



# Data Sheet

## Electrical contact lubrication

Electrical contact technology has become an increasingly complex subject with the advent of specialised alloys and bi-metallic contacts; in fact the number of different types has proliferated of recent years. The reason for this may be found in the continuing search by manufacturers for a materials, or combination of materials, which will provide longer life and higher reliability to their contacts or switching mechanisms.

Long life and reliability are, relatively speaking, in short supply in the contactor field for a number of reasons inherent in the physical construction and action of contactors. The problems associated with contactor technology have been aggravated of recent years by the competitiveness of the market, forcing manufacturers to use less expensive, lower grade materials in an attempt to win or maintain market share against overseas competition.

Looking at the field of contactor technology and possible solutions to its problems, it will be seen that these fall into the following categories:

- Surface finish; wear and arc erosion
- Contamination; oxidation and silicone contamination
- Fretage and fretage corrosion
- Contact bounce.

### The problems

#### Surface finish

Quality of the surface finish is vitally important as this determines the amount of wear and contact resistance experienced during use of the contact. Surfaces, which may appear smooth, are in fact composed of minute peaks and troughs, and over their surface area will only make contact at a few relatively high points. Wear will occur at the high points, and debris from the abrading process will collect in the troughs, and will act like carborundum to increase wear.

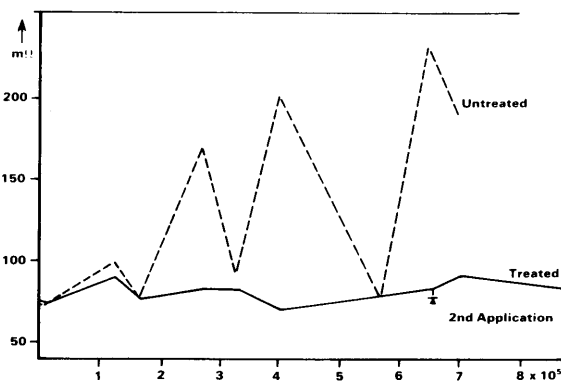
Figure 1 Contacting surfaces magnified



Additionally, the worn surfaces will oxidise and increase contact resistance. The problem is worsened by the use of dissimilar metals, as the softer metal will be worn away by the harder; when this takes place the exposed base metal will oxidise, forming a resistive area, and contact efficiency will be further reduced. Operating temperatures will also rise due to reduction

of contact area and increased resistance, leading to further damage to the contact.

Figure 2 Effect of contact treatment lubrication

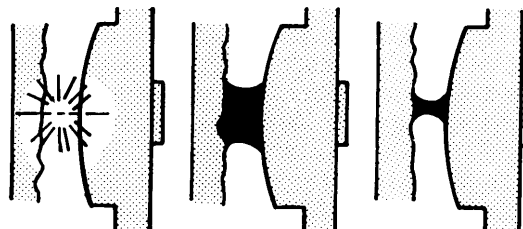


This graph shows the contact resistance on the sliding contact of a wire wound potentiometer. One contact has been treated with a contact grease (a second application was made after 650,000 operations). The second contact (dotted line) was untreated and failed after 650,000 operations. The sliding contact in this case wore through entirely.

#### Arc erosion

In power switching systems the peak-and-trough surface configuration means that heavy currents are being fed through very small contact areas, which have the effect on make or break of creating damaging arcing. When the contacts are being opened, as the surfaces separate, a very high resistance is suddenly introduced into the circuit, and the whole open circuit voltage appears across the gap. This is increased by a much higher inductive voltage due to the sudden drop in current, and this results in the air film between the open contacts breaking down, causing ionisation and a momentary very high temperature arc being formed. Because of the ionised air, metal transfer takes place between contacts, and this forms the typical 'pip and crater' effect. Current continues to flow while metal

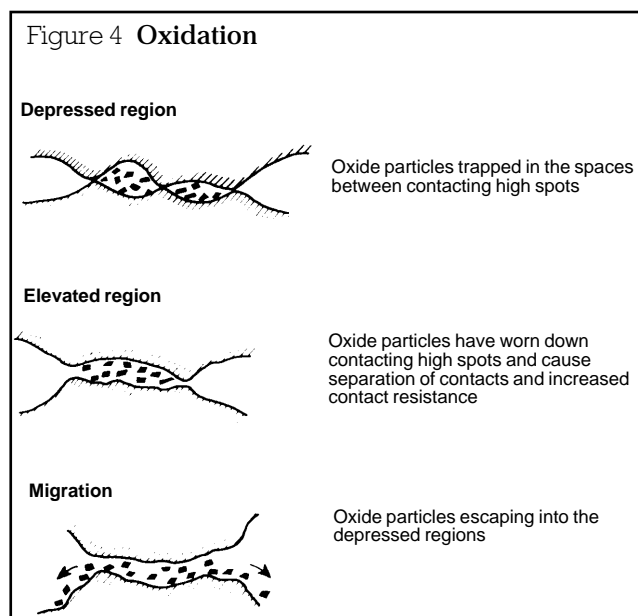
Figure 3 Arcing at dry contacts and the separation of contacts treated with contact lubricant



transfer is taking place, and in some cases welding of the contacts can occur. A concurrent subsidiary effect is the formation of small amounts of nitric acid through electrolysis of the air during arcing; this condenses on the contact surfaces as a corrosive film.

### Oxidation

Oxidation of contacts is a common cause of poor contact and high resistance; it will occur wherever there is a surface with no protective coating and takes place as a result of reaction between oxygen in the air and the bare metal. Oxide particles on a surface fill in the troughs between contacting high spots, and cause wear and accentuation of the peaks, reducing still further the effective contact area. The film of oxide which forms also causes problems due to its different thermal coefficient and brittleness.



Gold is a special case, in that it does not oxidise, but has problems of its own by reason of its porosity. Gold, as found on contacts, is normally in the shape of plating, or 'flashing' over a base metal, where the gold is porous, as it usually is, then moisture, metal salts, or other contaminants can creep under the plating layer and separate it from the base metal, causing first blisters and subsequently holes in the gold plating, which leaves a crater of base metal exposed which will corrode or oxidise. Once commenced this delamination process is fairly rapid.

### Silicone contamination

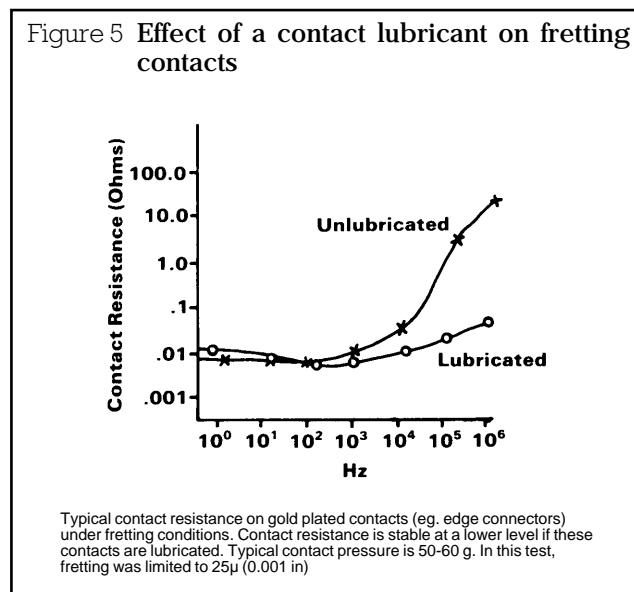
Exposed metal surfaces will inevitably become contaminated through atmospheric impurities, handling and servicing forming a film on the surface with high contact resistance. Should there be silicone present in the vicinity of the contact, this will form a very high contamination source. It may be present merely through the use of silicone furniture or floor polishes. It will usually be in the form of a silicone oligomer which can travel long distances from its point of origin to contaminate equipment. When present, silicone is converted by the temperature inherent in the arcing or fretting processes into hard crystals, usually of silicone carbide, which have a high abrasive action and which prevent proper mating of contacts, leading to break-down. Silicone materials are sometimes sprayed on to

contacts in the erroneous belief that their properties of decreasing friction and repelling water will assist in making a better contact; indeed, many proprietary sprays supposedly for electrical use, contain silicone oils, such as those for car engines. Additionally silicone can be present on plastic mouldings through having been used as a mould release agent.

### Fretage and fretage corrosion

Fretage is the minute movement of the mating surfaces together whilst in contact; it may be infinitely small, as low as 100 microns, and is caused by changing temperature, vibration, sonic vibration and electromagnetic forces.

Results are metal transfer and wear on the contacts. Once fretage has occurred, further corrosion of the affected surface or amassing of particles of debris is called fretage corrosion, and takes different forms according to the materials involved. It occurs on the majority of metals, including copper, tin, silver or combinations and alloys of these metals. Gold is a special case, because whilst it is chemically inert and thus might be expected to only suffer from fretage, in fact it experiences corrosion also owing to fretage debris working its way through the gold layer. Once this has occurred, fretage corrosion of the substrate layer takes place, leading to delamination.



Probably the worst effects of fretage take place when the contacts are of dissimilar metals, as inevitably the harder metal will cause a metal transfer to occur, the softer metal forming a layer on the harder metal. In the case of gold and solder, the solder will be transferred to the gold and form a surface layer, which then develops an oxide film and further increases contact resistance and reduces efficiency. As the gold and the solder have similar thermal coefficients of expansion, the solder layer is unlikely to be cracked by differing expansion rates. Platinum and its alloys are less prone to fretage corrosion, but have a different problem; catalytic action of the metals causes organic materials on the surface to be cross-linked by polymerisation, forming a fairly thick polymer layer which increases electrical resistance.

## Contact bounce

The mechanical action of contacts when closing is not, typically, a single action; usually the contacts bounce together several times before finally settling. Naturally while this is happening, arcing is taking place, together with surges of current. The bouncing action repeatedly heats the contact faces, and subjects them to high energy arcing which causes pronounced wear; the surges are not beneficial to the loads to which they are connected and in precision measuring equipment it can cause 'ghost' readings and inaccuracies.

## The solution

A large proportion of the foregoing problems is susceptible to a single solution, that of electrical contact lubrication. Proper lubrication overcomes most of the problems and additionally ensures ease of movement of all working parts. However, the lubricant must be of very special type, as when normal oils are used in this role it was found that they soon dried out and became sticky, or the hydrocarbons in the oil carbonise by sparking contacts, become conductive, or dry out, leaving the surface unprotected. A range of oils was developed for specialist electrical applications, and dramatically improved the situation for contacts in a number of ways. When a film of oil is applied to cleaned contact faces, it ensures a low voltage drop in the closed position by inhibiting corrosion and improving the current flow across the contacts through filling up the troughs and increasing conductivity. As the contacts open, the viscosity of the oil is such that a temporary bridge is formed in the gap by the lubricant, so that the circuit is not broken abruptly; although the resistance of this 'bridge' is high, and increases as the gap widens, it is much less than an open circuit. The oil link between the two faces gradually elongates until it parts, but while it is still formed it is acting like a semiconductor and the current is able to continue to flow, dwindling gradually. This gradual elongation is the primary benefit, because there is no longer suddenly an open gap for the current to arc across; instead the current flow drops rapidly but not all at once, so that arcing is eliminated, inductive voltage is minimal, and temperature stays lower. The lubricant on the contacts prevents any burning or pitting of faces from any arcing which may occur in some high current applications.

A contact lubricant will fill up the troughs on the surface of a contact, thereby increasing the contact area since it is semi-conductive; this has the benefit of reducing 'hot-spots' and obviating the problems of pits and craters, and the welding of contacts. While in situ the lubricant will have the effect of reducing friction, so that wear from fretting is minimised.

Where a contact lubricant has been applied to already corroded, oxidised or polymer covered contacts, it has the beneficial effect of breaking down these layers and washing them away over a period; fretting debris and contaminants from the atmosphere will collect in coagulated lumps in the oil, to be brushed aside later by the action of the contacts. Oxide films will be assisted to eventually break up and be washed away by the lubricant.

On a gold plated contact, the lubricant will form reservoirs in areas where the gold is porous and thereby prevent the ingress of contaminants which would otherwise cause delamination. Some contact lubricants, though not combining with the gold, have an affinity for it, and will form a durable film on the surface

of the gold. This has the effect of minimising wear, stripping and contamination problems, giving longer life and better contact.

If a contact set has been silicone contaminated, this is a problem requiring a particular solution, but is capable of solution; a special lubricant may be used in the first instance which will loosen and eventually shift silicone crystals, and later prevent further formation. Some modified fluorinated oils will react with silicone carbide to form silicone tetrafluoride gas, which will then dissipate.

Vibration problems are alleviated by a contact lubricant, as the oil acts as a damper. Naturally this removes a prime cause of fretting, and where fretting still takes place the debris is washed away by the oil before it can do harm. Contact bounce problems can be greatly helped by the use of the proper lubricant also, as it will form a 'cushion' layer to absorb a proportion of the impact, thereby reducing wear and tear and giving cleaner switching and less contact erosion.

Overall, researchers have come to the unanimous conclusion that a suitable contact lubricant will greatly reduce damage to contacts and improve longevity; obviously different applications will require a different lubricant, and **RS** has a range of lubricants to cover the great majority of potential applications. Consult the appended chart to make a selection of the lubricant for your application.

i) A range of viscosities must be available. Some pointers:

	Grease Oil		
Horizontal contacts	x	x	
Vertical contacts	x		Oil will run off
Low current/voltage		x	Grease too thick
High current/voltage	x		Oil protection inadequate
Contacts indoors	x	x	
Contacts outdoors	x		Grease more tenacious
Low contact pressure		x	Contact resistance too high
High contact pressure	x		Wear otherwise too high
Frequent operation	x	x	Depending on other factors
Infrequent operation	x	x	Depending on other factors
Sliding contacts	x	x	Depending on other factors

ii) The viscosity chosen must remain constant. If a grease is chosen and this melts as the temperature rises, or if an oil solidifies as it cools then the contact will stick at low temperatures and suffer from inadequate mechanical and electrical protection as the temperature rises.

Table 1 Indicative examples of use of contact lubricants

Application	Grease	Oil	Diluted oil	Maintenance notes
Heavy switchgear	x			Clean all contacts
Light switches	x	x		Apply liberally
Car battery conns.	x			Apply by aerosol
Car light switches		x	x	Apply liberally
Volume controls, etc.			x	Apply by aerosol
PCB edge conns.		x	x	Aerosol or pen
Starter switches, motors or cars	x			Aerosol or syringe
Electroplating contacts or bus bars	x			Special greases
Carbon brushes		x		Aerosol when warm or impregnation
Distributors	x	x		Apply by aerosol
Potentiometers		x	x	As necessary

iii) The **RS** range of contact treatment products includes:

Type	Description	<b>RS</b> stock no.	
Oil/Solvent	Contact cleaner lubricant aerosol	494-742	} Contain no propellants alleged to damage the ozone layer.
Oil	Contact treatment oil aerosol	494-720	
Grease	Contact treatment grease aerosol	494-758	
Grease	Contact treatment grease syringe 20ml	566-730	
Grease	Contact treatment grease syringe 35ml	503-335	
Oil	Fluid pens	554-282	
Oil	Contact cleaning strips	554-298	

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