

PHASE I

**SPACE STATION** LONG TERM **LUBRICATION** ANALYSIS PHASE I PRELIMINARY **TRIBOLOGICAL SURVEY** 

То

GEORGE C. MARSHALL SPACE FLIGHT

CENTER

MARSHALL SPACE FLIGHT CENTER,

ALABAMA

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P.O. Box 8757				
Airport, Maryland 21240	···· ·····			
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E.E. Montgomery				
SRS Technologies				
990 Explorer Blvd. N.W.				
Cummings Research Park West				•
Huntsville, AL 35808				
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### PHASE I REPORT

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### GEORGE C. MARSHALL SPACE FLIGHT CENTER Marshall Space Flight Center, Alabama 35812

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September 21, 1990

by

K.F. Dufrane, J.W. Kannel, and J.A. Lowry

BATTELLE

505 King Avenue Columbus, Ohio 43201

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E.E. Montgomery SRS Technologies 990 Explorer Blvd., NW Huntsville, AL 35806

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### INTRODUCTION

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Increases in the size, complexity, and life requirements of satellites and space vehicles have put increasing demands on the lubrication requirements for troublefree service. Since the development costs of large systems are high, long lives with minimum maintenance are dictated. The Space Station represents the latest level of size and complexity in satellite development; it will be nearly 100 meters in major dimensions and will have a life requirement of thirty years. It will have numerous mechanisms critical to its success, some of which will be exposed to the space environment. Designing long-life lubrication systems and choosing appropriate lubricants for these systems will be necessary for their meeting the requirements and for avoiding failures with associated dependent mechanisms. The purpose of this program was to identify the various critical mechanisms and review their designs during the overall design and development stage so that problem areas could be avoided or minimized prior to the fabrication of hardware.

The specific objectives were fourfold:

(1) To perform a tribology survey of the Space Station for the purpose of documenting each wear point as to materials involved, environmental conditions, and operating characteristics.

- (2) To review each wear point (point of relative motion) as to the lubrication used and substrate materials selected in the context of its operating characteristics and the environmental conditions imposed.
- (3) To make recommendations for improvement in areas where the lubricant chosen and/or where the substrate (materials of the wear couple) are not considered optimum for the application.
- (4) To make or recommend simulated or full scale tests in tribological areas where the state-of-the-art is being advanced, in areas where new designs are obviously being employed and a critical review would indicate that problems are a strong possibility, and/or where excessive wear, a malfunction, or excessive leakage

would create fluid systems problems or contamination of exposed optical equipment.

The contract, which was initiated on June 24, 1985, was originally to be conducted in two Phases over a three-year period. Phase I was a preliminary tribological survey of the Space Station structure, systems, and equipment and a forecast of probable problem areas. Phase II was to be a detailed tribological survey to be conducted in concert with the maturing design. Because of the lack of availability of detailed design data and of repeated scheduling and funding delays with the overall Space Station program, the detailed tribological survey of Phase II was not initiated in January, 1987, which would have been in accordance with the original schedule. Instead, the program was halted until April, 1990, when the overall scope was modified and the program was reinstated. The modified scope has included three phases.

Phase I. Preliminary Tribology Survey, Preliminary Assessment, and Forecast of Probable Problem Areas.

> The Phase I activities were conducted in accordance with the original program scope and were essentially completed by early 1987. This report summarizes the Phase I activities.

Phase II.

Lubrication Evaluation of the Alpha and Beta joints.

The Phase I efforts have identified the alpha and beta joints as critical and potentially problem-prone because of their size, service life requirements, and lack of previous comparable experience. Phase II

Phase II. will consist of a review of these joints. The intent is to evaluate whether alpha and beta joints of the current (cont.) design (incorporating reasonable modifications if found necessary) are likely to meet the requirements of consistent torque and outgassing specifications for a service life of 25 years. The review will include the lubrication methodology (grease, transfer films, or solid films) and the trade-offs considered in arriving at the methodology (maintenance intervals, outgassing, seals, friction levels, and debris generation). In addition, a review will be made of the tests already performed in support of the design and those specified for future evaluations. The results of the review, including an evaluation of the current design and recommendations for modifications or needed tests, will be documented in the Phase II section of the final report.

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Phase III. Lubricant Selection Guide

Phase III will consist of preparation of a practical lubricant selection guide for use by designers of Space Station components. While the potentially available liquid and dry-film lubricants number in the hundreds, a large percentage are not practical for Space Station components because of such factors as outgassing properties, creep properties, viscosity, long-term stability, corrosive properties, or wear protection. The purpose of the Phase III effort will be to reduce the number of lubricants to a practical

working number for designers to consider. Guides will be given for the selection of specific lubricants from the recommended list. The design guide will be incorporated in the final report.

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This report is to document the Phase I activities. It describes the general Space Station requirements that will affect lubrication and the basic lubrication approaches available to address these requirements. The report by SRS Technologies, a major subcontractor on Phase I, is included in its entirety as Appendix A. SRS Technologies had responsibility for documenting the Space Station components and mechanisms regarding lubrication requirements.

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## SUMMARY

The Phase I activities began with a review of the various work packages of the primary contractors to identify tribological points of interest (SRS Technologies) and a review of pertinent literature to identify likely lubricants for use in the tribological applications (Battelle). As details of the various tribological points were identified, Battelle was to perform a review to assess the likelihood of success. Difficulties were encountered in attaining the needed design details because of the early stage of the design (details on loads and sizes were not available) and because of overall program delays. Consequently, a comprehensive review could not be made of most of the 72 specific components identified in the survey of 14 target projects. Of these, the most critical by far were the alpha and beta joints because of their size, lack of prior history, and their criticability to the Space Station. Since a change was made in contractors for these joints from the time the Phase I survey was conducted, the detailed design information obtained in the survey was useful only in a general sense. Because of the importance of these joints, the modified scope for the Phase II activities of the program concentrates specifically on these joints.

The literature review identified papers, reports, and books dealing with developments in lubricants for aerospace mechanisms. Recent advances in solid lubricants have involved the additions of antimony and antimony compounds to improve the friction and wear properties of bonded molybdenum disulfide solid lubricants. The selection criteria are based on the longevity needed and the possible deterioration of the binder from exposure to the space environment. Of the various candidate liquid (and grease) lubricants, the perfluoro ethers have come to dominate the field because of their low vapor pressure and acceptable lubricating properties. Friction and wear data and flight history data are available to assist in the selection and application of the perfluoro ethers. The Lubricant Selection Guide of Phase III will detail the specific preferred lubricants for example families of tribological contacts and provide data on advantages, disadvantages, and life-limiting considerations for their application.

### SPACE STATION LUBRICATION REQUIREMENTS

The combination of size, complexity, and desired life of the Space Station is unprecedented in satellite design. As shown in Figure 1, the overall layout of the Space Station includes a central module that will be held in alignment to the surface of the earth. Large solar panels to provide power will be attached through "alpha" and "beta" joints to permit orienting the panels toward the sun. The size of the joints (approximately 3 meters in diameter for the bearing at the alpha joint) and associated structure demands that these bearings be capable of operation for the intended thirty year life. Changing the bearings would require major unacceptable provisions for astronaut time and for restraining the panel assembly. Inherent reliability of the bearing and lubrication systems for these large structures is therefore required.

The thirty year life will also expose components to 175,000 thermal cycles. The range of these cycles will be controlled primarily by the optical properties of the surfaces involved unless active thermal control is provided. Thermal cycles can affect lubricants in several ways. For liquid lubricants, the immediate effect is a change in viscosity. If the lower temperature extreme is below the pour point of the

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liquid, it may be unable to reach the critical surfaces in the bearing or mechanism needing lubrication. Similarly, the high temperature extreme may lower the viscosity to a level where the lubricant cannot function properly. High temperatures can also degrade the lubricant through a variety of thermal degradation mechanisms. While dry film (solid) lubricants are relatively unaffected by temperature cycles, the binding agent must be chosen appropriately to avoid thermal degradation at the upper temperatures.

The thirty year life requirement introduces time-related lubrication degradation mechanisms, which must also be considered. Evaporation, creep, and degradation by atomic oxygen all represent potential problems that must be addressed in the design of mechanisms and selection of lubricants. Evaporation and creep of liquid lubricants present the dual problems of lubricant loss at the needed surface and of potential contamination of optical surfaces by the lost lubricant. These problems are controlled primarily by the basic chemical composition of the lubricant. Atomic oxygen, however, presents a new challenge for spacecraft design in that a variety of organic materials are attacked. Experiments on two Space Shuttle missions, Space Transportation Systems 5 and 8 (STS-5 and STS-8), provided data that showed materials containing carbon, silver, and osmium react with atomic oxygen to form volatile oxides<sup>(1)</sup>. Table 1 lists the reaction efficiencies for a representative set of materials<sup>(2)</sup>. Because of the reactions with organic materials, liquid lubricants and dry film lubricants having organic binders must be protected from exposure or selected with a knowledge that continual degradation will occur. In the case of thin solid films using an epoxy-based binder, exposure to atomic oxygen may degrade the binder in a matter of days<sup>(2)</sup>. For practical systems requiring exposure, therefore, inorganic binders, such as silicates, may be required to avoid the problem.

ATOMIC OXYGEN I	N LOW EARTH ORBIT (REFERENCE 2)
Material	Reaction Efficiency, 10 <sup>-24</sup> cm <sup>3</sup> /atom
Kapton	3
Mylar	3.4
Tedlar	3.2
Polyethylene	3.7
Polysulfone	2.4
Graphite/epoxy	
1034C	2.1
5208/T300	2.6
Ероху	1.7
Silicones	< 0.02*
White paint A276	0.3 to 0.4*
Black paint Z302	2.3*
Perfluorinated polymers	
Teflon, TFE	< 0.05
Teflon, FEP	< 0.05
Carbon (various forms)	0.9 to 1.7
Silver (various forms)	Heavily attacked

TABLE 1. REACTION EFFICIENCIES OF SELECTED MATERIALS WITH

\*Units of mg/cm<sup>2</sup> for STS-8 mission. Loss is assumed to occur in early part of exposure; therefore, no assessment of efficiency can be made.

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### Lubricant Considerations

Lubricants can be divided into two basic classes: solid films and liquids. Both types have been used extensively in space applications. Both have advantages and disadvantages that must be carefully considered in their selection. The factors of particular importance for Space Station lubrication are considered in this section.

### Solid Film Lubrication

### **Advantages and Disadvantages**

From Reference 3, the following lists the basic advantages and disadvantages of solid film lubricants.

### **Advantages of Solid Lubricants**

- 1. Do not collect grit.
- 2. Can be used under extremely high load conditions.
- 3. Excellent storage stability.
- 4. LOX and oxygen compatible (inorganically bonded films).
- 5. Suitable for use over wide temperature range.
- 6. Resistent to the effects of nuclear and gamma radiation.
- 7. No disposal problem.
- 8. Friction decreases with increasing load.
- 9. In some applications solid films will provide lubrication for the life of the parts.

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### **Disadvantages of Solid Lubricants**

1. Limited amount of lubricant available.

2. Friction coefficient higher than with hydrodynamic lubrication.

- 3. Provisions for the effective removal of wear debris must be provided.
- 4. Considerations must be given to removing heat from contact zone of bearings and gears when using solid film lubricants.
- 5. More expensive (costly relubrication).
- 6. Avoidance of contamination during coating processes and assembly of parts lubricated with solid film lubricants.
- 7. Elevated temperature cure cycle of some solid films will damage the mechanical properties of some materials.

### Selection of Solid Lubricants

Solid lubricants provide capabilities unavailable with liquid lubricants, but they are not a universal lubricant. The requirements of some applications prevent their use entirely. Also, there is no single solid lubricant that will meet all of the requirements. Therefore, the selection of the basic class of lubricant (solid or liquid) and the specific lubricant must consider the needs of the particular application and the requirements of the system of which the application is a part.

The obvious advantages of solid films are that they add virtually no weight to the system and create virtually no problems due to outgassing. The primary disadvantages of solid films are that they have limited life and are very difficult to replenish.

The three basic solid film lubricants that have traditionally been given the most attention and used most extensively are:

- Graphite,
- Polytetrafluorethelene (PTFE), and
- Molybdenum disulfide (MoS<sub>2</sub>).

Table  $2^{(4)}$  lists several bonded films and application methods. Recent work in solid films has involved some compositional variations in these lubricants primarily to

TABLE 2.	BONDED SOLID FILM LUBRICAN	VTS (REFERENCE 4)
Mater	rials	
Binder	Additives	Application Method
Polyimide	$MoS_2 + Sb_20_3$	Sprayed, then heat-cured 1 hr. at 200 F, followed by 1 hr. at 575 F.
Polybenzothiazole	$MoS_2 + Sb_20_3$	Sprayed, then heat-cured 1 hr. at 200 F, followed by 1 hr. at 600 F.
Polybenzimidazole	$MoS_2 + Sb_20_3 + Zn0$	Sprayed, then heat-cured 1 hr. at 200 F, followed by 1 hr. at 575 F.
Methylphenylsilicone	$MoS_2 + Sb_20_3$	Sprayed, then cured at room temperature for 24 hours
Sodium silicate	MoS <sub>2</sub> + graphite + Au	Sprayed, then heat-cured 2 hrs. at 180 F, followed by 2-16 hrs. at 400 F.
Aluminum phosphate	$MoSe_2 + TaS_2 + graphite$	Sprayed, then heat-cured 1 hr. at 150 F, 2 hrs. at 200 F, 8 hrs. at 400 F.
Aluminum phosphate	BaF <sub>2</sub> :CaF <sub>2</sub>	Sprayed, then heat-cured 1 hr. at 95 C, 200 C, 300 C, 1 hr. at 800-1100 C.
Polybenzimidazole	MoS <sub>2</sub> + Sb <sub>2</sub> 0 <sub>3</sub> + prefused fluorides	Sprayed, then heat-cured 1 hr. at 95 C, 200 C, 300 C, 1 hr. at 800-1100 C.

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achieve improved wear life and possibly reduced friction.

Bartz, Holeniski, and Xu<sup>(5)</sup> indicate that there exists optimum concentrations for  $MoS_2$  doped with materials such as graphite and antimony compounds to yield longer wear life than attainable with single components. A comparison of wear lives as obtained in rub block experiments is given in Table 3, and the friction coefficients are presented in Table 4. Table 5 shows the test conditions. Wear lives of 100,000 cycles are possible with this approach, which should be adequate for many components of Space Station. While graphite is probably inappropriate for vacuum service. Bartz research indicates that solid films exist that should provide good service life.

Fleshauer<sup>(6)</sup> is doing extensive work in evaluation of solid films, especially  $MoS_2$  formulations. Table 6 summarizes the wear lives obtained with three different contact conditions. The pin-on-disk tests were run at a load of 700 MPa. The results have shown that the wear life can be increased significantly if the  $MoS_2$  is doped with antimony. Again, a wear life of  $10^5$  cycles is shown to be possible.

### **Rolling Contacts**

Friction in rolling contact can be lower with solid films than with grease lubrication. Todd and Bentall<sup>(7)</sup> present data (Figure 2) that illustrate this effect. Table 7 summarizes data for solid lubricated ball bearings<sup>(7)</sup>. In some ball bearings, it is possible to extend the coating life by using transfer film technology<sup>(8,9)</sup>. In this technology the solid film is transferred from the bearing cage to the ball and races. The cage in essence is then the lubricant supply. Transfer film technology represents a good approach for extending the life of space bearings beyond that attained with solid lubricant coatings.

A summary of examples of successful applications of solid film lubricants to cams, gears, and bearings in spacecraft<sup>(10,11)</sup> is given in Table 8.

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TABLE 3. WEAR L	IFE OF SOLID FILMS (F	REFERENCE 5)
Material	K Cycles 980 N (500 min <sup>-1</sup> )	980 N (1000 min <sup>-1</sup> )
MoS <sub>2</sub>	50	< 10
Graphite	< 10	<5
Sb(SbS <sub>4</sub> )		
$MoS_2 + Sb(SbS_4)$	140	40
Graphite + $Sb(SbS_4)$	20	10
$MoS_2 + Graphite$	200	75
$MoS_2 + Graphite + Sb(SbS_4)$	500	100
Bonded Solid Lubricant	200	50

TAI	BLE 4. STABL	E FRICTION	COEFFICIEN	r (referenc	E 5)
			Lubr	icant	
Load N	Speed min <sup>-1</sup>	Graphite	CSb-B	MoS <sub>2</sub>	MSb-B
245	500	none	0.14-0.15	0.03-0.05	0.02-0.04
980	- 500	none	none	0.05	0.01-0.03
1470	500	none	none	none	none

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TABLE 5. EXPERIMENTAL IN TABLES 3 AN	. CONDITIONS FOR DATA ID 4 (REFERENCE 5)
Ring	
outer diameter: material: hardness: roughness of surface after	0.47 mm 100 CrMn6 steel HRC 60
sandblasting:	12 μm CLA
Block	
dimensions: material: hardness: roughness of surface:	24 x 15 x 6 90 MnCrV8 steel HRC 54 1.6 μm CLA

# TABLE 6. WEAR TEST RESULTS FOR MoS2 FILMS(500 - 1000 nm THICK) FROM DIFFERENTLABORATORIES (REFERENCE 6)

Wea	r Life, Thousands of Revolu	tions
Pin-On-Disk	Dual-Rub-Shoe	Thrust-Washer
201	19ª	600-700
	55°	800
156	60 <sup>b</sup>	300
45	35 K <sup>a</sup>	900

"Tested in air; <sup>b</sup>Air or vacuum; <sup>c</sup>Vacuum

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FIGURE 2. COMPARISON OF BALL BEARING OPERATING TORQUES SHOWING THAT SOLID FILM LUBRICATION CAN PRODUCE LOWER TORQUES THAN OBTAINED WITH LIQUIDS (REFERENCE 7)

Method of Lubrication	Preload (N)	Cumulative time at	Torque ( to ose	N-m x 10 <sup>-4</sup> ) cillation	Remarks
		100 rpm (min)	Average (±)	Peak-Peak	
PTFE/MoS <sub>2</sub> / glass fiber cage, degreased races and balls	40	0 30 60	21 25 57	76 98 147	Progressive torque increase
MoS <sub>2</sub> -coated raceways, Phenolic cage	100	0 5 15 30 60 74	34.5 31.5 42 45 39	148 156 246 282 168	Smooth start } trace } developing } spikes
			failed to	by excess orque	
IP lead on raceways, lead bronze cage	100	0 5 15 35 60 240	50 45 45 45 45 failed to	320 132 120 135 180 by excess orque	Spikes during run-in } very smooth } stable } torque traces

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TABI	JE 8. SUMMARY	of solid	FILM APPLICATION	IS FOR SPACECRAFT	(REFERENCE 10	), 11)
Spacecraft	Item	Pitch	Material	Part Coated	Lubricant	Thickness (mm)
TRIAD	Gear Box Gears	48	Corrosion Resistent	Gear teeth	Coating No. 2	0.005-0.0127
	Worm	48	Corrosion Resistent steel	Gear teeth	Coating No. 2	0.005-0.0127
	Worm gear	48	Bronze	Gear teeth	Coating No. 1	0.0127-0.0254
	Miter gears	48	Titanium	Gear teeth	Coating No. 1	0.0127-0.0254
	Miter gears Thrust bearing	4 <del>8</del> 1	Aluminum Corrosion Resistent	Cear teeth Ball Raceways	Coating No. 1 Sputtered MoS <sub>2</sub>	0.0015/-0.024 0.0015
			steel		Continue Mont	
	ball bearings	1	corrosion resistent steel	Inner race Outer race	COMILING INO. 1	+c70.0-1710.0
				Retainer		
APOLLO 17	U.V. Spectrometer	1		Cam	Coating No. 2	> 0.0076
	wavelengui cam	1 1	52100 steel 52100 steel	Drive motor R6 bearings Follower R.8 bearings	Coating No. 1 Coating No. 1	•
SAS-C	Worm	48	Corrosion Resistent steel	Gear teeth	Coating No. 2	0.005-0.127
	Worm gear	48	Bronze	Gear teeth	Coating No. 2	0.005-0.0127
	Bearings	I	Corrosion Resistent	Inner race	Coating No. 1	0.0127-0.0254
			steel	Outer race Retainer		
	Spur gear	48	Corrosion Resistent	Gear teeth	Coating No. 2	0.005-0.0127
	Spur gear	48	Aluminum	Gear teeth	Coating No. 1	0.0127-0.0254

Spacecraft Applications of Bonded Coatings<sup>(8)</sup>

Coating No. 1. Molybdenum disulfide, graphite, gold, sodium silicate. Coating No. 2. Molybdenum disulfide, antimony trioxide, polyimide. الجب

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### Liquid/Grease Lubrication

### Advantages and Disadvantages

The primary advantage obtained with liquid lubricants is that bearing surfaces separated by hydrodynamic films of liquid lubricants have virtually no wear and thereby have the potential for indefinite lives. Liquid lubricants provide the viscosity needed for forming the hydrodynamic films, low shear strengths for low friction, cooling capability in recirculating systems, and the ability to minimize wear in low-speed (nonhydrodynamic) situations. Since no single lubricant can meet the often conflicting requirements of various applications for liquids, hundreds of specialty lubricants have been developed for aerospace applications<sup>(3)</sup>. The primary disadvantages of liquid lubricants are the need for containment, the propensity to creep, large changes in viscosity with temperature, and loss by evaporation under vacuum conditions. The use of thickeners to form greases provides a means of retaining the liquids in the needed region, thereby addressing one of the primary disadvantages. Greases are widely used for aerospace lubricants. The loss by evaporation greatly restricts the available liquids for vacuum applications to the few chemical species having low vapor pressures. The following sections consider the evaporation rates and the lubricating performance of liquids (and greases based on these liquids) in bearing applications.

### Thermo-Vacuum Evaporation

The evaporation rate of lubricants in a vacuum is a function of their molecular weight, their vapor pressure, and the temperature. The Langmiur expression<sup>(12)</sup> relates these factors and permits predicting the loss rate when the vapor pressure and temperature are known:

$$R_{evap} = \frac{P}{17.14} \left(\frac{M}{T}\right)^{1/2}$$

where,

P = vapor pressure (mm of Hg), M = molecular weight, and T = temperature of lubricant (°K).

The vapor pressure is strongly dependent on temperature, as shown for a perfluoro ether in Figure  $3^{(2)}$ . Perfluoro ethers are among the fluids having the lowest vapor pressures and are leading candidates for satellite applications exposed to vacuum. At the top of Figure 3 is the time predicted to evaporate a film 2.5 x  $10^{-4}$  cm (100 microinches) thick in accordance with the Langmiur expression. With this strong temperature dependence, two conclusions are drawn:

1. The temperature of lubricant films exposed to vacuum must be controlled to retain the lubricant.

2. Provisions must be made for the reapplication of lubricant if temperature cannot be controlled to acceptable levels.

The chemical composition of a lubricant and its molecular weight are the dominating factors in determining the resulting vapor pressures and loss rates. For vacuum applications, silicones and perfluoro ethers have lower loss rates by 4 to 5



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orders of magnitude compared with mineral oils (hydrocarbons) or diesters<sup>(13)</sup>. On the basis of loss rates by evaporation, the selection of lubricants is limited to the perfluoro ethers or silicones -- both from the standpoint of retaining the lubricant on the bearing surfaces where they are needed and of preventing contamination of optical systems by condensation of the evaporated lubricant. As discussed in the next section, the wear performance of the various lubricants combined with the creep behavior of silicones further limits the practical choice to the perfluoro ether fluids.

### Friction and Wear Performance

Among the many properties provided by liquid lubricants for bearing applications, the ability to generate hydrodynamic films to separate the surfaces in relative motion and the ability to maintain low wear rates if the operating conditions prevent film formation are two of the most important properties. Film formation capabilities are largely determined by the viscosity, which is generally high in fluids selected to have low evaporation rates. Therefore, the ability to lubricate under very thin film (boundary) conditions is the performance property of interest.

Table 9 presents a summary of comparison data obtained from LFW-1 ringon-block tests with various lubricants and 440C rings and blocks<sup>(14)</sup>. Of particular interest is the performance of the perfluoro ether (Krytox 143AB oil and Krytox 240AB grease) relative to the silicones, mineral oil, and diesters. No instances of galling were observed with the perfluoro ethers, but several instances of galling were encountered with the silicones, diesters, and mineral oils. Although the lowest wear was measured with the FS1265 silicones, its viscosity was also the highest, which may have influenced the results. The wear with the perfluoro ether was less than that measured with the mineral oils and was considered acceptable since no instances of galling occurred. As shown in Table 10, similar results were obtained in slow-speed sliding tests using a ball-on-flat geometry<sup>(15)</sup>. The perfluoro ether (Fomblin Z25) had a friction coefficient tying the lowest of the five and a specific wear rate only slightly

Scar Width (mm) 1.52<sup>b</sup> 1.52<sup>b</sup> 0.76<sup>b</sup> (mm) 0.76 1.78 2.03 TABLE 9. COMPARISON OF VARIOUS LUBRICANTS BASED ON WEAR OF 440C BLOCKS  $> 1 \times 10^{3}$  $> 1 \times 10^{3}$  $> 1 \times 10^{3}$ Revs (K)<sup>a</sup>  $10.4^{\rm b}$ 30.8<sup>b</sup> IN LFW-1 RING-ON-BLOCK TESTS (FROM REFERENCE 14) Viscosity (cs at °C) 300/25 49/25 27/38 85/38 52/38 Methylchlorophenylsilicone Methylalkylpolysiloxane Perfluoralkylpolyether Type Fluorosilicone Mineral Diester **Common Name** Versilube F50 Krytox143AB FS1265 SRG40 L245-x SF1147

a. Revolutions to reach friction coefficient of 0.33 at 667N (150 lb) load, in thousands. b. Test terminated because of galling; scar width at time of galling

 $> 1 \times 10^3$ 2.1<sup>b</sup> 20/25 15/38 Diester + 5% TCP

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1.27<sup>b</sup>

1.27

 $> 1 \times 10^{3}$ 

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Perfluoroalkylpolyether

Krytox 240AB

Andok-C

P-10

Grease

Mineral Oil Grease

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40.8<sup>b</sup>

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TABLE 10. FRIC DISK	CTION AND WEAR (S IN PRESENCE O	RESULTS WITH EN31 STEEL	BALLS SLIDING O NTS (REFERENCE	N EN31 STEEL 15)
Lubricant	Vapour Pressure at 20° C (torr)	Description and Comments	Mean Friction Coefficient	Specific Wear Rate (m <sup>3</sup> /Nm x 10 <sup>-15</sup> )
Apiezon C	4 x 10 <sup>-9</sup>	Mineral oil with no additives. Used as a reference oil	0.20	0.93
BP 135	7.9 x 10 <sup>-9</sup>	Synthetic, tri-ester base. Boundary lubricant and anti-oxidant additives.	0.12	1.04
BP 110	3.7 х 10 <sup>-8</sup>	Mineral oil base, high viscosity. Refined to give low vapour pressure. Boundary lubricant additives.	0.13	0.41
KG80	< 10 <sup>-8</sup>	Petroleum base with boundary lubricant additive, Tricresyl- phosphate. Also anti-oxidant.	0.13	0.69
Fomblin 225	< 5 x 10 <sup>-12</sup>	Synthetic fluorinated oil. High density, low surface tension. High temperature/viscosity index. No boundary lubricant additives.	0.12	0.49

Notes:

EN31 is equivalent to 52100 steel.
Total load on three balls was 4N.
Sliding speed was 3 x 10<sup>-3</sup> m/s.

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higher than the lowest recorded (a mineral oil with boundary lubricant additives). Based on friction and wear results such as these, a much lower propensity to creep, and satisfactory flight experience, the perfluoro ethers have displaced the silicones in spacecraft applications<sup>(16)</sup>.

Besides the Krytox and Fomblin fluids, the Bray Oil Co. has produced a series of lubricants by further distilling and refining the Fomblin fluid base stock to produce Bray 815Z oil and 3L38RP grease, which have had flight experience in spacecraft mechanisms. The products are now available through the Bray Products Division of Burmah-Castrol, Inc. Braycote 601 is the new designation for the 3L38RP grease.

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### **IDENTIFICATION OF SPECIFIC TRIBOLOGICAL COMPONENTS**

SRS Technologies, as a major subcontractor on the Space Station Long Term Lubrication Analysis program, undertook the effort to identify the specific wear/bearing points in the overall Space Station and obtain design information to permit a review from a tribology standpoint. From the relatively broad range of assemblies, components, and mechanisms, a group of 14 target projects were identified as being likely to contain wear points of interest. A listing of these 14 target projects is presented in Table 11. A discussion of the efforts to attain detailed design data are presented on pages 22 through 29 of the SRS Technologies report in Appendix A. Specific tribological components identified in the survey are summarized in Table 2, pages 35 through 39 of the SRS Technologies report. While 72 specific components were identified, insufficient details were available at the time the survey was done to permit a review of their likely performance.

While sufficient design details were not forthcoming, the survey clearly identified the large alpha and beta joints to be critical components without comparable prior flight performance. Therefore, the bearings comprising these joints are worthy of more detailed examination. The design of the hundreds of other tribological contacts will range in difficulty from relatively routine (conservative designs with flight history) to the complexity and size of the alpha and beta joints. To assist the process, the preparation of a lubrication guide for use by the designers as a practical guide for choosing lubricants suitable for various types of applications appeared to be a useful and attainable goal. Therefore, the remainder of the program was structured to be:

- Phase II. Evaluation of Lubrication of the alpha and beta joints
- Phase III. The preparation of a lubricant guide for NASA and/or contractors to use in selecting and evaluating component lubrication techniques.
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| TABLE 11. SUMMARY OF TARGET PROJECTS IN SPACE STATION      |
| OMV Mechanisms   |
| Mobile Servicing Center                                    |
| SS Control Moment Gyro                                     |
| MDAC Berthing Mechanism                                    |
| GE Compressor  |
| Rockwell Rotary Joint Mechanism                            |
| MDAC Rotary Joint Mechanism                                |
| Sperry Rotary Joint Mechanism                              |
| Space Station Alpha Rotary Joint Mechanism                 |
| Space Station Propulsion Thruster/Storage Tank Assembly    |
| • Space Station Solar Array and Solar Dynamic Concentrator |
| OMV and Payload Mechanisms                                 |
| Antenna System Rotary Joints                               |
| Health Maintenance Facility                                |

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# APPENDIX A

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# SRS TECHNOLOGIES SUBCONTRACTOR REPORT

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SRS/STG TR90-84

# Space Station Long Term Lubrication Study Final Report

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June, 1990

# BY EDWARD. E. MONTGOMERY

SRS Purchase Contract Number: G-9038 NASA Contract: NAS8-36655

APPROVED BY: Jay  $\mathcal{N}$ Jay H. Laue

Director, Aerospace Systems

harly W Mead APPROVED BY:\_\_(

C. W. Mead General Manager, Systems Technology Group

# Foreword

This document was prepared by SRS Technologies under subcontract to Battelle Columbus Laboratories for work relating to the "Space Station Long Term Lubrication Study" for the Materials and Processes Laboratory at NASA's George C. Marshall Space Flight Center. The work was performed under the supervision of Mr. Keith Dufrane, the Battelle project manager and the NASA COTR, Mr. Fred Dolan. It presents a comprehensive final reporting of the Phase I activities of this project. The study was performed by SRS during the period from August, 1985 to May, 1990. The SRS contract manager is Jay H. Laue of SRS Technologies' Systems Technology Group, Aerospace Systems Directorate, in Huntsville, Alabama. The SRS project leader is Edward E. Montgomery. Other significant contributors at SRS included:

James C. Pearson, Jr. Rod Myers Anthony Stone Cynthia Koontz

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# 1.0 INTRODUCTION

Under subcontract to Battelle Columbus Laboratories (SRS purchase contract G-9038) SRS performed selected activities in support of the "Space Station Long Term Lubrication Study" (NAS8-36655), a contract effort with the Materials and Processes Laboratory at MSFC/NASA. Mr. Fred Dolan is the NASA COTR, Mr. Keith Dufrane is the BCL Project Leader, and Mr. Edward Montgomery is the SRS Project Leader.

The Space Station Long Term Lubrication Study (LTLS) is part of the Advanced Development Program (ADP) within the Space Station Program. In fiscal Year 1985, the ADP was initiated to accelerate the development of a series of new technologies. Its objectives were to enhance the performance of the Space Station, reduce the life cycle cost during the operations phase, and reduce the risk that might be encountered with new technologies during the development phase.

# 1.1 Background

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Work on the contract began on August 1, 1985. The project was scheduled to be conducted over a 3-year time frame in two phases. Phase I was a preliminary analysis conducted in parallel with the preliminary design phases of the Space Station program. Phase II was to be a more detailed analysis conducted during Phase C/D when the design became more established. Phase I was to conclude 20 months into the study (April 1987) and be based primarily on design data packages planned to be released along with the Space Station Phase B SDR in September 1986. However, the Space Station program schedule began to slip significantly. In addition, major configuration changes continued to occur. As a result, the design information was not maturing to a level sufficient to support the kinds of analyses planned in the LTLS. An interim approach was taken in which the LTLS utilized preliminary design data resulting from other ADP programs in lieu of mainstream SSF design review packages (which were not available). The problem became evident as early as October 1986 when it was first addressed in monthly progress reports to the government. In April, 1987, at the originally planned date for conclusion of the phase I activities, effort was suspended on the study to allow the Space Station program schedule to catch up. Unfortunately, further SSF slippages and major redesign efforts continued to keep the Long Term Lubrication Study dormant through the original LTLS contract end date in August, 1988.

In October, 1988, an SRS representative attended a Space Station Space Environmental Effects Data Exchange meeting at MSFC which included a lubrication concerns topic on the agenda. Otherwise, no effort was expended on the contract by SRS after April, 1987 until April, 1990. At that time, NASA extended the LTLS contract schedule and, subsequently, a new subcontract was negotiated between SRS and BCL. The scope and deliverables of the renegotiated effort were reduced from previous subcontract. During the renegotiations, it was mutually agreed that one of the previously established deliverables, a magnetic tape containing data from SRS survey results for use by Battelle in performing tribological assessments in Phase II, would no longer be a significant benefit to BCL or NASA. The remaining deliverable for SRS would be this final report.

# 1.2 Objectives/Approach

The overall objective of the Space Station Long Term Lubrication Study was:

"to assure NASA that all Space Station mechanical, electrical, and electromechanical equipment will function as intended for their required lives."

The goals of the study were to document and evaluate each wear point on the Space Station and assist in the improvement/resolution of suspected excessive wear or high maintenance areas. The prime duties for SRS were to gain access to design data for each wear point and assemble, organize, and document tribological data for analysis and evaluation. Battelles's prime duties were to analyze and evaluate each wear point and report on the estimated life of the hardware and the probability of success.

The Phase I approach established for the SRS activities included five major tasks:

- 1.2.1.1 Develop a system/component work breakdown structure for the Space Station to identify major moving mechanical assemblies.
- 1.2.1.2-4 Identify wear points and operating characteristics as to materials and surface treatments, lubrication scheme, operating characteristics, and environments.

1.2.1.4 Indicate the location of potentially contamination-causing fittings, lubricants, and bearing materials.

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- 1.2.1.5 Develop a detailed tribology matrix containing the synthesized data to support the tribology assessment.
- 1.2.3.3 Implement a survey data tape on the NASA/MSFC computer system to include the results of the tribology survey and assessment.

Phase II tasks for SRS were originally planned to accomplish an update of these same tasks after the release of Space Station Phase B SDR data packages and again near the Phase C/D Space Station Preliminary Design Review. Figure 1 illustrates the logic flow of this approach. SRS deliverables were to include a comprehensive work breakdown structure for the Space Station identifying major moving mechanical assemblies (MMA), a complete list of operating characteristics, materials, and environments for each identified MMA used to support tribology assessment, an identification of potential contamination sources on Space Station (location and distribution of greases and lubricants), a data tape containing the results of the tribology survey and assessment, and an identification of high priority areas for further long-term lubrication study.



# 1.3 Project Schedule

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The original schedule for Phases I and II of the Space Station Long Term Lubrication Study and major milestones are shown in Figure 2. Also shown on the figure are the dates of major Space Station Program milestones as planned at the start of the study. Close coordination was planned between the activities of this study and the progress of design activities. Figures 3 through 6 show the expected publication dates for major outputs of the four major space station work packages.

# Figure 2. Planned Phase I and II Project Schedules

### SCHEDULE PHASE I



SCHEDULE PHASE II

HONTHS AFTER START OF CONTRACT																		
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1.3.2 Final Tribology Assessment 1.3.2.1 Estimate Tribological and Materials Performance 1.3.2.2 Identify Unacceptable Performance Pisss and Recommend Potential Tribological Solutions 1.3.2.3 Recommend Critical Experiments Aimed at Reducing Pisss																	   	
<ul> <li>1.3. Final Update of Data Tape</li> <li>Update of Tribology Matrix</li> <li>Incorporate Component Data into Data Tape</li> </ul>				8		ر اکنین		I										-
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FIGURE 1-3. PROPOSED HILESTONE SCHEDULE FOR LONG TERH LUBRICATION STUDY

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# 2.0 TECHNICAL ACCOMPLISHMENTS

During the Phase I efforts, a number of achievements occurred despite the difficulties in obtaining solid detailed design information. Some of the results are no longer applicable due to differences in the station configuration at the start of the study and now, the "75 kW Space Station reference IOC" concept represented in Pre-Phase B White Papers document and the current Space Station Freedom Configuration. Also, atomic oxygen effects were just coming under close analysis through data obtained from shuttle experiments. Since the time of these analyses, the understanding of physical mechanisms and orbital environments has increased significantly and may advance further in the near future as the results of the recently recovered Long Duration Exposure Facility are analyzed and documented. The results of the task activities are presented in greater detail in the following sections of this report. Included are discussions of the development of a Space Station Work Breakdown Structure, environment identification, wear points, materials, lubricants, & outgassing, operating requirements and characteristics, and the data tape.

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## 2.1 Development of Space Station Work Breakdown Structure

A comprehensive listing of the Work Breakdown including all major system, subsystems, equipment, was developed and used as the basis for for identifying wear points and critical lubrication concerns. The Space Station IOC reference configuration shown in figure 7 served as the baseline configuration for this analysis. This configuration is based on a set of deployed linear trusses constituting the keel and booms to which the modules, subsystems, and equipment are connected. It contains numerous mechanisms and joints that provide interfaces with and support to external payloads and equipment for various experiments and servicing functions (e.g., satellite, orbital/space transfer vehicle, and orbital maneuvering vehicle servicing). Phase I of this program began about the time Phase B of the Space Station program began in which there were still a number of parallel contractors involved in each work package. SRS obtained design data products from the Martin Marietta and Boeing Work Package efforts early in the study and compared these with the reference configuration. Some variances occurred as can be expected, especially at the lower levels. It should be noted that there existed an official Space Station Work Breakdown Structure for the program, the top levels of which are shown in figure 8. For the purposes of this study it was necessary to modify the program WBS which includes functional elements (e.g., safety, reliability, etc.). The WBS for this study was intended as a cataloging tool to promote a complete identification of wear points in space hardware and therefore only includes the breakdown of on-orbit hardware items. Much similarity exists in the two items. Figure 9 depicts the difference in those structures at the top level. Both agree at the program level and the project level definition was retained in anticipation of continuing further with WP-1 than the others.

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The basic concept of the hierarchical network as shown in figure 10 was used to identify the Space Station breakdown structure levels and contents. The use of this system to catalog and describe the large number of equipment hardware items in the space station provided a systematic approach which was easily automated for computer analyses of the interrelationships of all elements within a breakdown structure level. Figure 11 illustrates the manner in which each level is subdivided to provide a detailed listing of components and parts for identifying wear points. The WBS structure levels were defined along the approach NASA uses.



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Figure 9. Redefined LTLS Work Breakdown Structure

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Figure 11. Branched Network of Breakdown Structure to identify Points of Wear

The development of the LTLS WBS began at the program level 2 and proceeded with analysis of each element at a level to identify major pieces of equipment at that level. The depth to which the tree could be defined was limited by the availability of design information (related to the maturity of the design) and study resources. The "Space Station Reference Configuration Description" document (JSC-19989) addressed the growth of the manned and unmanned station concepts and contained a configuration evaluation and subsystem definition of the IOC configuration. Being the most comprehensive and programmatically substantial source of reference information at the time the study began, it was used as a guideline for the definition of levels 3-6. Similarly, a companion volume, the "Space Station Subsystem White Papers" document (JSC-20054), was used in the definition of the 7-8 levels of the WBS. Even so, it was not possible to complete the WBS for all work packages completely down to the 7th or 8th levels. Instead, the structure was defined to the 4th and 5th level, which are the System/modules and subsystems, then an evaluation of the elements was performed to determine the major Moving Mechanical Assemblies (MMAs). These were selected in a process of evaluation in which each element was assessed against the selection criteria shown in figure 12. Those elements which registered in the largest number of criteria categories, for which significant design data existed, and were Work Package 1 elements were prioritized and selected for further WBS level definition and evaluation.

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Figure 12. Criteria for Ranking Risks or Probability of Failure

Code	Selection Criteria
0	SELECTION CRITERIA NOT APPLICABLE.
1	OPERATES UNDER HIGH LOADS/CONTACT STRESSES, FREQUENT OR CONSTANT.
	MOTION, ENVIRONMENTAL EXTREMES, AND/OR HIGH DUTY CYCLES.
2	POTENTIAL SOURCE FOR CONTAMINATION RESULTING FROM PREMATURE FAILURE.
3	MISSION OR LIFE CRITICAL IF PREMATURE FAILURE OCCURS.
4	UNIQUE PRELIMINARY DESIGN CONCEPT/NEW TECHNOLOGY INVOLVED.
5	WILL OR LIKELY TO REQUIRE MAINTENANCE/REFURBISHMENT.
EXAM	PLES:
00000:	No elements of selection criteria applicable.
10000	IVIDC and and a second as high logical destruction of constant motion
10000:	was component only operates under high loads/contact stresses, frequent or constant motion,
	environmental extremes, and/or high duty cycles.
02340:	WBS component is a potential source of contamination resulting from premature failure, is
	mission or life critical if premature failure if premature failure occurs, and involves a unique
	preliminary design concept or new technology.

# 2.2 Environment Identification

Establishment of the environments for each wear point was required for the assessment of performance and life characteristics of the particular surfaces of interest in the identified wear points. In general, environments enclosing surfaces in relative motion can be different depending on the duty cycle of the mechanism. For example, when the mechanism is not operating, the environment may be at a different temperature and pressure than when the mechanism is operating. Mechanisms at rest may, however, be under static load and, depending on materials and environments, failures such as long term stress corrosion may occur. If high loads and;or high relative speeds are present such as in the contacts of high speed rolling bearings, temperature in the contacts will be vastly different from those for static conditions. These thermal environments and temperature cycling set stringent requirements on long term lubricants and the ability of the lubricants to provide the necessary elastohydrodynamic for proper lubrication at operation temperature. In general, the life of these contact surfaces is dependent on the elastohydrodynamic conditions in the contacts which is a complex function of load levels, speeds, and operating environment.

In some specific applications, such as the Space Station refrigeration systems, the lubrication system for refrigerant compressors may require isolation to prevent lubricant contamination of evaporator and condenser surfaces. In some designs this may involve dynamic seals in a refrigerant and high temperature lubricant environment. These environments must be identified and characterized to support wear and life assessments of these components. Other mechanisms, such as external fluid rotary joints and docking mechanisms, will have external surfaces exposed to the space environment for long periods of time. Lubricants used for these applications must therefore be compatible with these environments. The assessment of environmental effects on contacts and/or wear point performance, durability, and life requires a definition of these environments over the entire duty cycle of the mechanism and/or component.

The objectives of this effort were to identify the environment for each wear point over the duty cycle of the mechanism, characterize the environment for assessment of wear point durability and life, provide comprehensive rationale to support findings, data base, and documentation requirements. Environments over the complete duty cycle were determined for each Space Station MMA component.
These environments were then characterized to determine the specific environmental components that affected wear point performance and durability.

Many components, such as thermal control coolant pumps, essentially operate continuously at relatively steady loads. Other components, such as docking mechanisms and latches, may not operate over several times per year. Mechanisms such as Space Station Solar Array actuators and drive mechanisms will operate several times per orbital period. These are examples of mechanisms that have relatively steady environments and large fluctuations in environments depending on duty cycles. Surfaces exposed to the orbital environment (latches, docking probes, etc.) will be exposed to many elements that could cause surface degradation leading to loss of performance and decreased durability. The space environmental effects most likely to affect materials and lubricants in Low Earth Orbit are:

- Vacuum Outgassing (1 X 10<sup>-6</sup> to 1 X 10<sup>-7</sup> Torr (per specification SP-R-0022A)
- Solar Radiation

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- Proton 2.9 X 10<sup>3</sup> rad (c), Energy >100 keV to 2.2 X 10<sup>3</sup> rad (Si)
- Electron 7.5 X  $10^5$  rad (C), Energy >40 keV to 6.8 X  $10^5$  rad (Si)
- Ultraviolet 55,000 Sun Hours
- Atomic Oxygen
- Concentration Approximately 1 X 10<sup>9</sup> atoms/cm<sup>3</sup> @ 290 nmi. altitude
- Exposure perpendicular to Flight Path
  - 2.36 X 10<sup>15</sup> atoms/cm<sup>2</sup>/sec
  - $-3.5 \times 10^{20} \text{ atoms/cm}^2 \text{ in } 41.0 \text{ hours}$
- Micrometeoroids 8200 impacts/m<sup>2</sup> (mass < 10-12 gm)
- Meteoroids & Debris 4 impacts/m<sup>2</sup> (diameter > 0.01 cm)
- Thermal Cycles 58,500 over 10 years

The space vacuum has varied effects on materials depending on the material characteristics. For example, it has a beneficial effect on the fatigue life of alloys susceptible to stress corrosion (removed or absorbed molecules eliminating the electrolyte). Vacuum and thermal effects can cause removal of surface gases from materials with detrimental effects. Losses of absorbed gases for materials in sliding surfaces can cause appreciable changes in friction coefficients. Lubrication characteristics may also change significantly when exposed to space vacuum over long periods of time. A lubricant's volatility is a function of its vapor pressure, and vapor pressure is related inversely to molecular weight. In general, lower weight

fractions of a lubricant will be lost through vaporization before the heavier constituents. This does not necessarily mean that those with very low vapor pressure and evaporation rates will give the longest life in vacuum service. The only conclusive means in determining lubricant service life in vacuum is by experimentation. Long term tests of grease type lubricants are underway at MSFC and will provide valuable information for the assessment of long term vacuum effect on these lubricants.

In low earth orbit the principal source of electromagnetic radiation is the sun. Solar radiation covers the wave length region from around 0.01  $\mu$ m to greater than 10<sup>4</sup>  $\mu$ m. This region includes low energy gamma ray, x-ray, UV, visible, infrared, and microwave photons with an energy density of 1353 W/m<sup>2</sup>. In developing the solar environments for specific components the location of the component relative to the sun and earth is important as well as shading and/or blockage from adjacent structures. For estimates of material degradation due to sun exposure, total exposure times will be estimated based on orbital time averages of solar exposure for each mechanism. Solar flux distributions for outer surfaces of the Space Station will be the principal source of data for this environmental information. In specific cases where data may not be available, SRS has the capability to develop this information.

The trapped particles of the South Atlantic Anomaly are essentially electrons and protons trapped in magnetic flux lines an reach a low point at about 30 degrees inclination or greater, there will be approximately five passes through this anomalous area each 24 hours. Material degradation occurs through ionization of the atoms or molecules by the electrons and energy deposition in the materials by protons.

Atomic oxygen effects on materials and surface degradation is a strong function of the direction of the surface with respect to the velocity vector. The greatest amount of degradation occurs on the forward surface of the STS Orbiter perpendicular to the velocity vector. Therefore, atomic oxygen fluxes must be estimated based on the relative location of the surface of interest. Materials experiments have been flown on many STS flights and data reported in the literature. The recently retrieved Long Duration Exposure Facility should provide some very relevant information from AO experiment results.

During the LTLS study, the responsibility for leading space station propulsion system design was being transferred to JSC. Mr. Walt Karakulko at NASA/JSC was

contacted and provided these guidelines on operating characteristics of the space station thruster/storage tank assembly.

gaseous fuel: <3000 psi; (20 deg. F.)<T<(150 deg. F) liquid fuel: 400-500 psi; (20 deg. F.)<T<(150 deg. F)

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## 2.3 Identification of Wear Points

In this section, the activities performed in pursuit of the tribology survey data and the MMA's identified in this process are discussed. This first subsection summarizes these activities and includes a list of the MMA's selected. Succeeding subsections discuss each MMA separately.

#### 2.3.1 Summary

From a relatively broad range of assemblies, components, and mechanisms, a group of items were selected for focus in the evaluation and assessment activities. For these items, a contacts were established, usually with the NASA technical monitor and the contractor (or subcontractor) performing technology studies or advanced developments for the items. In many cases SRS met with project leaders and discussed lubrication concerns directly with the individuals involved in the studies. This was made possible in most cases by scheduling splinter sessions in conjunction with SS Phase B Work Package Reviews and SS Advanced Development Program Reviews held at MSFC. The list of areas below comprise this set of target projects.

Collection of data and survey of lubrication aspects of:

o OMV Mechanisms,

o Mobile Servicing Center,

o SS Control Moment Gyro,

o MDAC Berthing Mechanism,

o GE Compressor,

- o Rockwell Rotary Joint Mechanism,
- o MDAC Rotary Joint Mechanism,
- o Sperry Rotary Joint Mechanism,

o Space Station Alpha Rotary Joint Mechanism,

o Space Station Propulsion Thruster/Storage Tank Assembly,

o Space Station Solar Array and Solar Dynamic Concentrator,

o OMV and Payload Mechanisms,

o Antenna System Rotary Joints, and

o Health Maintenance Facility.

Lubrication issues, although of concern to all such projects, were not the main goal of most of these projects. Typically, the objectives were to assess relevant technologies in areas like mechanisms, power generation, or LOX/LH2 propulsion concepts and produce proof-of-concept prototypes. Therefore, the effort which these projects could put forth in coordinating with the LTLS was limited. In all cases, SRS, in conjunction with the COTR for this study, Mr. Fred Dolan, sent written requests for pertinent information and provided lubrication survey forms. In several instances, the projects were able to make an assessment and provide very useful feedback. In other cases, the projects provided data products (technical reports, concept descriptions, design drawings, etc.) which allowed SRS to perform assessments for lubrication concerns connected with the item. Also, through alternate sources and basic research, enough information was obtained to make some evaluation. Some projects never reached a level of maturity to support definition of all the the structural, mechanical, lubricant selection, outgassing information necessary for a complete survey of the concern. Looking forward to updates planned for later in the LTLS project, SRS retained these items in the tribology data base with as much information as was available.

In addition, SRS continued to track the the global program to monitor for the identification of additional lubrication concerns/items as they became apparent. Those activities included acquisition and assessment for wear points in Boeing WP-1 and SS ADP Review Data, participation in Space Station Materials Sub-Panel Meeting at NASA/Langley Research Center, communications with MSFC, Phase B contractors, and ADP's to obtain environment and operating characteristics of MMA's, and coordination with ADP centers to request inclusion of the completed Survey Forms as part of Phase C/D PDR data requirements.

At the Langley Materials Sub-Panel Meeting, the issue of design maturity and the timeliness of LTLS study products was addressed. In response to the need for a tribology assessment for the Major Moving Mechanical Assemblies (MMA's) prior to their respective Critical Design Reviews (CDRs), the LTLS study aproach was revised. The initial approach was based on making use of Design data published in Preliminary Design Review (PDR) data packages. However, this data has been neither complete nor mature enough to support a tribology assessment. It has been determined a more direct method of obtaining environmental and operating characteristics of the MMAs is needed if the tribology assessments are to be made before CDR.

To resolve this problem, the tribology survey forms previously developed in this study for in-house use, were sent to the responsible COTR's and contractors prior to design reviews. Letters of explanation and Survey Forms were sent to:

- o Sperry -Alpha and Beta Rotary Joints
- o Boeing -Gimballed Radiator and Two Phase Thermal Bus
- o Grumman -Space Erectable Radiator and Two Phase Thermal Bus
- o General Electric -Compressor for SS Refrigeration system
- o MacDonnell Douglas -Berthing Mechanism

In addition, a letter and survey form encouraging their inputs to this study were sent to David Thomasson of the Huntsville Boeing office. Boeing Aerospace Company is an MSFC WP-1 Prime Contractor. Also, a complete set of the red-books containing the presentation materials from the Space Station Advanced Development Program Review were obtained and reviewed for information indicating possible Major Moving Mechanical Assembly candidates for further lubrication study in this program.

## 2.3.2 Orbital Maneuvering Vehicle & Mobile Servicing Center

John Forbes/MSFC, the manager for Orbital Maneuvering Vehicle (OMV) Mechanisms was contacted and agreed to follow through in providing wear point information towards the objective of developing a survey response. The OMV became an LTLS topic of focus when SRS attended the annual review of the Grumman Aerospace "Advanced Orbital Servicing Technology" effort at MSFC on June 24. No hardware design activities pertinent to this study were identified as part of that AOST study, but during the review suggestions were made to research the mechanisms on the Mobile Remote Manipulator System (MRMS) and the Orbital Maneuvering Vehicle (OMV). SRS followed up in the pursuit of lubrication aspects of the mechanisms on the Mobile Remote Manipulator System (MRMS) and the Orbital Maneuvering Vehicle (OMV) by contacting Luther Powell, then director of the MSFC Space Station Program Office. He provided SRS with a contact in the MRMS program-Brian Erb of the NASA Johnson Space Center. JSC was to develop the base with SPAR of Canada providing the manipulator arm. In initial discussions with Mr. Erb, he indicated project was still very much in the conceptual phase, but he would do some checking and call back on the availability of data. Later, Brian Erb

(also of the Canadian Research Council) was sent LTLS survey forms and forwarded them to appropriate technologists. There was no further response from that source. Additional discussions with Zack Thompson, Stan MacIntyre, and Tom Byrd of MSFC indicated there was some potential for lubrication issues associated with fluid, electrical, and payload quick disconnects. In a follow-up to that meeting, Tom Byrd of NASA/MSFC indicated three design areas with possible lubrication concerns and agreed to supply pertinent data on:

- (1) 3-point latch mechanism for Space Telescope,
- (2) Fluid coupling for propulsion system, and
- (3) Payload gimbaling.

Also, on July 16, 1986, SRS sent a letter to Mr. Jeffrey Corbin of Martin Marietta requesting contacts to provide data on OMV/OTV Accommodations items relating to docking mechanisms and pumps from their Phase B work:

2.3.3 Space Station Control Moment Gyro

Early conversations with Lewis Cook, COTR for this Bendix project indicated that a survey was underway for supporting mechanisms with an expected time of completion is two weeks. In the Attitude Control and Stabilization session of an ADP program review held later, Mr. Cook of MSFC presented the status of a Control Moment Gyro design activity. Parts of this system were currently on order for a CMG prototype. However, only limited design data pertinent to lubrication was available.

2.3.4 GE Compressor

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Lockheed Missiles and Space Company studies of mechanical assemblies in the Thermal Storage Unit and Refrigerator System focused on the GE compressor. Mr. Rudy Trabanino of NASA/JSC agreed to forward a survey data form to the appropriate individuals at the General Electric operations in Houston. A survey was sent for the advanced development program they were pursuing on a Compressor for the Space Station Refrigeration system. Later, Mr. Trabinino requested additional survey forms to send to General Electric. During the project, GE Houston operations underwent a cut in workforce. The original request and form may have been lost.

## 2.3.5 Truss & Rotary Joint Mechanism

Discussions with Leon Smith of the McDonnell Douglas Astronautics Company identified Lockheed Missiles and Space Company as the provider of a rotary joint design as part of the Work Package 2 Phase B activity. However, not enough detail was then available to justify a survey. The competition sensitive nature of the design/configuration was expected to limit the availability of significant design information until mid to late 1987.

Lubrication survey data forms were provided to Mr. Harley Rockoff of Rockwell for their Rotary Joint Mechanism work. A second request was made as a result of an Space Station Advanced Development Program Review meeting held at LaRC.

Conversation with Fred Jankowski of NASA/MSFC indicated that little pertinent information to support a tribological analysis of the McDonnell Douglas Rotary Joint Mechanism was available at the ADP review. Detail drawings were only beginning to be prepared at the time.

John Gustasson of NASA/LaRC was contacted and agreed to send a package of documentation containing all available design information on the Space Station Truss and Joint Designs being sponsored by LaRC.

Mr. Obie Bradley of the NASA Langley Research Center provided SRS with a report on testing and design drawings of three Rotary Joint Mechanism concepts. Upon Evaluation of the Sperry Alpha Rotary Joint Design Drawings, seven areas of potential wear problems were identified:

- (1) Power/Signal Transfer Bearing
- (2) Pinion Gear/Bearing Housing Gear Interface
- (3) Shaft Bearing (P/N 3HKR102 P7)
- (4) Pinion Bearing (P/N KAA10 AG)
- (5) Follower Bearing (P/N KB020 CPO)
- (6) & Solar Array Joint 36 inch Bearing Assembly (Alternate Construction)
- (7) Alpha Solar Array Joint 108 inch Bearing Assembly (Alternate Construction)

Along with the preliminary survey data forms, other pertinent drawings and specifications were sent to Battelle Columbus Laboratories for further tribology assessment.

Harold Bush of NASA/LaRC) was contacted and agreed to send a package of documentation containing all available design information. SRS received a data package on a preferred truss concept (several were still being considered). After review of this package, additional information on a few specifics was requested.

The rotary joints in the antenna system had similarities to the Ball Aerospace and Sperry designs in the solar array application. Jim Kelly of NASA/JSC, agreed to send lubrication reports and drawings on the shuttle KU band antenna gimbal system. That system was produced by Hughes Aircraft in El Segundo, California.

2.3.6 Berthing Mechanism

The McDonnell Douglas Astronautics Company began Berthing Mechanism design activities in mid 1986. In July, at the request of SRS, Mr. Fred Jankowski MSFC/EP33 forwarded a survey data form to MDAC for completion. Results were expected on or about August 1986.

2.3.7 Radiator

Through Mr. Richard Parish of NASA/JSC, LTLS survey forms were distributed to appropriate individuals at the Boeing Aerospace Company for the Two Phase TCS and Gimbal Radiator and Grumman for the Two Phase TCS and Space Erectable Radiator. In follow-up discussions it was reported that they were being prepared and might be available within a month.

2.3.8 Coarse Pointing Mechanism

In telephone contacts with Kevin Grady of the NASA Goddard Space Flight Center, the Coarse Pointing Mechanism project was still in a very conceptual stage. He suggested contacting the work package 2 contractors General Electric and Ball Brothers again around the first of September when more mature data may be available.

## 2.3.9 Propulsion System Thrusters

Mr. Ralph Burns MSFC/EP33 provided SRS with a data package containing a schematic and drawing of portions of the space station thruster/storage tank assembly. SRS reviewed this information to identify possible wear point candidates. Initially, potential areas of concern included O-rings, V-seals, K-seals, screw threads, fuel/oxidizer quick disconnects, and solenoid and latching valves. In the end, the SRS evaluations resulted in the identification of 36 wear points with possible long-term lubrication concerns. The points identified were associated with the fuel and oxygen solenoid valves, the oxygen and nitrogen latching valves, and the thruster assembly.

During this time, the responsibility for leading space station propulsion system design was being transferred to JSC. Walt Karakulko at NASA/JSC was contacted and provided these guidelines on operating characteristics.

gaseous fuel: <3000 psi; (20 deg. F.)<T<(150 deg. F) liquid fuel: 400-500 psi; (20 deg. F.)<T<(150 deg. F)

On July 16,1986 SRS sent a letter to Mr. Jeffrey Corbin of Martin Marietta requesting contacts to provide data on items from their Phase B work on the Space Station Propulsion System including an electromechanical solenoid quick disconnect fitting, thruster valves, isolation valves, and propellant/pressurant quick disconnects.

2.3.10 Solar Array

Mr. Wayne Bartlett of the NASA Lewis Research Center provided SRS with three sets of detailed notes on lubrication aspects of the LMSC Space Station Solar Array. His notes included a drawing and addressed mechanical assemblies at the base of the array connecting to the Beta joint. Another set of notes prepared by Mr. Rick Elms of LMSC identified a large number of wear points and proposed lubricants for locations on the array, base, and deployment mechanism. Also included was a copy of a memo from Mr. Fred Dolan MSFC/EH14 to Ann Whitaker MSFC/EH12 on the lubrication recommendations for the Solar Electric Propulsion / Solar Array Flight Experiment dated February 15, 1979. Although the depth of information was limited in these notes, they were sufficient to identify the location of potential lubrication concerns and some candidate lubricants for evaluation. From this information, SRS identified a number of wear points and collected

tribology data associated with the items. SRS concentrated mainly on the component description and materials summary. Mr. Bartlett later met with SRS contract representatives, providing survey forms completed by Rocketdyne also on components of the Solar array structure. The information was complementary since Rocketdyne concentrated on operating characteristics and also served to verify the points identified. Mr. Bartlett anticipated sending more detailed drawings/pictures of the individual components as they became available. A total of eight wear points were identified and surveyed in connection with the solar array and solar dynamic generator components.

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2.3.11 Health Maintenance Facility

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The in-flight clinical medical care facility onboard the Space Station was still in the definition process, according to Mr. James Logan, Medical Operations Branch Chief, at NASA's Johnson Space Center when he was contacted by SRS. Some small pumps were potential sources of lubrication concerns, but design candidates had not yet been defined.

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## 2.4 Operating Requirements and Characteristics

Lubrication schemes may be classified according to the general type of lubricants, whether dry film or fluids. Typical dry film lubricants include MoS<sub>2</sub>, Teflon, and graphite. Typical fluid lubricants include oil and greases. Determining the type of lubrication scheme for a specific element and the performance characteristics of the lubricant to reduce surface wear is an important factor in support of tribology assessments. However, the type of lubrication scheme depends on the operating characteristics of the component such as loads, rotational speeds, relative velocities and environment. Consequently, a characterization of lubricants and operating characteristics was necessary.

Lubricants operating near optical or thermal control surfaces were assessed against the outgassing requirements defined in SP-R-0022A, "General Specification Vacuum Stability Requirements of Polymeric Material for Spacecraft Application". This outgassing requirement restricts the use of polymeric materials near critical optical and thermal control surfaces to those materials having a maximum volatile condensed material (VCM) content of 0.1 percent and a total mass loss (TML) of 1.0 percent or less when tested under the following controlled test conditions:

- o Pressure: 10-6 torr or less
- o Temperature of Specimen: 125 deg. C 1 deg. C
- Temperature of Condensable Plates: 25 deg. C 1 deg. C
- o Vacuum Exposure Time: 24 hours

Representative outgassing data for typical greases and lubricants are listed in Table 1. SP-R-0022A defines specific procedures for NASA approval of polymeric material selected for application near optical and thermal control surfaces. These procedures served as a baseline guide to evaluate the performance characteristics of lubricants identified during the survey. The pertinent survey data base data consisted of listing:

- o Manufacturer's trade name
- o Manufacturer of the material
- o Thermal vacuum stability (VCM and TML) data
- o Rationale for use of material which failed outgassing requirement.

OUTGASSING DATA FOR TYPICAL GREASES AND LUBRICANTS 

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Material	Code	KTH.	NCVCN	1. Me		Atmos	Application
Activity Control Control Manh	YCM	1.78	1	24K	2	Alr	l uhr ic ant
Aerodag u colloldal Braphice/Isuprupy: Aicumo Azodos E folloldal Eraphite/Isubrody] Alcohol	Ş	2.05	8	24H	8	AIL	Lubricant
Across Constant Control MC2/Iconcovi Alcohol	Q	4.97	.19	24H	\$	AIr	Lubricant
Astaron C Ot1 Vacuum Decassed	019	61.19	47.47	H	65	6-2	Grease
Asteron H Nydrocarbon Grease	010	<u>ي</u>	.0				Grease
Aniezon L Gresse	019	2	<u>9</u>				Grease
Astezon M Grease Yacuum Degassed	019	¥.	۶.	H	5	<b>-</b> -3	Lubricant
Aplezon N Grease		8;	8:				Grease
Aplezon 7 Grease		9/-	21.		1	i	6rease
Black Magic Moly Spray/Foll - Aerosol MOS2	SPR	Ņ	5	HÞZ	ŝ	AIL	Lubricant
Brayco 813 Clear Oil Batch EIA3			3				LUDICAT
Brayco 8152 Clear Oil Batch DLM3		8.	8				Lubricant
Braycote 3L-38 Grease Batch CLD1 White		<b>10</b>	3	į			Grease
Braycote 338 Greese White	202	<b>.</b> 0	8:	F	8	9-9	Lubricant
Braycote M-38-WS Grease Batch DLG1 Gray	20	Ş	6.				Grease
Braycote 31-38-RP Grease Batch CLT7 Yellow	202	8	Ş				Grease
Braycote 3t-36-2N Grease Batch ELM Black	202	ຮຸ	5				Lubricant
Braycote 803 Grease Batch ELJ12 White	ğ	2.					Grease
Crown 6065 Green TRE Aerosol Coating/F	<b>CIP</b>	S.	8	Ð	1/1	Air	Lubricant
				24H	121	3	
C6-1103 Stittcone Grease	2	11.	8				Grease
DC 20-057 Silicone Optical Coupling Compound	22	8	.27				Grease
Dr1-Slip Powdered Lubricant · Aerosol	Ē	10.73	4.60				Lubricant
Drilube 822 Fluorosilicone Lubricating Grease	ž	6.51	2.47			;	Lubricant
Eccessis TM-24 Low Friction Epoxy	5	<del>9</del>	8	S.	8	Ar	Epoxy Lube
				H	8	AIT AIT	
		Ĩ		24.1	011	AIL	
EXXCEL UR-25 Aromatic Polyester/IFE Blend Tan		5	8;				Solid Luce
Envez 1000			5.5				
Eaves 1000	BOG BOG	1.74	6,1	24H	Ŕ		Bearing Material
Enver 1000X	ROG	18.1	5	H#2	5		
Envez 1000X Polyimide	ROG		Bi				Bearing Material
Enver 1115			į		ŝ		Bearing Material
Enven 1115			ŝ	1157	5		fabring Material
2771 <b>2740</b>			ġ8	2AN	202	Air	Bearing Material
CHTTER 1220		] [	:8				Bearing Naterial
CHVER 1313		5	9 9	2AM	740	Air	Bearing Naterial
CUCH IJIO Clubbar Ann Cile (.Andres Annes)					X	AIr	Lubricant
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r Herrog 1104 fu Adrosos Ury film Luoricent/f		; X	; E		•		Bearing Naterial
Fleeresing Sou Mica Filied Fre Af 1143 Machai Abad Salaata Labo Af			3.4				01)
LE LIST MELLIYI AIKYI DILICONE LUBE ULI			2				Lubric ant /Creat
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## 2.5 <u>Tribology Matrix / Data Tape</u>

The results of the tribology survey and assessment were to be stored on a data tape implemented on the MSFC computer system. The RFP required the delivery of the data tape at the completion of Phase II. However, SRS proposed an option to implement the data tape during the conduct of Phase I and incrementally update the data tape as more mature data became available. By implementing the data tape early in the study, it was hoped a listing of major Space Station elements could be provided to MSFC facilitating later updating efforts. Supporting this option, a lubrication evaluation tool was to be made available to the MSFC for use in identifying probable problem areas early into the Space Station studies. This would to support test plan development and conduct in critical, deficient, or advanced technologies areas.

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A description of the proposed formats of the data tape and descriptions of the individual data items to be recorded are discussed below. The actual format of the tape would have been to a small degree dependent on the computer system on which it was to be loaded. It was assumed that the Univac 1100 Series computers at MSFC would be the host system. After the start of the study, MSFC upgraded the central computer facility with a Cray mainframe. However, no significant impacts on the data tape plans resulted from another computer being chosen since interfaces to Univac peripherals and systems were retained. The SRS staff maintains familiarity with all the major computer systems at MSFC.

The standard tapes used in the MSFC tape library are the 9 Track, 1600 BPI, 10inch diameter magnetic tapes. The tapes were planned to be recorded in a standard format, such as unlabeled Univac COPY, G format (the format of COSMIC UNIVAC NASTRAN TAPES), or the standard Univac COPIN format. SRS staff have used these formats when transferring data recorded on tapes from several sources including COSMIC, the UAH Univac, and IBM machines to MSFC computers.

The organization of the data was structured to take on a matrix format. The results of the tribology survey were to be synthesized into a row column table. The tribology matrix included an identification of the components, points of wear, and data in five major categories: structural, lubrication, environment, operating conditions and characteristics, and failure mechanisms and consequences. An illustration of the planned matrix structure is provided in figure 13. Shown is a representative of a fluid coupling design presented in JSC-19989. The fluid coupling

has been broken down to the structured element level, and materials, surface finishes, environments, and oeprating characteistics have been identified.

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	Structu	1	1)	Lubricat	ien	Enviro	ment		Operating	Conditions		Failure Hec	hansse/Consequer
istic	Recental	Surface Finish	Type	Designation	Outgassing Characteristics	Туре	Effects on Operating Performance	Loads/ Stresses	Torque	Antational Speeds	Regulred Life	Pechanism	Consequences
Anaonia fluid Coupling Seal	Virgin TFE Lefton Against 316 Stainless Steel	6-8 inch molded 6-8 hich polished	0r,	Unlubricated	ÛK.	Mii Inside Air outside	•Corrosive to certain material •Leads to corrosion failure and		B65E Inch-pounds	1 Rev/90 ain	10 yrs	Wear. Corrosion	Leakage to Nabilable area Could cause Nealth problem
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## 3.0 <u>CONCLUSIONS</u>

Upon completion of the Phase I activities, the information was organized into the tribology matrix format and compiled into a preliminary tribology matrix as depicted as table 2 in the following pages. The information necessary to provide meaningful indications of failure mechanisms and consequences was not available and was deleted from the format. Originally, there were planned to be two updates to the matrix. Those updates were eliminated in the renegotiations of the contracted effort. Since the LTLS program was brought to focus on a few items early in the program, there no longer existed a need for a computer system to host and manipulate vast amounts of data. Early data base programming efforts using the RIM 5 relational data base software were discontinued when it became apparent that a different scope was prudent in the data requirements of the project. Appendix A contains the individual data sheets prepared from the survey results for each of the line items summarized below.

Most of the wear points identified were in conjunction with the RCS thruster assemblies and the solar array. A few wear points were identified for the Beta Joint, the Solar Dynamic Concentrator, and pumps in the fluid control system.

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					A PRIVATE AND A LOD.			
Substrate         Tenton         Constration	-	an in der a						
Montania         Control (Montania) / Co	nction	Description	Contact	Lubrication	Load, Life, and Motion	SuntTemperature ( deg F)	Operating Conditions	Comment
NumberNumbe	VO DATVE ASSEMBLY	Shaft Bearing Priv 3HKR102P7	Surface #1 440 C Surface Finish Set by Sperry	Lubrication Scheme: Fluid	Operating 11 Life (years) Peak 20 20	Exposure None Percent Time: 0 %	DN value at 8 Rpm min	Skryje 15mm bore ball bearing (catalog number 3HKR102P7 by MPB Corp.)
Material         Instantion         Environ			Surface #2 440 c Surface Finish Set by Sperry	Micronic SP R 0022A Comparitude F	Rolate Speed (rpm) 0.5 Oscillation Type None	Low: 8 F Environment High: 105 F Vacuum		400 ID Max static load capacity. Cage Is Contad machined phenotic.
Multication         Summer Constrain	epioyment.	Bearings in PV array deproyment motor	Surface #1 Unspecified Surface Finish	Lubrication Bicheme: Fluid	Operating 0 Life (years) Peak 0 10	Exposure Continuous Percent Time: 100 %		STS Cargo Bay wheration qualification level
Number of the part of the start of			Surface #2 Unspecified Surface Finish	Erayoole SP R 0022A Compatible 1 Brayoole O Yes O No C	Rotate Speed (rpm) 1200 Oscillation Type Unspecified	Low 112 F Environment High: 176 F Vacuum		
Control         Current of the state state and current of the state and curent of the state and current of the state and current of the st	or solar array masi extension	PV array mast carititier rotating mut	Surface #1 Unspectified	Lubrication Scheme: Dry Film	Operating 0 Life (years)	Exposure Intermittent		STS Cargo Bay qualification woration lavel
Constraint         Protein frame relation         Constraint			Surface Finan Surface #2 Unspecified Surface Finan	Lubricam SP R 0022A Compatible Feethole O Yes O No 620	Peak 0 10 10 Relate Speed (rpm) 2 Oscillation Type Unspecified	Percent Time: 50 % Low: 112 F Environment Han: 178 A Vacuum		
Contraction	oning actuation of Solar	Actuater motor	Surface #1 TBD sheet	Lubrication Scheme: Fult	Operating 100 Life (years)	Exposure:Nane	< 1 Hz continuous oscillation.	for additional information, contact Surveyors Snews, Surveyors
Monte I         Butte de la Prima         Curta de la Prima         Cur			Surface Hittah TBD Surface #2 TBD steel	Lubricami SP R 0022A Compatible	Peak 200 10 Polate Speed (rpm) 60	Percent Time: 0 % Low: -140 F Environment		Rectified, Mirrols, 61125. Dual Taulure Idenant electromechanical
Market         Instrume         Market         Marke	Constraint and the		Surface Fright (BU)		Ouc Mattern Type Intermittent	HQn: 140 F vacuum		Actualor Bending to Annany Anton
monomic         monomic <t< td=""><td>o concernation capacyments ichtentism.</td><td>Calch Journal</td><td>Surface Finish Unapecified</td><td>Lubrication Scheme: Dry Film</td><td>Operating 0 Lite (years) Peak 0 15</td><td>Exposure Intermittent Percent Time: 70 %</td><td></td><td>deployment or revector or during</td></t<>	o concernation capacyments ichtentism.	Calch Journal	Surface Finish Unapecified	Lubrication Scheme: Dry Film	Operating 0 Lite (years) Peak 0 15	Exposure Intermittent Percent Time: 70 %		deployment or revector or during
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Matter         Concritation Interfaction Interfaction         Matter         Concritation Interfaction         Matter         Concritation         Matter         Matter <t< td=""><td></td><td></td><td>Burtace Ritch Unspecified Burtace #2 TBD A</td><td>Lubricant Sr R 0022A Compatible</td><td>Peak 0 15 Rotate Speed (rpm) 0.16667</td><td>Percent Time: 70 % Low: 150 F Environment</td><td></td><td>. 1940/214 7</td></t<>			Burtace Ritch Unspecified Burtace #2 TBD A	Lubricant Sr R 0022A Compatible	Peak 0 15 Rotate Speed (rpm) 0.16667	Percent Time: 70 % Low: 150 F Environment		. 1940/214 7
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Constraction         Burler of This         This         Outside This	Reflector Deployment	Harge Needle Bearing	Surface #1 TBO Surface Firith tinuncified	Lutertcation Scheme: Dry Film	Operating 100 Life (years)	Exposure Intermittent	Required to function only during deployment and retraction on orbit.	Roter bearing
Member Is         Bentiser Filter Umpeteited         Description         Offer Amountain         Offer Amo			Surtace #2 TBD	Unspecified SP R 0022A Compatible	Polate Speed (rpm) 0, 16667	Low: -150 F Environment		
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Martiel         Profine         Desires         Failures         Failures <t< td=""><td>ation Power Conversion Unit.</td><td></td><td>Burtace #2 Fed Leaves</td><td>Haltum/Xen</td><td>Rotate Speed (rpm) 32000</td><td>Low: 100 F Environment</td><td>Operating load is given as approximately 100 kW Shaff</td><td>velocity.Volatile fluid (s contained in welded housing. Extreme operating</td></t<>	ation Power Conversion Unit.		Burtace #2 Fed Leaves	Haltum/Xen	Rotate Speed (rpm) 32000	Low: 100 F Environment	Operating load is given as approximately 100 kW Shaff	velocity.Volatile fluid (s contained in welded housing. Extreme operating
Mumerer         Contrast for the Properties of the Multiply Standard Multiply Standard Standard M			Burnace Hansh Unspectived		Occitation Type Continuous	High: 300 F Presentized	Pressure in housing is 20 to 50 psi.	conditions may include tamps -100
Contractive intervention         Prese convertion prove understand bear and intervention         Contractive prove         Contractive prove<	Aste radiator Budd. The Rediator Package of the Bolar Dynamic	Hydrodynamic Journal Bearings	Burtace #1 Motor Shaft Burtace Printh LinuxedBed	Lubrication Scheme: Fluid	Operating 0 Life (years)	Exposure:None	High temperature of 200 deg F in extreme operating conditions.	Hundreds of pounds of votatle coolarm/ubricant contained in sealed
univer     10     10     position for frequestion dystem fruster     Excise first Unspecified     Unspecified     0     0       corractors     expension     standay submedianty and when instand is not going     Bartises first Unspecified     Unspecified     0     0     0       corractors     expension     bartises first Unspecified     Unspecified     0     0     0     0       corractors     expension     bartises first Unspecified     Unspecified     0     0     0     0     0       corractors     expension     bartises first Unspecified     Unspecified     0     0     0     0       corractors     bartises first Unspecified     Unspecified     0     0     0     0     0       corractors     bartises first Unspecified     0     0     0     0     0     0       corractors     bartises first Unspecified     0     0     0     0     0       corractors     bartises first Unspecified     0     0     0     0     0       corractors     bartises first Unspecified     0     0     0     0     0       corractors     bartises first Unspecified     0     0     0     0     0       cores     bartises first Unspeci	alon System has an integrated repetter Centringal Pump.		Burtace #2 Housing Journal	FC76 OYAN ON COMPARING	Poteie Speed (rpm) 0	Low: 0 F Environment	-Operating load gien as "2 fb/sec 60 psid".	coolant loop at 10-20 psi A Moog pump qualified for Peacekeeper
under       1       position       Underside       0 production					Cacillation Type Continuous	High: 100 F Pressuriad		program under consideration
Model         Burlison         Relates         Relation         Number Ist         Number Relation         Number Relatio	te Propulsion System truster moid valve when sciencid is not	Ends of spring at shall and spring step	Burtace #1 Unapecified Burtace Pirtsh Unspecified	Lubrication Scheme: Unspecifie	Operating 0 Life (years)	Exposure:Unspecified Percent Time: 0 %		
Muthole     1     Paulo connector for Proputed Neuron     Derivation     Extende Fields     Under Entrol     Extende Relies     Under Entrol     Extende Relies     Derivation       Contraction:     Preview assembly;     Berliso Fields     Under Entrol     Under Entrol     Entrol </td <td></td> <td></td> <td>Burtace #2 Unapacifiad Burtace Fintsh Unapacified</td> <td>Umspecified O Yes A No</td> <td>Rotate Speed (rpm) 0 Oscillation Type Unspecified</td> <td>Low: 0 F Environment Hagn: 0 F Unspecified</td> <td>1</td> <td></td>			Burtace #2 Unapacifiad Burtace Fintsh Unapacified	Umspecified O Yes A No	Rotate Speed (rpm) 0 Oscillation Type Unspecified	Low: 0 F Environment Hagn: 0 F Unspecified	1	
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Instruction         Burties PC Montry Para         Number ID         Over Table         PC No	of the valve shall on the stem thruster assembly	Gectomagnatic Plans	Surface 61 Fixed Plate Surface Pirish Unspecified	Lubrication Scheme: Unspecifie	Operating 0 Life (years) Peak 0	Exposure:Unspecified Percent Time: 0 %		
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Corractor: use head of the Proputation System Pruster Austraction: assembly: Austraction: a frequencies of the Proputation System Pruster Austraction: a frequencies of view same in calorido where Vane Shalt Quides 11 view same Austraction: of the Proputation System Pruster assembly: Austraction: System Austraction: Austr	tetol fluid fow in the solenoid	Valve Seals/Stems	Burtace 81 Valve Seat	Lubrication Scheme: Unapecilie	Concentration of Life (years)	Exposure:Unspecified		
Notestifine Notestified Notes of value all in transmission of value all in the needed of motion of value all in the needed value all values freeh Unspecified Unspecified O value all in the results are not value all values freeh Unspecified Unspecified O value all in the results are not values freeh Unspecified Unspecified O value all in the results are not value and the needed value all values freeh Unspecified Unspecified O value all in the results are not value and the needed value all values freeh Unspectian Contracting O value all in the results are not value all in the results are not value and the needed value all values freeh Unspectian Unspecified O value all in the results are not value and the needed value all values freeh Unspectian O value allo values freeh Unspectian O values of the out O values O values of the out O values O va	f the Propulsion System truster		Burtace Finish Unspecified	Lubricarie BP R 0022A Compatible	Peart 0 0	Percent Time: 0 %	<b>r</b>	
Number 14     Outdot modern of value stam in solenoid value     Value Shall     Bufface 81 value Shall     Lubrication Bohame. Unspecifie     Pass       Contractori:     of the Propulsion System truster stamming/     Suitace Frank Unspecified     Lubricating     Anal.       Restaurce:     failed modern of value stamming/     Bufface 81 value Shall     Unspecified     Anal.       Restaurce:     failed modern of value stamming/     Bufface 81 value Shall     Lubricating     Anal.       Restaurce:     failed modern of value stamming/     Dummy upark Unspecified     Oval     Oval     Oval       Runne:     15 form a connection between ubding and the Domminy upark Unspecified     Lubrication     Euricate 82 Dummy Spark Unspecified     Oval     Oval       Runne:     Svistee Frash Unspecified     Lubrication     Sovia     Sovia     Oval     Oval			Burtace Finteh Unspecified		Rotate Speed (rpm) 0 Oscillation Type Unspecified	Low: 0.F Environment High: 0.F Unspecified		
Connector: Connector: Animal Surface #2 Vane Bhai Duffes National Paral Animal Surface #1 Types Landon Animal Surface #1	of value stam in solenoid value sion System truster assembly.	Value Shalk Guides	Surface #1 Valve Stem Surface Pirish Lennandard	Lubrication Scheme: Unspecifie	Operating 0 Life (years)	Exposure: Unspecified	-	
Aurone 15 To form a connection between uching and the Dummy spark Up/lear/holing Burlison 81 Tygen Lehng Ludorcation Scheme-Lungeclie Dee Connection: System Encate assembly. Successfor System Encate assembly.			Burlace #2 Vaive Shain Outdes Surtace Pritch Unspecified	Unspecified O Yes O No	Rotate Speed (rpm) 0 Oscillation Type Unspecified	Low: 0 F Environment Mgn: 0 F Unspecified		
Contractor: SYstem throater assembly. Surface #720 Unspecified Luchicam Ser A 0022A Compatible heat tocketchine Surface Prists Unspecified Unspecified O Yes @ No Outsi	mection between tubing and the	Dummy spark igniter/holing	Burtace #1 Tygen subing	Lubrication Scheme: Unspecifie	Operating 0 Life (years)	Exposure:Unspecified		
	ster assembly.		Surface #2 Dummy Spark Igniter	Lubricam Unspecified O Yes (1) No.	Point Speed (rpm) 0	Percent Time: 0 %		
					Oucliation Type Unspectied	Hagn: 0 H Unspecimed		

Survey	Function	Description	Contact	Lubr	ic atton	Load, Life, and Motion	SurvTemperature ( deg F)	Operating Conditions	Соттеги
Number 1	handare attachmant device. Her head boli	Screw Breads/boli	Surface #1 Screw threads	Lubrication Sche	me: Fluid	Operating 0 Life (year	13) Exposure Unspecified		
Contractor:	Propulation S Value Interest 2150 mby.		Surface Rirish	Lubricant		Peak 0	0 Percent Time: 0 %		
Hocke Ryne			Surface #2 Hex head boll Surface Finish Unspecified	14082	2	Rotate Speed (rpm) Oscillation Type Unspecifier	0 Low 0 F Environment		
Number 1	7 handware attactment device, screwbolt		Burtace #1 Screw threads	Lubrication Sche			Evenue I		Contai Infrated at 22 ( ) () how at
Contractor	assembly in the Propusition System thruster		Surface Pinish Unspecified				0 Percent Time 0 %		Soluzza (1 - /*) 22 na membros tauroso
Rockettyne	essential power read.		Burtace #2 Screw Cap Sochel	MoS2	P R 0022A Comparible	Rotate Speed (rpm)	0 Low 0 F Environment	-	
			Surface Britsh Unspecified		Cver Car	Oscillation Type Unspecified	1 High: 0 F Unspecified		•
Number 1	8 Swepsioack to a union (CRES) in propellant Build the connectors of the Promision	contact purisons and screw freads	Burtace #1 Screw Breads	Lubrication Sche	me: Unspecifie	Operating 0 Life (year	13) Exposure Unspecified		
Contactor.	Syttem truster assembly		Surface Firlth Unspecified	Lubricani	P B 0000 Committee	Peak 0	0 Percent Time: 0 %		
Hocker of the			Surface Prinsh Unspecified	Unspecified	92 <b>8</b> 10	Rotate Speed (rpm) Oscillation Type Unspecifier	0 Low: 0 F Environment		
Number 11	To seal the fuel line connection between the	V See	Burtace #1 V-Seat-Inco 718	Lubrication Sche	me. Ory Film	Operating 0 (Life (vers	a) Exposure Linenarian		
Contactor.	the coercol value and the value assembly bracket in the Propulation System thrusher		Surface Rinish Tellon Cealing	Lubricant a			0 Percent Time: 0 %		
Nacketoyne	a sa embiy		Surface #2 Valve Assy Bracket Surface Presh Unservited	Teffon	N N N	Rolate Speed (rpm)	0 Low 0 F Environment		
Marthan 2	a Sea fre correction between the Prossinitar	V San				Oscillation Type Unspecties	1 High: 0 F Unspecified		
Cantacter	system thruster assembly power head and		Burtace Firth Moder (Con Part	Lucrasen scre	ma. Unkpecifie	Operating 0 Life (year	(s) Exposure:Unspectied		
Rockettyme	· combuttion chamber,		Surface 62 Power Haad	Lubricant 8	P R 0022A Compatible		Percent Time: 0 %		
			Surface Finish Unspecified		2 9 1 0	Cacitation Type Unspecified	U LOW: 0 F Environment High: 0 F Unspecified		
Number 2	1 Seal the threaded connection between the	K Seal	Buriace #1 K Saul	Lubrication Sche	me: Unapecitie	Operating 0 Life (year	(s) Exposure: Unspecified	Lubricant is under pressure at the	
Contractor	the Propulsion System Bruster assembly.		Burtace Pirish Unspecified		P 0022A Completion	Peak 0	0 Percent Time: 0 %	contact surface and in vacuum at the	
			Burtace Rinteh Umpecified	Unspecified	2	Rotate Speed (rpm) Oscillation Type Unspecifier	0 Low: 0 F Environment 3 Hoh: 0 F Unspecified		
Mmmer 2	2 O' this seal for the threaded connector on	Two bai ring sads	Burtace #1 Unspectingd	Lubrication Sche	me: Unspecifie	Operating 0 Life (vesi	14) Exposure:Unspecified		
Contactor	Este current spart agene of the Propueson		Burtace Ritch Umpecified	Lubricant			0 Percent Time: 0 %		
Reckettyne			Burtace #2 Unspecified	Unspecified		Rotate Speed (rpm)	0 Low: 0 F Environment		
			SATTACE HITST Unspected			Oscillation Type Unspecified	1 Hgh: 0 F Unspecified		
	3 Valve guides for the Carygen Sciencid Valve of Propulation system	PopperPlurger Tetlen Guides	Burface #1 Popper	Lubrication Sche	me. Ory Film	Operating 0 Life (year	s) Exposure Unapecified		
Contractor			Surface #2 Pturner	Lubricant	P R 0022A Compatible		0 Percent Time: 0 %		
			Surface Rrish Unspecified	Teffor	4 • • • • • • • • • •	Rotate Spaed (rpm) Oscillation Type Unicpectifier	0 Low: 0 F Environment 3 Han: 0 A Unspecified		
Number 2	4 Position the Origan Solenoid Valve of the	Low streets helical spring	Burtace #1 Helical Spring	Lubricason Sche	me: Unspecifie	Constant of the fuer	al Frances Anne		
Contractor	AVE'CS control system in the Space Suation Propulation System when the solenoid is not		Burtace Pirish Unspecified	Lubricant			10 Percent Time: 0 %		
1	- patrolus		Surface #2 Valve Seal	Unspecified	P R 0022A Companies	Rotate Speed (rpm)	0 Low: 0 F Environment		
			Surface Finish Unspecified			Oscillation Type Unspecified	1 High: 0 F Unspecified		
Number 2	the APPCS control system in the Space	Valve head / seal contact	Burtace #1 Valve seat	Lubrication Sche	me: Dry Film	Operating 0 Life (year	(s) Exposure Name		
	Station Propulsion system.		Surface #2 Valve Head	Lubricant St	P R 0022A Compatible	0	10 Percent Time: 0 %		
			Burtace Rinteh Umspecified	(Jedney)	9 9 9	route opera (rpm) Osciliation Type Unspecified	0 Low: 0 F Environment		
Nume	6 Ball Origen Sciencia Valve Components In the APPCS control availant of the Scace	teven Oringe	Burtace #1 OrBing	Lubrication Biche	me: Unspecifie	Operating 0 Life (year	(s) Esposure Name		
Contractor	Station Propulation system.		Burlace Finish Unspecified	Lubricani			10 Percent Time: 0 %		
			Burtace Pirtsh Unspecified	Unspecified	20	Polate Speed (rpm) Declaration Tune (transition	0 Low: 0 F Environment		
Number 2	7 Corrector in the Original Sciencial Value of	Borew Threads	Burlace #1 Screw threads	Lubrication Scha	Me: Unapacifie	Operating of Line (very	et Erposure I hunaritad		
Contractor			Burtace Finish Unspecified	Lubricane		Parts 0	Percent Time: 0 %		
			Burtace #2 Thread Grooves Burtace Antish Unsaccilled	Unspecified	20 1,0	Rotate Speed (rpm)	0 Lew: 0 F Environment		
Number 2	a O Ring sail between latching mechanism	Or three week	Bufface #1 Course and and			UNCERTING LAND UNDECIDED	HIGH: 0 H MURDECINER		
Contractor	cashg and phriger mechanism of the Orygen		Surface Pinish Unspecified	Lubrication 8076	THE: Unspecifie	Operating 0 Life (year	() Exposure:Name		
Proof	Control System of the Space Station		Burtace #2 plunger mechantem	Unspecified	P R 0022A Compatible	Potate Speed (rpm)	0 Low 0 E Entenment		
	Propulsion System		Burtace Rivish Unspecified		2	Oscillation Type Unspecified	High: 0 F Pressurized		
~ Multiple	Assembly and Adjustment Breaded corrections in the Oxygen and Nevogen	Scre Threade	Surface #1 Screw Threads	Lubrication Sche	me: Unspecifie	Operating o Life (year	s) Exposure:Unapecified		
Contractor	Latriting value of the ARPCS Control System		Burtoce Fritsh Unapecified	Lubricant Si	R 0022A Company	- 0 	0 Percent Time: 0 %		
•	usesta uotando i usere ando en la		Burtace Presh Unapecified	Unspection	20	Rolate Speed (rpm) Deciliation Type Unspecified	0 Law: 0 F Environment I Haph: 0 F Unspecified		
Number 3	Piere Seal in the Orygen and Mitogen a structure value in the Abarta Control Section	Surface contact	Burtace #1 Miler seal	Lubrication Sche	me: Unspecifie	Operating 0 Life (year	s) Exposure Name		
Contractor	of the Space Staten Propulsion System		Surface Pinish Unapeched	Lubricam Su	B MOTA Commenter	Pade 0	0 Percent Time 0 %		
Doom			Burlace #2 Miler seal Burlace Pirish Unspecified			Rolate Speed (rpm)	0 Low: 0 F Environment		
						ORCHARION Type Unspectied	High: 0 R Pressurred		

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Survey	Function	Description	Contact	Lubrication	Load, Life, and Motion	SurvTemperature ( deg F)	Operating Conditions	Comment	Т
TE and	O Ring between and cap mechatism and Valve Adhustment mechanism in the Oppoint and		Surface #1 O-Pung	Lubrication Schema: Unspecifie	Operating 0 Life (years)	Exposure Name			
ontractor:	Nitogen Latching Valve of the APPCE Control System in the Space Station		Surface #2 End cap/valve adjust	Unspecified SP R 0022A Compations	Rotate Speed (rpm) 0	Low: 0 F Environment			
	Proputsion system		Surface Rhish Unapecified	2	Oscillation Type Unspecified	High 0 F Pressurized			-
umber 32	Seal the Orygen & Nerogen Latching Valve casing from the electric office motor in the	Bellevile Spring Baal	Surface 91 Butte Spring Inner Surface Phrish Innerestent	Lubrication Scheme: Unspecifie	Operating 0 Life (years) Past	Exposure:Unspecified			
	ARPCS COmo System of the Space Station Propulation System		Surface #2 Buttle Spring Outer Surface Prish Unspecified	Unspecified O Yes O No	Potate Speed (rpm) 0 Oscillation Type Unspecified	Low 0 F Environment High 0 R Unspecified			
umber 33	O Ring to said the Relief Valve to the motor	Orieng	Surface #1 OrBing	Lubrication Scheme: Unspecifie	Operating 0 Lite (years)	Exposure Name			1
on tractor:	case in the ARPCS Control System Orygen and Notrogen Latching Valve of Space Station		Surface Rnish Unspecified	Lubricant SP R 0022A Compatible	Peek 0 10	Percent Time: 0 %			
8	Propulsion Bystem		Surface #2 Relief Valve Surface Pittish Unspecified		Polate Spaed (rpm) 0 Oscillation Type Unspected	Low: 0 F Environment High: 0 F Pressurized			
umber 34	Electric Drive motor actuator for the Orrygen	Bearingul Planetary Gears	Burtace #1 Unapecified	Lubrication Scheme Unspecifie	Operating 0 Life (years)	Exposure: Unspecified			[—
ontactor:	Biston Propulsion System APCS Control		Burtace Prish Unapacified Burtace #2 Linescentiant	Lubricarii 8P A 0022A Compatible	Peak 0 10	Percent Time: 0 %		-	
8	System		Burtaca Pintah Unspecified		Oscillation Type Unspecified	Low: 0 F Environment High: 0 F Unitpecified			
umber 35	Whe Wrap banafers power and data across	Relative Motion & Contact w/	Burlace 61 Wire Wrap	Lubrication Scheme: None Plarn	Operating 0 Life (years)	Exposure Intermitiant			<b>–</b>
ontractor:	Bets John	Structure	Surface Finish Unapecified	Lubricam SP R 0022A Compatible	Past 0 10	Percent Time: 64 %		-	
politicaed			Burtace Fintsh Unspecified	°2 € 10,0	Potate Speed (rpm) 0.00000405 Oscillation Type Continuous	Low: 0 F Environment			
Lumber 38	Beta Joint Control Motor and Gearbox	Bearings / Geans	Surface #1 Unupecified	Lubrication Scheme: Unspecifie	Operating 0 Life (years)	Exposure None			
contractor:			Burtace Finish Umpecified	LUDICETH SP R 0022A Comparison	Pault 0 10	Percent Time: 0 %			
octrimed			Burtace #2 Unspecified Burtace Finish Unspecified		Rotate Speed (rpm) 0 Oscillation Type Unspected	Low: 0 F Environment High: 0 F Vacuum			
Armber 37	Main Bearings in the housing of the Bets Joint	Main Bearings	Burlace 01 true Race	Lubrication Scheme: Unapecifie	Operating 0 Life (years)	Exposure Intermittent			Г
Contractor:	of the Bectrical Power System		Burbace Pintah Umpecified	Lubricari es a 00224 Compatibilit	Part 0 10	Percent Time: 64 %			
odilheed			Burtice #2 Outer Race Burtice Brish Unsolded		Rotate Speed (rpm) 0 Cacitation Tree Investigat	Low: 0 F Environment			
	Reaction in terms of water search asserbity	Besting	Burlana At	I determine former i ter serie					Т
aumber 36 Contractor	of white electrolysis system		Surface Finish Unspecified	Ludricated scrime: Unspecifie	Peak 0 Life (years)	Percent Time: 0 %			
ochreed			Burtace 62	Unipersitied SP R 0022A Compatible	Rotate Speed (rpm) 0	Low 0 F Environment			
									T
Aumber 39 Too karling	Code tak lead pulleys in blanket tersoning	Cattor tair (seed pulleys	Surface 61 pinual Surface Phrish Umapecified	Lubrication Scheme: Dry Film	Operating 0 Life (yaars) Peak 0 10	Exposure:Intermittent Percent Tene: 64 %			
	electrical power		Surface #2 bushing/al	Eventues Br R 0022A Compatible	Rotate Speed (rpm) 0	Low: 0 F Environment			
			Burtace Finten Unapecified		Oscillation Type	HIGH: 0 F Vacuum			Т
Armber 40	Drive motors in the pointing mechanism of solar dynamic system of electrical power	Drive motors	Surface #1 Surface Pinteh Unabacited	Lubrication Scheme: Unapecifie	Operating 0 Life (years)	Exposure:Unspecified			
	system		Surface #2	Working SP R 0022A Computition	Rotate Speed (rpm) 0	Low 0 F Environment			
			Surface Prish Unspecified		Oscillation Type	Mgh: 0 F Unspecified			Т
Amber Al	dynamic system in electrical power system	Canadrocan	Burtace #1 Burtace Pritsh Unupecified	Lubrication Scheme: Unspecifie	Operating 0 Life (years) Pres. 0 10	Exposure:Unspecified Percent Time: 0 %		- L23	
polyment			Burtace #2 Burtace #7	worked Sr A 0022A Compatible Fud	Potate Speed (rpm) 0 Oscillation Type Unspecified	Low: 0 F Environment Han: 0 F Unspecified			
Number 42	Baltacrew in the pointing mechanism of solar An even statem of stateful count sector	Bailscrow	Burtace #1	Lubrication Scheme: Unapecifie	Operating 0 Life (years)	Exposure: Unapecified			
Contractor: octimed			Burtace Press Unapecified Surface P2	Lubricant S.P. R. 0022A. Comparishe Westerno	Peak 0 10 10 Potate Sceed (rpm) 0	Percent Time: 0 %			
			Burtace Prrish Unspecified		Oscillation Type	High: 0 F Unspecified			1
Aumber 43	Actuator to concentrator VF of the pointing mechanism of solar dynamic system of	Actuator to concentrator VF	Surface #1 Surface Prish (pumerited)	Lubrication Bohame: Unspecifie	Operating 0 Life (years)	Exposure: Unspecified			
Contractor; oddmed	sectical power system		Surface #2 Surface Rrish Unsocified	Working Br A 0022A Companies Monking O Yes O No	Rotate Speed (rpm) 0 Occiliation Tune Instruction	Low: 0 F Environment			
tumber 44	, Qas of foll bearings in heat engine of selar	Gas or hell bearings	Burlace 01	Lubrication Scheme: Unspecifie	Operating 0 Life (years)	Exposure Unspecified			<u> </u>
Contractor:	dynamic system of electrical power system		Surface Pintah Unapecified	LUbricari Re a month Commentation	Pert 0 10	Percent Time: 0 %			
addineed			Surface Rintsh Unupecified		Rotate Speed (rpm) 0 Cectitation Type Unspecified	Low: 0 F Environment High: 0 F Unspecified			
Armber 45	Mast base spider bushing in mast cantaler of	Masi base upider bushing	Surface #1 spider bushting/Al.	Lubrication Scheme: Dry Film	Operating 0 Life (years)	Exposure Intermittent	Radiation type: NASA TM-86480		Γ
Contractor: odiheed			Burtace Prilah Unspectied Surtace #2 spider/Ai	Eventude SP R 0022A Compatible	Peek 0 10 10 Polate Speed (rpm) 0	Percent Time: 63 % Low: 0 F Environment			
			Burtace Britsh Unspecified	150 C	Oeciliation Type Intermittent	Hegh. 0 F Vacuum			Т

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No in must cartater of critical power loyer invested in mast array of electrical power array of electrical power	Rilling to epider AL to AL	Surface #1 On and stangA. Surface Arrish Unspecified Surface #2 Phr to spicer/A. Surface Phrsh Innovested	Lubrication Scheme Dry Film Lubricant Scheme Dry Film Lubricant SP R 0022A Compatib Eventude	Cperating 0 Life (year) Peak 0 10 10 10 10 10 10 10 10 10 10 10 10 1	Exposure intermistent Ru Percent Time: 6.3 % No.	adiation type: NASA TM 86460 ormal operating Environment 160°F	
loyer interlace in mass array of electrical power ballbaarings in masi array of electrical power		Surface #2 Pin to spider/AL Burface #2 Pin to spider/AL	Lubricant SP R 0022A Compatib Eventube	Rotate Speed (tpm) 0 0	Percent Time. 63 %. Law: 0 F Environment		
toyer investad in mass array of electrical power ballbearings in meal array of electrical power		Burtace Printi (moveller)		Consisting Type Intermittent	Law: 0 F Environment		
koyet invertace in must array of decretal power ballbaarings in must array of decretal power			520 C	VIBINITIANN and I management	High: 0 F Vacuum		
bathbaarbegs in maal array of electrical power	BORANUI ARADADO DI MANUNANA MERANA	Surface &1 mast ele rollen/N	Lubrication Scheme. Dry Film	Operating 0 Life (years)	Exposure intermittent Ru	aduation Type: NASA The Berleo	
ballbaarings in maai array of electrical power	•	Surface #2 Deployer nut thread	Evertube	Rotate Speed (rpm) 0	Percent Time: 63 %		
array of electrical power		Surface Finish Unspecified		Oscillation Type Intermittent	High: 0 A Vacuum		
	Captoyer musing ballbaarings	Surface #1 nutring bearings/58 Surface Pintsh Unspecified	Lubrication Scheme: Dry Film Lubricani	Concerna 0 Life (years)	Exposure:Intermitient Ru	adiation Type: NASA TM-86460 ormal Operating Environment 160°F	
		Surface #2 Novering bearings/55 Surface Finten Unapedited	Eventube SP R 0022A Comparitie Eventube O Yes O No	Rolais Speed (rpm) 0 Oscillation Type intermitient	Low: 0 F. Environment High: 0 F Vacuum		
ng tri masi of solar array	Butten comer Immg	Burtace #1 Being roller/Al	Lubrication Scheme: Dry Film	Operating 0 Line (years)	Exposure Intermittent	adiation Type NASA THI-BEAGO	
		Burtace Rrish Unapecified Burtace #2 Miting cup/Al.	Lubricant SP A 0022A Compatib	Receit Speed (rpm) 0	Percent Time: 63 %	ormal Operating Environment: 160°F	-
		Surface Finish Unspecified	620 OYM ON	Oscillation Type Intermittent	High: 0 F Vacuum		-
ol pressure control Hr electrolysis system	Bearings	Burtace 41 Burtace Brief ( Incompany	Lubrication Scheme: Unspecifie	Operating 0 Life (years)	Exposure:Unspecified O	perating Load: 300 psi, 180°F,	
		Burtace #2	Lubricant SP R 0022A Compatib Unsocrified	Rotate Sceed (rom) 0	Placent Time: 0 %		
		Surface Prish Unspecified	92 10 11 12 12 12 12 12 12 12 12 12	Oscillation Type Unspecified	High: 0 F Unipecified		
in cover blartial pressed anay of electrical power	Moter phyton gear	Burtace 61 Worn gear/A.	Lubrication Scheme: Dry Film	Operating 0 Life (years)	Exposure intermittent		
		Burtinos #2 Latch member/88	Lubricani SP R 0022A Competito	Potere Speed (rpm) 0	Percent Time: 64 %		
		Burtace Rhish Unspecified	620 O Ym @ M	Oscillation Type Unspecified	HAGN: 0 F Vacuum		
s in ocver blartiel preioad array of electrical power	Meter balltearings	Burtisce of Bearings/58	Lubrication Scheme: Fluto *	Operating 0 Life (years)	Exposure Intermittent		· Grease
		Surface Firth Unspecified	Lubricari SP R 0022A Compatib		Percent Time: 64 %		
		Surface Pinish Unspecified	Braycola O Yea O No	Plotes Speed (rpm) 0 Oscillation Type Unspecified	Low: 0 F Environment High: 0 F Viscum		
over blanket preioad	Lath system	Surface #1 pins in latch/A.	Lubrication Scheme: Dry Film	Operating 0 Life (years)	Exposure intermittent		
aray of electrical power		Burtace Finish Unspecified	Lubricant ap a anota Committe	-	Percent Time: 54 %		
		Surface #2 Bushing in Islov.A. Surface Rinkh Unspecified		Pours Speed (rpm) 0 Oscillation Type Unspecified	Low 0 F Environment		
o rage reel in blankel	Negatar springs to rage neet	Burlace of hub/A or Dehn	Lubrication Scheme: Dry Film	Oberating o Life (veare)	Esposure intermittent		· None for Detrin Hub
Ade whe system in solar al power		Surface Philich Unspecified	Lubricam ca mont C	Per 0	Percent Time: 64 %		
		Burtace #2 Axie/Al. Burtace Prvish Unspecified		Poute Speed (rpm) 0 Oncitation Type Lipscodad	Low: 0 F Environment		
array motors of solar	Limit switches	Surface 81 Pine/88	Lubrication Scheme: Dry Film	Operating 0 Life (years)	Exposure Intermittent		
ment in		Burtace Prish Unspecified	LUDREAM as a month framework	Press 0 10	Percent Time: 64 %		
		Surface #2 Brachats/65 Burface Pinteh Umpeched		Polate Spaed (rpm) 0 Occiliation Type Unspecified	Low: 0 F Environment Han: 0 A Vacum		
nister to beau chive in	InterlaceMast cartoler to beta	Gurlace 81 Mass cartaler/\$68.44.	Lubrication Scheme: Dry Film	Operating 0 Life (years)	Exposure: Intermittent		
		Burtace Presh Unspectated	Lubricarri SP A 0022A Comeante	•	Percent Time: 44 %		
		Burlace Pinteh Unspecified		Poulate Speed (rpm) 0 Oscillation Type Unspecified	Low: 0 F Environment High: 0 F Vacuum		
a in mast motor drive is array of electrical power	Poior ball bearings	Burlace 61 Bearinguras	Lubrication Bicheme: Fluid *	Operating 0 Life (years)	Exposure intermittent		· Grain
		Burtace #2 Race/BB	Braycote D	Proteine Styneed (rpm) 0	Percent Time: 84 % Low: 0 F Environment		
		Burtace Rrish Unspecified		Oscillation Type Unspectfed	High: 0 F Vacum		
l in locking mechanism of chical/mechanisms	chutch or solenoid	Burtace #1 churchoin Burtace Finish Linuxediad	Lubrication Scheme: Unspecifie	Operating 0 Life (years)	Erpowe Unspecified		
		Surface #2 Liseve	Lubricam SP A 0022A Compatib Unspecified	Rotate Speed (rpm) 0	Parcent Time: 0 %		
		Burtace Rivish Unspecified	2 <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b> <b>1</b>	Oscillation Type Unspecified	Hagh: 0 F Unapediled		
or solenoid piction in launch as for box ands of solar	Pur putter platton or solenoid platen	Burtace 81 Piston/Ai Burtace Pinton Umpecified	Lubrication Boheme: Dry Film	Operating 0 Life (years)	Erposure Intermitient		
a power		Surface #2 Sieeve/Al.	Evenue SP R 0022A Compatib	Rotate Speed (rpm)	Low: A E Entroment		·
1		Burtace Retain Unspecified	620 O YM C T	Oscillation Type Unspecified	High: 0 F Vacuum		
Mugal pump of H2 of Muld control system	Bearings	Surface 81 Burtace Printh (Innounteed	Lubrication Boheme: Unspecifie	Operating 0 Life (years)	Exposure: Unspecified		Operating Load 60 pel, 140°F.
		Surface #2	Unspecified SP R 0022A Compatibution	Rotate Speed (rpm) 0	Low: 0 F Environment		
		Surface Mitten Unspectified	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	Oscillation Type Unspecified	High: 0 F Unspecified		
	er excretering system in cover barran present array of electrical power cover barran present array of electrical power array	<ul> <li>In cover blanker presentings</li> <li>In medit presentings</li> <li>In blanker</li> <li>In blanker</li></ul>	Runders of the second	In sectory a year         Cubes Prior         Cubes Prior <thcubes prior<="" th=""></thcubes>	In the field in the price interviewed in the price interviewed in the price interviewed int	In reaction type       Description       Description <thdescription< <="" th=""><th></th></thdescription<>	

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## 4.0 REFERENCES

Dolan, F., "Space Station Long Term Lubrication Studies Contract, 'Kickoff' Meeting", Presentation Charts, National Aeronautics and Space Administration, MSFC/EH14, August 1985.

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"General Specification Vacuum Stability Requirements of Polymeric Material for Spacecraft Application", SP-R-0022A.

# Appendix A Survey Forms

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<b>1</b>							
		SPACE STAT	ON LONG T	CERM LUBI	RICATION S	STUDY	1
	Contractor	Sperry		Su	irvey Numbe	ər1	
	WBS Number	1116112	224131	S	urvey Date	6/18/86	<u> </u>
	Function	SHAFT BEARING	DRIVE ASSE	MBLY			
	Description	Shaft Bea	tring P/N 3H	KR102P7			
	(	Surface #1			Surf	ace #2	
	Contact Surface 4	40 C		Contact Surfa	ice 440 c		
	Surface Finish S	et by Sperry		Surface Finis	sh Set by S	Sperry	
	Surface Treatment			Surface Trea	tment		
: <b>1</b>	Lubrication Sch	eme Fluid	SF	P R 0022A	Compatible	?   Require	d Lite
	Lubricant Micro	onic 601		() Yes	No		20 years
	Total Mass Los	s0	%	CVCM		) %	
	Loads: Operation	ng 1 1	<sup>ib</sup> Peak	2	20 lb Pre	load	1 Ib
	Rotational Spe	ed `	Oscillat	ion None			
	0.5	<sup>rpm</sup> Frequenc	y	0 cycles/ sec	Amplitud	e	0 inches
	Sun Exposure	None		Low Ter	nperature [	8	degrees F
a ko u	% Time	0		High Ter	nperature [	105	degrees F
a <u>e</u> letti 1	Environment	t Gas					
	Vacuum	Liquid					
	Operating Conditions	DN value at 8 F	lpm-min.			· · · · · · · · · · · · · · · · · · ·	
	Non-Operating Conditions						
1 8. 7 1 1 1					<u></u>		
	Comment	Single15mm bor	e ball bearin	g (catalog	number 3Hk	(R102P7 by N	ЛРВ
		Corp.). 400 lb n phenolic.	ax static loa	d capacity.	Cage is Co	onrad machine	) Dé

	SPA	CE STATIO	ON LONG SURVEY F	CERM LUE	BRICATION	STUDY	2
Contractor	Ŀ	Rocketdyn	e	S	urvey Nurr	iber 2	
WBS Number	-	16.2.2.1		\$	Survey Date	e 8/15/86	3
Function	Solar a	array depl	oyment.				
Description	Ŀ	Bearings ir	PV array	deployme	nt motor		
	Surface	#1			Su	irface #2	
Contact Surface	Jnspecifie	d		Contact Surf	ace Unspe	cified	
Surface Finish				Surface Fini	sh		
Surface Treatment				Surface Trea	atment		
Lubrication Sch Lubricant Bray	neme  F cote 60	luid 1	SF	P R 0022A O Yes	Compatib No	ne? Requ	ired Life 10 years
Total Mass Los	s	0	%	CVCM		0 %	<u></u>
Loads: Operati	ng	0	<sup>Ib</sup> Peak		0 ib Pi	reload	0 lb
Rotational Spe 1200	ed <sup>rpm</sup> I	Frequency	Oscillati	on Unspe 0 <sup>cycles/</sup>	ecified Amplitu	de	0 inches
Sun Exposure	Continu	ous		Low Te	mperature	-11	2 degrees F
% Time		100		High Te	mperature	17	76 degrees F
Environmen Vacuum	t	Gas _ Liquid _					
Operating Conditions				· · · · · · · · · · · · · · · · · · ·			
Non-Operating Conditions				<u></u>			
Comment	STS Ca	argo Bay	vibration qu	alification	level.		

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•		SPA	ACE STATI	ON LONG 1 SURVEY F		UBRICATION	STUDY		3
	Contractor		Rocketdyn	IE		Survey Num		3	
L	WBS Number		16.2.2.1			- Survey Date	8/15	/86	
	Function	Rotati	ing nut for	solar array	mast	extension			
	Description		PV array	mast canist	er rota	ting nut			-
	(	Surfac	e #1			Su	rface #2	>	
	Contact Surface	Inspecif	fied		Contact	Surface Unspec	cified		
	Surface Finish				Surface	Finish			
	Surface Treatment				Surface	Treatment			
	Lubrication Sch		Dry Film	SE	P R 002	22A Compatib	le? F		Life
	Lubricant Ever	lube 6	S20		O Yes	s <ul> <li>No</li> </ul>			10 years
	Total Mass Los	s 厂	0	%	CVC	м [	0 %		
	Loads: Operati	ng \_	0	<sup>Ib</sup> Peak		0 ib Pr	eload		0 іь
	Rotational Spe	ed		Oscillat	ion Ur	specified			
	2	rpm	Frequency	/	0 cyc sec	<sup>les/</sup> Amplitu	de [		0 inches
	Sun Exposure	ntern	nittent		Low	Temperature		-112 c	legrees F
1 K. J 1 p. J	% Time		50		High	Temperature		<u>176</u> с	legrees F
: •	Environmen	t	Gas						
	Vacuum		Liquid		Service and the service of the servi				
	Operating Conditions								
	Non-Operating Conditions				· · <u>·</u>	<u></u>		ti	
	-								
	Comment	STS	Cargo Bay	qualification	n vibrat	tion level			
· · · ·		<b></b>	,		-	· · · · ·			

	SP	ACE STATI	ON LONG SURVEY F		RICATION	STUDY	4
Contractor		Rocketdyn	e	Su	rvey Numb	er 4	
WBS Number	-	· · ·		Su	urvey Date	8/13/86	
Function	Provid reflec	de fine poir ctor.	nting actuat	ion of Sola	r Dynamic	Concentrator	
Description		Actuator n	notor bearir	ngs,threads,	nuts		
	Surfac	e #1			Surf	ace #2	
Contact Surface	BD stee	1		Contact Surfac	ce TBD stee	el	
Surface Finish	IBD			Surface Finis	h TBD		
Surface Treatment	BD			Surface Treat	mentTBD		
Lubrication Sch Lubricant TBD	neme	Fluid	SF	P R 0022A O Yes	Compatible No	? Require	d Life 10 years
Total Mass Los	s L	0	%		C	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	
Loads: Operati	ng 📃	100	<sup>Ib</sup> Peak	20	<mark>0</mark> ıь Pre	load	0 ib
Rotational Spe	ed		Oscillat	ion Interm	ittent		
60	rpm	Frequency		2 cycles/ sec	Amplitud	e [	0 inches
Sun Exposure	None			Low Tem	perature	-140	degrees F
% Time [		0		High Tem	perature	140	degrees F
Environment	t	Gas	·····				
Vacuum		Liquid [	· · · · · · · · · · · · · · · · · · ·				
Operating Conditions	<.1 H:	z continuou	s oscillation	l.			
Non-Operating Conditions	NSTS	Cargo Bat	Environmen	ts			
Comment	for ad Rockfo actuat	ditional info ord, Illinois, or.	ormation, co 61125. Di	ontact Sund ual faulure	strans Ene tolerant el	rgy Systems, ectromechani	cal

	······································	<ul> <li>Contact and the second s</li></ul>	······
	SPACE STATION LON	IG TERM LUBRICATION STUDY	5
Contractor	Rocketdyne	Survey Number 5	
WBS Number	· · · · · · · · · · · · · · · · · ·	Survey Date 8/13/86	
Function	Solar Dynamic Concentr	rator deployment latch catch mechanisn	n.
L Description	Catch Journal		
(	Surface #1	Surface #2	
Contact Surface	BD	Contact Surface TBD	
Surface Finish	nspecified	Surface Finish Unspecified	
Surface Treatment	nspecified	Surface Treatment Unspecified	<del></del>
Lubrication Sch Lubricant TBD	eme Dry Film	SP R 0022A Compatible? Require O Yes  No	d Life <u>15</u> <sup>year</sup>
Total Mass Loss	s <u> </u>	CVCM0 %	
Loads: Operatir		eak 0 ю Preload	0 Ib
Rotational Spee	ed Osc	illation Intermittent	
0 r	Frequency	o sec Amplitude	0 inches
Sun Exposure	ntermittent	Low Temperature 0	degrees F
% Time	70	High Temperature 0	degrees F
Environment	Gas		
Vacuum	Liquid		
Operating Conditions			
Non-Operating Conditions			
Comment	Required to function on concentrator. Journal be	ly during deployment or retraction of earing with <0.5 inch radius	

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SP	ACE STATION LONG SURVEY F	TERM LUBRICATION STUDY	6
Contractor	Rocketdyne	Survey Number 6	
WBS Number	_ · · ·	Survey Date 8/13/86	
Function Fine	Pointing for the Solar	Dynamic Concentrator	
Description	Universal Joint Journ	al Bearings	J
Surfa	ce #1	Surface #2	
Contact Surface TBD AI		Contact Surface TBD AI	
Surface Finish Unspec	fied	Surface Finish Unspecified	. <u></u> .
Surface TreatmentUnspec	fied	Surface Treatment Unspecified	
Lubrication Scheme Lubricant Unspecific	Dry Film SF	P R 0022A Compatible? Required	Life 15 years
Total Mass Loss	0 %	CVCM0 %	
Loads: Operating	0 <sup>Ib</sup> Peak	0 ю Preload	0 Ib
Rotational Speed 0.16667 rpm	Oscillat Frequency	ion TBD 0 <sup>cycles/</sup> Amplitude	0 inches
Sun Exposure Intern	nittent	Low Temperature	egrees F
% Time	70	High Temperature 150 d	egrees F
Environment Vacuum	Gas Liquid		
Operating Conti Conditions	nuous, low load, low v	elocity, random motion.	
Non-Operating Conditions			
	al bearing radius given	as "TRD 2 inches"	

1.11.1

1 1012

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	SP	ACE STATION LONG T	TERM LUBRICATION STUDY	7
نصة	Contractor	Rocketdyne	Survey Number 7	
	WBS Number	-	Survey Date 8/13/86	
	Function Con	centrator Reflector Dep	oloyment	
	Description	Hinge Needle Bearing		
	Surfa	ace #1	Surface #2	
	Contact Surface TBD		Contact Surface TBD	
	Surface Finish Unspec	cified	Surface Finish Unspecified	
	Surface TreatmentUnspec	sified	Surface Treatment Unspecified	
	Lubrication Scheme	Dry Film SI	P R 0022A Compatible? Require	d Life
-	Lubricant Unspecifi	ed	O Yes	<u>15</u> years
	Total Mass Loss	0 %	CVCM0 %	
	Loads: Operating	100 lb Peak	150 ib Preload	0 іь
1::::: 1:::::: 1::::::	Rotational Speed	Oscillat	ion None	
	0.16667 rpm	Frequency	0 <sup>cycles/</sup> Amplitude	0 inches
	Sun Exposure Inter	mittent	Low Temperature -150	degrees F
-	% Time	70	High Temperature 150	degrees F
	Environment	Gas		
÷;	Vacuum	Liquid		
-	Operating Req Conditions	uired to function only c	during deployment and retraction o	n-orbit.
•	Non-Operating Conditions	· ·		
-	Comment Roll	er bearing		

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	SPACE STATION LONG SURVEY I	TERM LUBRICATION STUDY	8
Contractor	Rocketdyne	Survey Number 8	
WBS Number	-	Survey Date 8/15/86	
Function	Altenator foil journal and th Cycle Solar Dynamic Power	hrust bearings for the Closed Brayton r Generation Power Conversion Unit.	n
Description	Rotor/Housing Interf	ace	-
	Surface #1	Surface #2	
Contact Surface	Rotor Journal	Contact Surface Foil Leaves	
Surface Finish	Unspecified	Surface Finish Unspecified	
Surface Treatment	Unspecified	Surface TreatmentUnspecified	
Lubrication Sc Lubricant Heli	heme Fluid S um/Xenon (MW=40)	P R 0022A Compatible? Required	Life 30 years
Total Mass Los	ss0 %	CVCM0 %	
Loads: Operat	ing 0 <sup>Ib</sup> Peak	0 Ib Preload	0 Ib
Rotational Spe 32000	ed Oscillat <sup>rpm</sup> Frequency 1	tion <mark>Continuous</mark> 060 <sup>cycles/</sup> Amplitude (	) inches
Sun Exposure	None	Low Temperature 100 de	egrees F
% Time	0	High Temperature 300 de	egrees F
Environmen Pressurized	it Gas Helium/Xen Liquid	on (MW=40)	
Operating Conditions	Rotor lubricant inventory is Operating load is given as housing is 20 to 60 psi.	approximately 4 lbs of lubricant. "approximately 100 kW Shaft". Pressu	ire in
Non-Operating Conditions			
_	Journal Bearing with 2.726	inch radius operating at a 760 fps r	elative

	SP/	ACE STATION LONG T	ERM LUBRICATION	STUDY	9
	Contractor	Rocketdyne	Survey Num	iber 9	
	WBS Number		Survey Dat	e 8/15/86	
- · · · · · · · · · · · · · · · · · · ·	Function Pump of the motor	to circulate radiator flue Solar Dynamic Power shaft/impeller Centri	uid. The Radiator Co Generation System fugal Pump.	polant Pump Pa has an integrat	ckage ed
	Description	Hydrodynamic Journal	Bearings		_
	Surfac	:e #1	Su	urface #2	
	Contact Surface Motor S	haft	Contact Surface Housi	ng Journal	
	Surface Finish Unspeci	fied	Surface Finish Unspe	ecified	
_	Surface TreatmentUnspeci	ied	Surface Treatment Unspe	ecified	
				Bequire	d Life
	Lubricant EC75 Imm	ersion Sr	OYes ONo		20 years
					<u></u>
	Total Mass Loss	0 %		0 %	
	Loads: Operating	0 <sup>Ib</sup> Peak	0 в Р	reload	0 lb
	Rotational Speed	Oscillat	ion Continuous		
		Frequency	<u> </u>	ude [	0 inches
	Sun Exposure None		Low Temperature	0	degrees F
	% Time	0	High Temperature	100	degrees F
	Environment	Gas			
	Pressurized	Liquid FC75 Imme	rsion		
	Operating Conditions Opera	temperature of 200 deg ating load gien as "2 lb	g F in extreme oper /sec 60 psid".	ating conditions.	
	Non-Operating Low 1 Conditions	emperature extreme of	-100 deg F in non-	operating mode	
				contained in a	
	Comment Hund coola progr	reds of pounds of vola nt loop at 10-20 psi. A am under consideration	Moog pump qualifie n	d for Peacekeep	Der
		- 19: - 19:	C-2		

C-2

	SPACE STATION LONG SURVEY	TERM LUBRICATION STUDY	10
Contractor	Rocketdyne	Survey Number 10	
WBS Number	· · · ·	Survey Date 8/4/86	
Function To wh	position the Propulsion nen solenoid is not engag	System thruster assembly solenoid ged.	valve
Description	Ends of spring at sh	naft and spring stop	
Su	urface #1	Surface #2	
Contact Surface Uns	pecified	Contact Surface Unspecified	
Surface Finish	pecified	Surface Finish Unspecified	
Surface TreatmentUns	pecified	Surface Treatment Unspecified	
Lubrication Schen Lubricant Unspec	ne Unspecifie Stified	SP R 0022A Compatible? Required	d Life O years
Total Mass Loss	0 %	CVCM0 %	<u> </u>
Loads: Operating	0 <sup>Ib</sup> Peak	с 0 ю Preload	0 Ib
Rotational Speed	Oscilla	ation Unspecified	
0 rpm	Frequency	0 <sup>cycles/</sup> Amplitude	0 inches
Sun Exposure Un	specified	Low Temperature 0	degrees F
% Time	0	High Temperature0	degrees F
Environment	Gas		
Unspecified	Liquid		
Operating Conditions			
Non-Operating Conditions			
Comment		· · · · · · · · · · · · · · · · · · ·	

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		SP/	ACE STATI	ON LON SURVE	IG T EY F	ERM LUB	RIC	ATION S	STUE	)Y		11
	Contractor		Rocketdyn	е		S	urve	y Numbe	er [	11		
	WBS Number	-				S	urve	ey Date	8/	5/86		_
	Function	Fluid	connector	for Prop	ousli	on Syster	n th	ruster a	ssen	n <b>bly</b> .		
	Description		Screw thre	ads on	pro	pellant fee	əd li	ines				
	(	Surfac	ce #1					Surfa	ace	#2		
نى يەر سېي	Contact Surface	lale cor	nnector			Contact Surf	ace	Female c	оппе	ctor		
	Surface Finish	Inspeci	fied		;	Surface Fini	sh	Unspecif	ied			- <u></u>
	Surface Treatment	Inspeci	fied			Surface Trea	atme	nt Unspecif	ied			
	Lubrication Sch	ieme	Unspecifie		SF	PR 0022A	Co	ompatible	?	Requir	ed	Life
	Lubricant Unsp	ecifie	ed			() Yes	•	) No				0 years
	Total Mass Los	s 🗋	0	%		CVCM [		C	%			
	Loads: Operati	ng 🕒	0	њ Ре	ak [	1992 Walt	0	ib Pre	load			0 lb
	Rotational Spe	ed		Osci	illat	ion Unsp	ecifi	ed				
	0	rpm	Frequency	/		0 cycles/ sec	A	mplitud	e [		0	, inches
	Sun Exposure	Jnspe	cified			Low Te	mpe	erature [		(	) de	grees F
	% Time	·	0			. High Te	mpe	erature			) de	grees F
	Environmen	t	Gas									
	Unspecified		Liquid									
	Operating Conditions											
-	Non-Operating Conditions											
-	Comment											
سيم		L										

	SP	ACE STAT	ION LONG SURVEY F	TERM LUE	RICATION	STUDY	12		
Contractor		Rocketdyr	ne	S	urvey Num	ber 12			
WBS Number	-			S	urvey Date	8/5/86			
Function	Affect assen	t motion of nbly soler	the valve to the valve.	shaft on th	ne Propulsi	ion System th	nruster		
Description		Electroma	gnetic Plat	es					
	Surfac	e #1			Su	rface #2			
Contact Surface	Fixed Pla	ate		Contact Surf	ace Moving	Plate			
Surface Finish	Jnspecif	ied		Surface Fini	sh Unspe	cified			
Surface Treatment	Jnspecif	ied		Surface Trea	atmentUnspe	cified			
Lubrication Sch Lubricant Unsp	neme ( pecifie	Unspecifie d	) SF	P R 0022A O Yes	Compatib	le? Requir	ed Life 0 years		
Total Mass Los	s	0	%	сусм [		0 %			
Loads: Operati	ng [	0	<sup>Ib</sup> Peak		<u>0</u> ю Pr	eload	0 lb		
Rotational Spe	rpm	Frequency	Oscillat	ion Unspe 0 <sup>cycles/</sup>	ecified Amplitu	de [	0 inches		
Sun Exposure	Unspe	cified		Low Te	mperature	C	degrees F		
% Time		0		High Te	mperature	c	degrees F		
Environmen	t	Gas							
Unspecified		Liquid							
Operating Conditions									
Non-Operating Conditions							,		
Comment									
 1 1							_		
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		SPACE STATI	ON LONG T		BRICATION S	TUDY	13		
	Contractor	Rocketdyn	e	S	Survey Number	13			
	WBS Number				Survey Date	8/5/86			
Lida and a fac.	Function	Permit or restric Propulsion Syste	t fluid flow em thruster	in the so assembly	lenoid valve h /.	nead of the			
	Description	Valve Sea	ats/Stems						
	(	Surface #1			Surfac	ce #2			
	Contact Surface Va		Contact Sur	face Valve Ster	1				
	Surface Finish	specified	Surface Fir	nish Unspecifie	d				
	Surface TreatmentUr	nspecified	Surface Treatment Unspecified						
						Bequired	l l ife		
	Lubrication Sche	ame Unspecifie	5P		Compatible?     No		0 vears		
	Total Mass Loss	0	%	CVCM	0	%	<u></u>		
	Loads: Operatin	g0	<sup>ib</sup> Peak		<u>0</u> њ Prelo	bad	0 lb		
	Rotational Spee	d	Oscillat	ion Unsp	pecified				
	0 r	<sup>pm</sup> Frequency	·	0 cycles	<sup>67</sup> Amplitude		0 inches		
	Sun Exposure U	nspecified		Low Te	emperature	0 c	legrees F		
	% Time	0		High Te	emperature	<u> </u>	legrees F		
	Environment	Gas							
	Unspecified	Liquid [							
	Conditions								
	L								
	Non-Operating								
;	Conditions								
-									
	Comment								
	L					<u>_</u>			

	SPACE ST	ATION LONG SURVEY F		ATION STUDY	14
Contractor	Rocket	dyne	Surve	y Number14	-
WBS Number	· •	• •	Surve	ey Date 8/5/86	
Function	Guide motion thruster asse	of valve stem embly.	in solenoid va	live of the Propuls	sion System
Description	Valve S	Shaft Guides		······	
	Surface #1			Surface #2	
Contact Surface	/alve Stem	· · · · · · · · · · · · · · · · · · ·	Contact Surface	Valve Shaft Guides	
Surface Finish	Inspecified		Surface Finish	Unspecified	
Surface Treatment	Inspecified		Surface Treatmen	tUnspecified	
Lubrication Sch Lubricant Unsp	neme Unspec pecified	i <u>fie</u> SF	PR 0022A Co OYes O	mpatible? Requ No	uired Life 0 years
Total Mass Los	s	0 %		0 %	
Loads: Operati	ng	0 <sup>Ib</sup> Peak	0	ь Preload	0 Ib
Rotational Spe	ed <sup>rpm</sup> Freque	Oscillat	ion Unspecifie 0 <sup>cycles/</sup> A	ed mplitude	0_ inches
Sun Exposure	Unspecified		Low Temper	rature	0 degrees F
% Time	0		High Temper	rature	0 degrees F
Environmen	t Ga	s			
Unspecified	Liqui	d	· · · · · · · · · · · · · · · · · · ·		
Operating Conditions					
Non-Operating Conditions			<u>i</u>		: 
Comment					

		SPA	CE STATI	ON LONG SURVEY I		ICATION ST	UDY	15		
	Contractor	<u></u>	Rocketdyr	1e	Survey Number15					
	WBS Number		· · ·		Survey Date 00/00/00					
	Function	rm a conne ropulsion (	ection betwe SYstem thru	een tubing an uster assemb	id the dumm ly.	y spark ign	iter in			
	Description Dummy spark igniter/tubing connection									
	(	Surfac	e #1			Surface	a #2			
	Contact Surface Tygon tubing				Contact Surface	e Dummy Sp	ark Igniter			
	Surface Finish	nspecif	ied		Surface Finish	Unspecified	<u> </u>			
	Surface Treatment	nspecif	ied		Surface Treatm	nent Unspecified	<u>i</u>			
						<b>.</b>	Roquire			
	Lubrication Scheme Unspecifie									
 	Lubricant Unsp	ecifie	a	······································	0 165					
- a.k 4 	Total Mass Loss	s [	0	%	сусм	0	%			
	Loads: Operatir	g	0	<sup>Ib</sup> Peak	(	) ıs Prelo	ad	0 іь		
	Rotational Spee	əd		Oscilla	tion Unspec	ified				
		rpm	Frequency	y [	O cycles/ sec		0 inches			
	Sun Exposure L	Jnspe	cified		Low Tem	perature	0	degrees F		
	% Time [		0		High Tem	perature	0	degrees F		
	Environment		Gas							
	Unspecified		Liquid							
	Operating						<u></u>			
	Conditions									
	Non-Operating				<u> </u>					
	Conditions									
	Commont									
	Comment									
an and a second se										

	SPA	CE STAT	ION LONG	TERM LUB	RICATION	STUDY	16
Contractor		Rocketdyr	1e	Si	urvey Numb	er <u>16</u>	
WBS Number	· •	· · ·		s	urvey Date	8/5/86	
Function	n hardare attachment device. Hex head bolt asembly in the valve brace assembly of the Propulsion SYstem thruster assembly.						
Description		Screw th	reads/bolt				
(	Surfac	e #1			Surf	ace #2	
Contact Surface	crew th	reads		Contact Surfa	ace Hex head	d bolt	
Surface Finish	Surface Finish					fied	
Surface Treatment	· · · · · · · · ·		Surface Trea	itment Unspeci	fied		
Lubrication Sch Lubricant MoS2	eme [	Fluid	SF	P R 0022A O Yes	Compatible No	equire	d Life 0 years
Total Mass Loss	s [	0	%	сусм [	C	) %	
Loads: Operatir	ng 📘	0	<sup>ib</sup> Peak		0 в Рге	load	0 Ib
Rotational Spec	ed rpm	Frequency	Oscillat	ion Unspe 0 <sup>cycles/</sup>	ecified Amplitud	e	0 inches
Sun Exposure	Jnspe	cified		Low Ter	nperature	0	degrees F
% Time		0		. High Ter	nperature	0	degrees F
Environment	:	Gas			······································		
Unspecified		Liquid					
Operating Conditions							
Non-Operating Conditions							
Comment							

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		SPA	CE STAT	ION LON	G TERM L Y FORM	UBRIC	ATION ST	JDY	17
	Contractor		Rocketdyr	ne	n - 197 - En anno 19 - En agus	Surve	y Number	17	
	WBS Number	-	· ·			Surve	y Date 8	/4/86	
	Function	hardwa Systen	are attach n thruster	iment dev assembly	vice. screw y power h	v/bolt a ead.	ssembly in	the Propu	uslion
. <u>.</u> .	Description	L							
	(	Surface	#1	<u> </u>			Surface	#2	
	Contact Surface Sc	crew thr	eads		Contact	Surface	Screw Cap S	Socket	
	Surface Finish	nspecifie	ed		Surface	Finish	Unspecified		
فسا ا	Surface TreatmentUr	nspecifie	ed		Surface	Treatmer	Unspecified		
	Lubrication Sche Lubricant MoS2	eme [F	Fluid		SP R 002	22A Co s <b>()</b>	mpatible?	Require	d Life <u>0</u> years
	Total Mass Loss	 ;	0	%	CVCI	м [	0	%	
	Loads: Operatin	 1g	C		ak	0	њ Preloa	ad	0 іь
	Rotational Spee	ed be		 Oscil	lation Ur		ed		
	r	pm	Frequenc	y	0 cyc	les/ A	mplitude		0 inches
	Sun Exposure	Jnspec	cified		Low	Tempe	rature	0	degrees F
	% Time		0	•	High	Tempe	rature	0	degrees F
	Environment	<b>,</b>	Gas						
	Unspecified		Liquid						
	Operating Conditions				-				
	Non-Operating Conditions								
	Comment	Socket	torqued	to 22 (+/	/- 1) inch-	lbs.			
	L	anna aire iste P		<u>+</u>	B. Ft. 14. 1 				

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		SPAC	E STATIC	N LONG T	ERM LU	JBRIC	ATION ST	UDY		18
	Contractor	R	ocketdyne	)	-	Survey	/ Number	18		
	WBS Number		· · · · · · · · ·			Surve	y Date	8/6/86		_
	Function F	Swagelo Propulsi	ack to a on Syste	union (CRE m thruster	ES) in pi assemb	ropellai oly.	nt fluid lin	e connec	ctors	of the
	Description	cc	ontact sur	faces and	screw t	hreads				
	(5	Surface	#1				Surfac	e #2		
Ħ	Contact Surface Sci	rew threa	ıds	Contact Surface Unspecified						
	Surface Finish Unspecified				Surface F	Finish	Unspecified	d		
	Surface TreatmentUnspecified				Surface T	<b>'rea</b> tmen	Unspecified	d		
	Lubrication Sche	me llir	Ispecifie	SF	B 0022	PA Co	mpatible?	Requ	ired	Life
	Lubricant Unspe	ecified			O Yes	•	No			0 years
	Total Mass Loss		0	%	CVCM		0	%		
	Loads: Operating	g	0	<sup>Ib</sup> Peak		0	ib Prelo	ad		0 ib
	Rotational Speed	d	Oscillation Unspecified				_			
	0 rp	<sup>pm</sup> F	Frequency		0 <sup>cycles/</sup> Amplitude				0	inches
	Sun Exposure U	nspecif	ied		Low <sup>-</sup>	Temper	rature		0 de	grees F
<u>t</u>	% Time		0		High <sup>-</sup>	Tempe	rature	······································	0 de	grees F
	Environment		Gas [							
	Unspecified		Liquid [							
	Operating Conditions				Colone (17 19					
	Non-Operating Conditions									
	Comment									

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<u>19</u> 6 I valve and uster
6 I valve and uster
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 t
t
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<u></u>
equired Life
0 lb
0_ inches
0 degrees F
0 degrees F

	SPACE S	SUF	ONG T	ERM LUB	RICA	TION ST	UDY		20
Contractor	Rocke	etdyne	· .	Si	urvey	Number	20		
WBS Number	-			S	urvey	Date 8	8/5/86		_
Function	Seal the co power head	nnection b and comb	etwee ustion	n the Prop chamber.	pulsio	n system	thruster	ass	embly
Description	V Sea	L							
(	Surface #1					Surface	#2		
Contact Surface	-Seal-Inco 718	3		Contact Surfa	ace [	Power Head			
Surface Finish Modified Gold Plated			Surface Fini	sh [	Unspecified	 			
Surface TreatmentUnspecified				Surface Trea	atment	Unspecified	l	<b></b>	
Lubrication Sch	eme Unspe	cifie	SP	R 0022A O Yes	Com	npatible?	Requ	ired	Life O year
Total Mass Los	S [	%		CVCM [		0	% 		
Loads: Operatin	ng [	<u> </u>	Peak [	e.e.	<u>0</u> ib	Preloa	ad [		<u> </u>
	r <sup>pm</sup> Frequ	ency	scillati	on Unspe 0 <sup>cycles/</sup> sec	Arr	plitude [		- 0	inches
Sun Exposure	Jnspecified			Low Te	mpera	iture		0 de	grees F
% Time	0			High Te	mpera	iture		0 de	grees F
Environment	1 (	àas							
Unspecified	Liq	biu							
Operating Conditions									
Non-Operating Conditions									
Comment						• •			

	SPACE STATION LONG	G TERM LUBRICATION STUDY 21						
Contractor	Rocketdyne	Survey Number 21						
WBS Number	- · ·	Survey Date 8/5/86						
Function	Inction Seal the threaded connection between the Dummy Spark Igniter and the Power Head in the Propulsion System thruster assembly.							
Description	K Seal							
(	Surface #1	Surface #2						
Contact Surface	( Seal	Contact Surface Power Head						
Surface Finish	Inspecified	Surface Finish Unspecified						
Surface Treatment	Inspecified	Surface Treatment Unspecified						
Lubrication Sch Lubricant Unsp	neme Unspecifie	SP R 0022A Compatible? Required Life O Yes  No						
Total Mass Los	s %	CVCM0 %						
Loads: Operati	ng0 <sup>Ib</sup> Pea	k 0 ю Preload 0 ю						
Rotational Spec	ed Oscill <sup>rpm</sup> Frequency	ation Unspecified 0 cycles/ Amplitude0 inches						
Sun Exposure [ % Time	Unspecified 0	Low Temperature 0 degrees F High Temperature 0 degrees F						
Environment	Gas							
Unspecified	Liquid							
Operating Conditions	Lubricant is under pressur the outer edge of the con	e at the contact surface and in vacuum at tact surface.						
Non-Operating Conditions								
Commont								

		 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -		
-	S	PACE STATION LONG SURVEY	TERM LUBRICATION STUDY	22
	Contractor	Rocketdyne	Survey Number 22	
	WBS Number		Survey Date 8/4/86	
	Function "O" the	ring seal for the thread Propulsion System thr	led connector on the Dummy Spark Ig uster assembly.	niter of
	Description	Two flat ring seals		-
	Sur	face #1	Surface #2	
	Contact Surface Unspe	cified	Contact Surface Unspecified	
	Surface Finish Unspe	cified	Surface Finish Unspecified	
	Surface TreatmentUnspe	cified	Surface TreatmentUnspecified	
а.а	Lubrication Scheme	e Unspecifie S	P R 0022A Compatible? Required	Life
a state	Lubricant Unspecif	fied	○ Yes	0 years
	Total Mass Loss	0 %	CVCM0 %	
J	Loads: Operating	0 lb Peak	0 в Preload	0 lb
	Rotational Speed	Oscilla	tion Unspecified	
_	0 rpm	Frequency	0 <sup>cycles/</sup> Amplitude	0 inches
نع	Sun Exposure Uns	pecified	Low Temperature 0	legrees F
	% Time	0	High Temperature 0 d	legrees F
1	Environment	Gas		
	Unspecified	Liquid		
	Operating			
-	Conditions			
-	Non-Operating Conditions	•		
~	Comment			
_		· . · W. ·		

S	PACE STATION LONG	TERM LUBRICATION STUDY	23			
Contractor WBS Number Function Valv	Moog	Survey Number 2 Survey Date 8/6/86 An Solenoid Valve of Propulsion	3 System			
Description	Poppet/Plunger Teflo	on Guides	J			
Surface Surface Poppe Surface Finish Teflon Surface TreatmentUnspe	ace #1 t Coating cified	Surface       #2         Contact Surface       Plunger         Surface Finish       Unspecified         Surface Treatment       Unspecified				
Lubrication Scheme Lubricant Teflon	Dry Film S	SP R 0022A Compatible? Rec O Yes  No	quired Life 0 years			
Total Mass Loss	0 %	CVCM 0 %				
Loads: Operating	0 <sup>Ib</sup> Peak	0 lb Preload	0 lb			
Rotational Speed	Oscilla Frequency	tion Unspecified 0 cycles/ Amplitude0 inches				
Sun Exposure Unsp	pecified	Low Temperature	0 degrees F			
% Time	0	High Temperature	0 degrees F			
Environment Unspecified	Gas Liquid					
Operating Conditions						
Non-Operating Conditions						
Comment						

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	SI	PACE STATIC	ON LONG T	ERM L	UBRIC	ATION	STUDY	24
	Contractor	Moog			Surve	y Numb	per 24	
	WBS Number		······································		Surve	y Date	8/6/86	
1 (1997) 1 (	Function Pos the	ition the Oxy Space Statio	gen Solenoid n Propulsior	d Valve Syster	of the m when	ARPCS the so	S control syste plenoid is not	em in engaged
	Description	Low stress	s helical sp	oring				
	Sur	face #1				Sur	face #2	
	Contact Surface Helica	I Spring		Contact	Surface	Valve S	eat	
	Surface Finish Unspe	Surface Finish Unspecified				Unspec	ified	
	Surface TreatmentUnspe	cified		Surface	Treatmen	Unspec	lified	
	Lubrication Scheme Lubricant Unspeci	e Unspecifie fied	SF	P R 002	22A Co 6	mpatibl No	e? Require	d Life 10 years
<u>=</u>	Total Mass Loss	0	%	CVCI	м [		0 %	
تحت	Loads: Operating	0	<sup>Ib</sup> Peak		0	ıь Pr	eload	0 іь
	Rotational Speed		Oscillat	ion Un	specifi	ed		
	0 rpm	Frequency		O cyc sec	les/ A	mplitu	de	0 inches
	Sun Exposure None	)	······	Low	Tempe	rature	0	degrees F
	% Time	0		High	Tempe	rature	0	degrees F
<u>L</u>	Environment	Gas						
	Unspecified	Liquid [						
	Operating Conditions							
	Non-Operating Conditions							
	Comment							
	L			· · · · · ·				

	SPA	ACE STAT	ION LONG SURVEY F			STUDY	2 5
Contractor		Moog		Sur	vey Numb	er 25	
WBS Number	-	· ·		Su	rvey Date	8/6/86	
Function	Valve in the	seat for the Space St	ne Oxygen S tation Propu	Solenoid Valv Ision system	ve of the .	ARPCS contro	l system
Description		Valve hea	id / seat co	ntact			
(	Surfac	e #1			Sur	face #2	
Contact Surface	alve sea	at		Contact Surfac	e Valve He	ad	]
Surface Finish	ied		Surface Finish	Unspec	ified		
Surface TreatmentU	nspecifi	ied		Surface Treatm	nent Unspec	fied	
Lubrication Sch Lubricant Polyi	eme   mide	Dry Film (Vespel)	SF	P R 0022A O Yes	Compatible No	e? Required	d Life <u>10</u> years
Total Mass Loss	s	0	%	СУСМ		<u>)</u> %	
Loads: Operatir	ng 📃	0	<sup>Ib</sup> Peak	(	<u>)</u> њ Pre	load	0 іь
Rotational Spee	əd rpm	Frequency	Oscillat	ion Unspec	ified Amplituc	le	0 inches
Sun Exposure	None			Low Tem	perature	0	degrees F
% Time		0		High Tem	perature	0	degrees F
Environment		Gas		···· • •			
Unspecified		Liquid			<u>_</u> _		
Operating Conditions							
Non-Operating Conditions						-	
Comment							

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-		SPA	CE STAT		LONG JRVEY F	ORM	BRIC	ATION STU		26
<b>C.</b> (64.1).	Contractor		Moog				Surve	y Number	26	
	WBS Number	-		- i			Surve	ey Date 8	/18/86	
	Function	Seal ( of the	Oxygen So Space S	lenoi	d Valve Propu	Compone Ision syst	ents i tem.	in the ARPC	S control	system
	Description	<b>.</b>	Seven O-	rings					<u></u>	
	(	Surfac	e #1					Surface	#2	
Lläd	Contact Surface	) Ring				Contact Su	rface	Various		
	Surface Finish	Inspecif	ied			Surface Fi	nish	Unspecified		
	Surface Treatment	Inspecif	ied			Surface Tr	eatme	ntUnspecified		
	Lubrication Sch	eme	Unspecifi	Э	S	P R 0022	A Co	ompatible?	Require	d Life
	Lubricant Unsp	ecifie	d			O Yes	۲	) No		10 years
	Total Mass Los	s 🗌	0	%		CVCM		0 %	, o	
	Loads: Operati	ng 🕒	С	lb	Peak		0	њ Preloa	d	<u>0</u> ib
	Rotational Spe	ed		(	Oscillat	ion Uns	pecifi	ied		
	0	rpm	Frequenc	у 厂		0 cycle sec	s/ A	Amplitude		0 inches
	Sun Exposure	None				Low T	empe	erature	0	degrees F
	% Time		0			High T	empe	erature	0	degrees F
	Environment	t	Gas	Oxy	gen					
	Pressurized		Liquid	LOX						
_	Operating			-	. <u>,</u>				<u></u>	
#E	Conditions									
	Non-Operating Conditions									
	Comment		· · · · ·							

S	PACE STATION LC	ONG TERM LUBRICATION STUDY 27
Contractor	Moog	Survey Number 27
WBS Number		Survey Date 8/19/86
Function Cor Pro	nector in the Oxyge poulsion System	en Solenoid Valve of the Space Station
Description	Screw Threads	
Suri	iace #1	Surface #2
Contact Surface Screw	threads	Contact Surface Thread Grooves
Surface Finish Unspe	cified	Surface Finish Unspecified
Surface TreatmentUnspe	cified	Surface Treatment Unspecified
Lubrication Scheme Lubricant Unspecif	e Unspecifie fied	SP R 0022A Compatible? Required Life
Total Mass Loss	0 %	CVCM %
Loads: Operating	<u> </u>	Peak 0 ib Preload 0 ib
Rotational Speed	Os	cillation Unspecified
0 rpm	Frequency	0 cycles/ Amplitude 0 inches
Sun Exposure Uns	becified .	Low Temperature 0 degrees F
% Time	0	High Temperature 0 degrees F
Environment	Gas	
Unspecified	Liquid	
Operating Conditions		
Non-Operating		
Conditions		1

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-		SPACE STATI	ON LONG T	ERM LU	JBRICA	ATION ST	TUDY	28
ي. د. د نيب	Contractor	Moog			Survey	Number	28	
	WBS Number		-		Surve	y Date	8/15/86	
	Function O- me Co	Ring seal betw echanism of the ontrol System	veen latchin e Oxygen ar of the Spac	g mecha nd Nitrog e Statior	nism c en Lato n Prop	asing and ching Val ulsion Sy	d plunger ve in th AR rstem	PCS
	Description	O- ring se	al					
11	Su	urface #1				Surfac	e #2	
3	Contact Surface Casi	ng mechanism		Contact Si	urface	plunger m	echanism	
	Surface Finish Uns	pecified		Surface F	inish	Unspecifie	d	
	Surface TreatmentUns	Surface T	reatmen	Unspecifie	d			
	Lubrication Schoo	no lunsposifio	<u> </u>			mnatible?	Require	ed Life
	Lubricant Unspec	vified		O Yes		No -		10 years
نسینی <b>ا</b> بر ب	Total Mass Loss	0	%	CVCM		0	%	
	Loads: Operating	0	<sup>Ib</sup> Peak		0 1	b Preic	ad	0 іь
	Rotational Speed		Oscillat	ion Uns	pecifie	ed		
	0 rpn	<sup>n</sup> Frequency		0 cycle sec	es/ A	mplitude	L	0 inches
	Sun Exposure Nor	ne	·	Low 1	lemper	ature	0	degrees F
	% Time	0		High 1	Tempei	rature	0	degrees F
	Environment	Gas						
	Pressurized	Liquid					,	
	Operating Conditions							
								]
	Non-Operating Conditions							
	Comment	<u> </u>						

	SPA	CE STATIC	N LONG SURVEY F	CERM LUBP	RICATION	STUDY	29		
Contractor		Moog		Su	rvey Numt	per 29			
WBS Number	-	· · ·		Survey Date 8/15/86					
Function	Assen Nitrog Statio	nbly and Ad en Latching n Propulsio	justment th Valve of tl n System	readed cont ne ARPCS	nectors in Control Sy	the Oxygen a stem in the S	nd bace		
Description	•	Scre Threa	ds		· · · · · · · · · · · · · · · · · · ·				
	Surfac	e #1)			Sur	face #2			
Contact Surface	Screw Th	ireads		Contact Surfac	ce Thread	Grooves			
Surface Finish	Jnspecif	ed	· · · · · · · · · · · · · · · · · · ·	Surface Finis	h Unspec	ified			
Surface Treatment	ed		Surface Treatment Unspecified						
Lubrication Sch Lubricant Unsp	neme   pecifie	Unspecifie d	SF	P R 0022A O Yes	Compatibl No	e? Require	d Life <u>10</u> years		
Total Mass Los	s	0	%	сусм		0 %			
Loads: Operati	ng	0	<sup>Ib</sup> Peak		<u>0</u> њ Pre	eload	0 іь		
Rotational Spe	ed rpm	Frequency	Oscillat	ion Unspec	cified Amplitud	de	0 inches		
Sun Exposure	Unspe	cified		Low Tem	perature	0	degrees F		
% Time		0		High Tem	perature	0	degrees F		
Environmen	t	Gas							
Unspecified		Liquid [			<u> </u>				
Operating Conditions									
Non-Operating Conditions					<u> </u>				
Comment				,					

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S	PACE STATION LONG SURVEY	TERM LUBRICATION STUDY	30
Contractor	Moog	Survey Number 30	
WBS Number		Survey Date 8/15/86	
Function Filte	er Seal in the Oxygen ar htrol System of the Space	nd Nitrogen Latching Valve in the AR ce Station Propulsion SYstem	PCS
Description	Surface contact		
Sur	face #1	Surface #2	
Contact Surface filter	seal	Contact Surface filter seat	
Surface Finish Unspe	ecified	Surface Finish Unspecified	
Surface TreatmentUnspe	ecified	Surface Treatment Unspecified	
Lubrication Scheme Lubricant Unspeci	e Unspecifie S fied	PR 0022A Compatible? Required	d Life 10 year
Total Mass Loss	0 %	CVCM 0 %	
Loads: Operating	0 <sup>Ib</sup> Peak	0 ю Preload	0 іь
Rotational Speed	Oscilla	tion Unspecified	
0 rpm	Frequency	0 <sup>cycles/</sup> Amplitude	0 inches
Sun Exposure None	9	Low Temperature 0	degrees F
% Time	0	High Temperature 0	degrees F
Environment	Gas		
Pressurized	Liquid		
Operating Conditions			
Non-Operating Conditions			
Comment			

	SPACE STAT	ION LONG SURVEY F	TERM LUBR	ICATION STU	YOU	31
Contractor	Moog		Surv	vey Number	31	
WBS Number	· · · · ·		Sur	vey Date 8	/13/86	
Function	O Ring betweer the Oxygen and in the Space S	n end cap me Nitrogen La tation Propu	echnism and tching Valve Ision system	Valve Adjusti of the ARPC	ment mech S Conttrol	anism in System
Description	O-Ring					
(	Surface #1			Surface	#2	
Contact Surface	D-Ring		Contact Surface	End cap/Val	ve adjust	
Surface Finish	Inspecified		Surface Finish	Unspecified		
Surface Treatment	Inspecified		Surface Treatm	ent Unspecified		
Lubrication Sch Lubricant Unsp	neme Unspecifi pecified	e SF	P R 0022A ( O Yes	Compatible? No	Require	d Life <u>10</u> years
Total Mass Los	s0	%		0 %	, o	
Loads: Operati	ng (	b Peak	0	ь Preloa	d [	0 іь
Rotational Spe	ed	Oscillat	ion Unspeci	ified	<u>_</u>	
0	<sup>rpm</sup> Frequenc	у	0 cycles/ sec	Amplitude		0 inches
Sun Exposure	None		Low Temp	perature	0	degrees F
% Time	0		High Temp	perature	0	degrees F
Environment	t Gas					
Pressurized	Liquid					
Operating					·····	
Conditions						
Non-Operating Conditions						
Comment						

		SPACE STATI			ATION STU	DY	3 2			
	Contractor	Moog	0011721	Surve	v Number	32				
	WBS Number	-		Survey Date 8/12/86						
	Function	Seal the Oxyger drive motor in th Propulsion Syst	a & Nitrogen e ARPCS C em	Latching Valv Ontro System	ve casing fro of the Space	om the elec e Station	otric			
	Description	Bellevile	Spring Seal							
	Contact Surface	Surface #1 Byille Spring Inner		Contact Surface	Surface Bville Spring	#2 Outer				
1 1000 1 1 1000 1	Surface Finish	Inspecified		Surface Finish	Unspecified					
	Surface Treatment	Inspecified	· · · ·	Surface Treatme	ntUnspecified					
	Lubrication Sch Lubricant Unsp	eme Unspecifie becified	9 SF	PR 0022A Co O Yes ()	ompatible? ) No	Required	Life 0 years			
	Total Mass Loss	s   0	%	CVCM	0 %					
	Loads: Operatir	ng 0	<sup>Ib</sup> Peak	0	ь Preload	4	0 lb			
	Rotational Spec	ed <sup>rpm</sup> Frequency	Oscillat	ion Unspecifi 0 <sup>cycles/</sup> A	ed mplitude [		0 inches			
	Sun Exposure L % Time	Jnspecified 0		Low Tempe High Tempe	erature	0 d 0 d	egrees F egrees F			
	Environment Unspecified	t Gas Liquid								
· ·	Operating Conditions									
 	Non-Operating Conditions									
	Comment									
		L	·····							

SPACE STATION	LONG TERM LUBRICATION STUDY 33 URVEY FORM
Contractor Moog	Survey Number 33
WBS Number	Survey Date 00/00/00
Function O Ring to seal the R System Oxygen and Propulsion System	elief Valve to the motor case in the ARPCS Control Niotrogen Latching Valve of Space Station
Description O-RIng	
Surface #1	Surface #2
Contact Surface O-RIng	Contact Surface Relief Valve
Surface Finish Unspecified	Surface Finish Unspecified
Surface TreatmentUnspecified	Surface Treatment Unspecified
Lubrication Scheme Unspecifie Lubricant Unspecified	- O Yes O No 10 years
Total Mass Loss 0 %	CVCM0 %
Loads: Operating0 Ib	Peak 0 ю Preload 0 ю
Rotational Speed C	Oscillation Unspecified Unspecified Oscillation Oscillatio Oscillation Oscillation Oscillation Oscillation Oscilla
Sun Exposure None	Low Temperature 0 degrees F
% Time0	High Temperature 0 degrees F
Environment Gas	
Pressurized Liquid	
Operating Conditions	
Non-Operating Conditions	
Comment	

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		SPACE STAT	ION LONG T	CERM LUBR		STUDY	34
	Contractor	Moog	· · · · · · · · · · · · · · · · · · ·	Sur	rvey Numb	er 34	
	WBS Number			Su	rvey Date	8/12/86	
	Function EI Va	ectric Drive r alve in the Sp	notor actuato bace Staion F	r for the Ox Propulsion Sy	ygen and ystem ARI	Nitrogen Lat PCS Control S	ching System
	Description	Bearings	/Planetary G	ears			
	Su	urface #1			Sur	face #2	
نصا	Contact Surface Uns	pecified		Contact Surfac	e Unspec	ified	
	Surface Finish Uns	pecified	<u></u>	Surface Finist	n Unspec	ified	
	Surface TreatmentUns	pecified		Surface Treatr	mentUnspec	ified	
	Ochor				Compatibl	-2 Bequire	ed Life
_	Lubrication Schen	ne Unspecifi					10 years
	Lubricant Unspec			0.160	<u> </u>		
	Total Mass Loss	(	) %			0%	
	Loads: Operating		0 Ib Peak		0 ib Pr	eload	d Ib
	Rotational Speed		Oscillat	ion Unspec	cified		
9 - 1 - 1 - 1 - F	0 rpn	<sup>n</sup> Frequen	су	0 cycles/ sec	Amplitue	de	0 inches
-	Sun Exposure Un	specified		Low Tem	perature	0	degrees F
	% Time	0		High Tem	nperature	0	degrees F
	Environment	Gas					
	Unspecified	Liquid		······································			
<b>1</b>	Operating	· · · · · · · · · · · · · · · · · · ·				·····	
	Conditions						
<u>ـــ</u>		<u></u>				······································	
<u> </u>	Non-Operating Conditions						
	Comment						
<u> </u>	Ĭ						

	SPACE STATION LONG T	ORM LUBRICATION STUDY	35
Contractor	Lockheed	Survey Number 35	
WBS Number		Survey Date 3/1/86	
Function W	/ire Wrap transfers power a	and data across Beta Joint	
Description	Relative Motion & Co	entact w/ Structure	
S	urface #1	Surface #2	
Contact Surface Wire	e Wrap	Contact Surface Axle Housing	
Surface Finish Uns	pecified	Surface Finish Unspecified	
Surface TreatmentUns	pecified	Surface Treatment Unspecified	
Lubrication Scher	me None Plann SF	R 0022A Compatible? Require	d Life 10 years
Total Mass Loss	0 %	CVCM0 %	
Loads: Operating	0 <sup>Ib</sup> Peak	0 в Preload	0 іь
Rotational Speed	Oscillat Frequency	on Continuous 0 <sup>cycles/</sup> Amplitude	0 inches
Sun Exposure Int	ermittent	Low Temperature 0	degrees F
% Time	64	High Temperature0	degrees F
Environment	Gas		
Vacuum	Liquid		<u></u>
Operating Conditions			
Non-Operating Conditions			
Comment			

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	SP	ACE STATI	ON LO	ONG T	ERM LU	BRIC	CATION ST	UDY		36
Contractor		Lockheed	-1			Surve	ey Number	36		
WBS Number				, 		Surv	ey Date 3	/1/86		_
Function	Beta	Joint Contr	ol Mot	or and	l Gearbo	x				
Description		Bearings /	Gear	s						
	Surfa	ce #1					Surface	#2		
Contact Surface	Unspeci	fied	<u></u>		Contact Su	urface	Unspecified			
Surface Finish	Unspeci	fied			Surface F	inish	Unspecified	<b>j</b>		
Surface Treatment	Unspeci	fied			Surface Tr	reatme	ntUnspecified		-	
Lubrication Sc Lubricant Uns	heme pecifie	Unspecifie ed	)	SF —	P R 0022 O Yes	A C	ompatible? No	Requ	uired	Life I O yea
Total Mass Lo	ss 📘	0	%		CVCM		0	%		
Loads: Operat	ing 📘	0	lb	Peak [		0	ь Preloa	ad		0 lb
Rotational Spe	ed		Os	scillat	ion Uns	pecif	ied		-	
0	rpm	Frequency			0 cycle sec	s/	Amplitude		0	inche
Sun Exposure	None				Low T	empe	erature		0 de	grees F
% Time	L	. 0			High T	emp	erature		0 de	grees F
Environmer	nt	Gas								
Vacuum		Liquid					·····			
Operating Conditions										
Non-Operating Conditions										
Comment				· · · · · · · · · · · · · · · · · · ·		<u></u>	<u>.</u>			

5P	ACE STATION LONG	G TERM LUBRICATION STUDY 37
Contractor	Lockheed	Survey Number 37
WBS Number	· · ·	Survey Date 3/1/86
Function Main Syste	Bearings in the hous em	sing of the Beta Joint of the Electrical Power
Description	Main Bearings	
Surfa	ce #1	Surface #2
Contact Surface Inner Ra	ace	Contact Surface Outer Race
Surface Finish Unspeci	fied	Surface Finish Unspecified
Surface TreatmentUnspeci	fied	Surface Treatment Unspecified
Lubrication Scheme Lubricant Unspecifie	Unspecifie ed	SP R 0022A Compatible? Required Life O Yes  No 10 years
Total Mass Loss	0 %	CVCM0 %
Loads: Operating	<u> </u>	k0 в Preload0 в
Rotational Speed	Oscill Frequency	ation Unspecified 0 cycles/ Amplitude0 inches
Sun Exposure Interr	nittent	Low Temperature 0 degrees F
% Time	64	High Temperature 0 degrees F
Environment	Gas	
Vacuum	Liquid	
Operating		
Conditions		
Non-Operating Conditions		

	SP	ACE STATION LONG SURVEY F	TERM LUBRICATION STUDY	38
	Contractor WBS Number	Lockheed	Survey Number 38 Survey Date 3/1/86	
	Function Bear syst	ings in pump of wate em	supply assembly of water electron	olysis
	Description	Bearings		
	Surfa	ace #1	Surface #2	
	Contact Surface Surface Finish Unspec Surface TreatmentUnspec	ified	Contact Surface Surface Finish Unspecified Surface Treatment Unspecified	
	Lubrication Scheme Lubricant Unspecifi	Unspecifie SI ed	P R 0022A Compatible? Requir O Yes  No	red Life 10 years
	Total Mass Loss	0 %	CVCM0 %	
8	Loads: Operating	0 <sup>Ib</sup> Peak	0 b Preload	<u> </u>
		Frequency	0 <sup>cycles/</sup> Amplitude	0 inches
	Sun Exposure Unsp	ecified	Low Temperature	<u>)</u> degrees F
نين النيا	% Time [		High Temperature	) degrees F
- -	Environment Unspecified	Liquid		
	Operating Conditions	······································		
	Non-Operating Conditions			
	Comment		- -	

	SPACE STATIC	ON LONG SURVEY F		RICATION ST	UDY	39
Contractor	Lockheed		Su	rvey Number	39	
WBS Number			Su	urvey Date	3/1/86	
Function	Cable fair lead p solar array of e	oulleys in b lectrical po	lanket tensi ower	oning and gu	idewire sys	tem of
Description	Cable fair	lead pulley	/S			
(	Surface #1			Surface	• #2	
Contact Surface	in/al		Contact Surfa	ce bushing/al		
Surface Finish	nspecified		Surface Finis	h Unspecified	ł	
Surface Treatment	nspecified		Surface Treat	mentUnspecified	3	<u> </u>
Lubrication Sch Lubricant Everl	eme Dry Film ube 620	SI	P R 0022A O Yes	Compatible? No	Required	d Life 10 years
Total Mass Loss	s 0	%		0	%	
Loads: Operatir	g0	Ib Peak		<u>0</u> њ Prelo	ad	0 ib
Rotational Spee	əd	Oscillat	ion			
0	Frequency		C	Amplitude		0 inches
Sun Exposure	ntermittent		Low Tem	nperature	0	degrees F
% Time	64		High Ten	nperature	0	degrees F
Environment	Gas					
Vacuum	Liquid				<u></u>	
Operating Conditions						
Non-Operating Conditions						
Comment						

				utera e Tratecco		
	SF	PACE STATION		CERM LUBR	CATION STUDY	40
	Contractor	Lockheed		Sur	vey Number   40	
	WBS Number		· · · · · · · ·	Sur	vey Date 3/1/86	
	Function Driv elec	e motors in fin strical power s	e pointing system	g mechanism	n of solar dynamic sys	tem of
	Description	Drive motor	S			
·	Surt	ace #1			Surface #2	
	Contact Surface			Contact Surface		
	Surface Finish Unspe	cified		Surface Finish	Unspecified	
1	Surface TreatmentUnspe	cified	. <u> </u>	Surface Treatm	nentUnspecified	
	Lubrication Scheme	Unspecifie	SF	P R 0022A	Compatible? Require	ed Life
	Lubricant Working	Fluid		O Yes	No	10 years
i <b>l i</b>	Total Mass Loss	0 %		сусм	%	
	Loads: Operating	0 11	• Peak		) в Preload	0 Ib
: <u>=</u> ::::	Rotational Speed		Oscillat	ion		
	0 rpm	Frequency		0 cycles/	Amplitude	0 inches
	Sun Exposure Unsp	pecified		Low Tem	perature 0	degrees F
5 <b>8</b>	% Time	0		High Tem	perature 0	degrees F
1 1 1 <b>1</b>	Environment	Gas	· · ·			
	Unspecified	Liquid				
	Operating Conditions					
 -	Non-Operating Conditions					
•	Comment					

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Contractor       Lockheed       Survey Number       41         WBS Number	SPACE STATIC	ON LONG TERM LUBRICATION STUDY 41
WBS Number	Contractor Lockheed	Survey Number 41
Function       Gearbox of fine pointing mechanism in solar dynamic system in electrical power system         Description       Gearbox         Surface #)         Contact Surface #)         Surface #)         Contact Surface #)         Surface #)         Contact Surface #)         Surface Finish         Surface Finish         Unspecified       Surface Finish         Surface Finish         Unspecified       Surface Treatment[Unspecified         Surface Treatment[Unspecified       Surface Treatment[Unspecified         Lubricant Scheme       Unspecifie       SP R 0022A         Compatible?       Required Life         Lubricant Working Fluid       O Yes       No         Total Mass Loss       0       %       CVCM       0 %         Loads: Operating       0       %       Decode       0       inches         Sun Exposure [Unspecified       Low Temperature       0       degrees F         % Time       0       High Temperature       0       degrees F         Environment       Gas	WBS Number	Survey Date 3/1/86
Description       Gearbox         Surface       Surface         Contact Surface       Contact Surface         Surface Finish       Unspecified         Surface TreatmentUnspecified       Surface TreatmentUnspecified         Surface TreatmentUnspecified       Surface TreatmentUnspecified         Lubrication Scheme       Unspecifie       SP R 0022A Compatible?         Lubricant       Working Fluid       O Yes       No         Total Mass Loss       0       %       CVCM       0         Rotational Speed       0 %       CVCM       0       %         Loads: Operating       0       %       Preload       0       10         Sun Exposure       Unspecified       Low Temperature       0       degrees F         % Time       0       High Temperature       0       degrees F         Operating       Conditions       Inches       Inches	Function Gearbox of fine pelectrical power	pointing mechanism in solar dynamic system in system
Surface       #1       Surface       Surface       #2         Contact Surface       Contact Surface       Surface Finish       Unspecified         Surface Finish       Unspecified       Surface Finish       Unspecified         Surface TreatmentUnspecified       Surface TreatmentUnspecified       Surface TreatmentUnspecified         Lubrication       Scheme       Unspecifie       SP R 0022A       Compatible?       Required Life         Lubricant       Working Fluid       O Yes       No       10       year         Total Mass Loss       0       %       CVCM       0       %         Loads: Operating       0       Ib       Preload       0       Ib         Rotational Speed       Oscillation       Unspecified       0       inches         Sun Exposure       Unspecified       Low Temperature       0       degrees F         % Time       0       High Temperature       0       degrees F         Unspecified       Liquid       Inquid       Indus <t< td=""><td>Description Gearbox</td><td></td></t<>	Description Gearbox	
Contact Surface       Contact Surface         Surface Finish       Unspecified         Surface Treatment       Unspecified         Surface Treatment       Unspecified         Lubrication Scheme       Unspecifie         Lubricant       Working Fluid         Total Mass Loss       0         0       10         Peak       0         No       10         Ves       No         Condact Surface       10         Ves       No         10       year         Total Mass Loss       0         0       10         Peak       0         0       rpm         Frequency       0         0       rpm         Frequency       0         0       sec         Sun Exposure       Unspecified         Liquid       Low         Unspecified       Liquid         Unspecified       Liquid         Operating       Ondegrees F         Non-Operating       Non-Operating         Conditions       Indegrees	Surface #1	Surface #2
Surface Finish       Unspecified       Surface Finish       Unspecified         Surface Treatment       Unspecified       Surface Treatment       Unspecified         Lubrication Scheme       Unspecifie       SP R 0022A       Compatible?       Required Life         Lubricant       Working Fluid       O Yes       No       10 year         Total Mass Loss       0       CVCM       0       %         Loads: Operating       0       Ib       Peak       0       Ib         Rotational Speed       Oscillation       Unspecified       0       inches         Sun Exposure       Unspecified       Low Temperature       0       degrees F         % Time       0       High Temperature       0       degrees F         Operating       Conditions       Inspecified       Inspecified       Inspecified	Contact Surface	Contact Surface
Surface Treatment[Unspecified       Surface Treatment[Unspecified         Lubrication Scheme Unspecifie       SP R 0022A Compatible?       Required Life         Lubricant Working Fluid       O Yes       No       10 year         Total Mass Loss       0       CVCM       0       %         Loads: Operating       0       Ib       Peak       0       ib       Preload       0       ib         Rotational Speed       Oscillation       Unspecified        0       inches         Sun Exposure Unspecified       Low Temperature       0       degrees F       %       Time       0       degrees F         Working       Liquid         Operating       Operating       0       degrees F	Surface Finish Unspecified	Surface Finish Unspecified
Lubrication Scheme       Unspecifie       SP R 0022A       Compatible?       Required Life         Lubricant       Working Fluid       O Yes       No       10       year         Total Mass Loss       0       %       CVCM       0       %         Loads: Operating       0       Ib       Peak       0       Ib       Preload       0       Ib         Rotational Speed       Oscillation       Unspecified       0       inches         Sun Exposure       Unspecified       Low       Temperature       0       degrees F         % Time       0       High Temperature       0       degrees F         Operating       Liquid	Surface TreatmentUnspecified	Surface Treatment Unspecified
Total Mass Loss       0 %       CVCM       0 %         Loads: Operating       0 lb       Peak       0 lb       Preload       0 lb         Rotational Speed       Oscillation       Unspecified       0 inches         0 rpm       Frequency       0 sec       Amplitude       0 inches         Sun Exposure Unspecified       Low Temperature       0 degrees F         % Time       0       High Temperature       0 degrees F         Environment       Gas	Lubrication Scheme Unspecifie Lubricant Working Fluid	SP R 0022A Compatible? Required Life O Yes I No 10 years
Loads: Operating       0       Ib       Peak       0       Ib       Preload       0       Ib         Rotational Speed       Oscillation       Unspecified       0       inches         0       rpm       Frequency       0       cycles/       Amplitude       0       inches         Sun Exposure       Unspecified       Low       Temperature       0       degrees F         % Time       0       High       Temperature       0       degrees F         Environment       Gas	Total Mass Loss 0	% CVCM 0 %
Rotational Speed       Oscillation       Unspecified         0       rpm       Frequency       0       cycles/ Amplitude       0       inches         Sun Exposure       Unspecified       Low Temperature       0       degrees F         % Time       0       High Temperature       0       degrees F         Environment       Gas	Loads: Operating 0	Ib Peak 0 Ib Preload 0 Ib
0       rpm       Frequency       0       cycles/ sec       Amplitude       0       inches         Sun Exposure       Unspecified       Low       Temperature       0       degrees F         % Time       0       High       Temperature       0       degrees F         Environment       Gas	Rotational Speed	Oscillation Unspecified
Sun Exposure Unspecified       Low Temperature       0 degrees F         % Time       0       High Temperature       0 degrees F         Environment       Gas	0 rpm Frequency	0 cycles/ Amplitude 0 inches
% Time       0       High Temperature       0       degrees F         Environment       Gas	Sun Exposure Unspecified	Low Temperature 0 degrees F
Environment Gas   Unspecified Liquid   Operating Conditions   Non-Operating Conditions	% Time0	High Temperature 0 degrees F
Unspecified       Liquid         Operating       Conditions         Non-Operating       Conditions	Environment Gas	
Operating Conditions Non-Operating Conditions	Unspecified Liquid	
Non-Operating Conditions	Operating Conditions	
Non-Operating Conditions		
	Non-Operating Conditions	
Comment	Comment	

	5	SPACE STATI	ON LONG 1 SURVEY F	ERM LUB	RICATION STU	IDY	4 2
تنا	Contractor	Lockheed		Si	urvey Number	42	
	WBS Number	 		S	urvey Date 3	/1/86	
	Function Ba ele	llscrew in fine ectrical power	pointing m system	echanism	of solar dynam	nic system	of
	L Description	Ballscrew				······	
ا زا . مانغانینانه	Su	rface #1			Surface	#2	
-	Contact Surface			Contact Surfa	ace		
	Surface Finish Unsp	ecified		Surface Finit	sh Unspecified		
ليق	Surface TreatmentUnsp	ecified		Surface Trea	tment Unspecified		
:				1. FF. 1			·····
	Lubrication Schem	e Unspecifie	SF	R 0022A	Compatible?	Required	d Life
	Lubricant Working	Fluid		() Yes	No		<u>10</u> year
	Total Mass Loss	0	%	сусм Г	0 %	5	
	Loads: Operating	0	<sup>Ib</sup> Peak		<u>0</u> њ Preloa	d	0 lb
El	Rotational Speed		Oscillat	ion			
لىتە : :	0 rpm	Frequency		0 cycles/ sec	Amplitude		0 inches
	Sun Exposure Uns	specified		Low Ter	mperature	0	degrees F
	% Time	0		High Tei	mperature	0	degrees F
	Environment	Gas			·····		
	Unspecified	Liquid [					
	Operating Conditions						
(i) of the second s	Non-Operating						
	Conditions						
	Comment		· · · · · · · · · · · · · · · · · · ·				
					•		

	SPACE ST	ATION			BRICATION ST	JDY	43
Contractor	Lockhe	ed		s	urvey Number	43	
WBS Number					Survey Date 3	/1/86	
Function	Actuator-to-c dynamic sys	oncent em of	rator I/F electric	of fine p al power	oointing mecha system	nism of s	olar
Description	Actuat	or-to-c	concentra	ator I/F		· · · · · · · · · · · · · · · · · · ·	
(	Surface #1				Surface	#2	
Contact Surface				Contact Sur	face		
Surface Finish	Inspecified			Surface Fin	ish Unspecified		
Surface Treatment	Inspecified			Surface Tre	atment Unspecified		
Lubrication Sch Lubricant Work	ieme Unspec king fluid	ifie	SI	P R 0022A O Yes	Compatible?	Require	d Life 10 years
Total Mass Los	s [	0 %		сусм [	0	%	<u> </u>
Loads: Operati	ng [	<u>0</u> ib	Peak		<u>0</u> ю Preloa	id	0 lb
Rotational Spe	ed		Oscillat	ion Unsp	ecified		
0	<sup>rpm</sup> Freque	ncy L		Cycles/ sec	Amplitude		0 inches
Sun Exposure	Jnspecified	<u></u>		Low Te	mperature	0	degrees F
% Time	0			High Te	mperature	0	degrees F
Environmen	t G	as 📃	······				
Unspecified	Liqu	id 🗌			<u></u>		
Operating							
Conditions					· · · · · · · · · · · · · · · · · · ·		
Non-Operating Conditions					<u></u>		
Comment							

		SPACE	STATIO	N LONG 1 SURVEY F		BRICA	ATION S	STUDY		44
ت	Contractor	Lock	heed		S	Survey	Numbe	er 44		
	WBS Number				v <sub>A</sub>	Surve	y Date	3/1/86		
	Function	Gas or foil electrical	bearin power	gs in heat system	engine of	sola	r dynam	ic system	of	
	Description	Gas	or foil	bearings						
<b>6</b> - 1	(	Surface #1	)				Surfa	ace #2		
	Contact Surface				Contact Sur	face				
	Surface Finish	nspecified			Surface Fir	nish	Unspecif	ied		
	Surface Treatment	nspecified			Surface Tre	atment	Unspecif	ied		
	Lubrication Sch	eme Unsp	ecifie	SF	? R 0022A		mpatible	? Requ	ired	Life
	Lubricant Work	ing fluid			() Yes	•	NO		••••••	10 years
	Total Mass Loss	6	0	%	CVCM	L	0	- %		
Ľ	Loads: Operatir	ng [	0	<sup>Ib</sup> Peak		<u> </u>	ь Pre	load		<u>0</u> ib
	Rotational Spee	ed		Oscillat	ion Unsp	ecifie	d		_	
<b>R</b>	0 r	<sup>rpm</sup> Frec	luency			<sup>./</sup> Ar	nplitud	e		0 inches
	Sun Exposure	Inspecified		· · · ·	Low Te	emper	ature [		0 0	legrees F
-	% Time [		0		High Te	emper	ature [		0 0	legrees F
4	Environment		Gas _							
	Unspecified	Lie	quid _							
1	Operating									
	Conditions									
_	Non-Operating Conditions									
	Comment							···	<u></u>	
· · · ·								·		

	SPACE STATION LO	NG TERM LUBRICATION STUDY	4 5
Contractor	Lockheed	Survey Number 45	
WBS Number	1.1.4.3.16.16.1.2	.2 Survey Date 3/1/86	<u> </u>
Function	Mast base spider bush power	ing in mast canister of solar array of el	ectrical
Description	Mast base spider	bushing	
(	Surface #1	Surface #2	
Contact Surface	pider bushing/Al.	Contact Surface spider/AI.	
Surface Finish	nspecified	Surface Finish Unspecified	
Surface Treatment	nspecified	Surface Treatment Unspecified	
Lubrication Sch Lubricant Everl	eme Dry Film ube 620	SP R 0022A Compatible? Required	d Life <u>10</u> years
Total Mass Los	5 %	CVCM0 %	
Loads: Operation	ng0 ib P	Реак0 в Preload	0 іь
Rotational Spec	ed Os	cillation Intermittent	
	<sup>rpm</sup> Frequency	0 cycles/ Amplitude	0 inches
Sun Exposure	ntermittent	Low Temperature 0	degrees F
% Time	63	High Temperature 0	degrees F
Environment	Gas		
Vacuum	Liquid		
Operating Conditions	Radiation type: NASA Normal operating enviro	TM-86460 onment 160 °F	
Non-Operating Conditions			
Comment			

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	5	SPACE STATION LONG T	ERM LUBRICATION STUDY	46
1711	Contractor	Lockheed	Survey Number 46	
	WBS Number	1.1.4.3.16.16.1.2.3	Survey Date 3/1/86	
	Function Lo po	nger on end fitting in ma wer	st canister of solar array of elect	rical
	Description	Fitting to spider Al. to	o Al.	
È.	Su	arface #1	Surface #2	
	Contact Surface On e	end fitting/Al.	Contact Surface Pin to spider/Al.	
	Surface Finish Unsp	pecified	Surface Finish Unspecified	
	Surface TreatmentUnsp	pecified	Surface Treatment Unspecified	
	Lubrication Schem	ne Dry Film SF	P R 0022A Compatible? Require	ed Life
	Lubricant Everlub	e 620	O Yes	<u>10</u> years
	Total Mass Loss	0 %	CVCM0 %	
n-1412 1941 - 1942	Loads: Operating	0 Ib Peak	0 в Preload	0 Ib
and the second s	Rotational Speed	Oscillat Frequency	ion Intermittent 0 <sup>cycles/</sup> Amplitude	0 inches
	Sun Exposure Int	ermittent	Low Temperature 0	degrees F
لستتظ	% Time	63	High Temperature 0	degrees F
· · · · · · · · · · · · · · · · · · ·	Environment	Gas		
	Vacuum	Liquid		
	Operating Ra Conditions No	adiation type: NASA TM-8 ormal operating Environme	96460 ent: 160°F	
<b></b>	Non-Operating Conditions	•		
<b>Brande</b> r	Comment			

	SPACE STATION LONG SURVEY F	TERM LUBRICATION STUDY 47						
Contractor	Lockheed	Survey Number 47						
WBS Number	1.1.4.3.16.16.1.2.4	Survey Date 3/1/86						
Function	Mast element/deployer inter electrical power	rface in mast canister of solar array of						
Description	Mast element to dep	loyer interface						
(	Surface #1	Surface #2						
Contact Surface	nast ele. roller/Al.	Contact Surface Deployer nut thread						
Surface Finish	Inspecified	Surface Finish Unspecified						
Surface Treatment	Inspecified	Surface Treatment Unspecified						
Lubrication Sch Lubricant Ever	eme Dry FilmS lube 620	P R 0022A Compatible? Required Life						
Total Mass Los	s %	CVCM0 %						
Loads: Operati	ng 0 <sup>Ib</sup> Peak	0 ю Preload 0 и						
Rotational Spe	ed Oscillat	tion Intermittent						
0	<sup>rpm</sup> Frequency	0 cycles/ Amplitude 0 inche						
Sun Exposure	ntermittent	Low Temperature 0 degrees F						
% Time [	63	High Temperature 0 degrees F						
Environmen Vacuum	t Gas Liquid	· · · · · · · · · · · · · · · · · · ·						
Operating Conditions	Radiation Type: NASA TM- Normal Operating Environm	86460 ent: 160°F						
Non-Operating Conditions								
Comment	· · · · · · · · · · · · · · · · · · ·							
	SPACI	E STATIC	N LONG T	ERM LUBP	RICAT	TION STU	JDY	48
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Contractor	Lo	ckheed		Su	rvey	Number	48	
WBS Number	- [1.	1.4.3.16.	16.1.2.1	Su	ırvey	Date 3	/1/86	
Function	Deploye electrica	r nutring Il power	ballbearing	s in mast o	canist	ter of sol	ar array o	f
Description	D	eployer n	utring ball	bearings				
(	Surface	#1				Surface	#2	
Contact Surface	nutring bea	rings/SS		Contact Surface	ce 🔼	lutring bea	rings/SS	
Surface Finish	Inspecified			Surface Finis	h L	Inspecified		
Surface Treatment	Inspecified			Surface Treat	ment	Inspecified		······
Lubrication Sch	neme  Dr	y Film	SF	P R 0022A	Com	patible?	Require	d Life
Lubricant Ever	lube 620			() Yes	N	io 🛛	L	10 years
Total Mass Los	s	0	%			0 %	, ,	
Loads: Operati	ng	0	<sup>Ib</sup> Peak		0 іь	Preloa	d	0 lb
Rotational Spe	ed		Oscillat	ion Interm	nitter	nt		
0	<sup>rpm</sup> F	requency		O cycles/	Am	plitude		0 inches
Sun Exposure	Intermit	tent	<u></u>	Low Tem	npera	ture	0	degrees F
% Time [		63		High Ten	npera	ture	0	degrees F
Environmen	t	Gas				=		
Vacuum		Liquid						
Operating Conditions	Radiatio Normal	n Type: Operating	NASA TM-{ Environme	36460 ent: 160°F				
Non-Operating Conditions								
Comment								

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	SPA	CE STATI	ON LONG SURVEY F		ICATION	STUDY	49
Contractor	l	Lockheed		Su	rvey Numb	oer 49	
WBS Number	-	1.1.4.3.16	.16.1.1.1	Su	rvey Date	3/1/86	
Function	Batten	corner fi	tting in ma	st of solar	array of e	electrical pow	ver
Description		Batten co	rner fitting				
(	Surface	#1)			Sur	face #2	
Contact Surface [fi	tting ro	oller/Al.		Contact Surfac	e fitting	cup/Al.	
Surface Finish	Inspecifie	ed		Surface Finisl	Unspec	ified	
Surface Treatment	Inspecifie	ed	<u>-,</u>	Surface Treat	ment Unspec	ified	
Lubrication Sch Lubricant Everl	ieme [[ ube 62	Dry Film 20	SF	P R 0022A O Yes	Compatibl No	e? Require	ed Life 10 years
Total Mass Loss	s 📃	0	%	сусм		0 %	
Loads: Operatir	ng [	0	<sup>ib</sup> Peak		<u>0</u> іь Рге	eload	0 іь
Rotational Spee	ed		Oscillat	ion Interm	ittent	······	
	rpm	Frequency	/ L	cycles/ sec	Amplitud	de	0 inches
Sun Exposure	nterm	ittent	•••••	Low Tem	perature	0	degrees F
% Time		63		High Tem	perature	0	degrees F
Environment	ł	Gas		······			
Vacuum		Liquid [					
Operating Conditions	Radisti Norma	on Type: I Operating	NASA TM-8 g Environme	36460 ent: 160°F			
Non-Operating Conditions							
Comment							

	SPA	CE STATIO	ON LON SURVE	IG TE	RM LUB	RIC	ATION	STUD	Y		50
Contractor		Lockheed			SL	irvey	/ Numl	ber	50		
WBS Number	· -	· ·		· · · · · · · · · · · · · · · · · · ·	SI	urve	y Date	3/	1/86		-
Function	Bearin syster	ig in pump m	of pres	ssure	control a	isse	mbly c	of wat	er elec	troly	sis
Description		Bearings		·							
	Surfac	e #1					Sur	face	#2		
Contact Surface					Contact Surfa	ice					
Surface Finish	Jnspecifi	ed			Surface Finis	sh	Unspec	cified			
Surface Treatment	Jnspecifi	ed		s	Surface Trea	tmen	tUnspec	cified		p=	
Lubrication Sch	neme [	Unspecifie		SP	R 0022A	Co	mpatib	le?	Requi	red	Life
Lubricant Uns	pecifie	d		·		•	INO			1	<u>()</u> yea
Total Mass Los	s	0	%		сусм Г			0 %			
Loads: Operati	ng 🔄	0	в Ре	ak 🗌		0	ib, Pr	eload			0 іь
Rotational Spe	ed		Osci	llatio	n Unspe	cifie	ed			-	
<b>`</b>		Frequency			0 sec		mplitu				
	Unspe	cified			Low Ter	nper	rature	L		U deg	rees F
% nme [		<u> </u>			High Ter	nper	rature			0 deg	rees F
Environmen	t	Gas									
Unspecified											
Operating Conditions	Opera	ting Load:	300 ps	si, 18	0°F, Inter	mitte	ent as	req'd			
Non-Operating Conditions					<u></u> , <u></u> , <u>.</u> , <u>.</u> , <u>.</u> ,		<u></u>				
Comment											
								<u>.</u>			

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	SPA	CE STATI	ON LONG SURVEY F		ICATION S	STUDY	51
Contractor		Lockheed		Sur	vey Numb	er <u>51</u>	
WBS Number	· -	· ·		Su	rvey Date	3/1/86	
Function	Motor electr	pinion gea ical powe	r in cover r	blanket prelo	ad system	of solar ar	ray of
Description	<b></b>	Moter pinio	on gear				
(	Surfac	e #1			Surf	ace #2	
Contact Surface	Vorn ge	ar/Al.		Contact Surface	e Latch m	ember/SS	
Surface Finish	Jnspecifi	ed		Surface Finish	Unspeci	lied	
Surface Treatment	Inspecifi	ed		Surface Treatn	nentUnspecif	lied	
Lubrication Sch Lubricant Ever	neme ( lube 6	Dry Film 20	SF	P R 0022A O Yes	Compatible No	? Requir	ed Life 10 years
Total Mass Los	s 🗋	0	%	сусм	C	) %	
Loads: Operati	ng 📃	0	<sup>ib</sup> Peak	(	) ıb Pre	load	<u>0</u> Ib
Rotational Spe	ed		Oscillat	ion Unspec	ified		
0	rpm	Frequency		cycles/ sec	Amplitud	e	0 inches
Sun Exposure	Interm	nittent		Low Tem	perature [	0	degrees F
% Time		64		, High Tem	perature	0	degrees F
Environmen	t	Gas					
Vacuum		Liquid [					
Operating Conditions							
Non-Operating Conditions							
Comment							

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		SPAC	CE STATI	ON LONG T		RICATION STUDY	52
نگ	Contractor	1	_ockheed	•	Su	rvey Number 52	
	WBS Number			1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	Sı	rvey Date 3/1/86	
	Function	Motor electric	ballbearin cal powe	gs in ocver r	blanket pre	load system of solar an	ay of
	Description	Į	Motor bal	lbearings			
	(	Surface	#1			Surface #2	
-	Contact Surface B	earings/	SS		Contact Surfac	ce Race/SS	
	Surface Finish	nspecifie	d		Surface Finis	h Unspecified	
	Surface Treatment	nspecifie	ed		Surface Treat	mentUnspecified	
				CI		Compatible? Require	d Life
	Lubricant Braye	cote 60	01		O Yes		10 years
	Total Mass Loss	s [	0	%	сусм [	0 %	
	Loads: Operatir	ng 📃	0	<sup>ib</sup> Peak		0 в Preload	0 lb
	Rotational Spee	ed		Oscillat	ion Unspe	cified	
1 Bargana	0	rpm	Frequenc	y [	0 cycles/	Amplitude	0 inches
1 1 	Sun Exposure	nterm	ittent		Low Ten	nperature 0	degrees F
	% Time		64		High Ten	nperature 0	degrees F
	Environment	t	Gas				
	Vacuum		Liquid				
	Operating		·····				
8	Conditions						
<b>Name</b>	l						
	Non-Operating Conditions						
; <b> </b>		*					
- K - 2	Comment	Grea	ase				

	SPA	CE STAT	ON LONG T	CERM LUBRI	CATION	STUDY	53		
Contractor		Lockheed		Surv	ey Numb	oer <u>53</u>			
WBS Number	-			Survey Date 3/1/86					
Function	Latch electr	system in ical powe	cover blank er	et preload sy	ystem of	solar array o	of		
Description	<b>_</b>	Latch sys	stem						
	Surfac	e #1			Sur	face #2			
Contact Surface	oins in I	atch/Al.		Contact Surface	Bushing	in latch/Al.			
Surface Finish	Jnspecif	ied		Surface Finish	Unspec	ified			
Surface Treatment	Jnspecif	ied		Surface Treatm	ent Unspec	ified			
Lubrication Sch Lubricant Ever	neme ( Iube 6	Dry Film 20	SF	PR 0022A ( OYes (	ompatible No	e? Require	ed Life 10 years		
Total Mass Los	s	0	%			0 %			
Loads: Operati	ng 🗌	0	<sup>ib</sup> Peak	0	ib Pre	eload	d <u>0</u>		
Rotational Spe	ed rpm	Frequency	Oscillat	ion Unspeci 0 <sup>cycles/</sup> sec	fied Amplituc	de	0 inches		
Sun Exposure	Interm	nittent		Low Temp	erature	0	degrees F		
% Time		64		High Temp	erature	0	degrees F		
Environmen	t	Gas							
Vacuum		Liquid							
Operating Conditions									
Non-Operating Conditions									
Comment									

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A NUMBER OF STREET

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- 1			
_	SF	ACE STATION LON	NG TERM LUBRICATION STUDY 54
- 141-	Contractor	Lockheed	Survey Number 54
Lab. San	WBS Number		Survey Date 3/1/86
	Function Nega	ator spirngs to rage em in solar array i	reel in blanket tensioning and guide wire in electrical power
	Description	Negator springs to	to rage reel
a tublet.	Surfa	ace #1	Surface #2
_	Contact Surface hub/Al	or Delrin	Contact Surface Axle/AI.
	Surface Finish Unspec	pified	Surface Finish Unspecified
-	Surface TreatmentUnspec	lified	Surface Treatment Unspecified
l util	Lubrication Scheme		SP R 00224 Compatible2 Required Life
	Lubricant Everlube	620 *	O Yes  No
	Total Mass Loss	0 %	CVCM 0 %
	Loads: Operating	0 lb P€	eak 0 ib Preload 0 ii
•	Rotational Speed	Osc	cillation Unspecified
	0 rpm	Frequency	0 cycles/ Amplitude0 inche
	Sun Exposure Inter	mittent	Low Temperature 0 degrees F
	% Time	64	High Temperature 0 degrees F
	Environment	Gas	
	Vacuum	Liquid	
Lando da	Operating Conditions		
	Non-Operating Conditions		
	Comment * No	ne for Delrin Hub	

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	SPA	CE STAT	ON LONG T	CERM LUB	RICATION	STUDY	55
Contractor		Lockheed		Su	rvey Numl	per 55	
WBS Number			···	Si	urvey Date	3/1/86	
Function	Limit	switches i	n array mo	tors of sola	ar array o	f electrical po	ower
Description	L	Limit swi	itches		<u> </u>		
(	Surfac	e #1)	<u>,</u>		Sui	rface #2	
Contact Surface P	ins/SS			Contact Surfa	ce Bracke	ts/SS	
Surface Finish	Inspecifi	ied		Surface Finis	h Unspec	cified	
Surface Treatment	Inspecifi	ied		Surface Treat	tmentUnspec	cified	
Lubrication Sch Lubricant Everl	ieme ( lube 6	Dry Film 20	SF	P R 0022A O Yes	Compatib No	le? Require	ed Life <u>10</u> years
Total Mass Los	s [	0	%	сусм Г		0 %	
Loads: Operation	ng 🕒	0	<sup>Ib</sup> Peak		<u>0</u> њ Рг	eload	0 іь
Rotational Spee	ed		Oscillat	ion Unspe	cified		
0	rpm	Frequency	/	0 cycles/ sec	Amplitu	de	0 inches
Sun Exposure	nterm	nittent		Low Ten	nperature	0	degrees F
% Time		64		High Ten	nperature	0	degrees F
Environment	t	Gas					
Vacuum		Liquid					
Operating Conditions					·		
Non-Operating Conditions			- <sub>10</sub>				
Comment					4 		
		<u></u>			a	·	

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	SPACE STATION LONG	TERM LUBRICATION STUDY	5.6
	SURVEY	FORM	50
Contractor	Lockheed	Survey Number 56	
WBS Number	-	Survey Date 3/1/86	
Function Ir o	nterface/Mast canister to f electical power	beta drive in mast canister of solar	array
Description	Interface/Mast canist	ter to beta drive	
Ś	Surface #1	Surface #2	
Contact Surface Ma	st canister/SS&Al.	Contact Surface Beta drive/Al	
Surface Finish Ung	specified	Surface Finish Unspecified	
Surface TreatmentUns	specified	Surface Treatment Unspecified	
Lubrication Sche Lubricant Everlu	me Dry Film S be 620	PR 0022A Compatible? Required	J Life 10 years
Total Mass Loss	0 %	CVCM 0 %	
Loads: Operating	g0 <sup>Ib</sup> Peak	0 њ Preload	0 lb
Rotational Speed	d Oscilla <sup>m</sup> Frequency	tion Unspecified 0 <sup>cycles/</sup> Amplitude	0 inches
Sun Exposure In	termittent	Low Temperature 0	degrees F
% Time	64	High Temperature 0	degrees F
Environment Vacuum	Gas Liquid		
Operating Conditions			
Non-Operating Conditions			
Comment			

	SPA	CE STATI	ON LONG T	FERM LUBRI	CATION ST	JDY	57
Contractor WBS Number	-	Lockheed		Surv	vey Number vey Date 3	57 /1/86	
Function	Rotor electr	ballbearing ical powe	gs in mast i r	motor drive a	assembly of	solar array	of
Description		Rotor ball	bearings				
(	Surfac	e #1			Surface	#2	
Contact Surface B	learings	/SS		Contact Surface	Race/SS		
Surface Finish	Inspecifi	ed		Surface Finish	Unspecified	<u> </u>	
Surface Treatment	Inspecifi	ed		Surface Treatm	ent Unspecified		
Lubrication Sch Lubricant Braye	ieme [ cote 6	Fluid *	SF	PR 0022A ( OYes (	Compatible? No	Require	d Life 10 years
Total Mass Los	s [	0	%		0	%	
Loads: Operation	ng [	0	<sup>ib</sup> Peak	0	ь Preloa	ad	0 Ib
Rotational Spec	ed rpm	Frequency	Oscillat	ion Unspeci 0 <sup>cycles/</sup> sec	fied Amplitude [		0 inches
Sun Exposure	nterm	nittent		Low Temp	oerature	0	degrees F
% Time		64		High Temp	perature	0	degrees F
Environment Vacuum	t	Gas Liquid			· · · · · · · · · · · · · · · · · · ·		
Operating Conditions			·····				
Non-Operating Conditions							
Comment	* Grea	150					

		SPA	CE STATI	ON LONG T		BRICATION S	TUDY	58
	Contractor		Lockheed		S	Survey Numbe	r <u>58</u>	
	WBS Number	· -				Survey Date	3/1/86	
	Function	Clutch electr	or soleno ical/mech	id in locking ansims	g mechan	ism of beta jo	pint of	
1 1	Description		clutch or	solenoid				
-	(	Surfac	e #1			Surfa	ice #2	
	Contact Surface	utchpir	1		Contact Sur	face sleeve		
5	Surface Finish	nspecifi	ed		Surface Fir	nish Unspecifi	ed	
	Surface Treatment	nspecifi	ed		Surface Tre	eatment Unspecifi	ed	<u></u>
	Lubrication Sch		Llaspecifis		B 00224		2 Require	ed Life
1 E -	Lubricant Unsp	enie l ecifie	d d	Or	O Yes			10 years
	Total Mass Loss	\$	0	%	CVCM	0		
	Loads: Operatir	ו <u>g</u>	0	<sup>Ib</sup> Peak		0 ib Prel	oad	0 lb
	Rotational Spee	эd		Oscillat	ion Unsp	pecified		_
		rpm	Frequency	/	<u> </u>	" Amplitude	•	0 inches
	Sun Exposure	Jnspe	cified		Low Te	emperature	0	degrees F
	% Time [		0		High Te	emperature	0	degrees F
	Environment	•	Gas					
	Unspecified		Liquid		<u></u>			
	Operating Conditions							
<u> </u>	Non-Operating Conditions		****					
	Comment	-		<u> </u>				
								]

	SPACE STAT	ON LONG SURVEY F		N STUDY	59
Contractor	Lockheed		Survey Nu	mber 59	
WBS Number			Survey Da	te 3/1/86	
Function	Pin puller pistor box ends of sol	or solenoic ar array of	d pistion in launch electrical power	support and rel	ease for
Description	Pin puller	pistion or	solenoid pistion		
(	Surface #1			Surface #2	
Contact Surface	iston/Al		Contact Surface Slee	ve/Al.	
Surface Finish	Inspecified		Surface Finish Uns	pecified	<u></u>
Surface Treatment	nspecified		Surface TreatmentUns	pecified	
Lubrication Sch Lubricant Everl	eme [Dry Film ube 620	SF 	Yes   No		10 years
		% 		<u> </u>	
Loads: Operation		<sup>Ib</sup> Peak	U lb	Preload	<u> </u>
Rotational Spe	ed <sup>rpm</sup> Frequency	Oscillat / [	ion Unspecified 0 <sup>cycles/</sup> Ampli	ude	0 inches
Sun Exposure	ntermittent		Low Temperature	ə 🔤 🛛 0	degrees F
% Time	64		High Temperature	e0	degrees F
Environment	Gas				
Vacuum	Liquid				
Operating Conditions					
Non-Operating Conditions	•				
Comment			-		

			50 - 10 10 - 10 10 - 10					
	S	PACE STATIC	ON LONG T		UBRICA	ATION S	STUDY	60
<b>E</b> .772	Contractor	Lockheed			Survey	Numbe	ər <u>60</u>	
	WBS Number	 	<u></u>		Surve	y Date	3/1/86	· · · · · · · · ·
	Function Bea sys	rings in centi tem	rifugal pum	o of H2	pump/	separat	or of fluid co	ontrol
	Description	Bearings						
	Surt	ace #1				Surfa	ace #2	
B	Contact Surface			Contact S	Surface			
	Surface Finish Unspecified			Surface F	Finish	Unspecif	ied	
				Surface 1	reatment	Unspeci		
= : 	Lubrication Scheme Unspecifie S				2A Coi	npatible	? Require	d Life
	Lubricant Unspecif	ied		() Yes	۲	NO		10 years
	Total Mass Loss	0	%	CVCN	۱ 厂	0	%	
<b>B</b> .2.7	Loads: Operating	0	<sup>ib</sup> Peak		<u> </u>	D Pre	load	0 lb
	Rotational Speed		Oscillati	on Uns	specifie	d		0
		Frequency		0 sec Amplitude			e [	U inches
	Sun Exposure Unsp % Time l			Low	lemper	ature L	0	degrees F
		 	····	High	lemper	ature [	0	degrees F
	Unspecified	Liquid						
	Operating						<u> </u>	]
	Conditions							
	Non-Operating	,					······································	
	Conditions							
	Comment Ope	rating Load:	60 psi, 140	°F, Con	tinuous	<u></u>		
L								
	L						<u></u>	

	SPA	CE STATI	ON LONG T	CERM LUBI	RICATION	STUDY	61
Contractor		Lockheed		Su	rvey Numt	per <u>61</u>	
WBS Number	-			Si	urvey Date	3/1/86	·······
Function	Bearin	gs in pum	p of coolan	t pump of	fluid contro	ol system	
Description	L	Bearings					
	Surface	e #1)			Sur	face #2	
Contact Surface				Contact Surfa	ce		
Surface Finish	ed		Surface Finish Unspecified				
Surface Treatment	Jnspecifie	ed		Surface Treatment Unspecified			
Lubrication Sch Lubricant Unsp	neme (L pecified	Jnspecifie J	9 SF	P R 0022A O Yes	Compatibl	le? Requ	iired Life 10 years
Total Mass Los	s	0	%			0%	<u> </u>
Loads: Operati	ng 🗌	0	<sup>ib</sup> Peak		<u>0</u> ю Рг	eload	0 lb
Rotational Spe	ed		Oscillat	ion Unspe	cified		
0	rpm	Frequency	/	0 cycles/ sec	Amplitu	de	0 inches
Sun Exposure	Unspec	cified	u	Low Ten	nperature		0 degrees F
% Time		0		High Ter	nperature		0 degrees F
Environmen	t	Gas					
Unspecified		Liquid					
Operating Conditions	Operat	ting Load:	60 psi, 180	0°F, continu	ous		
Non-Operating Conditions							
Comment						· · · · · · · · · · · · · · · · · · ·	
	L						

		SPACE STA	TION LONG	CERM LUBR	ICATION STU	YOU	62		
	Contractor	Lockhee	d	Sur	vey Number [	62			
3	WBS Number	· [		Su	rvey Date 3	/1/86			
	Function	Deployer guid	e in mast car	nister of soli	ar array of e	lectrical po	wer		
	Description	Deploye	r guide	· · · · ·					
	(	Surface #1		Surface #2					
	Contact Surface	ixed dep. gu./delr	···	Contact Surfac	e Mast ele. r	oller/al.			
	Surface Finish	nspecified		Surface Finish	Unspecified				
n n Brain anns	Surface Treatment	nspecified		Surface Treatr	mentUnspecified				
	Lubrication Sch	eme Unspeci	fie S	P R 0022A	Compatible?	Require	d Life		
	Lubricant None	<u>د ا</u>		O Yes	No		10 years		
	Total Mass Los	5	0 %	сусм	0 9	%			
	Loads: Operation	ng	0 <sup>Ib</sup> Peak		<u>0</u> њ Preloa	ld	0 lb		
	Rotational Spec	ed	Oscillat	ion Unspec	cified				
	0	<sup>rpm</sup> Frequer	1су	cycles/ sec	Amplitude		0 inches		
	Sun Exposure	ntermittent		Low Tem	perature	0	degrees F		
	% Time	64		High Tem	perature	0	degrees F		
	Environment	t Ga	s						
1	Vacuum	Liqui	t						
	Operating			<u></u>					
	Conditions								
	Non-Operating								
	Conditions								
	Comment								
	Comment								
				·					

Contractor       Lockheed       Survey Number       63         WBS Number       Survey Date       3/1/86         Function       Bearings in pump of coolant control assembly of water electrolysis system         Description       Bearings         Contact Surface       Surface #1         Contact Surface       Contact Surface         Surface Finish       Unspecified         Surface TreatmentUnspecified       Surface TreatmentUnspecified         Surface TreatmentUnspecified       Surface TreatmentUnspecified         Lubrication Scheme       Unspecified         Surface TreatmentUnspecified       SP R 0022A Compatible?         Required Life       Unspecified         Lubrication Scheme       0 %         Cotal Mass Loss       0 %         O reprim       Frequency         Oscillation       Unspecified         O reprim       Frequency         O secillation       Unspecified         Sun Exposure Unspecified       Low Temperature       0 degrees F         % Time       0       High Temperature       0 degrees F         Sun Exposure Unspecified       Liquid       Conditions       Conditions         Operating       Operating Load: 300 psi, 180°F, continuous       Conditions		SPACE STATION LONG SURVEY	TERM LUBRICATION STUDY 63				
WBS Number	Contractor	Lockheed	Survey Number 63				
Function       Bearings in pump of coolant control assembly of water electrolysis system         Description       Bearings	WBS Number		Survey Date 3/1/86				
Description       Bearings         Surface #1         Contact Surface         Surface Finish         Lubrication Scheme         Unspecified         Lubrication Scheme         Unspecified         Lubrication Scheme         Unspecified         Contact Surface         O Yes         No         10         No         O %         Conditions         O %         O %         O %         O %         O %         O %         O % <td colspan<="" td=""><td>Function</td><td>Bearings in pump of coola system</td><td>ant control assembly of water electrolysis</td></td>	<td>Function</td> <td>Bearings in pump of coola system</td> <td>ant control assembly of water electrolysis</td>	Function	Bearings in pump of coola system	ant control assembly of water electrolysis			
Surface       #1       Surface       Surface       #2         Contact Surface       Contact Surface       Contact Surface       Surface Finish       Unspecified         Surface Finish       Unspecified       Surface Finish       Unspecified       Surface Finish       Unspecified         Surface TreatmentUnspecified       Surface TreatmentUnspecified       Surface TreatmentUnspecified       Required Life         Lubrication       Scheme       Unspecified       O Yes       No       10       years         Total Mass Loss       0       %       CVCM       0       %       Loads: Operating       0       Ib       Preload       0       Ib         Rotational Speed       0       %       CVCM       0       %       0       inches         Sun Exposure       Unspecified       Low       Temperature       0       degrees F         % Time       0       High Temperature       0       degrees F         Environment       Gas	Description	Bearings					
Contact Surface       Contact Surface         Surface Finish       Unspecified         Surface Finish       Unspecified         Surface Treatment[Unspecified       Surface Treatment[Unspecified         Lubrication Scheme       Unspecified         Surface Treatment[Unspecified       SP R 0022A Compatible?         Lubrication Scheme       Unspecified         Surface Treatment[Unspecified       O Yes         Lubrication Scheme       0         Suface Treatment[Unspecified       0         Lubrication Scheme       0         Suface Treatment[Unspecified       0         Lubrication Scheme       0         Suface Treatment[Unspecified       0         Total Mass Loss       0       %         Codds:       Operating       0         Required Life       0       10         Vears       0       %         Required Life       0       10         Sun Exposure       0       0		Surface #1)	Surface #2				
Surface Finish       Unspecified         Surface Treatment       Unspecified         Subscript       0         Years       0         No       0         Total Mass Loss       0         0       %         Codes:       Operating         0       re         Required       0         Non-Operating       Operating Load:         Operating       Operating Load:         Conditions       Pumps water or fluorinert through electrolyzer	Contact Surface		Contact Surface				
Surface Treatment       Unspecified       Surface Treatment       Unspecified         Lubrication Scheme       Unspecified       SP R 0022A Compatible?       Required Life         Lubricant       Unspecified       O Yes       No       10         Total Mass Loss       0       %       CVCM       0       %         Loads: Operating       0       Ib       Peak       0       Ib       Preload       0       Ib         Rotational Speed       O rpm       Frequency       0       cycles/       Amplitude       0       inches         Sun Exposure       Unspecified       Low Temperature       0       degrees F         % Time       0       High Temperature       0       degrees F         Unspecified       Liquid	Surface Finish	Unspecified	Surface Finish Unspecified				
Lubrication Scheme Unspecifie       SP R 0022A Compatible?       Required Life         Lubricant Unspecified       O Yes       No       10         Total Mass Loss       0       %       CVCM       0       %         Loads: Operating       0       1b       Peak       0       b       Preload       0       1b         Rotational Speed       0       rpm       Frequency       0       cycles/       Amplitude       0       inches         Sun Exposure Unspecified       Low Temperature       0       degrees F       %       Time       0       degrees F         Environment       Gas	Surface Treatment	Unspecified	Surface Treatment Unspecified				
Loads: Operating       0       ib       Peak       0       ib       Preload       0       ib         Rotational Speed       Oscillation       Unspecified       0       inches         Sun Exposure       Unspecified       Low Temperature       0       degrees F         % Time       0       High Temperature       0       degrees F         Environment       Gas	Lubrication Sci Lubricant Uns	heme Unspecifie S pecified	SP R 0022A   Compatible?   Required Life     O Yes   No   10     CVCM   0 %				
Coads: Operating       O is reak       O is read       O is read         Rotational Speed       Oscillation       Unspecified         0       rpm       Frequency       0       cycles/ Amplitude       0         Sun Exposure       Unspecified       Low Temperature       0       degrees F         % Time       0       High Temperature       0       degrees F         Environment       Gas	Loode: Operat						
Non-Operating Conditions       Operating Operating Conditions       Operating Conditions       Comment       Pumps water or fluorinert through electrolyzer							
Sun Exposure       Unspecified       Low Temperature       0       degrees F         % Time       0       High Temperature       0       degrees F         Environment       Gas		<sup>rpm</sup> Frequency	0 cycles/ Amplitude 0 inches				
% Time       0       High Temperature       0 degrees F         Environment       Gas	Sun Exposure	Unspecified	Low Temperature 0 degrees F				
Environment       Gas         Unspecified       Liquid         Operating       Operating Load: 300 psi, 180°F, continuous         Conditions       Operating         Non-Operating       Operating         Conditions       Pumps water or fluorinert through electrolyzer	% Time	0	High Temperature 0 degrees F				
Unspecified       Liquid         Operating Conditions       Operating Load: 300 psi, 180°F, continuous         Non-Operating Conditions       Image: Condition set of the set of th	Environmen	nt Gas					
Operating Conditions       Operating Load: 300 psi, 180°F, continuous         Non-Operating Conditions       Image: Condition set of the set of t	Unspecified	Liquid					
Non-Operating Conditions         Comment         Pumps water or fluorinert through electrolyzer	Operating Conditions	Operating Load: 300 psi,	180°F, continuous				
Comment Pumps water or fluorinert through electrolyzer	Non-Operating Conditions						
	Comment	Pumps water or fluorinert	through electrolyzer				

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		SPACE STATIC	ON LONG T SURVEY F	ERM LUBRI	CATION STU	DY	64		
L	Contractor	Lockheed	•	Surv	ey Number	64			
	WBS Number	· - · ·		Surv	vey Date 3	/1/86	<u></u>		
	Function II	nterface/containr of electrical pov	nent box to wer	mast in co	ntainment bo	x of solar	array		
	Description	Interface/c	ontainment	box to mas	st				
	Surface #1			Surface #2					
ن ال متيا	Contact Surface Co	ntain box/SS & Al.		Contact Surface	Mast/AI.				
	Surface Finish Unspecified			Surface Finish Unspecified					
				Surface Treatme	entUnspecified				
نـــا	Lubrication Sche	me Dry Film	SF	R 0022A C	Compatible?	Required	l Life		
	Lubricant Everlu	be 620		O Yes (	● No		<u>10</u> years		
1 <u>1</u> 1	Total Mass Loss	0	%		0 %	5			
	Loads: Operating	g0	<sup>Ib</sup> Peak	0	ь Preloa	d []	0 lb		
	Rotational Spee	d	Oscillat	ion Unspeci	fied				
	0 rp	<sup>m</sup> Frequency		0 cycles/ sec	Amplitude		0 inches		
	Sun Exposure In	itermittent		Low Temp	erature	0 0	legrees F		
	% Time	64	64		High Temperature 0				
	Environment	Gas	51 200 2	# 2* · · · · · · · · · · · · · · · · · ·					
	Vacuum	Liquid							
		=							
	Operating			1					
	Conditions								
					<u></u>				
	Non-Operating								
	Conditions				. <u> </u>				
•	Comment [				<u> </u>		]		
• • •									
						<u> </u>			
			· <del>.</del> .						

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Contractor       Lockheed       Survey Number       65         WBS Number       Survey Date       3/1/86         Function       Motor drive pinion gear in array containment box positioning sy of solar array of electrical power								
WBS Number       Survey Date       3/1/86         Function       Motor drive pinion gear in array containment box positioning sy of solar array of electrical power								
Function Motor drive pinion gear in array containment box positioning sy of solar array of electrical power								
	rstem							
Description Motor drive plinion gear	<b></b>							
Surface #1 Surface #2								
Contact Surface Actuator/SS								
Surface Finish Unspecified Surface Finish Unspecified	Surface Finish Unspecified							
Surface Treatment Unspecified Surface Treatment Unspecified								
Lubrication Scheme       Dry Film       SP R 0022A       Compatible?       Required Life         Lubricant       Everlube 620       O Yes       No       10       years								
Total Mass Loss 0 % CVCM 0 %								
Loads: Operating0 в Preload	0 іь							
Rotational Speed     Oscillation     Unspecified       0     rpm     Frequency     0     cycles/ sec     Amplitude	0 inches							
Sun Exposure Intermittent Low Temperature 0 d	legrees F							
% Time 64 High Temperature 0 d	legrees F							
Environment Gas								
Vacuum Liquid								
Operating Conditions								
Non-Operating Conditions								
Comment * Motor drive pinion or worm gear/Al.								

	p										T	
1 1 5 1 6 1 3		SPA(	CE STATI	ON LON	G T Y F(	ERM LUBF		ATION	STU	DY 		66
نا	Contractor	L	ockheed			Su	rvey	/ Numb	er [	66		
	WBS Number	· - [	- ·			Su	irve	y Date	3/	1/86		
	Function P s	osition olar a	ner syster array of e	m in arra electrical	ay ( por	containment wer	t bo	ox posit	ionir	ng syste	əm	of
	Description	[F	Poistioner	system								
	s	Surface	#1					Surt	ace	#2		
Ener, et Engrad	Contact Surface pin	s in po	s. sys./Al			Contact Surfa	ce	Bushing	in p	.s./Al		
	Surface Finish	specifie	d			Surface Finis	h	Unspeci	ified	<u></u>		
	Surface TreatmentUn	specifie	d	,	<u></u>	Surface Treat	men	Unspec	ified			
	Lubrication Sche		)ry Film		SE	B 0022A	Co	mpatible	e?	Requi	irec	d Life
	Lubricant Everlu	be 62	20			O Yes	0	No				<u>10</u> years
	Total Mass Loss	L	0	%				(	0 %			
n Record	Loads: Operating 0 <sup>Ib</sup> Peak			ak [		0	ib Pre	eload	±		0 lb	
	Rotational Speed	d		Oscil	lati	ion Unspe	cifi	ed			_	
	0 rp	m	Frequency	/		C cycles/ sec	A	mplituc	le			0 inches
-	Sun Exposure In	itermi	ttent			Low Ten	npe	rature			0	degrees F
<b>È</b> :	% Time		64			High Ten	npe	rature			0	degrees F
	Environment		Gas									
	Vacuum		Liquid	1								
	Operating Conditions						-	<u> </u>				
	Non-Operating Conditions											
	Comment		. <u></u>		<u></u>	/ . <u></u>						
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	SPACE STATION LON	G TERM LUBRICATION STUDY 67				
Contractor	Lockheed	Survey Number 67				
WBS Number	-	Survey Date 3/1/86				
Function	Motor ball bearings in a solar array of electrical	rray containment box positioning system of power				
Description	Motor ball bearing	<u>S</u>				
(	Surface #1	Surface #2				
Contact Surface	Bearings/SS	Contact Surface Race/SS				
Surface Finish	Inspecified	Surface Finish Unspecified				
Surface Treatment	Inspecified	Surface Treatment Unspecified				
Lubrication Sch Lubricant Bray	neme Fluid * cote 601	SP R 0022A Compatible? Required Life O Yes  No				
Total Mass Los	s %	CVCM0 %				
Loads: Operati	ng <u>0</u> Ib Pe	ak0 ib Preload0 it				
Rotational Spe	ed Osci	llation Unspecified				
0	<sup>rpm</sup> Frequency	0 cycles/ Amplitude 0 inche				
Sun Exposure	Intermittent	Low Temperature 0 degrees F				
% Time	64	High Temperature     0 degrees F				
Environmen	t Gas					
Vacuum	Liquid					
Operating						
Conditions						
Non-Operating Conditions						
Comment	* Grease					

							1		
k ::		SPACE STATIC	SURVEY F	ERM LUBRIC	ATION STU	DY	68		
	Contractor	Lockheed	2 - <u>1 - 1 - 1</u>	Surve	y Number	68			
	WBS Number	·	2 and 120 3 a me	Surve	ey Date 3/	1/86			
All the second s	Function L s	atch and release system of solar	e mechanis array of el	m in array co ectrical power	ntainment b	ox position	ing		
	Description	Latch and	release me	chanism					
	(	Surface #1		Surface #2					
<b></b>	Contact Surface La	tch/Al		Contact Surface	Release/Al				
1	Surface Finish Un	specified		Surface Finish Unspecified					
	Surface Treatment	specified		Surface Treatment Unspecified					
	<u></u>			1					
	Lubrication Sche	eme Dry Film	SF	PR 0022A Co	ompatible?	Required	I LITE		
11111111111111111111111111111111111111	Lubricant Everlu	ıbe 620		O Yes 🖲	) No		10 years		
	Total Mass Loss	<u>0</u>	%		0 %	, 			
	Loads: Operatin	g0	<sup>Ib</sup> Peak	0	ib Preload	d [	0 іь		
	Rotational Spee	d	Oscillat	ion Unspecifi	ed				
	0 rp	<sup>om</sup> Frequency		cycles/A	mplitude		0 inches		
	Sun Exposure Ir	ntermittent		Low Tempe	erature	0 (	Jegrees F		
	% Time	64	5 m - 10 m	High Tempe	erature	0	Jegrees F		
	Environment	Gas							
	Vacuum	Liquid [							
	Operating Conditions								
	Non-Operating Conditions		<u> </u>	<u></u>					
	Comment I	Mechanism holds	box positio	 on					
			•						

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Lockheed to-mast hinges system em of solar array of el Box-to-mast hinges s	Survey Number 69 Survey Date 3/1/86 in array containment box postion ectrical power system Contact Surface Bushings/Al. *	ning			
to-mast hinges system em of solar array of el Box-to-mast hinges s	Survey Date 3/1/86 in array containment box postion ectrical power system Contact Surface Bushings/Al. *	ning			
to-mast hinges system em of solar array of el Box-to-mast hinges s	in array containment box postion ectrical power system Contact Surface Bushings/Al. *	ning			
Box-to-mast hinges s	Contact Surface Bushings/Al. *				
cified	Contact Surface Bushings/Al. *				
cified	Contact Surface Bushings/AI. *				
sified					
	Surface Finish Unspecified	<u> </u>			
Dified	Surface TreatmentUnspecified				
Dry Film SF	PR 0022A Compatible? Requir O Yes  No	red Life 10 years			
0 %	CVCM0 %				
0 <sup>ib</sup> Peak	0 ь Preload	0 іь			
Oscillati	ion Unspecified	-			
Frequency	0 <sup>cycles/</sup> Amplitude	0 inches			
mittent	Low Temperature	0 degrees F			
64	High Temperature	0 degrees F			
Gas					
Liquid					
box-to-mast hinges sys	stem				
	fied fied fied Dry Film SF 520 0 % 0 b Peak Oscillati Frequency mittent 64 Gas Liquid box-to-mast hinges system SF SF SF SF SF SF SF SF SF SF	fied       Surface Finish       Unspecified         fied       Surface Treatment[Unspecified         Dry Film       SP R 0022A       Compatible?         Base       O Yes       No         0       %       CVCM       0         0       %       CVCM       0         0       %       CVCM       0         0       %       O to       Preload         0       %       O scillation       Unspecified         Frequency       0       %       Amplitude         nittent       Low Temperature       64         Gas			

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a baka mam		SPACE STATIC	ON LONG T		CATION STU	DY	70
	Contractor	Lockheed		Surve	ey Number [	70	
	WBS Number			Surv	vey Date 3/	1/86	
	Function Pi	inion gear in m	ast caniste	r of solar an	ray of electr	ical power	
	L. Description	Pinion gea	r	an a			
	s	urface #1			Surface	#2	
	Contact Surface			Contact Surface			
	Surface Finish Uns	pecified		Surface Finish	Unspecified	<u> </u>	<u> </u>
	Surface TreatmentUns	pecified		Surface Treatme	ent Unspecified	<u></u> , <u></u> ,	
	Lubrication Scher	me Dry Film	SF	PR 0022A C	compatible?	Require	d Life
	Lubricant Everlut	be 620		O Yes	) No		10 years
	Total Mass Loss	0	%		0 %	)	
	Loads: Operating	0	<sup>Ib</sup> Peak	0	ib Preloa	d []	0 lb
	Rotational Speed		Oscillat	ion Unspeci	fied		
· · ·	0 rpi	<sup>m</sup> Frequency		0 cycles/	Amplitude		0 inches
1 <b>1</b>	Sun Exposure	termittent		Low Temp	erature	0	degrees F
	% Time	64	1.3	High Temp	erature	0	degrees F
	Environment	Gas					
	Vacuum	Liquid [					
	Operating Conditions						
	Non-Operating Conditions		<u></u>		. <u> </u>		
	Comment	Deployer nut ri Drive assemb	ng gear Al. Iy pinion g	ear/SS			
	L	<u></u>				· · · · · · · · · · · · · · · · · · ·	

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	SPACE STATION LONG SURVEY F	TERM LUBRICATION STUDY 71								
Contractor	Lockheed	Survey Number 71								
Function	Pinion gear in mast canister of solar array of electrical power									
Description	Pinion gear									
Contact Surface  *	Surface #1	Contact Surface * *								
ے Surface Finish ال Surface Treatment	Unspecified Unspecified	Surface Finish Unspecified Surface TreatmentUnspecified								
Lubrication Sch Lubricant Ever	neme Dry Film Si lube 620	P R 0022A Compatible? Required Life O Yes  No 10 years								
Total Mass Los	s0 %	CVCM0 %								
Loads: Operati	ng0 <sup>Ib</sup> Peak	0 в Preload 0 в								
Rotational Spe	ed Oscillat <sup>rpm</sup> Frequency	ion Unspecified 0 cycles/ Amplitude0 inches								
Sun Exposure	Intermittent	Low Temperature 0 degrees F								
% Time	64	High Temperature 0 degrees F								
Environmen Vacuum	t Gas Liquid									
Operating Conditions										
Non-Operating Conditions										
Comment	* Deployer nut ring gear/AL ** Drive assembly pinion g	- jear/SS								

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	SPACE STATION LONG TERM LUBRICATION STUDY SURVEY FORM									
	Contractor		Lockheed	·····						
	WBS Number			Survey Date 3/1/86						
	Function Cables to rage reel in blanket tensioning and guideline wire system solar array of electrical power									
	L		Cables to	rage reel			····			
	Surface #1				Surface #2					
· •	Contact Surface Hub/Al or Delrin				Contact Surface Axle/AL					
	Surface Finish Unspecified				Surface Finish Unspecified					
	Surface TreatmentUnspecified				Surface Treatment Unspecified					
	Lubrication Sch	eme [[	Dry Film	SF	PR 002	2A Co	mpatible	e? Require	ed Life	
<u> </u>	Lubricant Everlube 620 *			O Yes	; O	No 10 year				
	Total Mass Loss	s 厂	0	%	CVC	и [		<u>)</u> %		
	Loads: Operating C			<sup>Ib</sup> Peak		0	ib Pre	load	0 ю	
	Rotational Speed Oscill			Oscillat	ion Un	specifi	ed			
	0 <sup>rpm</sup> Frequency		/	o <sup>cycles/</sup> Amplitude						
	Sun Exposure	ittent		Low Temperature			0	degrees F		
1 karı 1 karı	% Time _	·····	64		High	Tempe	rature	0	degrees F	
	Environment		Gas							
	Vacuum		Liquid		· · · · · · · · · · · · · · · · · · ·					
	Operating Conditions									
_	Non-Operating Conditions									
•	Comment [	* none	for Delrir	n hub						
·	Sommont									
	-			·						

