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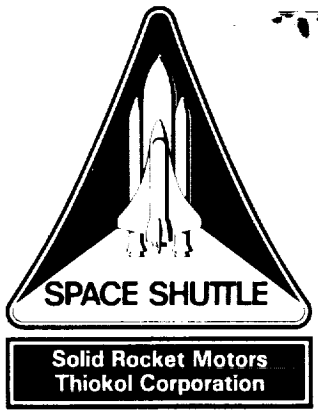

TWR-17592 VOL. VII

Space Shuttle Production Verification Motor 1 (PV-1) Field Joint Protection System Final Report Volume VII

10 December 1990

Prepared for:

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Abstract

This report documents the performance of the field joint protection system (FJPS) of the Space Shuttle Production Verification Motor 1 (PV-1), as evaluated by postfire hardware inspection. Compliance with specification CPW1-3600 is shown for the FJPS assembly and components.

The simplified FJPS and field joint heaters performed nominally, maintaining all joint seal temperatures within the required range. One anomaly was noted on the igniter-to-case joint heater during postfire inspection. The heater buckled off the surface in two areas, resulting in two hot spots on the heater and darkened heater insulation. The condition did not affect heater performance during ignition countdown and all igniter seals were maintained within required temperature limits.

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ACRONYMS

DWV	dielectric withstanding voltage
FJPS	field joint protection system
in	inch
PEEP	Postfire Engineering Evaluation Plan
PV-1	production verification motor 1
RSRM	Redesigned Solid Rocket Motor
SRB	Solid Rocket Booster
RTD	resistive temperature device
TPS	thermal protection system
W	watt
°F	degrees Fahrenheit

1.0 INTRODUCTION

The Space Shuttle Production Verification Motor (PV-1) test was a full-scale Redesigned Solid Rocket Motor (RSRM) static firing. PV-1 was successfully fired on 18 August 1988 at the Thiokol, Utah-based operations, test bay T-24. Postfire inspections of PV-1 were performed per Postfire Engineering Evaluation Plan (PEEP) TWR-16473 (reference 2).

Field joint seal temperatures were maintained using a simplified field joint protection system (FJPS), shown in figure 1, consisting of heaters and sensors only. The heaters consisted of primary and redundant chemically etched foil circuits which were superimposed upon one another and laminated in Kapton and fluoroethylene polymer Teflon. Adjacent to the heaters were two temperature sensor assemblies, each containing two resistive temperature devices (RTD). These were covered by a 0.25-in thick strip of cork held in place by a single Kevlar strap.

The igniter-to-case joint was fitted with an igniter heater to keep the igniter seals within the required temperature limits. The heater consisted of a flexible strip heating element secured around the igniter adapter flange with adhesive backed tape. Thick cork (0.25-in) was wrapped around the heater, and the heater and cork were secured in place with a steel T-bolt latch band clamp.

2.0 OBJECTIVE

The objective of this report is to document any heater anomalies prior to motor ignition and any anomalies to the FJPS during test firing. This report will also show PV-1 static test compliance with specification CPW1-3600, Addendum D, dated 3 August 1987.

Qualification Objectives (CEI Paragraph)

BR. Certify the ability of the field joint assembly to maintain the temperature of the field joints. (3.2.1.11.a)

CH. Certify the function of the igniter heater. (3.2.1.5.3., SCN 42)

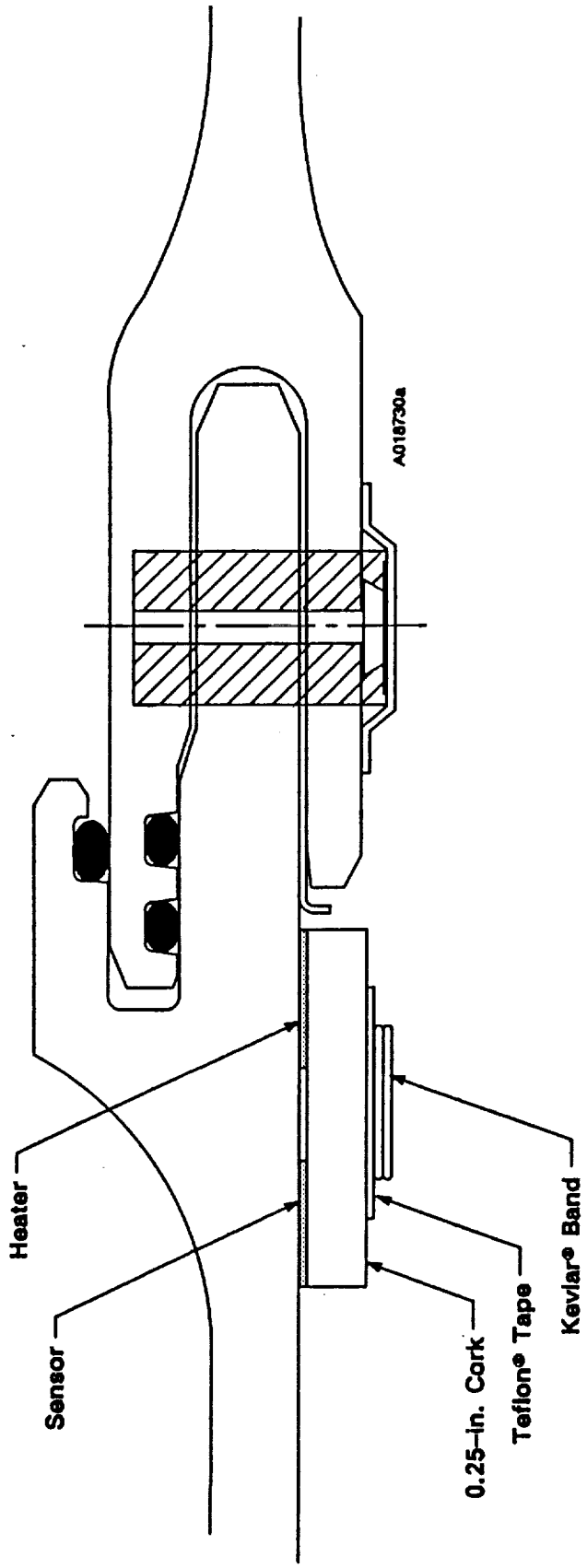

Figure 1. Simplified Field Joint Protection System

3.0 SUMMARY

Postfire inspection results indicate that the simplified FJPS was in excellent condition with no signs of abnormal heat effects. The field joint heaters performed nominally during ignition countdown, maintaining the field joints within the required temperature limits. No anomalies were observed on the FJPS.

One anomaly was noted on the igniter-to-case joint heater during postfire inspection. The heater buckled off the surface in two areas, resulting in two hot spots on the heater and darkened heater insulation. A corrective action was initiated to remove the adhesive backed tape from the heater-to-igniter adapter interface. This will eliminate bondline stresses induced by improper alignment of the heater strip during installation. The condition did not effect heater performance during ignition countdown and all igniter seals were maintained within the required 75° to 120°F temperature range.

4.0 CONCLUSIONS/RECOMMENDATIONS

The JPS heaters and igniter-to-case joint heater performed adequately and maintained the joint temperatures within the required range during test fire countdown. Postflight inspection verified that the FJPS performed as designed. The anomaly reported on the igniter-to-case joint heater did not effect heater performance during ignition countdown.

Listed below are the conclusions as they relate to the objectives and CEI paragraphs.

Qualification Objectives (CEI paragraph number)	Pass/Fail Criteria	Conclusions
BR. Certify the ability of the field joint heater assembly to maintain the temperature of the field joint. (3.2.1.11.a)	The field joint temperature must be maintained between 75° and 120°F prior to motor ignition.	Certified. Minimum recorded joint heater sensor temperature was 86°F at T-0, ensuring acceptable field joint temperatures.

CH.	Certify the function of the igniter heater. (3.2.1.5.3, SCN 42)	The igniter heater must maintain the igniter seals between 64° and 130°F prior to motor ignition.	Certified. The igniter heater functioned adequately throughout ignition countdown and maintained all igniter and safe and arm seal temperatures within required limits.

5.0 DISCUSSION

5.1 PREFLIGHT HEATER CONTROL SYSTEM AND PERFORMANCE

The three field joint heaters performed nominally during ignition countdown, maintaining the temperature at the controlling RTD at or above 100°F, with a maximum deviation of -0.1° and +0.4°F. The remaining RTD's showed a minimum joint temperature of 86°F at T-0, ensuring field joint temperatures within the required 75° to 120° range.

The igniter-to-case joint heater performed nominally, maintaining the igniter joint within the required 64° to 130°F range during ignition countdown. The minimum igniter joint temperature occurred during building rollaway when one temperature sensor dropped from 128° to 115°F as a result of convective cooling.

5.2 POSTFLIGHT INSPECTION OF FJPS AND IGNITER HEATER INSTALLATION

5.2.1 Field Joint Protection System

The simplified FJPS was in excellent condition with no signs of abnormal heat effects on the cork strip or Kevlar band. No anomalies were observed on the FJPS.

5.2.2 Igniter Heater and Forward Dome Power Cable Installation

One anomaly on the igniter-to-case joint heater was noted during postfire inspection. The heater buckled off the surface of the igniter adapter in two places, which caused two hot spots on the heater and darkened heater insulation. Subsequent testing of the heater showed no degradation of insulation resistance, dielectric withstanding voltage (DWV), or continuity.

The condition was caused by stresses induced on the igniter heater-to-igniter adapter bondline during heater installation and operation. During installation adhesive backed tape was applied between the heater and adapter. Local stress areas were introduced into the bondline in places where the flexible heater strip was not properly aligned, yet was held in place by the tape. Normal expansion of the heater strip during heater operation caused the strips to buckle in these areas. As a result of this anomaly a corrective action was initiated to remove the adhesive backed tape from the heater to adapter interface.

Inspection of the heater power cables revealed no anomalies.

REFERENCES

1. TWR-17592, VOL. I, Revision B, 'Space Shuttle Production Verification Motor 1 (PV-1) Static Fire Final Test Report', D.M. Garecht, August 1989.

2. TWR-16473, VOL. VII, Revision A, 'Qualification and Production Verification Motor Postfire Engineering Evaluation Plan (Joint Protection System Component)', S.W. Olsen, 13 January 1989.