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Contact Lubrication

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CONTACT LUBRICATION

PURPOSE AND SCOPE

The purpose of this document is to review contact lubricants used in signal contact systems for electronics. Factors affecting the use of lubricants will be discussed including those area's requiring further study. Applicable advantages, limitation and cautions are indicated. A bibliography is included if further investigation is desired.

It is not the intent of this document to make a conclusion or forward a recommendation.

Due to the wide variation of available lubricants (both generic and proprietary), the specific situations briefly discussed herein may not be of issue contingent on the lubricant formulation which may have been designed to resolve a specific problem.

In considering the use of a lubricant, the reader is advised to assess the specific areas of interest and chose a lubricant which best fits the application after proper evaluation techniques have been performed.

A. BIBLIOGRAPHY

The information contained herein has been based from various publications and papers as indicated in the bibliography contained at the end of this document. For more specific information, these publications should be researched as applicable.

B. BASIC PHENOMENON

Two surfaces in contact with each other appear to form a relatively large continuous contact area. In reality the real area of contact is formed by contact asperities (commonly called "a-spots"). These asperities are actually metallic peaks in contact with each other and represent as low as 1% of the apparent contact area.

When a contact force is applied these peaks contact each other and may actually enlarge dependent on the magnitude of the applied force. This may result in localized cold welding and/or potential galling.

Cold welding is defined as the solid state bonding between atoms of the metallic surface areas in contact. Contamination free surfaces are required for this to fully occur. The presence of contaminants on the surface can minimize cold welding.

Galling is defined as a wear condition resulting from friction between the asperities of the contacting surfaces. This can result in localized welding and subsequent metal surface disruption, metal transfer and/or further roughening of the mating surfaces.

In addition, when one of the two, or both contacting surfaces are moved relative to each other, any localize cold welding between the asperities has to be broken or sheared. This shearing force is a function of a number of variables such as compressive forces, surface conditions, cleanliness etc.

BASIC PHENOMENON - Continued

When a lubricant is applied to a surface, the fluid generally forms small droplets. When surfaces are brought into contact, these droplets are spread over the entire surfaces in the form of a thin film. The film is thin enough to be penetrated in several areas by the material asperities thus not affecting electrical resistance. The impact of this film results in minimizing cold welding, reduces shear forces involved and hence reduces wear, galling and frictional forces.

C. CONNECTOR ATTRIBUTES AFFECTED BY LUBRICATION

1. WEAR: The term "wear" indicates the "forced" removal of contact material during the sliding action which occurs. This removal may be a result of the transfer phenomena, loss of loose particles (debris), pushing material aside, etc. The following are the basic wear mechanisms which exist.

   a) ABRASIVE: Wear resulting from rough, sharp hard materials or a combination thereof in contact with a softer material. An example of this is a lead-in chamfer of a mating pcb against a gold or tin (ally) plating of the mating contact. Lubricants may not be effective in these situations.

   b) BRITTLE FRACTURE: This is the cracking of a plated surface perpendicular to the direction of sliding. This type of wear can occur on low strength materials or a poorly controlled plating process. Lubrication by itself will not prevent this type of wear from occurring.

CONNECTOR ATTRIBUTES AFFECTED BY LUBRICATION - Continued

c) ADHESIVE: This is the most common type of wear common to connectors. Basically this type of wear results from cold welding and/or the transfer phenomena. This type of wear is significantly reduced when a lubricant is used on the surfaces.

The rate of wear sharply increases from "mild" to "severe" usually when a specific load is achieved. Use of a lubricant will result in this transition to occur at higher force levels with all other factors being equal.

Lubrication will also allow thinner gold plating to be used due to the reduction of the wear rate.

2. CORROSION: A lubricant can "seal" off reactive surfaces from the surrounding atmosphere. It can also significantly reduce pore corrosion as well. Microcrystaline wax or a mixture of wax and an oil are effective in this case.

   Fretting corrosion may be inhibited by the use of a fluid lubricant. It will reduce fretting wear on of gold platings as well as inhibiting frictional polymers in palladium (alloy) systems.

3. LOWER MATING FORCES: A lubricant by its inherent nature reduces coefficient of friction and this decreases the mating force of a connector system. This can be an important feature for high density connector currently evolving. Said reduction may be as great as 80% contingent on contact configuration (entry geometry), surface, conditions (eg. roughness, cleanliness, etc.). This reduction may be achieved without reducing normal force and may allow an actual increase in this attribute without adversely affecting the resultant mating force.

CONNECTOR ATTRIBUTES AFFECTED BY LUBRICATION - Continued

Typical coefficient of frictions are as follows:

Clean surfaces	: 0.3 to 1.0
Lubricated Surfaces	: 0.15 to 0.2

There are two basic equations which may be used in understanding frictional forces:

a) $F = (KN/H)S$

F = Frictional Force
K = Constant, Proportionality
N = Normal Force
H = Hardness of the soft material
S = Shear Strength of the soft material

b) $F = \mu N$

F = Frictional Force
μ = Coefficient of Friction
N = Normal Force

In essence, frictional forces is a function of cold welding. Cold Welding is a function of the adhesive bonding of metals in contact relative to the "real" area contact and the shearing force required. A lubricant will minimize the "real" area of contact. It also exhibits a much lower shear force and as a result of these factors, the frictional forces are reduced.

D. CONDITIONS TO BE EVALUATED

1. COSTS: The addition of a lubricant is an additional step in the manufacturing process and as a result represents additional costs. This cost can greatly vary contingent on the technique.

CONDITIONS TO BE EVALUATED - Continued

2. CLEANING: If a lubricant is applied by the connector manufacturer, cleaning will remove the lubricant and, hence, no advantage will be gained.

3. PARTICULATE RETENTION: A lubricate can increase the retention of particulates from the environment. This can be in the form of dust and/or fibers. Recent studies have indicated that dust does not adversely affect the function of a lubricant. Further study is required relative to fibers.

4. CONTAMINATION OF ADJACENT SURFACES: Certain lubricants and the volatile carriers can transfer to adjacent surfaces. Non-spreading, low volatility lubricants are, however, unlikely to transfer.

5. A lubricant reduces mating forces. It will also reduce unmating forces. Thus, to prevent "walk out", connectors with a lubricant should be "locked" together by jackscrews or other hardware locking techniques used in its application.

6. Fluid lubricants contingent on their formulation may evaporate. The rate of evaporation varies and is temperature dependent. Lubricants used in applications beyond 65°C should be researched prior to using.

E. COMMON CONTACT LUBRICANTS

The following are typical contact lubricants available:

a) Polyphenylethers : 5-PPE and 6-PPE
b) Hydrocarbon oils : Mineral Oils
c) Perfluroalkylpolyethers
d) Polyolefin

For additional information relative to generic or proprietary contact lubricants, the following companies may be contacted:

Monsanto, St. Louis, MO
William F. Nye, New Bedford, MA
Dow Chemical Corporation, Midland, MI
Tenneco Chemicals, Piscataway, NJ
Rohm & Haas, Philadelphia, PA
Electrotube Corporation, Syosset, NY

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