

## OVERVIEW

Several factors affect the performance of expansion loops. The key factors are: temperature changes and span length which directly affect the amount of excursion length of cable into and out of an expansion loop. This technical note also examines the effects of sag and loop depth on the performance of expansion loops. Unlike temperature changes and span length over which you have little or no control, sag and loop depth have a significant effect on loop life and can be controlled.

### Reasons For Expansion Loops

Expansion loops are installed to reduce or eliminate tension and compression forces on cable. If these forces are not reduced, center conductor pull-outs, cable kinking, and premature cable fracture can occur as the temperature changes.

## FACTORS TO CONSIDER

### Temperature Changes

Normal average daily temperature changes can be anywhere from 10° F to 30° F, while normal average yearly temperature changes can be from as little as 15° F to as much as 65° F depending on the location. Extreme yearly temperature changes can be anywhere from 50° F to 140° F.

In addition to cable temperature changes caused by ambient air temperature changes, solar heating and radiative cooling should also be considered. Direct sunlight can elevate bare aluminum cable temperature 24° F over ambient and 45° F over ambient for jacketed cable. On clear nights, bare aluminum cable can drop 4° F below ambient and jacketed cable can drop 8° F below ambient.

The cable, being largely aluminum, has a coefficient of thermal expansion of about 0.000 013 per degree F. Steel's expansion coefficient is about 0.000 007 2 per degree F.

### Span Length

Since the expansion length of the cable is directly related to the cable length, the longer the span the more differential movement there will be between the cable and the support strand.

### Sag

The effect of sag on cable movement is a bit more difficult to describe and envision than the effects of span length or temperature changes. In a normal plant, as the temperature drops the steel support strand contracts. Its ends are attached to poles so they can not move. The sag

of the span decreases to compensate for the reduced length of the steel strand. As the sag decreases the tension increases. The increasing tension causes the steel strand to strain (i.e., get longer) so as to decrease the amount of sag reduction.

The cable length also changes with temperature. As the temperature drops, cable from the expansion loop feeds into the span to make up for the shorter cable length. Also, as the temperature drops the sag is reduced which reduces how much cable is fed into the span and therefore has the opposite effect on cable movement.

The smaller the sag, the less the sag changes as temperature changes. Changes in sag reduce cable movement due to temperature changes. Therefore there will be more cable movement in spans with little sag than there will be in spans with more sag.

### Load

Load refers to tension on the steel strand due to not only the weight of the cable but other factors such as ice build up over the cable and wind blowing against the cable.

As the load changes, the steel support strand strains (i.e., its length increases). If the cable has expansion loops and the lashing wire does not restrict cable movement, the cable will have no load on it and it will not strain. If the strand strains and the cable does not strain there will be differential cable movement that the expansion loop must compensate for.

Although changes in load may have a significant effect on the life of an expansion loop, the purpose of this technical note is to focus on the other factors previously mentioned.

## DISCUSSION

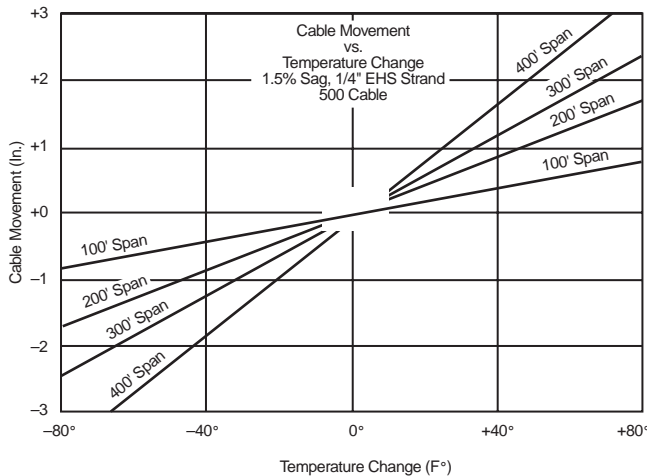
### Temperature Effects

With the above factors in mind, charts can be generated that will show how these factors interact. Fig. 1 quantifies cable movement as a function of temperature for 100 to 400 foot spans. Although it was generated based on 0.500 inch cable and 1.5% initial sag, the principles apply to other cables and sags. In general Fig. 1 shows that larger temperature changes correspond to more cable movement.

As a specific example, consider a 200 foot span of plain cable exposed to sunlight. If the normal daily temperature increases 10° F during the day and drops 10° F during the night, then the cable temperature will increase about 35° F during the day and decrease 15° F on clear nights (if solar heating and radiative cooling are included). From Fig. 1, plain cable will expand about 0.7 inch during the day and contract about 0.3 inch at night for a total excursion of 1.0 inch.

Jacketed cable will have a larger excursion because it can absorb and radiate heat better than bare aluminum. With the same +10° F and -10° F ambient temperature change and sunlight exposure, the jacketed cable temperature increases about 55° F during the day and decrease 20° F during clear nights. This temperature change of +55° F and -20° F corresponds to a total cable excursion of 1.4 inches from Fig. 1.

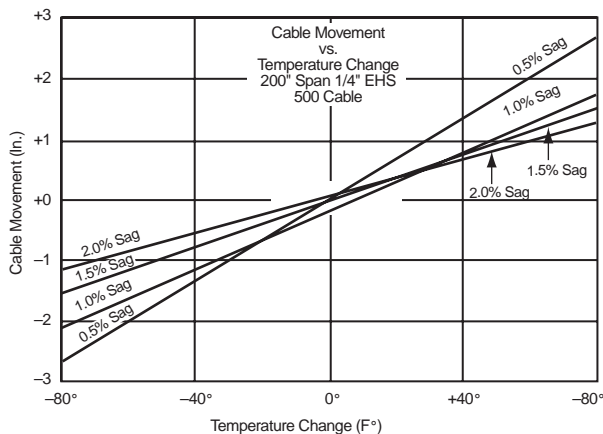
**Figure 1.**



### Effects of Tight Sag

Fig. 2 shows the dramatic effect sag has on cable movement. In general, the tighter the sag the more cable movement there will be as temperature changes. For the same example given above except with 0.5% sag instead of 1.5% sag cable movement would be 1.6 inches instead of 1.0 inch for bare aluminum cable and 2.3 inches instead of 1.4 inches for jacketed cable.

**Figure 2.**

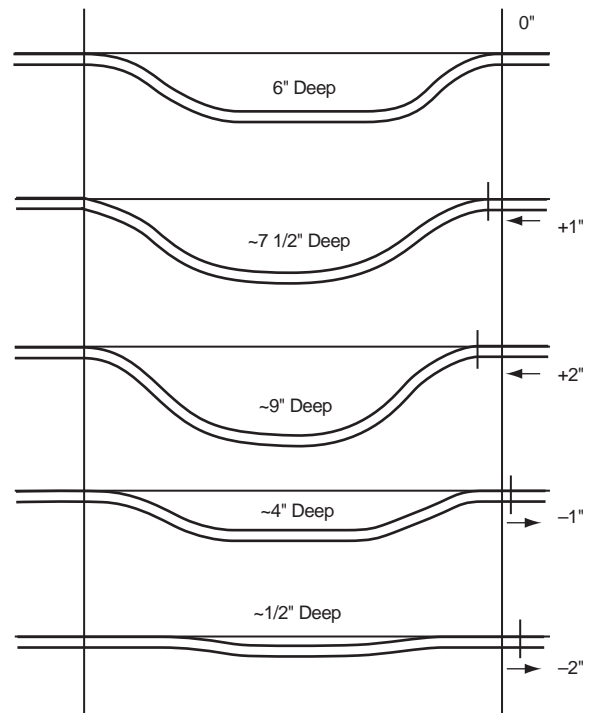


### Loop Depth

Fig. 3 pictorially shows how the depth of an expansion loop changes as the cable moves in and out of the loop. The loop is initially 6 inches deep. As the temperature increases the cable expands more than the steel support strand. The excess cable pushes into the expansion loop. One inch movement causes the depth to increase to about 7.5 inches; 2 inches movement causes the depth to increase to about 9 inches.

As the temperature drops the cable contracts more than the steel support strand. One inch of movement results in a loop about 4 inches deep. Two inch movement results in a loop only about 0.5 inch deep.

**Figure 3.**



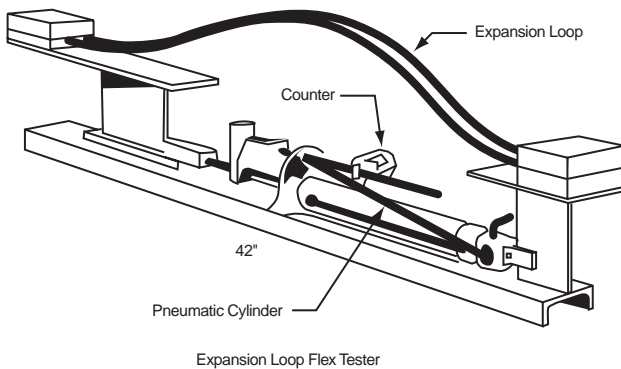
### Strand Creep

As a side comment, if the support strand is strung too tight and is exposed to extreme loading conditions, it may permanently deform or creep. If a 200 foot span was exposed to such extreme loading and the strand was caused to creep 0.09%, the strand would get longer by about 2 inches. The result would be an expansion loop only about 0.5 inch deep. As will be shown, such loops will have practically no life. With enough sag the occurrence of such extreme forces can be minimized if not completely avoided.

## Testing Expansion Loop Performance

A device similar to the one shown in Fig. 4 is used to predict the life of expansion loops. An expansion loop is installed in the device. One end of the loop is fixed in place while the other end is caused to move back and forth a certain distance. The loop is considered to have failed the test when the outer conductor fractures. With this device loop life can be determined as a function of loop depth and excursion distance.

Figure 4.

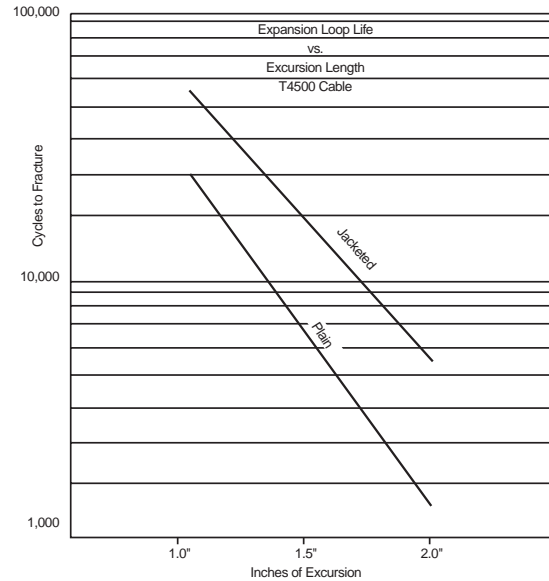


## Loop Life Versus Excursion Distance

Fig. 5 shows the number of cycles to failure as a function of excursion distance of plain and jacketed 0.500 inch cable. If each cycle represents one day of life due to changes in temperature and other factors such as wind and wind gusting are ignored, then, from Fig. 5, plain 0.500 inch cable will last about 32,000 cycles or about 88 years with a 1 inch excursion. If on the other hand the excursion is 1.6 inches, which simulates a 0.5% sag in a 200 foot span, the life of the loop will drop to about 4,500 cycles or about 12 years. Clearly, excursion distance has a dramatic effect on loop life.

Although jacketed cable seems to perform better than bare cable, the temperature change is greater on jacketed cable due to its heat absorption and radiation characteristics. For the same conditions described above for plain cable, jacketed cable would move 1.4 inches. Its life, from Fig. 5, would be 22,000 cycles or about 60 years. Although not shown on the graph a 2.3 inch excursion would result in a life of about 3,000 cycles or about 8 years.

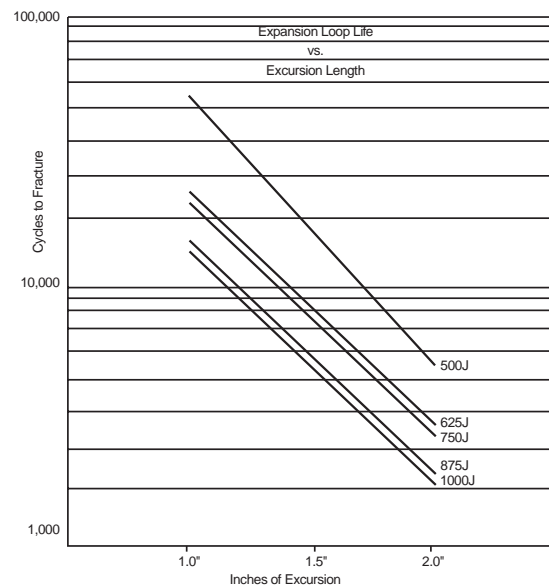
Figure 5.



## Cable Size Versus Loop Life

Fig. 6 shows the life of various size jacketed cables versus excursion distance. In general the larger the cable diameter the shorter the loop life. Given a 1.4 inch excursion, jacketed 0.500 inch cable will last 60 years, jacketed 0.750 inch cable would last 27 years, and jacketed 1.000 inch cable would last about 20 years. Again, the effects of wind and wind gusting can cause rapid expansion loop cycling.

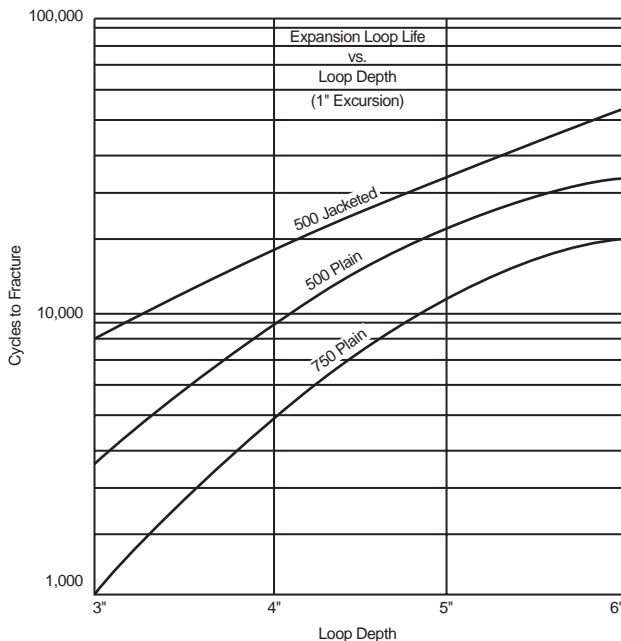
Figure 6.



### Loop Depth Versus Loop Life

Fig. 7 shows how loop depth affects the life of expansion loops. Plain 0.500 inch cable with a 6 inch depth will last about 32,000 cycles or about 88 years, as mentioned before. As shown in Fig. 7, if the depth is decreased to 3 inches, the loop life drops to about 3,500 cycles or about 9.5 years. Under the same conditions 0.750 inch cable will drop from a 55 year life to less than a 3 year life. Clearly, the depth of the loop has a

Figure 7.

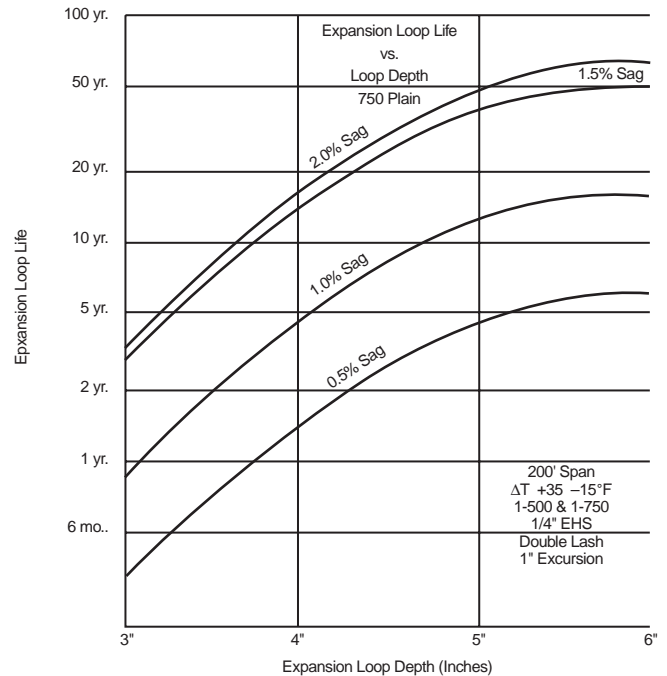


dramatic effect on loop life also.

### Loop Life Versus Loop Depth and Sag

Fig. 8 shows the composite effects of loop depth and sag on the loop life of a 200 foot span of plain 0.750 inch cable. Depending on how the cable was installed the loop life can vary anywhere from less than 0.5 year for shallow 3 inch deep loops and tight sags to an excess of 50 years with the proper loop depth and sag.

Figure 8.



### CONCLUSION

Several factors affect the life of expansion loops. The obvious factors are temperature change and span length. Unfortunately we have little or no control over these factors. Of significant importance are loop depth and installation sag. Both of these factors can be controlled through the proper installation techniques and can extend cable life. In the example given, the life of 0.750 inch cable was increased from only 0.5 year to an excess of 50 years simply by installing the cable with the proper sag and proper loop depth.