

Technical Paper

Tyco Electronics HM-15 Lubricant Stability Projected Weight Loss

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Projected Weight Loss

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Abstract:

A comprehensive study was undertaken to monitor the weight loss of Tyco's HM-15 contact lubricant at various elevated temperatures, and to use that data to estimate the thermal stability of the lubricant at service life temperatures through an Arrhenius approach. While it was found that the lubricant formulation could lose a significant amount of weight (25 % or more), it would take many years at a normal operating environment depending on the average service temperature.

Introduction:

The HM-15 lubricant is a complex mixture of solid, liquid and polymeric lubricant ingredients, as well as specialty additives for thermal stability and corrosion resistance. Applied to an electrical contact, the lubricant can protect the plating finish from friction, wear and corrosive gases. Because it is a dielectric material, it is important that the lubricant can be easily displaced by relatively low normal forces to allow good metal-to-metal electrical connection between two mating contacts.

If the liquid components of the lubricant evaporate over time, the lubricant film could become drier. This could result in the formation of a more solid-like film that is harder to displace under low normal forces. The risk is that a loss of weight from the lubricant could create an impenetrable film on the contact, and interfere with the electrical connection across a contact interface. To better understand the risks associated with the weight loss the HM-15 lubricant during its service life, the weight loss profiles of the lubricant at various elevated temperatures was obtained. An Arrhenius approach was used to project a significant, but realistic weight loss (25 %) that could be expected over a reasonable service temperature (40 °C). Then after forcing that amount of weight loss by accelerated means, the functionality of the lubricant was evaluated.

Test Program:

The weight loss data was collected on phosphor bronze, CuSn4, test coupons plated with 50 micro-inches (1.27um) of nickel under 30 micro-inches (0.76um) of gold. The lubricant was applied to numerous coupons and placed in forced air convection ovens set at various temperatures (80, 90, 100, 110 and 120 °C). Lubricated coupons from each oven were periodically removed for analysis. An example of the weight loss profile at 90 °C is shown in Figure 1.

HM-15 Weight Loss at 90 °C

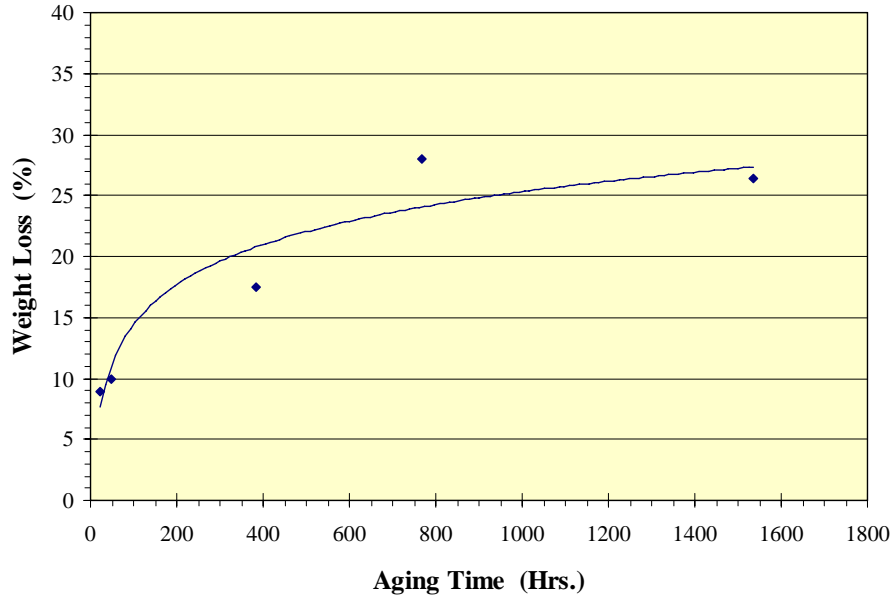


Figure 1. HM-15 weight loss profile fitted with a logarithmic curve.

The data corresponding to weight losses of 20, 25 and 30 % at temperatures from 90 to 120 °C were plotted using a classic Arrhenius approach. This approach allows one to extrapolate a linear fit of the Ln Time vs. 1/T (°K) data to predict weight loss times at normally much lower service temperatures. Figure 2 shows the Arrhenius representation for HM-15 weight loss times

Arrhenius Plot for HM-15 Wt. Loss

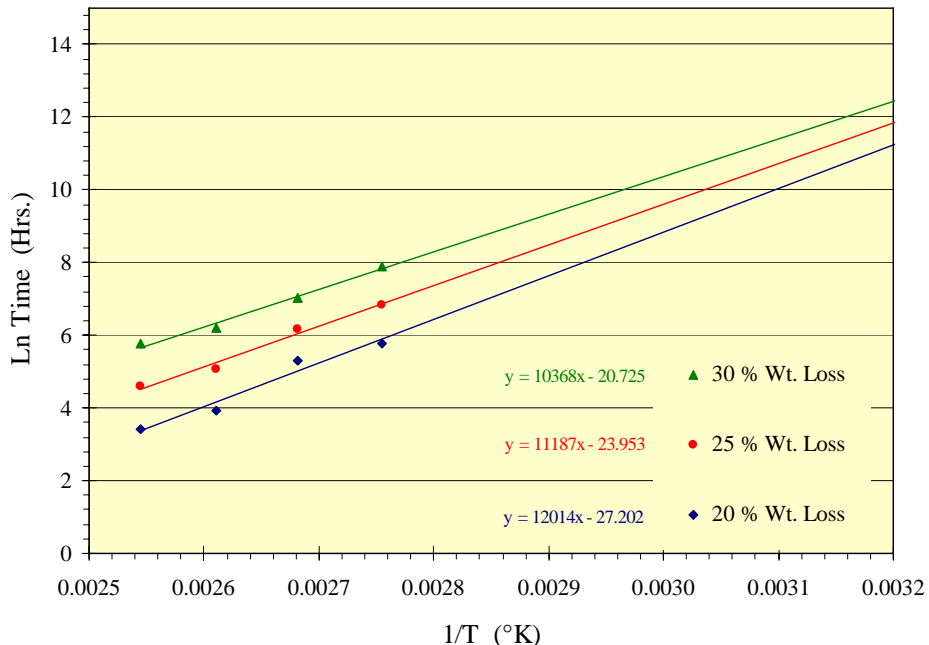


Figure 2. Linear fit of Arrhenius data for weight losses of 20, 25, and 30 %.

corresponding to weight losses of 20, 25 and 30 %. The amount of time it takes for the HM-15 lubricant to lose a certain percentage of its weight depends on the average service temperature at which the lubricant will be used. Table 1 lists the predicted service times necessary to evaporate 20, 25 and 30 % of the lubricant weight at various service temperatures (40, 50 and 60 °C). As an example, it is estimated to take about 15 years for the HM-15 lubricant to lose 25 % of its weight at an average service temperature of 40 °C (104 °F).

Wt. Loss (%)	Service Time at Temperature (years)		
	40 °C	50 °C	60 °C
20	8.2	2.5	0.8
25	15.1	5.0	1.8
30	27.7	9.9	3.8

Table 1. Arrhenius projections for weight losses at lower service temperatures.

It is believed that the weight loss associated with the heat aging experiments is primarily due to the evaporation of low volatile fractions of one or more of the liquid lubricant components of the HM-15 formulation. In subsequent experiments, it was found that exposing the lubricant to short term durations at 260 °C (such as would be experienced in a lead-free soldering process) results in a weight loss of the lubricant on the order of 25 %. Similar gold-plated test coupons lubricated with HM-15 were exposed to lead-free reflow conditions, and then tested for the lubricant's functionality in preventing porosity corrosion without interfering with the electrical connection.

Corrosion Protection:

The Bellcore Class IIA Mixed Flowing Gas (MFG) test was used to evaluate the lubricant's continued ability to prevent porosity corrosion after losing 25 % of its weight from a lead-free solder reflow process. For this part of the study, the test coupons were plated with 15 micro-inches (0.38um) of gold plating. Samples lubricated with the HM-15 lubricant were exposed to a lead-free solder reflow process with a peak temperature of 260 °C in order to force a 25 % weight loss of the lubricant. Figure 3 shows unlubricated and lubricated test coupons after 10 days exposure to the MFG test. The unlubricated sample (on the left) shows porosity and creep corrosion. The sample lubricated with HM-15 (right) shows that the lubricant remains effective in preventing porosity corrosion despite the loss of 25 % of its weight.

Electrical Performance:

A critical requirement of a contact lubricant is that it does not interfere with good electrical connections. This is typically evaluated by measuring the low level contact resistance (LLCR) across a lubricated interface at various normal forces. Such a force versus resistance measurement can be made by increasing the force of a conductive probe on a conductive substrate while measuring resistance between the two interfaces. In this particular measurement, a gold-plated hemispherical probe tip was applied to the lubricated, gold-plated coupon with increasing force (up to 50 grams). The test is repeated 9 to 18 times and the results are provided in terms of a median response. Prior to the measurement, the lubricated coupon was subjected to a lead-free solder reflow process (with a peak temperature of 260 °C) in order to force a weight

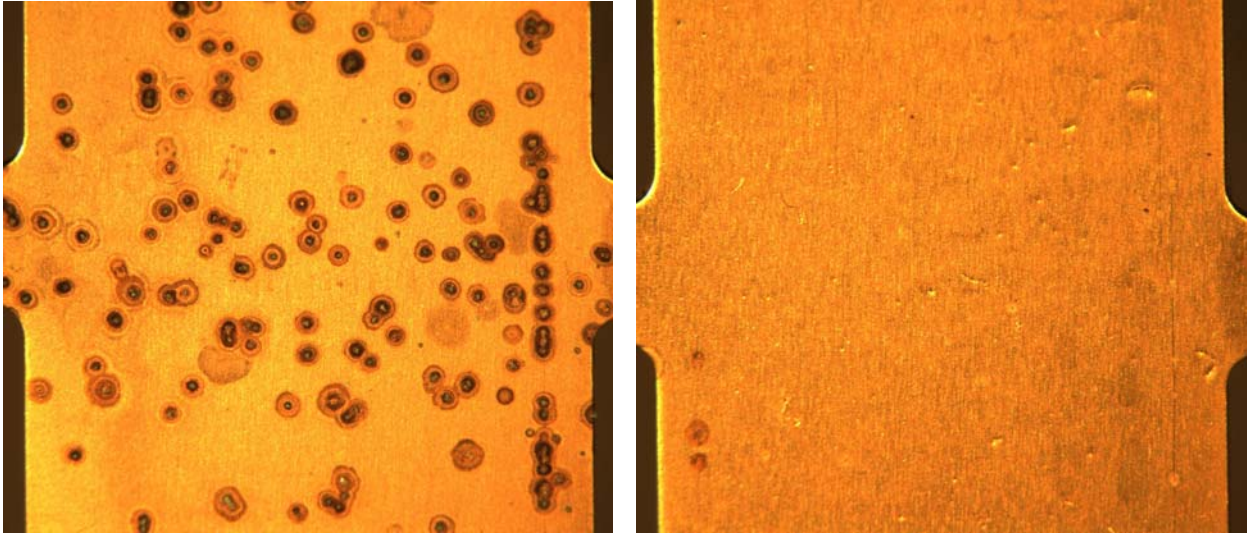


Figure 3. MFG porosity on unlubricated (left) and lubricated (right) gold plated coupons.

loss of about 25 % from the lubricant. The HM-15 lubricant's ability to resist the formation of an impenetrable film is shown in the curves in Figure 4. It shows that there is little difference in the median LLCR of the as applied lubricant compared to the lubricant that lost 25 % of its weight through high temperature exposure.

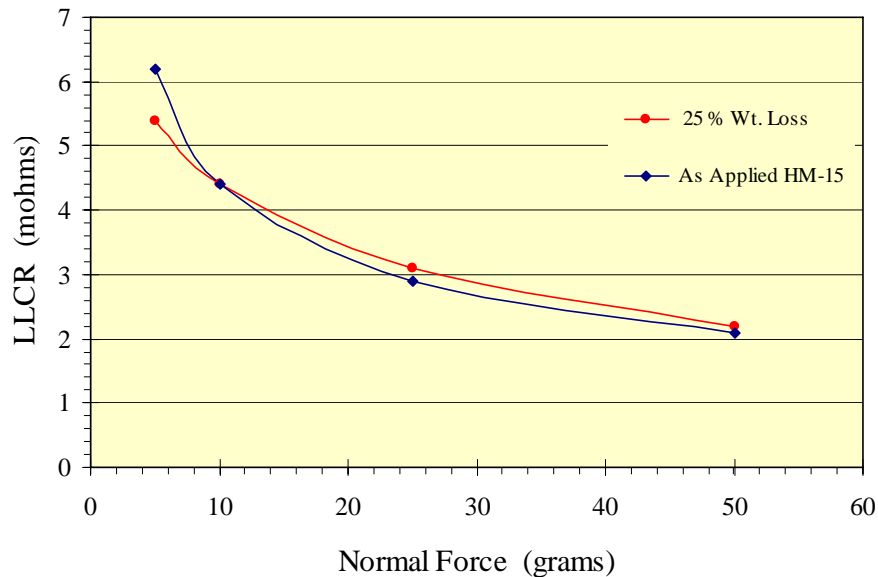


Figure 4. Electrical resistance across an interface containing HM-15 lubricant.

Summary:

The results of the testing indicates that at a reasonable average service temperature of 40 °C (104 °F) the HM-15 lubricant may lose 25 % of its weight, but it would take about 15 years to lose that amount of weight. Furthermore, it was demonstrated that even with a loss of 25 wt. %, the HM-15 lubricant retained its functionality in preventing porosity corrosion without adversely affecting electrical performance.