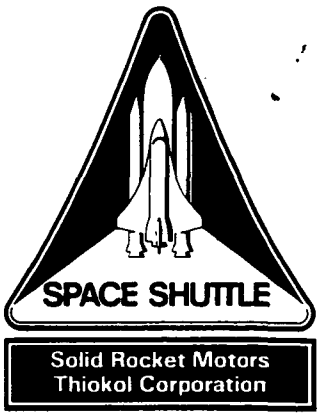
CR-184289



TWR-60826

SIMILARITY ANALYSIS FOR THE USE OF THE 1U50228-47 O-RING IN THE S&A ASSEMBLY

1 October 1990

Prepared for:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812

Contract No. NAS8-30490

DR. No. 3-5

WBS.No. 4C102

Thiokol CORPORATION
SPACE OPERATIONS

P.O. Box 707, Brigham City, UT 84302-0707 (801) 863-3511

DOC NO. VOL REV

TITLE

TWR-60826

SIMILARITY ANALYSIS FOR USE OF THE 1U50228-47 O-RING IN THE S&A ASSEMBLY

1 October 1990

Prepared by:

G. S. Eden
Joints and Seals Design

Approved by:

J. Burn, Supervisor
Joints and Seals Design

D. C. Pulleyn
Systems Integration Engineering

C. D. Rice
Program Management

Released by:

Dolores Mills 10-26-90
Data Management
ECS-SS4150

Thiokol CORPORATION
SPACE OPERATIONS
P.O. Box 707, Brigham City, UT 84302-0707 (801) 863-3511

CONTENTS

FIGURES

TABLES

APPENDICES

1.0 INTRODUCTION

All pressure seals for the Redesigned Solid Rocket Motor (RSRM) have been designed using a minimum 10 percent O-ring squeeze criteria. Government furnished SRM Ignition Initiators (SII, part number: SED26100107-301), for the Safety and Arming Device (S&A), use the 1U52296-01 or alternate 1U50228-38 O-ring as the secondary O-ring. Figure 1 illustrates the SII O-ring configuration used in the S&A assembly.

SIIs currently used in the RSRM have an actual secondary seal surface flatness variation that exceeds the allowable tolerance. As a result, the minimum squeeze on the SII secondary O-ring falls significantly below the 10 percent criteria (4.6 percent). The 1U50228-47 O-ring, with a 0.071 inch minimum cross-sectional diameter, will compensate for the excessive flatness variation and ensure the minimum 10 percent O-ring squeeze.

This report analyzes the similarity between the current 1U52296-01 or alternate 1U50228-38 O-ring and the proposed 1U50228-47 O-ring. The intent of the analysis is to qualify the 1U50228-47 O-ring to replace the current configuration SII secondary O-rings.

2.0 SUMMARY

The 1U50228-47 O-ring is fully qualified to be used as the SII secondary O-ring for the RSRM S&A based on similarity to the current configuration (1U52296-01 or 1U50228-38) O-rings. The larger minimum cross-sectional diameter will compensate for excessive SII flatness variation and ensure 10 percent minimum O-ring squeeze.

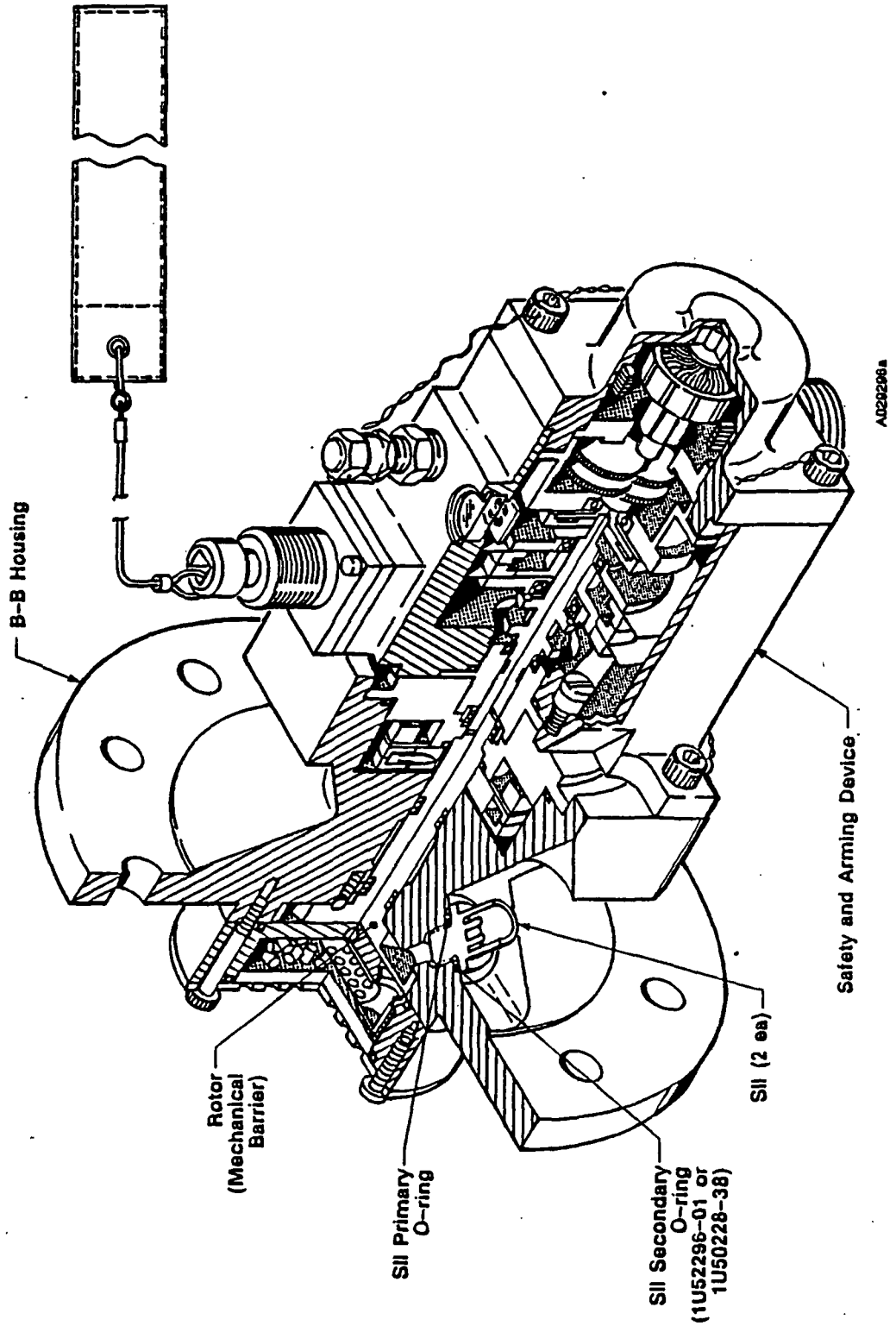


Figure 1. SII Seal Configuration

This is a short-term solution to the problem of SII flatness variation; the long-term solution is to incorporate the unibody SII which will have tighter control on the secondary seal surface flatness.

3.0 DISCUSSION

The SIIs currently available for use in the RSRM S&A have a secondary seal surface flatness variation (TIR) of 0.004 to 0.013 inch, as measured by Receiving and Inspection; this exceeds the design tolerance of 0.004 inch. (All SIIs with flatness variation exceeding 0.0079 inch have been tagged out "Use Prohibited" and will be returned to the vendor). To ensure a minimum of 10 percent squeeze on the SII secondary O-ring and compensate for the large SII flatness variation, a larger "W" diameter O-ring must be used.

The cross-sectional ("W") diameter of the current configuration (1U52296-01 or 1U50228-38) O-ring is 0.067 to 0.073 inch. The "W" diameter for the proposed (1U50228-47) O-ring is 0.071 to 0.073 inch which is the upper limit of the current tolerance. All other dimensions and properties of the 1U50228-47 O-ring are the same as those of current configuration O-rings. Table 1 shows a dimensional comparison between the two O-ring configurations.

Table 2 (compiled from Appendix A) shows a comparison between the O-ring squeeze and gland fill of the two O-ring configurations. Using the worst case "blueprint allowable" flatness variation of 0.004 inch, the minimum squeeze on the current configuration O-ring results in 10.4 percent. Using the worst case "actual" flatness variation of 0.0079 inch, the minimum squeeze on the current configuration O-ring results in 4.6 percent; the tighter "W" diameter

tolerance of the 1U50228-47 O-ring results in 10.0 percent. The minimum O-ring gland fill will increase 7.5 percent when using the 1U50228-47 O-ring.

The 1U50228-47 O-ring is a short-term solution to the SII secondary O-ring squeeze problem. The long-term solution, to incorporate a unibody SII, will eliminate the need for the larger "W" diameter O-ring since tolerances on the secondary seal surface will be more tightly controlled.

In conclusion, the 1U50228-47 O-ring has the same properties and dimensions, except for a larger minimum "W" diameter, as the current configuration O-ring, and will ensure a minimum 10 percent O-ring squeeze by compensating for the excessive SII flatness variation. The analysis has shown, by similarity, that the 1U50228-47 O-ring is fully qualified to replace the current configuration SII secondary O-rings.

TABLE 1

Dimensional Comparison of O-rings

DESIGN PARAMETERS	CURRENT	PROPOSED	EFFECTIVE CHANGE
Part Number	1U52296-01/ 1U50228-38	1U50228-47	N/A
Minimum "W" diameter, in.	0.067	0.071	Increase 0.004
Maximum "W" diameter, in.	0.073	0.073	No change
Minimum "A" diameter, in.	0.556	0.556	No Change
Maximum "A" diameter, in.	0.566	0.566	No Change

TABLE 2

O-ring Squeeze and Gland Fill Comparison

DESIGN PARAMETERS	1U52296-01/ 1U50228-38	1U50228-47	EFFECTIVE CHANGE
Initial Extrusion Gap: 0.004 inch (Worst Case: Blueprint)			
Minimum squeeze	10.4%	15.5%	5.1% increase
Maximum squeeze	29.2%	29.2%	No change
Minimum gland fill	61.6%	69.6%	8.0% increase
Maximum gland fill	100.9%	100.9%	No change
Initial Extrusion Gap: 0.0079 inch (Worst Case: Actual)			
Minimum squeeze	4.6%	10.0%	5.4% increase
Maximum squeeze	29.2%	29.2%	No change
Minimum gland fill	57.9%	65.4%	7.5% increase
Maximum gland fill	100.9%	100.9%	No change

4.0 REFERENCES

1.0 Pulleyn, D. C., TWR-15771, "O-ring squeeze and Gland Fill Calculation Method", Morton Thiokol, Inc., 8 June 1987.

2.0 St. Aubin, B. K., TWR-16682, Revision A., "O-ring Squeeze Calculations for the RSRM", Morton Thiokol, Inc., 10 September 1987.

5.0 APPLICABLE DOCUMENTS

Eden, G. S., Memo L613:FY90:538, "Acceptability for 'Flight Use' SII's and SII Secondary O-rings", Thiokol, Corp., 14 May 1990.

Eden, G. S., TWR-60175, "Seal Analysis of the SII", Thiokol, Corp., 5 September 1990.

Thiokol Drawings

1U50228	Packing, Preformed
1U52296	Packing, Preformed
1U52294	Barrier-Booster Assembly, S/A Device-Loaded
1U52295	Safety and Arming Device, Rocket Motor

APPENDIX A

Squeeze and Gland Fill Calculations

The depth of the SII port secondary O-ring groove, the cross-sectional diameter of the SII O-ring, and the flatness variation of the SII secondary seal surface are given in Table A1.

TABLE A1

SII Secondary Seal Dimensions

GROOVE	Depth: 0.052 to 0.056 in.	Width: 0.084 to 0.094 in.
O-RING	"W" Dia: 0.067 to 0.073 in.	"A" Dia: 0.556 to 0.566 in.
SII SURFACE	Flatness*: 0.000 to 0.004 in.	

* Prior to welding back-up ring and seal washer

Worst-case blueprint tolerances, instead of actual dimensions, are used to calculate the SII secondary O-ring squeeze, ensuring design limits do not violate the minimum 10 percent O-ring squeeze criteria. Worst-case conditions are the deepest O-ring groove (0.056 inch), the smallest O-ring cross-section ("W" diameter = 0.067 inch), and the maximum flatness variation (0.004 inch) on the SII secondary seal surface.

The squeeze on the SII secondary O-ring, using the worst-case conditions, results in a minimum of 10.4 percent, which is above the 10.0 percent minimum criteria. Tables A2 and A3 show the calculation results for the current 1U52296-01/1U50228-38 O-ring using the 0.004 inch and the 0.0079 inch SII flatness variations, respectively. Tables A4 and A5 show the calculation results for the proposed 1U50228-47 O-ring using the 0.004 and the 0.0079 inch SII flatness variations, respectively.

TABLE A2

CURRENT RSRM DESIGN: SII SECONDARY O-RING SQUEEZE/VOLUME FILL
(0.004 INCH MAX. FLATNESS VARIATION)

	MINIMUM	MAXIMUM	UNITS
	ASSEMBLED RESULTS		
STRETCH	0.0000	0.0000	%
STRETCH RED	0.0000	0.0000	%
TEMP ADJ DIA	0.0670	0.0734	inches
TOTAL ADJ DIA	0.0670	0.0734	inches
SQUEEZE	0.0070	0.0214	inches
SQUEEZE	10.4478	29.1796	%
FILL	61.6212	100.9340	%
	INPUT PARAMETERS		
O-RING DIA	0.0670	0.0730	inches
O-RING I.D.	0.5560	0.5660	inches
GROOVE I.D.	0.5450	0.5550	inches
GROOVE DEPTH	0.0520	0.0560	inches
GROOVE WIDTH	0.0840	0.0920	inches
TEMPERATURE	68.0000	120.0000	Deg F
INITIAL GAP	0.0000	0.0040	inches

TABLE A3

CURRENT RSRM DESIGN: SII SECONDARY O-RING SQUEEZE/VOLUME FILL
(0.0079 INCH MAX. FLATNESS VARIATION)

	MINIMUM	MAXIMUM	UNITS
	ASSEMBLED RESULTS		
STRETCH	0.0000	0.0000	%
STRETCH RED	0.0000	0.0000	%
TEMP ADJ DIA	0.0670	0.0734	inches
TOTAL ADJ DIA	0.0670	0.0734	inches
SQUEEZE	0.0031	0.0214	inches
SQUEEZE	4.6269	29.1796	%
FILL	57.8534	100.9340	%
	INPUT PARAMETERS		
O-RING DIA	0.0670	0.0730	inches
O-RING I.D.	0.5560	0.5660	inches
GROOVE I.D.	0.5450	0.5550	inches
GROOVE DEPTH	0.0520	0.0560	inches
GROOVE WIDTH	0.0840	0.0920	inches
TEMPERATURE	68.0000	120.0000	Deg F
INITIAL GAP	0.0000	0.0079	inches

TABLE A4

MODIFIED RSRM DESIGN: SII SECONDARY O-RING SQUEEZE/VOLUME FILL
(0.004 INCH MAX. FLATNESS VARIATION)

	MINIMUM	MAXIMUM	UNITS
ASSEMBLED RESULTS			
STRETCH	0.0000	0.0000	%
STRETCH RED	0.0000	0.0000	%
TEMP ADJ DIA	0.0710	0.0734	inches
TOTAL ADJ DIA	0.0710	0.0734	inches
SQUEEZE	0.0110	0.0214	inches
SQUEEZE	15.4930	29.1796	%
FILL	69.6429	100.9340	%
INPUT PARAMETERS			
O-RING DIA	0.0710	0.0730	inches
O-RING I.D.	0.5560	0.5660	inches
GROOVE I.D.	0.5450	0.5550	inches
GROOVE DEPTH	0.0520	0.0560	inches
GROOVE WIDTH	0.0840	0.0920	inches
TEMPERATURE	68.0000	120.0000	Deg F
INITIAL GAP	0.0000	0.0040	inches

TABLE A5

MODIFIED RSRM DESIGN: SII SECONDARY O-RING SQUEEZE/VOLUME FILL
(0.0079 INCH MAX. FLATNESS VARIATION)

	MINIMUM	MAXIMUM	UNITS
ASSEMBLED RESULTS			
STRETCH	0.0000	0.0000	%
STRETCH RED	0.0000	0.0000	%
TEMP ADJ DIA	0.0710	0.0734	inches
TOTAL ADJ DIA	0.0710	0.0734	inches
SQUEEZE	0.0071	0.0214	inches
SQUEEZE	10.0000	29.1796	%
FILL	65.3846	100.9340	%
INPUT PARAMETERS			
O-RING DIA	0.0710	0.0730	inches
O-RING I.D.	0.5560	0.5660	inches
GROOVE I.D.	0.5450	0.5550	inches
GROOVE DEPTH	0.0520	0.0560	inches
GROOVE WIDTH	0.0840	0.0920	inches
TEMPERATURE	68.0000	120.0000	Deg F
INITIAL GAP	0.0000	0.0079	inches

****

** NOTE-

ALL CALCULATIONS WERE PERFORMED PER REFERENCES 1 AND 2 USING THE FOLLOWING PARAMETERS (FOUR DECIMAL PLACES ARE NOT TO IMPLY MAGNITUDE OF ACCURACY, EXCEPT FOR INITIAL GAP VALUES WHICH ARE ACTUAL MEASUREMENTS):

AMBIENT TEMP	68.0 Deg F
COMP SET	0.0 %
COEF EXPANSION O-RING	0.11E-03 in./in./°F
COEF EXPANSION GROOVE	0.96E-05 in./in./°F