366

* PRESSURE IN PRIMARY-TO-SECONDARY SEAL CAVITY DURING PRIMARY SEAL-TO-CAPTURE FEATURE O-RING CAVITY PRESSURIZATION TO 100 psig

Objective Y requires the certification that the ignition system seal verification does not degrade performance or integrity of the sealing system. This is verified by post-test inspection of the seals, detailed in Section 5.4. No damage was seen because of leak testing. Objective Y was met.

Objective AB requires the certification that the nozzle internal seals and the aft exit cone field joint seal verification does not degrade the performance or integrity of the sealing system. This is verified by post-test inspection of the seals detailed in Section 5.5. Completed inspections show no damage caused by leak testing. This objective was met.

Objective AC requires the certification that the bore seals for the nozzle are verifiable in the proper direction. This is verified by the successful completion of a leak test. Nozzle joints 2 and 4 have the only bore seals. The bore seals are both secondary seals, so pressurization between the seals verifies them in the proper direction. The pressures used for leak testing are 920 psig and 144 psig for joints 2 and 4, respectively.

Full-scale testing on a field joint with a minimum 21 percent squeeze has shown that approximately 65 psig is sufficient to move and seat an O-ring in the proper direction after it was seated in the opposite direction with 1000 psig. The internal nozzle joints are designed with minimum ten percent squeeze, resulting in easier movement. With the application of 144 psig and greater, it is assured the seal is seated in the proper direction. Results of the leak tests are given in Table 2. This objective was met.

Objective BD requires the certification of the field joint, nozzle-to-case joint and igniter-to-case joint leak test compatibility. This is accomplished by performing post-test inspections to determine that no damage to the insulation was caused by leak testing, and that the insulation performed acceptably. These inspections and analyses were performed with no anomalous conditions found. Detailed inspection reports are found in Section 5.0. This objective was satisfied.

TABLE 2
QM-8 INTERNAL NOZZLE JOINT LEAK TEST RESULTS

JOINT #	MAX TEST PRESSURE	*ALLOWABLE LEAK RATE,HI/LO(sccs)	ACTUAL LEAK RATE HI/LO (sccs)
#1	83	0.029/0.0082	0.0067/ 0.0011
#2	920	0.084/0.0082	0.0140/ 0.0053
#3	740	0.070/0.0082	0.0060/ 0.0000
#4	144	0.053/0.0082	0.0142/ 0.0004
#5	920	0.084/0.0082	0.0065/ 0.0072

* HI = MAX TEST PRESSURE, LO = 30 psig

(#1) => FWD / AFT EXIT CONE
(#2) => FWD END RING / NOSE INLET HOUSING
(#3) => NOSE INLET HOUSING / THROAT SUPPORT HOUSING
(#4) => THROAT SUPPORT HOUSING / FWD EXIT CONE
(#5) => AFT END RING / FIXED HOUSING

3.2 QM-8 Field Joint Assembly Procedure

Assembly of the field joints proceeded in the following order:

1. Cleaning and greasing the joint
2. V-2 filler installation
3. O-ring cleaning, greasing, and installation
4. Field Joint Assembly Fixture (FJAF) installation
5. Application of J-seal adhesive
6. Joint mating
7. Pin installation and FJAF removal
8. Installation of shims
9. Leak test procedure

3.2.1 Grease Application

Grease application was accomplished per STW7-2999 (see Reference 5). Rational for the method of grease application can be found in TWR-18135, Revision A, Section 3.1.1 (see Reference 6).

3.2.2 V-2 Filler Installation

The V-2 filler installation is fully described in TWR-18135, Revision A, Section 3.1.2 (see Reference 6). However, the starting locations for the lengths at 91 and 136 degrees were changed to 90 and 137 degrees to allow a larger V-2 gap where the vent port is located. This was done to ensure the vent port was not obstructed.

For the purpose of convenience, a cross-section drawing showing some fundamental dimensions is shown in Figure 9.

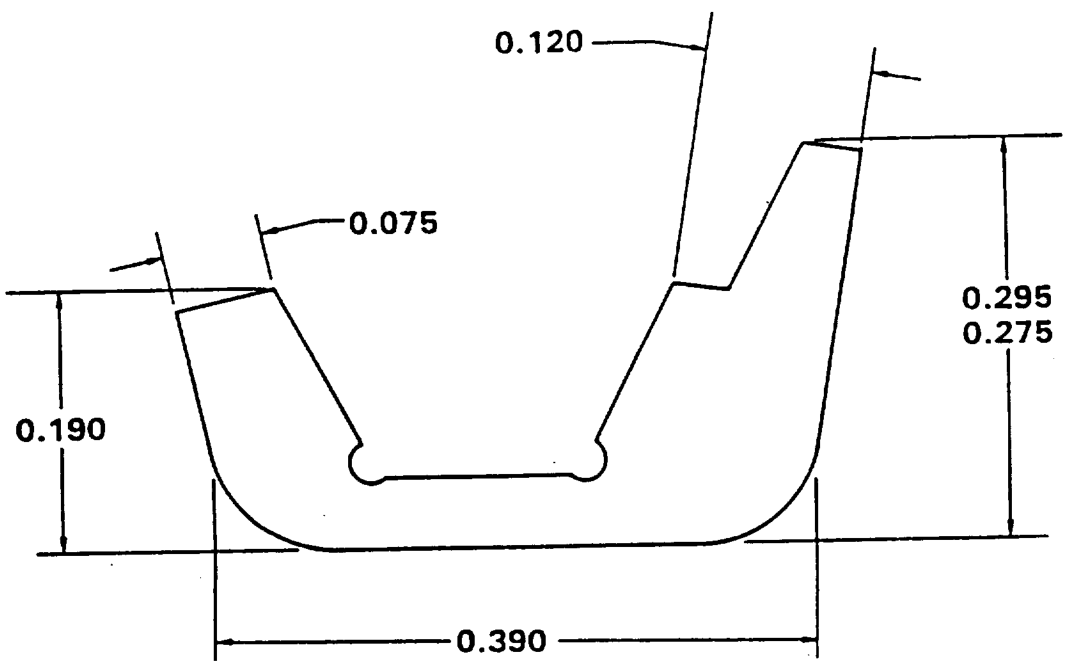


Figure 9

QM-8 V2 Filler

3.2.3 O-Ring Installation

O-rings were installed per STW7-2999 (see Reference 5) which details the O-ring installation procedures.

3.2.4 FJAF Installation and Mating

Installation procedures for the FJAF are detailed in ETP-0228, Revision A (see Reference 6), which discusses how the FJAF is used to mate the joints to full pin installation.

3.3 Nozzle-to-Case Joint Assembly

Assembly of the nozzle-to-case joint proceeded in the following order:

1. Fixed housing metal parts were cleaned and regreased
2. The pregreased O-rings were installed.
3. The fixed housing was covered to keep it clean
4. Aft dome metal parts were cleaned
5. Radial bolt hole plugs were installed in the aft dome
6. Teflon tape was applied to the aft dome metal surface from the insulation to approximately half way across the radial hole plugs

7. Polysulfide was mixed and applied to the aft dome.

8. Teflon tape was removed and aft dome metal surface was recleaned then greased. Radial bolt hole plugs were checked for proper alignment.

9. The joint was assembled vertically.

Details of the assembly procedure and radial bolt hole plug design can be found in TWR-18135, Section 3.2 (see Reference 7).

3.4 Leak Check Tests

3.4.1 Leak Test Introduction

After each RSRM joint is assembled, a leak test is performed to determine the integrity of the seals (excluding the factory joint seal and the flex bearing). The leak tests usually consist of a joint volume determination and a pressure decay test. The volume and pressure information is combined with temperature and time data, which is collected during the test, and used in the calculation of a leak rate, expressed in terms of standard cubic centimeters per second (SCCS). Each leak test has a maximum leak rate allowed. Some specifications require only a maximum pressure decay over time. This method has been determined as sufficient based on the small, constant volumes, and the equivalent leak rates, which are conservative when using all worst-case variables.

Table 3 contains a list of all joints, the Thiokol Corporation leak test specifications, and the equipment used to test the joints. The leak tests will be discussed in detail in Section 3.4.3

TABLE 3
QM-8 SEAL LEAK TESTING

	Joint	Specification	Equipment
1.	Case Field Joints	STW7-3447	8U75902
2.	Forward-to-Aft Exit Cone Joint	STW7-3475	8U76248
3.	Nozzle Internal		
	- Joint 2	STW7-3476	2U129718
	- Joint 3	STW7-3477	2U129718
	- Joint 4	STW7-3478	2U129718
	- Joint 5	STW7-3320	2U129718
4.	Vent Port Plug	STW7-3661	7U76357
5.	Nozzle/Case Joint	STW7-3448	2U129718
6.	Case Factory Joints	STW7-2747	2U129718
7.	Ignition System		
	- Inner/Outer Gaskets and Special Bolt Installation	STW7-3632	2U129718
	- S&A Joint	STW7-3633	8U76500
	- X-ducer Assembly	STW7-2853	2U65686
	- Barrier Booster	STW7-2913	2U65848

3.4.2 Leak Check Conclusions and Recommendations

Based on the satisfaction of all QM-8 objectives as discussed in Section 3.1.3, it is concluded that all leak tests currently performed on the RSRM joints are certified for use on flight motors. These certification objectives were also satisfied during DM-9, QM-6, QM-7, and PV-1, except for the igniter inner gasket leak test, which was certified on QM-7 and PV-1. No further conclusions or recommendations are reached.

3.4.3 Leak Check Results and Discussion

The case field joint leak test results are shown in Table 4. All tests were performed with the 8U75902 leak test system. The "8U" system was used to test the flight motor field joints (360L001, 360L002, and 360L003), aft-to-forward exit cone joints, and the S&A-to-igniter joint. The results from the QM-8 field joint leak tests were nominal.

TABLE 4
QM-8 CASE FIELD JOINT LEAK TEST RESULTS

PRESSURE (psig)	CAVITY*	MAXIMUM LEAK RATE (sccs)	ACTUAL LEAK RATES (sccs)		
			FWD	CTR	AFT
1000	P-S	0.10	0.0002	0.0693	0.0081
30	P-S	0.0082	0.0005	0.0002	-0.0003
100	P-C	0.037	0.0102	0.0124	0.0163
**0	P-S	-0.037	-0.0005	-0.0006	-0.0006
30	P-C	0.0082	0.0006	0.0006	0.0001
**0	P-S	-0.0082	-0.0002	-0.0002	-0.0002

* P-S PRIMARY-TO-SECONDARY SEAL
P-C PRIMARY SEAL-TO-CAPTURE FEATURE O-RING
** MONITOR PRESSURE RISE IN P-S CAVITY

The QM-8 ignition system leak test results are shown in Table 5. The tests were performed with a variety of equipment as shown in Table 3. The equipment was identical to that used on the flight motors. All results were well within limits.

TABLE 5
QM-8 IGNITION SYSTEM LEAK TEST RESULTS

JOINT SEAL	ALLOWABLE LEAK RATE (sccs), HI/LO*	ACTUAL LEAK RATE (sccs), HI/LO
IGNITER INNER	0.10 / 0.0082	0.0017 / 0.0055
OUTER	0.10 / 0.0082	0.0123 /-0.0004
TRANSDUCER INSTALLATION	0.10 / 0.0082	-0.0009 / 0.0000
OPT **	10 psi IN 10 min/ 1 psi IN 10 min	3.0 / 0.0 3.0 / 0.0 3.0 / 0.0 3.0 / 0.0
BARRIER˙ BOOSTER	1 psi IN 20 min	0.0 PSI
S & A	0.10 / 0.0082	0.0303 /-0.0005

* HI = 1000 psig, LO = 30 psig
** OPT's TESTED AT 1024 psig AND 30 psig, ACTUAL LEAK RATE UNITS ARE psi/10 min
˙ BARRIER BOOSTER TESTED AT 55-60 psig

Table 6 lists the results of the QM-8 nozzle-to-case joint leak test. The 2U129718 equipment was used. This equipment is identical to that used on the nozzle-to-case joints of the flight motors. All results were well within limits.

TABLE 6
QM-8 NOZZLE-TO-CASE JOINT LEAK TEST RESULTS

PRESSURE (psig)	CAVITY*	MAXIMUM ALLOWABLE LEAK RATE (sccs)	ACTUAL LEAK RATE (sccs)
920	P-S	0.084	0.0213
30	P-S	0.0082	-0.0002
25	P-W	**	0.140 psi/min
25	P-S^	-0.0082	-0.0002
STAT-O-SEAL	P-W	0 BUBBLES/SEC	0

* P-S = PRIMARY-TO-SECONDARY SEAL
P-W = PRIMARY SEAL-TO-WIPER O-RING
** 5 psi DROP IN 5 MINUTES
^ MONITOR PRESSURE RISE RATE WITH P-W PRESSURIZED

Table 2 shows the results of the internal nozzle joint leak tests. Joint No. 1 was tested with the 8U75248, S/N 006 equipment, while Joints 2 through 5 were tested with the 2U129718 equipment. The "8U" was used on all flight motor No. 1 joints. The "2U" was used on the all flight motor nozzle internal joints. All data were well within limits.

Table 7 shows results of leak test performed on the vent port plugs used on QM-8. All results were will within limits.

TABLE 7
QM-8 VENT PORT PLUGS LEAK TEST RESULTS

PRESSURE (psig)	ALLOWABLE LEAK RATE (sccs)	ACTUAL LEAK RATE (sccs)			
		AFT	CENTER	FORWARD	NOZZLE/CASE
1000	0.10	-0.0055	0.0051	0.0015	-0.0015

3.5 Adjustable Vent Port Plugs

The adjustable vent port plug (AVPP), illustrated in Figure 7, was tested in QM-8. Four AVPPs were successfully installed in the case field joints and the nozzle-to-case joint vent ports at 135 and 43.2 degrees, respectively. A 2U132133 (8U76549) installation tool, shown in Figure 8, was used to install the bottom portion of the AVPPs in the vent ports. Each AVPP was installed per STW7-3499 (see Reference 8) and leak checked per STW7-3661 (see Reference 9).

No major problems occurred during the installation of the AVPPs. Three bottom portions were replaced when the AVVP tool slipped causing raised metal on the bottom plug. This anomaly was caused from the incorrect use of the installation tool. After training technicians in the use of the tool, no additional problems with the tool occurred. Training should be implemented to teach the correct use of the tool to prevent further problems with raised metal on the bottom plug. TWR-18838 (see Reference 10), documents the procedure for correct use of the AVPP installation tool.

The AVPP installation tool worked as designed to install the bottom portion of the AVPP into the port to the 70 in.lb maximum torque. The removal of the tool did not affect the installed plug. In addition, the installation process using the AVPP installation tool did not cause any damage to the tool. Two bottom portions were replaced because the installation torques exceeded the requirements (too much locking device). The installation specification STW7-3499 (see Reference 8) has provisions to remove any plugs that exceed the initial installation torque.

Each AVPP successfully passed leak check. All were below the 0.1 sccs allowable leak rate. Actual leak rates are given in Table 7. Post-test inspection results indicate all AVPPs were nominal. No motor pressure reached the AVPPs, thus, no assessment of blow by or erosion can be made on the seals.

3.6 Squeeze Calculations

No DRs were generated on the QM-8 O-rings addressing the minimum squeeze. All O-rings were within the drawing tolerances, therefore, all QM-8 O-ring squeezes were within limits outlined in TWR-18811, Revision A (see Reference 11).

4.0 TEST RESULTS

The test results monitored by Structural Applications and Structural Design are described in this section. In most cases, actual test data are compared to predicted values for each location and are shown in the Data Summary Tables, Tables 8 through 33. Test data from each joint are summarized in these tables. Biaxial gages are presented in two tables - one to show the maximum strain and a comparison with predictions (where applicable), and another to show the maximum calculated hoop and axial stress.

The predictions included in these tables are ratioed to QM-8 pressure with respect to gage location. The ratios were determined by multiplying the original prediction by the ratio of the estimated QM-8 pressure to the prediction pressure. This is done because each set of predictions were calculated assuming a common pressure, which in most cases is somewhat larger than the actual pressure for the specific location. Therefore, by using the ratio of the predictions to QM-8 values, a comparison can be made. The calculation of the pressure ratio works as follows:

0 Maximum radial growth, e.g., girth strain, for a particular location is found from test data, and the time at which it occurred. The head end pressure at this time is determined, and a predicted pressure drop to the gage location at this time is found. For QM-8, the predicted pressure drops were given in TWR-18990 (see Reference 12). Therefore, the pressure ratio is:

$$\text{Pressure Ratio} = \left[\frac{\text{Head End Pressure - Predicted Pressure Drop}}{\text{Predicted Pressure}} \right]$$

The percent difference between analysis and measured strain data is given by:

$$\left[\frac{\text{(Prediction)*(Pressure Ratio) - Measured}}{\text{Measured}} \right] \times 100$$

4.1 Instrumentation

Instrumentation gages were placed on and close to the field and nozzle-to-case joints to characterize joint performance. Following is a list of gages used and their function.

Joint Girth Gages-	Measures the hoop strain for the entire 360 degree circumference. From the averaged hoop strain, radial deflections are determined from the product of measured (average) girth strain and the nominal hardware radii at the corresponding gage location.
Biaxial Gages-	Measures local, rather than average (girth gages) axial and hoop strains incurred in the case during pressurization. From the strains, stress can be calculated.
Strainserts-	Added to the hollowed out heads of the nozzle-to-case radial and axial bolts to measure initial and final loads on the bolts in pounds.
Linearly Variable-Differential Transducer (LVDT)	Used to measure O-ring gap opening for the field joints via the 45 degree leak check port.
Pressure Transducer-	Installed in the igniter to measure head end pressure.
Thermocouple-	Instrumented on the field and nozzle-to-case joints to monitor temperature.
Axial Deflection-	Measures axial growth across the joint(s), gages and membrane.

4.2 Field Joint Performance

QM-8 instrumentation on the field joint consisted of four girth gages (except on the aft joint where there were none) and one LVDT per joint. Deflection gages were placed across each field joint to measure axial growth (see Section 4.8). Test results at these locations are compared to analytical results. To predict QM-8 field joint response, a three-dimensional finite element model was used for pretest predictions. The basic model represented a one degree cyclic-symmetric slice of the case and used friction interface elements to simulate the contact surfaces. A detailed description of the model can be found in TWR-17118, Supplement B, Revision A (see Reference 13).

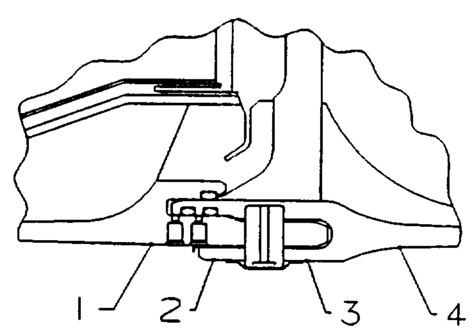
4.2.1 Field Joint Girth Gages

Tables 8 and 9 list the girth gage response (i.e., strain and radial growth) of the forward and center field joints, and compare it with the predictions. The results show a strong correlation between analysis and test data. Field joint predictions come within 8.5 percent of measured values.

Close study of the field joint growth behavior shows the joint is moving outward with the areas furthest from the pin centerline moving the most. This can be seen from the higher radial growth values at the forward and aft ends of each joint, and the lower values closer to the pin centerline.

TABLE 8
QM-8 FORWARD FIELD JOINT GIRTH GAGE RESPONSE (Zero to 120 seconds)

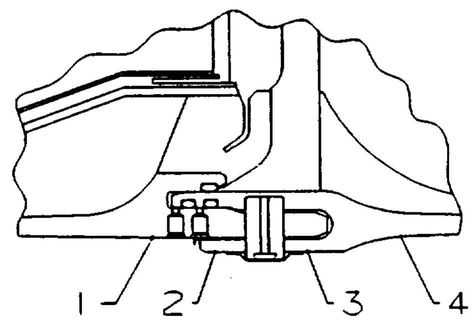
TEST NAME: QM-8
JOINT: FWD FIELD
DESCRIPTION: JOINT GIRTH GAGES
THE TIME RANGE IS 0.0 TO 120.0 SECONDS



GIRTH GAGE LOCATION	GAGE NUMBER	STATION	RADIUS (IN)	RADIAL GROWTH (IN)	TEST STRAIN (UIN/IN)	ADJUSTED ANALYSIS STRAIN (UIN/IN)	ADJUSTED ANALYSIS RADIAL GROWTH (IN)	DIFF IN RADIAL GROWTH (% DIFF)
1	R303	848.5	73.1	ND	ND	ND	ND	ND
2	S677	850.2	73.5	ND	ND	ND	ND	ND
3	S965	852.6	73.5	0.157	2140	1959	0.144	-8.5
4	S621	855.0	73.1	0.175	2400	2441	0.178	1.7

TABLE 9
QM-8 CENTER FIELD JOINT GIRTH GAGE RESPONSE (zero to 120 Seconds)

TEST NAME: QM-8
JOINT: CTR FIELD
DESCRIPTION: JOINT GIRTH GAGES
THE TIME RANGE IS 0.0 TO 120.0 SECONDS

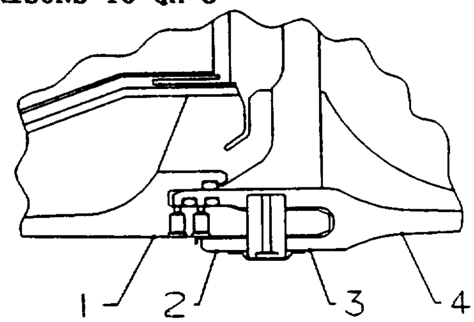


GIRTH GAGE LOCATION	GAGE NUMBER	STATION	RADIUS (IN)	RADIAL GROWTH (IN)	TEST STRAIN (UIN/IN)	ADJUSTED ANALYSIS STRAIN (UIN/IN)	ADJUSTED ANALYSIS RADIAL GROWTH (IN)	DIFF IN RADIAL GROWTH (% DIFF)
1	R304	1168.5	73.1	0.155	2118	1973	0.144	-6.9
2	S682	1170.2	73.5	0.136	1853	1880	0.138	1.4
3	S966	1172.6	73.5	0.151	2056	1915	0.141	-6.8
4	S635	1175.0	73.1	0.169	2316	2385	0.174	3.0

4.2.2 QM-8 Field Joint Radial Growth Comparisons

Tables 10 and 11, and Figures 10 and 11 compare QM-8 field joint radial growth to that on previous flights 360L001 and 360L002; and, full-scale static tests PV-1, QM-7, QM-6, DM-9, DM-8, and analysis. All values are pressure ratioed to the estimated QM-8 joint pressures. Radial growth values compare closely, considering the differences between each configuration. Actual radial growth at Location 3 on all three joints is much higher than the predictions, which is caused by the case thickness being smaller than the thickness used in the model. Figures 10 and 11 graphically illustrate data presented in Tables 10 and 11.

TABLE 10
FORWARD FIELD JOINT RADIAL GROWTH COMPARISONS TO QM-8

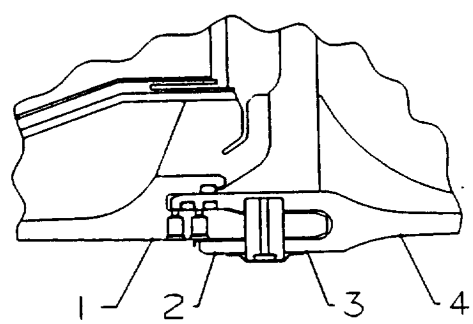


Fwd Field Girths AVERAGE JOINT PRESSURE AT MAX STRAIN = 827

		STRAIN		STS-27		STS-26				RADIAL GROWTH (Inches)			
LOC.	GAGE	QM-8	QM-8	RIGHT	LEFT	RIGHT	LEFT	PV-1	QM-7	QM-6	DM-9	DM-8	PRED
1	R303	ND	ND	ND	ND	ND	ND	ND	0.182	0.151	0.153	0.158	0.154
2	S677	ND	ND	ND	0.146	ND	0.145	ND	0.140	0.132	0.146	0.142	0.141
3*	S965	2150	0.157	ND	0.162	ND	0.164	ND	0.157	0.154	ND	0.155	0.144
4	S621	2400	0.175	0.175	0.174	ND	0.180	ND	0.174	0.173	0.166	0.177	0.178

* DM-8 is 1/3 Inch more Fwd than the other motors
Note: All Test Radial Growths Are Ratios of QM-8 Test Pressure

TABLE 11
CENTER FIELD JOINT RADIAL GROWTH COMPARISONS TO QM-8



Ctr Field Girths AVERAGE JOINT PRESSURE AT MAX STRAIN = 799

		STRAIN		STS-27		STS-26				RADIAL GROWTH (Inches)			
LOC.	GAGE	QM-8	QM-8	RIGHT	LEFT	RIGHT	LEFT	PV-1	QM-7	QM-6	DM-9	DM-8	PRED
1	R304	2118	0.155	ND	ND	ND	ND	ND	ND	ND	0.146	0.151	0.143
2	S682	1853	0.136	0.134	0.139	ND	0.140	ND	0.140	0.132	0.150	0.141	0.138
3*	S966	2056	0.151	ND	0.156	0.158	ND	0.154	0.155	0.149	0.135	0.155	0.141
4	S635	2316	0.169	0.165	0.166	ND	ND	0.173	0.171	0.167	0.165	0.176	0.174

* DM-8 is 1/3 Inch more Fwd than the other motors
Note: All Test Radial Growths Are Ratios of QM-8 Test Pressure

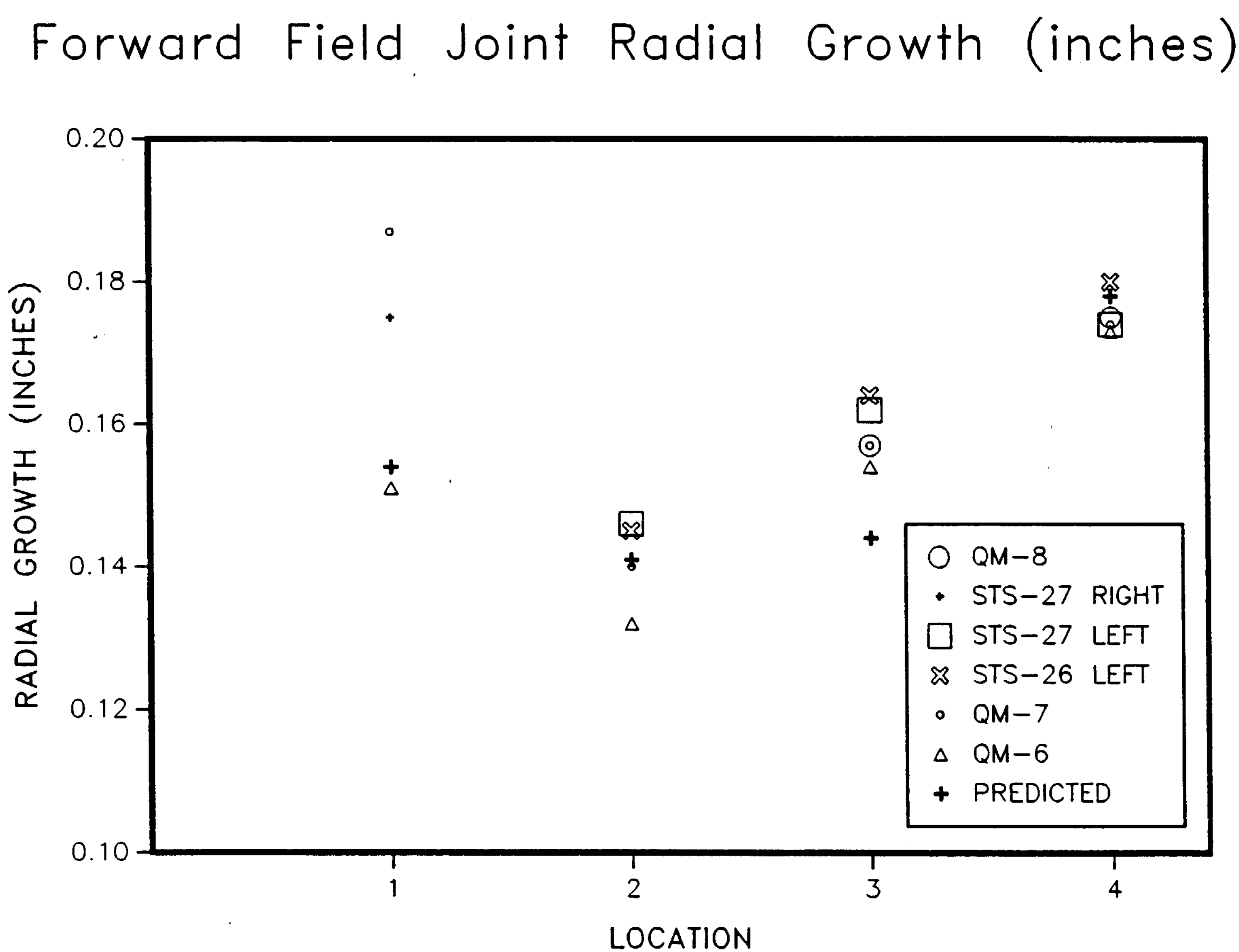


Figure 10 Forward Field Joint Radial Growth Comparisons

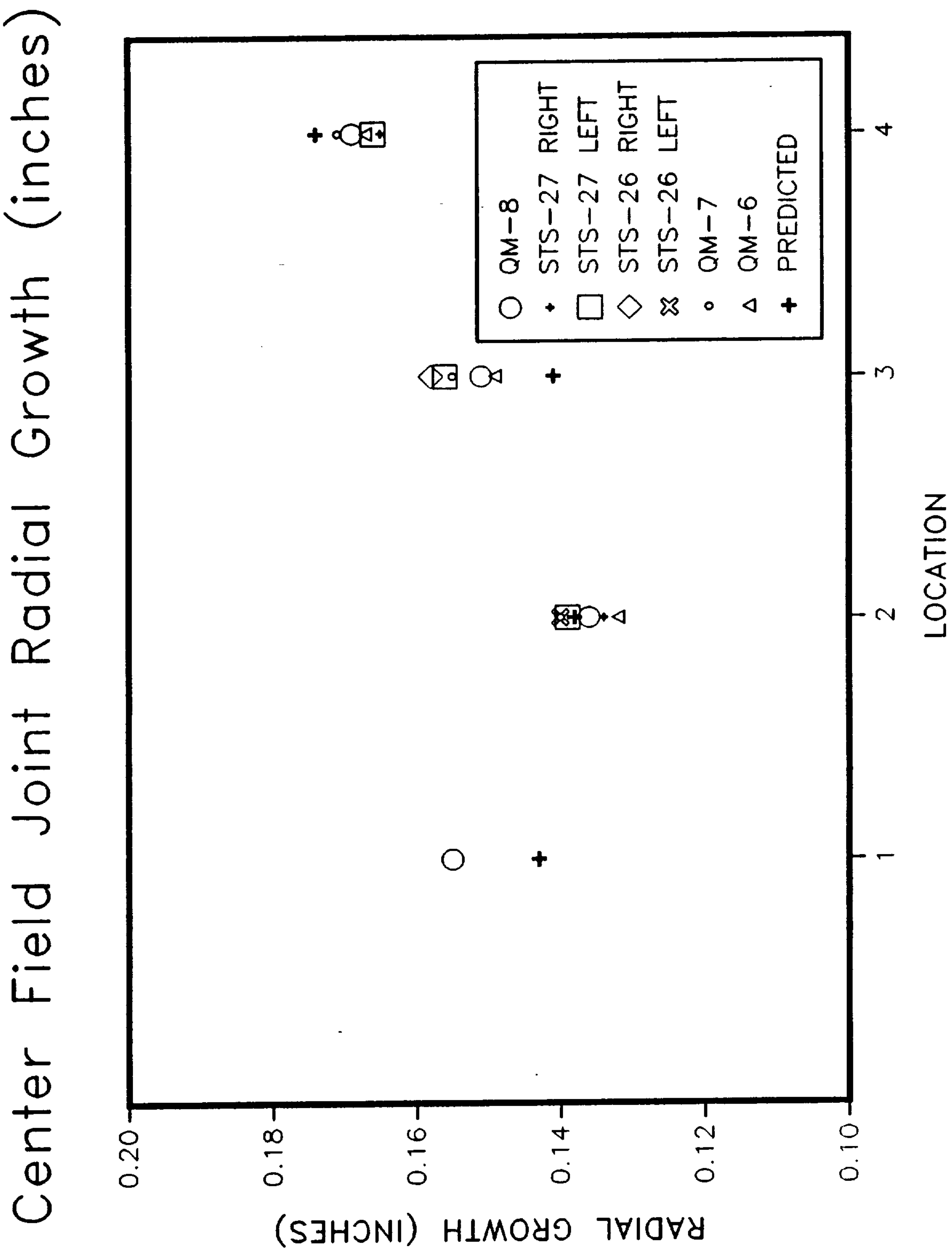


Figure 11 Center Field Joint Radial Growth Comparisons

4.2.3 LVDT Gages

The O-ring gap opening for QM-8 was measured directly for the forward, center and aft field joints via the 45 degree leak check ports. The LVDTs were lockwired, torque painted, and fitted tight into their respective ports. These measurements were also taken on the JES and TPTA tests. Figure 12 shows the actual test data for the forward field joint LVDT. The center, and aft field joint LVDT gages produced no data. Note that a negative value on the plot corresponds to gap opening and positive value to gap closing. Table 12 lists the maximum measured O-ring gap openings; the flaw, if any, to the joint; and the test pressure for QM-8, QM-7, QM-6, TPTA-1.1, JES-3A, and JES-3B. For QM-8, the maximum field joint gage pressure was estimated to be 833 psig, which occurred at the forward field joint between 9 to 11 seconds.

For the JES and TPTA tests, O-ring gap measurements were taken at more than one Location around the circumference, whereas QM-8 produced only one data point at 45 degrees on the forward field joint. Thus, it is probable the reading for QM-8 was not a maximum. On JES and TPTA, up to 12 LVDT readings were taken on a particular joint. The values used in Table 12 for the JES and TPTA tests are the measured maximums from these readings. The largest field joint O-ring gap measured (flawed or unflawed) was 0.007 inch (QM-6). The 0.004 inch gap opening on the QM-8 forward field joint at the 45 degree Location was the same as predicted by analysis.

TABLE 12
O-RING SEALING GAP OPENINGS, QM-7, QM-6, JES, NJES, TPTA

	Test	Joint	Max. O-ring Gap (in.)	Defect	Max. Test Pressure (psig)	ETA Ring
Field Joints	QM-8	Fwd	0.004	None	833	360
	QM-7	Fwd	0.004	None	877	360
	QM-6	Fwd	0.007	None	854	360
	QM-6	Aft	0.002	None	816	360
	JES-3A	A	0.006	None	939	270
	JES-3A	B	0.005	J Seal Wave	939	
	JES-3B	A	0.004	Channel to Feature O-ring	907	None
	JES-3B	B	0.005	Pressure to Primary O-ring	907	
	TPTA 1.1	A	0.001	None	901	360
	TPTA 1.1	B	0.006	None	901	
Nozzle to Case	NJES-2A	Primary O-ring	0.007	Flaw to Wiper (saw no pres.)	1025	
	NJES-2A	Secondary O-ring	No Data	"	1025	
	NJES-2B	Primary O-ring	0.005	Flaw to Wiper (saw pressure)	847	
	NJES-2B	Secondary O-ring	0.002*	"	847	
	TPTA 1.1	Primary O-ring	0.006	"	901	
	TPTA 1.1	Secondary	0.004	"	901	

* Maximum Gap Aft of Secondary

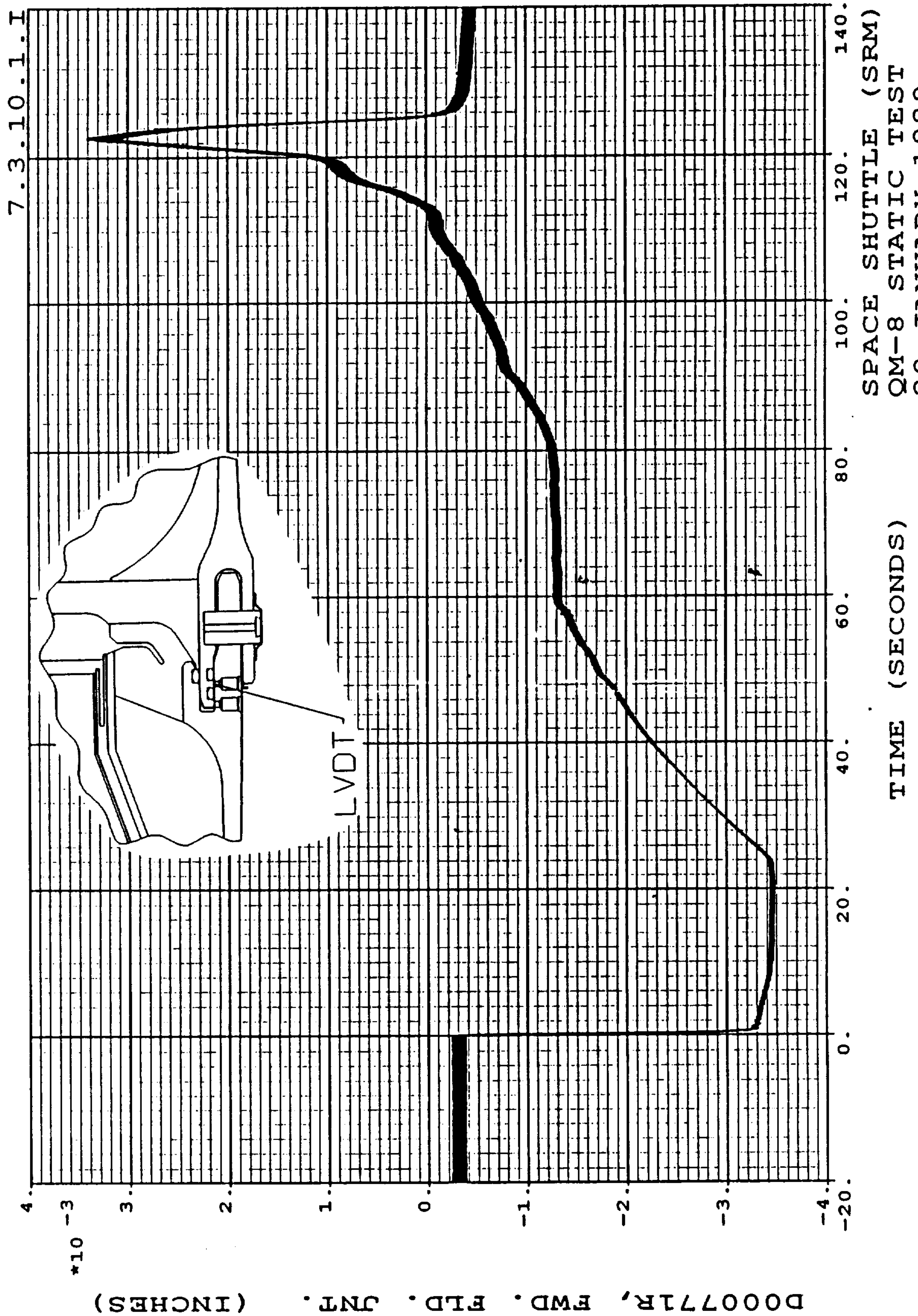


Figure 12 Forward Field Joint LVDT Measurement (Gap Opening)

Therefore the value measured on QM-8 falls within the TPTA and JES data base which demonstrates that the O-rings would of remained sealed if motor pressure reached the primary O-ring. Also resiliency testing, which is an on-going study at this time, has shown that fluorocarbon will track 0.018 inch gap opening (see TWR-17991, Reference 14), given the following conditions:

- Assembled with 16.5 percent squeeze for 180 days. O-ring at 75 °F at the time of test.
- Assembled with 18 percent squeeze for 365 days. O-ring at 75 °F at the time of test.
- O-rings stored at ambient temperatures.

The lowest calculated percent squeeze for the QM-8 field joints was 21.0 percent (TWR-18811, Reference 11). Also the joint heater temperatures (see Table 32) were in the appropriate range to assure a minimum O-ring temperature of 75 °F. None of the field joints or the nozzle-to-case joint were assembled beyond 365 days before the static test was conducted.

There was no evidence of gas reaching the forward and aft field joint O-rings because of the effectiveness of the J-Seal insulation. Therefore, the performance of these field joint O-rings cannot be fully evaluated.

4.3 Factory Joints

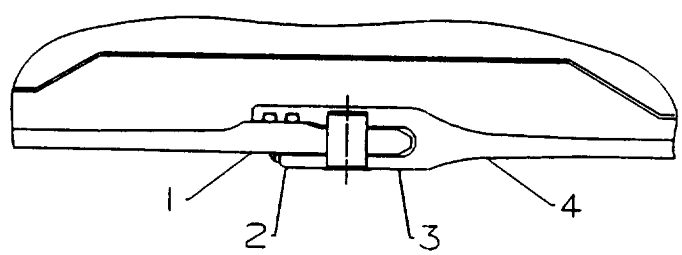
4.3.1 Forward Segment Factory Joint Girth Gage Response

QM-8 instrumentation on the forward segment factory joint consisted of four girth gages. Table 13 lists the girth gage response for the zero through

120 second range, and compares measured strain and corresponding radial growth with predicted values. Predictions were within 10.6 percent of measured test data. As expected, the pattern of joint rotation is the same as seen on the field joints. However, note the values of radial growth are generally higher than the field joints. This happens because this factory joint is nearer to the head end pressure, and the capture feature, which limits joint rotation, is not included in the factory joint design. Radial growth at Location 3 is higher than predicted, which was also the case in the field joints.

TABLE 13
QM-8 FORWARD SEGMENT FACTORY JOINT GIRTH GAGE RESPONSE (Zero to 120 seconds)

TEST NAME: QM-8
JOINT: FWD SEGMENT FACTORY JOINT
DESCRIPTION: GIRTH GAGES
THE TIME RANGE IS 0.0 TO 120.0 SECONDS



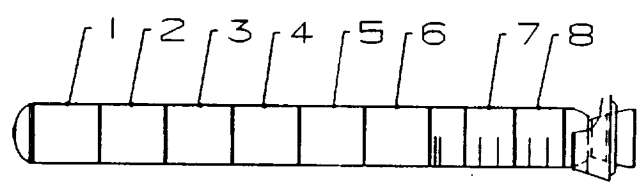
GIRTH GAGE LOCATION	GAGE NUMBER	STATION	RADIUS (IN)	RADIAL GROWTH (IN)	TEST STRAIN (UIN/IN)	ADJUSTED ANALYSIS STRAIN (UIN/IN)	ADJUSTED ANALYSIS RADIAL GROWTH (IN)	DIFF IN RADIAL GROWTH (% DIFF)
1	S1100	688.5	73.1	0.181	2472	2360	0.173	-4.5
2	S1101	690.2	73.5	0.168	2292	2179	0.160	-4.9
3	S1102	692.6	73.5	0.174	2369	2117	0.156	-10.6
4	S1103	695.0	73.1	0.181	2480	2354	0.172	-5.1

4.4 Case Membrane Girth Gage Response

QM-8 instrumentation on the case membrane consisted of eight girth gages. Table 14 lists the girth gage response and compares the measured strain and calculated radial growth with predicted values. Every prediction is within 5.7 percent of measured test data. The forward segment is made of standard weight cylinders, whereas the center and aft segments are made of thinner, lightweight cylinders, which affect radial growth. (The attach cylinder is standard weight, but there were no girth gages on this cylinder).

TABLE 14
QM-8 CASE RADIAL DEFLECTION, CASE GIRTH GAGE RESPONSE (Zero to 120 seconds)

TEST NAME: QM-8
JOINT: CASE RADIAL DEFLECTION
DESCRIPTION: CASE GIRTH GAGES
THE TIME RANGE IS 0.0 TO 120.0 SECONDS

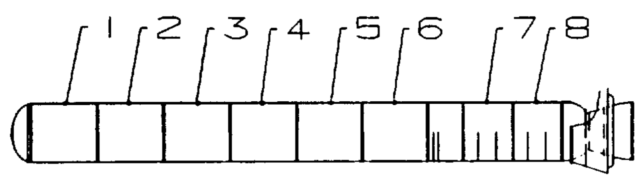


GIRTH GAGE LOCATION	GAGE NUMBER	STATION	RADIUS (IN)	RADIAL GROWTH (IN)	TEST STRAIN (UIN/IN)	ADJUSTED ANALYSIS STRAIN (UIN/IN)	ADJUSTED ANALYSIS RADIAL GROWTH (IN)	DIFF IN RADIAL GROWTH (% DIFF)
1	S584	611.5	73.0	0.270	3701	3699	0.270	-0.1
2	S585	771.5	73.0	0.258	3539	3637	0.266	2.8
3	S586	931.5	73.0	0.271	3712	3574	0.261	-3.7
4	S587	1091.5	73.0	0.268	3676	3533	0.258	-3.9
5	S588	1251.5	73.0	0.265	3628	3494	0.255	-3.7
6	S589	1411.5	73.0	0.268	3665	3456	0.252	-5.7
7	S591	1637.5	73.0	0.249	3407	3434	0.251	0.8
8	S592	1757.5	73.0	0.251	3432	3445	0.252	0.4

4.4.1 QM-8 Case Membrane Radial Growth Comparison

Analysis and data from 360L001, 360L002, QM-7, QM-6, and DM-8 (see Table 15 and Figure 13) show that radial growth for the forward segment reduces from the value at Station 1 to the value at Station 2, illustrating the pressure drop down the bore of the motor. Also, a comparison with these motors show that the radial growth increases from Station 2 to Station 3. Factually, even though there is a pressure drop from Station 2 to 3, the transition from a standard weight segment to a lightweight segment overpowers the pressure drop, and a net increase in radial growth occurs. From Station 4 to 8 there is a drop of radial growth, which is illustrated in Figure 13.

TABLE 15
CASE MEMBRANE RADIAL GROWTH COMPARISONS TO QM-8



Case Membrane Girths

LOC.	GAGE	STRAIN QM-8	QM-8	STS-27 RIGHT	STS-27 LEFT	STS-26 RIGHT	STS-26 LEFT	PV-1	QM-7	QM-6	DM-9	DM-8	PRED
			RADIAL GROWTH (Inches)										
1	S584	3701	0.270	0.280	0.279	ND	ND	ND	0.289	0.275	0.268	0.284	0.270
2	S585	3539	0.258	0.266	0.270	ND	0.275	ND	0.275	0.262	0.271	0.282	0.266
3	S586	3712	0.271	0.284	ND	ND	ND	ND	0.287	0.279	0.283	0.291	0.261
4	S587	3676	0.268	0.270	ND	0.281	0.279	ND	0.288	0.273	0.279	0.292	0.258
5	S588	3628	0.265	0.268	0.268	ND	ND	ND	0.279	0.264	ND	0.285	0.255
6	S589	3665	0.268	0.265	0.260	0.276	ND	ND	0.278	0.268	ND	ND	0.252
7	S591	3407	0.249	0.243	ND	0.261	0.260	ND	0.266	0.253	0.253	0.260	0.250
8	S592	3432	0.251	ND	ND	ERR	ND	ND	0.268	0.250	ND	ND	0.251

NOTE: Only the predictions are pressure ratioed to QM-8
Nozzle to Case Joint Radial Growth Comparisons to QM-8

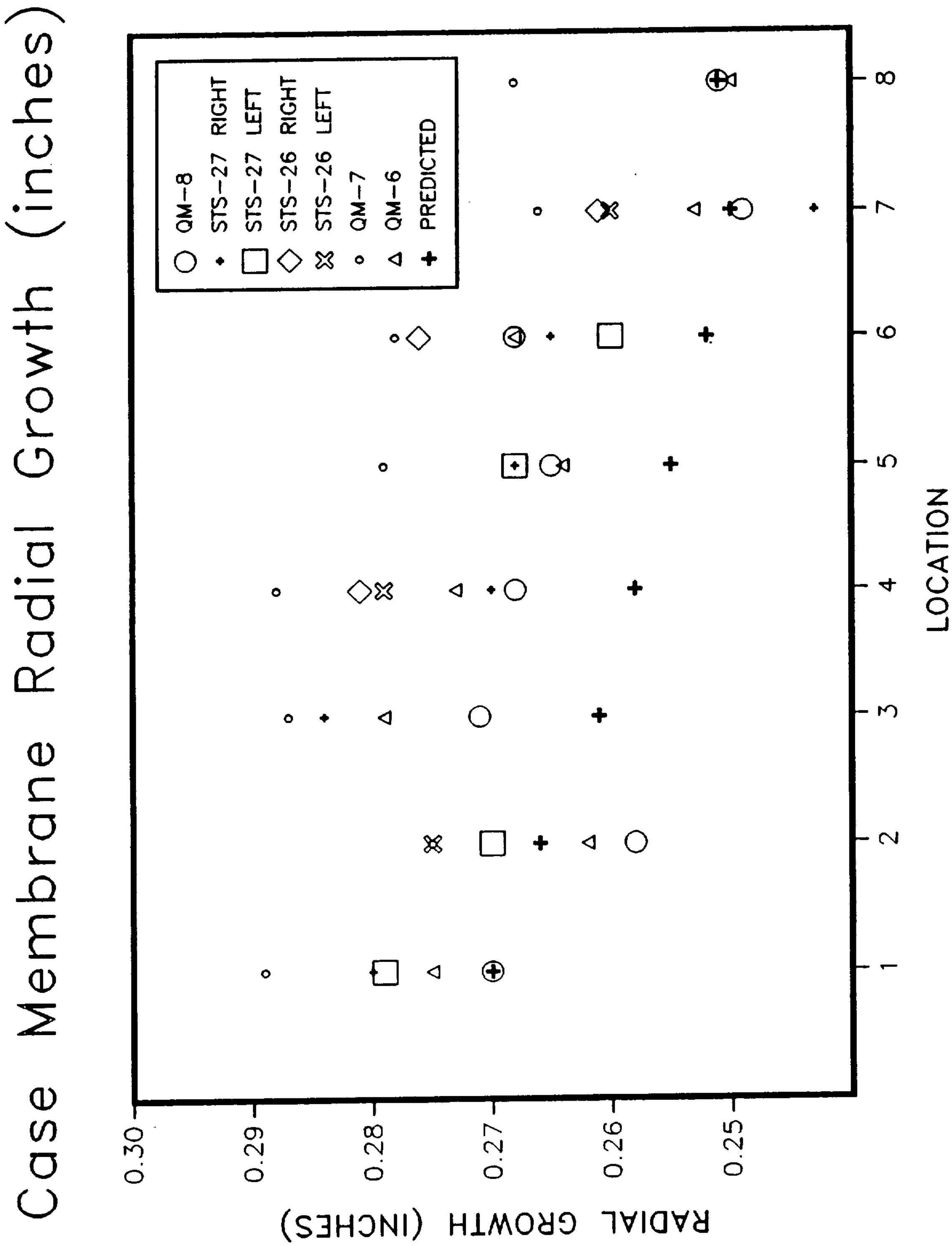


Figure 13 Case Membrane Radial Growth Comparisons

4.5 Case Biaxial Stresses

4.5.1 Aft-to-Center Segment Case Line Load

QM-8 biaxial gage instrumentation consisted of two sets of gages on the center aft segment (one on Station 1196.48 and one on Station 1466.00). Tables 16 and 17 show the moment biaxial strains with the corresponding predictions for the 120 second burn time. Tables 18 and 19 show the maximum hoop with the corresponding axial stress, and maximum axial stress with the corresponding hoop stress for this same time frame.

Hoop predictions compared more closely with the measured values than the gages in the axial direction, especially at zero and 188 degrees. The majority of this discrepancy can be attributed to the attempt to predict the pretest sag effects of the motor in the test stand, and the subsequent lessening of the sag during motor pressurization. This sagging effect, known as column bending, would theoretically change motor stresses at the zero and 188 degree locations as described:

> When the SRM chocks are removed, a sag in the motor results. This causes an induced tensile axial strain at zero degrees (bottom of the motor), and an induced compressive axial strain at 188 degrees (top of the motor). Then, just before the static-test, the biaxial gages in these areas are set to zero. Therefore, when the motor is fired, and the sag is lessened, an incorrect reading in both the zero and 188 degree area results.

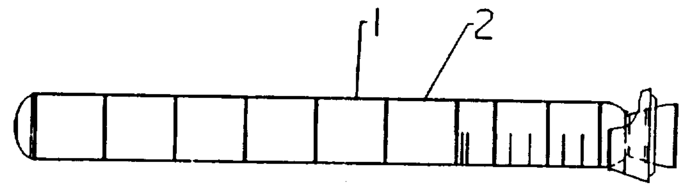
The maximum measured stress occurred in the hoop direction at Location 2, 270 degrees. The measured value was 145.1 ksi. Using biaxial improvement, the ultimate case strength increases from 200 ksi to 214.2 ksi (i.e., 200 x 1.071 = 214.2), giving a safety factor of 1.48. No local yielding was measured.

There was relatively little difference in maximum hoop stress and the time it occurred between Locations 1 and 2. Maximum axial stress was affected by the induced strut loads (those occurring during the initial second of burn time), whereas maximum hoop stress was not.

A comparison of the QM-8 strain versus time plots with those of QM-6 (which did not have strut loads applied) shows the QM-8 strain was greatly affected by the induced strut loads. The QM-8 axial and hoop gage plots followed the same trend as in QM-6. Between about 51 and 60 seconds, the axial strain shows a definite down spike at zero and 90 degrees, and an up spike, of the same magnitude, at 188 and 270 degrees. Because gages were zeroed prior to ignition, the propellant induced strains were ignored, thus, the gages do not return to zero following burn time. Upon the completion of the test, negative (compression) strain results at 200 degrees, with positive (tension) strain at 180 degrees.

TABLE 16
QM-8 AFT-TO-CENTER SEGMENT (STATION 1196.48) CASE LINE LOAD MOMENT BIAXIALS (Zero to 120 seconds)

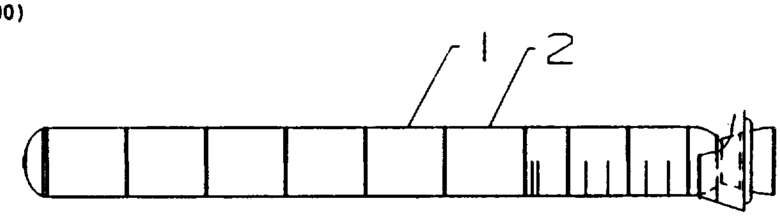
TEST NAME: QM-8
JOINT: AFT/CTR SEGMENT (STATION 1196.48)
DESCRIPTION: CASE LINE LOAD/ MOMENT BIAXIALS
THE TIME RANGE IS 0.0 TO 120.0 SECONDS



LOCAT	ANGULAR LOCATION	AXIAL GAGE	HOOP GAGE	TEST DATA AXIAL STRAIN (UIN/IN)	TEST DATA HOOP STRAIN (UIN/IN)	ADJUSTED ANALYSIS AXIAL STRAIN (UIN/IN)	ADJUSTED ANALYSIS HOOP STRAIN (UIN/IN)	%DIFF AXIAL	%DIFF HOOP
1	0.0	R680	R679	-845	3610	288	3103	-134.0	-14.0
	90.0	R740	R739	688	3506	740	3463	7.6	-1.2
	188.0	R720	R719	1148	3666	-142	3777	-112.4	3.0
	270.0	R686	R685	726	3550	747	3459	2.8	-2.6
			AVERAGE:	429	3583				

TABLE 17
QM-8 AFT-TO-CENTER SEGMENT (STATION 1466.00) CASE LINE LOAD MOMENT BIAXIALS (Zero to 120 seconds)

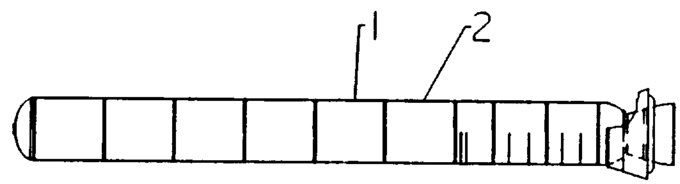
TEST NAME: QM-8
JOINT: AFT/CTR SEGMENT (STATION 1466.00)
DESCRIPTION: CASE LINE LOAD/ MOMENT BIAXIALS
THE TIME RANGE IS 0.0 TO 120.0 SECONDS



LOCAT	ANGULAR LOCATION	AXIAL GAGE	HOOP GAGE	TEST DATA AXIAL STRAIN (UIN/IN)	TEST DATA HOOP STRAIN (UIN/IN)	ADJUSTED ANALYSIS AXIAL STRAIN (UIN/IN)	ADJUSTED ANALYSIS HOOP STRAIN (UIN/IN)	%DIFF AXIAL	%DIFF HOOP
2	0.0	R780	R779	-896	4193	298	3075	-133.3	-26.7
	90.0	R782	R781	682	4126	715	3404	4.8	-17.5
	188.0	R788	R787	983	3497	-145	3688	-114.8	5.5
	270.0	R786	R785	781	4197	712	3404	-8.9	-18.9
			AVERAGE:	387	4003				

TABLE 18
QM-8 AFT-TO-CENTER SEGMENT (STATION 1196.48) CASE LINE LOAD MOMENT BIAXIALS, MAXIMUM HOOP STRESS (Zero to 120 seconds)

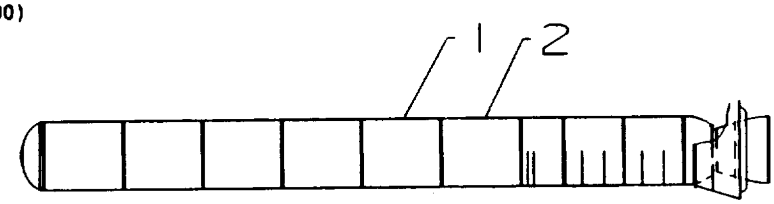
TEST NAME: QM-8
JOINT: AFT/CTR SEGMENT (STATION 1196.48)
DESCRIPTION: CASE LINE LOAD/ MOMENT BIAXIALS
THE TIME RANGE IS 0.0 TO 120.0 SECONDS



LOCAT	ANGULAR LOCATION	HOOP GAGE	AXIAL GAGE	MAX HOOP STRESS (KSI)	AXIAL STRESS (KSI)	TEST DATA HOOP STRAIN (UIN/IN)	TEST DATA AXIAL STRAIN (UIN/IN)	MAX AXIAL STRESS (KSI)	HOOP STRESS (KSI)	TEST DATA AXIAL STRAIN (UIN/IN)	TEST DATA HOOP STRAIN (UIN/IN)
1	0.0	R679	R680	122.7	49.4	3610	342	55.1	112.9	640	3220
	90.0	R739	R740	121.1	54.1	3506	520	55.6	110.0	688	3116
	188.0	R719	R720	127.8	60.8	3661	671	60.9	98.5	991	2671
	270.0	R685	R686	122.9	55.5	3550	548	57.8	113.4	726	3207
			AVERAGE:	123.6	54.9	3582	520	57.3	108.7	761	3053

TABLE 19
QM-8 AFT-TO-CENTER SEGMENT (STATION 1466.00) CASE LINE LOAD MOMENT BIAXIALS, MAXIMUM HOOP STRESS (Zero to 120 seconds)

TEST NAME: QM-8
JOINT: AFT/CTR SEGMENT (STATION 1466.00)
DESCRIPTION: CASE LINE LOAD/ MOMENT BIAXIALS
THE TIME RANGE IS 0.0 TO 120.0 SECONDS



LOCAT	ANGULAR LOCATION	HOOP GAGE	AXIAL GAGE	MAX HOOP STRESS (KSI)	AXIAL STRESS (KSI)	TEST DATA HOOP STRAIN (UIN/IN)	TEST DATA AXIAL STRAIN (UIN/IN)	MAX AXIAL STRESS (KSI)	HOOP STRESS (KSI)	TEST DATA AXIAL STRAIN (UIN/IN)	TEST DATA HOOP STRAIN (UIN/IN)
2	0.0	R779	R780	143.1	59.3	4193	456	61.1	139.9	554	4064
	90.0	R781	R782	142.2	62.7	4126	580	63.8	140.8	634	4067
	188.0	R787	R788	122.1	58.0	3497	641	58.2	122.0	647	3491
	270.0	R785	R786	145.1	65.2	4197	634	65.3	145.0	640	4192
			AVERAGE:	138.1	61.3	4003	578	62.1	136.9	618	3954

4.5.2 Aft Field-to-ET Attach Joint

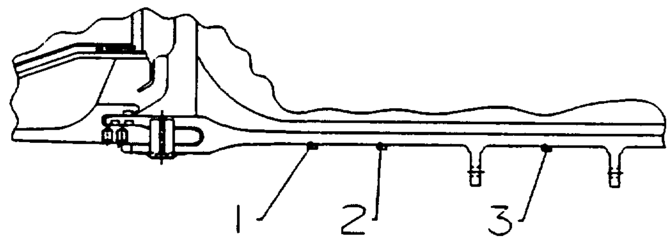
QM-8 biaxial gage instrumentation on the aft field-to-ET attach joint consisted of 54 gages on the aft field joint and ET attach areas. Tables 20 through 22 list the maximum hoop and axial strains measured from biaxial gages for the zero to 120 second burn time. Tables 23 through 25 list the maximum hoop and axial stresses for this same time frame. The biaxial strain gages at Locations 1, 2, and 3 are at Stations 1498, 1501, and 1511, respectively.

The maximum measured stress occurred at Station 1498.0, Location 1 in the hoop direction at 188 degrees, measuring a local stress of 109.8 ksi. This maximum measured stress results in a 1.95 safety factor. The yield strength of D6AC is 180 ksi, therefore, no local yielding was measured in this area. A few select axial gages (R650, R714, R668, R674, R676, R716, R678, S1182, and S1188) indicate that maximum axial stress is highly affected by the induced strut loads.

Because of the complex nature of this area, no comparison to predictions is given in this report. A detailed comparison is given in TWR-19506 (see Reference 3).

TABLE 20
QM-8 AFT FIELD-TO-ET ATTACH (STATION 1498.00) JOINT BIAXIAL GAGES (Zero to 120 seconds)

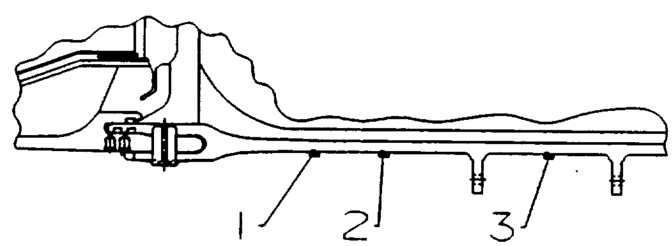
TEST NAME: QM-8
JOINT: AFT FIELD / ET ATTACH (STATION 1498.00)
DESCRIPTION: JOINT BIAXIAL GAGES
THE TIME RANGE IS 0.0 TO 120.0 SECONDS



				TEST DATA	
LOCAT	ANGULAR LOCATION	AXIAL GAGE	HOOP GAGE	AXIAL STRAIN (UIN/IN)	HOOP STRAIN (UIN/IN)
1	0.0	R644	R643	1634	2413
	90.0	R744	R743	1836	2432
	188.0	R726	R725	2420	2556
	220.0	R650	R649	2232	2460
	255.0	R656	R655	2068	2424
	270.0	R654	R653	1854	2460
	285.0	R658	R657	2021	2400
	300.0	R714	R713	1979	2389
	320.0	R660	R659	1896	2342
			AVERAGE:	1993	2431

TABLE 21
QM-8 AFT FIELD-TO-ET ATTACH (STATION 1501.00) JOINT BIAXIAL GAGES (Zero to 120 seconds)

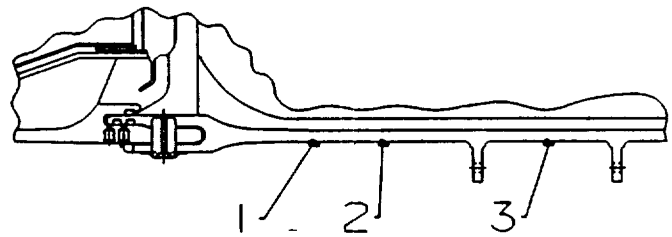
TEST NAME: QM-8
JOINT: AFT FIELD / ET ATTACH (STATION 1501.00)
DESCRIPTION: JOINT BIAXIAL GAGES
THE TIME RANGE IS 0.0 TO 120.0 SECONDS



				TEST DATA	
LOCAT	ANGULAR LOCATION	AXIAL GAGE	HOOP GAGE	AXIAL STRAIN (UIN/IN)	HOOP STRAIN (UIN/IN)
2	0.0	R662	R661	597	2108
	90.0	R746	R745	539	2281
	188.0	R728	R727	744	2262
	220.0	R668	R667	863	2193
	255.0	R674	R673	714	2170
	270.0	R672	R671	671	2248
	285.0	R676	R675	754	2138
	300.0	R716	R715	735	2192
	320.0	R678	R677	790	2101
			AVERAGE:	712	2188

TABLE 22
QM-8 AFT FIELD-TO-ET ATTACH (STATION 1511.00)
JOINT BIAXIAL GAGES (Zero to 120 seconds)

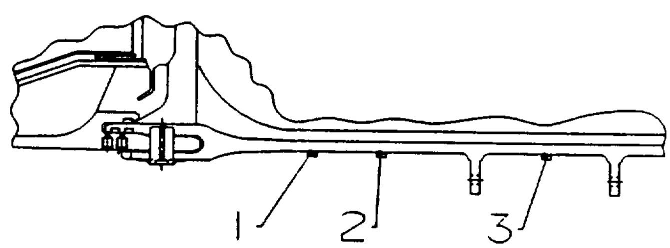
TEST NAME: QM-8
JOINT: AFT FIELD / ET ATTACH (STATION 1511.00)
DESCRIPTION: JOINT BIAXIAL GAGES
THE TIME RANGE IS 0.0 TO 120.0 SECONDS



LOCAT	ANGULAR LOCATION	AXIAL GAGE	HOOP GAGE	TEST DATA AXIAL STRAIN (UIN/IN)	TEST DATA HOOP STRAIN (UIN/IN)
3	0.0	S1176	S1175	997	2060
	90.0	S1178	S1177	940	2276
	188.0	S1180	S1179	1237	2062
	220.0	S1182	S1181	1327	2049
	255.0	S1188	S1187	1112	2095
	270.0	S1186	S1185	1019	2076
	285.0	S1190	S1189	1098	1981
	300.0	S1184	S1183	1127	2106
	320.0	S1192	S1191	1084	2083
			AVERAGE:	896	2087

TABLE 23
QM-8 AFT FIELD-TO-ET ATTACH (STATION 1498.00)
JOINT BIAXIAL GAGES MAXIMUM HOOP STRESS (Zero to 120 seconds)

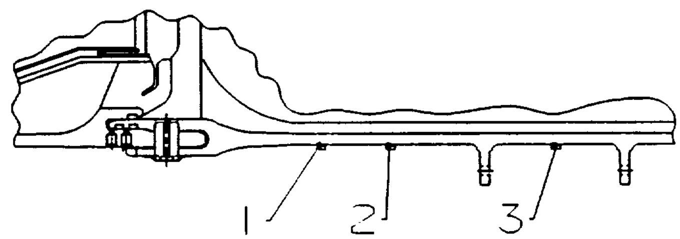
TEST NAME: QM-8
JOINT: AFT FIELD / ET ATTACH (STATION 1498.00)
DESCRIPTION: JOINT BIAXIAL GAGES
THE TIME RANGE IS 0.0 TO 120.0 SECONDS



LOCAT	ANGULAR LOCATION	HOOP GAGE	AXIAL GAGE	MAX HOOP STRESS (KSI)	AXIAL STRESS (KSI)	TEST DATA HOOP STRAIN (UIN/IN)	TEST DATA AXIAL STRAIN (UIN/IN)	MAX AXIAL STRESS (KSI)	HOOP STRESS (KSI)	TEST DATA AXIAL STRAIN (UIN/IN)	TEST DATA HOOP STRAIN (UIN/IN)
1	0.0	R643	R644	96.3	77.5	2413	1579	78.8	95.2	1634	2364
	90.0	R743	R744	99.1	85.7	2421	1825	86.0	98.9	1836	2410
	188.0	R725	R726	109.8	106.8	2556	2420	106.8	109.8	2420	2556
	220.0	R649	R650	101.3	88.9	2460	1909	93.3	85.0	2232	1864
	270.0	R653	R654	100.6	86.7	2460	1843	87.0	100.5	1854	2454
	255.0	R655	R656	101.7	93.8	2424	2068	93.8	101.7	2068	2424
	285.0	R657	R658	100.1	90.3	2400	1971	90.5	99.8	1977	2395
	300.0	R713	R714	98.9	88.1	2389	1908	88.6	97.8	1935	2345
	320.0	R659	R660	96.1	83.6	2342	1785	84.8	89.7	1896	2114
			AVERAGE:	100.4	89.1	2429	1923	89.9	97.6	1983	2325

TABLE 24
QM-8 AFT FIELD-TO-ET ATTACH (STATION 1501.00)
JOINT BIAXIAL GAGES MAXIMUM HOOP STRESS (Zero to 120 seconds)

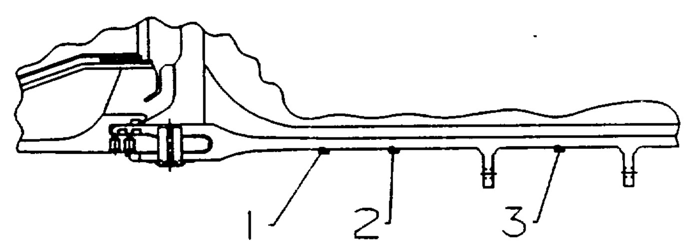
TEST NAME: QM-8
JOINT: AFT FIELD / ET ATTACH (STATION 1501.00)
DESCRIPTION: JOINT BIAXIAL GAGES
THE TIME RANGE IS 0.0 TO 120.0 SECONDS



LOCAT	ANGULAR LOCATION	HOOP GAGE	AXIAL GAGE	MAX HOOP STRESS (KSI)	AXIAL STRESS (KSI)	TEST DATA HOOP STRAIN (UIN/IN)	TEST DATA AXIAL STRAIN (UIN/IN)	MAX AXIAL STRESS (KSI)	HOOP STRESS (KSI)	TEST DATA AXIAL STRAIN (UIN/IN)	TEST DATA HOOP STRAIN (UIN/IN)
2	0.0	R661	R662	75.1	39.8	2108	532	40.6	73.6	576	2049
	90.0	R745	R746	80.6	40.8	2281	506	41.5	79.9	539	2249
	188.0	R727	R728	81.8	46.4	2262	684	46.5	81.5	689	2252
	220.0	R667	R668	77.7	39.8	2193	507	45.6	62.7	863	1624
	270.0	R671	R672	80.8	44.4	2248	627	44.4	80.8	627	2248
	255.0	R673	R674	78.9	45.6	2170	689	45.6	78.9	689	2170
	285.0	R675	R676	77.7	45.1	2138	683	45.2	76.4	699	2095
	300.0	R715	R716	79.1	44.5	2192	648	45.0	72.8	735	1972
	320.0	R677	R678	76.1	43.4	2101	643	46.8	73.0	790	1961
			AVERAGE:	78.6	43.3	2188	613	44.6	75.5	690	2069

TABLE 25
QM-8 AFT FIELD-TO-ET ATTACH (STATION 1511.00)
JOINT BIAXIAL GAGES MAXIMUM HOOP STRESS (Zero to 120 seconds)

TEST NAME: QM-8
JOINT: AFT FIELD / ET ATTACH (STATION 1511.00)
DESCRIPTION: JOINT BIAXIAL GAGES
THE TIME RANGE IS 0.0 TO 120.0 SECONDS



LOCAT	ANGULAR LOCATION	HOOP GAGE	AXIAL GAGE	MAX HOOP STRESS (KSI)	AXIAL STRESS (KSI)	TEST DATA HOOP STRAIN (UIN/IN)	TEST DATA AXIAL STRAIN (UIN/IN)	MAX AXIAL STRESS (KSI)	HOOP STRESS (KSI)	TEST DATA AXIAL STRAIN (UIN/IN)	TEST DATA HOOP STRAIN (UIN/IN)
3	0.0	S1175	S1176	77.9	53.0	2060	948	53.8	76.9	986	2017
	90.0	S1177	S1178	65.6	-5.6	2276	-897	-9.0	57.3	-924	2034
	188.0	S1179	S1180	81.0	62.4	2062	1232	62.4	81.0	1232	2062
	220.0	S1181	S1182	78.7	56.5	2049	1059	58.2	59.1	1327	1368
	300.0	S1183	S1184	80.7	57.2	2106	1062	57.6	79.7	1083	2069
	270.0	S1185	S1186	78.8	54.3	2076	981	54.3	78.8	981	2076
	255.0	S1187	S1188	80.6	58.0	2095	1090	58.0	80.6	1090	2095
	285.0	S1189	S1190	76.4	55.5	1981	1049	55.5	75.0	1066	1932
	320.0	S1191	S1192	79.2	54.9	2083	997	55.8	74.1	1084	1900
			AVERAGE:	77.7	49.6	2087	836	49.6	73.6	881	1950

4.6 Nozzle-to-Case Joint Performance

4.6.1 Nozzle-to-Case Joint

QM-8 instrumentation on the nozzle-to-case joint consisted of seven girth gages, three biaxial gage locations, and eight strainserted axial and radial bolts. Test results at these locations are compared to analytical results acquired from a three dimensional finite element analysis (see Reference 15).

The analysis was performed with the finite element code ANSYS using a 1.8 degree model of the nozzle-to-case joint. Near the joint region, the model was three-dimensional, transitioning into two-dimensional away from the joint.

The following assumptions and parameters were included in the model:

- Nominal values for material properties and hardware dimensions
- Preload of 140 kips in the axial bolts and 47 kips in the radial bolts
- Internal pressure of 909 psig applied to the backside of the primary O-ring groove
- Frictionless joint behavior
- Zero vectoring nozzle condition
- Propellant was not modeled

Because the model is cyclic-symmetric, any circumferential variation indicated by test data will not be taken into account. The analysis was performed at 909 psig, which was linearly scaled to the estimated 792 psig nozzle stagnation pressure that involves approximately five percent error caused by the nonlinear analysis. The estimated pressure corresponds to the maximum strain gage readings at the time interval of 20 seconds after ignition.

4.6.2 Nozzle-to-Case Girth Gages

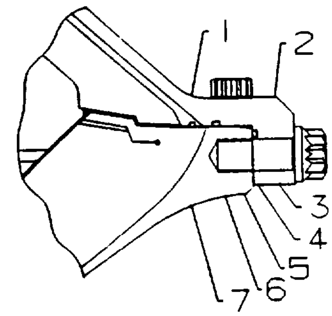
Radial deflection is an important parameter to characterize, since it is proportional to joint hoop stress and bolt hole stress concentration. Table 26 shows the girth gage response from 18 to 22 seconds. This time frame was selected to minimize the effects of vectoring. The results compare closely to the analytical results, ranging from 10.5 to 19.6 percent. Also included in the table is the maximum radial growth for the full duration of the test (zero to 120 seconds).

As expected, calculated radial growths indicated a "prying open" action and outward rotation of the joint. The maximum measured hoop strain (1778 in./in.) and radial growth (0.097 in.) occurred at Location 3.

Comparing QM-8 strain versus time plots to QM-6, it can be concluded that the strut loads had little effect on strain at this location (also see Table 27).

TABLE 26
QM-8 AFT DOME, FIXED HOUSING NOZZLE-TO-CASE JOINT
GIRTH GAGES (18 to 22 seconds)

TEST NAME: QM-8
JOINT: AFT DOME, FIXED HOUSING
DESCRIPTION: NOZZLE CASE GIRTH GAGES
THE TIME RANGE IS 18.0 TO 22.0 SECONDS



GIRTH GAGE LOCATION	GAGE NUMBER	STATION	RADIUS (IN)	RADIAL GROWTH (IN)	TEST STRAIN (UIN/IN)	ADJUSTED ANALYSIS STRAIN (UIN/IN)	ADJUSTED ANALYSIS RADIAL GROWTH (IN)	DIFF IN RADIAL GROWTH (% DIFF)	MAXIMUM RADIAL GROWTH 0-120 SECONDS
1	S880	1873.0	50.4	0.081	1598	1431	0.072	-10.5	0.087
2	S878	1876.3	50.5	ND	ND	ND	ND	ND	ND
3	S877	1876.3	54.4	0.097	1778	2126	0.116	19.6	0.126
4	S884	1875.7	54.4	0.092	1689	1999	0.109	18.4	0.120
5	S887	1874.9	54.8	0.083	1520	1784	0.098	18.1	0.110
6	S875	1874.2	54.8	0.076	1394	1622	0.089	16.4	0.100
7	S874	1872.5	55.2	0.066	1193	1345	0.074	12.7	0.105

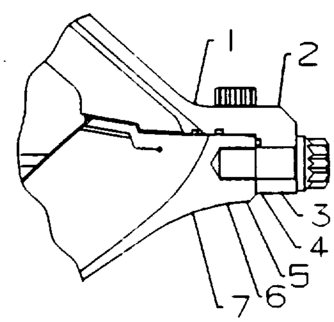
4.6.3 Nozzle-to-Case Joint Comparison

Table 27 and Figure 14 compare the radial growth of the QM-8 nozzle-to-case joint with the same joint configuration (radial bolt design) used in 360L001, 360L002, PV-1, QM-7, QM-6, DM-9, DM-8, and analysis. Data from QM-8 radial growth compares closely to the other motors which again confirm the minimal effect strut loads have on this joint as far as gap growth is concerned. Since the O-ring sealing surface gap growth was not directly measured, it is assumed the growth is similar to that measured from NJES-2A, NJES-2B, and TPTA-1.1 testing, and predicted by analysis.

Table 12 above lists the maximum measured O-ring gap openings, the flaw to the joint, and the test pressure for NJES-2A, NJES-2B, and TPTA-1.1. For QM-8, the maximum nozzle-to-case joint pressure did not exceed any maximum NJES and TPTA test pressures listed in Table 12 for the respective joints. The maximum measured gap opening for the nozzle-to-case joint was 0.007 inch (primary NJES-2A). Analysis predicts 0.006 inch for the primary O-ring.

TABLE 27

NOZZLE-TO-CASE JOINT RADIAL GROWTH COMPARISONS TO QM-8



Nozzle to Case Girths

AVERAGE JOINT PRESSURE AT MAX STRAIN = 793

		STRAIN		STS-27		STS-26				RADIAL GROWTH (Inches)			
LOC.	GAGE	QM-8	QM-8	RIGHT	LEFT	RIGHT	LEFT	PV-1	QM-7	QM-6	DM-9	DM-8	PRED
1	S880	1193	0.066	0.059	0.060	ND	0.051	0.086	0.067	0.080	0.072	ND	0.071
2	S878	ND	ND	0.097	0.096	0.096	0.096	0.127	0.127	0.129	0.115	ND	0.117
3	S877	1778	0.097	ND	ND	ND	ND	0.117	0.125	0.125	ND	0.124	0.114
4	S884	1689	0.092	0.091	0.090	0.100	0.100	0.124	0.120	0.118	0.114	ND	0.107
5	S887	1520	0.083	0.083	0.081	ND	ND	0.107	0.108	0.106	0.086	0.110	0.096
6	S875	1394	0.076	ND	ND	0.090	0.087	0.100	0.100	0.102	0.101	0.103	0.087
7	S874	1598	0.081	0.065	0.063	0.072	0.069	0.083	0.086	0.085	0.085	0.090	0.073

Note: All Test Radial Growths Are Ratios of QM-8 Test Pressure

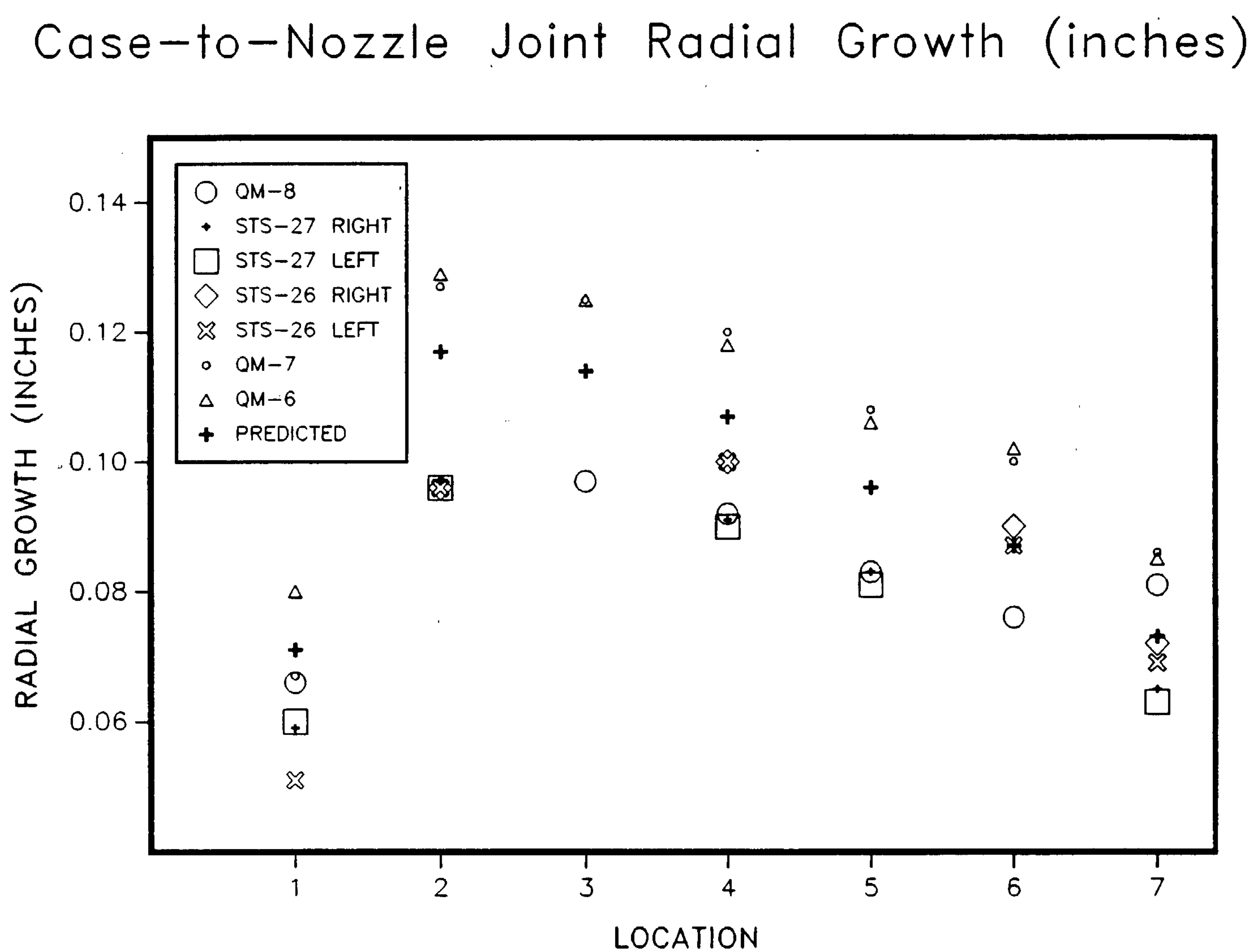


Figure 14 Case-to-Nozzle Joint Radial Growth Comparisons

4.6.4 Nozzle-to-Case Biaxial Strain Gages

Previous static tests have shown the nozzle-to-case joint biaxial gages do not compare as closely to analytical data as gages on other parts of the motor. The reason for the variation is:

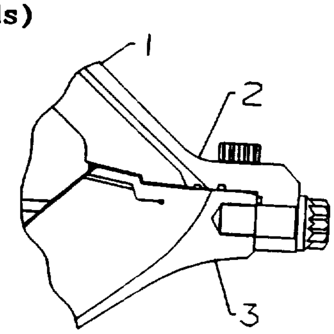
- o The girth gage at Location 1 is at the neck of the fixed housing; the 3-D model grid may not be fine enough to accurately predict circumferential strain.
- o Analytical data was linearly scaled to test data.
- o Nozzle stagnation pressure was estimated to be 792 psig, but not measured.
- o Nominal materials were used for the finite element model.
- o A slight variation in gage placement can greatly alter the expected results.

Two biaxial strain gages were placed on the fixed housing and one on the aft dome. Table 28 contains the test results for the burn time of zero to 120 seconds. Table 29 compares the test results between 18 and 22 seconds to analytical results to eliminate effects of nozzle vectoring. As previously mentioned, the analysis was cyclic-symmetric, which means analytical results will be identical at 90 degree increments about the circumference.

As shown in Table 29, hoop strain correlated better for the gage Locations 1 and 3 than gage Locations 2. Gage readings at Locations 1 and 3 ranged from 2.5 to 33.3 percent difference with the predictions. Gages readings at Location 2 ranged from 18.8 to 41.0 percent difference. Meridional strains at the three locations also varied, with the most favorable correlation at Location 1 (range of 2.5 to 9.3 percent difference) and the least favorable at Location 2 (range of 18.8 to 41.0 percent difference).

Stresses were calculated from the biaxial strains (see Table 28). The maximum calculated hoop stress was 41.2 ksi, and occurred at Location 3, 270 degrees. The maximum calculated meridional stress was -32.9 ksi, and occurred at Location 2, zero degrees. Based on the maximum calculated stress of 41.2 ksi and an ultimate material strength of 200 ksi, the safety factor is 4.85.

TABLE 28
QM-8 AFT DOME, FIXED HOUSING NOZZLE-TO-CASE JOINT
BIAXIAL GAGES (Zero to 120 seconds)

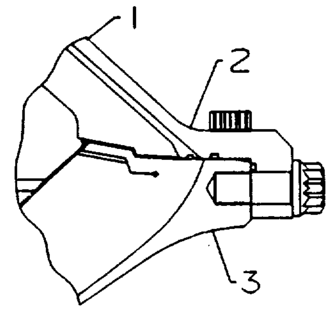


TEST NAME: QM-8
JOINT: FIXED HOUSING, AFT DOME
DESCRIPTION: NOZZLE / CASE BIAXIAL GAGES
THE TIME RANGE IS 0.0 TO 120.0 SECONDS

LOCAT	ANGULAR LOCATION	HOOP GAGE	MERID GAGE	MAX HOOP STRESS (KSI)	MERID STRESS (KSI)	TEST DATA HOOP STRAIN (UIN/IN)	TEST DATA MERID STRAIN (UIN/IN)	MAX MERID STRESS (KSI)	HOOP STRESS (KSI)	TEST DATA MERID STRAIN (UIN/IN)	TEST DATA HOOP STRAIN (UIN/IN)
1	0.0	R528	R527	-11.9	13.6	-550	589	14.3	-10.8	600	-520
	90.0	R530	R529	-14.9	9.9	-611	495	14.6	-3.0	526	-259
	180.0	R532	R531	-11.2	13.3	-521	572	14.5	-10.3	603	-505
	270.0	R534	R533	-8.6	11.5	-416	481	13.9	-6.7	540	-376
			AVERAGE:	-11.7	12.1	-525	534	14.3	-7.7	567	-415
2	0.0	R520	R519	28.5	-30.3	1290	-1331	-32.9	26.9	-1404	1265
	90.0	R522	R521	35.0	-17.0	1367	-952	-19.5	32.4	-1010	1306
	180.0	R524	R523	32.9	-20.0	1328	-1032	-22.4	31.5	-1098	1305
	270.0	R526	R525	29.2	-29.5	1306	-1312	-31.9	27.2	-1370	1263
			AVERAGE:	31.4	-24.2	1323	-1157	-26.7	29.5	-1220	1285
3	0.0	R602	R601	39.9	-16.5	1525	-989	-17.6	37.3	-999	1452
	90.0	R604	R603	40.6	-15.7	1542	-968	-17.2	34.5	-955	1353
	180.0	R606	R605	40.3	-16.2	1536	-981	-18.2	35.9	-1002	1410
	270.0	R608	R607	41.2	-15.6	1560	-971	-17.2	37.1	-981	1440
			AVERAGE:	40.5	-16.0	1541	-977	-17.5	36.2	-984	1414

TABLE 29
QM-8 AFT DOME, FIXED HOUSING NOZZLE-TO-CASE JOINT
BIAXIAL GAGES (18 to 22 seconds)

TEST NAME: QM-8
JOINT: FIXED HOUSING, AFT DOME
DESCRIPTION: NOZZLE / CASE BIAXIAL GAGES
THE TIME RANGE IS 18.0 TO 22.0 SECONDS



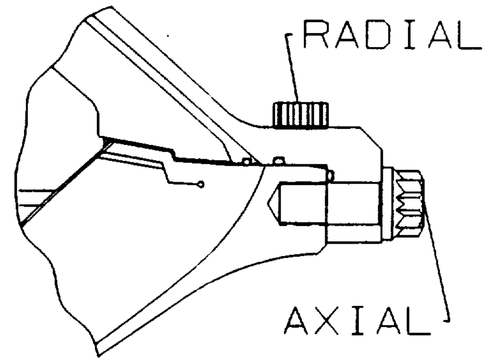
LOCAT	ANGULAR LOCATION	HOOP GAGE	MERID GAGE	TEST DATA HOOP STRAIN (UIN/IN)	TEST DATA MERID STRAIN (UIN/IN)	ADJUSTED ANALYSIS HOOP STRAIN (UIN/IN)	ADJUSTED ANALYSIS MERID STRAIN (UIN/IN)	%DIFF HOOP	%DIFF MERID
1	0.0	R528	R527	-513	551	-554	571	7.9	3.6
	90.0	R530	R529	-465	523	-554	571	19.1	9.3
	180.0	R532	R531	-482	558	-554	571	15.1	2.5
	270.0	R534	R533	-416	540	-555	570	33.3	5.5
			AVERAGE:	-469	543				
2	0.0	R520	R519	1276	-1404	1036	-829	-18.8	-41.0
	90.0	R522	R521	1356	-1021	1034	-828	-23.7	-18.9
	180.0	R524	R523	1309	-1098	1036	-829	-20.9	-24.5
	270.0	R526	R525	1288	-1370	1037	-829	-19.5	-39.5
			AVERAGE:	1307	-1223				
3	0.0	R602	R601	1525	-1006	1649	-848	8.1	-15.8
	90.0	R604	R603	1542	-989	1651	-848	7.1	-14.2
	180.0	R606	R605	1529	-1002	1650	-850	7.9	-15.2
	270.0	R608	R607	1540	-985	1653	-849	7.4	-13.8
			AVERAGE:	1534	-996				

4.6.5 Nozzle-to-Case Strainsert Gages

The Strainserts for QM-8 were added to eight radial and eight axial bolts. As Table 30 shows, the Strainserts at preload ranged from 40 to 54.9 kips for the radial bolts, and 122.6 to 139.2 kips for the axial bolts. The specification tolerances for QM-8 were 45.0, ± 4.5 kips for the radial bolts and 140.0, ± 14.0 kips for the axial bolts.

TABLE 30
QM-8 AFT DOME, FIXED HOUSING (STRAINSERT)
RADIAL STATION 1874.3, AXIAL STATION 1875.2 (Zero to 120 seconds)

TEST NAME: QM-8
JOINT: FIXED HOUSING, AFT DOME (STRAINSERT)
DESCRIPTION: RADIAL - STA 1874.3, AXIAL - STA 1875.2
THE TIME RANGE IS 0.0 TO 120.0 SECONDS



					0-1 SEC.		12-22 SEC.		120-130 SEC.			@920 PSIG
LOCAT	GAGE	ANGULAR LOCATION	PRELOAD STRESS (KSI)	PRELOAD LOAD (KIPS)	MEAS. STRESS (KSI)	MEAS. LOAD (KIPS)	MEAS. STRESS (KIPS)	MEAS. LOAD (KIPS)	MEAS. STRESS (KIPS)	MEAS. LOAD (KIPS)	ANAL. PRELOAD (KIPS)	ANAL. LOAD (KIPS)
RADIAL	R150	358.2	78.6	40.0	75.2	38.3	75.6	38.5	77.0	39.2	46	44
RADIAL	R151	45.0	85.4	43.5	80.9	41.2	80.7	41.1	84.4	42.9	46	44
RADIAL	R152	88.2	81.2	41.3	75.3	38.4	75.9	38.6	80.3	40.9	46	44
RADIAL	R153	135.0	81.9	41.7	76.9	39.1	76.2	38.8	80.0	40.7	46	44
RADIAL	R154	178.2	80.9	41.2	72.8	37.0	75.2	38.3	82.0	41.7	46	44
RADIAL	R155	225.0	80.4	40.9	73.6	37.5	75.2	38.3	80.0	40.7	46	44
RADIAL	R156	268.2	81.0	41.2	72.7	37.0	73.6	37.4	80.8	41.1	46	44
RADIAL	R157	315.0	107.7	54.9	98.7	50.2	98.1	49.9	107.8	54.9	46	44
AXIAL	S397	0.0	98.7	129.7	90.7	119.2	91.1	119.8	100.1	131.7	140.0	130.9
AXIAL	S401	46.8	96.6	127.0	89.6	117.8	89.0	117.0	96.1	126.4	140.0	130.9
AXIAL	S398	90.0	94.6	124.4	88.2	115.9	87.4	114.9	94.1	123.8	140.0	130.9
AXIAL	S399	180.0	94.2	123.9	87.2	114.6	87.1	114.6	94.5	124.3	140.0	130.9
AXIAL	S400	270.0	94.6	124.4	87.5	115.1	87.1	114.6	94.4	124.1	140.0	130.9
AXIAL	S402	136.8	93.2	122.6	86.3	113.6	86.5	113.7	94.2	123.9	140.0	130.9
AXIAL	S403	226.8	98.1	129.1	91.7	120.6	91.5	120.3	97.2	127.8	140.0	130.9
AXIAL	S404	316.8	105.8	139.2	99.6	131.0	99.0	130.2	104.9	138.0	140.0	130.9

4.6.5.1 Axial Bolts

Eight axial bolts were replaced with Strainsert bolts (see Table 30) to measure a tension load in the bolts. Therefore, the change in bolt load resulting from motor pressurization was monitored during the firing. All showed a bolt load decrease in the range of 8.2 to 10.5 kips from zero to 1 second, 8.8 to 10.0 kips from 12 to 22 seconds, and -2.0 (positive load recovery) to 1.3 kips from 120 to 130 seconds.

An analysis was performed using a preload value of 140 kips in the axial bolts. The analysis predicts a load decrease of 9.1 kips at 920 psig. The bolt load drops off because of thinning of the fixed housing flange. The flange thinning is attributable to Poisson's effect resulting from the flange displacing radially outward. The results correlate closely with actual measured data.

4.6.5.2 Radial Bolts

The radial bolts were a primary concern of the QM-8 (see Table 30) nozzle-to-case joint because the amount of preload in these bolts governs the amount of delta gap opening of the joint. Delta gap controls the amount of dynamic O-ring squeeze and consequently, the sealing of the joint.

Strainserts were added to eight radial bolts. Table 30 indicates the radial Strainsert bolts decreased in load during pressurization. The load decreased in a range between 1.7 to 4.7 kips from zero to one second, 1.5 to 5.0 kips from 12 to 22 seconds, and -0.5 (positive load recovery) to 0.8 kips from 120 to 130 seconds. The analysis, using a preload value of 46 kips, predicted the radial bolt loads would decrease by 2 kips at 920 psig. This correlates closely with actual measured data.

4.7 Head End Pressure and Joint Temperature

Table 31 lists the maximum measured head end pressures and the time at which they occurred. Table 32 gives the joint heater temperatures for the field and nozzle-to-case joints immediately prior to static test.

TABLE 31
QM-8 FORWARD DOME CHAMBER PRESSURE (ZERO TO 120 SECONDS)

GAGE NUMBER	CIRCUMFERENTIAL LOCATION (DEG)	MAXIMUM PRESSURE (PSIA)	TIME OF MAX PRES (SEC)
P001	40.0	863.7	0.664
P002	270.0	872.6	0.656
P003	180.0	871.7	0.656

TABLE 32
QM-8 FORWARD, CENTER, AFT FIELD JOINTS AND NOZZLE-TO-CASE JOINT AND HEATER TEMPERATURES (-10.0 to Zero seconds)

TEMPERATURE LOCAT	GAGE NUMBER	CIRCUMFERENTIAL LOCATION (DEG)	MAXIMUM TEMPERATURE (DEG F)	TIME OF MAX TEMP (SEC)
FWD	T1001	15.0	90.4	-6.968
	T1002	135.0	85.1	-4.984
	T1003	195.0	101.1	-9.784
	T1004	285.0	92.2	-7.576
CTR	T1005	15.0	86.2	-2.840
	T1006	135.0	84.9	-4.280
	T1007	195.0	97.7	-6.680
	T1008	285.0	105.7	-9.848
AFT	T1009	15.0	92.0	-4.248
	T1010	135.0	87.4	-3.736
	T1011	195.0	101.7	-8.984
	T1012	285.0	106.7	-9.768
NOZ	T0807	0.0	82.0	0.0
	T0808	120.0	78.5	0.0
	T0809	240.0	85.0	0.0

4.8 Axial Growth Deflections

Several long wire gages were installed along the length of the motor (see Figure 15), and across joints to measure the axial growth experienced in different areas of the motor during pressurization. Table 33 shows the maximum deflection experienced by each gage for the duration of the test. Locations 5, 7, and 8 are all across joints, and all show a negative deflection. Evaluation of the placement of these gage locations which experienced negative values supports that these values are in error. In other words, the instrument measured a negative value but the joint did not go negative. The measurement was that of of instrument, and not the joint. The aft field joint does not show a negative value because it has a higher stiffness due to the stiffener rings and struts.

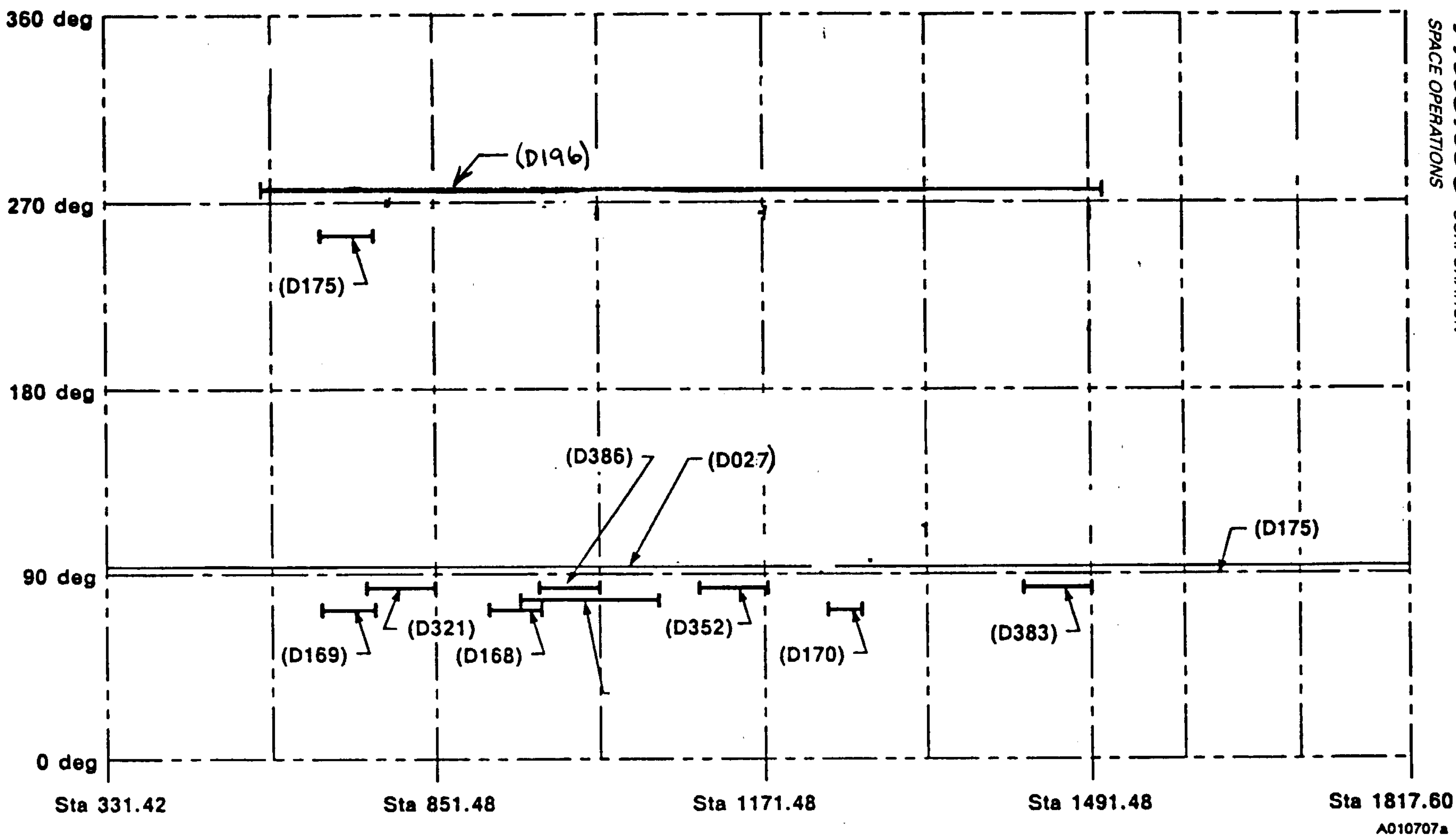
The largest measured axial growth was 1.002 inches and occurred between stations 527.0 and 1505.0 (270 degrees).

It is interesting to note that on the other side of the motor (90 degrees) between stations 527.0 and 1829.0, the measured axial growth was 0.406 inch. The maximums for both of these gages occurred during the ignition transient. Since the struts are located on the 270 degree side of the case, they had some influence in causing this difference between the two sides of the motor.

TABLE 33
QM-8 Axial Growth Deflections (Zero to 120 seconds)

TEST NAME: QM-8
DESCRIPTION: AXIAL GROWTH DEFLECTIONS
THE TIME RANGE IS 0.0 TO 120.0 SECONDS

LOCAT	FROM STATION	TO STATION	GAGE NUMBER	ANGULAR LOCATION	DEFLECTION (IN)	ANALYSIS	DEFLECTION DIFFERENCE
1	527.0	1505.0	D196	270.0	1.002	ND	ND
2	527.0	1829.0	D027	92.0	0.406	ND	ND
3	756.0	786.0	D169	80.0	0.021	0.017	0.004
4	756.0	786.0	D175	260.0	0.016	0.017	0.001
5	850.0	850.0	D321	86.0	-0.018	ND	ND
6	916.0	946.0	D168	80.0	0.028	0.014	0.014
7	1010.0		D386	86.0	-0.004	0.004	0.008
8	1170.0		D352	86.0	-0.012	0.023	0.035
9	1236.0	1266.0	D170	80.0	0.028	0.013	0.015
10	1490.0		D383	82.0	0.006	0.021	0.015



Longwire Locations

Figure 15 QM-8 Longwire Locations

5.0 DISASSEMBLY INSPECTION RESULTS

Structural Applications Design Engineering performed a post-fire evaluation of the QM-8 external case, field joints, internal nozzle joints, nozzle-to-case joint, the igniter and safe and arm joints, and the factory joints. The case and seals post-fire condition will be discussed with references made to the inspection forms found in the Evaluation Plan (see Reference 16), and the engineering evaluation limits plan (see Reference 17).

Following the initial O-ring inspection at time of disassembly, the O-rings were inspected by a specifically organized team made up of personnel from Structural Applications, Liaison/Problem Reporting, and Quality Assurance. The team function was to inspect the O-rings for damage which may have occurred during the static-test, assembly, or disassembly; and damage which may have gone undetected during disassembly inspection. Records are kept on each O-ring and gasket so that the seals may be tracked for possible reuse.

The following guidelines have been established to classify O-ring, Stat-O-Seal and corrosion damage found from post-flight test inspections. These guidelines were established so that each inspection database will be consistent and not be confusing or misleading. Some of these definitions are used in this document.

O-RINGS AND STAT-O-SEALS

Cut:	Width, essentially zero (have to open up to find the damage), and depth greater than 0.005 inch.
Scratch:	Width less than 0.005 inch and depth less than 0.005 inch.
Nick:	Width less than 0.020 inch, but greater than 0.005 inch; and depth less than 0.010 inch, but greater than 0.005 inch.
Gouge:	Width greater than 0.020 inch and depth greater than 0.010 inch.
Circumferential or Radial Flowline:	Visible evidence of incomplete flow or knit of the material.
(i) Closed:	Tightly adhered, not separable, does not open when lightly probed.
(ii) Separable:	Visually appears closed. Separates when lightly probed.
(iii) Open:	Obvious separation or gap.
Hard Inclusion:	Foreign material enclosed in the seal material.
Porosity/Soft Inclusion:	An air pocket enclosed in the seal material.
Extrusion Damage:	Seal material pinched and/or cut due to an overfill condition.
Heat Effect:	Glossy and/or hardened seal surface due to hot gas impingement.
Erosion:	Seal material missing due to hot gas impingement or blow by.

CORROSION

Light Corrosion:	Can be wiped off by hand. Surface discoloration.
Medium Corrosion:	Cannot be wiped off by hand without the use of a Scotch-Brite material, methyl chloroform, or grease soaked rag.
Heavy Corrosion:	Starting to penetrate into the metal surface such that pitting and/or metal material is significantly eroded.

The following sections contain the details of each joint at disassembly and subsequent seals examination by the Inspection Team.

5.1 External Walk Around

The external inspection of the fully assembled hardware at T-97 was performed on 21 January 1989 (see pages A-1 through A-5, Appendix A). The inspection included the case acreage, all field and factory joints, the igniter, and nozzle-to-case joint. The stiffeners and ETA ring bolts were also inspected. No anomalous conditions were encountered.

5.2 Field Joint Disassemblies

The QM-8 field joint configuration is shown in Figure 2. Joint conditions were as expected; there was no field joint O-ring damage found by inspection at the time of disassembly. The V2 filler did not obstruct the leak vent ports at 135 degrees. No corrosion was found on any field joint. Detailed inspection results are documented below.

5.2.1 Forward Field Joint

The QM-8 forward field joint was disassembled on 8 February 1989 (see pages A-6 through A-10, Appendix A). The overall condition of the joint was excellent. No hot gas or soot was observed past the J-leg. There was no evidence of damage to the O-rings while in the grooves. Inspection of the O-rings by the O-ring Inspection Team revealed a 13.5 inch circumferential scratch running from 1.6 to 12.6 degrees (see page A-10, Appendix A). The depth of this scratch is indeterminable (very shallow). Scratches of this nature have been found on PV-1, Flight 360L001 and 360L002 O-rings. The cause is suspected to be from cleaning the O-rings before final inspection. No damage was found by the O-ring Inspection Team on the primary or secondary O-rings.

There was no corrosion found on either the tang or clevis. The grease condition was per STW7-2999 on the sealing and non sealing surfaces. The V2 volume filler was in a nominal condition. Metal pinhole slivers were found in the bottom of the inner clevis leg pinholes in the following locations: 52, 54, 58, 60, 62, 232, 282, 286, 288, 290, and 292 degrees. This is a common occurrence. No other metal damage was found in the joint.

A long thin line of white colored material was found on the aft edge of the capture feature O-ring at 169 degrees. More thin lines of the white colored material were found intermittently on the aft edge from 164 to 167 degrees. The long thin line at 169 degrees was approximately 0.400 inch long. All thin lines of the white colored material ran circumferential on the O-ring. Lab analysis of a sample of the material indicated that it was Teflon tape adhesive. Teflon tape is used to mask the J-leg insulation during grease application and O-ring installation processes.

Small thin lines of Teflon tape adhesive were also found on the capture feature metal-to-J-leg interface (aft of the capture feature groove on the tang J-leg) at 153, 178, 180, 227, 228, and from 230 to 233 degrees. All thin lines of Teflon tape adhesive ran circumferentially on the joint except for the lines at 178 degrees. On the clevis, Teflon tape adhesive was found on the top of the J-leg (near the inner clevis leg metal) at 138, 150, 152, 178, 180, and from 162 to 165, 167 to 170, 230 to 234, and 252 to 254 degrees. As on the tang, all Teflon tape adhesive ran circumferentially on the joint except for the lines at 178 degrees.

5.2.2 Center Field Joint

The QM-8 center field joint was disassembled on 7 February 1989 (see pages A-11 through A-14, Appendix A). The overall condition of the joint was excellent. No hot gas or soot was observed past the J-leg. There was no evidence of damage to the O-rings while in the grooves. Inspection of the

O-rings by the O-ring Inspection Team revealed a similar 13.5 inch circumferential scratch as on the forward field joint capture feature O-ring. This scratch is also located on the capture feature O-ring and ranges from 4.7 to 15.7 degrees (see Page A-14, Appendix A). A series of radial scratches measuring 0.150 inch long was found on the capture feature O-ring at 345.8 degrees. The depth of these scratches is approximately 0.001 inch. No damage was found by the O-ring Inspection Team on the primary or secondary O-rings.

There was no corrosion found on either the tang or clevis with the exception of what appeared to be a very light thin line of corrosion which crossed the landing between the O-ring grooves at 134 degrees. The grease on the O-rings was intermittently heavier than prescribed in STW7-2999. However, the grease was heavier on the aft side of the primary and secondary O-rings. It was determined this grease was wiped from the inner tang (pin hole region) during disassembly. The grease condition was per STW7-2999 on the sealing and nonsealing surfaces. The V2 filler was nominal. There was no joint metal damage observed. A metal pin hole sliver was found in the 268 degree pin hole. This is a common occurrence.

5.2.3 Aft Field Joint

The QM-8 aft field joint was disassembled on 4 February 1989 (see pages A-15 through A-17, Appendix A). The condition of the joint was excellent. No hot gas or soot was observed past the J-leg Insulation. There was no evidence of damage to the O-rings while in the grooves or found by the O-ring Inspection Team. There was no corrosion found on either the tang or clevis. The pin hole at 136 degrees had a small metal pin hole sliver in it, which fell on the aft face of the secondary O-ring during joint disassembly operations. Otherwise, no apparent metal damage was found during the inspection.

The grease on the O-rings and sealing areas was as prescribed in STW7-2999, except not enough grease covered the clevis root from 232 to 282 degrees. There was a small amount of foreign material which had fallen onto the joint during or after disassembly.

5.3 Nozzle-to-Case Joint

The QM-8 nozzle-to-case joint (see Figure 3) was disassembled on 13 February 1989 (see pages A-18 through A-22, Appendix A). The overall condition of the joint was excellent. No hot gas or soot was observed past the polysulfide. There was no corrosion or metal damage found.

No O-ring damage was found during the in-groove inspection. A heavy rub mark was found on the primary O-ring at 354.6 degrees. This occurred on disassembly because the radial bolt hole plug at 354.6 degrees was in the bottom of the bolt hole. A heavy impact mark was found on the top of the plug. The plug appeared to be in this condition before disassembly. Inspection of the O-rings by the O-ring Inspection Team revealed one scratch on the primary O-ring and one scratch, one cut, and one nick on the wiper O-ring (see pages A-20 and A-21, Appendix A). This damage was caused by disassembly; these are located within close proximity to radial bolt hole locations. Also, the charred surface of the nozzle was not covered with plastic prior to O-ring removal. No damage was found on the secondary O-ring by the O-ring Inspection Team.

Polysulfide migrated past the wiper O-ring through the vent slots around the entire circumference of the joint. The grease condition was per STW7-2999 on the O-rings and sealing surfaces.

Inspection of the radial bolt Stat-O-Seals revealed that 35 of 100 had unacceptable flow line conditions which should have been rejected by Receiving Inspection. Drawing No. 1U75374 defines the Stat-O-Seals to be inspected per MIL-STD-413, which allows circumferential flow lines no greater than 0.180 inch in length. No radial flow marks are allowed. Presently there is a Stat-O-Seal TRACS class and inspection test each inspector must pass to qualify to perform an inspection. This class was not in force at the time of the QM-8 Stat-O-Seal inspection.

5.4 <u>Igniter Joints</u>

Figures 16 and 17 illustrate the Igniter and S & A seals and components, respectively. Post-test inspections were performed on the ignition system gaskets. All gaskets (Inner, Outer, and Safe & Arm) performed with no signs of heat effect or sooting past the primary seals, and all sealing surfaces were free of soot.

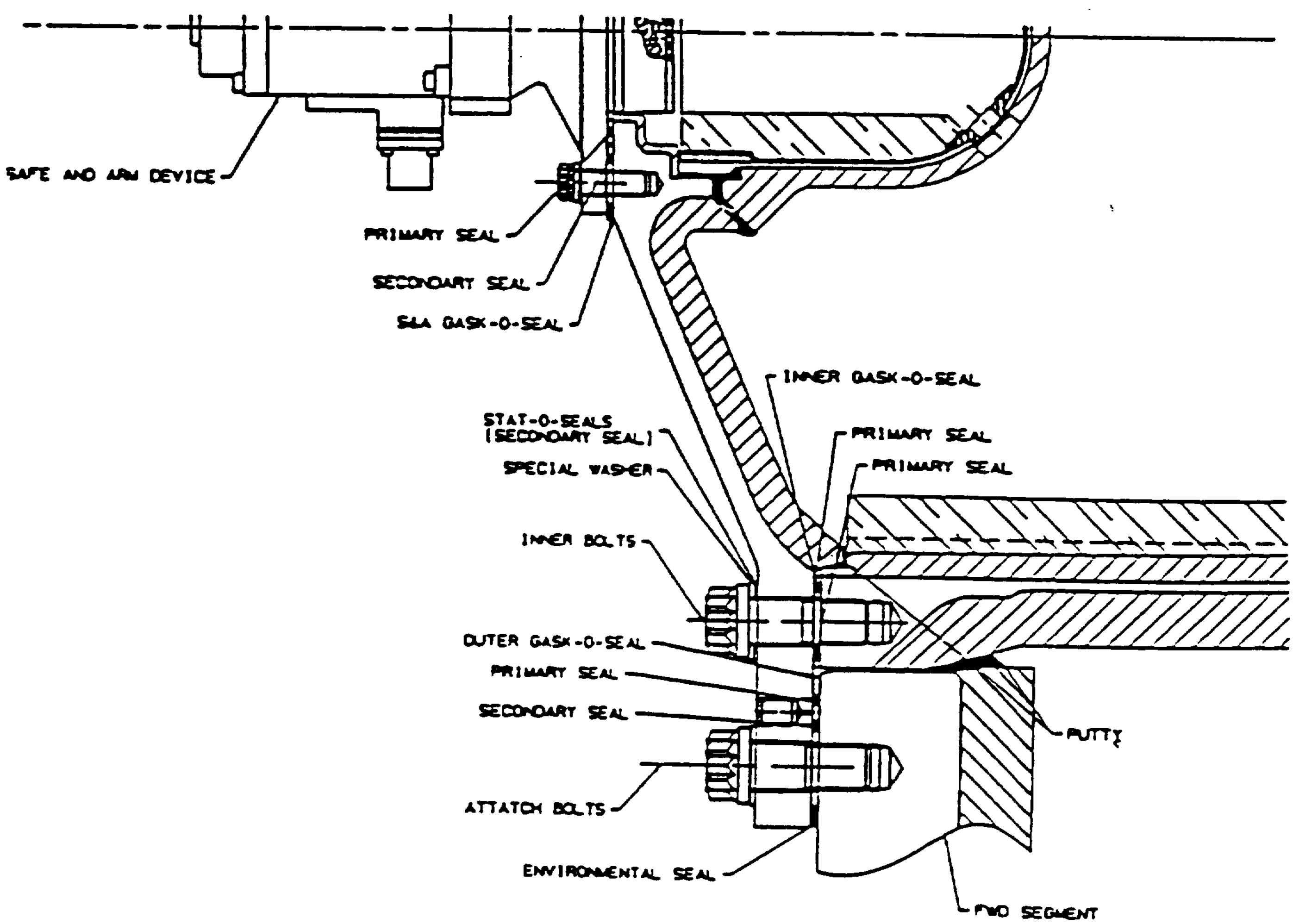


Figure 16 Ignition System Seals

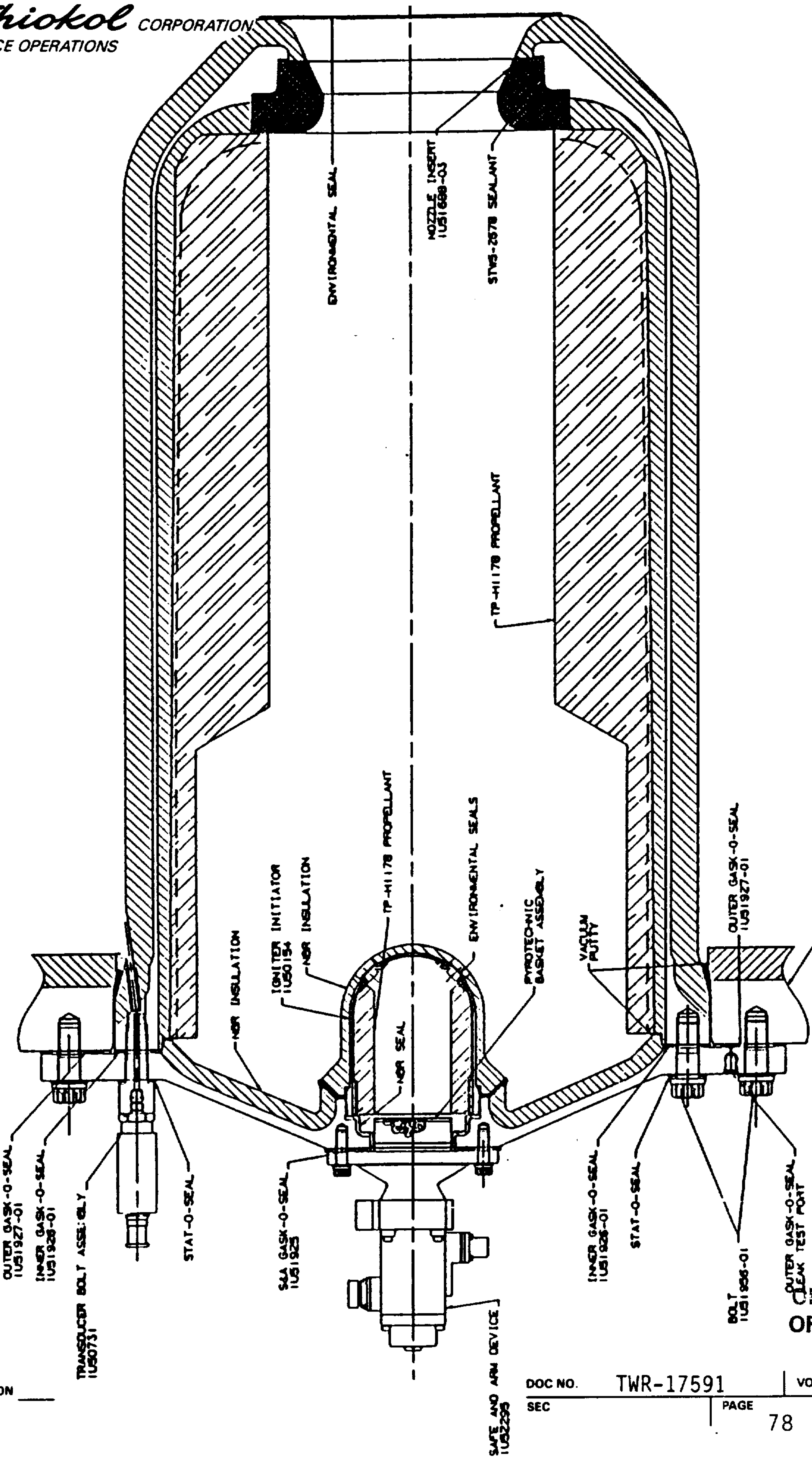


Figure 17 Igniter Cross Section

ORIGINAL PAGE IS
OF POOR QUALITY

5.4.1 Safe and Arm Joint

The post-fire evaluation of the QM-8 Safe and Arm-to-Igniter joint was conducted on 9 February 1989 (see pages A-23 through A-26, Appendix A). No evidence of hot gas or soot was observed past the primary seal. The S&A gasket and all sealing surfaces were visually inspected. No erosion or heat effects were observed. Soot was found around the circumference of the gasket retainer, inward of the primary seal, but not past. Detailed inspection at also showed the gasket to be in excellent condition with no seal damage observed. The sealing surfaces were in good condition with no evidence of contamination or corrosion. No corrosion or damage was found on the Barrier-Booster (S&A) or igniter adapter.

5.4.2 Outer Joint

The QM-8 igniter adapter-to-forward dome joint was disassembled on 1 March 1989 (see pages A-27 through A-29, Appendix A). A blowhole occurred through the igniter exterior putty at 15 degrees. No seal erosion or heat effects were observed. No soot was found to or past the primary seal. No soot was found on either side of the gasket retainer. Heavy soot deposits were found on the inside edge of the gasket, covering the entire circumference. No corrosion or joint contamination was found upon inspection of the sealing surfaces. Detailed inspection of the gasket by the O-ring Inspection Team revealed missing material in the outer void area and a nick on the inner bottom edge of the primary seal at 337 degrees (see page A-29, Appendix A). However, the nature of this damage suggested disassembly or handling after disassembly as the cause. Another nick was found on the crown of the secondary seal at 359 degrees (see page A-29, Appendix A). This nick is within the acceptable limits set forth by STW7-2790 (see Reference 18).

5.4.3 Inner Joint

The QM-8 adapter-to-chamber joint was disassembled on 5 May 1989 (see pages A-30 through A-32, Appendix A). No soot was found on either side (top and bottom) of the gasket retainer. Heavy sooting was present on the outside edge of the gasket because of the blowhole in the outer joint putty lay-up at 15 degrees. No blowhole was present in the inner putty lay-up, and no contamination was found on the sealing surfaces. Typical disassembly detorque damage was observed on the stat-o-seals. No damage was observed on the gasket seals.

5.5 Internal Nozzle

The internal nozzle joints are illustrated in Figures 18 through 22.

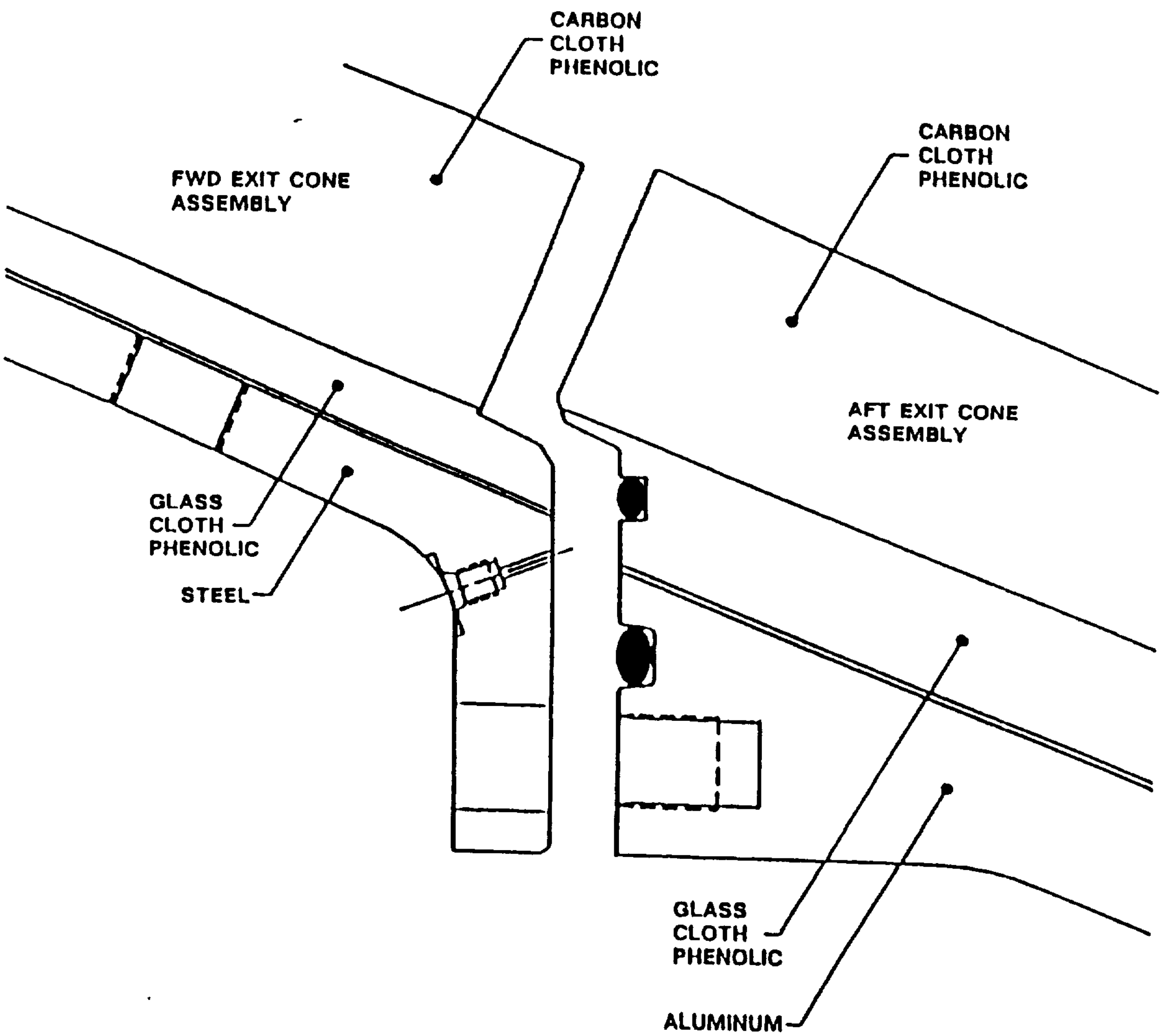


Figure 18 Forward Exit Cone-to-Aft Exit Cone Joint Interface

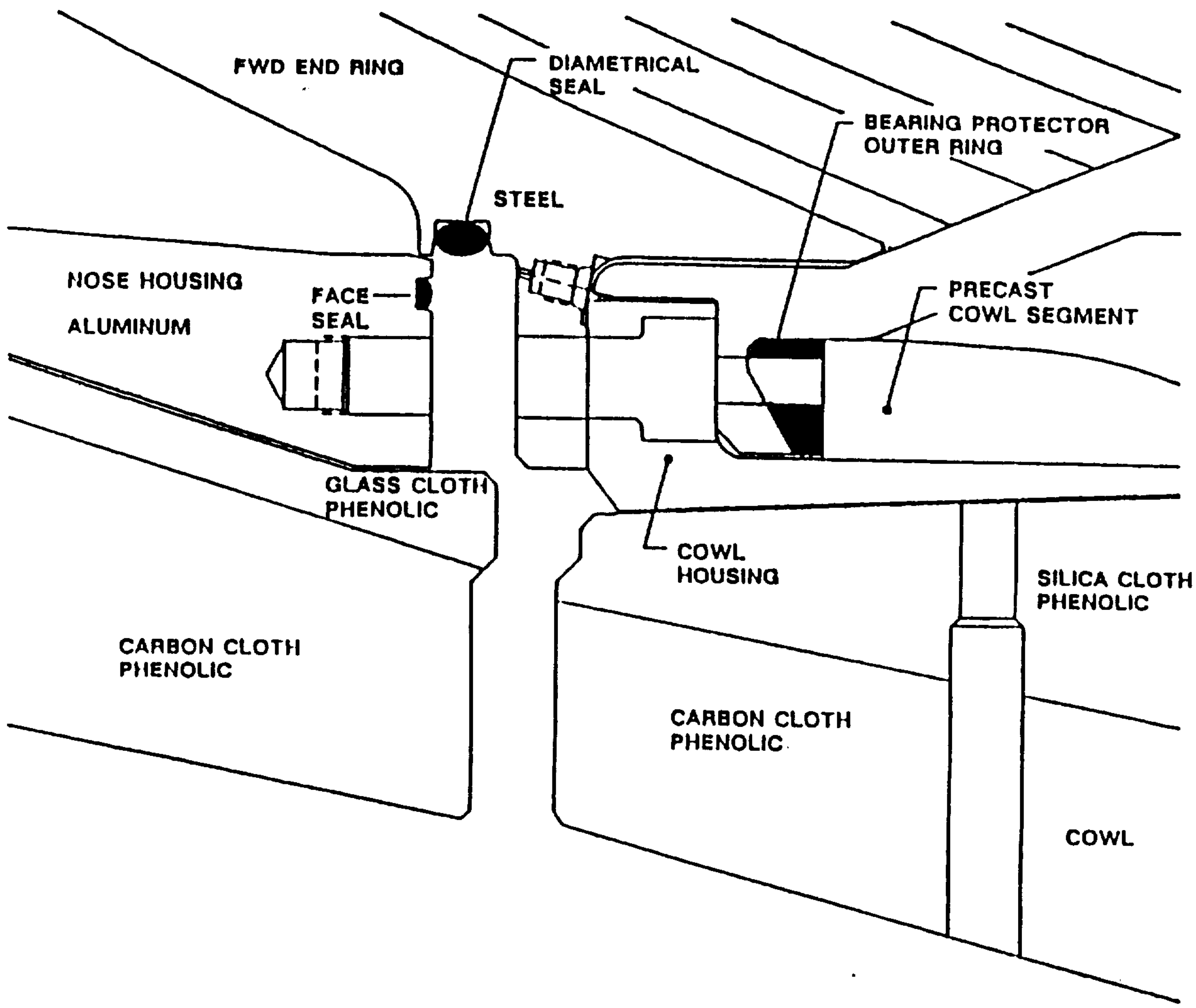


Figure 19 Nose Inlet Housing/Flex Bearing Joint

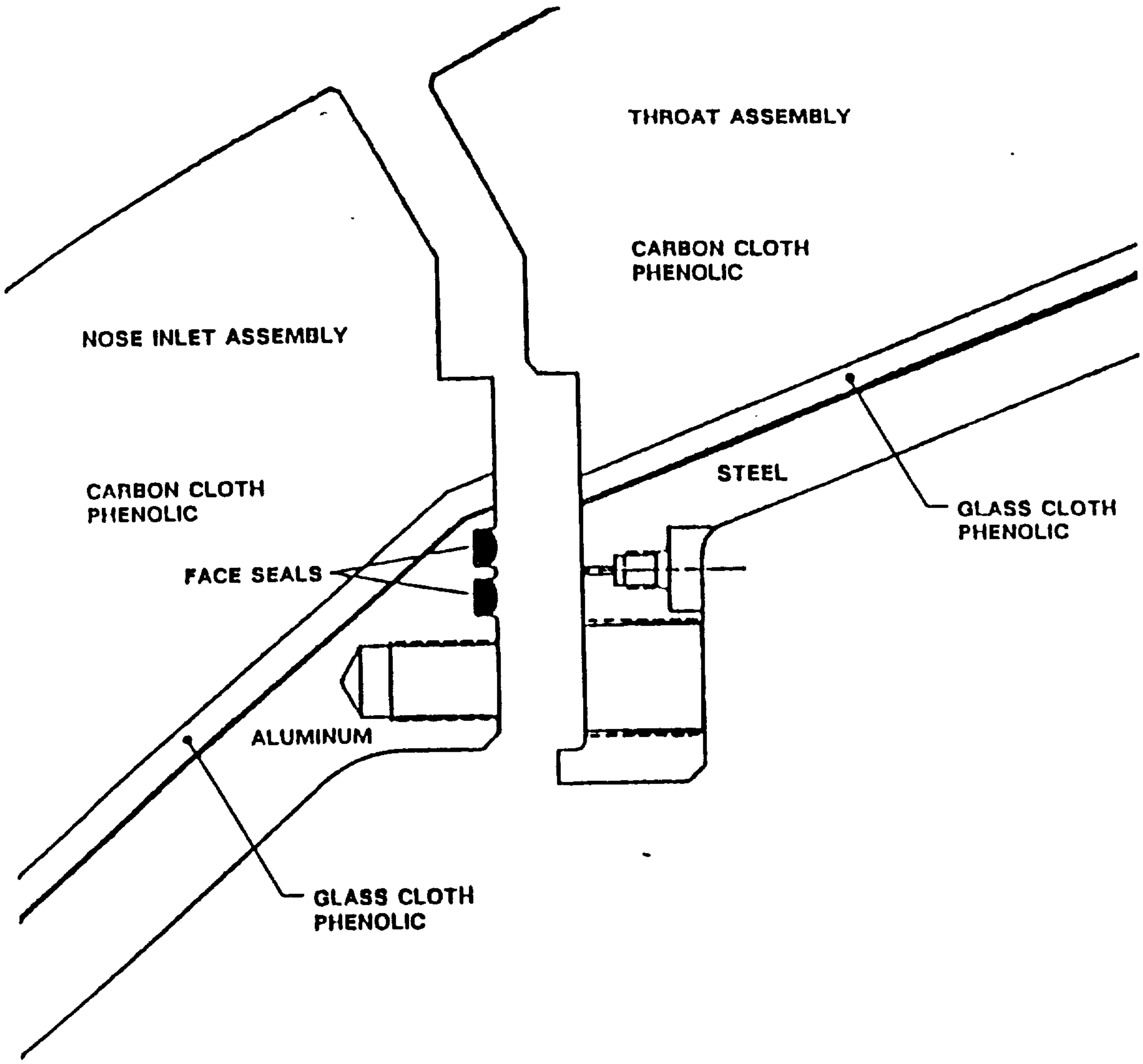


Figure 20 **Nose Inlet/Throat Housing Joint**

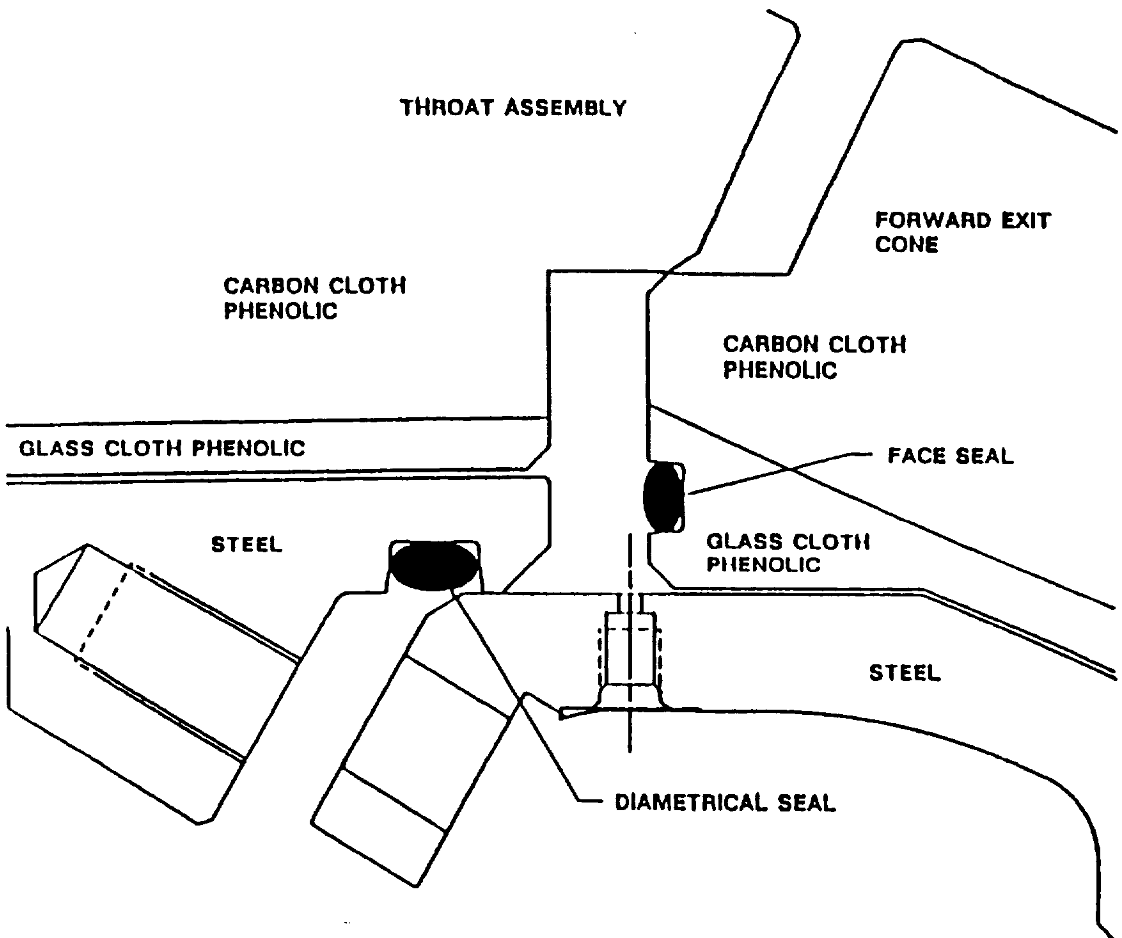


Figure 21 Throat/Forward Exit Cone Joint

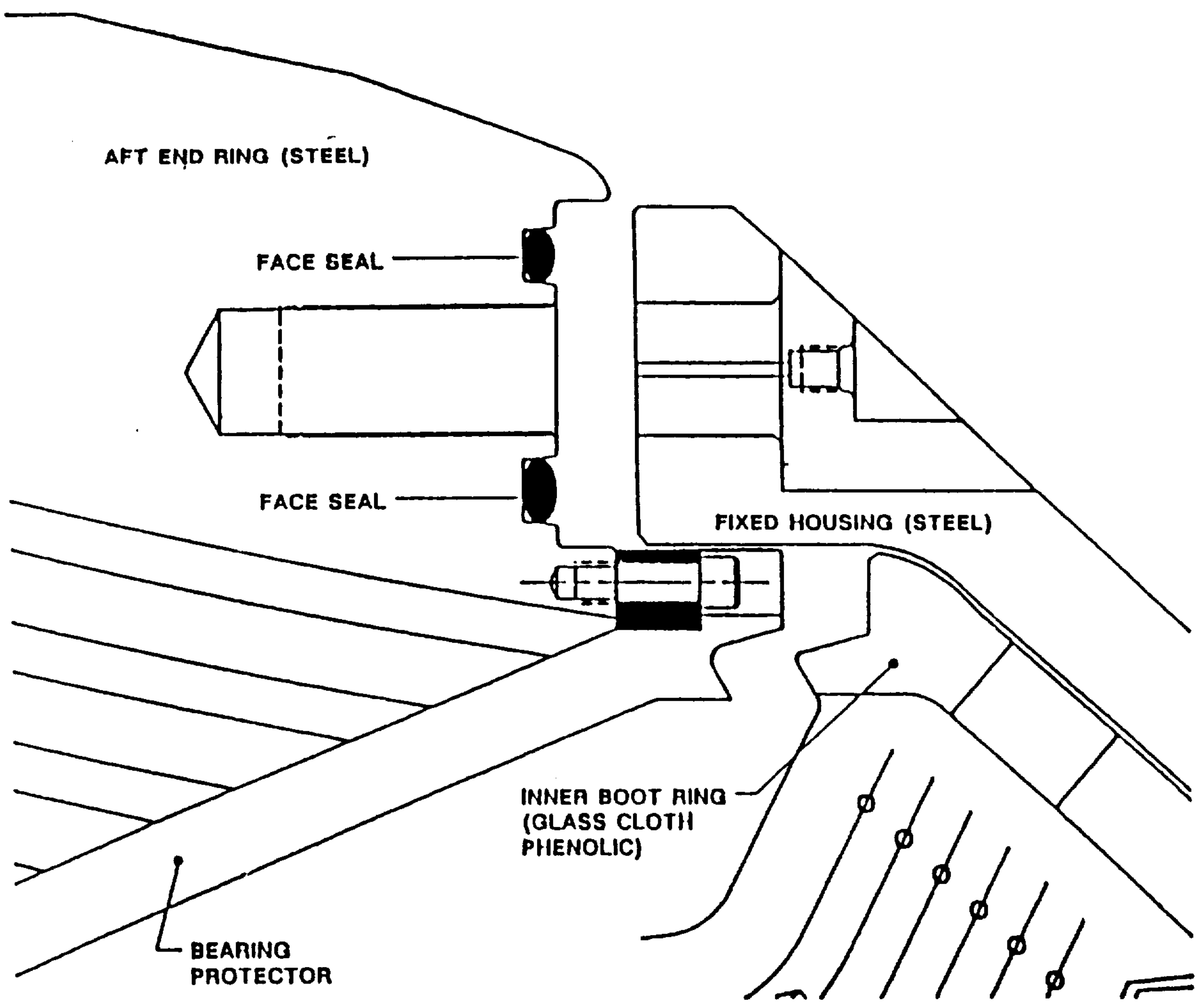


Figure 22 Flex Bearing/Fixed-Housing Joint

5.5.1 Aft Exit Cone Field Joint (Joint 1)

The aft exit cone-to-forward exit cone of QM-8 was disassembled and inspected on 30 January 1989 (see pages A-33 through A-34, Appendix A). The seals and case inspection included the sealing surfaces, seals, and joint metal components. No anomalous conditions were encountered. There was no evidence of damage to the O-rings while in the grooves, or found by the O-ring Inspection Team. There were no voids in the RTV which would allow pressure to reach the primary O-ring. The grease application was per design with no areas of corrosion found.

5.5.2 Forward End Ring-to-Nose Inlet Housing (Joint 2)

The nose-to-forward end ring was disassembled and inspected on 15 February 1989 (see pages A-35 through A-37, Appendix A). The primary O-ring experienced pressure, but no apparent damage to the O-ring was found. Inspection of the O-rings by the O-ring Inspection Team revealed a 2.67 inch indeterminable depth circumferential scratch on the primary O-ring similar to the scratches found on the forward and center field joint capture feature O-rings (see page A-37, Appendix A). No damage was found on the secondary O-ring by the Inspection Team.

Inspection of the joint revealed one very small pressure path through the RTV of the joint interface. The pressure path started at 355 degrees and flowed circumferentially to 350 degrees before penetrating into the metal interface of the joint. The RTV backfill of this joint was much better than the current application of RTV to this joint ("buttering application"). No soot or evidence of blow by was present past the primary O-ring. The sealing surfaces suffered no assembly or disassembly damage.

5.5.3 Nose Inlet Housing-to-Throat Support Housing (Joint 3)

The nose-to-throat was disassembled and inspected on 15 February 1989 (see pages A-38 through A-41, Appendix A). There was no joint pressurization, and the O-rings did not have any apparent damage at the time of disassembly. Inspection of the O-rings by the O-ring Inspection Team revealed two scratches on the primary O-ring and one on the secondary O-ring (see pages A-40 and A-41, Appendix A). This joint showed no signs of pressure past the RTV; i.e., heat-effected grease, soot, or an RTV void. The sealing surfaces showed no assembly or disassembly damage.

5.5.4 Forward Exit Cone-to-Throat Support Housing (Joint 4)

The forward exit cone-to-throat support housing was disassembled on 14 February 1989 (see pages A-42 through A-44, Appendix A). The primary O-ring experienced pressure, but no damage to the O-ring was found. No damage to the primary or secondary O-rings was found during the in grooves inspection or by the O-ring Inspection Team. Inspection of the joint revealed one pressure path through the RTV backfill at 205 degrees. The sealing surfaces suffered no assembly or disassembly damage.

5.5.5 Fixed Housing-to-Aft End Ring (Joint 5)

The aft end ring-to-fixed housing joint was disassembled on 14 February 1989 (see pages A-45 through A-47, Appendix A). There was no joint pressurization, and the in-groove O-ring inspection revealed no damage. Inspection of the O-rings by the O-ring Inspection Team also revealed no damage. This joint showed no signs of pressure past the RTV; i.e., heat-effected grease, soot, or an RTV void. There was no sealing surface damage.

5.6 Factory Joints

Post test inspection findings of the QM-8 factory joint O-rings and joint metal components are discussed in this section.

5.6.1 Disassembly of QM-8 Forward Dome and Forward Segment Factory Joints

The forward segment of QM-8 was disassembled on 24 April 1989 (see pages A-48 through A-53, Appendix A).

5.6.1.1 Forward Dome-to-Cylinder Factory Joint

No corrosion was observed on the outer clevis leg or in the joint areas including the tang. No scratches were observed in any joint area.

Very excessive insulation and Chemlok were on the land forward of the primary O-ring groove intermittently throughout the circumference of the joint. The leak check port plug was removed in the previous log, therefore the break-away torque was not observed or a preliminary inspection completed. Inspection of the port threads revealed they were in nominal condition but had no grease on them. Preliminary inspection of the O-rings showed nominal condition. The O-ring Inspection Team reported no O-ring damage.

5.6.1.2 Forward Segment Cylinder-to-Cylinder Factory Joint

No corrosion was observed on the outer clevis leg or in the joint areas including the tang. No scratches were observed in any joint area.

Very excessive insulation and Chemlok were on the land forward of the primary O-ring groove intermittently throughout the circumference of the joint. The leak check port plug break-away torque was not recorded. The port plug head was partially covered with residual weather seal. Also, scratches were present on the port plug head, which is typical due to the weather seal removal. The port plug and port threads were in nominal condition with a light coat of grease on them. Preliminary inspection of the O-rings showed nominal condition. The O-ring Inspection Team reported no O-ring damage.

5.6.2 Disassembly of QM-8 Center Forward Factory Joint

The QM-8 center forward factory joint was disassembled on 9 May 1989 (see pages A-54 through A-56, Appendix A). No corrosion was observed on the outer clevis leg or in the joint areas including the tang. No scratches were observed in any joint area.

Insulation and Chemlok were on the land forward of the primary O-ring groove intermittently throughout the circumference of the joint.

The leak check port plug break away torque was not recorded because the port plug had been removed in the previous log. Inspection of the port hole was difficult because of the amount of grease in the port, but it showed a nominal condition. The excessive amount of grease was present in the port as a normal preservative operation during the disassembly effort. Preliminary inspection of the O-rings showed nominal condition. The O-ring Inspection Team reported no O-ring damage.

5.6.3 Disassembly of QM-8 Center Aft Factory Joint

The QM-8 center aft factory joint was disassembled on 14 April 1989 (see pages A-57 through A-59, Appendix A). Inspection of the outer clevis leg showed no corrosion. Light corrosion was observed downstream of the secondary O-ring groove through the clevis root and up the inside surface of the outer clevis leg in the entire circumference of the joint. Light corrosion was observed on the tang downstream of the sealing surface on the entire circumference of the joint. No scratches were observed in any joint areas.

A particle of foreign material was observed between the forward wall of the primary O-ring groove and the primary O-ring at seven degrees. A laboratory analysis showed the particle to be aluminum oxide material with residual combustion by-products. It was determined that this particle fell into the joint during disassembly and remains an observation. A presentation was made to the EMT and RPRB for concurrence with this conclusion.

Insulation and Chemlok were on the land forward of the primary O-ring groove intermittently throughout the circumference of the joint. The leak check port plug was removed in the previous log so the break-away torque was not observed or an inspection done. The port threads were in nominal condition but had no grease on them. Preliminary inspection of the O-rings showed a nominal condition. The O-ring Inspection Team also revealed no findings.

5.6.4 Disassembly of QM-8 Aft Segment Factory Joints

The QM-8 aft segment was disassembled on 2 and 3 March 1989 (see pages A-60 through A-68, Appendix A).

5.6.4.1 Aft Segment Dome-to-Stiffener Joint

Intermittent spots of light to medium corrosion were observed on the outside of the outer clevis leg. No corrosion was observed in the joint. Scratches were observed on the land between the O-ring grooves at 8, 22, 24, 26, 28, 30, 34, 36, 38, 40, 44, 304, 306, 308 to 316 and 346 degrees. Scratches and pits were observed on the inside of the tang downstream of the seal surface to the chamfer at 302 to 346 degrees. Insulation and Chemlok were on the land forward of the primary O-ring groove and in contact with the forward edge of the primary O-ring intermittently throughout the circumference of the joint.

The initial inspection of the port hole was difficult because of the amount of grease in the port but it showed a nominal condition. The excessive amount of grease was present because the port plug had been removed in the previous log. Thus the grease was put in the port as a normal preservative operation during the disassembly effort.

Preliminary inspection of the O-rings showed a nominal condition. The A-2 O-ring Inspection Team also revealed no findings.

5.6.4.2 Stiffener-to-Stiffener Factory Joint

Intermittent spots of light to medium corrosion were observed on the outside of the outer clevis leg between 271 to 137 degrees. Light corrosion was observed downstream of the secondary groove at 17 to 21, 32, 36 to 45, 84, and 147 to 175 degrees. Scratches were observed on the land between the O-ring grooves at 358 degrees.

Insulation and Chemlok were on the land forward of the primary O-ring groove and in contact with the forward edge of the primary O-ring intermittently throughout the circumference of the joint.

The initial inspection of the port hole was difficult because of the amount of grease in the port but it showed a nominal condition. The excessive amount of grease was present because the port plug had been removed in the previous log. Thus, HD-2 grease was put in the port as a normal preservative operation during the disassembly effort.

Preliminary inspection of the O-rings showed a nominal condition. The O-ring Inspection Team also revealed no O-ring damage.

5.6.4.3 ET-to-Stiffener Factory Joint

Intermittent spots of light to medium corrosion were observed on the outside of the outer clevis leg. Light corrosion was observed in the clevis bottom at 101 to 107 degrees. Scratches were observed on the land between the O-ring groove at 18, 24, 38, and 316 degrees. Scratches were also observed on the land forward of the primary O-ring groove at 38 and 316 degrees.

Insulation and Chemlok were on the land forward of the primary O-ring groove and in contact with the forward edge of the primary O-ring intermittently throughout the circumference of the joint.

The initial inspection of the port hole was difficult because of the amount of grease in the port, but it showed a nominal condition. The excessive amount of grease was present because the port plug had been removed in the previous log. Thus HD-2 grease was put in the port as a normal preservative operation during the disassembly effort.

Preliminary inspection of the O-rings showed a nominal condition. The O-ring Inspection Team also revealed no O-ring damage.

5.7 Port Plug Evaluation

Only recently, a detailed evaluation of all port plugs and port plug seals have been evaluated by the O-ring Inspection Team (see pages A-69 through A-98, Appendix A). On past full-scale static tests (PV-1, QM-7, QM-6) the emphasis was focused mainly on the custom and adjustable plugs which were in the design and qualification phases. Inspection forms and engineering evaluation limits have since been added to the PEEP and PEEL documents, respectively (see References 17 and 18). Since there are so many port plugs in the RSRM, no attempt is made to discuss the post-test inspection findings of each plug. However, it can be stated that no gross unexpected conditions were encountered.

Copies of the completed PFORs (Post Fire Observation Records) are presented in Appendix A.

It should be noted that there were no port plugs installed in the 45 degree leak check ports of the field joints, and the 262.5 degree leak check port of the fixed housing-to-aft end ring (Nozzle Joint 5). There were pressure transducers installed in these ports. Also the leak check port plugs from the igniter inner and outer joints were not received.

5.8 Seals Component Program Team Recommendations

The Seals Component Program Team has reviewed all observations presented in this document and have determined that the following observations are potential anomalies, classified as critical, major, minor, or observation, as defined under Table 34 criteria.

5.8.1 Remains Observation

1. The aluminum oxide, combustion by-product particle observed between the forward wall of the primary O-ring groove and the primary O-ring at seven degrees on the center aft factory joint. It was determined that this particle fell into the joint during disassembly and remains an observation.

5.8.2 Minor Anomalies

1. The white colored material, which ran circumferentially found on the aft edge of the forward field joint capture feature O-ring at 169 degrees. More thin lines of the white colored material were found intermittently on the aft edge from 164 to 167 degrees. Also small thin lines of the white colored material were found on the capture feature metal to J-leg interface (aft of the capture feature groove on the tang J-leg) at intermittent degree locations. Lab analysis indicated the material was Teflon Tape adhesive.

2. Thirty five of 100 nozzle-to-case Stat-O-Seals had unacceptable flow line conditions.

5.8.3 Major Anomalies

There were no major anomalies.

5.8.4 Critical Anomalies

There were no critical anomalies.

5.9 RPRB Position

The RPRB has accepted as presented.

Table 34
Criteria for Classifying "Potential Anomalies"

Remains Observation	Anomaly		
	Minor	Major	Critical
Requires no Specific Action	Requires corrective action, but has no impact on: - Motor Performance - Program Schedule Does not reduce usability of part for its intended function Could cause damage preventing reuse of hardware in combination with other anomaly Significant departure from the historical database	Could cause failure in combination w/ other anomaly Could cause damage preventing reuse of hardware Program acceptance of cause, corrective action, and risk assessment required before subsequent static test or flight	Violates CEI Spec. requirements Could cause failure and possible loss of mission/life Mandatory resolution before subsequent static test/flight

Note: These criteria to be applied to the specific observed "potential anomaly" as it relates to the observed article and as it relates to subsequent articles.

6.0 REFERENCES

APPLICABLE DOCUMENTS

1. Hugh P.J., CTP-0060 Revision D, "Space Shuttle Qualification Motor #8 (QM-8) Static Fire Test Plan", Morton Thiokol, Inc., 19 January 1989.

2. Garecht D. M., TWR-17591 Vol. 1, "Space Shuttle Qualification Motor 8 (QM-8) Final Test Report", Morton Thiokol, Inc., March 1989.

3. TWR-19506 Has Not Been Released At This Time.

4. Swopes, C., TWR-16459, Rev. E., "CPW1-3600 Specification Deviations", Morton Thiokol, Inc., 7 October 1988.

5. Furgeson J. W., STW7-2999, "Calcium Grease, Field Joint, Factory Joint, Nozzle Joints Assembly, Application of, and Component Installation, Space Shuttle SRM", Morton Thiokol, Inc., March 1988.

6. Ferney D. G., ETP-0228, Revision A, "Horizontal Assembly Requirements for RSRM Segments with 7U75170 Field Joint Assembly Fixture", Morton Thiokol, Inc., January 1988.

7. Nelsen L. V., TWR-18135, Revision A, "DM-9 RSRM Structural Test Report", Morton Thiokol, Inc., 30 June 1988.

8. Tarbet G. F., STW7-3499, "Installation Procedure, Leak Check and Vent Port Plug, Space Shuttle Redesigned Solid Rocket Motor", Morton Thiokol, Inc., 25 July 1988.

9. Tarbet G. F., STW7-3661, Revision B, "Leak Testing, Field Joint and Nozzle-to-Case Vent Port Plugs, Space Shuttle, Redesigned Solid Rocket Motor", Morton Thiokol, Inc., 7 September 1988.

10. TWR-18838, Installing' "The Adjustable Vent Port Plug", Morton Thiokol, Inc., (A Presentation, Publications No. 89268)

11. Dean M. C., Ash R., TWR-18811, Revision A, "O-ring Squeeze Calculations and Temperature Requirements QM-8", Morton Thiokol, Inc., 13 December 1988.

12. Hutchison B. J., TWR-18990, "Predicted Ballistic Performance Characteristics for QM-8", Morton Thiokol, Inc., 15 December 1988.

13. Structural Design Section, TWR-17118, Supplement B, Revision A, "RSRM Case Structural Analysis Summary", Morton Thiokol Inc., April 1988.

14. St. Aubin, B. K., TWR-17991, "RSRM Seal Design Summary Report", Morton Thiokol, Inc., 1 September 1988.

15. Structural Design Section, TWR-17118, Supplement D, Revision A, "RSRM Case Structural Analysis Summary", Morton Thiokol Inc., April 1988.

16. Performance and Advanced Design, et. al., TWR-16473, Revision B, Volume 4, "Qualification and Production Verification Motor Postfire Engineering Evaluation Plan", Morton Thiokol, Inc., 13 January 1989

17. Performance and Advanced Design, et. al., TWR-17198, Revision A, Volume 4, "Postfire Engineering Evaluation Limits", Morton Thiokol, Inc., 18 April 1988

18. V. J. Straley, STW7-2790, Revision B, "Ignition System Gaskets, Reusable Acceptance Criteria For", Morton Thiokol, Inc., 20 November 1987.

APPLICABLE DRAWINGS

1. Drawing 8U76500, "Leak Test System, Safe and Arm Device, Installation", Morton Thiokol, Inc., 16 May 1988.

2. Drawing 8U75902, "Leak Check System, Installation", Morton Thiokol, Inc., 11 December 1987.

3. Drawing 7U76357, "Vent Port Plug Leak Test Fixture", Morton Thiokol, Inc., 15 March 1988.

4. Drawing 2U65686, "Transducer Leak Test Fixture", Morton Thiokol, Inc., 17 January 1989.

5. Drawing 2U129718, "Auxiliary Leak Test Equipment", Morton Thiokol, Inc., 18 May 1988.

APPENDIX A
INSPECTION FORMS

Morton Thiokol Inc.
Space Operations

Joint External Walk Around - Evaluation Checkoff Worksheet

Motor No.: QM-8	Date: JAN 21 1989	Time: 1400
Inspector(s): DAVE ROWSELL, JEFF CURRY, LOWELL NELSEN		

Evidence of Combustion Product Leakage (SOOT)?

	yes	no	Comment Number
A. Forward Dome Factory Joint (Sta. 531.5, FDS, CLEVIS)		✓	
B. Forward Segment Factory Joint (Sta. 691.5, FFS, CLEVIS)		✓	
C. Forward Field Joint (Sta. 851.5, FWD, CLEVIS)		✓	
D. Forward Center Segment Factory Joint (Sta. 1011.5, FCS, CLEVIS)		✓	
E. Center Field Joint (Sta. 1171.5, CTR, CLEVIS)		✓	
F. Aft Center Segment Factory Joint (Sta. 1331.5, ACS, CLEVIS)		✓	
G. Aft Field Joint (Sta. 1491.5, AFT, CLEVIS)		✓	
H. Aft Segment Factory Joint (Sta. 1577.5, FSS, CLEVIS)		✓	
I. Aft Segment Factory Joint (Sta. 1697.5, ASS, CLEVIS)		✓	
J. Aft Dome Factory Joint (Sta. 1817.6, ADS, CLEVIS)		✓	
K. Nozzle to Case Joint (Sta. 1875.2, NOZ, AFT)		✓	

If yes, record the indicated data below:

Morton Thiokol Inc.
Space Operations

External Igniter Interfaces – Evaluation Checkoff Worksheet

Motor No.: QM-8	Date: JAN 21 1989	Time: 1400
Inspector(s): DAVE ROWSELL, JEFF CURRY, LOWELL NELSEN		

Evidence of Combustion Product Leakage (SOOT)?

		yes	no	Comment Number
A.	Adapter / Forward Dome Interface (IGN, AFT)		✓	
B.	Adapter To Forward Dome Bolts (IGN, FWD)		✓	
C.	Adapter / Chamber Interface (IGI, AFT)		✓	
D.	Adapter To Chamber Bolts (IGI, FWD)		✓	
E.	S&A / Adapter Interface (S&A, AFT)		✓	
F.	S&A To Adapter Bolts (S&A, FWD)		✓	

If yes, record the indicated data below:

REV. ____

MORTON THIOKOL INC.

External Walk Around - Evaluation Checkoff Worksheet

Inspector(s): DAVE ROWSELL, JEFF CURRY, LOWELL NELSEN

Motor No.: QM-8 | Date: 21 JAN 87

I. Hotspots (Heat Affected Paint)?

1. Aft Segment ____ yes X no
2. Aft Center Segment ____ yes X no
3. Forward Center Segment ____ yes X no
4. Forward Segment ____ yes X no

II. Loose or Cracked ETA bolts? ____ yes X no

III. Loose or Cracked Stiffener Ring Bolts? ____ yes X no

IV. Additional Observations? ____ yes X no

If yes, record the indicated data below:

Segment (1 - 4)	Condition	Axial Location (In.)	Degree Location (Deg.)	Axial Length (In.) If Applicable	Circumferential Width (In.) If Applicable	Degree Arc If Applicable

Notes / Comments

Note: Clarify any observations on an OCF if necessary

Stiffener Ring - Evaluation Checkoff Worksheet

Inspector(s): DAVE ROWSELL, LOWELL NELSEN

Motor No.: QM-8 | Date: 21 JAN 89

I. Cracked or Deformed Bolts (Removed)? ___ yes _X_ no

II. Cracked or Warped Stiffener Flange? ___ yes _X_ no

III. Cracked or Warped Stiffener Web? ___ yes _X_ no

IV. Cracked or Warped Stiffener Stubs? ___ yes _X_ no

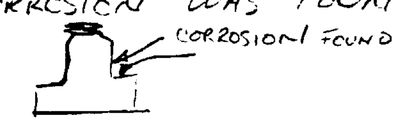
V. Cracked or Deformed Stiffener Ring Bolt Holes? ___ yes _X_ no

VI. Cracked or Deformed Stiffener Stub Bolt Holes? ___ yes _X_ no

If yes, record the indicated data below:

Affected Part (I-VI)	Condition	Axial Location (In.) (All)	Degree Location (Deg.) (All)	Axial Length (In.) (II Only)	Circumferential Width (In.) (II, III & IV)	Degree Arc (II, III & IV)	Radial Distance (In.) (III & IV)

Notes / Comments SMALL SPOTS OF VERY LIGHT SURFACE CORROSION WAS FOUND ON 10 OF THE STIFFENER BOLTS.



External Tank Attach (ETA) - Evaluation Checkoff Worksheet

Inspector(s): DAVE ROWSELL, KELLY BAKER

Motor No.: QM-8 Date: 21 JAN 89

I. Cracked or Deformed Bolts (Removed)? ____ yes X no

II. Cracked or Warped ETA Ring? ____ yes X no

III. Cracked or Warped ETA Segment Stubs? ____ yes X no

IV. Cracked or Deformed ETA Ring Bolt Holes? ____ yes X no

V. Cracked or Deformed ETA Segment Stub Bolt Holes? ____ yes X no

If yes, record the indicated data below:

Affected Part (I-V)	Condition	Axial Location (In.) (All)	Degree Location (Deg.) (All)	Axial Length (In.) (II Only)	Circumferential Width (In.) (II & III Only)	Degree Arc (II & III Only)	Radial Distance (In.) (II & III Only)

Notes / Comments

Rev. ____

Case Field Joint Condition - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 8 FEB 89

Joint: ☒ Forward (FWD) ☐ Center (CTR) ☐ Aft (AFT)

Inspector(s): DAVE ROWSELL, JEFF CURRY

Case Field Joint Observations:	Yes	No	Comment Number
A. Soot In Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		✓	
B. Sooted Grease (HAGRE)?		✓	
C. Discolored Grease (DIGRE)?		✓	
D. Volume 2 Filler Damage (V2FD)?		✓	
E. Leak Check Port Obstructed (LPOBS)?		✓	
F. Vent Port Obstructed (VPOBS)?		✓	
G. Foreign material in the sealing area during motor operation (FMIJ)?	✓		1
H. Rust on sealing surfaces (SSCOR)?		✓	
I. Rust on metal parts (PITCO)?		✓	
J. Heat affected metal (HTAFF)?		✓	
K. Damaged metal sealing surface (SSMET)?		✓	

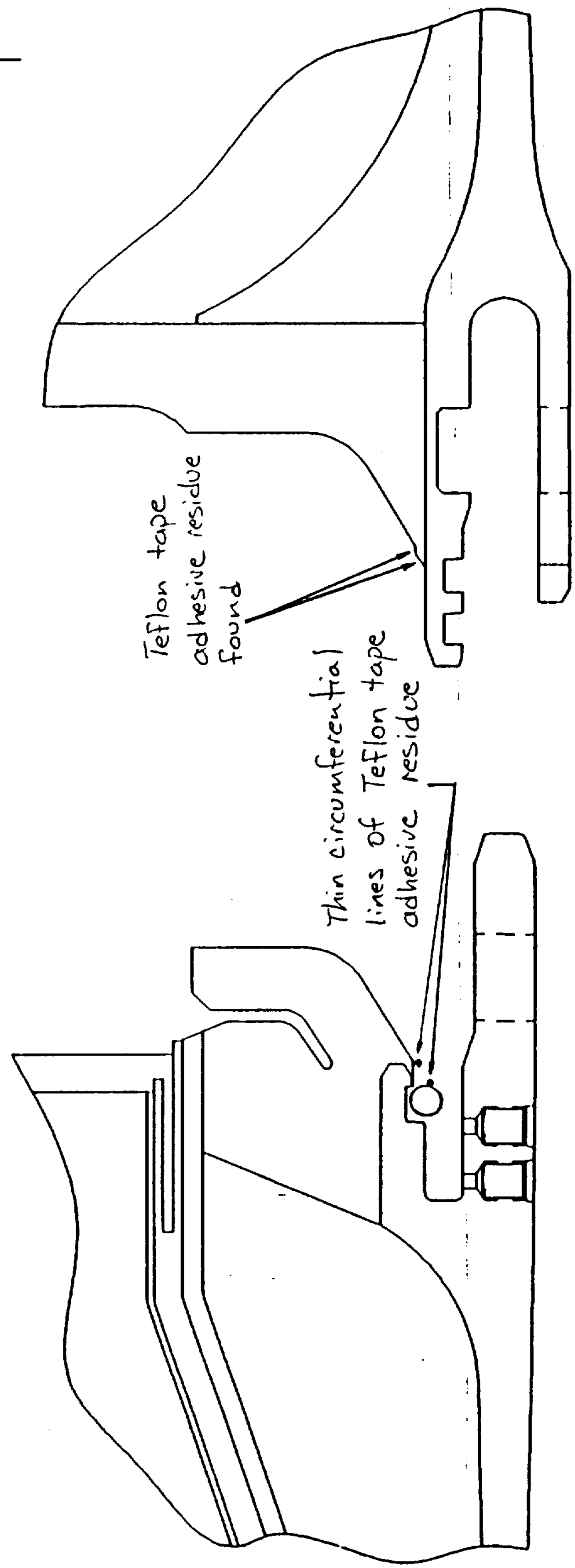
If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, a "T" if the condition is observed on the tang or a "C" if the condition is observed on the clevis and any other information needed to describe the observation:

1. A long thin line of white colored material was found on the aft edge of the capture feature o-ring at 169 degrees. More thin lines of white colored material were found intermittently on the aft edge of the capture feature o-ring from 164 to 167 degrees. The long thin line at 169 degrees was approximately 0.400 inch long. Suspect adhesive from teflon tape. (FMIJ)

NOTE: FOR YOUR INFORMATION (SEE ATTACHED FIGURE)

Small thin lines of the white colored material were found on the capture feature metal to J-leg interface (aft of the capture feature groove on the tang J-leg) at 153, 178, 180, 227, 228, and from 230 to 233 degrees. All of the thin lines of the white colored material ran circumferentially on the joint except for the lines of white colored material at 178 degrees. On the clevis, the white colored material was found on the top of the J-leg (near the inner clevis leg metal) at 138, 150, 152, 178, 180, and from 162 to 165, 167 to 170, 230 to 234, and 252 to 254 degrees. As on the tang, all of the thin lines of the white colored material ran circumferentially on the joint except for the lines of white colored material at 178 degrees.

QM-8 FORWARD FIELD JOINT



Morton Thiokol Inc.

Space Operations

Field and Factory Joint – Evaluation Checkoff Worksheet

Inspector(s): DAVE ROWSELL, JEFF CURRY

Motor No.: QM-8 | Date: 8 FEB 89

Joint:

- [ ] Forward Dome Factory Joint (531.5)
- [x] Forward Field Joint (851.5)
- [ ] Center Field Joint (1171.5)
- [ ] Aft Field Joint (1491.5)
- [ ] Aft Segment Factory Joint (1697.5)
- [ ] Forward Segment Factory Joint (691.5)
- [ ] Forward Center Segment Factory Joint (1011.5)
- [ ] Aft Center Segment Factory Joint (1331.5)
- [ ] Aft Segment Factory Joint (1577.5)
- [ ] Aft Dome Factory Joint (1817.5)

I. Rust on Metal Parts (Corrosion)? ____ yes ✓ no

II. Metal Damage? ____ yes ✓ no

Clarify below or on an OCF, if necessary

III. Metal Slivers from pin holes? ✓ yes ____ no

IV. Other? ____ yes ✓ no

Describe: ____________________

If yes, record the data below:

Axial Location (in.) If Applicable	Degree Location (Deg.)	Degree Arc If Applicable	Length If Applicable	Width If Applicable
251.5	SEE BELOW			

Notes / Comments: Pinhole slivers were found in the bottom of the inner clevis leg pinholes in the following holes: 52, 54, 58, 60, 62, 232, 282, 286, 288, 290, and 292. The slivers are case material (D6AC) and are typical. (   ) ? code ?

SF
13 MAR 89

MORTON THIOKOL INC.
Space Operations

Detailed Case Field Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Rocky Ash, Scott Eden, D. Gary Nelson
Motor No.: QM-8 | Date: 2-10-89
Joint: [x] Forward [ ] Center [ ] Aft

PRIMARY O-RING Part No.: 1U75150-25 Serial No.: 0000331

A. Erosion?	____ Yes	✓	No
B. Heat Affect?	____ Yes	✓	No
C. Assembly/Disassembly Damage?	____ Yes	✓	No
D. Other? Describe: ____	____ Yes	✓	No

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

SECONDARY O-RING Part No.: 1U75150-25 Serial No.: 0000287

A. Erosion?	____ Yes	✓	No
B. Heat Affect?	____ Yes	✓	No
C. Assembly/Disassembly Damage?	____ Yes	✓	No
D. Other? Describe: ____	____ Yes	✓	No

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

CAPTURE FEATURE O-RING Part No.: 1U75150-11 Serial No.: 0000024

A. Erosion?	____ Yes	✓	No
B. Heat Affect?	____ Yes	✓	No
C. Assembly/Disassembly Damage?	____ Yes	✓	No
D. Other? Describe: ____	✓ Yes	____	No

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)
D	1.6°	indeterminable	.001		13.5"

Notes / Comments:

Morton Thiokol Inc.

Space Operations

SE
13 MARCH 89

O-RING OBSERVATION CLARIFICATION FORM

Date: 2-10-89 Inspector(s): Scott Eden, Rocky Ash, D. Gary Nelson

Motor No.: QM-8

☐ Left (A) ☐ Right (B) Joint: FWD FIELD JOINT

O-ring Location: ☐ Primary ☐ Secondary ☑ Capture Feature ☐ Wiper

Part Number: 1U75150-11

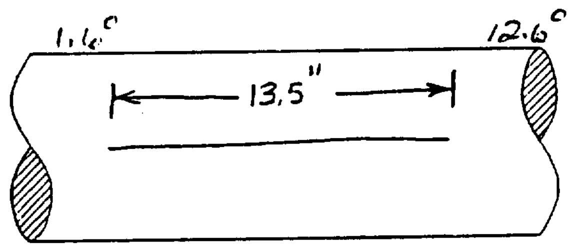
Serial Number: 0000024

Depth:

Description: See Below

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.

Circumferential Scratch



L = 13.5°
W = .001
D = indeterminable

REV. ___

Morton Thiokol Inc.
Space Operations

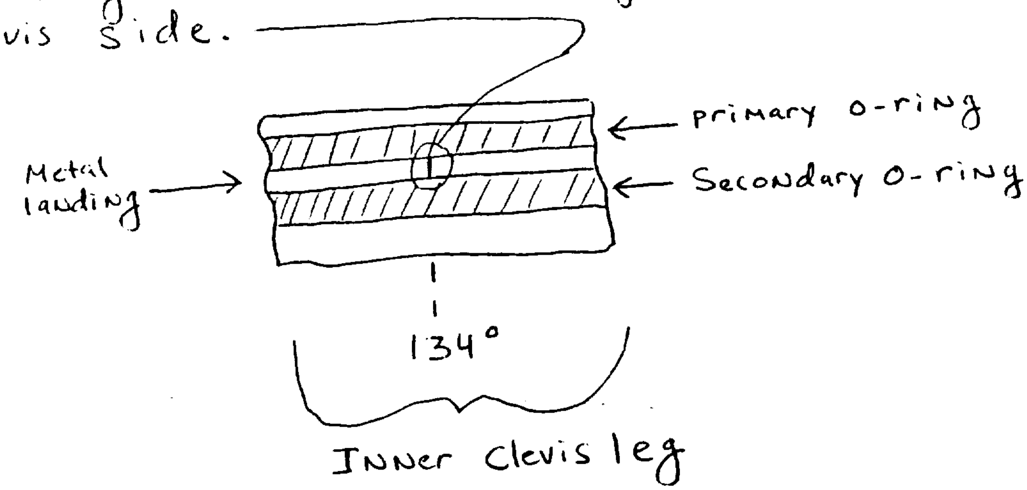
Case Field Joint Condition - Evaluation Checkoff Worksheet

Motor No.: QM-8	Date: 2-7-89
Joint: ☐ Forward (FWD) ☒ Center (CTR) ☐ Aft (AFT)	
Inspector(s): Lowell Nelsen	

Case Field Joint Observations:		Yes		No	Comment Number
A. Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		Yes	✓	No	
B. Sooted Grease (HAGRE)?		Yes	✓	No	
C. Discolored Grease (DIGRE)?		Yes	✓	No	
D. Volume 2 Filler Damage (V2FD)?		Yes	✓	No	
E. Leak Check Port Obstructed (LPOBS)?		Yes	✓	No	
F. Vent Port Obstructed (VPOBS)?		Yes	✓	No	
G. Foreign material in the sealing area during motor operation (FMIJ)?		Yes	✓	No	
H. Rust on sealing surfaces (SSCOR)?	✓	Yes		No	1
I. Rust on metal parts (PITCO)?		Yes	✓	No	
J. Heat affected metal (HTAFF)?		Yes	✓	No	
K. Damaged metal sealing surface (SSMET)?		Yes	✓	No	

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, a "T" if the condition is observed on the tang or a "C" if the condition is observed on the clevis and any other information needed to describe the observation:

1. Very light thin line of corrosion on the landing between the O-ring grooves at 134°, clevis side.



Field and Factory Joint – Evaluation Checkoff Worksheet

Inspector(s): Lowell Nelsen

Motor No.: QM-8

Date: 2-7-89

Joint:

- ☐ Forward Dome Factory Joint (531.5)
- ☐ Forward Field Joint (851.5)
- ☒ Center Field Joint (1171.5)
- ☐ Aft Field Joint (1491.5)
- ☐ Aft Segment Factory Joint (1697.5)
- ☐ Forward Segment Factory Joint (691.5)
- ☐ Forward Center Segment Factory Joint (1011.5)
- ☐ Aft Center Segment Factory Joint (1331.5)
- ☐ Aft Segment Factory Joint (1577.5)
- ☐ Aft Dome Factory Joint (1817.5)

I. Rust on Metal Parts (Corrosion)? ✓ yes ___ no

II. Metal Damage? ___ yes ✓ no

Clarify below or on an OCF, if necessary

III. Metal Slivers from pin holes? ✓ yes ✓ no

IV. Other? ___ yes ✓ no

Describe: ____________

If yes, record the data below:

	Axial Location (In.) If Applicable	Degree Location (Deg.)	Degree Arc If Applicable	Length If Applicable	Width If Applicable
1.	1171.5	134°	—	Across clevis o-ring landing	—
3.	1171.5	268°	—	~0.60"	—

Notes / Comments:

See Table B-III of TWR-16473, Vol. 4 For corrosion illustration. (PFOR used)

SE

MORTON THIOKOL INC.

Space Operations

Detailed Case Field Joint O-ring (Post-Removal) – Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Wayne Sperry, Parky A..., Scott Eden, D. Gary Nelson

Motor No.: QM-8 | Date: 2-9-89

Joint: ☐ Forward ☒ Center ☐ Aft

PRIMARY O-RING

Part No.: 1U75150-25 Serial No.: 0000334

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

SECONDARY O-RING

Part No.: 1U75150-25 Serial No.: 0000333

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

CAPTURE FEATURE O-RING

Part No.: 1U75150-11 Serial No.: 0000051

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:	✓	

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)
D	47°	indeterminable	.001		13.5"
D	345.8°	.001	.001		.150

Notes / Comments:

REVISION____

Morton Thiokol Inc.
Space Operations

SE

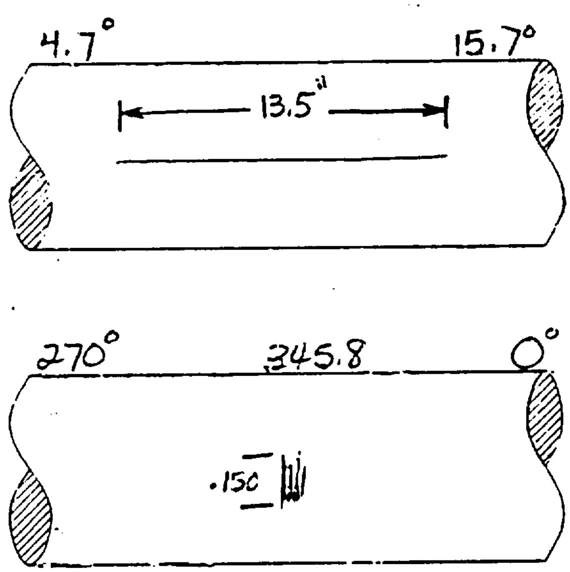
O-RING OBSERVATION CLARIFICATION FORM

Date: 2-9-89 Inspector(s): Rocky Ash, Scott Eden, Wayne Sperry, D. Gary Nelson
Motor No.: QM-8
☐ Left (A) ☐ Right (R) Joint: CTR FIELD JOINT
O-ring Location: ☐ Primary ☐ Secondary ☑ Capture Feature ☐ Wiper
Part Number: 1U75150-11
Serial Number: 0000051
Depth:
Description: See Below

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.

Circumferential Scratch

Radial Scratches



L = 13.5"
W = .001
D = indeterminable

L = .150
W = .001
D = .001

SE

Morton Thiokol Inc.
Space Operations

Case Field Joint Condition - Evaluation Checkoff Worksheet

Motor No.: QM-8	Date: 2-6-89
Joint: ☐ Forward (FWD) ☐ Center (CTR) ☒ Aft (AFT)	
Inspector(s): K. Baker	

Case Field Joint Observations:					Comment Number
A. Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		Yes	✓	No	
B. Sooted Grease (HAGRE)?		Yes	✓	No	
C. Discolored Grease (DIGRE)?		Yes	✓	No	
D. Volume 2 Filler Damage (V2FD)?		Yes	✓	No	
E. Leak Check Port Obstructed (LPOBS)?		Yes	✓	No	
F. Vent Port Obstructed (VPOBS)?		Yes	✓	No	
G. Foreign material in the sealing area during motor operation (FMIJ)?		Yes	✓	No	
H. Rust on sealing surfaces (SSCOR)?		Yes	✓	No	
I. Rust on metal parts (PITCO)?		Yes	✓	No	
J. Heat affected metal (HTAFF)?		Yes	✓	No	
K. Damaged metal sealing surface (SSMET)?		Yes	✓	No	

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, a "T" if the condition is observed on the tang or a "C" if the condition is observed on the clevis and any other information needed to describe the observation:

REV. ____

SE

MORTON THIOKOL INC.
Space Operations

Field and Factory Joint – Evaluation Checkoff Worksheet

Inspector(s): K. Baker

Motor No.: QM-8 Date: 2-6-89

Joint:

- ☐ Forward Dome Factory Joint (531.5)
- ☐ Forward Segment Factory Joint (691.5)
- ☐ Forward Field Joint (851.5)
- ☐ Forward Center Segment Factory Joint (1011.5)
- ☐ Center Field Joint (1171.5)
- ☐ Aft Center Segment Factory Joint (1331.5)
- ☒ Aft Field Joint (1491.5)
- ☐ Aft Segment Factory Joint (1577.5)
- ☐ Aft Segment Factory Joint (1697.5)
- ☐ Aft Dome Factory Joint (1817.5)

I. Rust on Metal Parts (Corrosion)? ____ yes ____ no

II. Metal Damage? ____ yes ____ no

Clarify below or on an OCF, if necessary

III. Metal Slivers from pin holes? ✓ yes ____ no

IV. Other? ✓ yes ____ no

Describe: Missing Grease in Clevis Root

If yes, record the data below:

	Axial Location (In.) If Applicable	Degree Location (Deg.)	Degree Arc If Applicable	Length If Applicable	Width If Applicable
III	~~[illegible]~~	136			
IV		232	50		

Notes / Comments:

III Pinhole sliver found on the aft edge of the secondary o-ring at 136 degrees. Pinhole sliver fell there on disassembly.

SE

MORTON THIOKOL INC.
Space Operations

Detailed Case Field Joint O-ring (Post-Removal) – Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Wayne Sperry, Scott Eden, D. Gary Nelson

Motor No.: QM-8 | Date: 2/8/89

Joint: ☐ Forward ☐ Center ☒ Aft

PRIMARY O-RING
Part No.: 1U75150-25 Serial No.: 0000356

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

SECONDARY O-RING
Part No.: 1U75150-25 Serial No.: 0000351

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

CAPTURE FEATURE O-RING
Part No.: 1U75150-11 Serial No.: 0000052

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

Notes / Comments:

5E

Morton Thiokol Inc.
Space Operations

Nozzle-to-Case Joint Condition - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 10 FEB 89

Joint: Nozzle-to-Case (NOZ)

Inspector(s): DAVE ROWSELL

Case Field Joint Observations:	Yes	No	Comment Number
A. Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		✓	
B. Sooted Grease (HAGRE)?		✓	
C. Discolored Grease (DIGRE)?		✓	
D. Polysulfide Past Wiper O-ring (PSEX)?	✓		1
E. Leak Check Port Obstructed (LPOBS)?		✓	
F. Vent Port Obstructed (VPOBS)?		✓	
G. Foreign material in the sealing area during motor operation (FMIJ)?		✓	
H. Rust on sealing surfaces (SSCOR)?		✓	
I. Rust on metal parts (PITCO)?		✓	
J. Heat affected metal (HTAFF)?		✓	
K. Damaged metal sealing surface (SSMET)?		✓	

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, an "F" if the condition is observed on the aft dome or an "A" if the condition is observed on the fixed housing and any other information needed to completely describe the observation and its location:

1. POLYSULFIDE GOT PAST THE WIPER O-RING THROUGH THE VENT SLOTS 360 DEGREES AROUND THE JOINT. (PSEX)

NOTE: RADIAL BOLT HOLE PLUG WAS SMASHED INTO THE BOTTOM OF THE 354.6 DEGREE RADIAL BOLT HOLE. THE PLUG APPEARED TO BE IN THIS CONDITION BEFORE DISASSEMBLY, A HEAVY RUB MARK WAS FOUND ON THE PRIMARY O-RING AT 354.6 DEGREES.

SE

MORTON THIOKOL INC.
Space Operations

Detailed Nozzle-to-Case Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Scott Eden, Rocky Ash, D. Gary Nelson
Motor No.: QM-8 Date: 2-14-89
Joint: Nozzle-to-Case

PRIMARY O-RING -

Part No.: 1U75801-15 Serial No.: 0000004

	Yes	No
A. Erosion?		✓
B. Heat Affect?		✓
C. Assembly/Disassembly Damage?	✓	
D. Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)
C	132.7	0.003	0.002		0.050

SECONDARY O-RING

Part No.: 1U75801-16 Serial No.: 0000004

	Yes	No
A. Erosion?		✓
B. Heat Affect?		✓
C. Assembly/Disassembly Damage?		✓
D. Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

WIPER O-RING

Part No.: 1U75801-14 Serial No.: 0000004

	Yes	No
A. Erosion?		✓
B. Heat Affect?		✓
C. Assembly/Disassembly Damage?	✓	
D. Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)
C	255.2°	0.003	0.003		0.040
C	316.4°	0.002	0.001		0.040
C	354.3°	0.005	0.025		0.050

SE

Morton Thiokol Inc.

Space Operations

O-RING OBSERVATION CLARIFICATION FORM

Date: 2-15-89 Inspector(s): SCOTT EDEN, ROCKY ASH, D. GARY NELSON

Motor No.: QM-8

☐ Left (A) ☐ Right (B) Joint: NOZZLE / CASE

O-ring Location: ☑ Primary ☐ Secondary ☐ Capture Feature ☐ Wiper

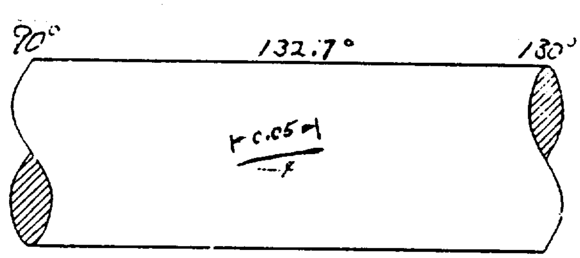
Part Number: 1U75801-15

Serial Number: 0000004

Depth:

Description: (SEE BELOW)

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.



CIRCUMFERENTIAL SCRATCH

L ≈ 0.050

W ≈ 0.002

D ≈ 0.003

Ø ≈ 8°

REV. ____

Morton Thiokol Inc.

Space Operations

SE

O-RING OBSERVATION CLARIFICATION FORM

Date: 2-14-89 Inspector(s): SCOTT EDEN, ROCKY ASH, D. GARY NELSON

Motor No.: QM-8

☐ Left (A) ☐ Right (B) Joint: NOZZLE / CASE

O-ring Location: ☐ Primary ☐ Secondary ☐ Capture Feature ☑ Wiper

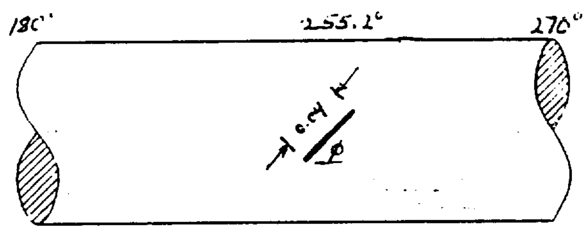
Part Number: 1U75801-14

Serial Number: 0000004

Depth:

Description: (SEE BELOW)

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.



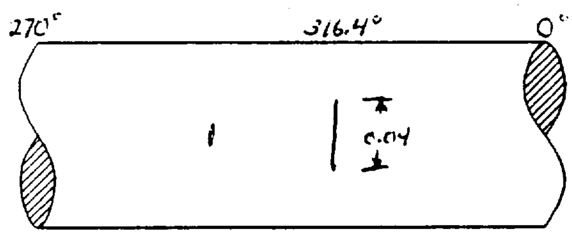
DIAGONAL SCRATCH

L ≈ 0.040

W ≈ 0.003

D ≈ 0.003

φ ≈ 35°

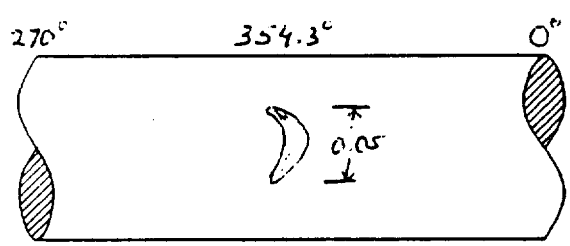


RADIAL CUT

L ≈ 0.040

W ≈ 0.001

D ≈ 0.002



RADIAL NICK

L ≈ 0.050

W ≈ 0.025

D ≈ 0.005

REV. ____

SE

Nozzle-To-Case Radial Bolt Stat-O-Seals - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 2-24-89

Joint: Nozzle-To-Case Radial Bolt (NOZ, STAT)

P/N 1U75374-02 Lot Number ECL 0003

Inspector(s): SCOTT EDEN, LON HYER, GARY NELSON

Bolt Stat-O-Seal Observations:

		Yes	No	Comment Number
A.	Eroded Stat-O-Seals (SORE)?		✓	
B.	Heat Affected Stat-O-Seals (HASOR)?		✓	
C.	Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?	✓		

If any of the above conditions exist, describe below:

C: Separation of circumferential flow mark ~ ∠≈190° (SDMG)
C: Circumferential tear in seal at retainer/rubber interface ~ ∠≈30° (SDIS)
C: Circumferential flow mark open under magnification (SDMG)
C: Radial flow mark opens when probed (SDMG)

Note: 35 out of 100 stat-o-seals had unacceptable flow line conditions.

REV. ____

Morton Thiokol Inc.
Space Operations

Ignition System Sealing Surface Condition - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 2/9/89

Joint: ☒ S&A to Adapter (S&A) ☐ Adapter to Case (IGN) ☐ Adapter to Chamber (IGI)

Inspector(s): G. Abawi, D. Rowsell

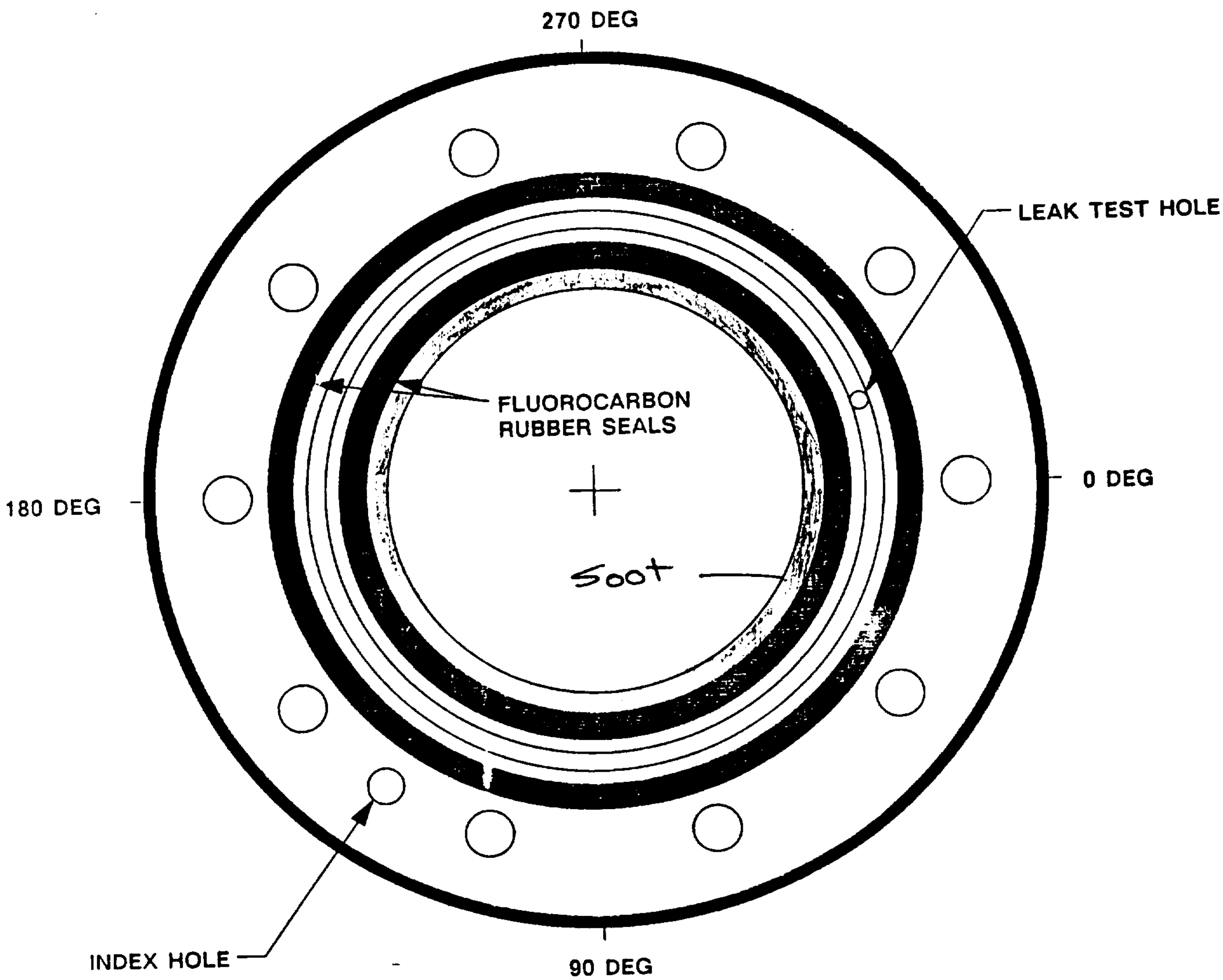
		Yes		No	Comment Number
A.	Soot in Proximity to / Past O-ring Groove (SPINS, SPPOR, SPSOR)?	____	✓		____
B.	Sooted Grease (HAGRE)?	____	✓		____
C.	Discolored Grease (DIGRE)?	____	✓		____
D.	Leak Check Port Obstructed (LPOBS)?	____	✓		____
E.	Foreign material in the sealing area during motor operation (FMIJ)?	____	✓		____
F.	Rust on sealing surfaces (SSCOR)?	____	✓		____
G.	Rust on metal parts (PITCO)?	____	✓		____
H.	Heat affected metal (HTAFF)?	____	✓		____
I.	Damaged metal sealing surface (SSMET)?	____	✓		____
J.	Damaged metal other than sealing surface (DAMML)?	____	✓		____

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, a "FWD" if the condition is observed on the S&A on the S&A joint or the adapter on the inner and outer joints or a "AFT" if the condition is observed on the adapter on the S&A joint, the chamber on the inner joint or the dome on the outer joint and any other information needed to describe the observation:

SE

Morton Thiokol Inc.
Space Operations

Motor No.: QM-8	Date: 2/9/89	Time: 0900
Corresponding Comment Number ______	Inspector(s): G. Abawi, D. Rowsell	

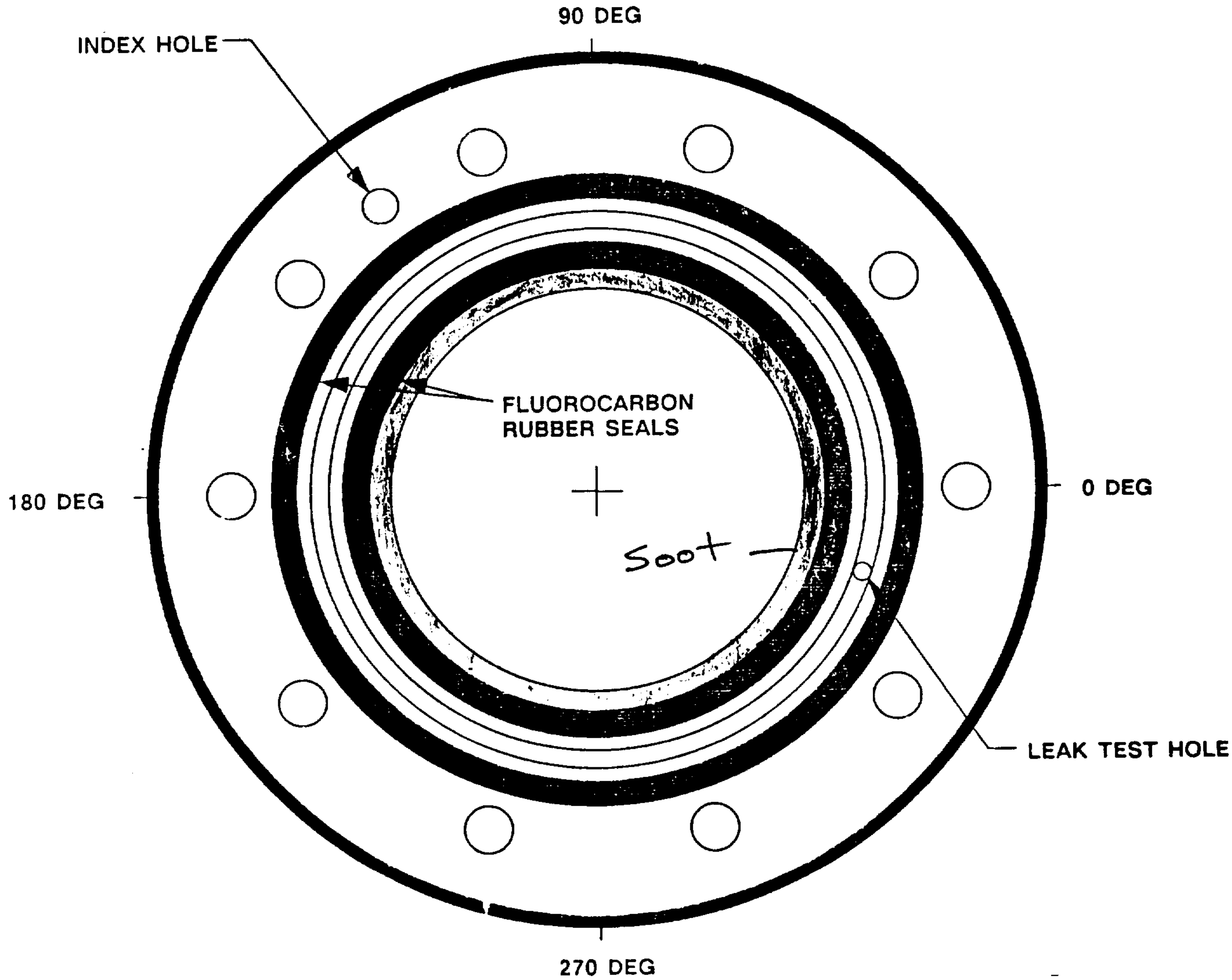


Observation Drawing Worksheet - Igniter S&A Gasket (Forward Face)

SE

Morton Thiokol Inc.
Space Operations

Motor No.: QM-8	Date: 2/9/89	Time: 0900
Corresponding Comment Number ______	Inspector(s): G. Abawi, D. Rowsell	



Observation Drawing Worksheet - Igniter S&A Gasket (Aft Face)

Detailed Igniter Gasket - Evaluation Checkoff Worksheet

Motor No.: QM-8	Date: 2-9-89
Gasket: ☐ Inner (IGI) ☐ Outer (IGN) ☑ S&A (S&A)	
P/N: 1U51925-01 S/N: 0000032	
Inspector(s): SCOTT EDEN, ROCKY ASH	

				Comment Number
I. Soot Past Seals (SPINS, SPPOR, SPSOR)?	___ yes	✓ no		___
II. Foreign Material (FMIJ)?	___ yes	✓ no		___
III. Seal Damage (PCUT, PDIS, PDMG, SCUT, SDIS, SDMG)?	___ yes	✓ no		___
IV. Heat Affected Seals or Retainer (PORE, HAPOR SORE, HASOR, HTAFF)?	___ yes	✓ no		___
V. Rust (SSCOR, PITCO)?	___ yes	✓ no		___
VI. Metal Damage (SSMET, DAMML)?	___ yes	✓ no		___

If yes, describe below:

Ignition System Sealing Surface Condition - Evaluation Checkoff Worksheet

Motor No.: QM-8		Date: 1 MAR 1989
Joint: ☐ S&A to Adapter (S&A)	☒ Adapter to Case (IGN)	☐ Adapter to Chamber (IGI)
Inspector(s): G. ABAWI		

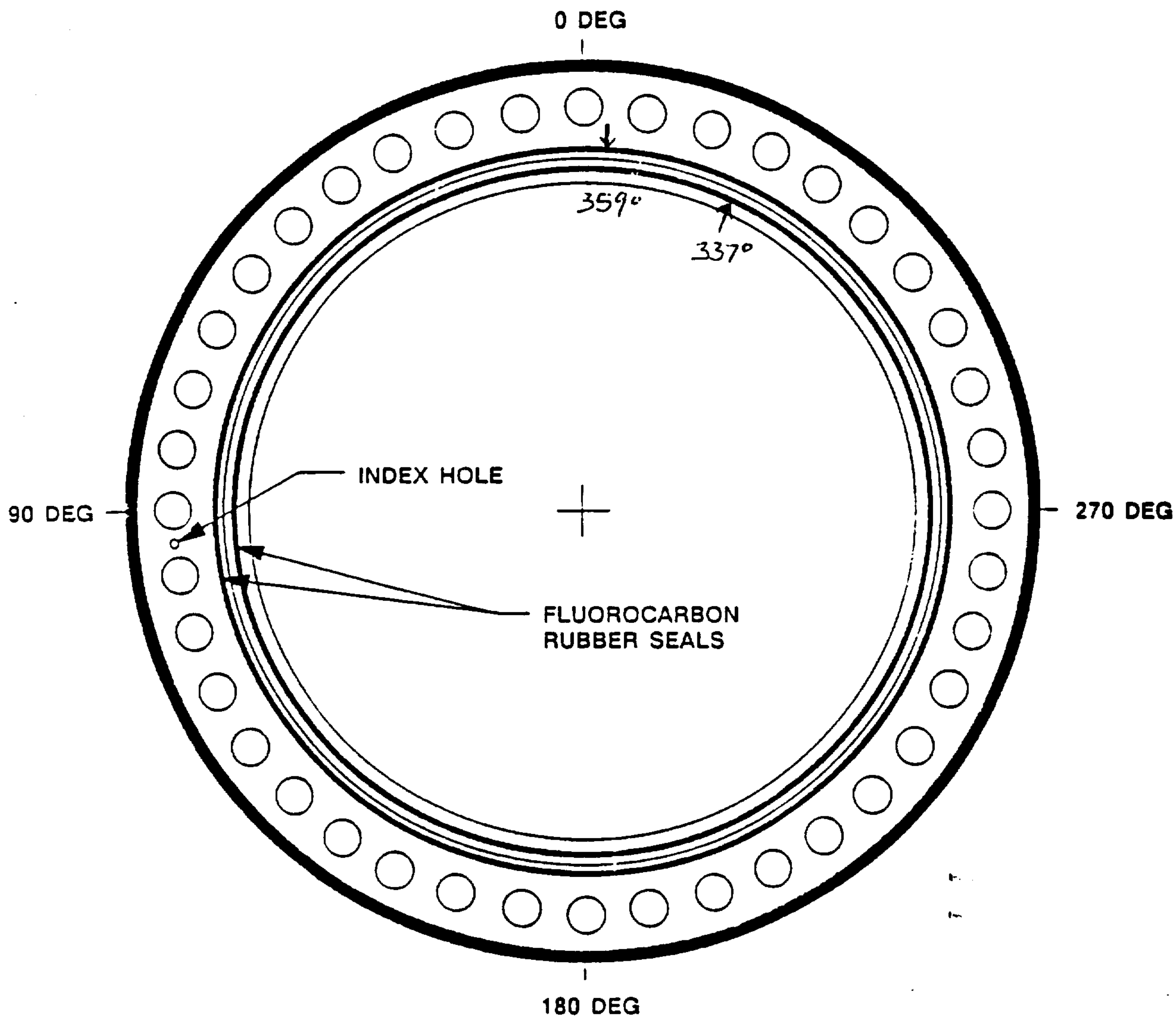
						Comment Number
A.	Soot in Proximity to / Past O-ring Groove (SPINS, SPPOR, SPSOR)?	___	Yes	✓	No	___
B.	Sooted Grease (HAGRE)?	___	Yes	✓	No	___
C.	Discolored Grease (DIGRE)?	___	Yes	✓	No	___
D.	Leak Check Port Obstructed (LPOBS)?	___	Yes	✓	No	___
E.	Foreign material in the sealing area during motor operation (FMIJ)?	___	Yes	✓	No	___
F.	Rust on sealing surfaces (SSCOR)?	___	Yes	✓	No	___
G.	Rust on metal parts (PITCO)?	___	Yes	✓	No	___
H.	Heat affected metal (HTAFF)?	___	Yes	✓	No	___
I.	Damaged metal sealing surface (SSMET)?	___	Yes	✓	No	___
J.	Damaged metal other than sealing surface (DAMML)?	___	Yes	✓	No	___

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, a "FWD" if the condition is observed on the S&A on the S&A joint or the adapter on the inner and outer joints or a "AFT" if the condition is observed on the adapter on the S&A joint, the chamber on the inner joint or the dome on the outer joint and any other information needed to describe the observation:

A blowhole through the putty occured at 15 degrees. No soot was found on either side of the gasket. Heavy soot deposits were found on the gasket inside edge.

Morton Thiokol Inc.
Space Operations

Motor No.: QM-8	Date: 20 April 1989	Time:
Corresponding Comment Number 1	Inspector(s): Wayne Sperry, Rocky Ash, Dan Pulleur	



Observation Drawing Worksheet - Igniter Outer Gasket (Aft Face)

Detailed Igniter Gasket - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 20 April 1989

Gasket: ☐ Inner (IGI) ☒ Outer (IGN) ☐ S&A (S&A)

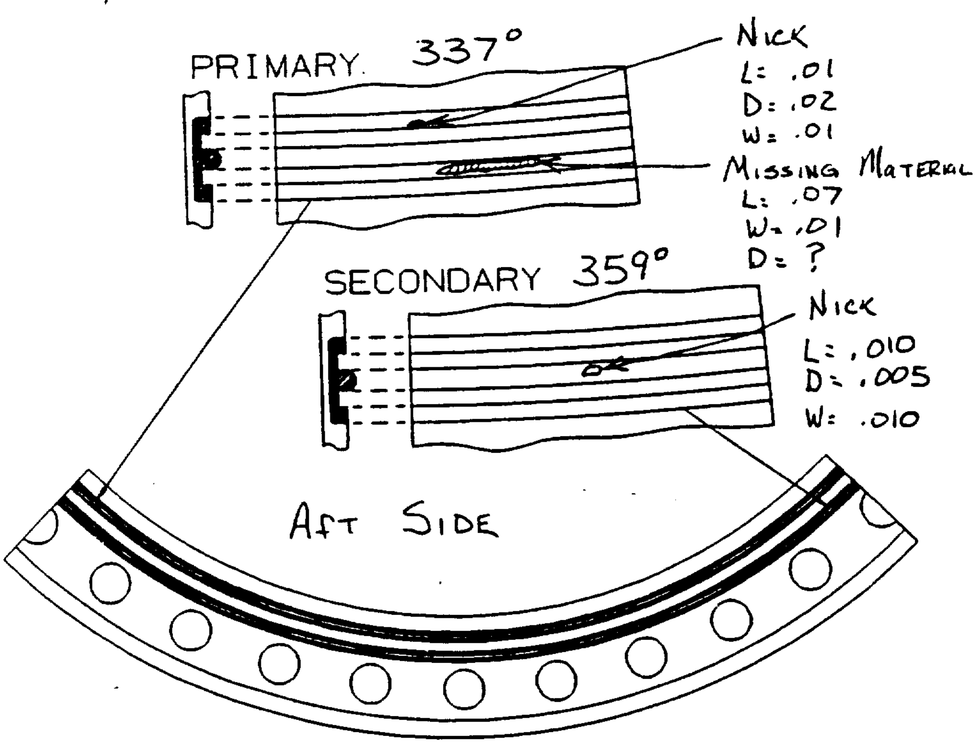
P/N: 1U51926-01 S/N: 0000040R1

Inspector(s): Wayne Speiry, Rocky Ash, Dan Helleger

					Comment Number
I.	Soot Past Seals (SPINS, SPPOR, SPSOR)?	___ yes	✓ no		
II.	Foreign Material (FMIJ)?	___ yes	✓ no		
III.	Seal Damage (PCUT, PDIS, PDMG, SCUT, SDIS, SDMG)?	✓ yes	___ no		1
IV.	Heat Affected Seals or Retainer (PORE, HAPOR SORE, HASOR, HTAFF)?	___ yes	✓ no		
V.	Rust (SSCOR, PITCO)?	___ yes	✓ no		
VI.	Metal Damage (SSMET, DAMML)?	___ yes	✓ no		

If yes, describe below:

Primary Seal Aft side missing material and a nick @ 337°
Secondary Seal Aft side nick @ 359°



Ignition System Sealing Surface Condition - Evaluation Checkoff Worksheet

Motor No.: QM-8	Date: 5-5-89
Joint: ☐ S&A to Adapter (S&A) ☐ Adapter to Case (IGN) ☒ Adapter to Chamber (IGI)	
Inspector(s): K. Baker	

		Yes	No	Comment Number
A.	Soot in Proximity to / Past O-ring Groove (SPINS, SPPOR, SPSOR)?		✓	
B.	Sooted Grease (HAGRE)?		✓	
C.	Discolored Grease (DIGRE)?		✓	
D.	Leak Check Port Obstructed (LPOBS)?		✓	
E.	Foreign material in the sealing area during motor operation (FMIJ)?		✓	
F.	Rust on sealing surfaces (SSCOR)?		✓	
G.	Rust on metal parts (PITCO)?	✓		1
H.	Heat affected metal (HTAFF)?		✓	
I.	Damaged metal sealing surface (SSMET)?		✓	
J.	Damaged metal other than sealing surface (DAMML)?		✓	

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, a "FWD" if the condition is observed on the S&A on the S&A joint or the adapter on the inner and outer joints or a "AFT" if the condition is observed on the adapter on the S&A joint, the chamber on the inner joint or the dome on the outer joint and any other information needed to describe the observation:

1 light surface corrosion on adapter at O.D. of Inner gasket, about 1/8 inch wide around entire circumference.

Morton Thiokol Inc.
Space Operations

Detailed Igniter Gasket - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 5/22/89

Gasket: ☑ Inner (IGI) ☐ Outer (IGN) ☐ S&A (S&A)

P/N: 1U51926-01 S/N: 0000054

Inspector(s): Rocky Ash, Wayne Sperry

				Comment Number
I. Soot Past Seals (SPINS, SPPOR, SPSOR)?	___ yes	✓ no		___
II. Foreign Material (FMIJ)?	___ yes	✓ no		___
III. Seal Damage (PCUT, PDIS, PDMG, SCUT, SDIS, SDMG)?	___ yes	✓ no		___
IV. Heat Affected Seals or Retainer (PORE, HAPOR SORE, HASOR, HTAFF)?	___ yes	✓ no		___
V. Rust (SSCOR, PITCO)?	___ yes	✓ no		___
VI. Metal Damage (SSMET, DAMML)?	___ yes	✓ no		___

If yes, describe below:

Morton Thiokol Inc.
Space Operations

Ignition System Stat-O-Seals - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 5-5-89

Joint: Adapter/Chamber (IGI) Case End: STAT

P/N 1U75374-01 Lot Number ECL 0010

Inspector(s): K. Baker

Bolt Stat-O-Seal Observations:

	Yes	No	Comment Number
A. Eroded Stat-O-Seals (SORE)?		✓	
B. Heat Affected Stat-O-Seals (HASOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?	✓		1

If any of the above conditions exist, describe below:

1. Typical disassemby damage was seen on all stat-O-seals

SE

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Space Operations

Nozzle Joint Condition - Evaluation Checkoff Worksheet

Inspector(s): K. Baker, J. Curry, L. Nelsen

Motor No.: QM-8 | Date: 2-6-89

Joint:
- ☐ Throat/Fwd Exit Cone (4)
- ☐ Fixed Housing/Aft End Ring (5)
- ☒ Fwd Exit Cone/Aft Exit Cone (1)
- ☐ Fwd End Ring/Nose Inlet (2)
- ☐ Nose Inlet/Throat (3)

Case Field Joint Observations:		Yes		No	Comment Number
A.	Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?	____	Yes	✓	No	____
B.	Sooted Grease (HAGRE)?	____	Yes	✓	No	____
C.	Discolored Grease (DIGRE)?	____	Yes	✓	No	____
D.	Leak Check Port Obstructed (LPOBS)?	____	Yes	✓	No	____
E.	Vent Port Obstructed (VPOBS)?	____	Yes	✓	No	____
F.	Foreign material in the sealing area during motor operation (FMIJ)?	____	Yes	✓	No	____
G.	Rust on sealing surfaces (SSCOR)?	____	Yes	✓	No	____
H.	Rust on metal parts (PITCO)?	____	Yes	✓	No	____
I.	Heat affected metal (HTAFF)?	____	Yes	✓	No	____
J.	Damaged metal sealing surface (SSMET)?	____	Yes	✓	No	____

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment letter, an "F" if the condition is observed on the forward end of the joint or an "A" if the condition is observed on the aft end of the joint and any other information needed to completely describe the observation and its location:

MORTON THIOKOL INC.

Space Operations

Detailed Nozzle Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Rocky Ash, Scott Eden, Wayne Sperry, D. Gary [illegible]

Motor No.: QM-8 | Date: 2-3-89

Joint:
- [x] Fwd Exit Cone/Aft Exit Cone
- [ ] Throat/Fwd Exit Cone
- [ ] Nose Inlet/Throat
- [ ] Fwd End Ring/Nose Inlet
- [ ] Fixed Housing/AFt End Ring

PRIMARY O-RING Part No.: 1U75150-03 Serial No.: C000019

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

SECONDARY O-RING (If Applicable) Part No.: 1U75150-04 Serial No.: C0000028

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

Notes / Comments

SE

Morton Thiokol Inc.
Space Operations

Nozzle Joint Condition - Evaluation Checkoff Worksheet

Inspector(s): LOWELL NELSEN, K. Baker

Motor No.: QM-8 | Date: 2/15/89

Joint:
- ☐ Throat/Fwd Exit Cone (4)
- ☐ Fixed Housing/Aft End Ring (5)
- ☐ Fwd Exit Cone/Aft Exit Cone (1)
- ☒ Fwd End Ring/Nose Inlet (2)
- ☐ Nose Inlet/Throat (3)

Case Field Joint Observations:	Yes	No	Comment Number
A. Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?	✓		1
B. Sooted Grease (HAGRE)?	✓		1
C. Discolored Grease (DIGRE)?		✓	
D. Leak Check Port Obstructed (LPOBS)?		✓	
E. Vent Port Obstructed (VPOBS)?		✓	
F. Foreign material in the sealing area during motor operation (FMIJ)?		✓	
G. Rust on sealing surfaces (SSCOR)?		✓	
H. Rust on metal parts (PITCO)?	✓		2.
I. Heat affected metal (HTAFF)?		✓	
J. Damaged metal sealing surface (SSMET)?		✓	

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment letter, an "F" if the condition is observed on the forward end of the joint or an "A" if the condition is observed on the aft end of the joint and any other information needed to completely describe the observation and its location:

1. Very small pressure path through RTV, started at 355 degrees then flowed Circumferentialy to 350 degrees to Allow pressure to reach primary O-ring groove. RTV Backfill looked Very good

2. metal discoloration of bearing flange at 110 degrees to 150 degrees And from 240 degrees to 280 degrees.

REV. ___

SE

MORTON THIOKOL INC.
Space Operations

Detailed Nozzle Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Wayne Sperry, Rocky Ash, D. Gary Nelson

Motor No.: QM-8 | Date: 2-17-89

Joint:
- ☐ Fwd Exit Cone/Aft Exit Cone
- ☐ Throat/Fwd Exit Cone
- ☐ Nose Inlet/Throat
- ☒ Fwd End Ring/Nose Inlet
- ☐ Fixed Housing/AFt End Ring

PRIMARY O-RING
Part No.: 1U75150-07 Serial No.: 0000014

	Yes	No
A. Erosion?		✓
B. Heat Affect?		✓
C. Assembly/Disassembly Damage?		✓
D. Other? Describe:	✓	

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)
D	297°	indeterminable	.001		2.67"

SECONDARY O-RING (If Applicable)
Part No.: 1U75150-08 Serial No.: 0000020

	Yes	No
A. Erosion?		✓
B. Heat Affect?		✓
C. Assembly/Disassembly Damage?		✓
D. Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

Notes / Comments

Morton Thiokol Inc.

Space Operations

O-RING OBSERVATION CLARIFICATION FORM

Date: 2-17-89 Inspector(s): Wayne Sperry, Rocky Ash, D. Gary Nelson

Motor No.:

☐ Left (A) ☐ Right (B) Joint: Fwd End Ring / Nose

O-ring Location: ☒ Primary ☐ Secondary ☐ Capture Feature ☐ Wiper

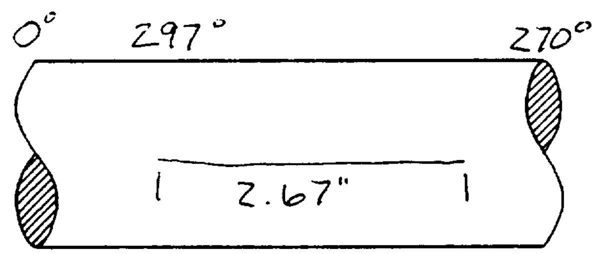
Part Number: 1U75150-07

Serial Number: 0000014

Depth:

Description: See Below

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.



W = .001

D = indeterminable

L = 2.67"

REV. ____

5E

Morton Thiokol Inc.
Space Operations

Nozzle Joint Condition - Evaluation Checkoff Worksheet

Inspector(s): LOWELL NELSEN, Kelly Baker

Motor No.: QM-8 Date: 2/15/89

Joint:
- ☐ Throat/Fwd Exit Cone (4)
- ☐ Fixed Housing/Aft End Ring (5)
- ☐ Fwd Exit Cone/Aft Exit Cone (1)
- ☐ Fwd End Ring/Nose Inlet (2)
- ☒ Nose Inlet/Throat (3)

Case Field Joint Observations:	Yes	No	Comment Number
A. Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		✓	
B. Sooted Grease (HAGRE)?		✓	
C. Discolored Grease (DIGRE)?		✓	
D. Leak Check Port Obstructed (LPOBS)?		✓	
E. Vent Port Obstructed (VPOBS)?		✓	
F. Foreign material in the sealing area during motor operation (FMIJ)?		✓	
G. Rust on sealing surfaces (SSCOR)?		✓	
H. Rust on metal parts (PITCO)?		✓	
I. Heat affected metal (HTAFF)?		✓	
J. Damaged metal sealing surface (SSMET)?		✓	

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment letter, an "F" if the condition is observed on the forward end of the joint or an "A" if the condition is observed on the aft end of the joint and any other information needed to completely describe the observation and its location:

MORTON THIOKOL INC.
Space Operations

Detailed Nozzle Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Rocky Ash, Wayne Sperry, Scott Eden, D. Gary Nelson

Motor No.: QM-8 | Date: 2-17-89

Joint:
- ☐ Fwd Exit Cone/Aft Exit Cone
- ☐ Throat/Fwd Exit Cone
- ☑ Nose Inlet/Throat
- ☐ Fwd End Ring/Nose Inlet
- ☐ Fixed Housing/AFt End Ring

PRIMARY O-RING

Part No.: 1U75150-10 Serial No.: 0000019

	Yes	No
A. Erosion?		✓
B. Heat Affect?		✓
C. Assembly/Disassembly Damage?		✓
D. Other? Describe:	✓	

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)
D	70.4°	indeterminable	.001		4.8
D	78.8°	.001	.001		.100

SECONDARY O-RING (If Applicable)

Part No.: 1U75150-09 Serial No.: 0000018

	Yes	No
A. Erosion?		✓
B. Heat Affect?		✓
C. Assembly/Disassembly Damage?		✓
D. Other? Describe:	✓	

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)
D	219.7°	.001	.001		.380

Notes / Comments

REVISION____

Morton Thiokol Inc.
Space Operations

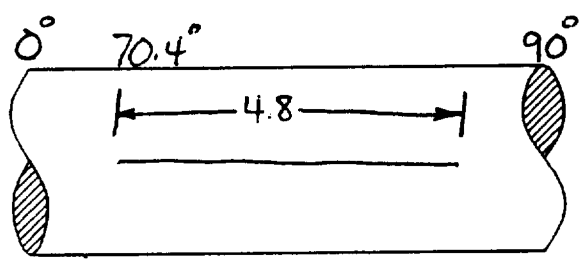
SE

O-RING OBSERVATION CLARIFICATION FORM

Date: 2-17-89
Inspector(s): Rocky Ash, Wayne Sperry, Scott Eden, D. Gary Nelson
Motor No.: QM-8
☐ Left (A) ☐ Right (B)
Joint: Nose Inlet/Throat
O-ring Location: ☑ Primary ☐ Secondary ☐ Capture Feature ☐ Wiper
Part Number: 1U75150-10
Serial Number: 0000019
Depth:
Description: See Below

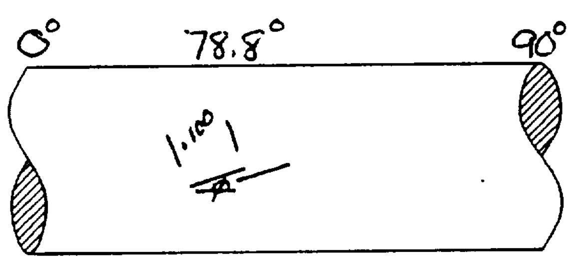
Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.

Circumferential scratch



L= 4.8
W= .001
D= indeterminable

Diagonal scratches



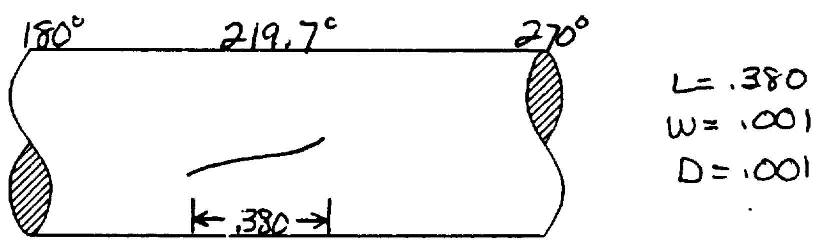
L= .100
W= .001
D= .001
ϕ = 10°

SE

O-RING OBSERVATION CLARIFICATION FORM

Date: 2-17-89 Inspector(s): Rocky Ash, Wayne Sperry, Scott Eden, D. Gary Nelson
Motor No.: QM-8
☐ Left (A) ☐ Right (B) Joint: Nose Inlet / Throat
O-ring Location: ☐ Primary ☑ Secondary ☐ Capture Feature ☐ Wiper
Part Number: 1U75150-09
Serial Number: 0000018
Depth:
Description: See Below

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.



SE

Morton Thiokol Inc.
Space Operations

Nozzle Joint Condition - Evaluation Checkoff Worksheet

Inspector(s): KELLY BAKER, LOWELL NELSEN

Motor No.: QM-8 | Date: 2/14/89

Joint:
- [x] Throat/Fwd Exit Cone (4)
- [ ] Fixed Housing/Aft End Ring (5)
- [ ] Fwd Exit Cone/Aft Exit Cone (1)
- [ ] Fwd End Ring/Nose Inlet (2)
- [ ] Nose Inlet/Throat (3)

Case Field Joint Observations:	Yes	No	Comment Number
A. Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?	✓		1
B. Sooted Grease (HAGRE)?		✓	
C. Discolored Grease (DIGRE)?		✓	
D. Leak Check Port Obstructed (LPOBS)?		✓	
E. Vent Port Obstructed (VPOBS)?		✓	
F. Foreign material in the sealing area during motor operation (FMIJ)?		✓	
G. Rust on sealing surfaces (SSCOR)?		✓	
H. Rust on metal parts (PITCO)?		✓	
I. Heat affected metal (HTAFF)?		✓	
J. Damaged metal sealing surface (SSMET)?		✓	

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment letter, an "F" if the condition is observed on the forward end of the joint or an "A" if the condition is observed on the aft end of the joint and any other information needed to completely describe the observation and its location:

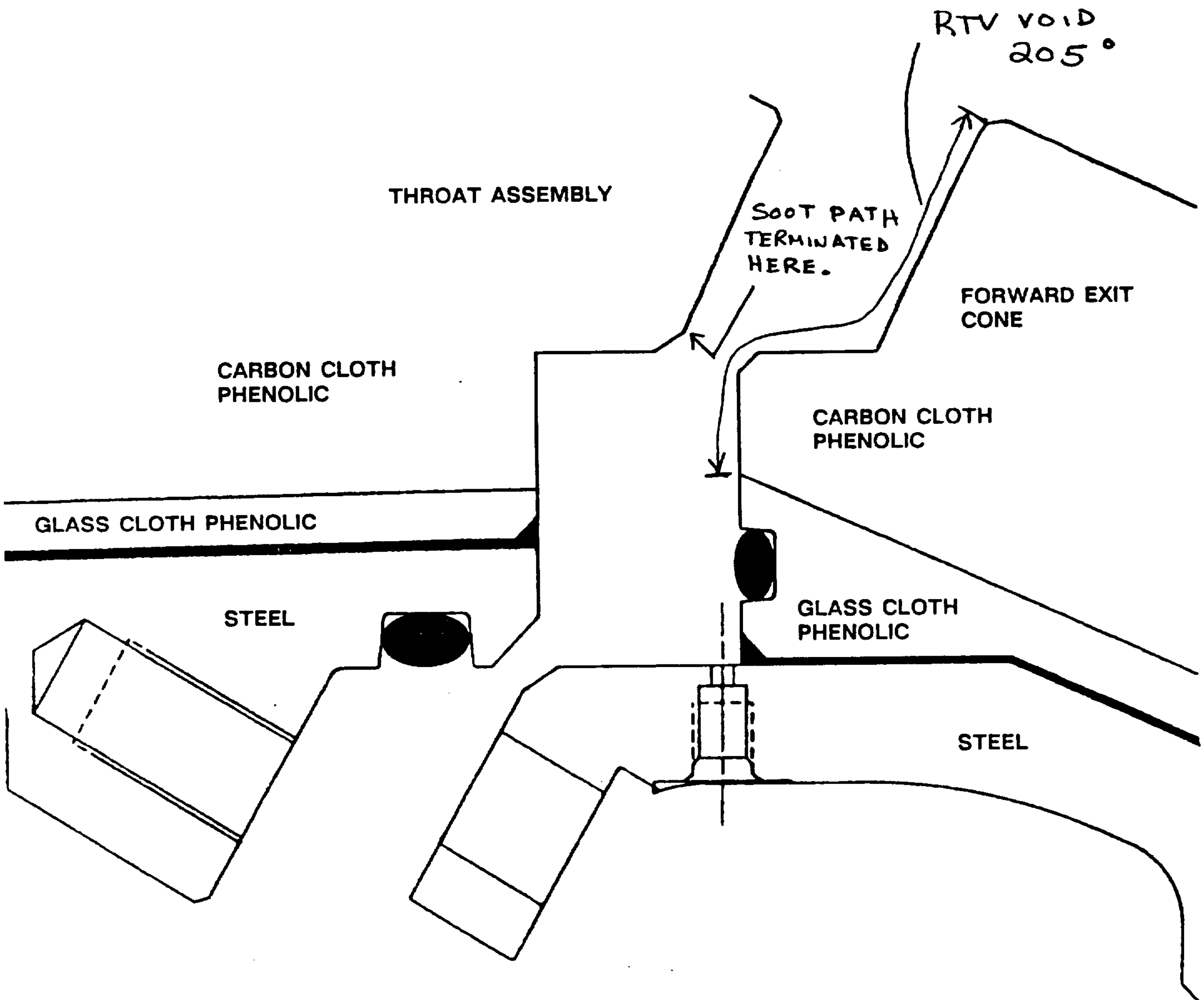
1. Grease penetrated the RTV bondline at 205° which created a RTV void to the primary o-ring. Soot did not reach the primary o-ring. See observation drawing worksheet.

REV. ____

SE

Morton Thiokol Inc.
Space Operations

Motor No.: QM-8	Date: 2/14/89	Time: 11:00
Corresponding Comment Number 1	Inspector(s): KELLY BAKER, LOWELL NELSEN	



Observation Drawing Worksheet – Throat/Forward Exit Cone Joint

MORTON THIOKOL INC.
Space Operations

Detailed Nozzle Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): SCOTT EDEN, WAYNE SPERRY, D. GARY NELSON

Motor No.: QM-8 | Date: 2-15-89

Joint:
- ☐ Fwd Exit Cone/Aft Exit Cone
- ☑ Throat/Fwd Exit Cone
- ☐ Nose Inlet/Throat
- ☐ Fwd End Ring/Nose Inlet
- ☐ Fixed Housing/AFt End Ring

PRIMARY O-RING Part No.: 1U75150-01 Serial No.: 0000020

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

SECONDARY O-RING (If Applicable) Part No.: 1U75150-02 Serial No.: 0000020

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

Notes / Comments

SE

Morton Thiokol Inc.
Space Operations

Nozzle Joint Condition - Evaluation Checkoff Worksheet

Inspector(s): KELLY BAKER, LOWELL NELSEN

Motor No.: QM-8 | Date: 2/14/89

Joint:
- [ ] Throat/Fwd Exit Cone (4)
- [x] Fixed Housing/Aft End Ring (5)
- [ ] Fwd Exit Cone/Aft Exit Cone (1)
- [ ] Fwd End Ring/Nose Inlet (2)
- [ ] Nose Inlet/Throat (3)

Case Field Joint Observations:	Yes	No	Comment Number
A. Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		✓	
B. Sooted Grease (HAGRE)?		✓	
C. Discolored Grease (DIGRE)?		✓	
D. Leak Check Port Obstructed (LPOBS)?		✓	
E. Vent Port Obstructed (VPOBS)?		✓	
F. Foreign material in the sealing area during motor operation (FMIJ)?		✓	
G. Rust on sealing surfaces (SSCOR)?		✓	
H. Rust on metal parts (PITCO)?		✓	
I. Heat affected metal (HTAFF)?		✓	
J. Damaged metal sealing surface (SSMET)?		✓	

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment letter, an "F" if the condition is observed on the forward end of the joint or an "A" if the condition is observed on the aft end of the joint and any other information needed to completely describe the observation and its location:

SE

MORTON THIOKOL INC.

Space Operations

Detailed Nozzle Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): WAYNE SPERRY, SCOTT EDEN, D. GARY NELSON

Motor No.: QM-8

Date: 2-15-89

Joint:
- ☐ Fwd Exit Cone/Aft Exit Cone
- ☐ Throat/Fwd Exit Cone
- ☐ Nose Inlet/Throat
- ☐ Fwd End Ring/Nose Inlet
- ☑ Fixed Housing/AFt End Ring

PRIMARY O-RING

Part No.: 1U75150-05 Serial No.: 0000027

A. Erosion? ____ Yes ✓ No

B. Heat Affect? ____ Yes ✓ No

C. Assembly/Disassembly Damage? ____ Yes ✓ No

D. Other? Describe: ____________ ____ Yes ✓ No

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

SECONDARY O-RING (If Applicable)

Part No.: 1U75150-06 Serial No.: 0000019

A. Erosion? ____ Yes ✓ No

B. Heat Affect? ____ Yes ✓ No

C. Assembly/Disassembly Damage? ____ Yes ✓ No

D. Other? Describe: ____________ ____ Yes ✓ No

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

Notes / Comments

SE

FIXED HOUSING/AFT END RING Stat-O-Seals - Evaluation Checkoff Worksheet

Motor No.: QM-8			Date: 2-24-89		
Joint: FIXED HOUSING/AFT END RING (STAT)					
P/N 1U75374-01	Lot Number ECL0010				
Inspector(s): SCOTT EDEN, ROCKY ASH					
Bolt Stat-O-Seal Observations:					Comment Number
A. Eroded Stat-O-Seals (SORE)?	___	Yes	✓	No	___
B. Heat Affected Stat-O-Seals (HASOR)?	___	Yes	✓	No	___
C. Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?	✓	Yes	___	No	___

If any of the above conditions exist, describe below:

All 72 stat-o-seals had extensive disassembly seal damage.

Morton Thiokol Inc.
Space Operations

Case Factory Joint Condition - Evaluation Checkoff Worksheet

Inspector(s): Alan Carlisle		
Motor No.: QM-8	Date: 4/24/89	Time: 2:00

Joint:

- [ ] Aft Dome Factory Joint (1817.6, ADS)
- [ ] ETA-To-Stiff. Factory Joint (1577.5, FSS)
- [ ] Fwd Segment Factory Joint (691.5, FFS)
- [x] Fwd Dome Factory Joint (531.5, FDS)
- [ ] Stiff.-To-Stiff. Factory Joint (1697.5, ASS)
- [ ] Aft Center Segment Factory Joint (1331.5, ACS)
- [ ] Forward Center Segment Factory Joint (1011.5, FCS)

Case field joint observations:	Yes	No	Comment Number
A. Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?	___	X	___
B. Sooted Grease (HAGRE)?	___	X	___
C. Discolored Grease (DIGRE)?	___	X	___
D. Leak Check Port Obstructed (LPOBS)?	___	X	___
E. Foreign material in the sealing area during motor operation (FMIJ)?	___	X	___
F. Rust on sealing surfaces (SSCOR)?	___	X	___
G. Rust on metal parts (PITCO)?	___	X	___
H. Heat affected metal (HTAFF)?	___	X	___
I. Damaged metal sealing surface (SSMET)?	___	X	___

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, a "T" if the condition is observed on the tang or a "C" if the condition is observed on the clevis and any other information needed to describe the observation:

Factory Joint – Evaluation Checkoff Worksheet

Inspector(s): Alan Carlisle

Motor No.: QM-8 | Date: 4/27/85 Time: 2:00

Joint:

- [ ] Aft Dome Factory Joint (1817.6, ADS)
- [ ] Stiff.-to-Stiff. Factory Joint (1697.5, ASS)
- [ ] ETA-to-Stiff. Factory Joint (1577.5, FSS)
- [ ] Aft Center Segment Factory Joint (1331.5, ACS)
- [ ] Fwd Segment Factory Joint (691.5, FFS)
- [ ] Forward Center Segment Factory Joint (1011.5, FCS)
- [x] Fwd Dome Factory Joint (531.5, FDS)

I.	Corrosion On Metal Parts (PITCO)?	___ yes	X no
II.	Sealing Surface Corrosion (SSCOR)?	___ yes	X no
III.	Metal Damage (DAMML)?	___ yes	X no
IV.	Sealing Surface Metal Damage (SSMET)?	___ yes	X no
V.	Metal Slivers In Pin Holes (MSIPH)?	___ yes	X no
VI.	Other?	___ yes	X no

Describe: ______________________

If yes, record the data below. Describe the observed condition using the observation code of the corresponding condition from above and the letter "C" if the condition is observed on the clevis or "T" if the condition is observed on the tang (i.e. PITCO-T). Field joint tang and clevis zones are mapped out on the second page of this form.

Comment Number	Description (Use symbols from above)	Degree Start Location (Deg.)	Degree Stop Location (Deg.)	Zone (See zone description)

Notes / Comments:

- [ ] See attached sheet(s)

Detailed Case Factory Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Rocky Ash, Wayne Sperry, Dan Pulleyn

Motor No.: QM-8 | Date: 4/25/89

Factory Joint:

- [x] Forward Dome Factory Joint (531.5)
- [ ] Forward Segment Factory Joint (691.5)
- [ ] Forward Center Segment Factory Joint (1011.5)
- [ ] Aft Center Segment Factory Joint (1331.5)
- [ ] Aft Segment Factory Joint (1577.5)
- [ ] Aft Segment Factory Joint (1697.5)
- [ ] Aft Dome Factory Joint (1817.6)

PRIMARY O-RING

Part No.: 1U75150-25 Serial No.: 0000264

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

SECONDARY O-RING

Part No.: 1U75150-25 Serial No.: 0000265

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

Notes / Comments

Morton Thiokol Inc.
Space Operations

Case Factory Joint Condition - Evaluation Checkoff Worksheet

Inspector(s): Alan Carlisle

Motor No.: QM-8 | Date: 4/24/89 | Time: 2330

Joint:

- ☐ Aft Dome Factory Joint (1817.6, ADS)
- ☐ Stiff.-To-Stiff. Factory Joint (1697.5, ASS)
- ☐ ETA-To-Stiff. Factory Joint (1577.5, FSS)
- ☐ Aft Center Segment Factory Joint (1331.5, ACS)
- ☒ Fwd Segment Factory Joint (691.5, FFS)
- ☐ Forward Center Segment Factory Joint (1011.5, FCS)
- ☐ Fwd Dome Factory Joint (531.5, FDS)

Case field joint observations:		Yes		No	Comment Number
A.	Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		Yes	X	No	
B.	Sooted Grease (HAGRE)?		Yes	X	No	
C.	Discolored Grease (DIGRE)?		Yes	X	No	
D.	Leak Check Port Obstructed (LPOBS)?		Yes	X	No	
E.	Foreign material in the sealing area during motor operation (FMIJ)?		Yes	X	No	
F.	Rust on sealing surfaces (SSCOR)?		Yes	X	No	
G.	Rust on metal parts (PITCO)?		Yes	X	No	
H.	Heat affected metal (HTAFF)?		Yes	X	No	
I.	Damaged metal sealing surface (SSMET)?		Yes	X	No	

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, a "T" if the condition is observed on the tang or a "C" if the condition is observed on the clevis and any other information needed to describe the observation:

Factory Joint - Evaluation Checkoff Worksheet

Inspector(s): Alan Carlisle

Motor No.: QM-8 | Date: 4/24/89 Time: 2330

Joint:

- ☐ Aft Dome Factory Joint (1817.6, ADS)
- ☐ Stiff.-to-Stiff. Factory Joint (1697.5, ASS)
- ☐ ETA-to-Stiff. Factory Joint (1577.5, FSS)
- ☐ Aft Center Segment Factory Joint (1331.5, ACS)
- ☒ Fwd Segment Factory Joint (691.5, FFS)
- ☐ Forward Center Segment Factory Joint (1011.5, FCS)
- ☐ Fwd Dome Factory Joint (531.5, FDS)

		yes	no
I.	Corrosion On Metal Parts (PITCO)?	____	X
II.	Sealing Surfaca Corrosion (SSCOR)?	____	X
III.	Metal Damage (DAMML)?	____	X
IV.	Sealing Surface Metal Damage (SSMET)?	____	X
V.	Metal Slivers In Pin Holes (MSIPH)?	____	X
VI.	Other?	____	X

Describe: ______________________________

If yes, record the data below. Describe the observed condition using the observation code of the corresponding condition from above and the letter "C" if the condition is observed on the clevis or "T" if the condition is observed on the tang (i.e. PITCO-T). Field joint tang and clevis zones are mapped out on the second page of this form.

Comment Number	Description (Use symbols from above)	Degree Start Location (Deg.)	Degree Stop Location (Deg.)	Zone (See zone description)

Notes / Comments:

☐ See attached sheet(s)

Detailed Case Factory Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Wayne Sperry, Rocky Ash, Jan Pullegin

Motor No.: QM-8

Date: 4-25-89

Factory Joint:

- [ ] Forward Dome Factory Joint (531.5)
- [ ] Forward Center Segment Factory Joint (1011.5)
- [ ] Aft Segment Factory Joint (1577.5)
- [ ] Aft Dome Factory Joint (1817.6)
- [x] Forward Segment Factory Joint (691.5)
- [ ] Aft Center Segment Factory Joint (1331.5)
- [ ] Aft Segment Factory Joint (1697.5)

PRIMARY O-RING Part No.: 1U75150-25 Serial No.: 0000247

	Yes	No
A. Erosion?		✓
B. Heat Affect?		✓
C. Assembly/Disassembly Damage?		✓
D. Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

SECONDARY O-RING Part No.: 1U75150-25 Serial No.: 0000216

	Yes	No
A. Erosion?		✓
B. Heat Affect?		✓
C. Assembly/Disassembly Damage?		✓
D. Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

Notes / Comments

Morton Thiokol Inc.
Space Operations

Case Factory Joint Condition - Evaluation Checkoff Worksheet

Inspector(s): Alan Carlisle
Motor No.: QM-8 | Date: 5/9/89 | Time: 1100

Joint:
- ☐ Aft Dome Factory Joint (1817.6, ADS)
- ☐ ETA-To-Stiff. Factory Joint (1577.5, FSS)
- ☐ Fwd Segment Factory Joint (691.5, FFS)
- ☐ Fwd Dome Factory Joint (531.5, FDS)
- ☐ Stiff.-To-Stiff. Factory Joint (1697.5, ASS)
- ☐ Aft Center Segment Factory Joint (1331.5, ACS)
- ☒ Forward Center Segment Factory Joint (1011.5, FCS)

Case field joint observations:	Yes	No	Comment Number
A. Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISCR, SPSOR)?	___	X	___
B. Sooted Grease (HAGRE)?	___	X	___
C. Discolored Grease (DIGRE)?	___	X	___
D. Leak Check Port Obstructed (LPOBS)?	___	X	___
E. Foreign material in the sealing area during motor operation (FMIJ)?	___	X	___
F. Rust on sealing surfaces (SSCOR)?	___	X	___
G. Rust on metal parts (PITCO)?	___	X	___
H. Heat affected metal (HTAFF)?	___	X	___
I. Damaged metal sealing surface (SSMET)?	___	X	___

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, a "T" if the condition is observed on the tang or a "C" if the condition is observed on the clevis and any other information needed to describe the observation:

Morton Thiokol Inc.
Space Operations

Factory Joint - Evaluation Checkoff Worksheet

Inspector(s): Allen Carlisle

Motor No.: QM-8 | Date: 5/9/89

Joint:

- ☐ Aft Dome Factory Joint (1817.6, ADS)
- ☐ Stiff.-to-Stiff. Factory Joint (1697.5, ASS)
- ☐ ETA-to-Stiff. Factory Joint (1577.5, FSS)
- ☐ Aft Center Segment Factory Joint (1331.5, ACS)
- ☐ Fwd Segment Factory Joint (691.5, FFS)
- ☒ Forward Center Segment Factory Joint (1011.5, FCS)
- ☐ Fwd Dome Factory Joint (531.5, FDS)

		yes	no
I.	Corrosion On Metal Parts (PITCO)?	___	X
II.	Sealing Surface Corrosion (SSCOR)?	___	X
III.	Metal Damage (DAMML)?	___	X
IV.	Sealing Surface Metal Damage (SSMET)?	___	X
V.	Metal Slivers In Pin Holes (MSIPH)?	___	X
VI.	Other?	___	X

Describe: ____________________

If yes, record the data below. Describe the observed condition using the observation code of the corresponding condition from above and the letter "C" if the condition is observed on the clevis or "T" if the condition is observed on the tang (i.e. PITCO-T). Field joint tang and clevis zones are mapped out on the second page of this form.

Comment Number	Description (Use symbols from above)	Degree Start Location (Deg.)	Degree Stop Location (Deg.)	Zone (See zone description)

Notes / Comments:

☐ See attached sheet(s)

MORTON THIOKOL INC.
Space Operations

Detailed Case Factory Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Rocky Ash, Wayne Sperry, Dan Pulleyn

Motor No.: QM-8 | Date: 5/10/89

Factory Joint:

- ☐ Forward Dome Factory Joint (531.5)
- ☐ Forward Segment Factory Joint (691.5)
- ☑ Forward Center Segment Factory Joint (1011.5)
- ☐ Aft Center Segment Factory Joint (1331.5)
- ☐ Aft Segment Factory Joint (1577.5)
- ☐ Aft Segment Factory Joint (1697.5)
- ☐ Aft Dome Factory Joint (1817.5)

PRIMARY O-RING Part No.: 1U75150-25 Serial No.: 0000293

		Yes		No
A.	Erosion?			✓
B.	Heat Affect?			✓
C.	Assembly/Disassembly Damage?			✓
D.	Other? Describe:			✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

SECONDARY O-RING Part No.: 1U75150-25 Serial No.: 0000250

		Yes		No
A.	Erosion?			✓
B.	Heat Affect?			✓
C.	Assembly/Disassembly Damage?			✓
D.	Other? Describe:			✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

Notes / Comments

REVISION_____

Morton Thiokol Inc.
Space Operations

Case Factory Joint Condition - Evaluation Checkoff Worksheet

Inspector(s): Alan Carlisle | Time: 1130
Motor No.: QM-8 | Date: 4/14/89

Joint:
- ☐ Aft Dome Factory Joint (1817.6, ADS)
- ☐ ETA-To-Stiff. Factory Joint (1577.5, FSS)
- ☐ Fwd Segment Factory Joint (691.5, FFS)
- ☐ Fwd Dome Factory Joint (531.5, FDS)
- ☐ Stiff.-To-Stiff. Factory Joint (1697.5, ASS)
- ☒ Aft Center Segment Factory Joint (1331.5, ACS)
- ☐ Forward Center Segment Factory Joint (1011.5, FCS)

Case field joint observations:

		Yes	No	Comment Number
A.	Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		X	
B.	Sooted Grease (HAGRE)?		X	
C.	Discolored Grease (DIGRE)?		X	
D.	Leak Check Port Obstructed (LPOBS)?		X	
E.	Foreign material in the sealing area during motor operation (FMIJ)?	X		1
F.	Rust on sealing surfaces (SSCOR)?		X	
G.	Rust on metal parts (PITCO)?	X		2
H.	Heat affected metal (HTAFF)?		X	
I.	Damaged metal sealing surface (SSMET)?		X	

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, a "T" if the condition is observed on the tang or a "C" if the condition is observed on the clevis and any other information needed to describe the observation:

1) E-C: Metallic foreign material between forward wall of groove and Primary O-ring @ 7°

2) G-C: Light corrosion in clevis root entire circumference
G-T: Light corrosion downstream of sealing surface entire circumference

Rev. ____

Morton Thiokol Inc.
Space Operations

Factory Joint - Evaluation Checkoff Worksheet

Inspector(s): Alan Carlisle

Motor No.: QM-8 | Date: 4/14/85 Khe! 1130

Joint:

- [ ] Aft Dome Factory Joint (1817.6, ADS)
- [ ] Stiff.-to-Stiff. Factory Joint (1697.5, ASS)
- [ ] ETA-to-Stiff. Factory Joint (1577.5, FSS)
- [x] Aft Center Segment Factory Joint (1331.5, ACS)
- [ ] Fwd Segment Factory Joint (691.5, FFS)
- [ ] Forward Center Segment Factory Joint (1011.5, FCS)
- [ ] Fwd Dome Factory Joint (531.5, FDS)

		yes	no
I.	Corrosion On Metal Parts (PITCO)?	X	
II.	Sealing Surface Corrosion (SSCOR)?		X
III.	Metal Damage (DAMML)?		X
IV.	Sealing Surface Metal Damage (SSMET)?		X
V.	Metal Slivers In Pin Holes (MSIPH)?		X
VI.	Other?		X

Describe: ____

If yes, record the data below. Describe the observed condition using the observation code of the corresponding condition from above and the letter "C" if the condition is observed on the clevis or "T" if the condition is observed on the tang (i.e. PITCO-T). Field joint tang and clevis zones are mapped out on the second page of this form.

Comment Number	Description (Use symbols from above)	Degree Start Location (Deg.)	Degree Stop Location (Deg.)	Zone (See zone description)
	1-C	0	360	H
	1-T	0	360	B

Notes / Comments:

- [ ] See attached sheet(s)

REV. ____

Detailed Case Factory Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Rocky Ash, Wayne Sperry, Dan Pulleyn
Motor No.: QM-8 Date: 4/18/89

Factory Joint:
- ☐ Forward Dome Factory Joint (531.5)
- ☐ Forward Center Segment Factory Joint (1011.5)
- ☐ Aft Segment Factory Joint (1577.5)
- ☐ Aft Dome Factory Joint (1817.6)
- ☐ Forward Segment Factory Joint (691.5)
- ☑ Aft Center Segment Factory Joint (1331.5)
- ☐ Aft Segment Factory Joint (1697.5)

PRIMARY O-RING Part No.: 1U75150-25 Serial No.: 0000252

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe: ______		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

SECONDARY O-RING Part No.: 1U75150-25 Serial No.: 0000241

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe: ______		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

Notes / Comments

Morton Thiokol Inc.
Space Operations

Case Factory Joint Condition - Evaluation Checkoff Worksheet

Inspector(s): Alan Carlisle, Dave Rowsell

Motor No.: QM-8 | Date: 3/2/88 | Time: 1330

Joint:

- ☐ Aft Dome Factory Joint (1817.5, ADS)
- ☐ Stiff.-To-Stiff. Factory Joint (1697.5, ASS)
- ☒ ETA-To-Stiff. Factory Joint (1577.5, FSS)
- ☐ Aft Center Segment Factory Joint (1331.5, ACS)
- ☐ Fwd Segment Factory Joint (691.5, FFS)
- ☐ Forward Center Segment Factory Joint (1011.5, FCS)
- ☐ Fwd Dome Factory Joint (531.5, FDS)

Case field joint observations:

	Observation	Yes	No	Comment Number
A.	Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		X	
B.	Sooted Grease (HAGRE)?		X	
C.	Discolored Grease (DIGRE)?		X	
D.	Leak Check Port Obstructed (LPOBS)?		X	
E.	Foreign material in the sealing area during motor operation (FMIJ)?		X	
F.	Rust on sealing surfaces (SSCOR)?		X	
G.	Rust on metal parts (PITCO)?	X		1,2
H.	Heat affected metal (HTAFF)?		X	
I.	Damaged metal sealing surface (SSMET)?		X	

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, a "T" if the condition is observed on the tang or a "C" if the condition is observed on the clevis and any other information needed to describe the observation:

1) Intermittent and spotty light to medium corrosion on outer clevis leg.

2) Light corrosion in clevis bottom at 101°-107°

Morton Thiokol Inc.
Space Operations

Factory Joint – Evaluation Checkoff Worksheet

Inspector(s): Alan Carlisle, Dave Rowsell

Motor No.: QM-8 | Date: 3/2/89

Joint:

- [ ] Aft Dome Factory Joint (1817.6, ADS)
- [x] ETA-to-Stiff. Factory Joint (1577.5, FSS)
- [ ] Fwd Segment Factory Joint (691.5, FFS)
- [ ] Fwd Dome Factory Joint (531.5, FDS)
- [ ] Stiff.-to-Stiff. Factory Joint (1697.5, ASS)
- [ ] Aft Center Segment Factory Joint (1331.5, ACS)
- [ ] Forward Center Segment Factory Joint (1011.5, FCS)

		yes	no
I.	Corrosion On Metal Parts (PITCO)?	X	
II.	Sealing Surface Corrosion (SSCOR)?		X
III.	Metal Damage (DAMML)?	X	
IV.	Sealing Surface Metal Damage (SSMET)?		X
V.	Metal Slivers In Pin Holes (MSIPH)?		X
VI.	Other?		X

Describe: ____

If yes, record the data below. Describe the observed condition using the observation code of the corresponding condition from above and the letter "C" if the condition is observed on the clevis or "T" if the condition is observed on the tang (i.e. PITCO-T). Field joint tang and clevis zones are mapped out on the second page of this form.

Comment Number	Description (Use symbols from above)	Degree Start Location (Deg.)	Degree Stop Location (Deg.)	Zone (See zone description)
1	PITCO-C	Intermittent and Spotty		M
2	PITCO-C	101	102	H
3	DAMML-C	18, 24, 38	316	F
3	DAMML-C	38, 316		E

Notes / Comments:
1) Intermittent and Spotty, light to medium
2) Light corrosion
3) Scratches

- [ ] See attached sheet(s)

REV. ____

MORTON THIOKOL INC.

Detailed Case Factory Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Wayne Sperry, Rocky Ash, D. Gary Nelson

Motor No.: QM-8 | Date: 3/6/89

Factory Joint:

- ☐ Forward Dome Factory Joint (531.5)
- ☐ Forward Segment Factory Joint (691.5)
- ☐ Forward Center Segment Factory Joint (1011.5)
- ☐ Aft Center Segment Factory Joint (1331.5)
- ☒ Aft Segment Factory Joint (1577.5)
- ☐ Aft Segment Factory Joint (1697.5)
- ☐ Aft Dome Factory Joint (1817.6)

PRIMARY O-RING Part No.: 1U75150-25 Serial No.: 0000280

	Yes	No
A. Erosion?		✓
B. Heat Affect?		✓
C. Assembly/Disassembly Damage?		✓
D. Other? Describe: ______		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

SECONDARY O-RING Part No.: 1U75150-25 Serial No.: 0000283

	Yes	No
A. Erosion?		✓
B. Heat Affect?		✓
C. Assembly/Disassembly Damage?		✓
D. Other? Describe: ______		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

Notes / Comments

REVISION ____

Morton Thiokol Inc.
Space Operations

Case Factory Joint Condition - Evaluation Checkoff Worksheet

Inspector(s): Alan Carlisle, Dave Rowsell | Time: 0600

Motor No.: QM-8 | Date: 3/2/89

Joint:

- [ ] Aft Dome Factory Joint (1817.6, ADS)
- [x] Stiff.-To-Stiff. Factory Joint (1697.5, ASS)
- [ ] ETA-To-Stiff. Factory Joint (1577.5, FSS)
- [ ] Aft Center Segment Factory Joint (1331.5, ACS)
- [ ] Fwd Segment Factory Joint (691.5, FFS)
- [ ] Forward Center Segment Factory Joint (1011.5, FCS)
- [ ] Fwd Dome Factory Joint (531.5, FDS)

Case field joint observations:	Yes	No	Comment Number
A. Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		X	
B. Sooted Grease (HAGRE)?		X	
C. Discolored Grease (DIGRE)?		X	
D. Leak Check Port Obstructed (LPOBS)?		X	
E. Foreign material in the sealing area during motor operation (FMIJ)?	X		1
F. Rust on sealing surfaces (SSCOR)?		X	
G. Rust on metal parts (PITCO)?	X		2
H. Heat affected metal (HTAFF)?		X	
I. Damaged metal sealing surface (SSMET)?		X	

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, a "T" if the condition is observed on the tang or a "C" if the condition is observed on the clevis and any other information needed to describe the observation:

1) FMIJ-C: Fiber on land between O-ring grooves

2) Light corrosion downstream of Secondary groove at 15°, 21°, 32°, 36°, 45°, 84°, 147-175

Morton Thiokol Inc.
Space Operations

Factory Joint – Evaluation Checkoff Worksheet

Inspector(s): Alan Carlisle, Dave Rowsell

Motor No.: QM-8 | Date: 3/2/89

Joint:

- [ ] Aft Dome Factory Joint (1817.6, ADS)
- [x] Stiff.-to-Stiff. Factory Joint (1697.5, ASS)
- [ ] ETA-to-Stiff. Factory Joint (1577.5, FSS)
- [ ] Aft Center Segment Factory Joint (1331.5, ACS)
- [ ] Fwd Segment Factory Joint (691.5, FFS)
- [ ] Forward Center Segment Factory Joint (1011.5, FCS)
- [ ] Fwd Dome Factory Joint (531.5, FDS)

I.	Corrosion On Metal Parts (PITCO)?	X yes	___ no
II.	Sealing Surfaca Corrosion (SSCOR)?	___ yes	X no
III.	Metal Damage (DAMML)?	X yes	___ no
IV.	Sealing Surface Metal Damage (SSMET)?	___ yes	X no
V.	Metal Slivers In Pin Holes (MSIPH)?	___ yes	X no
VI.	Other?	___ yes	X no

Describe: ____________________

If yes, record the data below. Describe the observed condition using the observation code of the corresponding condition from above and the letter "C" if the condition is observed on the clevis or "T" if the condition is observed on the tang (i.e. PITCO-T). Field joint tang and clevis zones are mapped out on the second page of this form.

Comment Number	Description (Use symbols from above)	Degree Start Location (Deg.)	Degree Stop Location (Deg.)	Zone (See zone description)
1	PITCO-C	271	132	M
2	PITCO-C	10-21, 32, 36-45, 84, 142-175		G
3	DAMML-C	358	358	F

Notes / Comments:

1) Intermittent medium corrosion on outer clevis between noted degree locations.
2) Intermittent light corrosion downstream of secondary groove to chamfer
3) Scratch

- [ ] See attached sheet(s)

Detailed Case Factory Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Rocky Ash, Wayne Sperry, D. Gary Nelson

Motor No.: QM-8 | Date: 3-6-89

Factory Joint:

- [ ] Forward Dome Factory Joint (531.5)
- [ ] Forward Segment Factory Joint (691.5)
- [ ] Forward Center Segment Factory Joint (1011.5)
- [ ] Aft Center Segment Factory Joint (1331.5)
- [ ] Aft Segment Factory Joint (1577.5)
- [x] Aft Segment Factory Joint (1697.5)
- [ ] Aft Dome Factory Joint (1817.6)

PRIMARY O-RING Part No.: 1U75150-25 Serial No.: 0000292

	Yes	No
A. Erosion?		✓
B. Heat Affect?		✓
C. Assembly/Disassembly Damage?		✓
D. Other? Describe: ______		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

SECONDARY O-RING Part No.: 1U75150-25 Serial No.: 0000276

	Yes	No
A. Erosion?		✓
B. Heat Affect?		✓
C. Assembly/Disassembly Damage?		✓
D. Other? Describe: ______		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

Notes / Comments

Morton Thiokol Inc.
Space Operations

Case Factory Joint Condition - Evaluation Checkoff Worksheet

Inspector(s): Alan Carlisle, Dave Rowsell

Motor No.: QM-8 | Date: 3/2/89 | Time: 0336

Joint:

☒ Aft Dome Factory Joint (1817.6, ADS) ☐ Stiff.-To-Stiff. Factory Joint (1697.5, ASS)
☐ ETA-To-Stiff. Factory Joint (1577.5, FSS) ☐ Aft Center Segment Factory Joint (1331.5, ACS)
☐ Fwd Segment Factory Joint (691.5, FFS) ☐ Forward Center Segment Factory Joint (1011.5, FCS)
☐ Fwd Dome Factory Joint (531.5, FDS)

Case field joint observations:		Yes		No	Comment Number
A.	Soot in Proximity to / Past O-ring Groove (SPINS, SICOR SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?	___	Yes	X	No	___
B.	Sooted Grease (HAGRE)?	___	Yes	X	No	___
C.	Discolored Grease (DIGRE)?	___	Yes	X	No	___
D.	Leak Check Port Obstructed (LPOBS)?	___	Yes	X	No	___
E.	Foreign material in the sealing area during motor operation (FMIJ)?	___	Yes	X	No	___
F.	Rust on sealing surfaces (SSCOR)?	___	Yes	X	No	___
G.	Rust on metal parts (PITCO)?	X	Yes	___	No	1
H.	Heat affected metal (HTAFF)?	___	Yes	X	No	___
I.	Damaged metal sealing surface (SSMET)?	___	Yes	X	No	___

If any of the above conditions exist, record applicable dimensions below. Describe the observed condition using a comment number, a "T" if the condition is observed on the tang or a "C" if the condition is observed on the clevis and any other information needed to describe the observation:

1) C-F - Intermitten medium corrosion on outside of outer clevis leg.

Rev. ___

Factory Joint – Evaluation Checkoff Worksheet

Inspector(s): Alan Carlisle, Dave Rowsell

Motor No.: QM-8 | Date: 3/2/89

Joint:

- [x] Aft Dome Factory Joint (1817.5, ADS)
- [ ] Stiff.-to-Stiff. Factory Joint (1697.5, ASS)
- [ ] ETA-to-Stiff. Factory Joint (1577.5, FSS)
- [ ] Aft Center Segment Factory Joint (1331.5, ACS)
- [ ] Fwd Segment Factory Joint (691.5, FFS)
- [ ] Forward Center Segment Factory Joint (1011.5, FCS)
- [ ] Fwd Dome Factory Joint (531.5, FDS)

		yes	no
I.	Corrosion On Metal Parts (PITCO)?	X	
II.	Sealing Surface Corrosion (SSCOR)?		X
III.	Metal Damage (DAMML)?	X	
IV.	Sealing Surface Metal Damage (SSMET)?		X
V.	Metal Slivers In Pin Holes (MSIPH)?		X
VI.	Other?		X

Describe: ______

If yes, record the data below. Describe the observed condition using the observation code of the corresponding condition from above and the letter "C" if the condition is observed on the clevis or "T" if the condition is observed on the tang (i.e. PITCO-T). Field joint tang and clevis zones are mapped out on the second page of this form.

Comment Number	Description (Use symbols from above)	Degree Start Location (Deg.)	Degree Stop Location (Deg.)	Zone (See zone description)
1	PITCO-#C	Intermitten entire circumference		M
2	DAMML-C	8,22,24,26,28,30,34,36,38,40,44,304, 306 308-316 346		F
3	DAMML-T	302	346	A/B

Notes / Comments:

1) medium corrosion
2) Scratches
3) Scratches + pits downstream of sealing surface to chamfer corner

- [ ] See attached sheet(s)

REV. ____

Detailed Case Factory Joint O-ring (Post-Removal) - Evaluation Checkoff Worksheet (Wasatch A-2 Bldg)

Inspector(s): Rocky Ash, Wayne Sperry, D. Gary Nelson

Motor No.: QM-8 | Date: 3-6-89

Factory Joint:

- [ ] Forward Dome Factory Joint (531.5)
- [ ] Forward Segment Factory Joint (691.5)
- [ ] Forward Center Segment Factory Joint (1011.5)
- [ ] Aft Center Segment Factory Joint (1331.5)
- [ ] Aft Segment Factory Joint (1577.5)
- [ ] Aft Segment Factory Joint (1697.5)
- [x] Aft Dome Factory Joint (1817.6)

PRIMARY O-RING Part No.: 1U75150-25 Serial No.: 0000107

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

SECONDARY O-RING Part No.: 1U75150-25 Serial No.: 0000291

		Yes	No
A.	Erosion?		✓
B.	Heat Affect?		✓
C.	Assembly/Disassembly Damage?		✓
D.	Other? Describe:		✓

If any of the above conditions exist, record applicable dimensions below:

Condition (A, B, C or D)	Degree Location	Maximum Depth	Circumferential Width	CSVAP	Distance (Length)

Notes / Comments

Morton Thiokol Inc.
Space Operations

Detailed Port Plug O-ring (Post-Removal) - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 3-13-89

Joint: [X] S&A to Adapter (S&A) [ ] Adapter to Case (IGN) [ ] Adapter to Chamber (IGI)

Plug: [X] Leak Check(LEAK) Degree 126

Inspector(s): Scott Eden, Rocky Ash, GARY NELSON

PRIMARY O-RING

Part No.: ______ Lot No.: ______

		Yes	No	Comment Number
A.	Erosion (PORE)?			
B.	Heat Affect (HAPOR)?			
C.	Cuts, Assembly/Disassembly Damage (PCUT, PDMG, PDIS)?			

If any of the above conditions exist, record below:

SECONDARY O-RING (or Shoulder)

Part No.: 1U50228-25 Lot No.: ECL0013

		Yes	No	Comment Number
A.	Erosion (SORE)?		✓	
B.	Heat Affect (HASOR)?		✓	
C.	Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?	✓		1

If any of the above conditions exist, record below:

1. O-ring had O.D. circumferential impression

CLOSURE SCREW O-RING

Part No.: ______ Lot No.: ______

		Yes	No	Comment Number
A.	Erosion (CORE)?			
B.	Heat Affect (HACOR)?			
C.	Cuts, Assembly/Disassembly Damage (CCUT, CDMG, CDIS)?			

If any of the above conditions exist, record below:

Detailed Port Plug O-ring (Post-Removal) - Evaluation Checkoff Worksheet

Date: 3-13-89

Motor No.: QM-8

Joint: ☒ S&A to Adapter (S&A) ☐ Adapter to Case (IGN) ☐ Adapter to Chamber (IGI)

Plug: ☒ Leak Check(LEAK) Degree 306

Inspector(s): Scott Eden, Rocky Ash, GARY NELSON

PRIMARY O-RING

Part No.: ______ Lot No.: ______

	Yes	No	Comment Number
A. Erosion (PORE)?			
B. Heat Affect (HAPOR)?			
C. Cuts, Assembly/Disassembly Damage (PCUT, PDMG, PDIS)?			

If any of the above conditions exist, record below:

SECONDARY O-RING (or Shoulder)

Part No.: 1U50228-25 Lot No.: ______

	Yes	No	Comment Number
A. Erosion (SORE)?		✓	
B. Heat Affect (HASOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?	✓		1

If any of the above conditions exist, record below:

1. See o-ring observation form.

CLOSURE SCREW O-RING

Part No.: ______ Lot No.: ______

	Yes	No	Comment Number
A. Erosion (CORE)?			
B. Heat Affect (HACOR)?			
C. Cuts, Assembly/Disassembly Damage (CCUT, CDMG, CDIS)?			

If any of the above conditions exist, record below:

Morton Thiokol Inc.
Space Operations

O-RING OBSERVATION CLARIFICATION FORM

Date 3-13-89 Inspector(s) Scott Eden, Rocky Ash, GARY Nelson

Motor No. QM-8

Joint (Or Plug and Degree): 306° S&A

O-Ring Location: ☐ Primary ☒ Secondary ☐ Capture Feature ☐ Wiper ☐ Closure

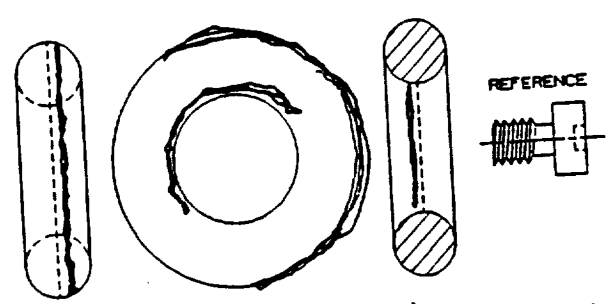
Part Number 1U50228-25

Serial or Lot Number:

Description: See below.

Note: Very, light coat of grease. O-ring was installed wrong size O-ring (Too large "W" diameter) O-ring positioned on thread side

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.



Morton Thiokol Inc.
Space Operations

Detailed Port Plug O-ring (Post-Removal) - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 3-13-89

Joint: ☐ S&A to Adapter (S&A) ☐ Adapter to Case (IGN) ☐ Adapter to Chamber (IGI)

Plug: ☒ Leak Check(LEAK) Degree SIIs at 18° and 198°

Inspector(s): Scott Eden, Rocky Ash, GARY Nelson

PRIMARY O-RING

Part No.: 1U50228-18 Lot No.: ______

	Yes	No	Comment Number
A. Erosion (PORE)?		✓	
B. Heat Affect (HAPOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (PCUT, PDMG, PDIS)?		✓	

If any of the above conditions exist, record below:

NOTE: This observation is for both SII plugs, primary seals.

SECONDARY O-RING (or Shoulder)

Part No.: 1U50228-38 Lot No.: ______

	Yes	No	Comment Number
A. Erosion (SORE)?		✓	
B. Heat Affect (HASOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?		✓	

If any of the above conditions exist, record below:

NOTE: This observation is for both SII plugs, secondary seals.

CLOSURE SCREW O-RING

Part No.: ______ Lot No.: ______

	Yes	No	Comment Number
A. Erosion (CORE)?			
B. Heat Affect (HACOR)?			
C. Cuts, Assembly/Disassembly Damage (CCUT, CDMG, CDIS)?			

If any of the above conditions exist, record below:

Case Joint Plug and Plug Hole - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 2-6-89

Inspector(s): K. Bak

Joint:

- [X] Forward Field Joint (851.5, FWD)
- [ ] Aft Field Joint (1491.5, AFT)
- [ ] Center Field Joint (1171.5, CTR)
- [ ] Nozzle-to-Case Joint (1875.2, NOZ)

Plug: [X] Vent Port (VENT) [ ] Leak Check (LEAK) | Degree Location: 135

P/N: 1U76425-03 Lot Number: ECL0001

Plug, plug hole observations:

		Yes	No	Comment Number
I.	Soot Past Seals(SPINS, SICOR, SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		✓	
II.	Foreign Material (FMIJ)?		✓	
III.	Heat Affected Plug (HAPOR, HASOR, HACOR)?		✓	
IV.	Rust on sealing surfaces (SSCOR)?		✓	
V.	Rust on metal parts (PITCO)?		✓	
VI.	Damaged metal sealing surface (SSMET)?		✓	
VII.	Damaged metal other than sealing surface (DAMML)?		✓	
VIII.	Plug hole damage, deformed threads (DBHOL)?		✓	

If any of the above conditions exist, describe below:

SE

Morton Thiokol Inc.
Space Operations

Detailed Port Plug O-ring (Post-Removal) - Evaluation Checkoff Worksheet

Motor No.: QM-6 | Date: 6 FEB 87

Joint: [X] FWD [ ] CTR [ ] AFT [ ] NOZ

Plug: [X] Vent Port(VENT) [ ] Leak Check(LEAK) Degree 135

Inspector(s): Scott Eden, Rocky Ash, Gary Nelson

PRIMARY O-RING

Part No.: 1050228-44 Lot No.: ECL0004

	Yes	No	Comment Number
A. Erosion (PORE)?		✓	
B. Heat Affect (HAPOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (PCUT, PDMG, PDIS)?	✓		1.

If any of the above conditions exist, record below:

1. Extrusion Damage (EXPECTED)

SEE ATTACHED CLARIFICATION SHEET

SECONDARY O-RING (or Shoulder)

Part No.: 1050228-15 Lot No.: ECL0053

	Yes	No	Comment Number
A. Erosion (SORE)?		✓	
Heat Affect (HASOR)?		✓	
Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?		✓	

If any of the above conditions exist, record below:

CLOSURE SCREW O-RING

Part No.: 1050228-25 Lot No.: ECL0015

	Yes	No	Comment Number
A. Erosion (CORE)?		✓	
B. Heat Affect (HACOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (CCUT, CDMG, CDIS)?		✓	

If any of the above conditions exist, record below:

NOTE: O-RING WAS POSITIONED ON THREAD SIDE OF PLUG GROOVE.

5E

Morton Thiokol Inc.
Space Operations

O-RING OBSERVATION CLARIFICATION FORM

Date 6 FEB 89 Inspector(s) Scott Eden, Rocky Ash, Gary Nelson

Motor No. QM-8

Joint (Or Plug and Degree): 135° FWD FIELD

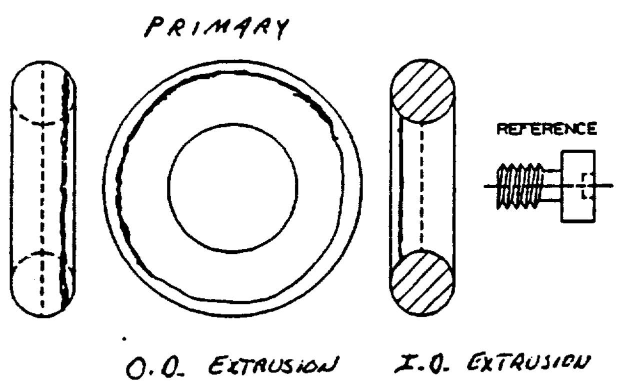
O-Ring Location: ☒ Primary ☐ Secondary ☐ Capture Feature ☐ Wiper ☐ Closure

Part Number: 1U50228-44

Serial or Lot Number: ECL 0009

Description: Typical O.D. & I.D. Extrusion damage (Acceptable)

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.



REV. ____

5E

Morton Thiokol Inc.
Space Operations

Case Joint Plug and Plug Hole – Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 2-6-89

Inspector(s): K. Baker

Joint:

- ☐ Forward Field Joint (851.5, FWD)
- ☒ Center Field Joint (1171.5, CTR)
- ☐ Aft Field Joint (1491.5, AFT)
- ☐ Nozzle-to-Case Joint (1875.2, NOZ)

Plug: ☒ Vent Port (VENT) ☐ Leak Check (LEAK) | Degree Location: 135

P/N: 1U76425-03 | Lot Number: ECL0004

Plug, plug hole observations:

		Yes	No	Comment Number
I.	Soot Past Seals(SPINS, SICOR, SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		✓	
II.	Foreign Material (FMIJ)?		✓	
III.	Heat Affected Plug (HAPOR, HASOR, HACOR)?		✓	
IV.	Rust on sealing surfaces (SSCOR)?		✓	
V.	Rust on metal parts (PITCO)?		✓	
VI.	Damaged metal sealing surface (SSMET)?		✓	
VII.	Damaged metal other than sealing surface (DAMML)?		✓	
VIII.	Plug hole damage, deformed threads (DBHOL)?		✓	

If any of the above conditions exist, describe below:

Morton Thiokol Inc.
Space Operations

Detailed Port Plug O-ring (Post-Removal) - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 6 FEB 89

Joint: ☐ FWD ☒ CTR ☐ AFT ☐ NOZ

Plug: ☒ Vent Port(VENT) ☐ Leak Check(LEAK) Degree 135°

Inspector(s): Scott Eden, Rocky Ash, Gary Nelson

PRIMARY O-RING

Part No.: 1U50228-44 Lot No.: ECL 0004

	Yes	No	Comment Number
A. Erosion (PORE)?		✓	
B. Heat Affect (HAPOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (PCUT, PDMG, PDIS)?		✓	1.

If any of the above conditions exist, record below:

1. I.D. and O.D. Circumferential impression (EXPECTED)

SECONDARY O-RING (or Shoulder)

Part No.: 1U50228-15 Lot No.: ECL 0053

	Yes	No	Comment Number
A. Erosion (SORE)?		✓	
Heat Affect (HASOR)?		✓	
Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?		✓	

If any of the above conditions exist, record below:

CLOSURE SCREW O-RING

Part No.: 1U50228-25 Lot No.: ECL 0015

	Yes	No	Comment Number
A. Erosion (CORE)?		✓	
B. Heat Affect (HACOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (CCUT, CDMG, CDIS)?		✓	

If any of the above conditions exist, record below:

Morton Thiokol Inc.
Space Operations

Case Joint Plug and Plug Hole - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 2-6-88

Inspector(s): K. Baker

Joint:

- ☐ Forward Field Joint (851.5, FWD)
- ☐ Center Field Joint (1171.5, CTR)
- ☒ Aft Field Joint (1491.5, AFT)
- ☐ Nozzle-to-Case Joint (1875.2, NOZ)

Plug: ☒ Vent Port (VENT) ☐ Leak Check (LEAK) | Degree Location: 135

P/N: 1U76425-03 | Lot Number: ECL0001

Plug, plug hole observations:	Yes	No	Comment Number
I. Soot Past Seals(SPINS, SICOR, SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		✓	
II. Foreign Material (FMIJ)?		✓	
III. Heat Affected Plug (HAPOR, HASOR, HACOR)?		✓	
IV. Rust on sealing surfaces (SSCOR)?		✓	
V. Rust on metal parts (PITCO)?		✓	
VI. Damaged metal sealing surface (SSMET)?		✓	
VII. Damaged metal other than sealing surface (DAMML)?	✓		1
VIII. Plug hole damage, deformed threads (DBHOL)?		✓	

If any of the above conditions exist, describe below:

1. Damage to 1U76425-01 during installation, looks like installation tool slipped out of groove during torquing operations.

REV. ___

SE

Morton Thiokol Inc.
Space Operations

Detailed Port Plug O-ring (Post-Removal) - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 6 FEB 89

Joint: ☐ FWD ☐ CTR ☒ AFT ☐ NOZ

Plug: ☒ Vent Port(VENT) ☐ Leak Check(LEAK) Degree 135°

Inspector(s): Scott Eden, Rocky Ash, Gary Nelson

PRIMARY O-RING

Part No.: 1050228-44 Lot No.: ECL0004

	Yes	No	Comment Number
A. Erosion (PORE)?		✓	
B. Heat Affect (HAPOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (PCUT, PDMG, PDIS)?	✓		1.

If any of the above conditions exist, record below:

1. Expected Extrusion DAMAGE
SEE ATTACHED SHEET

SECONDARY O-RING (or Shoulder)

Part No.: 1050228-15 Lot No.: ECL0047

	Yes	No	Comment Number
A. Erosion (SORE)?		✓	
Heat Affect (HASOR)?			
Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?		✓	

If any of the above conditions exist, record below:

CLOSURE SCREW O-RING

Part No.: 1050228-25 Lot No.: ECL 0015

	Yes	No	Comment Number
A. Erosion (CORE)?		✓	
B. Heat Affect (HACOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (CCUT, CDMG, CDIS)?		✓	

If any of the above conditions exist, record below:

NOTE: O-RING WAS POSITIONED ON PLUG SIDE OF O-RING GROOVE.

SE

Morton Thiokol Inc.
Space Operations

O-RING OBSERVATION CLARIFICATION FORM

Date 6 FEB 89 Inspector(s) Scott Eden, Rocky Ash, Gary Nelson

Motor No. QM-8

Joint (Or Plug and Degree): 135° AFT FIELD

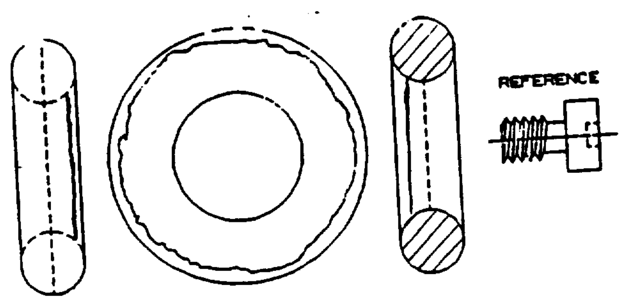
O-Ring Location: ☒ Primary ☐ Secondary ☐ Capture Feature ☐ Wiper ☐ Closure

Part Number: 1050228-44

Serial or Lot Number: ECL 0004

Description: Typical Expected Extrusion Damage

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.



O.D. circumferential extrusion

SE

Morton Thiokol Inc.
Space Operations

Case Joint Plug and Plug Hole – Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 13 FEB 89

Inspector(s): DAVID ROWSELL

Joint:

- ☐ Forward Field Joint (851.5, FWD)
- ☐ Aft Field Joint (1491.5, AFT)
- ☐ Center Field Joint (1171.5, CTR)
- ☒ Nozzle-to-Case Joint (1875.2, NOZ)

Plug: ☒ Vent Port (VENT) ☐ Leak Check (LEAK) | Degree Location: 43.2°

P/N: 1U76425-03 | Lot Number: ECL 0001

Plug, plug hole observations:

		Yes	No	Comment Number
I.	Soot Past Seals(SPINS, SICOR, SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		✓	
II.	Foreign Material (FMIJ)?		✓	
III.	Heat Affected Plug (HAPOR, HASOR, HACOR)?		✓	
IV.	Rust on sealing surfaces (SSCOR)?		✓	
V.	Rust on metal parts (PITCO)?		✓	
VI.	Damaged metal sealing surface (SSMET)?		✓	
VII.	Damaged metal other than sealing surface (DAMML)?		✓	
VIII.	Plug hole damage, deformed threads (DBHOL)?		✓	

If any of the above conditions exist, describe below:

SE

Morton Thiokol Inc.
Space Operations

Detailed Port Plug O-ring (Post-Removal) - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 17 FEB 89

Joint: ☐ FWD ☐ CTR ☐ AFT ☒ NOZ

Plug: ☒ Vent Port(VENT) ☐ Leak Check(LEAK) Degree 43.2°

Inspector(s): Scott Eden, Rocky Ash, Gary Nelson

PRIMARY O-RING

Part No.: 1050228-44 Lot No.: ECL0003

	Yes	No	Comment Number
A. Erosion (PORE)?		✓	
B. Heat Affect (HAPOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (PCUT, PDMG, PDIS)?	✓		1

If any of the above conditions exist, record below:

1. TYPICAL O.D & I.D. CIRCUMFERENTIAL EXTRUSION (EXPECTED)

SECONDARY O-RING (or Shoulder)

Part No.: 1050228-15 Lot No.: ECL0056

	Yes	No	Comment Number
A. Erosion (SORE)?		✓	
Heat Affect (HASOR)?		✓	
Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?		✓	2

If any of the above conditions exist, record below:

1. Note. Radial Flow MARK FOUND (MANUFACTURING PROBLEM) Radial Flow MARK NOT OPEN.

SEE ATTACHED CLARIFICATION SHEET

CLOSURE SCREW O-RING

Part No.: 1050228-25 Lot No.: ECL0014

	Yes	No	Comment Number
A. Erosion (CORE)?		✓	
B. Heat Affect (HACOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (CCUT, CDMG, CDIS)?		✓	

If any of the above conditions exist, record below:

Morton Thiokol Inc.
Space Operations

O-RING OBSERVATION CLARIFICATION FORM

Date 17 FEB 89 Inspector(s) Scott Eden, Rocky Asl, Gary Nelson
Motor No. QM-8
Joint (Or Plug and Degree): 43.2° NOZZLE TO CASE
O-Ring Location: ☐ Primary ☒ Secondary ☐ Capture Feature ☐ Wiper ☐ Closure
Part Number: 1U50228-15
Serial or Lot Number: ECL 0056
Description:
RADIAL FLOW MARK ON SECONDARY O-RING,
ADJ VENT PORT PLUG.

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.

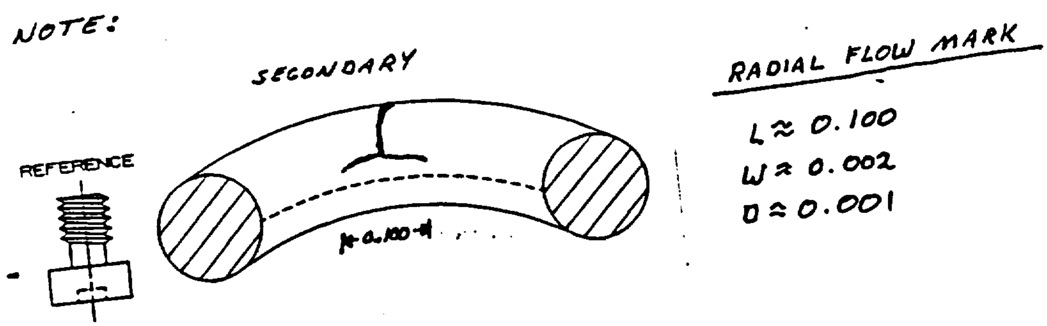


Figure B-3

Nozzle Joint Plug and Plug Hole – Evaluation Checkoff Worksheet

Inspector(s): KELLY BAKER, LOWELL NELSEN,

Motor No.: QM-8 | Date: 15 FEB 89

Joint:
- ☐ Throat/Fwd Exit Cone (4)
- ☐ Fixed Housing/Aft End Ring (5)
- ☒ Fwd Exit Cone/Aft Exit Cone (1)
- ☐ Fwd End Ring/Nose Inlet (2)
- ☐ Nose Inlet/Throat (3)

Degree Location: 262.3° P/N: 1U50159-02 ~~S/N~~ L/N: ECL0001

O-ring: P/N: 1U50228-25 L/N: ECL0012

Plug, plug hole observations:

				Comment Number
I. Soot Past Seals(SPINS, SICOR, SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?	___	Yes	✓ No	___
II. Foreign Material (FMIJ)?	___	Yes	✓ No	___
III. Heat Affected Plug (HAPOR, HASOR, HACOR)?	___	Yes	✓ No	___
IV. Rust on sealing surfaces (SSCOR)?	___	Yes	✓ No	___
V. Rust on metal parts (PITCO)?	___	Yes	✓ No	___
VI. Damaged metal sealing surface (SSMET)?	___	Yes	✓ No	___
VII. Damaged metal other than sealing surface (DAMML)?	___	Yes	✓ No	___
VIII. Plug hole damage, deformed threads (DBHOL)?	___	Yes	✓ No	___

If any of the above conditions exist, describe below:

Morton Thiokol Inc.
Space Operations

SE

Detailed Port Plug O-ring (Post-Removal) - Evaluation Checkoff Worksheet

Motor No.: QM-8   Date: 6 FEB 89

Joint: -
- ☐ Throat/Fwd Exit Cone (4)
- ☐ Fixed Housing/Aft End Ring (5)
- ☒ Fwd Exit Cone/Aft Exit Cone (1)
- ☐ Fwd End Ring/Nose Inlet (2)
- ☐ Nose Inlet/Throat (3)

Plug: ☒ Leak Check(LEAK)   Degree 262.5°

Inspector(s): Scott Eden, Rocky Ash, Gary Nelson

PRIMARY O-RING

Part No.: ____ Lot No.: ____

	Yes	No	Comment Number
A. Erosion (PORE)?			
B. Heat Affect (HAPOR)?			
C. Cuts, Assembly/Disassembly Damage (PCUT, PDMG, PDIS)?			

If any of the above conditions exist, record below:

SECONDARY O-RING (or Shoulder)

Part No.: 1U50228-25 Lot No.: ECL 0012

	Yes	No	Comment Number
A. Erosion (SORE)?		✓	
B. Heat Affect (HASOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?	✓		1.

If any of the above conditions exist, record below:

1. I.D. CUT ON O-RING (SDIS)

SEE ATTACHED CLARIFICATION SHEET

CLOSURE SCREW O-RING

Part No.: ____ Lot No.: ____

	Yes	No	Comment Number
A. Erosion (CORE)?			
B. Heat Affect (HACOR)?			
C. Cuts, Assembly/Disassembly Damage (CCUT, CDMG, CDIS)?			

If any of the above conditions exist, record below:

Morton Thiokol Inc.
Space Operations

O-RING OBSERVATION CLARIFICATION FORM

Date 6 FEB 89 Inspector(s) Scott Eden, Rocky Ash, Gary Nelson

Motor No. QM-8

Joint (Or Plug and Degree): 262.3° #(1)

O-Ring Location: ☐ Primary ☒ Secondary ☐ Capture Feature ☐ Wiper ☐ Closure

Part Number: 1U50228-25

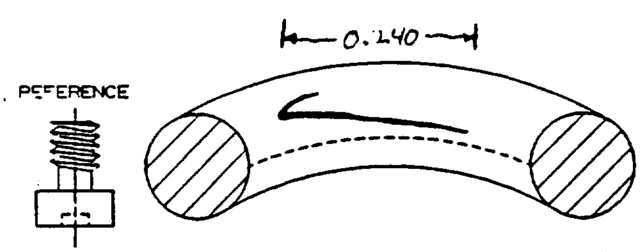
Serial or Lot Number: ECL0012

Description:

I.D. CUT (SEE BELOW)

NOTE: O-RING WAS POSITIONED ON THE THREAD SIDE OF THE PLUG GROOVE. LAST THREAD OF PLUG WAS SHARP.

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.



I.D. CUT

L ≈ 0.240

D ≈ 0.030

Morton Thiokol Inc.
Space Operations

Nozzle Joint Plug and Plug Hole - Evaluation Checkoff Worksheet

Inspector(s): Kelly Baker, Lowell Nelson

Motor No.:

Date: 2-15-89

Joint:
- ☐ Throat/Fwd Exit Cone (4)
- ☐ Fixed Housing/Aft End Ring (5)
- ☐ Fwd Exit Cone/Aft Exit Cone (1)
- ☒ Fwd End Ring/Nose Inlet (2)
- ☐ Nose Inlet/Throat (3)

Degree Location: 262.25 P/N: 1U50159-02 S/N: ECL0001

O-ring: P/N: 1U50228-25 L/N: ECL 0006

Plug, plug hole observations:

		Yes	No	Comment Number
I.	Soot Past Seals(SPINS, SICOR, SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		✓	
II.	Foreign Material (FMIJ)?		✓	
III.	Heat Affected Plug (HAPOR, HASOR, HACOR)?		✓	
IV.	Rust on sealing surfaces (SSCOR)?		✓	
V.	Rust on metal parts (PITCO)?		✓	
VI.	Damaged metal sealing surface (SSMET)?		✓	
VII.	Damaged metal other than sealing surface (DAMML)?		✓	
VIII.	Plug hole damage, deformed threads (DBHOL)?		✓	

If any of the above conditions exist, describe below:

Breakaway torque was 36 in-lbs

5E

Detailed Port Plug O-ring (Post-Removal) - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 17 FEB 89

Joint:
- [ ] Throat/Fwd Exit Cone (4)
- [ ] Fixed Housing/Aft End Ring (5)
- [ ] Fwd Exit Cone/Aft Exit Cone (1)
- [x] Fwd End Ring/Nose Inlet (2)
- [ ] Nose Inlet/Throat (3)

Plug: [ ] Leak Check(LEAK) Degree 265.3°

Inspector(s): Scott Eden, Rocky Ash, Gary Nelson

PRIMARY O-RING

Part No.: ______ Lot No.: ______

	Yes	No	Comment Number
A. Erosion (PORE)?			
B. Heat Affect (HAPOR)?			
C. Cuts, Assembly/Disassembly Damage (PCUT, PDMG, PDIS)?			

If any of the above conditions exist, record below:

SECONDARY O-RING (or Shoulder)

Part No.: 1U50228-25 Lot No.: ECL0006

	Yes	No	Comment Number
A. Erosion (SORE)?		✓	
B. Heat Affect (HASOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?		✓	

If any of the above conditions exist, record below:

NOTE! O-RING WAS POSITIONED ON THREAD SIDE OF PLUG GROOVE.

CLOSURE SCREW O-RING

Part No.: ______ Lot No.: ______

	Yes	No	Comment Number
A. Erosion (CORE)?			
B. Heat Affect (HACOR)?			
C. Cuts, Assembly/Disassembly Damage (CCUT, CDMG, CDIS)?			

If any of the above conditions exist, record below:

Morton Thiokol Inc.
Space Operations

Nozzle Joint Plug and Plug Hole - Evaluation Checkoff Worksheet

Inspector(s): K. Baker, L. Nelsen

Motor No.: QM-8

Date: 2-15-89

Joint:
- ☐ Throat/Fwd Exit Cone (4)
- ☐ Fixed Housing/Aft End Ring (5)
- ☐ Fwd Exit Cone/Aft Exit Cone (1)
- ☐ Fwd End Ring/Nose Inlet (2)
- ☒ Nose Inlet/Throat (3)

Degree Location: 265 P/N: 1U50159-02 S/N: ECL 0001

O-ring: P/N: 1U50228-25 L/N: ECL 0001

Plug, plug hole observations:

		Yes	No	Comment Number
I.	Soot Past Seals(SPINS, SICOR, SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		✓	
II.	Foreign Material (FMIJ)?		✓	
III.	Heat Affected Plug (HAPOR, HASOR, HACOR)?		✓	
IV.	Rust on sealing surfaces (SSCOR)?		✓	
V.	Rust on metal parts (PITCO)?		✓	
VI.	Damaged metal sealing surface (SSMET)?		✓	
VII.	Damaged metal other than sealing surface (DAMML)?		✓	
VIII.	Plug hole damage, deformed threads (DBHOL)?		✓	

If any of the above conditions exist, describe below:

Breakaway torque was 17 in-lbs

REV. ____

-2

Detailed Port Plug O-ring (Post-Removal) - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 17 FEB 87

Joint:
- ☐ Throat/Fwd Exit Cone (4)
- ☐ Fixed Housing/Aft End Ring (5)
- ☐ Fwd Exit Cone/Aft Exit Cone (1)
- ☐ Fwd End Ring/Nose Inlet (2)
- ☒ Nose Inlet/Throat (3)

Plug: ☒ Leak Check(LEAK) Degree 265°

Inspector(s): Scott Eden, Rocky Abl, Gary Nelson

PRIMARY O-RING

Part No.: ______ Lot No.: ______

	Yes	No	Comment Number
A. Erosion (PORE)?			
B. Heat Affect (HAPOR)?			
C. Cuts, Assembly/Disassembly Damage (PCUT, PDMG, PDIS)?			

If any of the above conditions exist, record below:

SECONDARY O-RING (or Shoulder)

Part No.: 1U50228-25 Lot No.: ECL00013

	Yes	No	Comment Number
A. Erosion (SORE)?		✓	
B. Heat Affect (HASOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?	✓		1.

If any of the above conditions exist, record below:

1. I.D. CIRCUMFERENTIAL SCRATCH (SDIS)

SEE ATTACHED ~~CLA~~ CLARIFICATION SHEET

CLOSURE SCREW O-RING

Part No.: ______ Lot No.: ______

	Yes	No	Comment Number
A. Erosion (CORE)?			
B. Heat Affect (HACOR)?			
C. Cuts, Assembly/Disassembly Damage (CCUT, CDMG, CDIS)?			

If any of the above conditions exist, record below:

Morton Thiokol Inc.
Space Operations

SE

O-RING OBSERVATION CLARIFICATION FORM

Date 17 FEB 87 Inspector(s) Scott Eden, Rocky Ash, Gary Nelson

Motor No. QM-8

Joint (Or Plug and Degree): 265° JOINT #(3)

O-Ring Location: ☐ Primary ☒ Secondary ☐ Capture Feature ☐ Wiper ☐ Closure

Part Number: 1050228-25

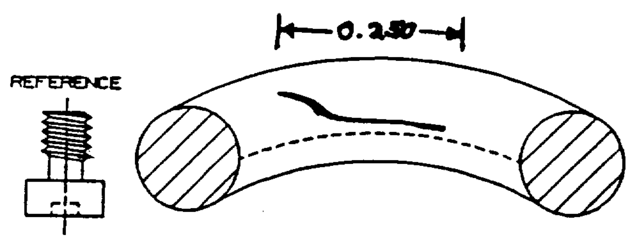
Serial or Lot Number: ICL 0013

Description:

I.D. CIRCUMFERENTIAL SCRATCH (SEE BELOW)

NOTE: O-RING WAS POSITIONED ON THREAD SIDE OF PLUG GROOVE.

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.



I.D. CIRCUMFERENTIAL SCRATCH

L ≈ 0.250
W ≈ 0.002
D < 0.001

REV. —

SE

Morton Thiokol Inc.
Space Operations

Nozzle Joint Plug and Plug Hole – Evaluation Checkoff Worksheet

Inspector(s): K. Baker, L. Nelsen

Motor No.: QM-8 | Date: 2-15-89

Joint:
- ☒ Throat/Fwd Exit Cone (4)
- ☐ Fixed Housing/Aft End Ring (5)
- ☐ Fwd Exit Cone/Aft Exit Cone (1)
- ☐ Fwd End Ring/Nose Inlet (2)
- ☐ Nose Inlet/Throat (3)

Degree Location: 268.75 P/N: 1U50159-02 S/N: ECL 0002

O-ring: P/N: 1U50228-25 L/N: ECL 0013

Plug, plug hole observations:	Yes	No	Comment Number
I. Soot Past Seals(SPINS, SICOR, SOINT, SPINT, SIPOR, SPPOR SISOR, SPSOR)?		✓	
II. Foreign Material (FMIJ)?		✓	
III. Heat Affected Plug (HAPOR, HASOR, HACOR)?		✓	
IV. Rust on sealing surfaces (SSCOR)?		✓	
V. Rust on metal parts (PITCO)?		✓	
VI. Damaged metal sealing surface (SSMET)?		✓	
VII. Damaged metal other than sealing surface (DAMML)?		✓	
VIII. Plug hole damage, deformed threads (DBHOL)?		✓	

If any of the above conditions exist, describe below:

Break away torque was 35 in-lbs

REV. ____

SE

Detailed Port Plug O-ring (Post-Removal) - Evaluation Checkoff Worksheet

Motor No.: QM-8 | Date: 15 FEB 89

Joint:
- [x] Throat/Fwd Exit Cone (4)
- [ ] Fixed Housing/Aft End Ring (5)
- [ ] Fwd Exit Cone/Aft Exit Cone (1)
- [ ] Fwd End Ring/Nose Inlet (2)
- [ ] Nose Inlet/Throat (3)

Plug: [x] Leak Check(LEAK) Degree 268.75°

Inspector(s): Scott Eden, Wayne Sperry, Gary Nelson

PRIMARY O-RING

Part No.: ________ Lot No.: ________

	Yes	No	Comment Number
A. Erosion (PORE)?			
B. Heat Affect (HAPOR)?			
C. Cuts, Assembly/Disassembly Damage (PCUT, PDMG, PDIS)?			

If any of the above conditions exist, record below:

SECONDARY O-RING (or Shoulder)

Part No.: 1050228-25 Lot No.: ECL0012

	Yes	No	Comment Number
A. Erosion (SORE)?		✓	
B. Heat Affect (HASOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?		✓	

If any of the above conditions exist, record below:

NOTE: O-RING WAS POSITIONED ON THREAD SIDE OF PLUG GROOVE.

CLOSURE SCREW O-RING

Part No.: ________ Lot No.: ________

	Yes	No	Comment Number
A. Erosion (CORE)?			
B. Heat Affect (HACOR)?			
C. Cuts, Assembly/Disassembly Damage (CCUT, CDMG, CDIS)?			

If any of the above conditions exist, record below:

Table D-II

Detailed Port Plug O-ring or Small O-ring (A-2) - Evaluation Checkoff Worksheet

Inspector(s): SCOTT EDEN, ROCKY ASH

Motor No.: QM-8 Date: 14 June '89

Side: ☐ Left (A) ☐ Right (B) Joint: Forward dome/cyl seg factory

Plug: ☐ Vent Port ☑ Leak Check ☐ Transducer ☐ Special Bolt Plug
☐ Special Bolt ☐ Degree 0° 1U100269-01 ECL0022

PRIMARY O-RING N/A: ✓

Part No.: ________ Lot No.: ________

	Yes	No	Comment Number
A. Erosion (PORE)?			
B. Heat Affect (HAPOR)?			
C. Cuts, Assembly/Disassembly Damage (PCUT, PDMG, PDIS)?			

If any of the above conditions exist, record below:

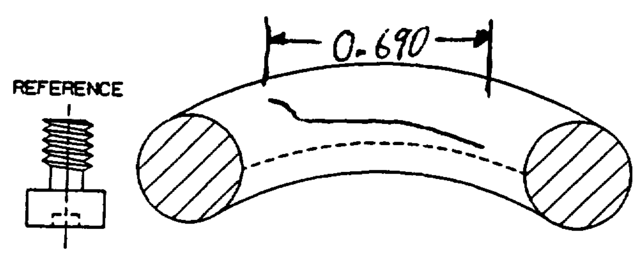
SECONDARY O-RING (or Shoulder) N/A: ______

Part No.: 1U50228-15 Lot No.: ECL0037

	Yes	No	Comment Number
A. Erosion (SORE)?		✓	
B. Heat Affect (HASOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?	✓		1

If any of the above conditions exist, record below:

1) I.D. circumferential cut
L ≈ 0.690
D ≈ 0.030



NOTE: O-ring positioned on thread side
Chisel gouge on plug head O.D.
Sharp last thread

CLOSURE SCREW O-RING N/A: ✓

Part No.: ________ Lot No.: ________

	Yes	No	Comment Number
A. Erosion (SORE)?			
B. Heat Affect (HASOR)?			
C. Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?			

If any of the above conditions exist, record below:

Morton Thiokol Inc.
Space Operations

O-RING OBSERVATION CLARIFICATION FORM

Date 4-25-89 Inspector(s) Scott Eden, Rocky Ash

Motor No. QM-8

Joint (Or (Plug) and Degree): 0° FWD FACTORY JOINT

O-Ring Location: ☐ Primary ☒ Secondary ☐ Capture Feature ☐ Wiper ☐ Closure

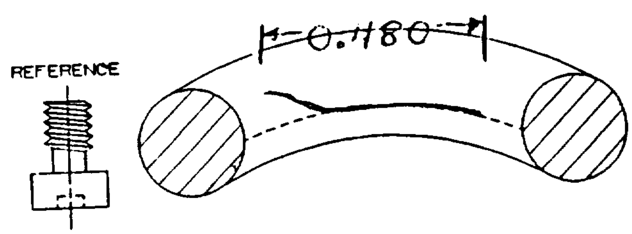
Part Number 1U50228-15

Serial or Lot Number: ECL0037

Description: See below.

NOTE: O-ring positioned on thread side.
Chisel gouge on plug O.D.

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.



I.D. CIRCUMFERENTIAL CUT

L ≈ 0.480
D ≈ 0.015

REV. ____

Table D-II

Detailed Port Plug O-ring or Small O-ring (A-2) - Evaluation Checkoff Worksheet

Inspector(s): Scott Eden, Rocky Ash

Motor No.: QM-8 Date: 14 June '89

Side: ☐ Left (A) ☐ Right (B) Joint: Center - forward cyl/cyl seg factory

Plug: ☐ Vent Port ☑ Leak Check ☐ Transducer ☐ Special Bolt Plug
☐ Special Bolt ☐ Degree 0° 1U100269-01 ECL0022

PRIMARY O-RING

N/A: ✓

Part No.: ______ Lot No.: ______

	Yes	No	Comment Number
A. Erosion (PORE)?			
B. Heat Affect (HAPOR)?			
C. Cuts, Assembly/Disassembly Damage (PCUT, PDMG, PDIS)?			

If any of the above conditions exist, record below:

SECONDARY O-RING (or Shoulder)

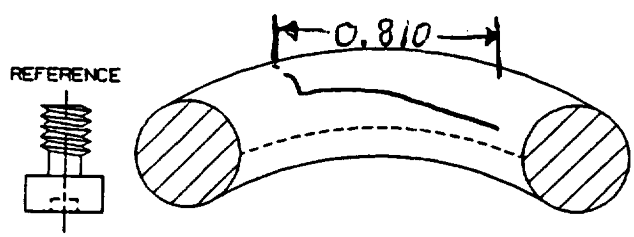
N/A: ______

Part No.: 1U50228-15 Lot No.: ECL0037

	Yes	No	Comment Number
A. Erosion (SORE)?		✓	
B. Heat Affect (HASOR)?		✓	
C. Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?	✓		1

If any of the above conditions exist, record below:

1) I.D. circumferential cut
L ≈ 0.810
D ≈ 0.030



NOTE: sharp last thread
Ding in last thread
O-ring positioned on last thread
Chisel gouge on O.D. of plug head

CLOSURE SCREW O-RING

N/A: ✓

Part No.: ______ Lot No.: ______

	Yes	No	Comment Number
A. Erosion (SORE)?			
B. Heat Affect (HASOR)?			
C. Cuts, Assembly/Disassembly Damage (SCUT, SDMG, SDIS)?			

If any of the above conditions exist, record below:

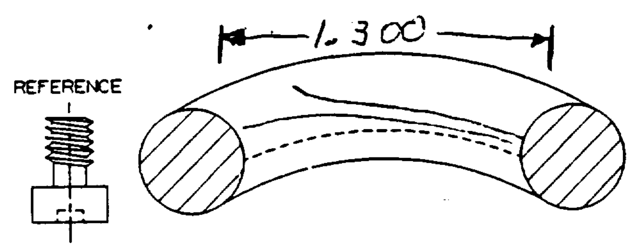
Morton Thiokol Inc.
Space Operations

O-RING OBSERVATION CLARIFICATION FORM

Date 4-20-89 Inspector(s) Scott Eden, Rocky Ash
Motor No. QM-8
Joint (Or Plug and Degree): 0° CTR AFT FACTORY JOINT
O-Ring Location: ☐ Primary ☒ Secondary ☐ Capture Feature ☐ Wiper ☐ Closure
Part Number: 1U50228-15
Serial or Lot Number: ECL0037
Description: See below.

Note: O-ring positioned on last thread, cut is opened on last thread. Plug and o-ring had little to no grease. Chisel gouge on top O.D. of plug.

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.



I.D. CIRCUMFERENTIAL CUT

L ≈ 1.300
D ≈ 0.030

REV. ____

Morton Thiokol Inc.
Space Operations

O-RING OBSERVATION CLARIFICATION FORM

Date 3-13-89 Inspector(s) Scott Eden, Rocky Ash, GARY Nelson

Motor No. QM-8

Joint (Or Plug and Degree): Aft Segment factory joints

O-Ring Location: ☐ Primary ☒ Secondary ☐ Capture Feature ☐ Wiper ☐ Closure

Part Number: See Description

Serial or Lot Number: See Description

Description:

	Ⓐ	Ⓑ	Ⓒ
	ET/STIF	STIF/STIF	STIF/AFT DOME
PART #	1U50228-15	1U50228-15	1U50228-15
LOT #	ECL0041	ECL0041	ECL0031

Sketch observation below or attach worksheets and list below. Indicate orientation and dimensions. Show as much detail as necessary to explain the observation.

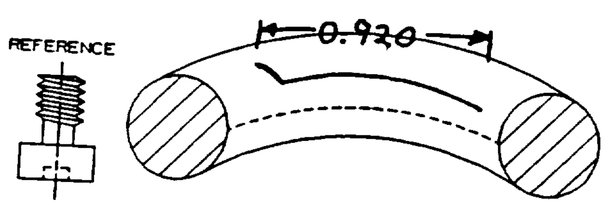
A: (See Below) Rolled last partial thread O-ring was positioned on last full thread still holding cut area open

B: (See Below) Rolled last partial thread

C: (See Below) Rolled last thread. Polysulfide on underside of plug head up to O-ring (Very slight amount)

Note: All three plugs have chisel gouge on plug head, all three O-rings were on thread side. Plug A had no apparent grease. Plugs B & C had very light/none

Ⓐ

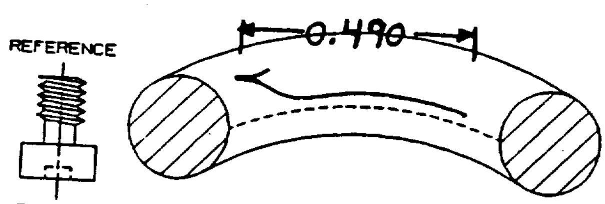


I.D. CIRCUMFERENTIAL CUT

L ≈ 0.920

D ≈ 0.040

Ⓑ

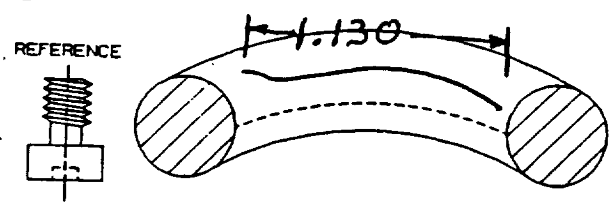


I.D. CIRCUMFERENTIAL CUT

L ≈ 0.490

D ≈ 0.020

Ⓒ



I.D. CIRCUMFERENTIAL CUT

L ≈ 1.130

D ≈ 0.020