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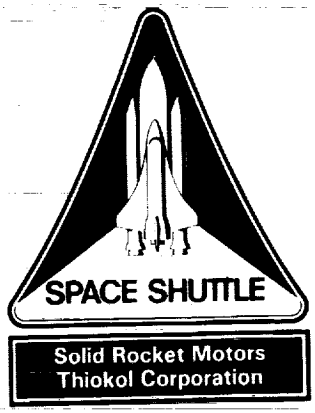

Evaluation of Newly Formulated Dow Corning 321 Dry Film Lubricant

Final Test Report

29 September 1989

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Evaluation of Newly Formulated Dow Corning 321 Dry Film Lubricant
Final Test Report

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ABSTRACT

An evaluation of the newly formulated Dow Corning 321 dry film lubricant was performed on 13 and 14 September 1989 at the Thiokol Engineering Development Laboratory, M-53. The purpose of the evaluation was to compare lubricating characteristics of Dow Corning 321 (STW4-2955, SCN No. 3) to those of Molykote 321R (STW4-2955).

Ten igniter bolts were installed and torqued on test plates using the old formulation thread lubricant (Molykote 321R), and 10 bolts were installed using the new formulation (Dow Corning 321). After bolt removal, no signs of galling were found on any of the bolts or test plate threaded holes. Average torque-load values for each formulation were very close. Test results showed there are no significant differences in lubrication abilities between Molykote 321R and Dow Corning 321.

It is recommended that, once current supplies of Molykote 321R are depleted, Dow Corning 321 dry film lubricant be used in place of Molykote 321R as a thread lubricant on redesigned solid rocket motor assemblies.

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1

INTRODUCTION

This report documents the procedures, performance, and results obtained from the evaluation of the newly formulated Dow Corning 321 dry film lubricant. The purpose of the evaluation was to compare lubricating characteristics of Dow Corning 321 (STW4-2955, SCN No. 3) to those of Molykote 321R (STW4-2955).

Molykote 321R air drying lubricant spray is currently used as a thread lubricant on various redesigned solid rocket motor (RSRM) bolted assemblies including the igniter-to-case joint, case-to-nozzle joint, and systems tunnel. For safety reasons, supplier Dow Corning Corporation recently changed the formulation of this lubricant (carcinogens were removed) and also changed the aerosol can packaging. The old formulation is no longer available. The following is a general description of the changes between old and new formulations:

a. Dow Corning 321 has the same formulation as Molykote 321R except that methylene chloride solvent (carcinogenic) has been removed and replaced with increased amounts of butyl acetate, 1,1,1-trichloroethane, propane, and butane. The comparative formulations of Molykote 321R and Dow Corning 321 are shown in Table 1.

b. The new aerosol can provides a more even spray than was provided in previous packaging.

Table 1. Aerosol Dry Film Lubricant Formulation

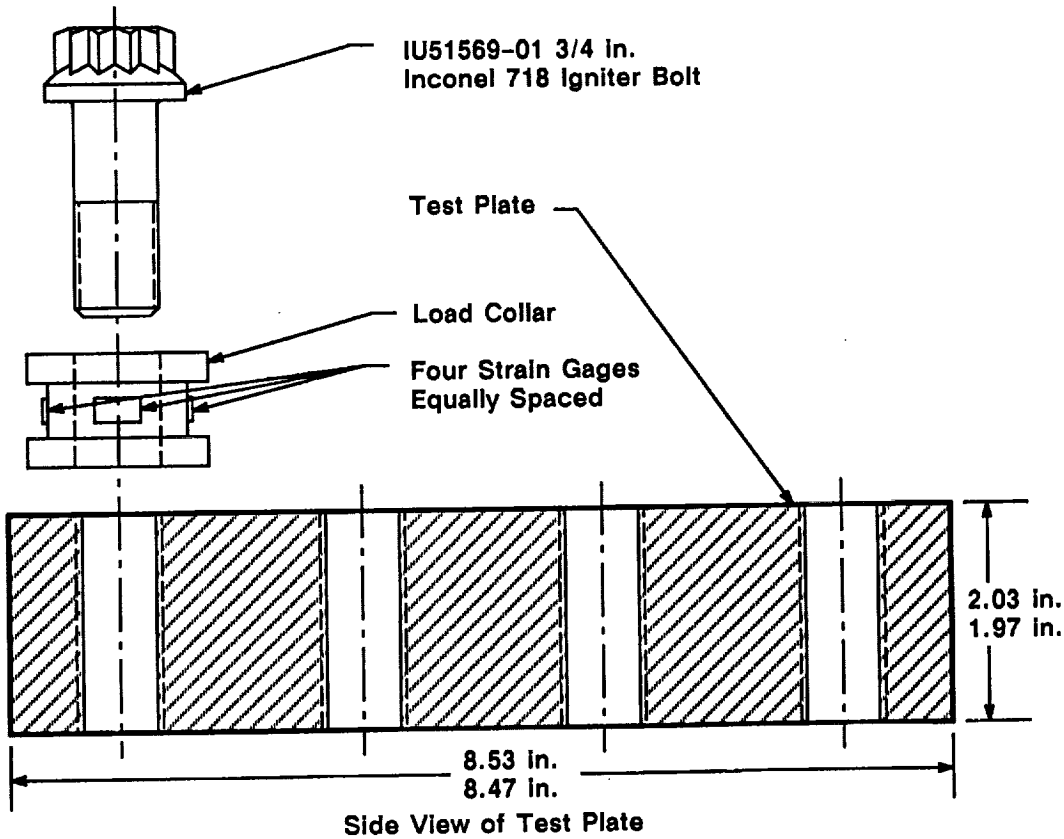
Ingredient	Dry Film Lubricant	
	Molykote 321R (percent by weight)	Dow Corning 321 (percent by weight)
Nonvolatiles	8	11
Butyl Acetate	2	9
1,1,1-trichloroethane	11	16
Methylene Chloride	44	--
Hydrocarbons	35	64
	100	100

Testing was therefore necessary to verify that the lubricating characteristics of the new formulation (Dow Corning 321) do not differ from those of the old formulation (Molykote 321R). Characteristic differences between the two formulations could affect the torque-load relationship of the bolts, thus requiring changes to the current torque values. The evaluation did not concern a specific RSRM assembly; only differences between the two formulations were investigated. Protection against galling from the new formulation was also evaluated.

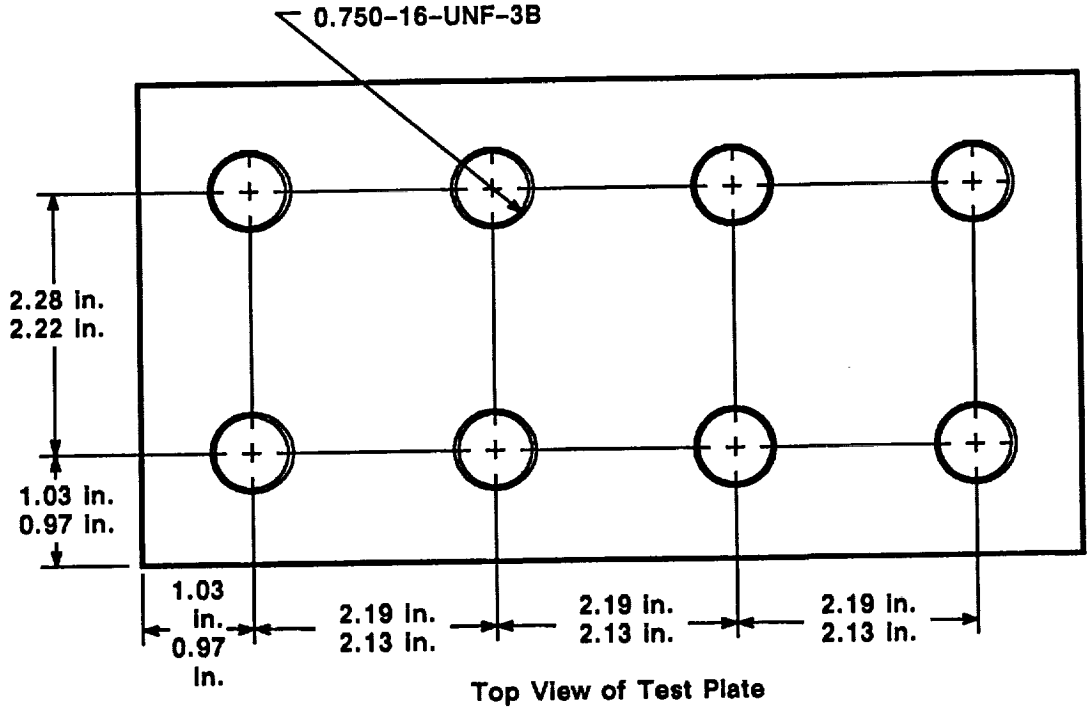
The evaluation was performed on 13 and 14 September 1989 at the Thiokol Engineering Development Laboratory, M-53. The evaluation was performed under CTP-0141, Test Plan to Evaluate the Newly Formulated Dow Corning 321 Dry Film Lubricant.

1.1 TEST ARTICLE DESCRIPTION

The test article consisted of two test plates and twenty 3/4-in. Inconel 718 igniter bolts (P/N 1U51569-01) as shown in Figure 1. The test plates were machined out of 4340 steel and heat treated to 180 to 200 ksi to resemble the RSRM case D6AC steel. Eight threaded holes were machined through the entire thickness of each plate, to allow the bolts to be run through either side without interference. The threaded holes complied with the threaded bolthole requirements of the forward case segment (1U51473), refurbished in compliance with the case refurbishment specification STW7-2744.



Side View of Test Plate



Top View of Test Plate

Figure 1. Test Article Assembly

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OBJECTIVE

The objective of test plan CTP-0141 was to evaluate lubricating characteristics of Dow Corning 321 (STW4-2955, SCN No. 3) compared with Molykote 321R (STW4-2955). The evaluation was to determine if any differences exist in the torque-load relationships between the two formulations. Also, the evaluation was to verify if galling exists with the use of Dow Corning 321.

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EXECUTIVE SUMMARY

3.1 SUMMARY

This section contains an executive summary of the key results from test data evaluation and post-test inspection. Additional information and details can be found in Section 6, Results and Discussion.

Ten igniter bolts were installed on the test plates using the old formulation thread lubricant (Molykote 321R), and 10 bolts were installed using the new formulation (Dow Corning 321). The bolts were installed, torqued, removed, and inspected one at a time. The bolts were torqued to the specified load of 55,000 ±5,000 lb in increments of 50 ft-lb.

No signs of galling were found on any of the bolts or the test plate threaded holes. Torque-load data from two bolts coated with Molykote 321R were inconsistent with the majority of the Molykote 321R data, and were not considered valid data for use in the overall comparison. Torque-load data from the newly formulated Dow Corning 321 formed a consistent group.

The average of each set of data points at a given bolt loading was plotted, and the averages of the two formulations were superimposed upon each other (results from two of the Molykote 321R-coated bolts were excluded from the comparison because they were inconsistent with the bulk of the other results). Average torque-load values for each formulation were very close.

3.2 CONCLUSIONS

Evaluation of the test data supports the conclusion that there are no significant differences in the lubricating or galling prevention abilities between Molykote 321R and Dow Corning 321.

3.3 RECOMMENDATIONS

It is recommended that, once current supplies of Molykote 321R are depleted, Dow Corning 321 dry film lubricant be used in place of Molykote 321R as a thread lubricant on RSRM assemblies.

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INSTRUMENTATION

A load collar was used to measure the load at each torque interval. The load collar was constructed from 4340 steel and heat treated to 190 ksi. The load collar utilized four equally spaced CEA-06-032UW-120 Micro-Measurements strain gages, mounted every 90 deg. Two of the gages were mounted 180 deg apart in the axial direction and two were mounted 180 deg apart in the hoop direction.

The load collar and signal conditioner were operationally verified and electrically zeroed in accordance with MIL-STD-45662 before and after each bolt evaluation. Initial calibration was performed with a Baldwin tensile tester.

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PHOTOGRAPHY

Still color photographs were taken of each bolt and bolthole before installation and after removal of each bolt. Copies of the photographs (Series No. 112789 and No. 112806) are available from the Thiokol Photographic Services department.

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RESULTS AND DISCUSSION

6.1 ASSEMBLY

The two test plates were machined out of 4340 steel and heat treated to 180 to 200 ksi to resemble the RSRM case D6AC steel (Figure 1). Eight threaded holes were machined through the entire thickness of each plate. The threaded holes complied with the threaded bolthole requirements of the forward case segment (1U51473), refurbished in compliance with the case refurbishment specification STW7-2744.

The test plates, bolts, and boltholes were cleaned with methylchloroform-soaked polywipes and cotton swabs. Each bolt and at least 20 of the boltholes were inspected, accepted, and numbered before the evaluation.

The bolt threads were sprayed with one of the two lubricants and allowed to dry for at least 30 sec. A small amount of STW5-2942 (HD-2) grease was applied to the underside of each bolt head before installation. A load collar was utilized to measure the load at each torque interval (refer to section 4.0 for additional information about the load collar). Before loading the bolts for the test, each bolt and threaded hole was exercised three times by torquing the bolt to 50 ft-lb and then backing out the bolt.

6.2 TEST

Ten of the igniter bolts were installed on the test plates using the old formulation thread lubricant (Molykote 321R), and 10 bolts were installed using the new formulation (Dow Corning 321). The bolts were installed, torqued, removed, and inspected one at a time.

Bolts with the same lubricant formulation were not installed next to each other. Each bolt and threaded hole end was used one time only. For threaded holes which had bolts tested through each end, the same lubricant formulation was used on each bolt. Sixteen bolts were installed on Block 1 (Holes 1 through 16), and four bolts were installed on Block 2 (Holes 25 through 28). The bolts were torqued to the specified load of 55,000 ±5,000 lb in increments of 50 ft-lb. Several bolts were torqued to loads slightly less than 50,000 lb, because it was predicted that they may have failed if they were tightened one more 50 ft-lb increment.

6.3 RESULTS

No signs of galling were found on any of the bolts or the test plate threaded holes.

Axial load values for each bolt were recorded for each torque increment. The results for Molykote 321R are shown in Table 2 and for Dow Corning 321 in Table 3. Results of Tables 2 and 3 are plotted in Figures 2 and 3, respectively. As shown in Figure 2, torque-load data from Bolts 6 and 7 were inconsistent with the majority of the Molykote 321R data, and were not considered valid data for use in the overall comparison. Torque-load data from the newly formulated Dow Corning 321 formed a consistent group (Figure 3).

The average of each set of data points at a given bolt loading is shown in Figure 4, and the averages of the two formulations are superimposed upon each other (results from Bolts 6 and 7 were excluded from the comparison because they were inconsistent with the bulk of the other results). As the plot shows, average values for each formulation at each bolt loading were very close.

Table 2. Molykote 321R Torque Test Results
(load in kips)

Torque	Bolt Number/Hole Number									
(ft-lb)	1/1	2/3	3/5	4/7	5/10	8/12	9/14	10/16	6/26	7/28
50	5.265	4.729	4.548	3.464	2.861	4.488	4.187	3.765	2.861	2.861
100	10.379	10.331	10.271	8.223	7.680	10.030	9.789	9.548	6.415	6.415
150	16.575	18.403	17.017	13.825	14.005	17.800	16.415	16.716	10.030	10.873
200	23.253	24.427	20.933	18.704	17.017	24.499	20.752	21.776	11.596	14.427
250	27.705	29.848	28.222	25.149	24.306	28.161	27.860	26.716	15.210	18.704
300	34.323	39.125	34.306	33.944	33.161	34.366	34.787	32.619	18.885	22.559
350	39.437	42.438	39.787	38.402	40.028	40.811	38.462	39.305	22.258	25.993
400	43.588	47.437	44.124	45.922	47.016	48.341	46.233	44.305	25.571	29.788
450	49.785	55.931	48.763	50.208	53.220	53.461	51.232	49.305	29.968	33.282
500	54.056		53.220					53.100	33.824	36.655
550									37.860	42.137
600									40.751	44.847

Table 3. Dow Corning 321 Torque Test Results
(load in kips)

Torque	Bolt Number/Hole Number									
(ft-lb)	11/2	12/4	13/6	14/8	15/9	18/11	19/13	20/15	16/25	17/27
50	6.341	5.873	3.946	4.307	3.524	3.464	3.705	4.307	3.765	3.825
100	11.943	10.933	9.307	9.849	8.584	7.439	9.729	9.729	8.524	8.343
150	17.778	18.343	17.258	17.499	14.427	15.391	18.644	18.523	14.548	15.331
200	20.125	24.246	23.824	23.945	18.885	19.427	23.101	21.535	18.644	21.595
250	27.465	31.535	32.017	33.462	25.210	25.511	32.077	30.330	23.945	28.342
300	31.435	37.920	38.161	41.715	30.390	30.691	39.546	35.992	30.390	35.571
350	36.369	43.100	43.040	46.112	35.089	35.089	47.317	43.281	33.643	40.149
400	41.783	46.594	48.883	51.473	39.607	42.016	52.919	49.004	38.823	45.148
450	46.656	51.895	60.148		44.489	46.654		53.943	43.161	49.184
500	53.635				49.907	51.534			49.305	54.786
550									52.497	

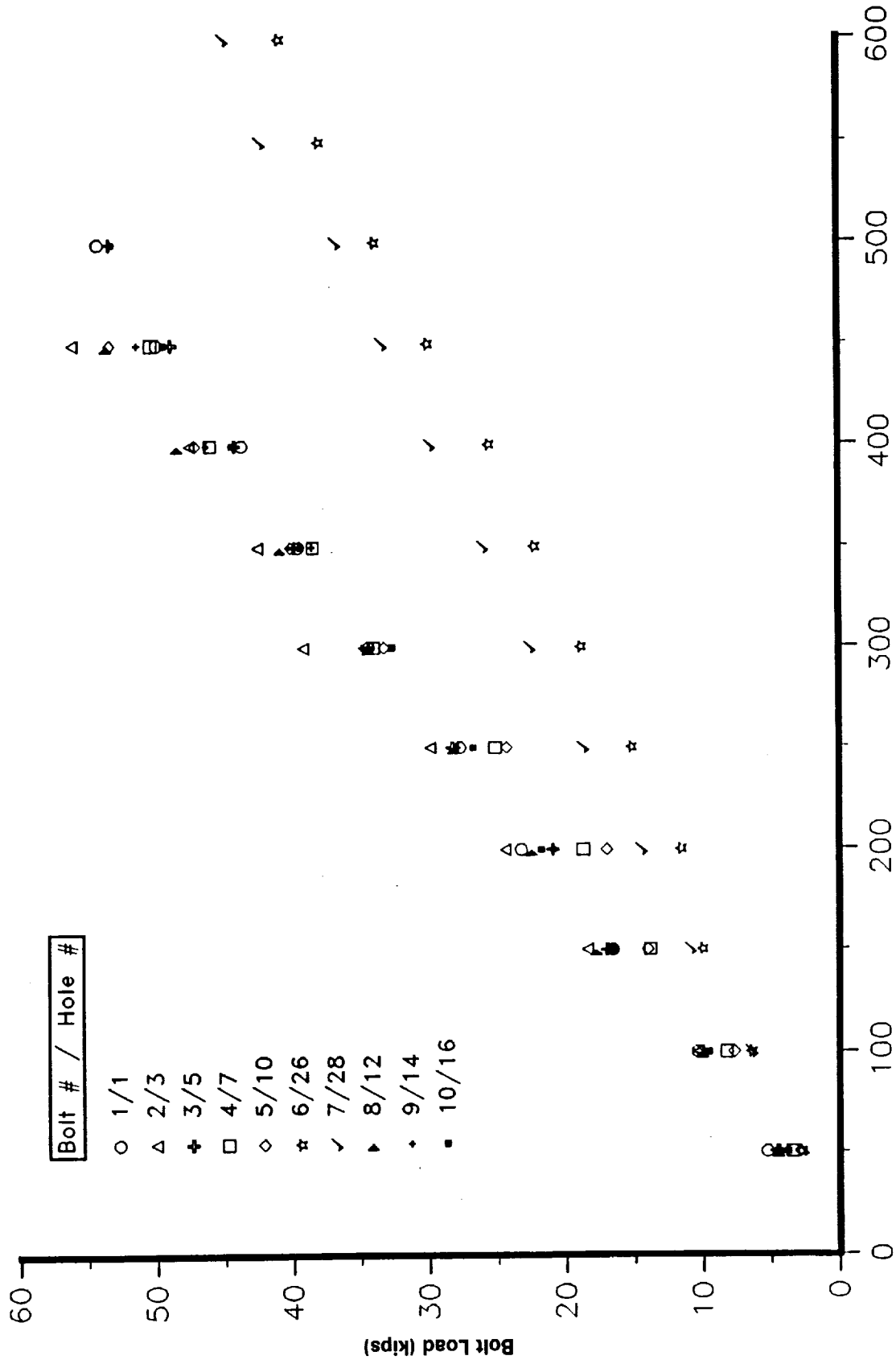

Figure 2. Molykote 321R Torque Test Results

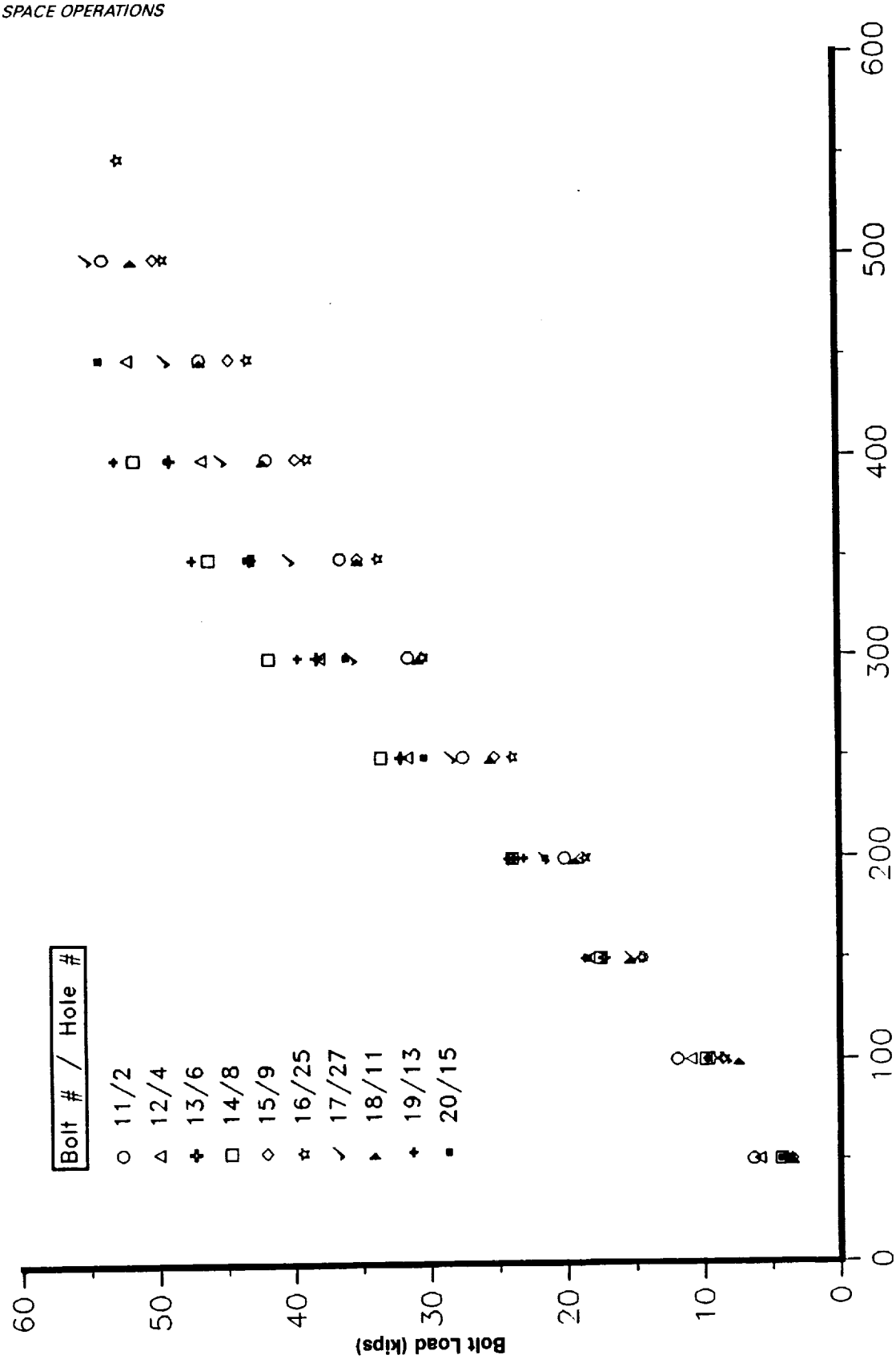

Figure 3. Dow Corning 321 Torque Test Results

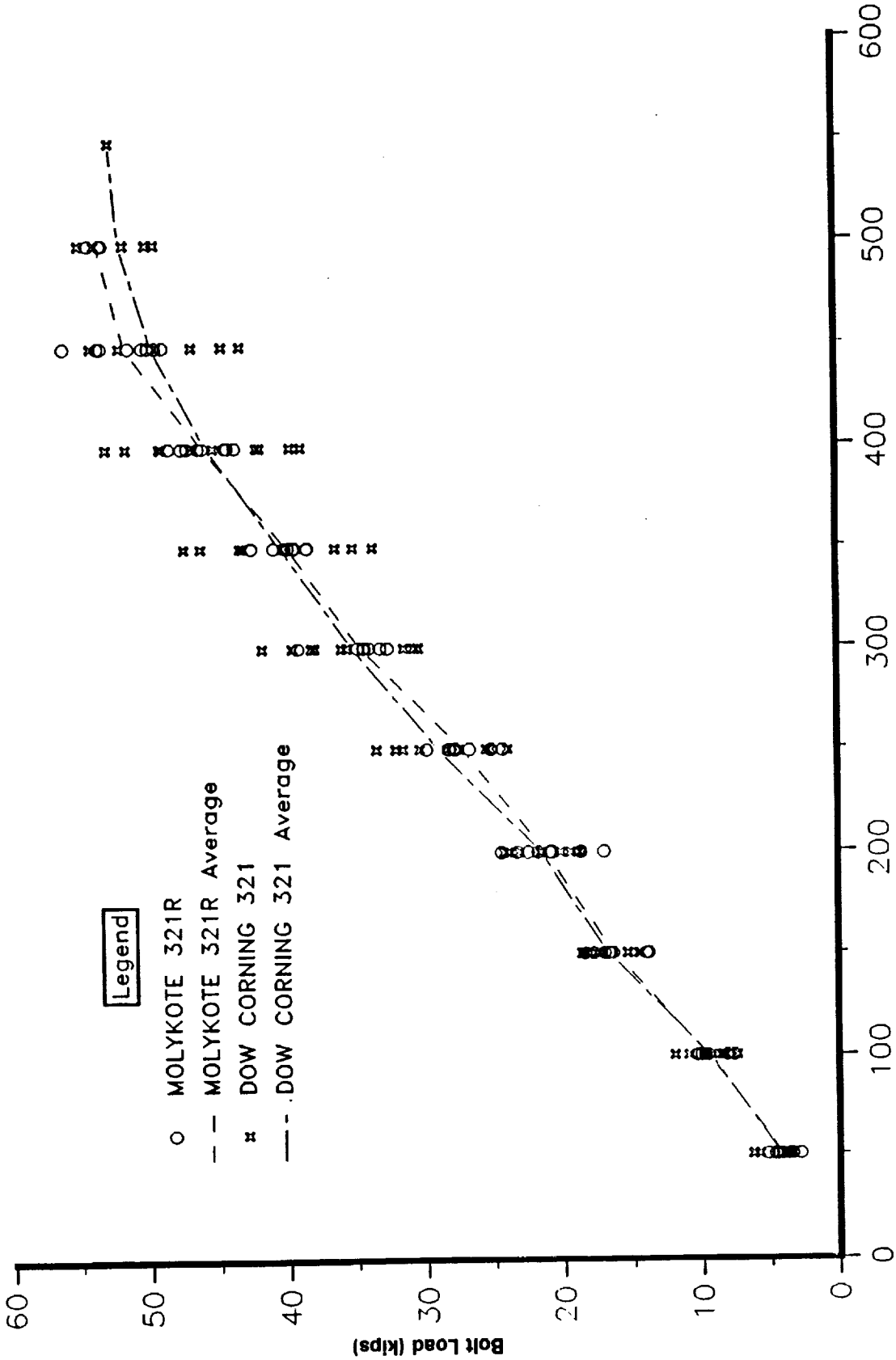

Figure 4. Molykote 321R and Dow Corning 321 Torque Test Results Comparison (data from Bolts 6 and 7 excluded)

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APPLICABLE DOCUMENTS

Document No.	Title
CTP-0141	Test Plan to Evaluate the Newly Formulated Dow Corning 321 Dry Film Lubricant
STW7-2744	Acceptance Criteria, Refurbished Case, Space Shuttle SRM
STW5-2942	Corrosion Preventative Compound and O-ring Lubricant
STW4-2955	Lubricant System, Air Drying (Molykote 321R bonded lubricant spray)
Military Standards	
MIL-STD-45662	Calibration System Requirements
Drawing No.	
1U51473	Case Segment, Forward
1U51569	Bolt, Machine

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