CASE STUDY

Protecting full-range fuses with a patented damage sensor

Industry: Electric utility

Challenge: Maintaining the high current interrupting capabilities of full-range fuses

Product: Hi-Tech® full-range fuses

Abstract:
Modern current-limiting fuses can be classified as either backup fuses or full-range fuses. Backup fuses are used in series with an expulsion fuse, such as a bayonet fuse or a fuse cutout link. Full-range fuses combine both high and low current interrupting capabilities into a single fuse body. The high current sections of full-range fuse elements are susceptible to damage from electrical surges. If undetected, the damage may result in a high current element melting at a later time when the fuse is carrying a current less than what it is designed to interrupt. This undetected damage might also cause the fuse to fail to interrupt. The patented damage sensor in Hi-Tech and Elastimold® full-range fuses greatly reduces this risk.

Solution:
Full-range fuse elements have both high and low current-interrupting sections. The high current sections consist of two punched ribbon sections. The low current section is built using a silver wire and a section of tin enclosed in a silicone rubber sleeve. A damage sensor, as shown in Figure 1, is also a feature of a Hi-Tech low current section. By design, the cross-sectional area and melting characteristic of the damage sensors lie slightly to the left of the high current section, as shown in Figure 2. This design feature results in the damage sensor portion always melting before the high current sections. In the event of a surge, the element temperatures begin to increase as a result of the increased current flow. As this occurs, the restrictions in the element are not melting simultaneously across the cross-sectional area, due to uneven current density in the ribbon (Figure 3). If the current that started the melting suddenly ceases, it can leave one or more restrictions partially melted or damaged. This leaves the high current element susceptible to melting at some time in the future, most likely at a lower current than would otherwise cause it to melt. Plain ribbon elements have difficulty interrupting currents below a certain level, which is why backup current-limiting fuses have a minimum interrupting current. Currents below this level do not result in sufficient series restrictions, melting or arcing to interrupt the current. For this reason, in full-range fuses, the low current-interrupting elements are connected in series with the high current elements. The low current and high current sections work together to help protect each other from currents that they are not designed to interrupt. Therefore, if the high current element is damaged or partially melted, the two element

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01 Figure 1: Full-range fuse element
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02 Figure 2: Damage sensor melting characteristics
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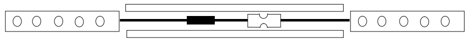
03 Figure 3: Intact restriction on left, and partially melted (damaged) restriction on right



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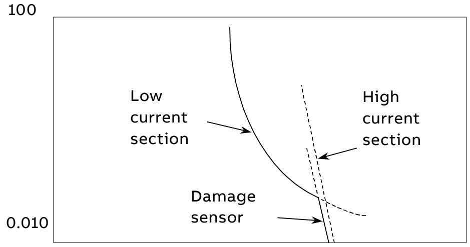

Current in amperes

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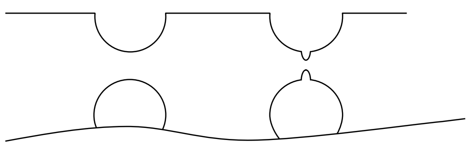

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sections are not fully operating as designed. This condition may result in the high current element melting at low currents, instead of the actual low current section. If this occurs at a current it cannot interrupt, a fuse failure will result.

Conclusion:
The damage sensors inside Hi-Tech and Elastimold full-range fuses greatly increase the likelihood that any melting or arcing that occurs as a result of fuse damage, either immediately or at some later time, will be initiated in the low current section, rather than the high current element. This occurs because any surge that melts or damages the element restrictions also melts or damages the damage sensor to an equal or greater extent, thus making it more likely that any subsequent fuse melting will occur in the low current section, at the damage sensor, which is better equipped to interrupt the current that causes the melting.

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