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REPORT NO. RN-S-0234
TO
AEC-NASA SPACE NUCLEAR PROPULSION OFFICE
FINAL TEST REPORT
FOR
RADIATION EFFECTS TEST
ON
PYLE ZZM-W-2416-1850 CONNECTOR
JUNE 1965
NERVA PROGRAM CONTRACT SNP-1

MASTER

AEROJET GENERAL CORPORATION

ROCKFORD, ILLINOIS

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ROCKET ENGINE OPERATIONS - NUCLEAR

NERVA PROGRAM

CONTRACT SNP-1

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FINAL TEST REPORT
FOR
RADIATION EFFECTS TEST
ON
PYLE ZZM-W-2416-1850 CONNECTOR

AEROJET - GENERAL CORPORATION
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ABSTRACT

A Pyle Model ZZM-W-2416-1850 hermetically sealed connector was irradiated at the Ground Test Reactor at General Dynamics/Fort Worth (GTR-15) during December 1964 to an integrated exposure of 7.18×10^{16} neutrons/cm² ($E > 0.9$ Mev) and 2.36×10^{11} ergs/gm (C) gamma radiation. The Buna N hermetic seal failed at an integrated exposure of 2.0×10^{16} neutrons/cm² ($E > 0.9$ Mev); however, the pin-to-pin electrical insulation never decreased below 8 megohms.

for

W. D. Stinnett
Program Manager
Rocket Engine Operations - Nuclear

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I. INTRODUCTION

The Pyle Model ZZM-W-2416-1850 connector is being considered for use on the engine side of the 30-in. water shield for all electrical and thermocouple cables passing through the water shield. The integrated doses which are shown below, were calculated for a 20 min. full-power run assuming no structure between the reactor and the connector.

The following values apply to the NERVA I engine:

Integrated gamma dose = 3.26×10^7 ergs/gm(C)

Integrated neutron exposure = 3.74×10^{13} nvt ($E > 0.9$ Mev)

The following values apply to the 3.5 NERVA engine:

Integrated gamma dose = 1.14×10^8 ergs/gm(C)

Integrated neutron exposure = 1.31×10^{14} nvt ($E > 0.9$ Mev)

The purpose of this test was to evaluate the performance of the connector in a nuclear environment that is more severe than the predicted service environment. Both the sealing characteristics and the electrical insulation of one unit of a Pyle Model ZZM-W-2416-1850 connector were measured during irradiation in test GTR-15 which was performed at the Ground Test Reactor at General Dynamics/Fort Worth in December 1964.

II. SUMMARY AND RECOMMENDATIONS

The Pyle Model ZZM-W-2416-1850 connector is satisfactory for use in the facility water shield. The connector tested at the Ground Test Reactor maintained pressure and electrical resistance far in excess of the predicted integrated exposure which might be accumulated in ten 20-min. full-power tests of NERVA I. It is recommended however that dosimetry be placed in the vicinity of the facility connectors and when the integrated dose reaches 2×10^8 ergs/gm(C), the connector be replaced.

III. TEST DATA AND TECHNICAL DISCUSSION

A. DESCRIPTION OF TEST COMPONENT

Figure 1 shows a cross sectional drawing of the Pyle Model ZZM-W-2416-1850 connector. It also depicts the major components and the materials employed in this design.

B. DESCRIPTION OF TEST FIXTURE

During irradiation, the Pyle connector was attached to a dewar and pressurized with helium to 5 psi. The valve was closed to trap this pressure on the connector. The pressure was then monitored by means of a Heise gage. The leakage currents between pins and between pins and the case were measured with a micro ammeter using a 50 volt power supply.

C. MATERIALS REVIEW

From a radiation effects point of view, the Buna-N seal is the material most prone to failure in a radiation environment. Table I lists the predicted changes in physical properties of both Buna-N and Neoprene for the predicted environment. (Neoprene is another material that can be used in place of the Buna N.)

D. PRESSURIZATION DATA

The Pyle connector was pressurized to 5 psi with helium before irradiation was initiated. After reactor startup however, the pressure continued to increase because of off-gassing of the Buna N. The excess pressure was periodically bled off. After an integrated exposure of 6.7×10^{10} ergs/gm(C), the pressure dropped to zero, indicating failure of the seal. Subsequently, the integrity of the seal was erratic and the pressure could not be maintained. Seal failure was predicted, as noted in Table I, because of changes in the physical properties of Buna N.

E. ELECTRICAL INSULATION DATA

The leakage current between pins and between the case and the pins was measured with a microammeter using a 50 watt power supply. Figure 2, which shows the leakage current during the tests, indicates that the minimum electrical insulation resistance between pins is 8 megohms. Upon reactor shutdown, the electrical insulation increased to greater than 100 megohms which is the pre-irradiation value. The resistance is influenced by gamma dose rate. Therefore the electrical insulation will not change this much in the facility shield because the service environment dose rate is less than 1% of the environment to which the connector was tested.

TABLE I

PREDICTED CHANGES IN CHARACTERISTICS

NEOPRENE AND BUNA N

Material	Characteristic Affected	Radiation Damage Threshold (ergs/gm(C))	25% Damage Point (ergs/gm(C))	Predicted change in Characteristic - %		
				GTR-16 @ Seal Failure (7.8×10^{10} ergs/gm(C))	GTR-16 Integrated Test (2.36×10^{11} ergs/gm(C))	Time Required for 25% Damage Full Power (NERVA I)* (minutes)
Neoprene	Tensile strength (2,900 psi)	1.0×10^9	6.6×10^9	-65%	-70%	3960
	Elongation (450%)	4.1×10^8	1.8×10^9	-95%	-95%	1180
	Compression set (9%)	1.8×10^8	5.0×10^8	-80%	-90%	300
	Set at break (6%)	1.6×10^9	3.2×10^9	-95%	-85%	1920
	Strain @ 400 psi (31%)	6.4×10^8	3.6×10^9	-85%	-95%	2160
Buna N	Tensile strength (1700 psi)	1.0×10^9	2.0×10^{10}	-55%	-40%	12000
	Elongation (270%)	7×10^8	2.0×10^9	-95%	-95%	1200
	Compression set (4.7%)	2×10^8	1.0×10^9	-95%	-95%	600
	Set at break (5%)	2×10^8	5.0×10^8	-80%	-55%	300
	Strain at 400 psi (25%)	3×10^8	2.0×10^9	-80%	-90%	1200

* Gamma dose rate = 1.0×10^8 ergs/gm(C)-hour.

FIGURE 1
CROSS SECTIONAL DRAWING OF PYLE
MODEL ZZ14-W-2416-1850 CONNECTOR

FIGURE 2
ELECTRICAL INSULATION -VS- INTEGRATED
RADIATION EXPOSURE