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SNAP 19 PROGRAM

MASTER

EJECT MECHANISM COLD WELDING EVALUATION

MND-3169-66

May 1965

S. Podlaseck

Approved: M. P. Norin

M. Norin

Project Engineer

C. R. Fink /mpn

C. R. Fink

Program Manager

Contract AT(30-1)3169

Martin Marietta Corp.

Nuclear Division

Phil Fink

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SNAP 19 PROGRAM
EJECT MECHANISM COLD WELDING
EVALUATION

A. Discussion

The term "cold welding" is normally defined as the welding of two metal masses by some mechanism in which neither of the masses are necessarily brought into the liquid state. The process is aided by both normal and tangential forces, by heat and by vibrational energy. It should also be recognized that the extent of physical bonding of two metallic surfaces will be influenced by oxides, sub-oxides, carbides, subcarbides or any other impurity monolayer present at one or both of the contacting surfaces.

There appears to be real cause for concern that, under ideal conditions, certain combinations of artificial and natural environments to which the SNAP 19 eject mechanism will be exposed could bring about strong physical junctions at metal contacting surfaces. The prime areas of concern are the back-up nut-piston assembly interface, the piston-cylinder interface, the guide pin-guide pin slot interface and the release bolt-upper spring interface. However, an examination of the assembly details of the SNAP 19 ejection mechanism has led this writer to conclude that the potential cold-welding problem in this device can be minimized with appropriate lubrication applications.

Before examining the various problem areas associated with the ejection mechanism, it should be noted that the subject of

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cold welding of clean, metallic surfaces has only recently been considered a problems worthy of intensive study. As a result, although many investigations are currently in progress throughout the country (see attached list), no thorough, fundamental understanding of this phenomenon exists. It is known, however, that environmental pressure, temperature, contact time, type of material couples, amount and type of impurities at the surface, amount and type of impurities in the bulk metal, and the applied load are all significant parameters.

It is also known that the phenomenon of cold-welding of two metallic surfaces is difficult to reproduce in the laboratory, and normally, scrupulous surface cleaning techniques are required to exhibit the phenomenon.^(1,2) This criteria for cold-welding i.e., surfaces void of contaminates (either solid or fluid), implies a mechanism for the prevention of the phenomenon.

For this ejection assembly, therefore, the problem reduces itself to that of providing an impurity or contamination at all contacting interfaces for a time period as great as 5 years. A further requirement shall be that combined friction and adhesion forces do not exceed the available ejection force (300-350 pounds) at the time that separation is desired. Assuming the lifetime requirement can be met, a lubricant would be the obvious solution to both these requirements.

Fluid lubricants would be the first choice because of the many types available and because of their ease of application.

Space hardware experience with greases and oils is limited, however, and laboratory experiences have been restricted to low load, high speed applications.⁽³⁾

Solid film lubricants have proved to be more popular for long term spacecraft applications in both sliding and rolling applications⁽⁴⁻⁹⁾. Many types of solid film lubricants have been developed for use in the temperature range -450 to +1500°F in both oxidizing and reducing environments.⁽⁶⁾ These lubricants are applied to the surface in either the pure condition or a filler material in a bonded matrix of organic or ceramic coating.

The most popular of the current solid film lubricants is molybdenum disulfide (MoS_2). A choice of application techniques are available utilizing the low friction characteristics of MoS_2 . These include:

1. dry powder
2. dispersions - mixture of solid lubricant in fluid lubricant or metal working fluid - used in applications where lubrication area is inaccessible or where application of powder is too complex.
3. bonded coatings - solid lubricant, together with binder dispersed in suitable solvent and applied to surfaces by brushing, dipping or spraying.

The latter two application techniques are used to alleviate friction and wear in sliding and rolling interfacial contact areas where long running life is required and an excess reservoir of lubricant is called for. This does not appear to be a consideration for the SNAP 19 eject assembly; therefore, any of the three application techniques would seem to be entirely adequate.

The two remaining questions regarding the effectiveness of the solid film in eliminating intimate metal contacting areas is the expected lifetime of the MoS_2 and the frictional characteristics of the lubricant at the extreme environmental conditions for the maximum exposure time.

Johnson et al (9) have shown that the expected weight loss through sublimation or dissociation of MoS_2 at temperatures below 200°F is immeasurably small (10^{-10} gm/cm²/sec) and for the expected lifetime of 1.5×10^8 sec, in a closed container, one would not expect to see any significant loss of MoS_2 .

With regard to the lubricating effectiveness of MoS_2 after prolonged vacuum exposure, Brown et al (8) have shown that the solid film actually may behave in a more desirable, more predictable fashion in vacuum than under normal atmospheric conditions. In an oxidizing environment, the tendency for MoS_2 to be converted to the oxide sometimes causes a change in the frictional behavior of the solid film over extended service periods. This does not appear to be the case when the solid film is used in vacuum application. As a result, so long as the film is present, one would expect a friction coefficient of approximately 0.1 on sliding surfaces (such as the piston-cylinders) throughout the expected life span of the ejection assembly.

It is felt that by applying dry film coatings (as per Martin proc. P-40007, type II) to the piston assembly (drawing 452A1050016) and to the upper spring assembly (drawing 452A1050008) in the areas indicated in Fig. 1, all problems of interfacial contact in the eject assembly mechanism are virtually eliminated and should be expected to remain that way for the duration of the intended 5 year life.

DRY FILM COATING PER MARTIN PROC. P-4007
TYPE II

FIGURE - I

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2. Gilbreath, W. P. and Sumsion, H. T., "Solid-Phase Welding of Metals Under High Vacuum", NASA Ames Research Center, Moffett Field, California.
3. Young, W. C. and Clauss, F. J., "Lubrication for Spacecraft Application", Preprint No. 65AM4A5, presented at the 20th Annual Meeting, American Society of Lubrication Engineers, May 4-7, 1965.
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8. Brown, R. D., Burton, R. A. and Ku, P. M., "Long Duration Lubrication Studies in Simulated Space Vacuum", *ibid*.

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B. REFERENCES - Continued

9. Johnson, R. L., Duckley, D. H. and Swikert, M. A., "Studies of Lubricating Materials in Vacuum", *ibid.*

**C. CURRENT GOVERNMENT SPONSORED STUDIES RELATED TO VACUUM
COLD-WELDING**

- a. Contract AF 01(611)-7411 (Rockets in Space Environment)
Performing Contractor: Aerojet General, Azusa (P.D. Gray)
Sponsored by: AFRPL Edwards AFB (P. A. Van Splinter)
- b. Contract NASr-48 (Metallic Cohesion in High Vacuum)
Performing Contractor: National Research Corp. (John Ham)
Sponsored by: NASA (Dr. H. Frankel GSFC)
- c. NASA Grant No. NSG-483 (Adhesion Between Atomically Clean Surfaces) Performing
Performing Contractor: Syracuse Univ. (Prof. D.V. Keller, Jr.)
Sponsored by: NASA Hdqtrs. (Joseph Maltz)
- d. Contract NAS8-11066 (Study of Adhesion and Cohesion in Vacuum)
Performing Contractor: Hughes Aircraft Co. (Paul Winslow)
Sponsored by: NASA Huntsville (Reith Demorest)
- e. Contract NASW-734 (Investigation of Adhesion and Cohesion in Ultra High Vacuum)
- f. Contract NAS9-3623 (Cold Molecular Welding Study)
Performing Contractor: Midwest Research Inst. (Dr. Paul Bryant)
Sponsored by: NASA Houston (J. A. Kimzey)
- g. Contract AF 04(611)-9717 (High Vacuum Welding Study)
Performing Contractor: National Research Corp. (Dr. W. Hordon)
Sponsored by: AFRPL Edwards AFB (Lt. D. T. Clift)

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h. Contract AF 04(611)=9883 (In Space Cold Welding Tests)

Performing Contractor: TRW Space Technology Labs. (R. Hammel)

Sponsored by: NASA Langley (John Mugler)

i. Contract NAS1-2691 (Surface Cleaning Techniques in Ultra High Vacuum)

Performing Contractor: National Research Corp. (Dr. N. Beacher)

Sponsored by: NASA Langley (John Mugler)

j. Contract NASr-63 (06) (Ultra High Vacuum Measurements and Associated Cold Welding Studies)

Performing Contractor: Midwest Research Inst. (Dr. Paul Bryant)

Sponsored by: NASA Hdqtrs (M. Charak)

K. Contract AF 33(615)-1280 (Vibrating Reed Analysis of Structural Materials)

Performing Contractor: Northrup Space Labs (Dr. James Piechocki)

Sponsored by: AFFDL Wright-Patterson AFB (Keith I. Collier)