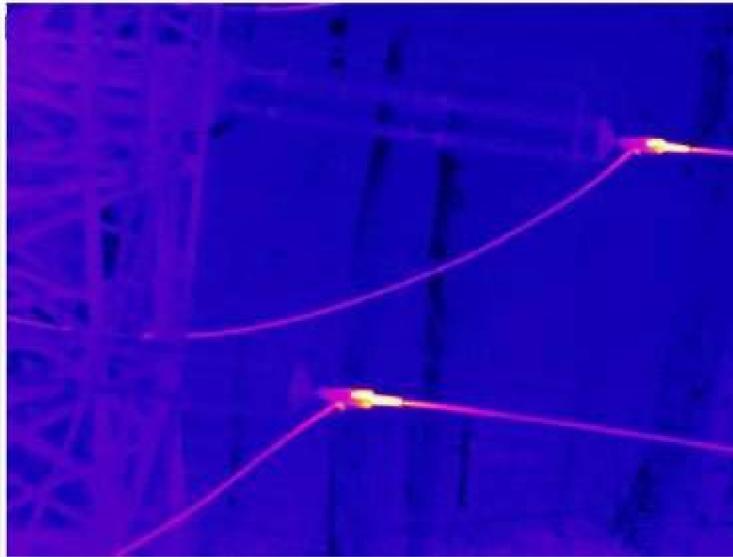
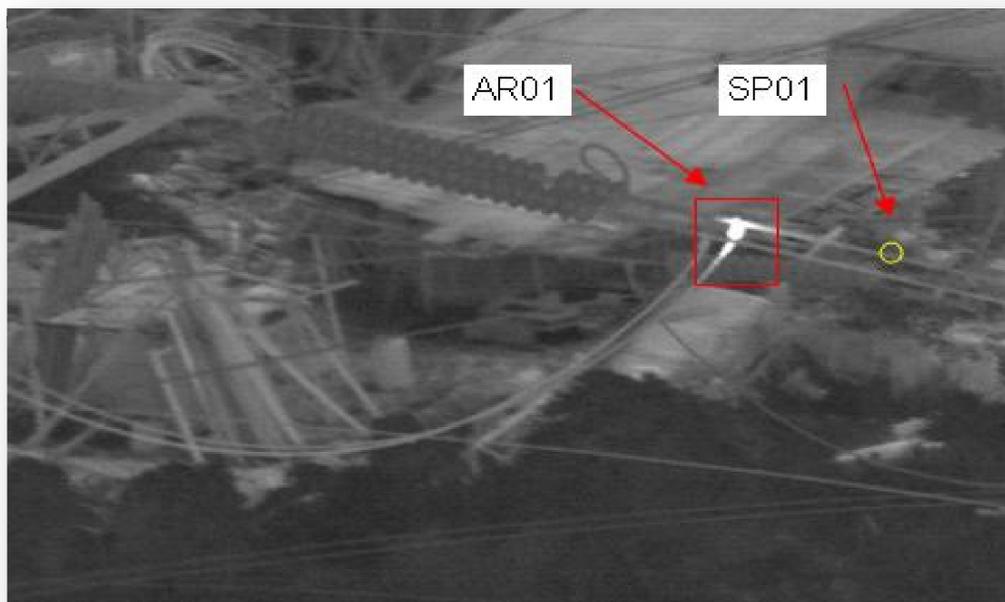


Problem Connectors on Multiple Sub-Conductors By, Carl R. Tamm

If you have a line with two or more sub-conductors per phase, and during an infrared inspection, a scenario is found where one of the sub-conductors has a fitting that is hotter than the one next to it, the natural tendency is to assume it is a high resistance connection. Were it a single conductor and we find a “hot fitting” it is a “no brainer” to understand that it is high resistance.



However, when we have two or more sub-conductors, and one fitting is hot and the other is not, it is not such a simple matter, as more often than not, the problem is elsewhere!



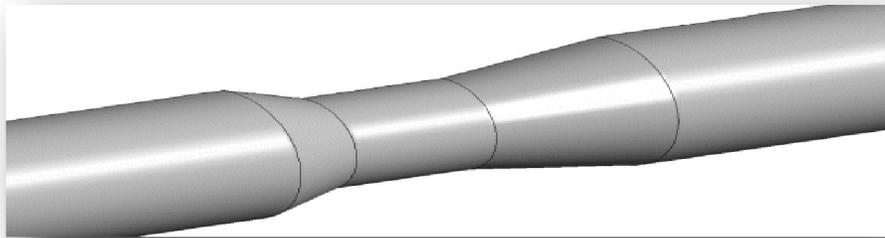
While this phenomenon applies to any multiple of sub-conductors, for simplicity, we will use the scenario of only two, or “twin sub-conductors” for the rest of this article.

To gain an appreciation of what happens, it may be easier to think of the old analogy of comparing electrical energy flow through conductors to water flowing through pipes.

If we think about having a specific flow rate of water, say 100 gallons per minute, and instead of having that flow through one pipe, we provide two pipes of equal size and equal levels (for simplicity, we’ll ignore number of fittings and other restrictions) we can expect the flow of water to be divided in half, with 50 gallons per minute flowing through each pipe.

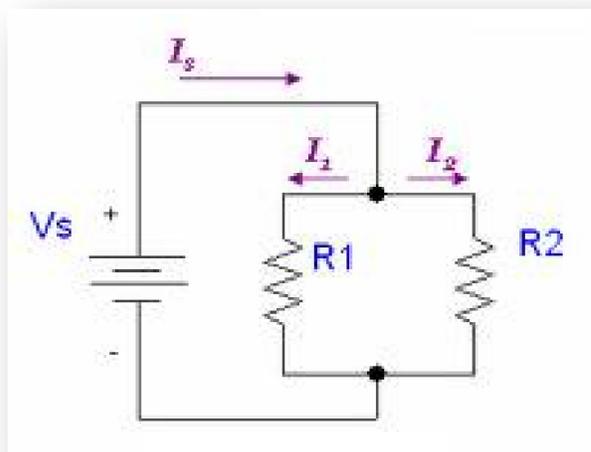
When we design a transmission line with twin sub-conductors, care is taken to assure both conductors are of equal length, with the same number of fittings so that if measured, they would have the same “electrical resistance” measured in ohms. And, if this is the case, we will achieve an equal voltage division, and therefore an equal current division, with each conductor carrying 50% of the entire electrical load (or flow).

If we go back to the pipes, and we put a restriction in one of them, possibly partially closing a valve, or some other mechanical restriction...



...now we expect more water to flow through the open pipe, such as 40 gallons through the restricted pipe, and 60 gallons through the open pipe!

With electricity, it works the same way. IF both sub-conductors are exactly the same, they will carry equal current.

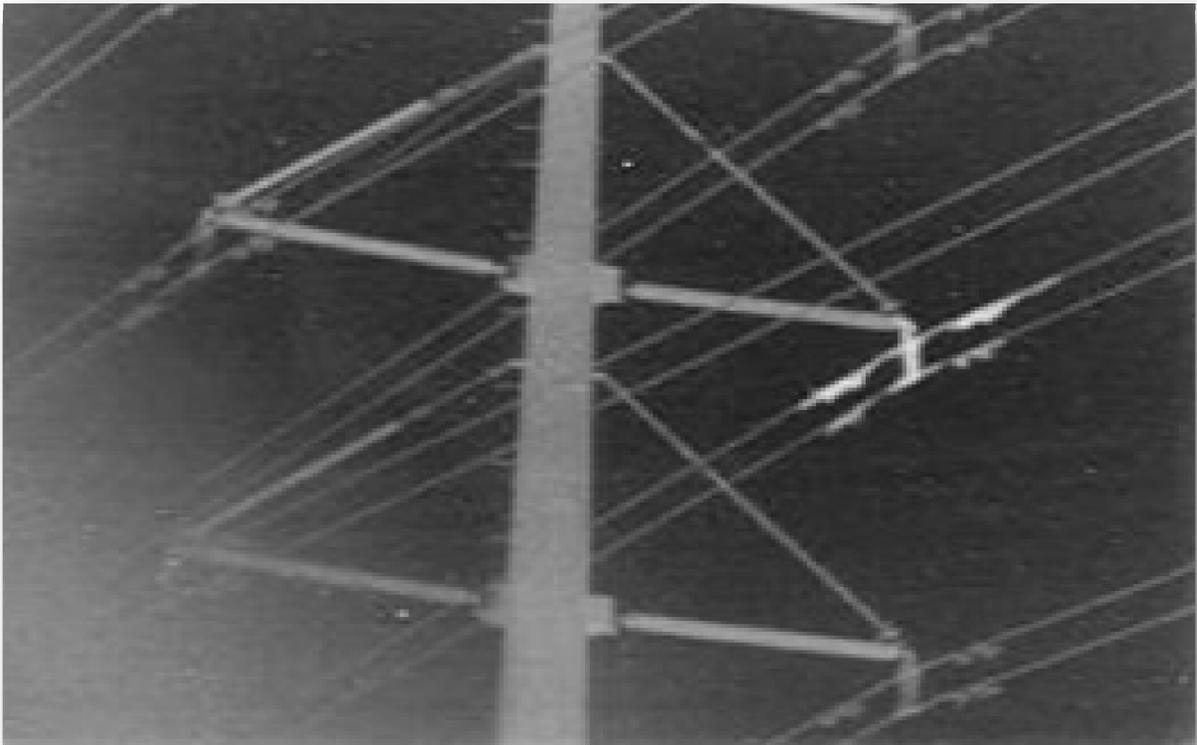


However, if one has more resistance than the other, such as having a high resistance connector in the circuit, MORE current flows through the conductor that has less resistance! Now – MORE CURRENT results in HIGHER OPERATING TEMPERATURES!

A transmission line has many connectors, and while they may be close, there will inevitably be some difference in electrical resistance, but with reasonably good craftsmanship, the normal result is so close it is of no concern.

However, when one or more of those connectors begin to increase in resistance with age, rarely will that degradation be equal, and the result will be an imbalance of current between the two sub-conductors.

Because the current is always trying to find equilibrium, the current will try to find other paths in order to maintain that balance. Oftentimes, this is through a yoke plate or other mechanical connection, which may be miles from the location where the hot connector was originally found!



While the hot connector may be bad, or going bad, it is very likely not the ONLY bad connection on the line. When using a ClampStar® to shunt that hot connector, it will behave as one would expect, it WILL cool down, simply because the ClampStar® has increased its ampacity by a factor of 3 or more, so it would take 3 times as much current to cause it to heat. But the story does not end there.



It becomes necessary to look for that current imbalance. Begin by doing a much more thorough inspection of the circuit, using a much more narrow range of bandwidths on your IR equipment, and look at all hardware that joins the sub-conductors in any manner, including spacers and yoke plates. It would be advisable to look for high resistance fittings using an Ohmstik (SensorLink®) which allows the measurement of resistance by measuring micro-voltage drop across a connector.



It may be advisable, while you are out on the line, up close and personal, to consider covering any critical connections with ClampStar®, even if they are not really bad today. If the line is aged, and you are finding some bad connectors today, you will find more next year, and more the year after that. A great portion of your expense is mobilization, and while you are there, it only takes minutes to correct a potentially bad situation.

Connections over roadways, waterways, or places frequented by pedestrian traffic should be given serious consideration. One failed connector and a dropped line will cost more than covering every connector on the line while you are there.

