OVERVIEW

Many systems have experienced pull-outs (also referred to as "suck-outs") where the center conductor of the cable slides out of the connector's seize basket. This technical note discusses some of the factors that could cause suck-outs and a solution to minimize their occurrence.

NEED FOR PROPER EXPANSION LOOPS

Consider a span of cable 150 feet long, of 0.625 inch jacketed cable lashed to a 0.25 (1/4) inch steel strand. If the cable were installed at 70° F with 0.5% sag (0.75 foot mid-span) then the tension on the strand would be about 1,090 pounds. The tension on the cable would be 0 pounds.

If expansion loops are installed and the lashing wire does not restrain cable movement then the cable is free to expand and contract as the temperature changes. At 0° F the strand would have about 1580 pounds tension on it while the cable would only have the few pounds of tension required to expand the expansion loop.

If there is essentially no tension on the cable, how can a suck-out occur? In essence none can. But, if we consider the same span except without expansion loops or with the lashing wire so tight as to restrain cable movement, an entirely different set of conditions can occur.

PROBLEM OF NO EXPANSION LOOPS

Cable Tension

As the temperature drops, the cable and strand attempt to contract. But the cable, being largely composed of aluminum, contracts about twice as much as the steel support strand. Since the cable's ends are fixed at the poles, tension on the cable increases. The cable, being elastic, elongates as a function of its elastic modulus. The increased tension reduces the sag slightly, but the additional cable from the reduction in sag is not enough to offset all the tension. At 0° F the total tension is about 2380 pounds. The steel strand supports about 1570 pounds, leaving the rest for the cable to accommodate. The tension on the center conductor will be about 124 pounds It should be noted that neither the cable nor the connector are designed to be load bearing elements which they will be under these conditions. At - 40° F the center conductor tension is about 200 pounds, and its yield strength is exceeded. See Table 1.

Connector Interface

Examining the cable-connector interface, we can see a number of possible conditions that will ultimately result in a suck-out.

The first thought might be that the center conductor cannot move because it is held in place by the dielectric and sheath. However, this is not true for cables that do not have the dielectric bonded to the outer conductor. At low temperatures the core-to-sheath adhesion is insufficient to resist the tension. The reason is simple. The plastic core contracts about ten times more than the aluminum sheath. As the temperature decreases, the center conductor and dielectric are free to move inside the sheath. The next thought might be that the conductor won't pull out because the seize basket is holding it in place. This is only partly true. Generally, a connector is designed to hold a conductor up to its yield point. As with any product, the connector pull force will vary from one connector to the next. However, even if every connector could hold the conductor to its yield, - 40° F could exceed the yield leaving the interface prone to suck-outs and conductor breakage. Metal fatigue could occur after a few cycles of stress beyond the yield, causing outages during severe temperature drops.

If the connector is not tightened properly, it cannot grip the conductor. This can easily be avoided by having the splicer follow the connector manufacturer's recommendations. If this same span had been installed with adequate expansion loops and lashed not so tight as to restrain cable movement, suck-outs would have been minimized if not entirely avoided. The expansion loops provide the additional cable needed during temperature drops, thus avoiding cable and connector stress. Of course, if the cable is connected to some device that is bolted to the strand, expansion loops are required on both sides of the device.

Effects of Sag on Cable Tension

The following table provides calculated conductor tensions which may result in suck-outs from various initial sags and temperature drops.

Table 1.

Center Conductor Tension (pounds) No Expansion Loops and/or Tight Lashing			
Sag @ 70°F	**70°F**	**0°F**	**-40°F**
0.5%	0	124	198
1.0%	0	97	169
1.5%	0	60	122
2.0%	0	38	72

**The yield strength of the 0.136 inch conductor is about 160 pounds. For those conditions listed in the table that exceed the yield, suck-outs and conductor breaks become very possible. If the connector is not fully tightened, conductor tensions of even less than 100 pounds may result in pull-outs.*

Solution

To solve the problems of suck-outs, all TFC semi-flexible coaxial cables have a dielectric that is bonded to the outer conductor. As the temperature drops, adhesion between the dielectric and outer conductor is not lost. Since its introduction, not a single center conductor pull-out has been reported on these types of cables. Although good construction practices, including proper sag and the use of expansion loops are still recommended, these cables, with dielectric bonded to the outer conductor, seem to have eliminated problems related to center conductor pull-outs.