DC Isolator Failures Resulting in Fire

In the first six months of 2014 four voluntary recalls for solar DC isolator switches were registered with the Australian Competition and Consumer Commission (ACCC). A further DC isolator was voluntarily recalled in 2012. All of the five rotary style DC isolators that were recalled experiencing the same defect; localised heating, due to higher than desirable contact resistance occurring on one of the contact points. That is, the failure mode was excessive heating at a contact when operation at normal current level.

The Design

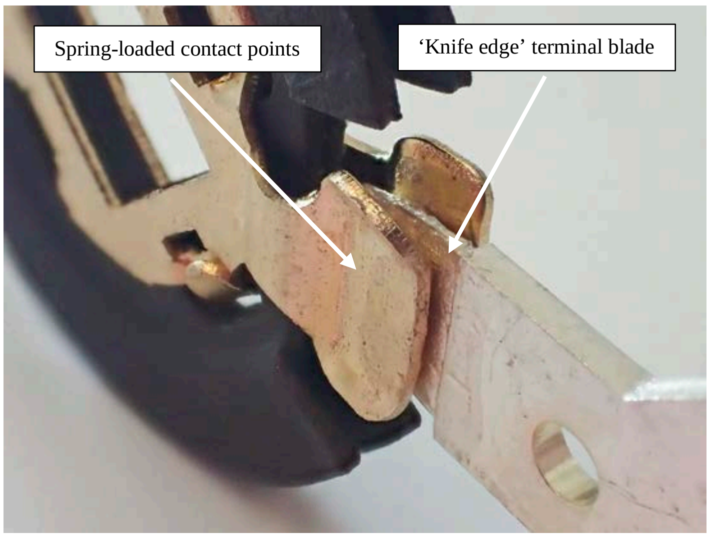

Photo 1: DC Isolator Contact Point

The rotary style contact point design shown in *Photo 1* is a very common design for the DC isolators used in the solar industry, including many that haven't been recalled by the ACCC. *Photo 1* shows one of the two contact points for one pole of a typical DC rotary isolator. As the rotary handle of the DC isolator is turned, the 'knife edge' terminal blade makes connection with the spring-loaded contact points.

The fast switching action allows for the constant DC load to make / break contact with minimal arcing. *Photo 2* shows the spring-loaded contact points in detail and the non-metallic material between the copper alloy plates. The failure mode of the rotary style DC isolator is usually at this point of contact. If the spring-loaded contact force is not adequate, localised heating can occur. Heating at this point can further reduce the contact force, which makes the situation worse.

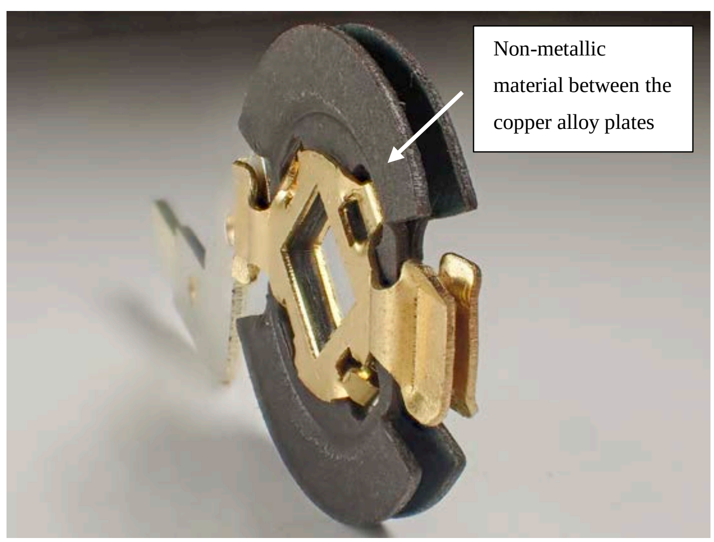

Photo 2: DC Isolator spring-loaded contact points

The Failure Mode

Photo 3: Welded contact points within a failed DC isolator

The failure mode of the rotary style DC isolator, is the result of higher than desirable contact resistance occurring on the contact interface between the spring-loaded contact points and the 'knife edge' terminal blade. The high contact resistance leads to localised heating at these points (*Photo 3*). As the metal parts within the isolator heat up they expand and distort very slightly. The spacer material may also soften and distort. This situation can lead to thermal runaway. As the contact points of the isolator expand / distort the contact resistance increases. This results in further localised heating, which in turn leads to a further increase in contact resistance. This process continues until the temperature is high enough to ignite surrounding combustible materials such as the plastic exterior case.

The example of the failed DC isolator shown in *Photo 3* shows the molten copper and welded contact as a result from electrical arcing and extreme temperature (> 1085ºC, the melting point of copper). The unpiloted ignition temperature of plastic is in the range of 400ºC – 550ºC. To further exacerbate this failure, the solar panels circuits remain energised, assisting in the spread of fire. There is no protection element on the output of the DC solar panel array that can detect a fault inside the DC isolator and so the fault condition persists until a complete failure occurs. Other investigations have found that the material selection (including the copper alloy contact material and the non-metallic material between these contacts) is not suitable for use in solar applications.

Corrective Action

The designer of the rotary style DC isolator, or for that matter any electrical switch, needs to consider the effects of temperature on the spring-loaded contact points. The design could incorporate a rib on the contact arms, designed to increase the clamping force onto the 'knife edge' terminal blade as the temperature increases. This could be modelled using Finite Element Analysis (FEA) to determine an acceptable design. Insulator selection also needs to be carefully considered.

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