RESULTS OF THE DEVELOPMENT MOTOR 8 TEST FIRING

HEARING

BEFORE THE

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

OF THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY HOUSE OF REPRESENTATIVES

ONE HUNDREDTH CONGRESS

FIRST SESSION

SEPTEMBER 16, 1987

[No. 34]

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*Ranking Republican Member.
**Resigned February 19, 1987 (H. Res. 89).
***Elected March 30, 1987 (H. Res. 133).

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WITNESSES

RESULTS OF THE DEVELOPMENT MOTOR 8 TEST FIRING

WEDNESDAY, SEPTEMBER 16, 1987

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Space Science and Applications,
Washington, DC.

The subcommittee met, pursuant to notice, at 1 p.m., in room 2318, Rayburn House Office Building, Hon. Bill Nelson (chairman of the subcommittee) presiding.

Mr. Nelson. Good afternoon.

This committee has had the responsibility as the follow-up to the recovery effort after the *Challenger* accident, and over the course of time, the full committee had done an in-depth investigation of the *Challenger* accident. It was being done concurrently with and after the Rogers Commission investigation.

The full committee then produced a voluminous report that in many instances agreed with the Rogers Commission and in some instances there was a departure. And we had quite a few questions that we proffered to NASA and NASA has been in the process of responding to those questions.

We then have shifted our role into the oversight role, away from the accident into the oversight role of the recovery effort. And so, it is on that occasion, particularly with regard to the Solid Rocket Booster and its redesign and its new performance that we have this subcommittee meeting today.

Now, as the major milestones are completed on the recovery effort, we expect to have a hearing to track that progress. And thus, two and a half weeks ago there was a major milestone, the successful firing of the Solid Rocket Motor. And so, what we want to do is examine that kind of progress today.

We want to get into the details of the results and we want to know about NASA's plans for the remainder of the recovery period.

Now, the bits and pieces of information in news stories that have come as a result of the test, it does appear that it is a tremendous success. And, by the way, we needed that. And I guess the grin on your face, Admiral Truly, on that day out in Utah said it all.

So, we are finally beginning to see some positive results of the long hours of hard work that an awful lot of dedicated men and women in this country have put in to get us back flying into space. That is so important for the country and everybody realizes it, and that is what we are all pulling together for.

So, we are very honored to have Admiral Truly. We are very happy to have Arnie Aldrich and John Thomas to be here with us. We appreciate it.

I will insert in the record a comment from our ranking member, Mr. Walker.

STATEMENT OF ADM. RICHARD TRULY, ASSOCIATE ADMINISTRATOR FOR OFFICE OF SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WASHINGTON, DC, ACCOMPANIED BY ARNOLD ALDRICH, DIRECTOR, NATIONAL SPACE TRANSPORTATION SYSTEM, AND JOHN THOMAS, MANAGER, SOLID ROCKET MOTOR REDESIGN TEAM, GEORGE C. MARSHALL SPACE FLIGHT CENTER

Admiral TRULY. Thank you, Mr. Chairman, and good afternoon. I can truly say that I am pleased to be here this afternoon to report on our progress on the Development Motor 8 firing. With your permission, I would like to submit my written testimony for the record and make a couple of remarks, and then turn it over to Mr. John Thomas and Mr. Arnie Aldrich to tell you in detail the results of the test.

Even though they are going to discuss it in detail, let me say that I believe that this is a major accomplishment in the recovery—the firing of the DM–8 or Development Motor 8 out in Utah.

And in summary, before John gives you the details, let me say that I think it is resounding affirmation that even though we still have a mountain of work to climb to get to the first flight, it is an affirmation that we are climbing the correct mountain.

We have a design that I believe you are going to see has every promise of being as good as we know it to be, but it is always nice to see the results. And I look forward to you hearing them today.

Best of all, let me say that I think that even though it is not a direct subject of this hearing, that the DM–8 firing is not an aberration but it is indicative of our progress across the program and across the country as we get the Space Shuttle back to flight.

Our engine testing in Mississippi is continuing to go well. We have the first flight main engines in acceptance tests down there today. The Columbia, which will fly the third flight, just one week ago was rolled into the OMRF, the Orbiter Maintenance and Refurbishment Facility, at Cape Kennedy, and is getting some final tile work done. The Atlantis, which is going to fly STS–27, the second flight, is now in one of the OPFs, will be powered up before long. And the Discovery is powered up and has been for several weeks, and the word that we get from the Cape is extremely encouraging about the avionics and the status of that first vehicle. The primary flight software for STS–26 has been delivered, and out in Palmdale, California we are building a replacement orbiter. We have no less than seven missions in some phase of the flight planning cycle in

Houston. We have an STS–26 crew that is training down in Houston today. Only two days ago we took another step and named the STS–27 crew for the second flight of the Space Shuttle, to be commanded by someone who is very familiar to you, Commander Hoot Gibson.

In short, I believe that the program is on the move. I think there is no better evidence of it than what you are going to hear today. And Arnie and John and I are proud to be here today.

With that, with your permission, I am going to turn over the program or our briefing to you for a few minutes and let Mr. John Thomas, the head of the Solid Rocket Motor Redesign Team, go through some facts about the redesign and also some of the results which I think will be of interest to you.

Thank you.

[The prepared statement of Admiral Truly follows:]

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS

Statement of

Richard H. Truly
Associate Administrator
Office of Space Flight

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Committee on Science, Space and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

I appreciate the opportunity to appear before you to discuss our Shuttle recovery program and the results of the Development Motor 8 (DM-8) test firing of the Solid Rocket Motor (SRM).

The DM-8 static firing test accomplished on August 30, 1987, was a major milestone for resumption of flight in June 1988. This motor incorporated the major design changes which are being made to correct the deficiencies of the 51-L SRM design. The changes which were tested included the redesigned field joint with a capture feature and bonded insulation seal, the redesigned case-to-nozzle joint, and several changes to the nozzle. Mr. John Thomas, who is the Marshall Space Flight Center Manager of the Solid Rocket Motor Redesign Team, will provide you details of these changes in his testimony. I am pleased to report that, based upon our preliminary data evaluation, all new designs performed as expected.

The results of this test increase my confidence that we are on the right track in correcting the deficiencies of the SRM and can return to flight with a safe, reliable booster.

An additional reason for my increased confidence is that there have also been two highly important tests conducted as precursors to the DM-8 test. These were the Joint Environment Simulator Test 3A and the Nozzle Joint Environment Simulator Test 2A. These tests used selected components of the full-scale motor case and a limited amount of propellant to subject the field joint and the case-to-nozzle joint to actual hot-firing conditions which occur during the critical ignition transient. In these tests, deliberate flaws were introduced in the insulation seal, such that a hot-gas path was present to the barrier o-ring. Despite these intentional flaws, the results of these tests were that no hot gas reached the barrier o-rings, and they successfully demonstrated that the new joint designs are tolerant to defects which, although unlikely, might be introduced during motor assembly. Prior to reflight, additional tests of this type are to be conducted, both at Morton Thiokol and at a new facility at MSFC, to fully evalulate the flaw tolerance of the joint designs. These subsequent tests will include combinations of flaws through the insulation seal, the barrier o-rings, and, eventually, through the primary o-ring.

There will be at least three additional static firing tests to be conducted prior to reflight. These tests, which will incorporate all the redesign changes, are Development Motor 9 (DM-9) to be tested in late November, Qualification Motor 6 (QM-6) in February, and QM-7 in March. QM-7 will be tested in a new static test stand at Morton Thiokol which will have the capability to apply side loads during test, thus simulating the in-flight structural loads on the motor. The new stand will also provide the capability to thermally condition the entire motor prior to a test. The QM-7 motor will be conditioned hot and, prior to a launch in the winter months, a static test with the motor temperature conditioned cold will also be conducted.

As you know, the redesigned SRM is just one of the many efforts we are working on. Every element of the Shuttle system has been reviewed, and improved hardware and software are being added to enhance safety. For example, the landing systems both in the Shuttle and on the ground are being improved; the main engines are being modified and extensively tested; and many other technical improvements to both flight and ground systems are being developed, tested, and incorporated. Additionally, we have established a quantitative risk assessment technique and are reviewing all flight critical documentation.

Testing of the redesigned SRM remains the critical path to resumption of safe flight. The schedule is tight but doable, and we are moving ahead well. Of significant importance is the increasing morale of our NASA/contractor workforce as they perceive the progress that is being made in all critical areas.

I would now like to introduce Mr. Arnie Aldrich, Director, National Space Transportation System, and Mr. John Thomas, Manager of the Solid Rocket Motor Redesign Team, Marshall Space Flight Center, who will provide you the details of the DM-8 test and the results.

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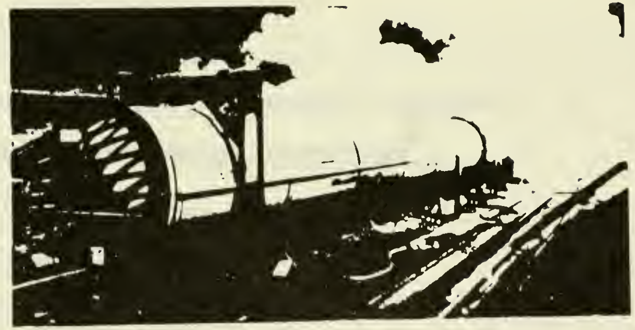


Testimony
Static Test Results
Shuttle SRM Development Motor-8
to
Subcommittee on Science, Space, and Applications
U.S. House of Representatives

16 September 1987

John W. Thomas, Manager
SRM Design Team
Marshall Space Flight Center
National Aeronautics and Space Administration

Agenda

- SRM Overview
- Test Evaluation Status
- Development Motor-8 (DM-8) Configuration
- Test Objective Assessment
- Test Operations
- Post-Test Conditions
- Program Summary
- Addendum—Backups
    - Findings of the Presidential Commission
    - Recommendation No. 1, Presidential Commission

88254 10

SRM Overview

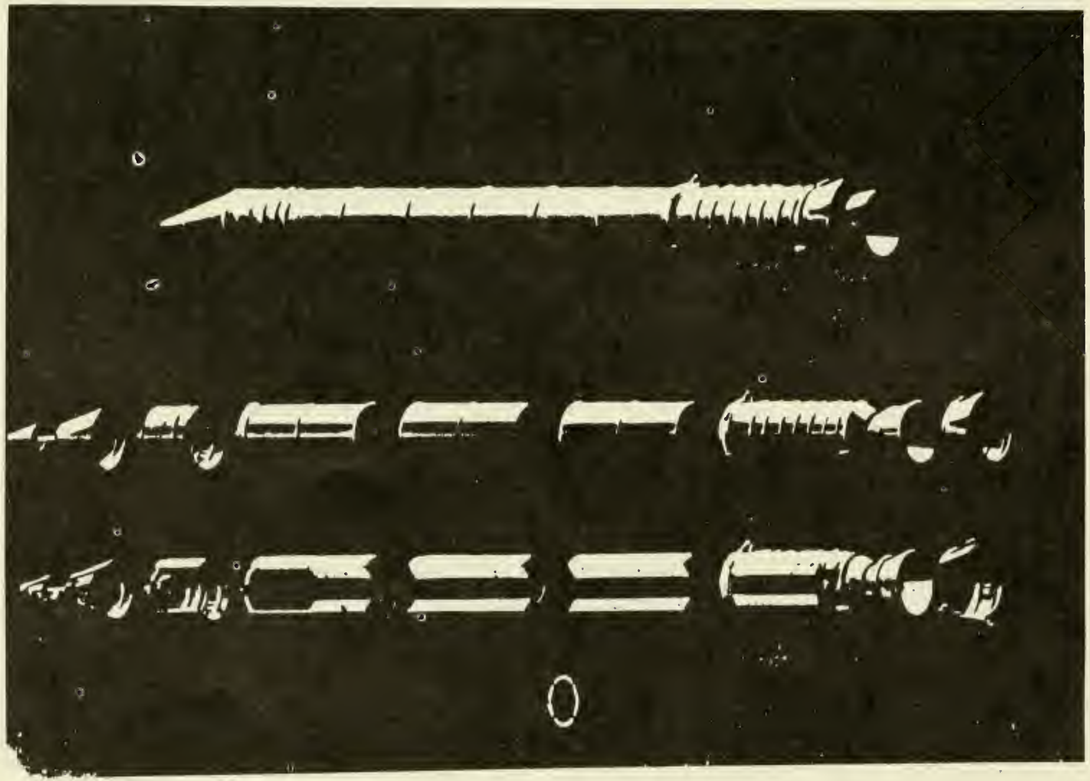
- Space Shuttle solid rocket booster
  - Solid rocket motor
  - Forward skirt, frustum, and nose cap
    - Decelerator system
    - Electronics
    - Separation motors
  - Aft skirt
    - Thrust vector control (TVC) system
    - Electronics
    - Separation motors
  - Development flight instrumentation
  - External tank attach ring and struts

88754 1C

SRM Overview (Cont)

- Solid rocket motor
  - Segmented (4) motor—joined by three field joints
  - Segments consist of multiple cylinders and closures—joined by factory joints
  - Systems tunnel
  - Nozzle assembly bolted to aft segment
  - Aft exit cone joined to nozzle at KSC
  - Igniter system
  - Development and operational instrumentation
  - Performance parameters (approximate)
    - Length—126 ft
    - Diameter—12 ft
    - Weight—1,250,000 lb
    - Thrust—3,300,000 lb
    - Chamber pressure—1,016 psia maximum
    - Chamber temperature—5,500°F

Solid Rocket Booster



Test Evaluation Status

- Data evaluation — total recorded instruments — 531
  - Seventy percent processed
  - Eighteen percent reviewed (quick look)
  - Data evaluation complete (final report) 29 Oct 1987
- Inspections
  - Nozzle flame front surface
  - Nozzle aft exit cone field joint
  - As-fired motor interior
  - All field joints demated
  - Case-to-nozzle joint demated
  - Joint O-rings
- Destructive tests
  - Aft field joint insulation
  - Nozzle aft exit cone dissected

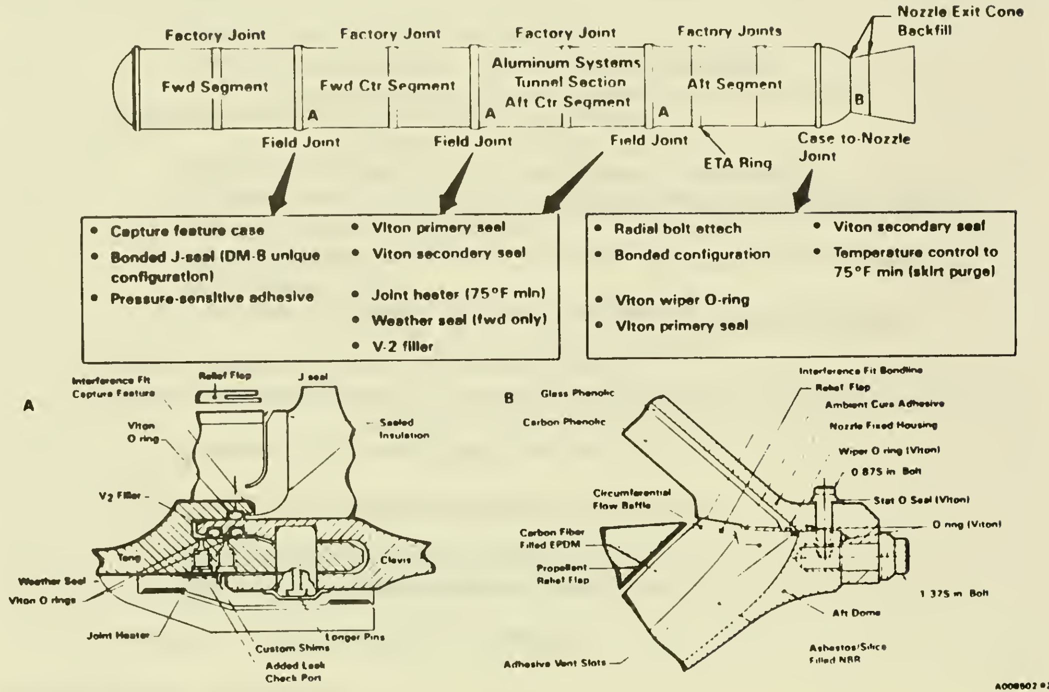
88254 1f

DM-8 Configuration

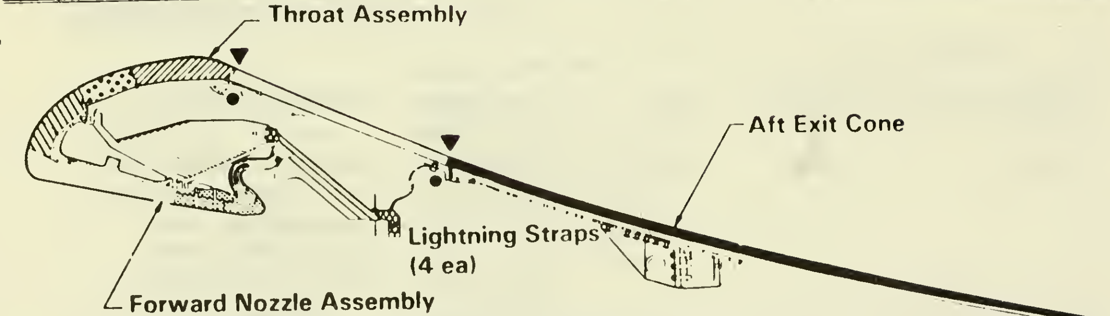
- Field joints essentially flight configuration
  - Minor recontouring of J-seal profile
  - DM-8 more severe test conditions
- Case-to-nozzle joint essentially flight configuration
  - Reworked 51-L nozzle fixed housing
- Nozzle redesigned components exposed to hot gas were flight configuration, except outer boot ring
  - Inlet housing thicker, with improved tooling planned for DM-9 and subsequent motors
  - DM-8 contained redundant O-rings at two of five joints planned for DM-9 and subsequent motors
  - DM-8 contained backfill at two of three joints planned for DM-9 and subsequent motors
- Weather protection system flight configuration
  - Forward joint reworked—Cork partially eliminated
  - Heaters only at center and aft joints

88254 1F

DM-8 Configuration



DM-8 Configuration — RSRM Nozzle



Design Changes From HPM Configuration

- Nose Inlet Ply Angle
- Cowl Outer Boot Ring
- Aft Exit Cone
- Case-to-Nozzle Joint
- Throat Ring Ply Angle, Machined Contour (Phase A) — Thinned Insulation and Thickened Liner
- Throat Inlet (Thicker Part With Revised Contour)
- ▼ RTV Backfill at Ablative Joints
- ● Dual Seals at Joints With Leak-Test Ports

A008489

DM-8 Test Objective Assessment

DM-8 Quick Look Test Results

Ballistic Performance

Test Objective		Prediction (Vacuum—60°F) Specification (min/max)	Predicted DM-8	Quick Look Results (Vacuum—60°F)
1. Assess redesigned solid rocket motor (RSRM) performance from motor chamber pressure and thrust data	Average Thrust (lbf)	2,450,000/ 2,720,000	2,570,000	2,606,000
• Demonstrate that pressure and thrust performances meet specification requirements	Average Pressure (psia)	625.8/695.8	656.8	667
• Determine pressure distribution within the motor during ignition and main burn				
• Headend pressure	MEOP/MOP (psia)	1,016	926*	928*
• Nozzle-end pressure	MEOP/MOP (psia)	932	848*	~848*

*Based on atmospheric pressure of 12.4 psia

8R254 9E

DM-8 Quick Look Test Results (Cont)

Ballistic Performance (Cont)

Test Objective	Prediction	Quick Look Results
2. Evaluate combustion stability from chamber pressure, thrust, strain, and acceleration data	• Combustion behavior will be similar to that occurring in previous HPM motors. First-longitudinal (15 Hz) and second-longitudinal (30 Hz) mode pressure oscillations will not exceed 2.0 psi (zero-to-peak)	• Pressure zero-to-peak oscillations less than 2.0 psi
3. Evaluate redesign forward segment propellant grain	• No indication of abnormal gas flow or pressure from forward segment grain redesign	• Pressure versus time data parallel predicted curve, indicating normal propellant burn back and gas flow from forward segment

88254 5F

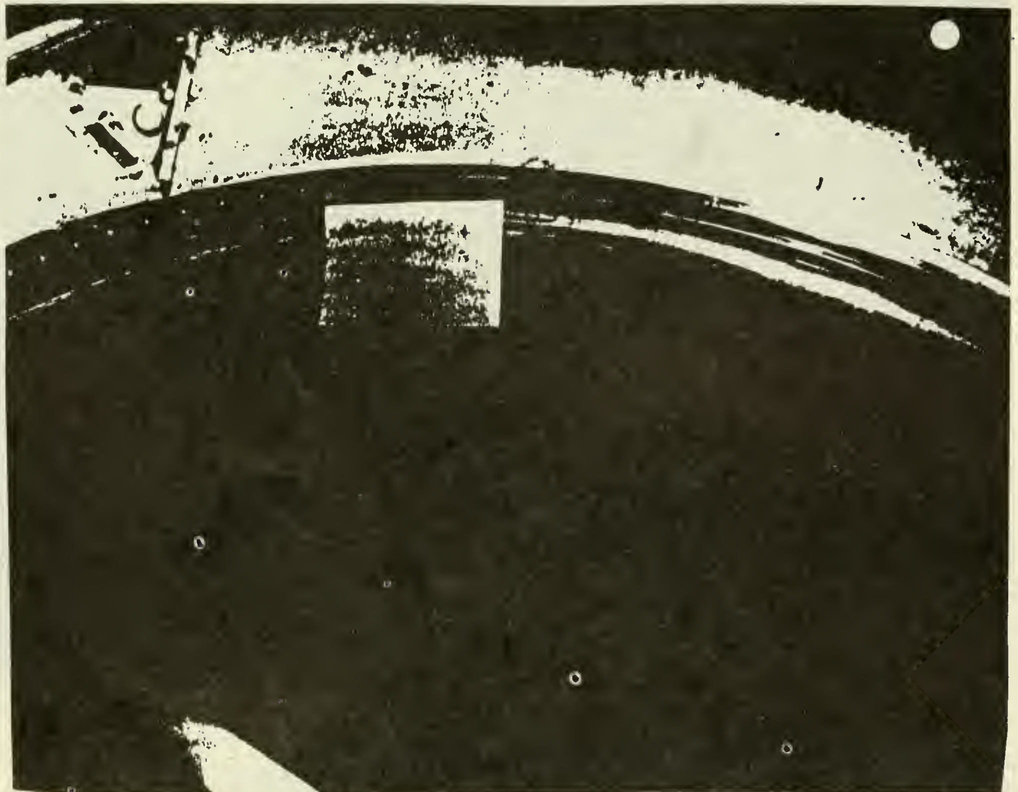
DM-8 Quick Look Test Results (Cont)

Field Joint Performance

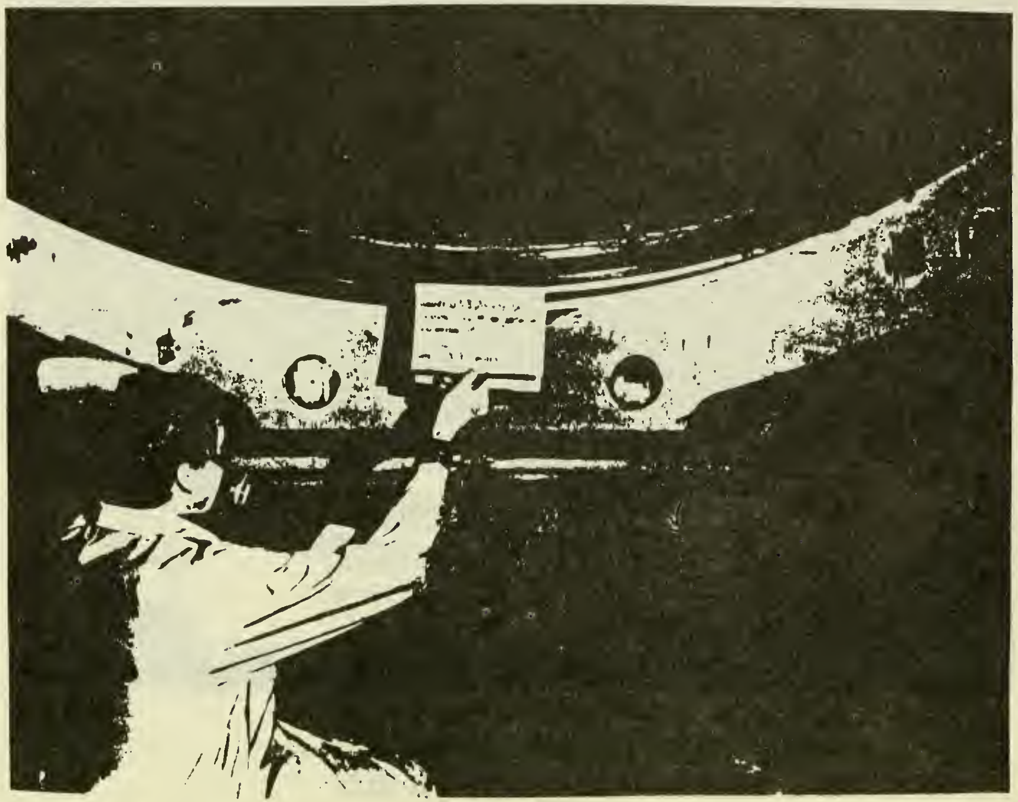
Test Objective	Prediction	Quick Look Results
1. Evaluate performance of capture feature field joint design from strain data and post-test inspection	• Gap opening is not greater than 0.005 in. • No evidence of deformation of the capture feature	• Indirect measurement of gap opening from girth gages indicate comparable joint deflections with JES-3A which showed maximum gap between primary and secondary O-rings of 0.006 in. (0.009 max allowable)
2. Evaluate performance of unvented initial J-seal field joint insulation	• No evidence of hot gases to the capture feature O-ring	• Visual inspection of field joints indicates J-seal functioned properly and allowed no hot gas to capture feature O-ring
3. Verify the assembly/disassembly of the unvented J-seal insulation field joint design in the horizontal position	• No damage to the field joint insulation, seals, or nonrepairable damage to the hardware	• DM-8 field joints were successfully assembled using new assembly/disassembly tooling and field joint assembly fixture • Visual inspection from the inside motor showed perfect fit of J-seals • Successful leak check verified integrity of O-rings after assembly • Nicks observed in primary aft field joint O-ring. Occurred during disassembly at slag-induced heated area. No consequence to flight operation

88264-5C

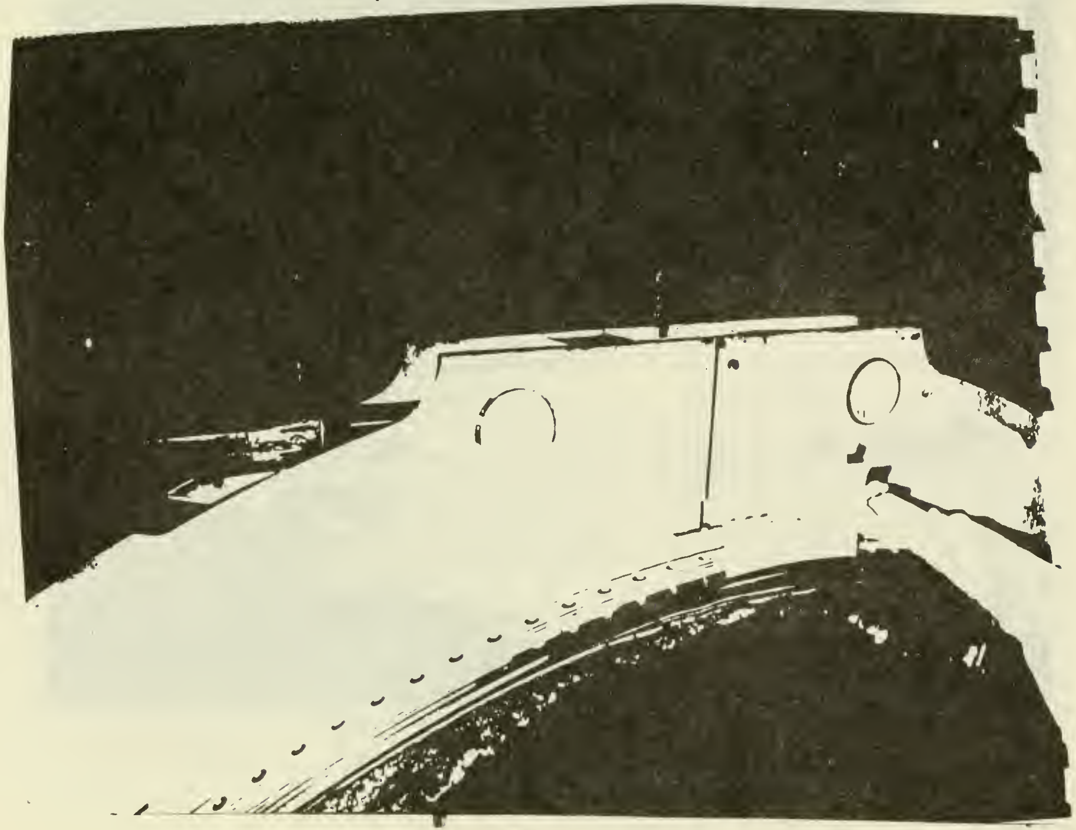
**DM-8 Postfire Disassembly
J-seal Tang Side of Aft Field Joint
(Left Side—No Slag at 225 deg)**

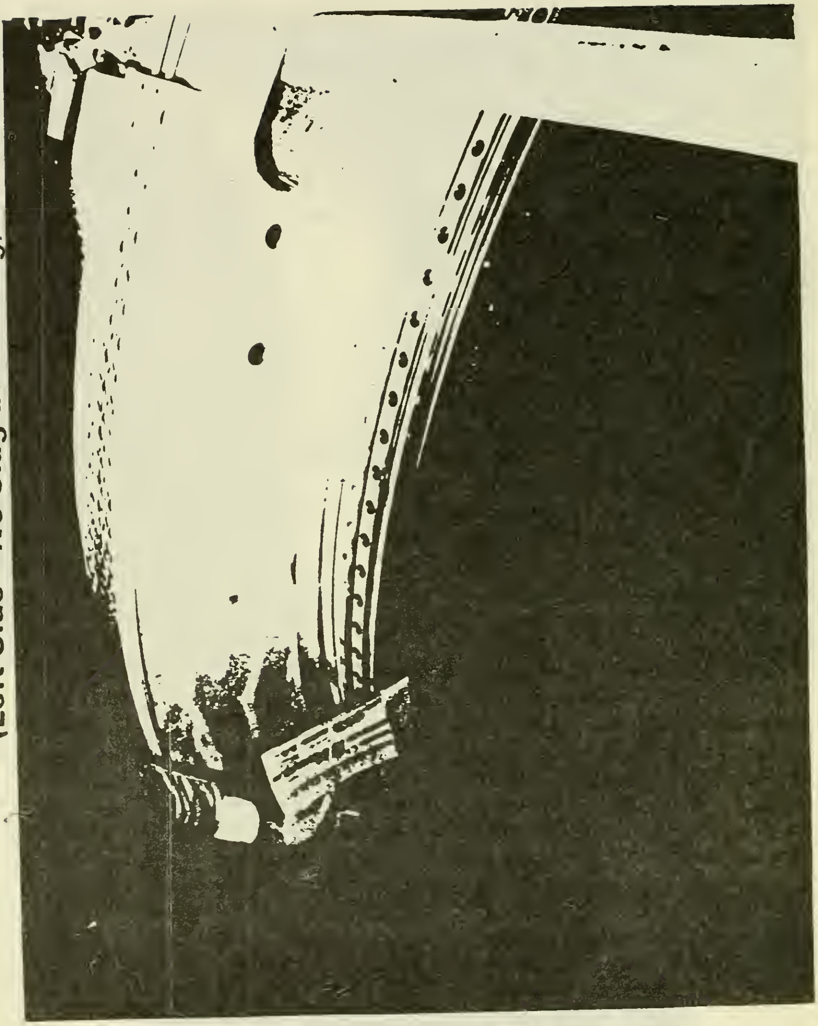


DM-8 Postfire Disassembly
J-seal Tang Side of Aft Field Joint
(Bottom Under Slag at 0 deg)



DM-8 Postfire Disassembly
Clevis Side of Aft Field Joint
(Bottom Under Slag at 0 deg)





DM-8 Postfire Disassembly
Clevis Side of Aft Field Joint
(Left Side—No Slag at 270 deg)

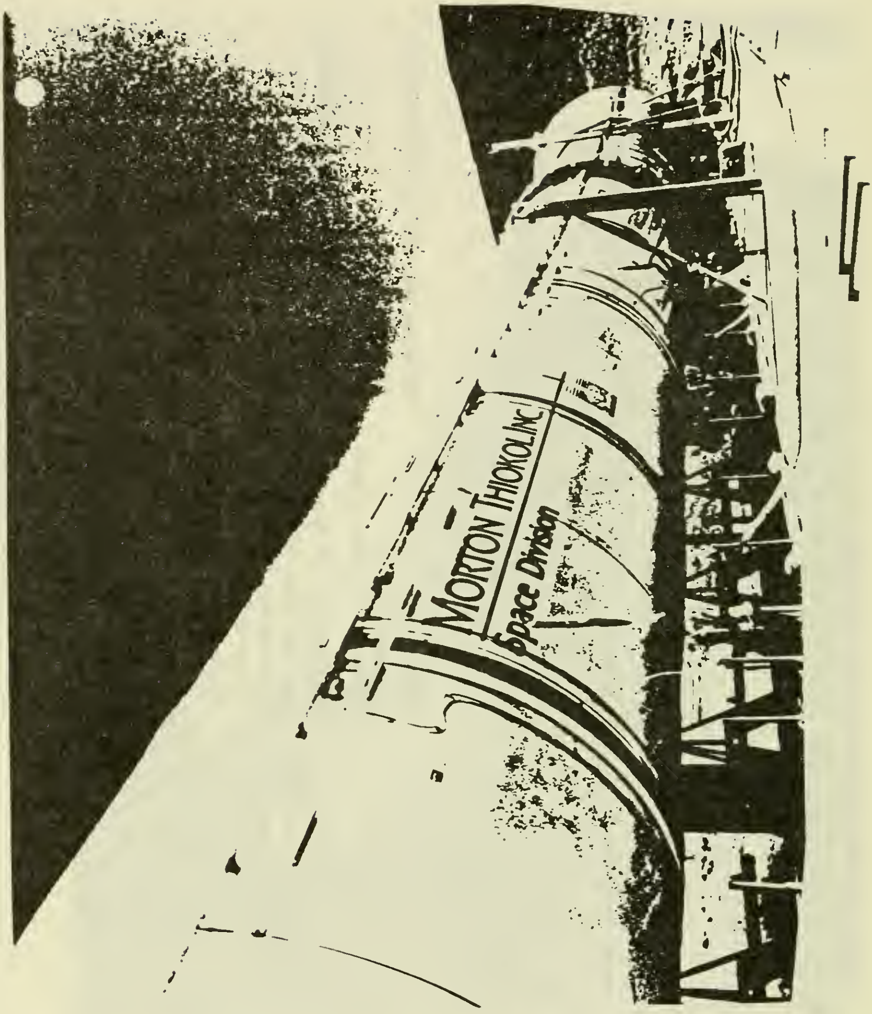
DM-8 Quick Look Test Results (Cont)

Field Joint Performance (Cont)

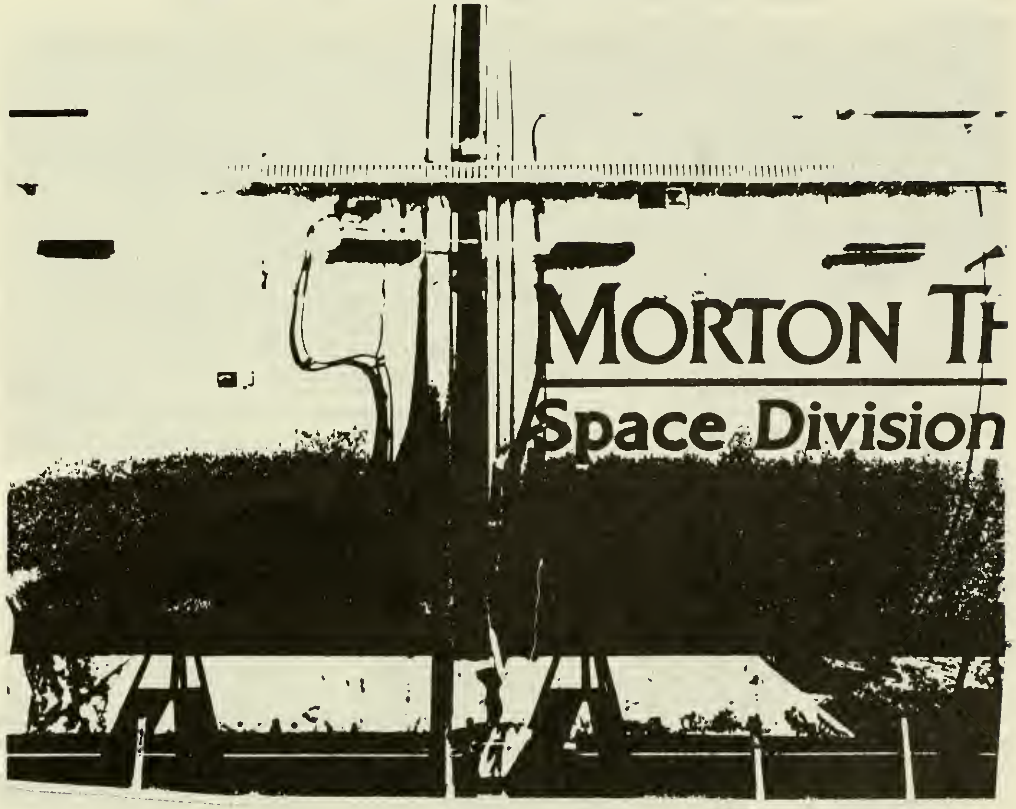
Test Objective	Prediction	Quick Look Results
4. Evaluate effectiveness of all seals from post-test examination	• No evidence of erosion or blowby detected during post-test inspection	• No blowby or erosion noted at field joint seals
5. Evaluate the joint heater's ability to maintain the field joints within specified limits	• Heaters will not allow joint temperatures to fall below 75°F	• Heaters maintained joint temperatures of 82° to 104°F
	• Weather protection will remain securely attached to forward joint	• Weather seal intact after test at forward field joint
6. Evaluate effects of the leak check procedures on all field joint seals	• No evidence of damage to insulation, adhesive, or seals due to leak-test procedures detected during post-test inspection	• Field joints show no visual damage to J-seal, adhesive, or O-ring seals

88254 6D

DM-8 Weather Protection System



DM-8 Forward Field Joint Weather Protection Seal



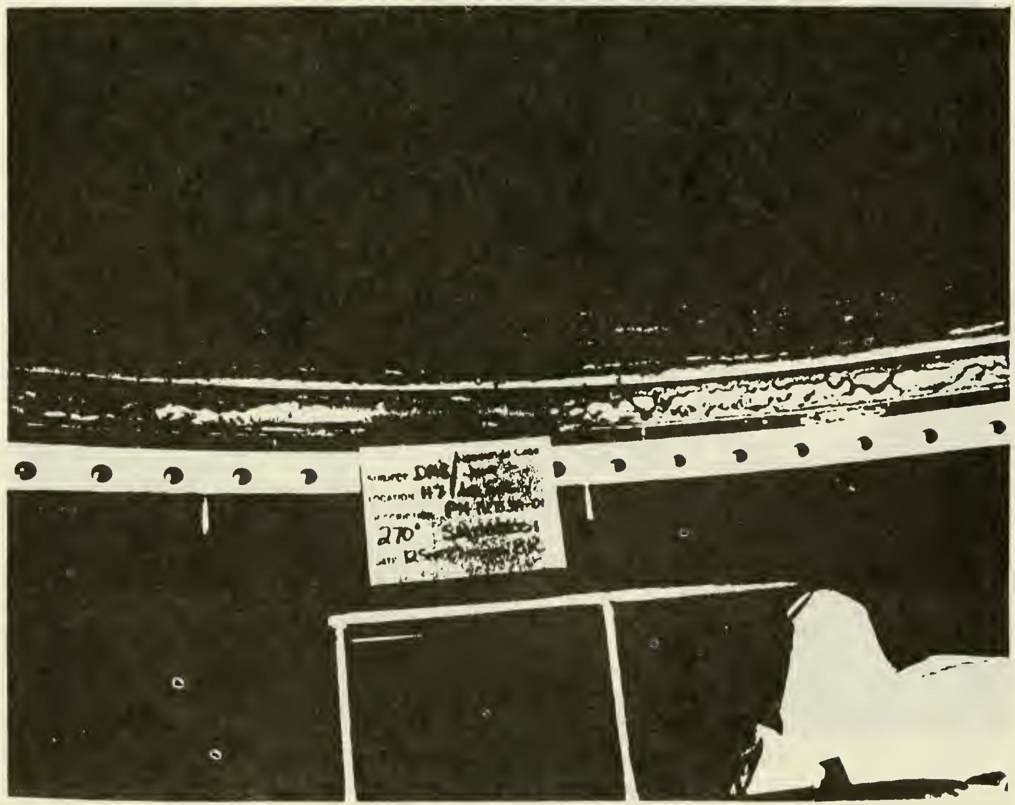
DM-8 Quick Look Test Results (Cont)

Nozzle-To-Case Joint Performance

Test Objective	Prediction	Quick Look Results
1. Evaluate performance of radially bolted nozzle-to-case joint hardware	• Gap opening is not greater than 0.007 in.	• Indirect measurement of gap opening from girth gages indicates comparable joint deflections with NJES-2A, which showed maximum deflections of 0.007 in.
2. Evaluate performance of unvented nozzle-to-case joint insulation	• No evidence of hot gases to the primary O-ring	• Visual inspection indicated polysulfide adhesive/wiper O-ring prevented hot gas from reaching wiper O-ring
3. Evaluate effectiveness of all seals from post-test examination	• No evidence of erosion or blowby on primary and secondary seals detected during post-test inspection	• No erosion or blowby of primary/secondary O-ring seals
4. Evaluate effects of the leak check procedures on nozzle-to-case joint seals	• No evidence of damage to insulation, adhesive, or seals due to leak-test procedures detected during post-test inspection	• Insulation and seals in excellent condition based on post-test disassembly visual inspection

88754-58

DM-8 Postfire Disassembly
Case (Dome) Side at Nozzle-to-Case Joint



DM-8 Postfire Disassembly
Nozzle Side at Nozzle-to-Case Joint

DM-8 Quick Look Test Results (Cont)

Nozzle Performance

Test Objective	Prediction	Quick Look Results
1. Evaluate nozzle design changes	• No ablative material pockets greater than 0.25 in. deep	• Overall erosion was smooth with no pockets or gouges; one small wash area observed in aft exit cone <0.2 in. deep
	• No adverse effect on nozzle joint performance	• Nozzle joint gaps and overall condition of all joints were good
	• Nozzle components meet erosion and char performance safety factors	• Eight core samples show safety factors >1.0
	• No wedge-out during firing	• No wedge-out occurred during firing
	• Structural integrity will be maintained to allow post-test evaluation of the new components	• Nozzle retained structural integrity for post-test sectioning and evaluation
	• Ply lifting as observed on ETM-1A could be present at end of motor burn	• No ply lifting observed

8R754 5A

DM-8 Quick Look Test Results (Cont)

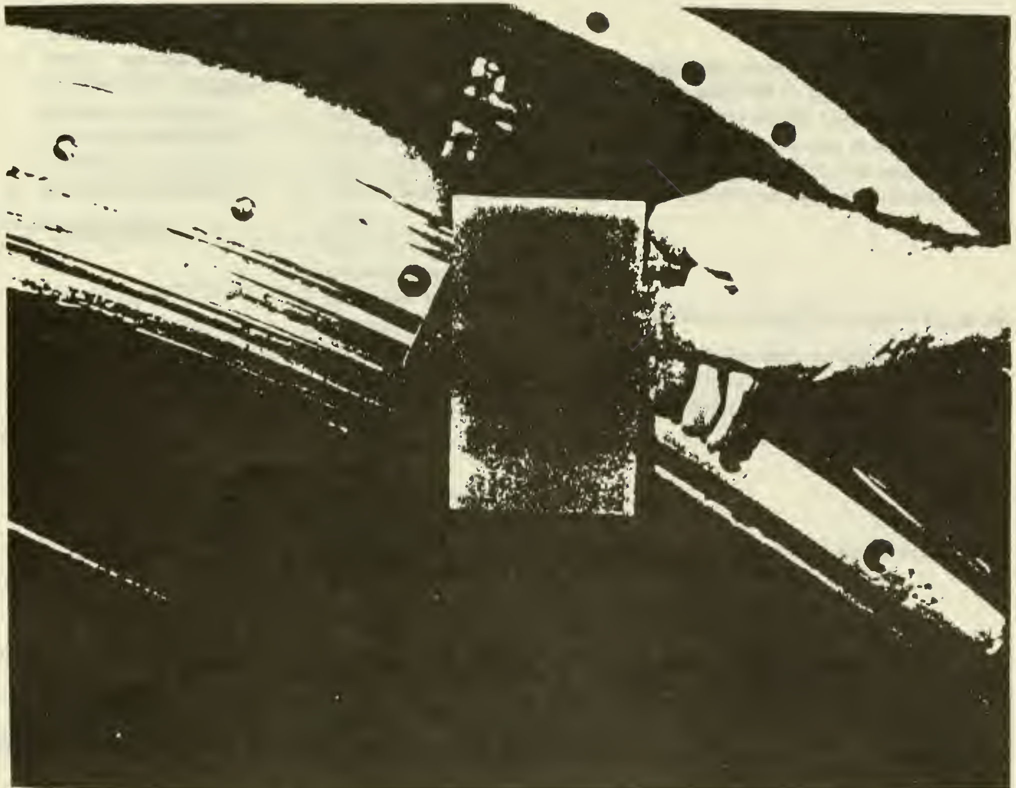
Nozzle Performance (Cont)

Test Objective	Prediction	Quick Look Results
2. Evaluate backfill of aft exit cone field joint and throat assembly-to-forward exit cone joint	• No adverse effect on the nozzle ablative joint performance • No hot gas to primary O-ring	• RTV backfill eroded down to char line as predicted and prevented hot gas from reaching primary O-ring of aft exit cone

88754 5AA

DM-8 Postfire Disassembly
Forward Exit Cone Side of Aft Exit Cone Joint
(Near Bottom at 330 deg)

DM-8 Postfire Disassembly
Aft Exit Cone Joint
(Near Bottom at 300 deg)



DM-8 Quick Look Test Results (Cont)

Systems Tunnel, External Tank (ET) Attach Ring, and Structural System

Test Objective	Prediction	Quick Look Results
Systems Tunnel		
1. Evaluate aluminum systems tunnel bondline integrity	• Tunnel bondline will be intact and tunnel will remain attached to case	• Floor plates intact and bonded after test
External Tank (ET) Attach Ring		
1. Evaluate structural integrity of STS 51-L configuration ETA ring under motor pressurization loads	• ETA ring and attachment hardware will retain structural integrity • Fastener yielding expected at tapered ends of ring cap and web	• ETA ring intact on case after test; some local heating and paint discoloration from slag-induced hot spot at case ETA stubs • Some fastener yielding similar to ETM-1A
Structural Systems		
1. Evaluate structural integrity of the case, ignition system and nozzle from strain, temperature, displacements, acceleration data and post-test analysis	• Case, ignition system, and nozzle hardware will retain structural integrity	• Structural integrity of all components maintained during test; slag-induced hot spots in aft segment due to malfunction in ground support water system. Incurred structural damage to ET attach and forward stiffener case segments

86264-9O

DM-8 Test Operations

- Motor assembly
  - Practice mates of forward and center field joints were conducted
  - Practiced nozzle installation twice
  - Nozzle aft exit cone removed twice due to excessive leakage
- Initial firing day—27 Aug 1987
  - Countdown began at 12:00 a.m.
  - Water main broke in morning
    - Repaired with only five-minute delay in firing time
  - Countdown and test were manually aborted at T - 10 sec due to water deluge malfunction
    - Connection repaired
    - Ground test controller reconfigured—TVC system

88254 2A

DM-8 Test Operations (Cont)

- Second countdown initiated at accelerated rate
  - Main computer (MC) error caused hold at T - 3 minutes
  - Recycled conditions to T - 1 hr
- Third countdown initiated at T - 1 hr
  - Firing was automatically aborted at T - 12 sec
  - TVC system hydraulic power units (HPU) failed to start
  - HPU start command was inhibited by the manual/automatic panel (MAP)—previous MC power on-off cycle reset MAP
- 27 to 30 August operations
  - Reconfigured and tested water system (twice)
  - Conducted one aborted and one full countdown flawlessly

88254 28

DM-8 Test Operations (Cont)

- Firing day — 30 Aug 1987
  - Countdown initiated at 12:00 a.m.
  - Operations were normal through end of test
  - Aft section water system malfunctioned

DM-8 Post-Test Conditions

- Modifications to water deluge system after initial hose disconnect malfunction incorporated
  - Operation of boost pump was delayed until post-test period
  - High-pressure connections were installed
  - System was proof tested for five minutes at approximately 100 psi
  - System was flow tested with boost pump operational
- Post-test observations
  - Slag (aluminum oxide) accumulation estimated to be approximately 2,500 lb
  - This is next highest to ETM-1A accumulation of over 3,000 lb
  - Aft motor spray section did not activate upon command after test
  - Firemen directed water-hose spray on ET attach cylinder when malfunction observed

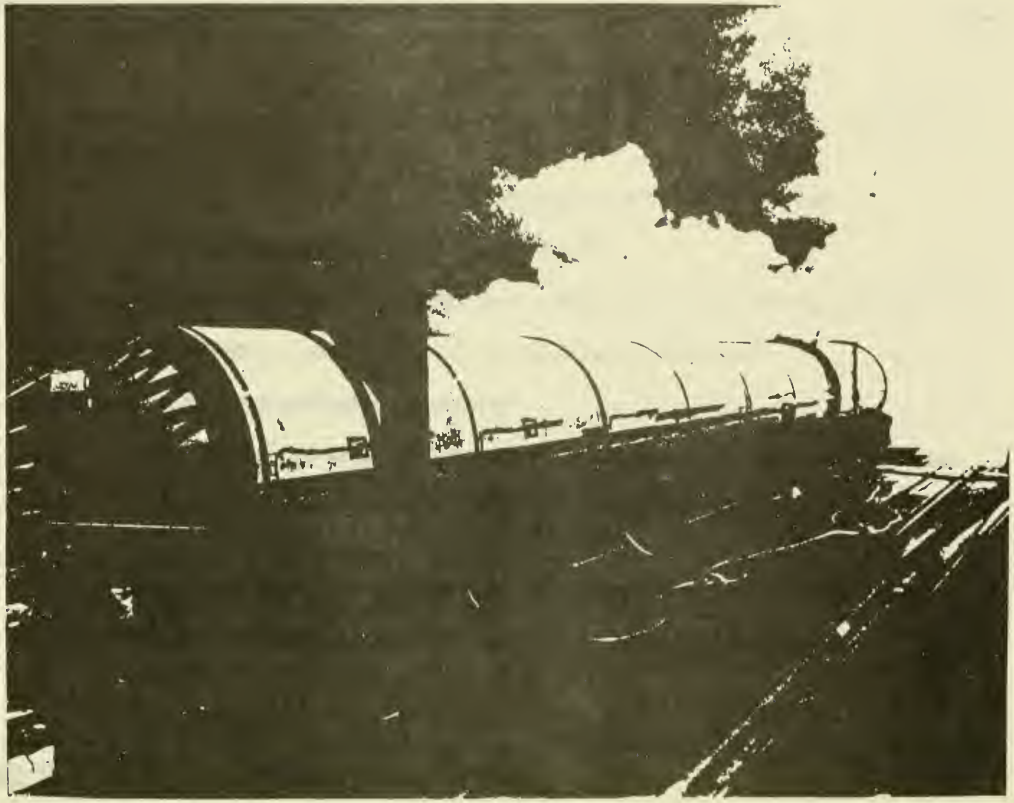
88754 2D

DM-8 Post-Test Conditions (Cont)

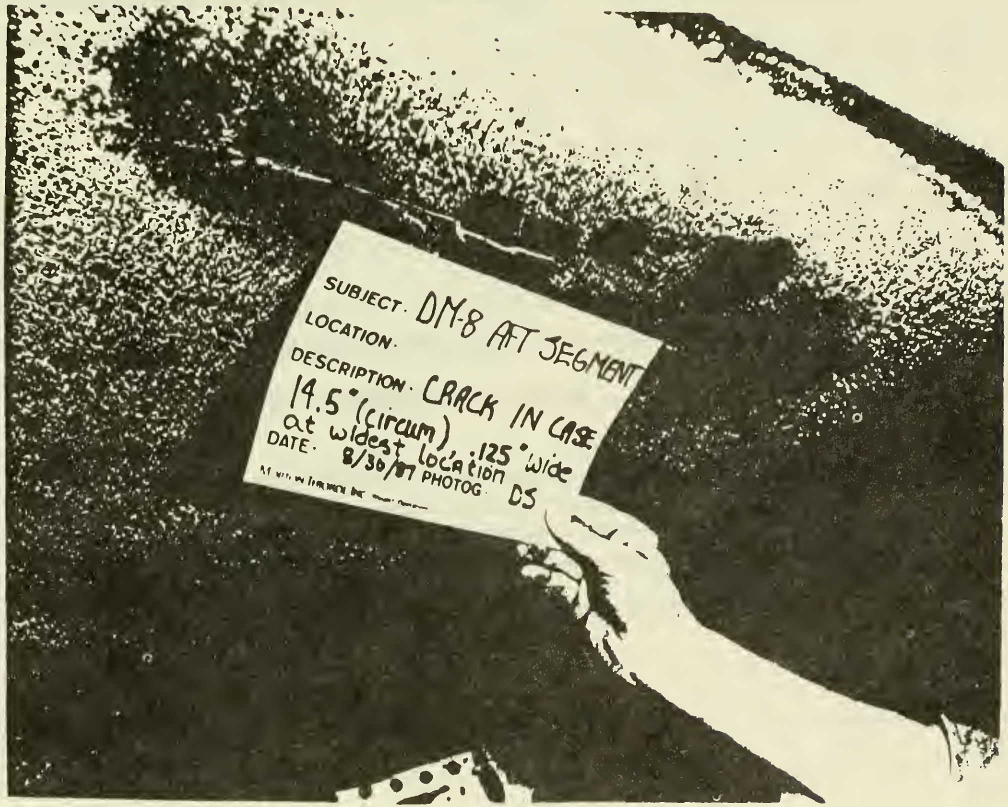
- Post-test observations (Cont)
  - Hot spots and paint discoloration observed on all three aft segment cylinders
    - Severe on ET attach and forward stiffener cylinders
    - Crack (14 in. long) through case membrane in ET attach cylinder
  - Two cylinders rendered unusable
- Corrective action
  - Investigation panel chartered
  - System redesign underway

88254 7E

DM-8 Water Deluge Hoses



DM-8 Slag Heat-Induced Crack—Aft Segment



Program Summary

- The DM-8 static test, together with simulator tests, demonstrates that the new design resolved 51-L and other deficiencies
- The first of the five remaining static test motors, DM-9, is being loaded with propellant
- STS-26 flight units are already in fabrication
- All activity directed toward next launch in mid-1988

The Challenger Accident Findings of the Presidential Commission

- The accident—SRM joint failure probable causes
  - Gap opening due to joint dynamics and motor pressure
  - Joint temperature at launch
    - O-ring resiliency
    - Ice in joint
  - O-ring squeeze after mating static O-ring compression
  - Putty performance variability
  - Joint damage/contamination at assembly (possible)

88254 38

The Challenger Accident Recommendations of the Presidential Commission

- Solid rocket motor design
    - Joints should be fully understood, tested, and verified
    - Integrity of joint should not be less than case walls
    - Desensitize joints to:
        - Examples
            - Dimensional tolerances
            - Assembly procedures
            - Environmental effects
    - New design certification tests should duplicate launch configuration over full operating range
    - Full consideration for static firing exact flight configuration in vertical attitude
    - Independent oversight committee—National Research Council

88264 3C

Mr. THOMAS. Thank you, Mr. Chairman and Admiral Truly.

What I have for you today for the briefing is the material that you have before you. There are some printed words in there. There are a lot of photographs and sketches. I don't plan to go through the printed word. I will describe the photographs as we show them. What I have before me here on the table is, to the left, the light green material is the so-called J seal, field joint, and that is from a practice cylinder that we laid up just prior to Development Motor No. 9. It is slightly different in profile to DM-8, but DM-8 is essentially that configuration and represents the worst case type testing.

Right behind it, in the sacks, white bags, is the identical items from the Development Motor No. 8. We excised those on Saturday evening, after having taken the joints apart. They are covered with the plastic because of the asbestos insulation. I can show you those at any time as we go through here.

This piece right here is the field joint from the DM-8. It is the clevis side. Of course, this is what it looked like essentially when it was installed.

The other side is the familiar J seal that mates in this condition right here. Maybe I should pick these up. If you take these, and of course they are bonded to the metal parts—if you takes these and put them just like that, as they would be during the assembly process, and shove them together, you see what a nice mate they make.

Mr. NELSON. Now, this is your new insulation material?

Mr. THOMAS. That is right.

Mr. NELSON. I see. This is the little valley in which the gases will come down in there and expand and expand that insulation against the glue, so that it really seals it up?

Mr. THOMAS. That is right. It in fact happened just like that.

Mr. NELSON. This is what is left of the whole thing?

Mr. THOMAS. That is what is left of one side. This is the J seal. You see the valley. We just came a short ways back and chopped it off, just like this.

Mr. NELSON. I see, yes.

Mr. THOMAS. From DM-8. This is this piece. So, we take it and put it back in its original position, to see that it shoved it up there. And you can tell from this color right here on the back side, which right there is the capture feature O ring, that hot gas never penetrated past this point right here, the tip of the J. And for certain, it never even got close to the O ring. You can look at that green there, compared to that, it is almost identical.

Mr. NELSON. Okay. Now, what is all the charring right here?

Mr. THOMAS. This is soot that is laid up from the combustion product. This is soot that was accumulated during the firing, laying right on top of that. It expended over into this area during the firing process. This is what is left of the aft inhibitor, with the propellant down where my left hand is.

Mr. NELSON. I see.

Mr. THOMAS. And as we took the joint apart, it came like that. There was some residual laying right on top. It fell in this area, which is what discolored this part.

Other than that, when we first went out and looked at it, as we disassembled it, it came apart in this fashion. The first thing you could see was this yellow or this green, which indicated to us all the way around that there was no gas that penetrated the seal.

Mr. NELSON. That is beautiful. Now, this right here is the part that is sitting up abutting the metal, isn't it?

Mr. THOMAS. That is the metal, right.

Mr. NELSON. And your field joint is right here?

Mr. THOMAS. Right there. That is where the capture feature sits.

Mr. NELSON. That is great.

Mr. THOMAS. Right there where my thumbnail is.

Mr. NELSON. That is great. So, what you are telling me is that the hot gas never even got to the first O ring?

Mr. THOMAS. That is right.

Mr. NELSON. And now you not only have two O rings in the redesign, but you have three?

Mr. THOMAS. Three.

Mr. NELSON. And it never got to the first one?

Mr. THOMAS. That is right.

Mr. NELSON. Who came up with this idea?

Mr. THOMAS. This was an idea that was devised by a combination of our design team and Thiokol. It originally started out to be just a slot. We then found that if we made this slot a little bit curved, we got a good pressure against this sealing surface here. And in fact, that provides a little bit better sealing than this one, even though this one sealed adequately during the DM-8 firing.

Mr. NELSON. Well, that is great. That is terrific. Had anybody ever tinkered with these kind of little exhaust troughs before?

Mr. THOMAS. That is a spinoff the stress relief flaps that are—for example, there is one right here that goes back down this way that stress relieves the propellant from the insulation. That was originally put in there to keep stress down within the component when you hit it with pressure, such that if you pulled it apart you didn't overstress this area down in here. It turned out to have an additional advantage of having its ability to pressure close or pressure seal these two devices.

Mr. NELSON. That is great. From an engineering and design standpoint, you don't ever worry that you get enough pressure coming into this trough that would blow it open in here?

Mr. THOMAS. It has got some healthy safety factors, on the order of greater than four, before you could ever get close to causing a crack here. Even if that happened, it is self relieving, an elastomeric material. It would just go so far until it relieved the stress that had built up, and stop.

Mr. NELSON. I see.

Anyone of the staff have any questions while we are here in "show and tell?"

[No response.]

Mr. THOMAS. The other joint of question was the case nozzle joint. And I think this is the aft dome here, the fixed housing of the nozzle goes up here.

Mr. NELSON. Right.

Mr. THOMAS. You know we put a polysulfide adhesive down in that joint, and then push the nozzle in, install the nozzle this way, which winds up with about a tenth of an inch here, a tenth of an inch down here, and about 50-thousandths of a glued surface all the way around the periphery.

And again, we used this split flap here to be sure that pressure comes down in this flap and shoves it closed and is not tending to pull the polysulfide or glue or adhesive apart.

It worked just that way in DM–8 and prior tests, and what we have done—this is a practice sample, again, out of DM–9. But this is a segment that was excised from DM–8, and you notice down at the bottom of this flap here there is an O ring. It is a stress relief factor.

Mr. NELSON. Is this it right here?

Mr. THOMAS. That is it right there.

Mr. NELSON. I see.

Mr. THOMAS. I am going to align those like this, and you can see that in the configuration—you will recall, there is a wiper O ring.

Mr. NELSON. Right.

Mr. THOMAS. And then there is the primary and the secondary O ring.

Mr. NELSON. Right.

Mr. THOMAS. That wiper O ring sits right here.

Mr. NELSON. Right.

Mr. THOMAS. Okay. This originally was of this configuration. The erosion took it down this far. No hot gas got down past that point. All of this polysulfide adhesive was intact. I have some photographs in the package to show you just how nice and clean it was. No gas passed. The furtherest gas ever got in the case of the nozzle joint was this area right here, and you had this much more adhesive to go through down to here to even get to the wiper seal. And had we gotten to there, there is still this much more distance before we ever got to the primary seal.

So, again, in this joint, which has been, to some of us, the more challenging joint to redesign, we were at least three or four inches away from ever putting hot gas on even the primary O ring.

Mr. NELSON. Do you happen to have the other piece of insulation that fits up against this?

Mr. THOMAS. No, sir. It is carbon phenolic that is very difficult to excise.

Mr. NELSON. I see.

Mr. THOMAS. We did not bring that. But it was sitting just like this, right at this point, about this far away, right straight up, and it doesn't erode like the NBR. So, it was essentially in its virgin state.

I have a photograph of that side that I will show you when we get to the viewgraphs on it.

Mr. NELSON. Okay. So, again, your little trough worked, your redesigned trough. What is the technical name for it? I am saying trough.

Mr. THOMAS. Stress relief flap.

Mr. NELSON. Stress relief flap. This is called the same thing?

Mr. THOMAS. That is essentially what it is.

Mr. NELSON. Okay. So, it works by pushing and sealing all the more the gap?

Mr. THOMAS. Yes, sir. To get this apart after it was fired, we had—this adhesive—we had 160,000 pounds pulling on the nozzle trying to pull it out of the dome, and we still had to apply additional pressure with jack screws to break it loose to pull it out. So, it was stuck with 160,000 pounds of force.

Mr. NELSON. Do you get more pressure here in the nozzle joint than you do in the field joints?

Mr. THOMAS. No, sir. It is higher there.

Mr. NELSON. It is higher.

Mr. THOMAS. Starts out higher at the front of the motor and decreases as it comes toward the rear.

Mr. NELSON. I see.

Mr. THOMAS. And this is the lowest pressure joint in the motor.

Mr. NELSON. So, in the highest field joint—or what do you call that?

Mr. THOMAS. Forward field joint.

Mr. NELSON. The most forward field joint is where you are getting the most pressure?

Mr. THOMAS. That is right.

Mr. NELSON. And you had similar experience on all of those field joints, not—where did this one come from?

Mr. THOMAS. That is the aft one. The forward one looked better than it did because the thermal environment up there is a little bit less severe.

Admiral TRULY. We have taken every joint apart, and the same result all the way around the motor on every joint was what was found.

Mr. NELSON. Very good. Now, what about the relationship of—you had some new pins in there. You had some new pins on the nozzle joint. You also put additional pins on the field joints, as well. Is that correct?

Mr. THOMAS. We used——

Admiral TRULY. Bolts.

Mr. NELSON. Bolts?

Admiral TRULY. Radial bolts.

Mr. THOMAS. We used radial bolts on the nozzle. And this is a radial bolt. It is an MP-35N, the highest strength material one can get. There are 100 of these that hold the nozzle in place radially. There are also 100 that are—this is a seven-eighths inch—one and three-eighths bolts that hold it in axially. They sit—I think you will see that in a photograph.

As we put this bolt in, this is the infamous stat-o-seal which has the elastomer inside. It has a recess in the fixed housing, such that it stays centered with respect to the center of the bolt. And as you tighten the bolt down—and we put 44,000 pounds of force on each bolt—as you pull it down, you contact first along this very smooth surface the elastomer. That is seal number one. When you pull it down with this 44,000 pounds of force, you get a metal to metal seal there also. So, it essentially has two different sealing effects.

Of course, on DM-8 and on the NJES prior to that, the insulation has sealed so well we have not had pressure to this area. We are just about to do that now. And as we put pressure on that, we expect it to seal better with pressure, because you are increasing the tightness of that joint. Those work nicely. As we put them in, we were able to hand tighten them up to the point of beginning to torque.

Mr. NELSON. So, none of your pins nor bolts you saw any evidence of any leakage there?
Mr. THOMAS. None at all.
Mr. NELSON. That is beautiful.
Mr. THOMAS. That is one of the sections out of the DM-8 O ring.
Mr. NELSON. But you never had a chance to know if the O ring worked this time, because the gas never got to the O ring.
Mr. THOMAS. True.
Admiral TRULY. That is right.
Mr. NELSON. That is a nice problem to have.
Admiral TRULY. That is right.
Mr. NELSON. All right. What is this other stuff?
Mr. THOMAS. This is a V-2 volume filler that sits right up into the capture feature, and it is used for nothing more than to take up space, such that if you get a hot gas past the capture feature O ring, it doesn't have as much volume to fill and therefore it chokes the flow off rather rapidly. We used this in DM-8.
Mr. NELSON. So, this is what is happening? The O ring is lying in there?
Mr. THOMAS. Not quite. You have the O ring setting in the inner clevis leg right here, and the tang sets up like this, and it presses right up into here.
Mr. NELSON. I see.
Mr. THOMAS. That is only a volume filler. Here is where you see that. It sets right in that area right there.
Mr. NELSON. I see.
Mr. THOMAS. Just right in front of the inner leg of the capture feature.
Mr. NELSON. Okay. Good.
Mr. THOMAS. This is a cross-section of the ETM nozzle, aft exit column. And as you recall, we ran into somewhat of an unexpected washing effect from what was called ply lifting, internal to the carbon phenolic. You see this little area right here. That apparently is a section where there is enough internal pressure built up after the—sometime during the firing and particularly afterward where the internal pressure trying to force its way out from pyrolysis, gases, et cetera, lifts the plies up.

If that ply lifting is near enough to the surface, you will get this kind of effect here. The erosion will kick those out. This, of course, is an undesirable condition to have in a nozzle. This has a processing anomaly on it. We knew it had one when we put it into the motor. When we were seeing what happened to it, we thought, as turned out to be the case, there was no hazard associated with it. But we do not want that to exist in the flight nozzle.

On DM-8 we had an aft exit cone there that did not have a processing anomaly and it turned out with zero of these. There was absolutely none of the ply lifting. In fact, I have some cross-sections here of the ETM ply lift. You see the accordion effect there. And this is DM-8. You see how nice and solid that is. This is the cork, the glass and the phenolic.

Mr. NELSON. I see. And the cork is on——
Mr. THOMAS. The outside.
Mr. NELSON. The cork is next to the metal?

Mr. THOMAS. The aft part of the exit cone doesn't have metal. It has a glass structural member.

Mr. NELSON. I see.

Mr. THOMAS. And this cork is down there. Up forward of the compliance ring where the actuators attach, there is metal there in place of the cork.

Mr. NELSON. I see.

Mr. THOMAS. I think that is all the goodies I have.

Mr. NELSON. Okay, good. Thanks.

Do staff have any questions?

Mr. KETCHUM. I have one question.

Mr. NELSON. Okay.

Mr. KETCHUM. On this little device here, this is like a spacer, or it sits in the space above the O ring?

Mr. THOMAS. Right. No, above the inner clevis leg.

Mr. KETCHUM. Above the inner clevis leg. So, what happens if the gas comes down? It protects the O ring by the gas hitting it first?

Mr. THOMAS. No. We in fact put that together and we leave holes in it, skips in it about that far apart all the way around the motor, such that it does not produce a seal. We want the gas to come around here and go ahead and pressurize that O ring.

Mr. KETCHUM. That is what I was wondering. So, what is the purpose of this?

Mr. THOMAS. The purpose is, if there is a leak—let me do it indirectly—if there is a leak through here, it will flow until all of this volume is filled with gas to the equivalent pressure of the chamber. What we want to do is to stop that gas flow for a long time, make it as short as possible. And to do that, if we filled the volume up with something, then it has a small volume, therefore a short flow time.

Mr. KETCHUM. Okay.

Mr. THOMAS. And it does not have enough time to transfer the heat to the O ring.

Mr. KETCHUM. You are trying to reduce the space between——

Mr. THOMAS. Reduce the time of exposure.

Mr. KETCHUM. Okay. I understand. Thank you. I hadn't heard about that one.

Mr. THOMAS. Mr. Chairman, the way I had intended to go through the presentation was a short overview of the motor, but I think that may not be necessary because of your familiarity with it. And then I would go to where we stand in the evaluation of the data. From there, the DM-8 configuration, then to address with you each one of the test objectives and our prediction of how it might work prior to the test. Then we could answer any further questions.

So, if we could then go to page 7, to the configuration. We were primarily addressing the joints here, the field joints and the case-to-nozzle joint.

I think we have discussed most of the features of the J seal, which is shown in Figure A on the lefthand side of the page, and it features the capture feature. It is bonded, it is bonded with a pressure sensitive adhesive. It has Viton O rings in it, and it has joint heaters over at each field joint, has a weather seal to keep out the water should that be the case at the Cape, and a V2 volume filler, which we just discussed. All three field joints are exactly the same in terms of J seal, O rings, et cetera.

The case-to-nozzle joint has the radial bolts, as we discussed earlier. It is bonded together with a polysulfide adhesive. All three O rings are Viton, and it is conditioned to 70 degrees, 75 degrees minimum by a purge into the aft skirt.

This represents the configuration of the field joints and the case-to-nozzle joint that we intend to certify and fly, with the exception of a slight profile change on the J seal in the field joint. Everything else is the same. And in the case-to-nozzle joint, the insulation is as we will fly it or as we have tested it on DM–8.

The metal part, the fixed housing that the radial bolt goes through, is a refurbished 51L piece of hardware. DM–9 has the new housing in it, and the difference is a slight change to eliminate the previous O ring groove that runs right past the bolts.

The next page is a picture of the nozzle. Everything in the nozzle is flight configuration that is exposed to the flame for DM–8 and subs with the exception of the cowl ring or outer boot ring—excuse me—which is the dotted part just to the left there that has polka dot looking crosshatching. That was of a 51L variety except that it was slightly modified to have a backup ply.

In DM–9 there will be a different configuration ring, which is a rosette type ring, and that will then complete all of the nonmetallics in the nozzle for test that is going to fly on the first flight motor.

The only other two remaining items that were not in DM–8 are the nose inlet housing structure, which is just to the left there behind the nose of the nozzle, and the—I guess the other one was the fixed housing.

So, all of the flame front material, the critical parts of the nozzle, were tested on DM–8 and performed satisfactorily.

Mr. Nelson. What are lightning straps?

Mr. Thomas. There are 12 straps that go from the metal part of the fixed housing over to the nozzle, and when they go into the nozzle they are bolted into the aluminum and they go straight on through and are anchored into the carbon, and that bleeds off any static electricity build-up back into the case and back into the basic structure of the Orbiter.

It also takes any lightning strike that comes in from the other way and transfers that back into the exhaust plume.

Now, to get on with the test objective assessment, we can go to No. 10.

Mr. Nelson. Mr. Thomas, have they always been on there?

Mr. Thomas. Yes, sir.

Relative to the ballistics of the motor, its pressure, burn time, burn rate, thrust, et cetera, the performance you see is predicted at 2.570 at vacuum and 60 degrees F, and we got 2.6, well within the specification limit. And the same is true for all the other parameters of the motor.

That is to be expected because the only change in the propellant was a slight change at the transition from the star to the bore in the forward segment to relieve some stresses. So, the internal shape did not change. There was a little less propellant because of the J seal, but it did not cause any reason for the ballistics to be different, and they weren't different.

On chart No. 11 is again the evaluation of the combustion stability, and the third item was to evaluate this structural transition section change, and that again did not produce any unexpected behavior.

The field joint is where the major interest and test objectives lie, and that is on page 12, to evaluate the performance of the capture feature field joint design from a strain standpoint and based on post test inspection.

We had predicted that the joint would open 5-thousandths of an inch and that there would be no evidence of deformation as a result of high stresses.

When we disassembled it, we saw no such deformation and based on the quick look data that we have seen so far, it indicates that comparing it with the prior joint environment simulators where we did have a direct measurement of gap opening, it is only the order of 6 mils, and 6 mils is about just slightly over the thickness of a sheet of paper.

Evaluate the performance of the unvented J seal field joint insulation. It worked just great, inasmuch as there was no hot gas reached any O ring. It did not penetrate that.

Verify the assembly and disassembly of the unvented J seal insulation in the horizontal position. It was our belief that if we could successfully assemble and disassemble this joint in the horizontal position with the capture feature and the insulation, that any condition we encountered in installing it in the vertical as KSC would be far overshadowed.

That, in fact, was the case. We assembled it without any difficulty. In fact, the first two joints were assembled, we did a dry run on them, took them apart and looked at them, and then put them back together for the test. The aft one, we just pressed on with that.

We did not damage any O rings during the assembly process. On the first segment, we did see some nicks in the O ring at the zero position, very near the hot spot that we got from the slag build-up. We know that occurred during disassembly because of the position of the material that we removed, and we believe that was aggravated by the heating of the grease surrounding the O ring and trying to drag it across a metal surface in a somewhat dry condition.

So, we believe that to be no consequence to any flight.

Some of the photographs that we have viewgraphs of—and if there is any question, we can probably flip the up there—but on page 13, the viewgraph following that is looking into the J seal from the aft, and that is at the 225 degree position.

You remember I showed you a while ago that we segmented that V2 volume filler. That orange device there is the V2 orange, or V2 filler, and that is one of the separations.

And you can see that other than a browning, slight browning of the adhesive on top of the J seal, that it looked just almost identical to the way we installed it. We got only 4-tenths of an inch, or thereabouts, erosion of the very top of the J, which is quite near the prediction.

So, that is essentially what all of them looked like. I do have, following this on the next photograph in the package, the J seal in the area of the slag on the aft field joint. And you can see some of the slag build-up there, the grayish material on the top.

You can see the white heat effect on the NBR insulation, but again you can see down below that it is green, brown, which indicates that there was no leakage whatsoever past it. On the other side, the next photograph is a photograph of the opposite end of that joint, and there is nothing of any unexpected phenomena there. Again, the same clevis side joint on the following photograph.

Mr. NELSON. Mr. Thomas, you are all tooled up now, so that if you need to produce these new segments of the Solid Rocket Motor, you are tooled up where you can produce them?

Mr. THOMAS. Yes, sir. There are several sets of tools in-house now to build these. On chart No. 17, continuing with the test objectives, we evaluate the effectiveness of all seals. We had no opportunity to test them, therefore we got no blow-by or erosion on them.

The joint heaters were placed on there to keep the joints above 75 degrees. In fact, they did. We had a rather warm day, but they started out at some 70 degrees and within 15 to 20 minutes they were up to 82, maintained the above 80 degrees except for the local environment which caused the heaters to go up to 104 degrees, which is well within the 120 degree max that we have.

I show on the other photographs following this, on No. 18, the photograph following 18, the three heaters that were added to the motor.

The one nearest the orange streamer there is the forward joint. The one where the orange streamer is, is the center joint. And you can see very near the end back there, adjacent to the external tank attach ring, is the last one.

We had the heaters on the back two joints and we had more than that on the forward joint. In fact, we had the weather seal on the forward joint, and that is shown on the following photograph.

You see the black strip is a rubber weather protection device that is cinched up to the tank or to the motor with two Kevlar bands that are loaded quite heavily to assure that there is no water seepage either way in there.

The heater is under the white cork material just to the left of the Kevlar strap, as well as is the sensor device. And that cork in the flight configuration will extend all the way across the top and to the back.

Our test objective there was, of course, to be sure that we didn't pop those Kevlar bands off during the ignition process, and we didn't. That photograph is essentially the way it looked post test.

Mr. NELSON. Now, what have you done to determine the flight dynamics and characteristics of this addition?

Mr. THOMAS. Of course, the conditions of the motor during the pressurization and expansion, that is rather straightforward. We have had the aerodynamists look at the protrusions and there does not appear to be any excess heating. In fact, we are very close to the same mold line that we had previously.

We will have that run through the level two aerodynamic heating analysis people to assure that we are not going to create any undue erosion of that insulation.

Mr. Nelson. Okay. And as far as an additional added exterior to what was there before——

Mr. Thomas. It is a very slight protuberance from what was there before.

Mr. Nelson. You are confident that doesn't change any of your aerodynamic qualities?

Mr. Thomas. No, sir, we are confident it is in the boundary layer still.

On page 20 is the test objective that deals with the case nozzle joint, and again we predicted we would have about 7 mils gaping, we believed, based on the data we had. In the joint environment simulator, NJES–2A, we were within the region of 7 mils opening.

The unvented insulation, we predicted there would not be any hot gas passage to the O ring. There was not any. And we had no seal erosion or blow-by, as well. So, from that standpoint, it was a complete success.

Now, the photographs that follow this, two photographs, are the as-disassembled before they were dirtied up with the soot and a photograph of the polysulfide adhesive in the case-to-nozzle joint. You see the radial bolt holes there along the lower bright section, which is the nozzle dome, and those bolts screw right in there, and the next photograph will show the other side.

The polysulfide is the purple looking material there and you can see that the step just very near the blackened char line, that blackened char line is as close as the hot gases ever got to any O ring, which is down just above the bright ring. I think you will see that on the following photograph.

I think it is interesting to note that no gas passed whatsoever. The rough looking appearance of the adhesive is from either adhesive or cohesive failure of the adhesive during the disassembly process under this tremendous load that I mentioned earlier.

The next photograph—and you need to turn that slightly clockwise to get it in the right position with the other—you see again the adhesive with the streamers off to the right-hand side. You see down from the separation from the grayish black into the purple color, that is as far down as the gas ever got. If you look down at the bottom of the adhesive, you see the wiper O ring. Down below that, just above the red ring, is the primary O ring, and the secondary O ring is laying in the corner between the radial bolts and the axial bolt slots. You can see that we were not within three and a half inches or so of getting any gas to the O ring. And there is no gas that passed through it.

The next test objective in order was dealing with the nozzle itself. We were, of course, looking to see if there were any pockets as had been observed sometime previously, particularly on STS–8A. We saw no pockets in the nozzle. We had no adverse effect by ply angle changes, et cetera, on the nozzle. In fact, one of our more critical designers of the nozzle said that this was the best looking nozzle we fired in some time, in fact maybe ever.

We did not encounter the ply lifting, as we did on ETM-1A. We had the good process that produced that aft exit cone and it was in good order.

We had backfill, which is a new technique for sealing the joints internal to the nozzle on the phenolic side. We had that at two locations in the nozzle, one of which we used as a pressure seal this time around because of our unbonds between the phenolic and the metal, and that was in fact a good seal also, shown on the next two or three photographs.

The first photograph in sequence there is a nozzle aft exit cone looking up from the aft end. And those little rays of sunlight coming through there, those round holes, is intentional. That was drilled post test to determine if we had any ply lifting, which we did not.

On page 26, the photograph following page 26 shows this backfill, which is a room temperature vulcanizing material, RTV. No hot gas ever reached the primary O ring.

Those two little marks there on the lefthand—left of center is where the adhesive adhered to the opposite side during the disassembly process and sheered out, operated very nicely.

The next photograph in sequence is the other side of that joint, and we found no gas passed through that part.

The remaining objectives for the motor, DM-8, was a system tunnel where we had adhered some panels to the upper part with the new adhesive process, and those in fact stayed in place as we anticipated they would.

We had an external tank attach ring on one of the older versions that is now in redesign. We anticipated that we would have some fastener yielding as we had seen many times before. It did get somewhat heat affected by the slag, but the damage to the fasteners was not anything in excess of what we had seen earlier.

And lastly, from a structural system standpoint, the motor was in fact intact in every way except for the crack that we introduced because of the water quench malfunction. But in any event, that was a post test type of problem.

I think going through those objectives and assessing them on a success/failure criteria, I think we were successful on all of them, which says that DM-8 was a resounding success.

We are in the casting process on DM-9. The flight motor is being insulated at this moment. And all of our activity is geared toward a mid-year launch for next year.

Thank you, Mr. Chairman.

Admiral TRULY. Mr. Chairman, that is all the prepared remarks that we have. So, any of us would be pleased to answer any questions that you have.

Mr. NELSON. Well, I know you are pleased, and we are pleased, and we are pleased for you, because your hair has gotten a little grayer, Admiral Truly, over the course of the last year and a half, and you are getting it back together.

Tell us about the rest of your test schedule.

Admiral TRULY. You mean with the motor or the——

Mr. NELSON. On the Solid Rocket Motor.

Admiral TRULY. I guess I would turn again to John and let him summarize that for you, because we do have a tremendous amount—even though we are pleased as to where we are, we have a tremendous long way to go. But I will let John summarize that for you.

Mr. THOMAS. Mr. Chairman, we have three more motors that we have identified as constraints to return to flight. That is Development Motor No. 9, Qual Motor 6 and Qual Motor 7.

We have added, sometime back, two additional motors called Production Verification Motors 1 and 2, which we expect to fire before return to flight, but they are not constraints to that.

The DM–9, the next motor out of the barrel, is scheduled for the end of November. It is being cast at this time.

The next test motor would be QM–6, which is in February, QM–7 in March, which is in the new test facility with the loads, with the high temperature tests. And then I believe in April we have PVM–1 and in May, PVM–2.

Mr. NELSON. What are those?

Mr. THOMAS. Those are fully production motors that fall right off of the line right after the others.

The subscale test program, which is ambitious and which is far more testing in that type simulator than has ever been subjected to this motor and any other that I am aware of, the so-called joint environment simulator and the nozzle joint environment simulator, there will be tests of each of those again, one this month and then again in October.

The transient pressure test article, which is down at Huntsville, where we are going to put five tests on the motor with dynamic loads, will begin with the Pathfinder this next month, and with the first version of TPTA—I hope we can get it off in October, but it may be the first week or so in November.

Mr. NELSON. Mr. Aldrich, did you want to add anything to this?

Mr. ALDRICH. Well, I would add to the general comments that Admiral Truly made at the beginning, the program is ecstatic over the success that we have had with DM–8.

For a long period of time, we have worked many issues on return to flight in the Shuttle, and during this period the work and the schedule for the Solid Rocket Motor has been the pacing critical path to flight. And with this firing, I feel very solid at our chance of achieving our scheduled date of next June.

There is much work ongoing in the project and parallel, but I feel good about its progress as we move forward.

I might say that we have talked to you in the past and reported to you at the periodic reports to your committee about all of the reviews, the technical reviews, the procedures reviews and the design reviews. It has been a very large amount of work for the entire Shuttle team. I would say today here, there is still a large part of that ahead of us, but we are on track and the reviews have yielded results that fit the program.

This culminates in early March of next year with what we call a design certification review for the entire Shuttle system, and we are already moving into the initial preparation period for that. So, DM–8 has been a very positive factor in our program and it typifies how I feel about the schedule today.

Mr. NELSON. Now, what will DM–9 and the two qual motors tell you different than what you were looking for in DM–8?

Mr. THOMAS. The configuration is 99 percent the same and the test objectives will be almost identical. It is an additional confidence builder type test. There will be one additional type, one additional change in there with the outer boot ring that we will be particularly concentrating on. And DM-9, at this time we are debating the addition of certain flaws in the forward joint and maybe even the aft joint to determine and prove to ourselves and to others that this system is quite tolerant to any unusual manufacturing or assembly process that might introduce a gas path to the primary O ring.

Mr. NELSON. Okay. Now, in the basic design of a field joint, on ignition you have got that joint rotation. Other than putting in additional pins and bolts, what are you doing, or have you done anything additional to try to lessen that joint rotation?

Mr. THOMAS. At the field joint, we predominantly eliminated or minimized the rotation with the capture feature.

Mr. NELSON. I see.

Mr. THOMAS. Just at your thumb there, that capture feature, based on all our testing so far, has caused the rotation to be substantially minimized from on the order of 40 to 50-thousandths of an inch down to—what we have measured so far is no greater than 6-thousandths of an inch.

Mr. NELSON. From 40 down to 6?

Mr. THOMAS. In that order.

Mr. NELSON. Just by the capture feature?

Mr. THOMAS. Yes, sir. And one additional thing, we did install custom shims, which are the little small pieces of metal adjacent to each pin around the outside. But that has shown repeatably on our JES testing and what we believe is the case on DM-8, that it has been reduced that much.

Now, to have margin on that, our design criteria is 9 mils. That is nominal. We assume that. And then we double it and say that everything has to operate nicely at 18 mils. And so far, it will do that.

Mr. NELSON. You know, you are talking about almost perfect fits here. And when you ship these motors by rail, they are going to get out-of-round, and then—of course, that was one of the problems that we had in the preparation of these boosters, was getting them back in round.

You seem to even have a greater or closer fit now than what you have had in the past with this retooled, redesigned joint. What do you do with it that close in a tolerance? How do you get it back in perfect round?

Mr. THOMAS. The problem that we were addressing in the 51L, when we were concerned with out-of-roundness, was, number one, damaging O rings, and number two was getting flat on flat metal. That is, getting a sharp corner against a sharp corner and making a chip and producing contamination on the O ring.

We have done two things to help us in that arena. One is that we have tapered and rounded off sharp corners. That says that if they get together, it is going to be not near so prone to chip.

The second is that we produced an assembly aid, a tool called a tang guide tool, that is very, very similar to a slight funnel that clamps around the lower segment and this has some slight bevels on the entrance cone. And as you said, we can stand quite a bit of out-of-roundness there, and that metal funnel, if you will, makes the two segments to conform. Neither are perfectly round, either the top or the bottom. But it makes them go to the same shape at the critical point of assembly. And we used that tool. We have demonstrated it at the Cape on two different occasions with the old segment, and we used that same one during the horizontal assembly process on the hill out there for DM-8. It works nicely.

Mr. NELSON. And that tool is called a tang guide?

Mr. THOMAS. I think there is a more sophisticated name for it, but that is all I remember it by.

Mr. NELSON. Is this a new tool? Or did you have that tool before?

Mr. THOMAS. This is new. Field joint assembly fixture.

Mr. NELSON. I see. I don't want to know what the acronym is on that.

All right. With the experience that you have now, do you have any doubts on the redesign?

Mr. THOMAS. I don't personally have any doubts. The tests that we have done so far on the NJES, the JES and DM-8 have said that it performed like we predicted.

Before we return to flight, we will have many more of those type tests plus at least three full scale motor tests. If we have missed anything, it should show up during that process. I don't believe we have. But we have got the best, I would say—not the best, maybe, but the most extensive program in testing of the Solid Rocket Motor industry of this size.

Mr. NELSON. So, what you are saying to the world is that this motor in its redesign is performing according to your predictions, and it is performing reliably and safely? That is your message to the world?

Mr. THOMAS. Yes, sir.

Mr. WALKER. Mr. Chairman, could I just follow up for a moment?

Mr. NELSON. Mr. Walker.

Mr. WALKER. Is there anyone that you know of that has questions about the SRM as redesigned since the test?

Mr. THOMAS. There is no one that I am aware of on the design team or within the area that look over the Solid Rocket Motor redesign that has any serious doubts about whether or not this motor is designed properly.

We continue to receive, of course, I think as we always will, letters that suggest that there are better ways of doing it.

Mr. WALKER. Well, I understand that. But what I am talking about is—and not just on the design team—are there engineers within the company, is there anybody with credibility on this issue that has questions about this?

The last thing we want to have happen is to have some failure in a mode at some point in the future and have somebody say, I warned you about this after the first test. You know, do you know of anybody out there that has questions at the present time about the SRM based upon the test?

Mr. THOMAS. I am not aware of anyone that has any questions about this motor design. I think if there are those that——

Mr. WALKER. Well, you indicated before that you know of no one who had serious questions. Now, are there people that have what you regard as non-serious questions?

Mr. THOMAS. Not to my knowledge.

Adm. TRULY. Mr. Walker, if I might, I would characterize it after this test that we are very pleased but we are not complacent.

Mr. Thomas is going to brief the details of this to the NRC Oversight Committee tomorrow. We have discussed it briefly with them but they have not taken a look.

But in direct answer to your question, with the people of credibility that we work with, both within the redesign team, within the contractor teams, both the prime contractor and those others that are assisting us and at the Marshall Space Flight Center, I am not aware of anyone who has a serious belief that we are not on the right track.

Mr. WALKER. So, what you are saying is that across the board, with the people who have credibility, the people that would have intimate knowledge of it, and so on, there is general satisfaction with the tests and with the redesign at this point?

Admiral TRULY. I would say yes, except for I should say that we have not briefed in detail, because of the timing, we are briefing you on the overall results and we have not briefed in detail our NRC Oversight Committee. We have communicated verbally what the initial quick look has been. I will let them speak for themselves. But I still stand by what I say. I am not aware of anyone who would seriously debate that this test has been anything but a demonstration that the design is on the right track.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. NELSON. Mr. Skaggs, before I recognize you, let me recognize a special friend of mine, someone with whom I had the privilege of training and flying, a member of the Columbia crew, Franklin Chang-Diaz.

Franklin, thank you for being here today. Franklin has been going through a round of meetings here on the Hill. He is one of the Nation's experts in plasma physics and plasma rockets and is trying to design a rocket with scientists and engineers and physicists at MIT that will ultimately take us to Mars in a month instead of eight months under conventional travel. Thank you for being here, Dr. Chang-Diaz.

Mr. Skaggs.

Mr. SKAGGS. Thank you, Mr. Chairman.

I would like to follow up on Mr. Walker's question, but before doing that, add my congratulations and cheers to those that you have already received for this major step forward in getting us back into the Shuttle program.

The follow-up is that I at least read something not too long ago—and I am not sure it was really in the professional press—dealing with the addition of the radial bolt on the joint between the aft motor section and the engine, and some criticism about that adding a potential weakness to that joint, which I gather from the test results was pretty absolutely refuted. But that seemed to be one of those lines of criticism, at least by some interested parties, that might have fallen into the category that Mr. Walker was getting at.

I am wondering if you could describe what the supposed concern was there and how the test indicated otherwise?

Mr. THOMAS. The concern is that, as expressed on two or three occasions, you are adding another 100 different leak paths or places for gas to leak from the motor.

Our reaction to that is, that is a fact. There are 100 additional leak paths through there, but they are in a secondary mode. That is, we have two O rings up front of that before it ever is even a consideration. The primary O ring is ahead of the stat-o-seals. The stat-o-seals forms a part of a secondary seal.

Our second reaction to that is that stat-o-seals are used extensively already in the Solid Rocket Motor up at the front end, on the igniter, where the igniter mounts to the front end of the motor. Our experience has been nothing but positive with those.

In theory, the seal is one of excellence. It can be leak checked prior to use and prior to being called upon to be used it only gets a tighter seal.

Whether or not that particular design concept is a good or bad one is subjective. Our conclusion is that we have a number of tests in the program, both subscale and full scale tests, the TPTA has the joint in it, and we will test it and if we are wrong it will show up in the tests. If we are right, that will also be proven. And we believe that is a good approach, based on our experience with them.

Mr. SKAGGS. In the redesign, did we give us anything in performance? I didn't know whether the specifications that, obviously, were more than met in thrust and so forth had been modified at all for purposes of the redesign. Or are those still the specs that applied originally to the SRB?

Mr. THOMAS. The performance specs for the motor are exactly the same. We have lost some payload because of the added weight for the additional metal on the capture feature, the additional bolts, slightly different insulation techniques, the heaters, the weather seal. I think all of that adds up to about 3,000 pounds per motor, which would be 6,000 pounds per flight. And the partial on that is about 12 to 1.

Now, there are some additional weight increases in the SRB with the external tank attach ring redesign and some others, and I am not sure what the final payload loss has been. Arnie may have a number on that.

Mr. ALDRICH. Well, I don't have a specific number because I didn't anticipate your question today. But because of the 12 to 1 factor, it is on the order of 100 pounds of delivery weight to orbit. Even though these rockets are much higher, they only go part way up and they don't have a great influence on our overall Shuttle performance.[1]

Mr. SKAGGS. Okay. Thank you very much, Mr. Chairman.

Mr. NELSON. What about communication? As you oversee the redesign effort, the retesting, talk to us about the communication problem being overcome that was evident in the past.

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[1] See appendix, p. 69.

Admiral TRULY. Well, that is certainly a different subject than the design that we took the first major step in proving in the development motor.

As you know from our previous testimony and from working so closely with us, we have done a number of reorganizations, we have a number of new people in the program.

We revitalized the Office of Space Flight Management Council, which is made up of myself and the center directors from Johnson, Kennedy, Marshall, and the National Space Technology Laboratory in Mississippi where we do our engine testing. We meet on a frequency of about once a month.

Immediately preceding our Management Council meetings, Arnie Aldrich holds a program level review for a couple of days with all of the project managers at all what we call the level three, not only the Solid Rocket Booster, but the main engine and the Orbiter. And then they come to us at the Management Council and report.

As recently as Monday of this week we had a meeting and I purposely was not present because I wanted it to be as free and open a conversation as could be. We hold meetings with the center directors and very senior representatives of the contractors down at Cape Kennedy to review their view of how the processing is going down there.

So, across the board, my feeling is that we have a totally open system, vertically and horizontally, as I view it.

I might ask Arnie to comment because he sees at a finer grain of detail within the program. But frankly, I am just extremely pleased. When somebody has a problem, my phone rings and I answer it and we deal with it at the proper level, but always through the program. I don't go around Arnie Aldrich when it comes to direction in the program, and I think that is true as he looks into the other levels of management, but I would rather have him speak for himself on this issue.

Mr. NELSON. As you answer the question, remember that one of the problems was that communication in the past was from the top down, and from the bottom up it was much more difficult. So, speak to that issue.

Mr. ALDRICH. I try to penetrate the program daily and weekly and monthly in the reviews that Admiral Truly has just highlighted. And we have a fixed focus structure to do that.

I believe I hear fully and regularly from each project, from the project manager on a regular basis each week and face to face each month. And then, together with those project managers, we jointly report to Admiral Truly and the center directors at the Management Council once a month.

It is a very communicative and effective process we are on and I believe it does provide for bottom to top flow of information and communications as well as full access for me to manage and understand the total program.

Mr. NELSON. Are the engineers communicating up to the project managers?

Mr. ALDRICH. I would say every aspect of dealing with the program that I run into, I would say very much so. There is great communication and participation and interest, and we have these forums set up to structure that. So, there is regular and frequent opportunities to do so.

Mr. NELSON. Let's take a case in point where there is a professional difference of opinion, which on anything that is new, state of the art, as complicated as this, there is going to be professional disagreement.

For example, some of the engineers have said in the redesign of the SRB that they would rather see the explosive propulsion vented, as opposed to non-vented.

Now, in the design that you have described here, Mr. Thomas, and so forth, with the seal that occurs there, it does not get vented all the way to the O ring.

Other engineers, as I understand it, have said that they would prefer a different design. Take that as a case study and talk to us about the communication.

Mr. ALDRICH. Well, as a case study on that subject, all of the design features and potential design features were studied in depth by the design team at Marshall and at Morton Thiokol, leading up to the design we have here. And each of the issues technically that were brought forward prior to that time and at that time were studied in depth, including that one. And I think it was understood as a critical design consideration at all program levels.

In any event, not only did the design engineers that report to the project at Marshall and at Morton Thiokol deal with that question and make their recommendations, the independent assessment team within NASA that was assembled also was asked to consider that in depth and provide recommendations and then deliberate with the project on the final recommendations.

Beyond that, the National Research Council commission also considered that as a significant issue and the question and the deliberations and the findings.

I believe that was communicated and understood right from the working level in the program all the way up through to the management level here in Washington, and known to be a sensitive, tough decision, and all of the communication paths were exercised to be sure that we arrived at a decision that most fit the aggregate opinion and data that was available to decide upon it.

Mr. NELSON. So, what you are saying, then, in layman's terms, is that the full discourse of the ideas is there, that the communication is going from the bottom up as well as from the top down, and you are satisfied that you are getting that full discourse?

Mr. ALDRICH. Yes, sir, I am.

Mr. NELSON. Well, that is as good as you can ask for. At some point you have to stop and make a decision, we are going to go this way or that way.

Admiral. TRULY. Well, that was the comment that I was going to add and endorse what Arnie said. Communication and open communication is healthy, but we will never lift off if we wait until all the professionals get on one side of every issue.

Mr. NELSON. Sure.

Adm. TRULY. There are thousands of decisions, some big, some little, that have been made in the last year and a half, and there are a lot more to be made in the next weeks and months ahead, and we will make them. And the way to do it, though, I believe, and I think this is what we are trying our best to do, is to look ahead, look to the date that these decisions must be made, so we can make the program move forward in between day and whatever that date is for that decision, to exercise the communication paths, and then, when we get there, we will make a decision. And if some people disagree with it, the final test is in the testing of the decision as we are doing in the motor.

Mr. ALDRICH. Mr. Chairman, could I add one more comment to that?

Mr. NELSON. Certainly.

Mr. ALDRICH. I believe that is a very positive assessment of our communications, but I can't remember in recent reports to your committee whether we have described for you the anonymous problem reporting system that has also been put in place within the program by the Safety, Reliability and Quality organization.

That was put into place some months ago to allow anyone within the NASA system to forward a report to our visible channels here in Washington to technically be assessed. And that is an additive step that has been taken that I think is carefully thought through.

I don't know about the timing of it, but to date we have not had that channel sing out with great difficulty or problems that haven't been heard. It has been effectively communicated to our teams, but I think it just adds to the overall process that we now have.

Mr. NELSON. Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

If I could ask a few budget questions. First of all, what is your current estimate of how much it is going to cost to get the SRM redesigned and requalified?

Admiral TRULY. Mr. Walker, I don't have the details of that with me. If I could answer that for the record, I would be pleased to do so.

Mr. WALKER. Sure.

[The information follows:]

Redesign, analysis and verifications testing will total $527 million. This cost also includes design team investigation, hardware redesign, tooling mofifictions, special test equipment, failure mode and effects analysis, and reclamation of existing hardware.

Mr. WALKER. Let me ask you this: Do you think that the funds you have currently available are sufficient to get the job done in a timely manner?

Admiral TRULY. Yes, I do. I believe that we have been supported in the recovery effort from within NASA, from within the Administration, and particularly from up here at the Congress. There are tremendous budget pressures in every agency, and certainly in NASA we have seen and are seeing them. But as far as I am concerned, the efforts to get that next Shuttle flight off have been and continue to be our first priority, and we are not going to let budgets stand in the way of getting the job done right.

Mr. WALKER. Is the prime driving force in your schedule to get the next Shuttle flight going the redesign of the Solid Rocket Motor?

Admiral TRULY. Yes, it is. There are other areas that we could have additional problems that would change that, but right now every indication that we have across the program is that when you look across it at the paperwork to be done, the engine work to be done, the Orbiter mods work to be done, we believe—and frankly, some of us are very adamant—that we are going to keep the system going such that the Solid Rocket Motor that was the original cause of us getting into this recovery effort is going to continue to be the pacing item.

And it is that test program that was started with the engineering test motor and the DM-8 firing, but will continue through the other major motor tests that will drive the schedule.

Mr. WALKER. So this committee can assume that if you stay on schedule with regard to the SRM, you will pretty much be on schedule toward your June, 1988 next launch of the Shuttle system?

Admiral TRULY. Yes. And the next few months are going to tell the tale on the June date. We need to deliver the flight motors to the Cape in December so that they can begin to be stacked, so that we can get off the flight readiness firing. And we need to continue to work the schedule on the next full scale motor firing. And then after that, the next, and after that, the next. But it is the Solid Rocket Motor that is pacing the schedule.

Mr. WALKER. Now, if I understand correctly, the next scheduled test firing is in December, as well. So, there will be——

Admiral TRULY. November 29 is the date that we are shooting for for the next full scale firing.

Mr. WALKER. So, the end of November, first part of December.

Admiral TRULY. Yes.

Mr. WALKER. So, we have two milestones in that time frame. You would expect in that time frame to have the second test plus delivery of the flight motors to Kennedy?

Admiral TRULY. That is correct. If we do not meet those dates, we will first look at the total program to see if there are legitimate and safe work-arounds. But I view those dates as crucial to getting off in the month of June.

Mr. WALKER. Can you tell me what the other milestone dates are, approximately?

Admiral TRULY. Arnie, do you want to take that?

Mr. ALDRICH. Yes, I would like to respond to that, Mr. Walker, if I could. Let me get my critical path chart up.

I mentioned one critical date earlier in the testimony, and that is that on March 2 of next year we will be doing a design certification review. I am not sure if we conveyed to you the significance of that, but that is the culmination of about a year's worth of work, of reviewing all the design requirements across all of the Shuttle system, and then reviewing again not just the work that has been done during the recovery but the initial work, as well, prior to first flight, to be sure that our total design is certified and meets our requirements and we feel totally comfortable that it is ready to fly.

Mr. WALKER. That is an entire system recertification, not just an SRM certification?

Admiral TRULY. Yes, sir. It is a total system-wide recertification.

Mr. ALDRICH. Other critical milestones, the Orbiter, of course, is already powered up—let me find it here in my chart—it essentially starts what we call the up mission processing, the procedural flow of checkout leading to first flight, on October 2. That is a critical milestone to start the testing to flight for the Orbiter. Right now we are testing redesigns and mods that have been made leading up to that start point.

The engines meet with the Orbiter on the 4th of January of next year, the three engines that are being test fired between now and then at NSTL, and so that is a critical date to complete the configuration of the Orbiter.

Then on the 2nd of March—happens to be the same date that this DCR is on—we meet the stack of the external tank and the Solid Rocket Booster with the Orbiter for rollout to the launch pad.

On the 8th of April we do the flight readiness firing. It is a critical milestone to demonstrate the all up configuration and the propulsion system.

Then, of course, our internal target for the launch is June 2, 1988.

Those are probably the most critical milestones, together with the several that Admiral Truly mentioned on the solid rocket motor test and flow that I am particularly keying on.

Mr. WALKER. How difficult, in your evaluation, is it going to be to meet those milestones?

Mr. ALDRICH. I believe it is a tremendous amount of work, but there has been a tremendous amount of work already behind us, and we are still in a good posture to be able to meet each of those milestones. I feel we have got a very solid shot at it.

The Solid Rocket Motor, I believe, is the pacing item, and with this test that we described today we are still successfully marching up that mountain, as it was described. I believe the other mountains we can hold within the same schedule. Barring some unforeseen problem that we can't predict, the work we have lined out is what is required to return to flight, and I believe we can do it to these schedules.

Mr. WALKER. Let me cover a couple of other items, just in passing here.

What is the status of the review of the range safety package on the external tank?

Mr. ALDRICH. We are reviewing that in conjunction with the Air Force, who runs the range, in terms of whether it would be possible to remove the range safety package from the tank.

The safety package on the rockets, of course, is not in question and will fly. The question is, for the different mission profiles, does the charge on the rockets provide the adequate protection for the areas of land threat that we would be concerned about.

There had been a number of deliberations and we need yet, in the middle of this year, to come together on a final recommendation for that. It does affect our range safety lines. It does affect in some degree the dispersal of the tank after separation from the Orbiter. And so, that is an open issue to be resolved, and currently our baseline is to carry the range safety system on the external tank.

In fact, the latest status report I had on it was that we would probably fly the range safety system with the ability to inhibit it on certain missions where the flight trajectory did not cross boundaries that would be still of concern to the range. It is an open issue at this point.

Mr. WALKER. What is the status of the security improvements at the Cape?

Mr. ALDRICH. We have reviewed the security improvements at the Cape. We have reviewed a very expansive potential list of improvements or of modifications that we could make over the next several years.

We have moved out with a moderate set of those improvements in the next fiscal year budget, and the agency is still deliberating on a much larger program for national security protection across the whole Shuttle system, not just the Cape, but at other locations.

Mr. WALKER. Did the hacker access to your data base have any adverse impact on the program?

Admiral TRULY. I have not been briefed on that particular news story that was just out. I think it is a good—and as a matter of fact, it is my understanding, however, that the data base that was violated, if in fact it was, was an unclassified post flight data base and wouldn't have had a safety of flight or mission success type of a thing.

But it is a good example of why we need, in this modern age, to keep our vigilance up, not only in a system like this one but in so many of our important national systems, and the connection between the need for national resource protection and good security, well applied with proper budgets across our system is one. I tore that article out of the newspaper and passed it on to some of the people who are debating the budgets on that issue.

Mr. WALKER. Can we assume that there are immediate steps being taken to prevent a reoccurrence?

Admiral TRULY. Yes, sir, you may.

Mr. WALKER. Thank you.

Thank you, Mr. Chairman.

Mr. NELSON. I was particularly interested in that story and made a speech this morning on the floor of the House calling on the Department of Justice to prosecute to the full extent under the law available to them, which is a law that I had something to do with, because before I ever came here I passed the first computer crime law in the country and Florida's law became a model, and it was on the basis of the Florida law that it took me about six years to finally get it through here. But it is now in the Federal statutes.

Nevertheless, since this was a West German group, the domestic law may not apply and therefore we would have to, as a matter of foreign policy, negotiate certain treaties with other countries to bring about legal effects.

I think that since this dastardly deed was done to NASA that you all ought to have a little fire in the belly and start beating the tom-toms about these kind of things just should not happen.

It was a rather tepid press release that NASA released after this thing which didn't say a lot, and I wish you would pass along those comments, Admiral Truly, to Dr. Fletcher.

Admiral TRULY. I certainly will.

Mr. NELSON. Obviously, NASA happened to be the one at whom, but this has been done to the alteration of medical records in the Kettering Sloan Foundation, where some cancer patients' records were altered, some of the national laboratories in DOD have been accessed, and we just can't tolerate this kind of stuff. It sort of gets close to home when they start fiddling around with data coming out of the Space Shuttle.

So, I think you ought to use this platform and get a little righteous indignation and let our Justice Department know that it is time for them to act.

Admiral TRULY. I appreciate your comments very much and I can assure you, I will pass it on, and I will do that.

I wonder if I might inject a small thing that is from another part of my responsibility and is not a part of the Shuttle. I was just handed a note that at 3:16 this afternoon, Eastern Standard Time, our Scout launch from Vandenberg Air Force Base lifted off, and the data from throughout the first three stages looks good.

That launch has two Navy transit navigation satellites aboard, operated by Naval Space Command, that are part of a major and important national network, and I hope the fourth stage goes as well as the first three, because we need those systems.

Thank you, sir.

Mr. NELSON. Well, congratulations to you.

Let me ask you about the Solid Rocket Motor and also in deliberations of the committee is the Advanced Solid Rocket Motor. Are you pleased with the studies that are underway since we last talked on that subject?

Admiral TRULY. Yes, I am. I am just as enthusiastic about the Advanced Solid Rocket Motor as I was on April 23, I think, when I came to this committee and you held a hearing on the various options as to what we should do in the future.

As a matter of fact, earlier a question was asked about performance loss in our redesign efforts. We are going to suffer not a huge but a performance loss on the various parts of the recovery. As you know, even prior to the accident the Shuttle performance was less than we had hoped for and there are some of our satellite systems that have suffered from that.

In addition to the advantages, we think, in the industry of quality and reliability across all the years that the Shuttle Program is going to be operated, the performance that we can gain back from the Advanced Solid Rocket Motor continues to be such that it is very much needed.

It is still, in my own mind, the number one priority of the Office of Space Flight for improvements into the capital investments that we have already made in our systems, and I am continuing to pursue it.

Mr. NELSON. And you are looking at, in your studies, liquid as well as solid?

Admiral TRULY. We are looking at several things. First of all, in the basic Advanced Solid Rocket Motor studies, of which we have five contractors under contract for the Phase B, each a $3.3 million study that was started on August 3 and will go about nine months, those five contractors are looking at a segmented case design and a monolithic case.

In parallel with that, we have started studies for a liquid rocket booster as to the feasibility of replacing the solids on the Shuttle, so that when we get to the proper decision point next year, we will have the results of all those studies on the table before we would move ahead, if it is submitted by the Administration and approved by the Congress, on the Advanced Solid Rocket Motor Program.

Mr. NELSON. In conclusion, Admiral Truly, Mr. Aldrich and Mr. Thomas—Mr. Walker and I want to extend to you, to your team, Government and contractor, a hearty congratulations for what is obviously a lot of hard work, and at a time in which the morale is coming back because we are starting to see tangible results after a searing experience.

So, we want you to know how pleased we are for you and how pleased we are of you and your team.

So, if you would convey those personal remarks from Mr. Walker and I, we would appreciate it very much.

Mr. WALKER. Right on, Mr. Chairman.

Admiral TRULY. Thank you, Mr. Chairman. And I accept them on behalf of the thousands of people that are working on the program.

As I said earlier, this test, I believe, is a success. It tells us that even though we have a tall mountain to climb, we are climbing the right one. And it is a long time between now and June, but we think we have a real shot at it and we are not going to give up.

Thank you, sir.

Mr. NELSON. Thank you. Mr. Aldrich.

Mr. ALDRICH. Could I make one correction? I am sorry Mr. Skaggs has gone. I should have said 1,000 pounds penalty to orbit, not 100. I don't know where my decimal point was, but that was the proper answer.

Mr. NELSON. Well, you are only missing it by a little. Every now and then we get billions and trillions mixed up up here in our deliberations. [Laughter.]

Thank you all. The meeting is adjourned.

[Whereupon, at 3:30 p.m., the subcommittee was adjourned, subject to the call of the Chair.]

APPENDIX

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: XC:MDD:C-22491f

OCT 16 1987

Honorable Robert A. Roe
Chairman
Committee on Science, Space
and Technology
House of Representatives
Washington, DC 20515

Attn: Subcommittee on Space Science and Applications

Dear Mr. Chairman:

As a witness before the Subcommittee on Space Science and Applications on September 16, 1987, I have edited and am returning the hearing transcript forwarded to me for review. I request that the following information be included in the hearing record:

Page	Line(s)	Proposed Wording
45	1066-1083	The total inert weight increase of each redesigned solid rocket motor and booster assembly components is 4,235 pounds. The ratio of inert weight change in each booster-to-payload loss is 5 to 1. The change in propellant weight is a loss of 1,700 pounds per motor, and the ratio-to-payload loss is 10.2 to 1. The resulting total payload loss is 1,014 pounds.

I understand that this letter may be inserted in the form of an appendix and referred to by footnote in the main text.

Sincerely,

Richard H. Truly
Associate Administrator
for Space Flight

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