ATK ALLIANT TECHSYSTEMS
THIOKOL PROPULSION

# CRITICAL ITEMS LISTS (CILS)

Nos. 10-01-01-01R/01, 10-01-01-02/01, 10-01-01-03R/01,
10-01-01-04R/01, 10-01-01-05/01, and 10-01-01-06/01

| | | | |
|---|---|---|---|
| SYSTEM: | Space Shuttle RSRM 10 | CRITICALITY CATEGORY: | 1 |
| SUBSYSTEM: | Case Subsystem 10-01 | PART NAME: | Case Membrane (1) |
| ASSEMBLY: | Case 10-01-01 | PART NO.: | (See Section 6.0) |
| FMEA ITEM NOS.: | 10-01-01-01R, 10-01-01-02, 10-01-01-03R, 10-01-01-04R, 10-01-01-05, 10-01-01-06 R N | PHASE(S): | Boost (BT) |
| | | QUANTITY: | (See Section 6.0) |
| CIL REVISION: | N | EFFECTIVITY: | (See Table 101-6) |
| DATE: | 27 Jul 2001 | HAZARD REF.: | BC-09 |
| SUPERSEDES PAGES: | 205-1ff. | | |
| DATED: | 31 Jul 2000 | | |
| CIL ANALYST: | F. Duersch | | |
| APPROVED BY: | | DATE: | |

RELIABILITY ENGINEERING: K. G. Sanofsky 27 July 2001

ENGINEERING: V. B. Call 27 July 2001

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1.0 FAILURE CONDITION: Failure during operation (D)

2.0 FAILURE MODE: 1.0 Structural failure

3.0 FAILURE EFFECTS: Structural failure of the case segment will cause the loss of RSRM, SRB, crew, and vehicle

4.0 FAILURE CAUSES (FC):

| FC NO. | DESCRIPTION | FAILURE CAUSE KEY |
|---|---|---|
| 1.1 | Metallic membrane failure | |
| 1.1.1 | Nonconforming dimensions | A |
| 1.1.2 | Nonconforming materials | B |
| 1.1.3 | Cracks, inclusions, voids, and other material defects | C |
| 1.1.4 | Stress corrosion | D |
| 1.1.5 | Nonconforming proof-testing | E |
| 1.1.6 | In-service degradation/fatigue | F |
| 1.1.7 | Transportation and handling damage | G |
| 1.1.8 | Nonconforming heat treatment | H |
| 1.1.9 | Improper assembly techniques | I |
| 1.1.10 | Skirt, stiffener, or attach stub loads/hole inboard cracking | J |
| 1.2 | Bushing replacement | |
| 1.2.1 | Nonconforming material | K |
| 1.2.2 | Nonconforming heat treatment of bushing | L |

| | | |
|---|---|---|
| 1.2.3 | Corrosion | M |
| 1.2.4 | Stress corrosion | N |
| 1.2.5 | Nonconforming dimensions | O |
| 1.2.6 | Cracks, voids, or other material defects | P |
| 1.2.7 | Improper assembly techniques | Q |

5.0 REDUNDANCY SCREENS:

SCREEN A: N/A
SCREEN B: N/A
SCREEN C: N/A

6.0 ITEM DESCRIPTION:

| | |
|---|---|
| Forward Segment | FMEA 10-01-01-01R (comprising forward dome, fwd cylinder and aft capture cylinder) |
| Forward Dome | FMEA 10-01-01-02 |
| Center Segments | FMEA 10-01-01-03R (comprising forward cylinder and aft capture cylinder) |
| Aft Segment, comprising: | |
| Aft dome | FMEA 10-01-01-04R |
| Stiffener segs. | FMEA 10-01-01-05 |
| Attach segment | FMEA 10-01-01-06 |

Materials are listed in Table 1.

TABLE 1. MATERIALS

| Drawing No. | Name | Material | Specification | Quantity |
|---|---|---|---|---|
| 1U76793 | Case Segment, Forward, Forging | D6AC Steel | STW4-2606, STW7-2608 | 1/motor |
| 1U76794 | Case Segment, Aft, Forging | D6AC Steel | STW4-2606, STW7-2608 | 1/motor |
| 1U76796 | Case Segment, Cylinder, Forging | D6AC Steel | STW4-2606, STW7-2608 | 6/motor |
| 1U76797 | Case Segment, Attach, Forging | D6AC Steel | STW4-2606, STW7-2608 | 1/motor |
| 1U76798 | Case Segment, Stiffener, Forging | D6AC Steel | STW4-2606, STW7-2608 | 2 (alt.) |
| 1U50129 | Case Segment, Aft | D6AC Steel | STW7-2744 | 1/motor |
| 1U50130 | Case Segment, Attach, Std Weight (refurb. only) | D6AC Steel | STW7-2744 | 1 (alt.) |
| 1U50131 | Case Segment, Cylinder (refurbishment only) | D6AC Steel | STW7-2744 | 1/motor |
| 1U50185 | Case Segment, Stiffener, Standard Weight | D6AC Steel | STW7-2744 | 2 (alt.) |
| 1U50715 | Case Segment, Stiffener, Light Weight | D6AC Steel | STW7-2744 | 2/motor |
| 1U50716 | Case Segment, Attach, Light Weight | D6AC Steel | STW7-2744 | 1/motor |
| 1U50717 | Case Segment, Cylinder, Light Wt (refurb. Only) | D6AC Steel | STW7-2744 | 2/motor |
| 1U51473 | Case Segment, Forward | D6AC Steel | STW7-2744 | 1/motor |
| 1U52982 | Case Segment, Capture Cylinder, Light Wt | D6AC Steel | STW7-2744 | 2/motor |
| 1U52983 | Case Segment, Capture Cylinder, Std Weight | D6AC Steel | STW7-2744 | 1/motor |
| 1U77713 | Case Assembly, Painted Forward Segment | Various | | 1/motor |
| 1U77714 | Case Assembly, Painted Center Segment | Various | | 2/motor |
| 1U77715 | Case Assembly, Painted Aft Segment | Various | | 1/motor |
| 1U77503 | Case Assembly, Aft Segment Insulated | Various | | 1/motor |
| 1U75642 | Case Assembly, Painted Aft Dome | Various | | 1/motor |
| | Top Coating (paint) | Epoxy | STW5-3225 | A/R |
| 1U77648 | Assembly and Closeout, RSRM, KSC | Composite of Various Components | | 1/motor |
| | Primer, Zinc-rich | Epoxy | STW5-3226 | A/R |
| | Corrosion-Preventive Compound and O-ring Lubricant | HD Calcium Grease | STW5-2942 | A/R |
| | Forging preservative | Oil, Grade 4 | MIL-C-16173 | A/R |
| | Bushing, RSRM Replacement | D6AC Steel | STW7-9135 | A/R |

6.1 CHARACTERISTICS:

1. The solid rocket motor case serves as a large pressure vessel that contains combustion pressure throughout the motor burn. The case is assembled near the launch site from forward, center, and aft casting segments (Figure 1). Casting segments are composed of case segments, made of high-strength D6AC steel, cast-in propellant, thermal insulation, etc. Metal case segments are joined by factory joints.

   Forward segment case cylinders are described as the forward cylinder and the aft capture cylinder. A factory joint joins the cylinders to form the forward casting segment. The forward dome segment mates to the forward cylinder. It is oblate spheroidal with a forward skirt stub, tang, and an opening at the apex for the ignition system.

   Center segment case cylinders are described as the forward cylinder and aft capture cylinder. A factory joint joins the two cylinders to form one center casting segment. There are two center casting segments, forward center and aft center, in each solid rocket motor.

   Aft casting segment metal parts include the attach segment, two stiffener segments, and aft dome. The aft case segment, or aft dome, is hemispherical with a central opening for the nozzle attachment. It incorporates a clevis for attachment to the aft stiffener segment and a tang to fit into the clevis joint in the aft skirt kick ring. The stiffener segments [two], are designed to withstand cavity collapse loads on the aft portion of the case at water impact. Each of the stiffener segments contains two sets of stiffener stubs that will accept T-stiffener rings. However, only three sets of stiffener rings are installed: the forward-most stub in the assembly is not used. The attach segment is made with two structural attachments that protrude from the case wall. The ET attach segment ring and attach struts are secured to the two stubs by bolts to connect the RSRM to the external tank.

2. There is no current need to control material properties of the standard weight attach cylinder and forward cylinders in the forward and center segments, since no new parts are being obtained, and experience indicates that properties of case steel are unchanged throughout its 20-use life.

3. RWW498R1 was written to waive the requirement for interchangeability of the stiffener segments between the right or left hand motor. This waiver is for Case Segment, Stiffener Light Weight, Serial Number 0000039 only. During refurbishment a required inspection, CIL Code FAB157, verifies case wall axial straightness variation (buckling criterion). The defect in the S/N 0000039 segment does not meet the intent of this inspection. Defect criteria allow 0.090 inch refurbishment anomalies. This stiffener has an anomaly of 0.125 inch at the 319$^{o}$, OD location.

   Minimum margins of safety for this component when flown in the LH forward position are +.07 for pre-launch and +.00 for rebound based on a 1.4 safety factor. The cylinder is limited use for only the LH forward position. Change in margins of safety from the basic waiver is due to improved measurement techniques, and not on condition worsening.

   This case segment will continue to be monitored during each flow with inspections and tests. Wall thickness of 0.479 inches is required at this location for each refurbishment. Hydro proof at 1.12 MEOP is also performed on the segment, along with magnetic particle inspection prior to flight use.

   No specific flight effectivity for this segment is identified since the waiver is hardware specific. The S/N 0000039 will continue to be used as long as the hardware condition does not change and calculated margins of safety remain positive.

7.0 FAILURE HISTORY/RELATED EXPERIENCE:

1. Current data on test failures, flight failures, unexplained failures, and other failures during RSRM ground processing activity can be found in the PRACA Database.

8.0 OPERATIONAL USE: N/A

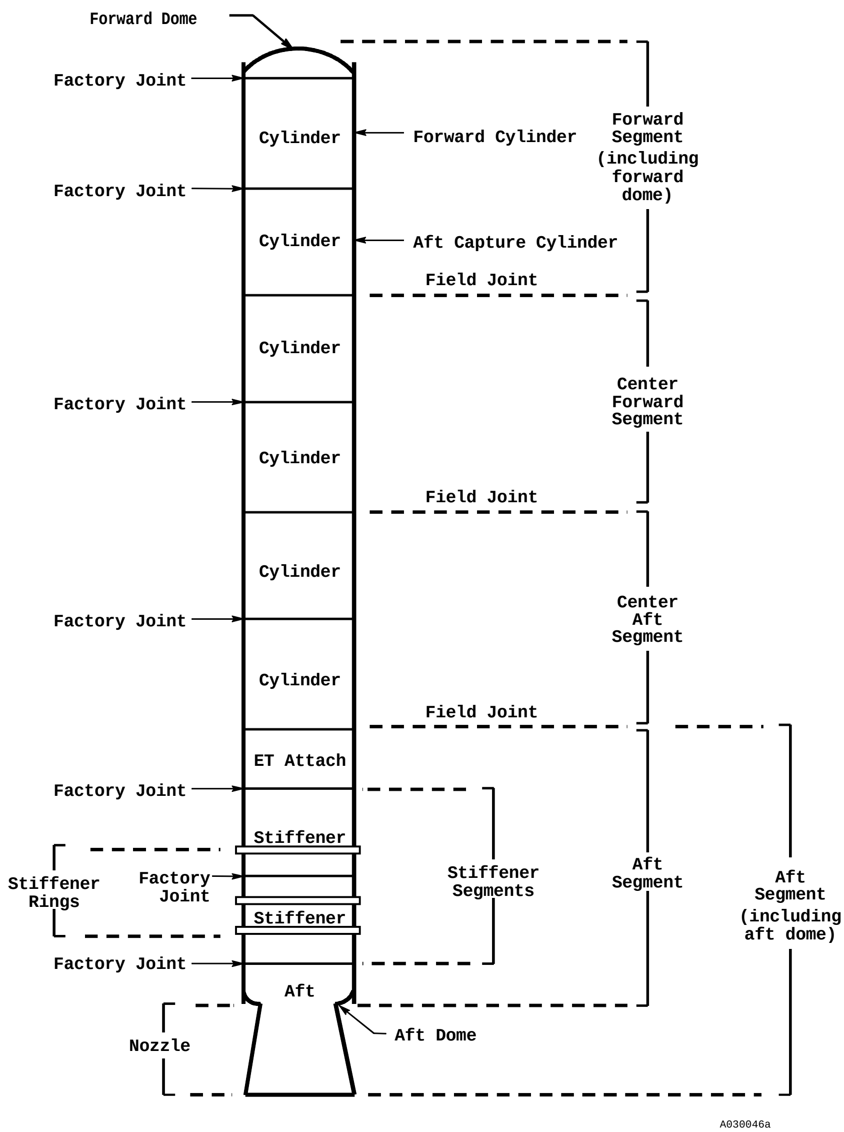


Figure 1. Case Segment Locations

9.0 RATIONALE FOR RETENTION:

9.1 DESIGN:

| DCN | FAILURE CAUSES |
|---|---|
| A,C,D,E,F | 1. Case metal components are capable of containing maximum expected internal operating pressure. RSRM case structural analysis per TWR-17118 verifies that the design achieves positive margins of safety over a safety factor of 1.4. The area of highest pressure in the RSRM case is at the forward dome. |
| A | 2. Factors with the potential to cause nonconforming dimensions such as machining processes, effects of hydroproof testing, effects of water impact loads, and corrosion are as follows:<br><br>a. New and refurbished case hardware acceptance criteria and dimensions are per engineering drawings and specifications.<br>b. The supplier applies corrosion-preventive oil to rough-machined forgings and grease to machined case parts for corrosion protection.<br>c. During processing, Thiokol takes steps to protect all case segment exposed bare metal surfaces as required to minimize corrosion. Superficial discoloration is allowed as long as it does not interfere with inspection of the hardware. Corrosion is removed prior to hardware assembly per engineering.<br>d. During local transportation, Thiokol uses environmentally controlled shipping containers, which allow case segments to be shipped without grease. This was demonstrated to be acceptable per TWR-65920.<br>e. The required factor of safety for membrane rupture is assured by verifying case membrane thickness.<br>f. A final cosmetic grit blast is performed after case wall thickness measurements are taken to prepare the internal surface for insulation bonding and the external surface for paint. This final grit blast does not significantly impact the case wall thickness per TWR-64382.<br>g. Case segments are painted with primer and top coat. |
| A | 3. Corrosion/oxidation pitting in the case membrane that does not exceed dimensional allowances is repaired per engineering for new and refurbished case hardware. Such repairs do not thin the case wall sufficiently to violate the safety factor requirement. Wall thickness measurements are taken of all thin wall areas and dispositioned per engineering. |
| A | 4. Risk of membrane failure is controlled by performing three hydroproofs on each new RSRM case segment. An additional hydroproof is performed after each refurbishment. The Case Assembly and Hydroproof Qualification (Test 3A, hydroproofs 6,7, and 8) Final Test Report per TWR-16205 demonstrates that case dimensional growth is negligible after three hydroproofs. |
| B,H | 5. Case material is high-strength, low-alloy D6AC steel per engineering. Steel mechanical properties meet the design intent for the case structure, providing positive margins of safety over a safety factor of 1.40 per TWR-11269 and TWR-17118. D6AC steel was selected for case segments because of broad, proven success in rocket motor applications such as Stage I Minuteman, Short Range Attack Missile (SRAM), and Titan III. |
| B,H | 6. The D6AC steel of the RSRM case is heat treated per engineering. Material properties are tested after heat treat including: Tensile properties, Fracture toughness, Grain size, Macro structure, inclusion rating, and Micro-hardness/decarburization. |

B,H 7. As a part of SRM case development, forging evaluations were performed to verify conformance to requirements for principal grain flow patterns, grain structure, and inclusions. Tests for mechanical properties were per JSC Specifications. Thiokol reports for forging evaluations and mechanical property tests are as follows:

| Thiokol Case part | Forging Reports |
|---|---|
| Case Segment, Aft | TWR-10701 |
| Case Segment, Attach, Standard Weight | TWR-10703 |
| Case Segment, Cylinder | TWR-16635 |
| Case Segment, Stiffener, Standard Weight | TWR-10703 |
| Case Segment, Stiffener, Light Weight | TWR-10703 |
| Case Segment, Attach, Light Weight | TWR-10703 |
| Case Segment, Cylinder, Light Weight | TWR-16635 |
| Case Segment, Forward | TWR-10705 |
| Case Segment, Capture Cylinder, Light Weight | TWR-18899 |
| Case Segment, Capture Cylinder, Standard Weight | TWR-18899 |

B,C,D,E,F,H 8. Development Motors DM-8 and DM-9 were static test fired to evaluate the performance of accepted baseline RSRM case hardware. The case is certified based on the static tests of Qualification Motors QM-6, QM-7, and QM-8 as reported in TWR-18764-01.

B,C,D,E,F,H 9. Thiokol performed a detailed experimental study of fracture behavior of D6AC steel obtained from six case segment forgings per ETP-0320. Results of the study are being used to improve accuracy of structural and fracture mechanics analyses. Test results were reported per TWR-18991 and TWR-60056. Continuing studies will evaluate hardware reusability and other long-term issues per CTP-0146.

C,D,E,F 10. High material cleanliness is required per engineering for successful manufacturing. Flaws in the billet that could cause failure are exposed during roll forming due to the severe nature of the process. Cracks, inclusions, or voids in the forgings are also detected by ultrasonic inspection of the forging blanks.

C,D,E,F 11. Case segments are fracture-controlled items per TWR-16873. This report indicates that proof test, complemented by nondestructive evaluation, shall satisfy safe-life requirements of four missions of the case membrane. In some elastic regions of case segments where proof test logic is not applicable, nondestructive evaluation alone shall satisfy the safe-life requirements. Fracture mechanics analysis is performed to determine the proof factor for the proof test is equal to or greater than 1.12 to satisfy the safe-life requirements. However, for some regions in case components where proof test cannot adequately screen the critical initial flaws, more sensitive methods for detecting flaws is required. The detectable flaw size has to be smaller than the critical initial flaw size.

595 C,D,E,F 12. The fracture control effort identified three elements required for case segment metal hardware to promote a condition called stress corrosion cracking (SCC). This is a condition where small flaws in the metal hardware grow and cause the metal hardware to fail prematurely (possible during motor operation). For this to happen, it was agreed that the following three conditions are necessary: 1) A susceptible material, 2) sustained tensile stress, and 3) moist/corrosive environment. The following address each condition:

a. **Initial Flaw Detection:** RSRM realized early in the program that D6AC steel used in the case segment is notch sensitive and can fail if it is not carefully scrutinized as new or refurbished hardware. All case segments are subjected to Non-Destructive Evaluation (NDE) and subsequent environmental protections that are essential for flight safety. The stiffener flanges and holes are inspected using magnetic particle and eddy current during the refurbishment process to assure any existing cracks, based on POD studies, are no greater than 0.050 inch. Any detected flaws are removed from the part. Cracks through the stub outer ligament are removed by machine repair. Areas adjacent to the machine repair are subsequently re-inspected using eddy current and magnetic particle methods. Non-crack like surface defects deeper than 0.006 inch (in the hole region), and 0.010 inch elsewhere on the flange are also removed by blending. All of this is completed before and after hydroproof testing to ensure the material is free from surface defects that could act as stress risers resulting in crack initiation locations.

b. **Stress State:** For undetectable cracks, especially in the cavity collapse centerline region of high tensile residual stress, proof test (at 1.24 proof factor) tends to blunt the crack tip, which mitigates SCC crack extension. Also, multiple glass bead and grit blasting operations tend to create a residual compressive stress field on the surface of the part. While not quantifiable, both of these are mitigating factors.

c. **Environment Control:** The RSRM program puts a very strong effort to control the environmental conditions the hardware will be subjected to. The stiffener flanges and holes are protected from moisture by careful and consistent application of grease, primer, paint, ablative material, and by environment controlled shipping containers to minimize SCC concerns. Throughout manufacturing, transportation, and pre-flight operations, the protective coatings of primer and paint are inspected and repaired as needed to minimize exposure of the metal hardware to moisture. The primer and paint also guard against the initiation of flaws in regions with sustained stress by protecting the free surface from moisture/corrosive environments. In particular, for the period between proof test/NDE and flight, environmental protections are in place mitigating the potential for SCC induced crack extension or crack initiation.

C,D,E,F,J

13. TWR-16873 identifies all areas which are not verified by proof testing, which include the ET attach area, stiffener ring attach area, forward dome and aft dome Y-joint areas, and specific areas of the tang-clevis joint. For these areas, the report 1) identifies the maximum limit applied stress in flight, 2) calculates the minimum critical flaw size during the flight loading condition, and 3) compares the critical flaw size with that detectable in a part by nondestructive inspection methods. The report asserts acceptability of the design based on readily detectable critical flaw sizes in the critical areas.

C,D,E,F

14. Hydroproof tests are performed on each new RSRM case segment three times, followed by magnetic particle inspection per engineering to detect and monitor flaws having potential to initiate part failure. Also, each time a case is refurbished it is hydroproof tested followed by magnetic particle inspection on the entire surface of the case per engineering. ET attach flange bolt holes and stiffener flange bolt holes are inspected before hydroproof by magnetic particle inspection. Concerns about crack detection capability of magnetic particle inspection in the case joint clevis, capture feature gap and forward Y-joint as reported in TWR-65649, led to qualification of eddy current and ultrasonic shear wave inspections in these areas.

C,D,E,F

15. The forward dome Y-joints are inspected using ultrasonic shear wave, eddy current and improved magnetic particle inspections. The new ultrasonic shear wave inspection was qualified and documented in TWR-73327. Leak check ports and vent ports are stress risers in the case, but are too small for magnetic particle inspection. After each hydroproof test, the interior of vent ports, leak check ports, bolt holes, alignment slots, stiffener stub holes and clevis pin holes are examined

for cracks by eddy current inspection as documented in TWR-17191 and TWR-66310.

C,D,E,F

16. All new RSRM case segments are hydroproof tested three times followed by magnetic particle inspection per engineering. The final hydroproof and magnetic particle inspection ensure a four-mission capability. Each refurbished RSRM case segment is hydroproofed one time to ensure a four-mission capability. The use of new tooling spools simulates joint hoop loads and therefore produces joint deflections similar to flight conditions. TWR-66845 reported test results and comparisons of measured strains to analytically predicted strains, thus verifying the analytical models. TWR-64835 analytically determined the joint stress ratios between proof test and flight meet or exceed the 1.05 proof factor requirement. TWR-16873 verifies that safe-life requirements are met. For all joint locations it was shown that safe-life is met by proof test, magnetic particle, and eddy current inspections.

C,D,E,F

17. RSRM case D6AC steel is susceptible to stress-corrosion cracking. Thus, a Material Use Agreement is required per MSFC specifications. The heat treat process of tempering reduces surface and internal residual stresses. The current design assures that all sustained applied or residual stresses are below the stress corrosion-cracking threshold. Steps are taken to protect all case segment exposed bare metal surfaces whenever required to minimize corrosion. Corrosion is removed prior to hardware assembly per engineering. Assembled case segments are painted with corrosion-resistant primer and topcoat.

C,D,E,F

18. TWR-12718 describes development test methods used to determine residual stresses in development case segments. A hole drilling method with strain gauge instrumentation was used to measure strain levels. The maximum tensile stress was found to be less than the stress corrosion-cracking threshold.

C,D,E,F

19. Measurements of fracture toughness at low temperatures combined with fracture mechanics analyses determined the minimum service temperature for the case membrane per TWR-16873. Case temperature is monitored prior to launch to satisfy minimum case temperature launch constraints.

G,I

20. Requirements for handling RSRM components during assembly, storage, and transportation are similar to those for previous and other current programs at Thiokol. These requirements dictate that RSRM case segments must be handled by or near a joint to avoid damage. All lifting hooks and slings are fitted with safety hooks per TWR-13880.

G,I

21. Positive cradling or support devices and tie downs that conform to shape, size, weight, and contour of components to be transported are provided to support RSRM segments and other components. Shock mounting and other protective devices are used on trucks and dollies to move sensitive loads per TWR-13880.

G,I

22. To assure that no damage occurs to flight hardware during transportation to the launch site, specially designed 200-ton railroad flatcars are used per TWR-13880.

G,I

23. To assure that no damage occurs to RSRM components during assembly and transportation, proof loading of all lifting equipment is conducted periodically to verify the integrity of the hardware. Structural support items are proof tested after fabrication completion, and re-tested if any changes are made. Ground support equipment is proof loaded by Thiokol. Proof-load requirements and general equipment categories are per TWR-10299.

G,I

24. In the final stages of case segment-to-case segment mating performed at Thiokol, shop planning requires the use of micro inch controls (extremely slow speeds) so

final alignments can be precisely made.

G,I

25. A specially designed Field Joint Assembly Fixture (FJAF) is used for segment mating. Tests were performed at KSC to develop mating procedures, determine acceptable mating insertion rates, and demonstrate use of FJAF "bear hugging" to improve segment match up per TWR-16979. The FJAF is installed with shims of appropriate thickness to give predetermined deflections of the tang and the clevis. Segment mating operations at KSC are per engineering. Compliance with these requirements minimizes assembly and post-assembly stresses.

G,I

26. Tests of vertical mating and de-mating of an RSRM center segment to an aft segment at KSC verified that the capture feature joint configuration can be successfully assembled and disassembled, and also served to characterize joint configuration during mating and de-mating per TWR-16829.

G,I

27. Installation of stiffener ring segments to stiffener segments is per engineering. Installation of ET attach rings is per USA drawings. Inspections are done at major assembly steps to verify procedures were followed.

J

28. Stubs are forged into the case metal parts and machined to print for use as attachment points for the external tank (ET) and RSRM parts external to the motor chamber. They are the ET attach stubs for the ET attach rings, stiffener stubs for the stiffener rings of the aft segment, forward dome attach stub for connection to the forward skirt, and aft dome attach stub for connection to the aft skirt. Structural analysis of the ET attach stubs is per TWR-17118, Supplement F. Strut loads imposed on the attach segment are per engineering. Analysis of the stiffener stubs is per TWR-17118, Supplement E. Calculations of forward dome and aft dome skirt attachment loads and margins of safety are per TWR-61930 and TWR-73715. Loads due to cavity collapse at water impact are considered. Reused stiffener segment stubs are certified safe for flight by proof testing.

J

29. Two experiments with Transient Pressure Test Articles, TPTA 1.2 and TPTA 2.2, tested the effect of representative launch loads. Loads applied were an axial load simulating shuttle vehicle weight and dynamic strut loads that simulate side loads imposed on the RSRM by the external tank during Space Shuttle Main Engine buildup. The strut load actuation applied as-designed dynamic strut loads during the ignition transient period. Performance of the RSRM hardware met all test objectives per TWR-18075 and TWR-18428.

J

30. Experiments with the Structural Test Article (STA-3) proved the load carrying capability of the ET attach and aft skirt stubs. An updated asymmetric load, representing a three-sigma upper limit burn rate ignition transient, was applied during the test and demonstrated positive margins of safety for a 1.4 factor of safety per TWR-18428.

J

31. Flaws in the forging blank that could cause failure are exposed during roll forming of the case stubs, due to the severe nature of the process. The blank is 100 percent ultrasonically inspected for cracks, inclusions, or voids before stubs or flanges are formed, thus assuring absence of deep internal flaws in all parts of the forging.

J

32. TWR-16873 identifies all areas that are not verified in proof testing, which include the membrane by the forward and aft skirts, stiffener, and ET attach stub areas. For these areas, the report 1) identifies the maximum limit applied stress in flight, 2) calculates the minimum critical flaw size during the flight loading condition, and 3) compares the critical flaw size with that consistently detectable by nondestructive inspection methods. The report asserts acceptability of the design, based on readily detectable critical flaw sizes in the stub areas. Bolt holes in the stiffener

and ET attach stubs are examined for cracks by a wet fluorescent magnetic particle inspection before and after proof testing, for both new and refurbished parts. Pin holes for skirt attachment are magnetic particle inspected after proof-testing.

C,D,E,F — 33. Case temperatures prior to launch are in compliance with Shuttle Launch Commit Criteria per NSTS-16007.

A — 34. The required factor of safety for membrane rupture is assured by verifying case membrane thickness, which is measured at Thiokol with a Thiokol-developed ultrasonic thickness instrument per TWR-60532. Use of the Thiokol instrument was certified per TWR-60532 and TWR-61166.

A,B,C,D,E, F,G,H,I,J — 35. TWR-61410 was updated to include boundary conditions created by the Performance Enhancement (PE) Program. This report analyzed temperature conditions created from flight loads. PE temperatures are equal to current generic temperatures for all locations for the critical time of liftoff. For a few locations at the factory joints and case acreage during flight, temperatures rise, but only slightly, and maximum case temperatures are lower than current generic certification. For flight load events, PE temperatures are not significantly different from current generic temperatures. There is no impact on previous analyses or margins of safety for the case membranes, factory joints, and field joints per TWR-61410.

A,B,C,D,E, F,G,H,I,J — 36. Case segments used for the RSRM were evaluated to include generic/Performance Enhancement loads. The evaluation shows that all areas still meet required safety factors and maintain positive margins of safety per TWR-61408.

582 A,B,C,D,E F,G,H,I,J — 37. As a result of implementing the SSME Block II engine, analyses were performed to determine structural responses to Block II engine load cases. Based on these loads, critical generic ground wind speeds were reduced to ensure that stiffener segments maintain a safety factor equal to or greater than 1.4, as referenced in TWR-61408.

K,L — 38. Bushings are made from low-alloy, high strength D6AC steel per engineering. D6AC mechanical properties meet the design intent.

K,L — 39. Tensile properties of the bushings are per engineering. Heat-treated sample material, representative of each heat of steel, must meet the properties and other requirements per engineering. The properties are verified by test methods and standards.

K,L — 40. Chemical composition of D6AC steels tested per mill analysis for each heat of steel. The analysis is per engineering.

M — 41. Bushings are made from the same material as the base material of the factory joint. Bushings and other metals used in the joint (MP35N, Inconel 718, and NAS 1135N) form an incompatible couple to galvanic corrosion with the D6AC steel used in the bushings. Protection against galvanic corrosion at the joint is provided by an application of grease to the bushings and other joint metal components. External coverings around the outside of the joints prevent moisture from setting up a galvanic cell.

N — 42. The bushing is fabricated from D6AC steel. D6AC steel has low-to-moderate resistance to stress corrosion. A Material Use Agreement (MUA) is required for D6AC steel per MSFC specifications.

N 43. Fracture control of the bushings and parent hole is addressed as follows:

a. Fracture control procedures are described in TWR-16873. Analysis of bushings and parent material found the increased tensile stresses of the parent material to be insignificant per TWR-73519. At refurbishment, bushings shall be removed, the parent material of the hole inspected for crack-like defects, raised metal, and sharp edges. Bushings and holes shall be protected by filtered grease, and bushings shall be protected by filtered grease prior to installation. Subsequent to bushing installation, case segments are proof tested. Joints, including bushed holes, are covered after assembly that provides protection from environments. Results of safe-life analysis in the elastic-plastic regions of the tang and clevis joint are presented in TWR-16873.

N 44. Heat treatment of bushings provides for high strength and high toughness with reduced internal and surface stresses per engineering.

O 45. Bushing general features and dimensions are per engineering. Machining and fabrication are also per engineering.

P 46. Bushing surfaces are visually inspected for surface defects. Defects or flaws that are crack-like in nature are unacceptable per engineering.

Q 47. Bushings are removed and installed per engineering. This technique was shown to have no detrimental impact per TWR-73965.

9.2 TEST AND INSPECTION:

| DCN | FAILURE CAUSES and TESTS | (T) | | | CIL CODES |
|---|---|---|---|---|---|
| | | | 1. | For New Case Segment, Cylinder, Forging, verify: | |
| | B,H | (T) | a. | Chemical composition (D6AC) | ADW123 |
| | B,H | (T) | b. | Heat treatment or re-heat treatment--austenitize | FAA032 |
| | B,H | (T) | c. | Heat treatment or re-heat treatment--quench | FAA033 |
| | B,H | (T) | d. | Heat treatment or re-heat treatment--snap temper | FAA034 |
| | B,H | (T) | e. | Heat treatment or re-heat treatment--cleaning | FAA035 |
| | B,H | (T) | f. | Heat treatment or re-heat treatment--first and second tempers | FAA036 |
| | B,H | (T) | g. | Heat treatment or re-heat treatment--additional thermal sizing | FAA038 |
| | B,C,D, E,F,H | (T) | h. | Ultimate strength, uniaxial, after heat treatment | ADW167,ADW169 |
| | B,C,D, E,F,H | (T) | i. | Yield strength after heat treatment | ADW189,ADW193 |
| | B,C,D, E,F,H | (T) | j. | Elongation after heat treatment | ADW061,ADW065 |
| | B,C,D, E,F,H | (T) | k. | Reduction in area after heat treatment | ADW009,ADW137 |
| | B,C,D, E,F,H | (T) | l. | Fracture toughness after heat treatment | ADW069,ADW074 |
| | B,H | (T) | m. | Micro-hardness/decarburization after heat treatment | FAA041,FAA042 |
| | B,C,D, E,F,H | (T) | n. | Grain size after heat treatment | FAA039A |
| | B,C,D, E,F,H | (T) | o. | Macro structure after heat treatment | FAA040A |
| | B,C,D, E,F,H | (T) | p. | Inclusion rating after heat treatment | ADX085A |
| | C,D,E,F | (T) | q. | Ultrasonic inspection of the forging | ADW175 |
| | C,D,E,F | | r. | Application of oil preservative to the forging | FAA030A |
| | A | | s. | Case wall thickness | ADW032 |
| | A | | t. | Wall thickness gradient | FAA052A |
| | | | 2. | For New Case Segment, Attach, Forging, verify: | |
| | B,H | (T) | a. | Chemical composition (D6AC) | ABL118 |
| | B,H | (T) | b. | Heat treatment or re-heat treatment--austenitize | FAA332 |
| | B,H | (T) | c. | Heat treatment or re-heat treatment--quench | FAA333 |
| | B,H | (T) | d. | Heat treatment or re-heat treatment--snap temper | FAA334 |
| | B,H | (T) | e. | Heat treatment or re-heat treatment--cleaning | FAA335 |
| | B,H | (T) | f. | Heat treatment or re-heat treatment--first and second tempers | FAA336 |
| | B,H | (T) | g. | Heat treatment or re-heat treatment--additional thermal sizing | FAA338 |
| | B,C,D, E,F,H | (T) | h. | Ultimate strength, uniaxial, after heat treatment | ABL154,ABL159 |
| | B,C,D, E,F,H | (T) | i. | Yield strength after heat treatment | ABL182,ABL183 |
| | B,C,D, E,F,H | (T) | j. | Elongation after heat treatment | ABL036,ABL037 |
| | B,C,D, E,F,H | (T) | k. | Reduction in area after heat treatment | ABL002,ABL003 |
| | B,C,D, E,F,H | (T) | l. | Fracture toughness after heat treatment | ABL043,ABL044 |
| | B,H | (T) | m. | Micro-hardness/decarburization after heat treatment | FAA341,FAA342 |

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|---|---|---|---|---|
| B,C,D, E,F,H | (T) | n. | Grain size after heat treatment | FAA339 |
| B,C,D, E,F,H | (T) | o. | Macro structure after heat treatment | FAA340 |
| B,C,D, E,F,H | (T) | p. | Inclusion rating after heat treatment | ABL066 |
| C,D,E,F,J | (T) | q. | Ultrasonic inspection of the forging | ABL163 |
| C,D,E,F | | r. | Application of oil preservative to the forging | FAA330 |
| A | | s. | Case wall thickness | FAA054 |

3. For New Case Segment, Stiffener, Forging, verify:

| | | | | |
|---|---|---|---|---|
| B,H | (T) | a. | Chemical composition (D6AC) | FAB904 |
| B,H | (T) | b. | Heat treatment or re-heat treatment--austenitize | FAB432 |
| B,H | (T) | c. | Heat treatment or re-heat treatment--quench | FAB433 |
| B,H | (T) | d. | Heat treatment or re-heat treatment--snap temper | FAB434 |
| B,H | (T) | e. | Heat treatment or re-heat treatment--cleaning | FAB435 |
| B,H | (T) | f. | Heat treatment or re-heat treatment--first and second tempers | FAB436 |
| B,H | (T) | g. | Heat treatment or re-heat treatment--additional thermal sizing | FAB438 |
| B,C,D, E,F,H | (T) | h. | Ultimate strength, uniaxial, after heat treatment | FAB912,FAB905 |
| B,C,D, E,F,H | (T) | i. | Yield strength after heat treatment | FAB913,FAB906 |
| B,C,D, E,F,H | (T) | j. | Elongation after heat treatment | FAB914,FAB907 |
| B,C,D, E,F,H | (T) | k. | Reduction in area after heat treatment | FAB915,FAB908 |
| B,C,D, E,F,H | (T) | l. | Fracture toughness after heat treatment | FAB916,FAB909 |
| B,H | (T) | m. | Micro-hardness/decarburization after heat treatment | FAB441,FAB911 |
| B,C,D, E,F,H | (T) | n. | Grain size after heat treatment | FAB439 |
| B,C,D, E,F,H | (T) | o. | Macro structure after heat treatment | FAB440 |
| B,C,D, E,F,H | (T) | p. | Inclusion rating after heat treatment | FAB910 |
| C,D,E,F,J | (T) | q. | Ultrasonic inspection of the forging | FAB917 |
| C,D,E,F | | r. | Application of oil preservative to the forging | FAB924 |
| A | | s. | Case wall thickness | FAB901 |
| A | | t. | Wall thickness gradient | FAB452 |

4. For New Case Segment, Aft, Forging, verify:

| | | | | |
|---|---|---|---|---|
| B | (T) | a. | Chemical composition (D6AC) | AAJ021 |
| B | (T) | b. | Heat treatment or re-heat treatment--austenitize | FAA532 |
| B | (T) | c. | Heat treatment or re-heat treatment--quench | FAA533 |
| B | (T) | d. | Heat treatment or re-heat treatment--snap temper | FAA534 |
| B | (T) | e. | Heat treatment or re-heat treatment--cleaning | FAA535 |
| B | (T) | f. | Heat treatment or re-heat treatment--first and second tempers | FAA536 |
| B | (T) | g. | Heat treatment or re-heat treatment--additional thermal sizing | FAA538 |
| B,C | (T) | h. | Ultimate strength, uniaxial, after heat treatment | AAJ174,AAJ175 |
| B,C | (T) | i. | Yield strength after heat treatment | AAJ201,AAJ204 |
| B,C | (T) | j. | Elongation after heat treatment | AAJ055,AAJ058 |
| B,C | (T) | k. | Reduction in area after heat treatment | AAJ006,AAJ153 |
| B,C | (T) | l. | Fracture toughness after heat treatment | AAJ065,AAJ068 |
| B | (T) | m. | Micro-hardness/decarburization after heat treatment | FAA541,FAA542 |
| B,C | (T) | n. | Grain size after heat treatment | FAA539 |
| B,C | (T) | o. | Macro structure after heat treatment | FAA540 |

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|---|---|---|---|---|---|
| B,C | (T) | | p. | Inclusion rating after heat treatment | AAJ089 |
| C,E | (T) | | q. | Ultrasonic inspection of the forging | AAJ177 |
| C | | | r. | Application of oil preservative to the forging | FAA530 |
| A | | | s. | Wall thickness at point B | AAJ016,AAJ192 |
| A | | | t. | Wall thickness near clevis | AAJ195,AAJ196 |
| A | | | u. | Wall thickness near Datum -G- | AAJ198,AAJ199 |
| A | | | v. | Wall thickness gradient | FAA552 |
| | | 5. | For New Case Segment, Forward, Forging verify: | | |
| B | (T) | | a. | Chemical composition (D6AC) | ACD135,ACD018 |
| B | (T) | | b. | Heat treatment or re-heat treatment--austenitize | FAA132 |
| B | (T) | | c. | Heat treatment or re-heat treatment--quench | FAA133 |
| B | (T) | | d. | Heat treatment or re-heat treatment--snap temper | FAA134 |
| B | (T) | | e. | Heat treatment or re-heat treatment--cleaning | FAA135 |
| B | (T) | | f. | Heat treatment or re-heat treatment--first and second tempers | FAA136 |
| B | (T) | | g. | Heat treatment or re-heat treatment--additional thermal sizing | FAA138 |
| B,C | (T) | | h. | Ultimate strength, uniaxial, after heat treatment | ACD189,ACD193 |
| B,C | (T) | | i. | Yield strength after heat treatment | ACD210,ACD212 |
| B,C | (T) | | j. | Elongation after heat treatment | ACD046,ACD047 |
| B,C | (T) | | k. | Reduction in area after heat treatment | ACD001,ACD002 |
| B,C | (T) | | l. | Fracture toughness after heat treatment | ACD060,ACD061 |
| B | (T) | | m. | Micro-hardness/decarburization after heat treatment | FAA141,FAA142 |
| B,C | (T) | | n. | Grain size after heat treatment | FAA139 |
| B,C | (T) | | o. | Macro structure after heat treatment | FAA140 |
| B,C | (T) | | p. | Inclusion rating after heat treatment | ACD085 |
| C,E | (T) | | q. | Ultrasonic inspection of the forging | ACD195,ACD199 |
| C | | | r. | Application of oil preservative to the forging | FAA130 |
| A | | | s. | Case wall thickness "T" dimensions per chart | ACD012 |
| A | | | t. | Wall thickness gradient | FAA152 |
| | | 6. | For New Case Segment, Capture Cylinder, Standard Weight, verify: | | |
| C,D,E,F | (T) | | a. | Hydroproof test | ADX074 |
| C,D,E,F | (T) | | b. | Magnetic particle inspection after hydroproof test | ADX105 |
| C,D,E,F | | | c. | Corrosion protection | ADX018 |
| C,D,E,F | (T) | | d. | Vent port and leak check port by eddy current probe after hydroproof | ADX057 |
| A | | | e. | Case wall thickness | FAA050 |
| A | | | f. | Surface defects and repair | FAA051 |
| C,D,E,F,J | (T) | | g. | Clevis pin hole by eddy current for cracks | BAA513A |
| | | 7. | For Refurbished Case Segment, Capture Cylinder, Standard Weight, verify: | | |
| A | | | a. | Case wall thickness | ADX031 |
| A | | | b. | Surface defects and repair | FAA070 |
| A | | | c. | Case wall thickness of thin wall areas | RAA248 |
| C,D,E,F | (T) | | d. | Hydroproof test | ADX073 |
| C,D,E,F,J | (T) | | e. | Magnetic particle inspection after hydroproof test | ADX113 |
| C,D,E,F,J | (T) | | f. | Vent port and leak check port by eddy current probe after hydroproof | FAA073 |
| C,D,E,F,J | (T) | | g. | Clevis pin holes by eddy current for cracks | BAA513 |
| | | 8. | For New Case Segment, Capture Cylinder, Light Weight, verify: | | |
| C,D,E,F | (T) | | a. | Hydroproof test | ADW084 |
| C,D,E,F,J | (T) | | b. | Magnetic particle inspection after hydroproof test | ADW107 |
| C,D,E,F | | | c. | Corrosion protection | ADW019 |
| C,D,E,F,J | (T) | | d. | Vent port and leak check port by eddy current probe after hydroproof | FAH004 |
| A | | | e. | Case wall thickness | FAA250 |

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|---|---|---|---|---|
| A | | f. | Surface defects and repair | FAA251 |
| C,D,E,F,J | (T) | g. | Clevis pin hole by eddy current for cracks | BAA511A |
| | | 9. | For Refurbished Case Segment, Capture Cylinder, Light Weight, verify: | |
| A | | a. | Case wall thickness | ADW033 |
| A | | b. | Surface defects and repair | FAA270 |
| A | | c. | Case wall thickness of thin wall areas | RAA247 |
| C,D,E,F | (T) | d. | Hydroproof test | ADW077 |
| C,D,E,F,J | (T) | e. | Magnetic particle inspection after hydroproof test | ADW117 |
| C,D,E,F,J | (T) | f. | Vent port and leak check port by eddy current probe after hydroproof | AFS030 |
| C,D,E,F,J | (T) | g. | Clevis pin holes by eddy current for cracks | BAA511 |
| | | 10. | For Refurbished Case Segment, Cylinder, verify: | |
| A | | a. | Case wall thickness | AAK011 |
| A | | b. | Surface defects and repair | FAA770 |
| A | | c. | Case wall thickness of thin wall areas | RAA241 |
| C,D,E,F | (T) | d. | Hydroproof test | AAK032 |
| C,D,E,F,J | (T) | e. | Magnetic particle inspection after hydroproof test | AAK048 |
| C,D,E,F,J | (T) | f. | Leak check port by eddy current probe after hydroproof | FAA773 |
| C,D,E,F,J | (T) | g. | Clevis pin holes by eddy current for cracks | BAA503 |
| | | 11. | For New Case Segment, Cylinder, Light Weight verify: | |
| C,D,E,F,J | (T) | a. | Clevis pin hole by eddy current for cracks | BAA509A |
| | | 12. | For Refurbished Case Segment, Cylinder, Light Weight, verify: | |
| A | | a. | Case wall thickness | FAA687 |
| A | | b. | Surface defects and repair | FAA670 |
| A | | c. | Case wall thickness of thin wall areas | RAA245 |
| C,D,E,F | (T) | d. | Hydroproof test | ABM060 |
| C,D,E,F,J | (T) | e. | Magnetic particle inspection after hydroproof test | ABM107 |
| C,D,E,F,J | (T) | f. | Leak check port by eddy current probe after hydroproof | ABM038 |
| C,D,E,F,J | (T) | g. | Clevis pin holes by eddy current for cracks | BAA509 |
| | | 13. | For Refurbished Case Segment, Attach, Standard Weight, verify: | |
| A | | a. | Case wall thickness | FAB150 |
| A | | b. | Surface defects and repair | FAB151 |
| A | | c. | Case wall thickness of thin wall areas | RAA240 |
| C,D,E,F | (T) | d. | Hydroproof test | ABL054A |
| C,D,E,F,J | (T) | e. | Magnetic particle inspection after hydroproof test | FAB921 |
| C,D,E,F,J | (T) | f. | Leak check port by eddy current probe after hydroproof | FAB373 |
| J | | g. | ET flange bolt holes for contamination, surface defects, and cracks | RAA200 |
| J | | h. | ET flange bolt hole diameters in the longitudinal direction | FAB722 |
| C,D,E,F,J | (T) | i. | Clevis pin holes by eddy current for cracks | BAA502 |
| N | (T) | j. | Eddy current inspection for crack-like flaws in parent material of flange bolt hole requiring bushing reinstallation | SER065 |
| O | | k. | Bushing outside diameter | SER058 |
| M,N,P | | l. | Inner and outer surface of bushing for contamination, crack-like defects, raised metal, and sharp edges | SER068 |
| M,N | | m. | Filtered grease applied to outer surface of bushing and surface of flange bolt hole requiring bushing reinstallation | SER067 |
| P | | n. | Visual inspection for contamination, raised metal, and sharp edges of flange bolt hole requiring bushing reinstallation | SER066 |
| Q | (T) | o. | Pull test of flange bushing following hydroproof test | SER069 |

14. For New Case Segment, Attach, Light Weight, verify:

| | | | | |
|---|---|---|---|---|
| C,D,E,F | (T) | a. | Hydroproof test | ABL055 |
| C,D,E,F,J | (T) | b. | Magnetic particle inspection after hydroproof test | ABL094 |
| C,D,E,F | | c. | Corrosion protection | ABL008 |
| C,D,E,F,J | (T) | d. | Leak check port by eddy current probe after hydroproof | ABL034 |
| A | | e. | Case wall thickness | FAA350 |
| A | | f. | Wall thickness gradient | FAA352 |
| A | | g. | Surface defects and repair | FAA351 |
| J | | h. | ET flange bolt holes for contamination, surface defects, and cracks | ABL137 |
| J | | i. | ET flange bolt hole diameters in the longitudinal direction | FAC309 |
| C,D,E,F,J | (T) | j. | Clevis pin holes by eddy current for cracks | BAA508A |

15. For Refurbished Case Segment, Attach, Light Weight, verify:

| | | | | |
|---|---|---|---|---|
| C,D,E,F | (T) | a. | Hydroproof test | ABL054 |
| C,D,E,F,J | (T) | b. | Magnetic particle inspection after hydroproof test | ABL112 |
| C,D,E,F,J | (T) | c. | Leak check port by eddy current probe after hydroproof | FAA373 |
| J | | d. | ET flange bolt holes for contamination, surface defects, and cracks | ABL137 |
| J | | e. | ET flange bolt hole diameters in the longitudinal direction | FAC309 |
| A | | f. | Case wall thickness | ABL014 |
| A | | g. | Surface defects and repair | FAA370 |
| A | | h. | Case wall thickness of thin wall areas | RAA244 |
| C,D,E,F,J | (T) | i. | Clevis pin holes by eddy current for cracks | BAA508 |
| N | (T) | j. | Eddy current inspection for crack-like flaws in parent material of flange bolt hole requiring bushing reinstallation | SER080 |
| O | | k. | Bushing outside diameter | SER073 |
| M,N | | l. | Inner and outer surface of bushing for contamination, crack-like defects, raised metal, and sharp edges | SER078 |
| M,N | | m. | Filtered grease applied to outer surface of bushing and surface of flange bolt hole requiring bushing reinstallation | SER082 |
| P | | n. | Visual inspection for contamination, raised metal, and sharp edges of flange bolt hole requiring bushing reinstallation | SER081 |
| Q | (T) | o. | Pull test of flange bushing following hydroproof test | SER084 |

16. For New Case Segment, Stiffener, Standard Weight, verify:

| | | | | |
|---|---|---|---|---|
| C,D,E,F | (T) | a. | Hydroproof test | FAB919 |
| C,D,E,F,J | (T) | b. | Magnetic particle inspection after hydroproof test | FAB920 |
| C,D,E,F | | c. | Corrosion protection | ABK006 |
| C,D,E,F,J | (T) | d. | Leak check port by eddy current probe after hydroproof | FAB463 |
| A | | e. | Case wall thickness | FAB450 |
| A | | f. | Case wall axial straightness variation (buckling criterion) | RAA206 |
| A | | g. | Surface defects and repair | FAB451 |
| C,D,E,F,J | (T) | h. | Clevis pin hole by eddy current for cracks | BAA504A |

17. For Refurbished Case Segment, Stiffener, Standard Weight, verify:

| | | | | |
|---|---|---|---|---|
| C,D,E,F | (T) | a. | Hydroproof test | ABK032A |
| C,D,E,F,J | (T) | b. | Magnetic particle inspection after hydroproof test | FAB922 |
| A | | c. | Case wall thickness | FAB153 |
| A | | d. | Case wall axial straightness variation (buckling criterion) | FAB156 |
| A | | e. | Surface defects and repair | FAB154 |
| A | | f. | Case wall thickness of thin wall areas | RAA242 |
| C,D,E,F,J | (T) | g. | Leak check port by eddy current probe after hydroproof | FAB473 |
| J | | h. | Flange bolt holes for contamination, surface defects, and cracks | FAB075 |
| C,D,E,F,J | (T) | i. | Clevis pin holes by eddy current for cracks | BAA504 |

| | | | |
|---|---|---|---|
| C,D,E,F,J (T) | j. | Stiffener Flange and hole regions by eddy current for cracks | BAA505 |
| C,D,E,F,J | k. | Stiffener flange radius of curvature | BAA515 |

18. For New Case Segment, Stiffener, Light Weight, verify:

| | | | |
|---|---|---|---|
| C,D,E,F (T) | a. | Hydroproof test | ABK033 |
| C,D,E,F,J (T) | b. | Magnetic particle inspection after hydroproof test | ABK053 |
| A | c. | Case wall axial straightness variation (buckling criterion) | RAA209 |
| A | d. | Case wall thickness | FAA450 |
| A | e. | Surface defects and repair | FAA451 |
| A | f. | Average membrane thickness (buckling criterion) | FAA454 |
| C,D,E,F,J (T) | g. | Leak check port by eddy current probe after hydroproof | FAA463 |
| C,D,E,F | h. | Corrosion protection | FAB925 |
| C,D,E,F,J (T) | i. | Clevis pin holes by eddy current for cracks | BAA506A |

19. For Refurbished Case Segment, Stiffener, Light Weight, verify:

| | | | |
|---|---|---|---|
| A | a. | Case wall thickness | FAA487 |
| A | b. | Case wall axial straightness variation (buckling criterion) | FAB157 |
| A | c. | Average membrane thickness (buckling criterion) | FAB158 |
| A | d. | Surface defects and repair | FAA470 |
| A | e. | Case wall thickness of thin wall areas | RAA243 |
| C,D,E,F (T) | f. | Hydroproof test | ABK032 |
| C,D,E,F,J (T) | g. | Magnetic particle inspection after hydroproof test | ABK051 |
| C,D,E,F,J (T) | h. | Leak check port by eddy current probe after hydroproof | FAA473 |
| J | i. | Flange bolt holes for contamination, surface defects, and cracks | FAB076 |
| C,D,E,F,J (T) | j. | Clevis pin holes by eddy current for cracks | BAA506 |
| C,D,E,F,J (T) | k. | Stiffener flange and hole regions by eddy current for cracks | BAA507 |
| C,D,E,F,J | l. | Stiffener flange radius of curvature | BAA516 |

20. For New Case Segment, Aft, verify:

| | | | |
|---|---|---|---|
| C,D,E,F | a. | Corrosion protection | AAJ013 |
| C,D,E,F | b. | Roundness of the aft skirt stub | FAC051 |
| C,D,E,F (T) | c. | Hydroproof test | AAJ078 |
| C,D,E,F,J (T) | d. | Magnetic particle inspection after hydroproof test | AAJ114 |
| C,D,E,F | e. | Aft skirt attachment holes for contamination, surface defects, and cracks | RAA264 |
| C,D,E,F,J (T) | f. | Alignment slots at aft skirt attachment by eddy current after hydroproof | RAA265 |
| A | g. | Case wall thickness | FAA550 |
| A | h. | Surface defects and repair | FAA551 |
| C,D,E,F,J (T) | i. | Clevis pin hole by eddy current for cracks | BAA501A |

21. For Refurbished Case Segment, Aft, verify:

| | | | |
|---|---|---|---|
| J | a. | Roundness of the aft skirt stub | FAC052 |
| C,D,E,F (T) | b. | Hydroproof test | AAJ075 |
| J | c. | Aft skirt attachment holes for contamination, surface defects, and cracks | FAB101 |
| J | d. | Aft skirt attachment hole diameters in the longitudinal direction | FAB102 |
| C,D,E,F,J (T) | e. | Magnetic-particle inspection after hydroproof test | AAJ105 |
| A | f. | Case wall thickness of thin wall areas | RAA239 |
| E (T) | g. | Alignment slots at aft skirt attachment by eddy current after hydroproof | RAA266 |
| A | h. | Surface defects and repair | FAA570 |
| A | i. | Case wall thickness | FAA587 |
| C,D,E,F,J (T) | j. | Clevis pin holes by eddy current for cracks | BAA501 |
| C,D,E,F,J (T) | k. | Aft Y-joint by eddy current for cracks | BAA512 |

| | | | | |
|---|---|---|---|---|
| N | (T) | l. | Eddy current inspection for crack-like flaws in parent material of stub pin hole requiring bushing reinstallation | SER110 |
| O | | m. | Bushing outside diameter | SER108 |
| M,N,P | | n. | Inner and outer surface of bushing for contamination, crack-like defects, raised metal, and sharp edges | SER113 |
| M,N | | o. | Filtered grease applied to outer surface of bushing and surface of stub pin hole requiring bushing reinstallation | SER112 |
| P | | p. | Visual inspection for contamination, raised metal, and sharp edges of stub pin hole requiring bushing reinstallation | SER111 |
| Q | (T) | q. | Pull test of stub bushing | SER114 |

22. For New Case Segment, Forward, verify:

| | | | | |
|---|---|---|---|---|
| A | | a. | Corrosion protection | ACD007 |
| C,D,E,F | (T) | b. | Hydroproof test | ACD074 |
| C,D,E,F,J | (T) | c. | Magnetic particle inspection after hydroproof test | ACD121 |
| A | | d. | Case wall thickness | FAA150 |
| A | | e. | Surface defects and repair | FAA151 |
| C,D,E,F,J | (T) | f. | Leak check port by eddy current probe after hydroproof | FAA163 |
| C,D,E,F | | g. | Forward skirt attachment holes for contamination, surface defects, and cracks | RAA267 |
| C,D,E,F | (T) | h. | Alignment slots at forward skirt attachment by eddy current after hydroproof | RAA268 |

23. For Refurbished Case Segment, Forward, verify:

| | | | | |
|---|---|---|---|---|
| A | | a. | Case wall thickness | ACD013 |
| C,D,E,F,J | (T) | b. | Leak check port by eddy current probe after hydroproof | ACD045 |
| C,D,E,F | (T) | c. | Hydroproof test | ACD073 |
| J | | d. | Forward skirt attachment holes for contamination, surface defects, and cracks | FAB079 |
| C,D,E,F,J | (T) | e. | Magnetic particle inspection after hydroproof test | ACD096 |
| A | | f. | Surface defects and repair | FAA170 |
| A | | g. | Case wall thickness of thin wall areas | RAA246 |
| | (T) | h. | Alignment slots at forward skirt attachment by eddy current after hydroproof | RAA269 |
| C,D,E,F,J | (T) | i. | Forward Y-joint by eddy current for cracks | BAA510 |
| C,D,E,F,J | (T) | j. | Ultrasonic shear wave inspection of Y-joint area after hydroproof test | FAB501 |
| N | (T) | k. | Eddy current inspection for crack-like flaws in parent material of stub bolt hole requiring bushing reinstallation | SER005 |
| O | | l. | Bushing outside diameter | SER008 |
| M,N,P | | m. | Inner and outer surface of bushing for contamination, crack-like defects, raised metal, and sharp edges | SER013 |
| M,N | | n. | Filtered grease applied to outer surface of bushing and surface of stub pin hole requiring bushing reinstallation | SER007 |
| P | | o. | Visual inspection for contamination, raised metal, and sharp edges of stub pin hole requiring bushing reinstallation | SER006 |
| Q | (T) | p. | Pull test of stub bushing following hydroproof test | SER009 |

24. For New Case Assembly, Painted Segment (Forward, Center, and Aft) verify:

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|---|---|---|---|---|
| C,D,E,F | | a. | Shelf life and environmental history, paint and primer | AEY035,AEY048,AEZ035,AEZ045,AFB035,AFB045 |
| C,D,E,F | | b. | For application of paint and primer, facilities and equipment are clean | AEY037,AEZ034,AFB034 |
| C,D,E,F | | c. | Surfaces to be primed are clean and free from contamination | AEY005,AEZ005,AFB005 |

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|---|---|---|---|---|
| C,D,E,F | | d. | For application of paint and primer, humidity and case temperature | AEY018,AEZ016,AFB016 |
| C,D,E,F | | e. | Container is covered after mixing, paint and primer | AEY034,AEY040,AEZ031, AEZ037,AFB031,AFB037 |
| C,D,E,F | | f. | Full cover coat, paint and primer | AEY014,AEY015,AEZ012, AEZ013,AFB012,AFB013 |
| C,D,E,F | | g. | Runs, sags, drips, and inclusions are acceptable per specification, paint and primer | AEY033,AEY047,AEZ030, AEZ044,AFB044,FAA103 |
| C,D,E,F | | h. | Dry film thickness, paint and primer | AEY025,AEY002,AEZ022, AEZ002,AFB022,AFB002 |
| G,I | (T) | i. | Weight test, NDT, and proper hookup of handling equipment used for mating | AEY009,AEZ008,AFB008 |
| G,I | | j. | Installation of pins, in case joints | AEY019,FAA060,AEZ017,AFB017,FAA360 |
| A | | k. | Final grit blast is complete and acceptable | RAA270,RAA271,RAA272 |
| | 25. | For New Case Assembly, Aft Dome, Painted verify: | | |
| A | | a. | Final grit blast is complete and acceptable | RAA273 |
| C,D,E,F | | b. | Shelf life and environmental history, paint and primer | FAA090,FAA091 |
| C,D,E,F | | c. | For application of paint and primer, facilities and equipment are clean | FAA092 |
| C,D,E,F | | d. | Surfaces to be primed are clean and free from contamination | FAA097 |
| C,D,E,F | | e. | For application of paint and primer, humidity and case temperature | FAA098 |
| C,D,E,F | | f. | Container is covered after mixing, paint and primer | FAA099,FAA100 |
| C,D,E,F | | g. | Full cover coat, paint and primer | FAA093,FAA094 |
| C,D,E,F | | h. | Runs, sags, drips, and inclusions are acceptable per specification, paint and primer | FAA095,FAA096 |
| C,D,E,F | | i. | Dry film thickness, paint and primer | FAA101,FAA102 |
| | 26. | For New Insulated Aft Segment Assembly, verify: | | |
| G,I | (T) | a. | Weight test, NDT, and proper hookup of handling equipment used for mating | AFA000 |
| G,I | | b. | Installation of Stiffener-to-Aft-Dome Joint pins | AFA001 |
| | 27. | For New Segment, Rocket Motor (Forward, Forward Center, Aft Center, and Aft), verify: | | |
| A | | a. | Case wall thickness after localized grit blasting | RAA202,RAA203, RAA204,RAA205 |
| | 28. | For New Bushing, Replacement verify: | | |
| K | | a. | Bushing material is D6AC | SER001 |
| L | | b. | Bushing material is heat treated | SER002 |
| | 29. | KSC verifies: | | |
| C,D,E,F,G,I | | a. | RSRM ET attach ring stubs for contamination, raised metal, surface defects, corrosion, or deformation per OMRSD File V, Vol I, B47AR0.011 | OMD025 |
| C,D,E,F,G,I | | b. | Segments and nozzle components are free of damage per OMRSD File V, Vol I, B47SG0.061 | OMD079 |
| C,D,E,F,G,I | | c. | No fungus or contamination upon TPS surface repair per OMRSD File V, Vol I, B47GEN.070 | OMD034 |
| J | | d. | Tang and Clevis Field Joint unpainted surfaces are free from surface defects or contamination per OMRSD File V, Vol I, B47SG0.122 | OMD085 |
| G,I | | e. | RSRM field joint (segments) radial alignment prior to mating per OMRSD File V, Vol I, B47SG0.170 | OMD089 |

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|---|---|---|---|
| G,I | f. | RSRM field joint parallel alignment per OMRSD File V, Vol I, B47SG0.180 | OMD090 |
| G,I | g. | For tang/clevis joint clocking, matching pins and slots are vertically aligned per OMRSD File V, Vol I, B47SG0.191 | OMD091 |
| G,I | h. | Segment mating occurs with contact of chamfered surfaces, no flat on flat contact per OMRSD File V, Vol I, B47SG0.200 | OMD092 |
| G,I,J | i. | Segment joint pin protrusion acceptable per OMRSD File V, Vol I, B47SG0.214 | OMD093 |
| C,D,E,F,G,I | j. | RSRM stiffener ring attach stubs for contamination, raised metal, surface defects, corrosion, or deformation and stiffener rings for contamination, corrosion, and TPS bond per OMRSD File V, Vol I, B47SG0.234 | OMD094 |
| G,I | k. | Acceptable field joint engagement rate during segment mating per OMRSD File V, Vol I, B47SG0.290 | OMD095 |
| G,I | l. | RSRM field joint geometry (tang and outer clevis leg) prior to mating per OMRSD File V, Vol I, B47SG0.330 | OMD100 |
| G,I | m. | Acceptable contact between FJAF and segment outer clevis leg during mating operations per OMRSD File V, Vol I, B47SG0.390 | OMD105 |
| G,I | n. | Correct field joint pin retainer clips (custom shims) are installed per OMRSD File V, Vol I, B47SG0.510 | OMD110 |