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A Primer on Cable Damage and Related Failure of Tiger® Brand Mining Cables

Although it may seem like more, there are actually only four basic causes of field failures (surface or underground) in trailing cables and drag cables. They are:

- mechanical damage
- current overload
- excessive tension
- poor temporary splices

Individually, or in combination, these can result in significant downtime. Awareness of symptoms, or other signs of problems, can aid cable users in determining what the problem might be and how to correct it. After one of the above events occurs the cable is either immediately rendered unusable or a series of subsequent problems begins which make it appear that the cable is at fault. Information regarding these events has been compiled and documented with photographs of typical failures. An explanation of what to look for and how to handle each situation is found below in Conditions, Possible Causes, and Corrective Action.

Mechanical Damage

Condition: Outer jacket is usually torn or crushed open and has rough edges or abrasion marks leading up to the opening. This is the obvious case. In other cases, the jacket may have little or no marks on the outside, but the conductor insulation inside is ruptured either partially or totally. If this is not a total electrical failure, it will lead to leakage current, nuisance tripping, and downtime. Figure 1 shows mechanical damage that was hidden beneath a small mark on the outer jacket. Mechanical damage to inner components also occurs when the cable is bent in a radius far smaller than the manufacturers' recommendations. When dragging cables, be sure to work all kinks, knots, and loops out of the run. Otherwise, the loop will become taut around the cable and end up "one" times the cable diameter (Figure 2) instead of the normal "twelve to sixteen" times the cable diameter. As a result of exceeding manufacturers' bend radius recommendations, damage to all conductors and insulation is imminent. Small diameter ropes can cut the jacket and/or squeeze the core until insulation damage occurs.

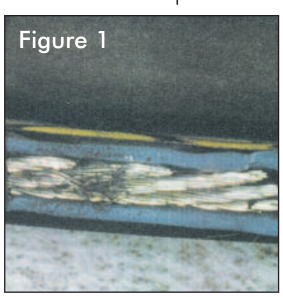

Figure 1

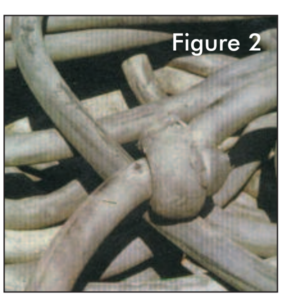

Figure 2

Possible Causes: Sharp rocks, roof falls, sharp edges on shuttle car reeling devices, run-over, small bend radiuses all contribute to cable failures of this nature.

Corrective Action: Cable handlers, machine helpers, and other operations personnel all need to be made aware of the sometimes delicate nature of soft copper stranding and the rubber materials inside the cable. Developing an appreciation for the product capabilities and limitations will go a long way toward reducing mechanical damage. Training on proper bending radius will also be helpful. Large diameter ropes or slings can reduce handling damage.

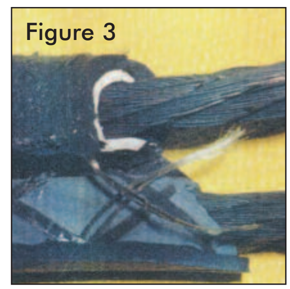

Figure 3

Current Overload

Condition: Cable insulation carries a 90° Celsius rating. Jacketing compounds have no temperature rating. Jackets are compounded for the highest mechanical strength, since that is its primary function. If power conductors are run at 90°C in free air and no greater than the rated amperage, the cable will perform for its anticipated life. Problems arise when the cable is:

1) wound up on a reel without the proper derating factor applied,
2) stacked in a "pile,"
3) direct buried without increase of conductor size, or
4) run at maximum amperes and voltage drop.

In these cases, the power conductor can reach temperatures up to 200°C (392° Fahrenheit). This melts the tin coating and darkens the conductors color. The jacket vitrifies and cracks open. Figure 3 shows the changes in the strand and

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Figure 4 the changes in jacketing after high heat.

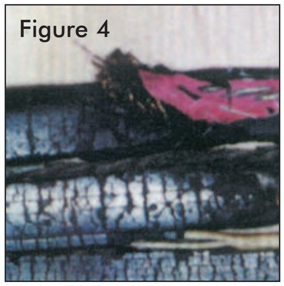
Figure 4

Possible Causes: When no longer in free air, the cable cannot dissipate the heat from the power conductors into the atmosphere. Heat builds up inside the cable; the conductors surpass their temperature rating, and the jacket heat-ages at a rapid rate.

Corrective Action: Always perform amperage calculations prior to ordering cable for new or rebuilt equipment. Be sure to derate for multiple layers of cable on the shuttle car reel. When upgrading the horsepower of mining equipment, a larger conductor size becomes necessary. On particularly long runs of cable, calculate voltage drop prior to ordering cable. High current at low voltage can also overheat a cable.

Excessive Tension

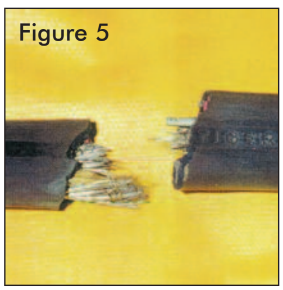
Figure 5

Condition: Excessive tension many times manifests itself rapidly, as shown in Figure 5. Other times it is hidden. When cables are operated somewhat above manufacturers' limits, the flexible stranded power conductor's start a fatigue process of high wear at intimate points of contact. This is particularly true where the center bunch's outer wires intersect the six-bunch layer's inner individual wires. Under normal tension and wear, a little "dust" is the by-product. Under higher tension, "notching" occurs, as shown in Figure 6. Individual wires literally abrade in two against each other. Once several wires fatigue-break, the ends continue to flex against surrounding wires and an exponential growth rate of broken wires results.

Possible Causes: Shuttle car reel tensioning is the single biggest cause. When the cable does not want to rise up off of wet mine floors, operators increase tension on the reel. For drag cables, expediency precipitates long lengths being dragged.

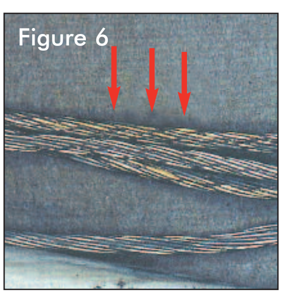
Figure 6

Corrective Action: Keep the shuttle car reel set so that 15 to 20 feet of cable is suspended between the shuttle car and the mine floor during reeling and de-reeling. Keep the tie-point back in a crosscut and not in the main haulage way. This spreads the tension of the "dynamic reel reverse" over 15 to 20 feet of cable instead of 3 to 4 feet. When dragging cable, a rule-of-thumb is to not exceed 200 feet when pulling by one rope or sling. Add extra slings and pull the cable up in loops of 200 feet.

Poor Temporary Splices

Condition: Splices have to be rebuilt regularly due to one of the following: ground check wire breaks, power conductor breaks by connector, splice pulls in two, jacket wearing rapidly, etc.

Possible Causes: Crimp sleeve too small or applied with improper compression. Bunches are sometimes cut out to facilitate connector application. If the conductors are not staggered within the splice, the splice becomes bulky. The splice jacket wears against the guiders on the shuttle car or against the mine floor when dragging a trailing cable.

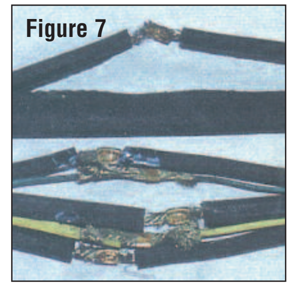
Figure 7

Corrective Action: Round cables must have the helix or twist of all conductors built back into the splice. Do not straighten the conductors out after jacket removal. Rebuild the splice using the factory helix. This alone will decrease fatigue failure at the connector on all round Type SHD-GC, Type G-GC, and Type W more than anything else will. Do not cut off any wires to make a connector fit. Get a larger connector. The connector sleeve must be compressed so the wires deform slightly, but are not crushed. If urgency dictates corner-cutting, flag the splice for rebuild during the next scheduled maintenance time. Flat cables must have the connectors staggered to reduce the bulkiness. Tensioning from power conductor to power conductor must be as equal as possible on all cable splices. This allows all power conductors to participate in the tensile load. Leave the grounding and ground check conductors approximately – inch slack so they do not carry any tensile load. Single conductor splices, as shown in Figure 7 (top), do not provide equal tensioning of the conductors and should only be used on a very temporary basis. Figure 7 (bottom) shows non-staggered power conductor connections, too much length on the ground check splice, and unequal tension of the power conductors. Figure 8 shows a short-lived splice on a round Type W cable due to the helix not being rebuilt.

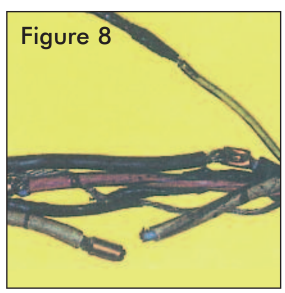
Figure 8

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