Equalization Melting/Parting
On Pump-downs and Pressure Work
Technical Bulletin Four

On pump downs and other pressure jobs the wellhead is equipped with a lubricator (6, 8 and 10) and flow tubes (4) to maintain well control when lowering the wireline tools and cable from atmospheric pressure into the well; which, can be at several thousands pounds of pressure. The process of bringing the wellbore and the lubricator to the same pressure is known as “equalization”. There have been several cases of cable failures where either the conductor was melted, or in more severe cases the cable parted during the equalization process. The failures have typically occurred one to two feet above the cable head. Wireline subjected to this failure mode will appear burned and the armor wires may become brittle.

How can this happen? Is it possible for enough heat to be created in the lubricator to melt the conductor and physically change the steel properties causing cable failure, even with bottomhole temperature less than 400°F?

The answer is “yes” if the equalization process is performed too rapidly. Let’s look at how this occurs. When the lubricator is filled very rapidly the air inside the lubricator will compress from atmospheric pressure (15 psi) to wellbore pressure (say 3,500 psi) extremely rapidly because there is very little room past the flow tubes for the gas to escape. This rapid compression causes an extreme increase in air temperature because the time frame does not permit significant heat loss. The formula to calculate this “adiabatic” (zero heat loss) temperature rise is as follows:

\[ T_2 = T_1 \left( \frac{P_2}{P_1} \right)^{\frac{\gamma-1}{\gamma}} \]

In practice you could never compress the air fast enough to keep some heat from being lost but this calculation sets an upper limit. Using the values above the calculated temperature of the air after an adiabatic compression would be 1,200°F. If these high temperatures seem unrealistic consider putting your hand on an air compressor. Even a 150 psi air compressor gets quite hot.

Consider a 26 foot riser with an ID of 5”. In the riser is a 24 foot tool that is 3.125” in diameter. The volume, \( V_r \), filled with air at 15 psia would be 16,000 cubic inches.

\[ V_r = \pi (Dr)^2 Ir - \pi (Dt)^2 Lt \]

The volume after adiabatic compression, \( V_{rc} \), according to the formulae to the right would be only 500 cubic inches.

\[ V_{rc} = V_r \left( \frac{T_1}{T_2} \right)^{\frac{1}{\gamma-1}} \]

The length of the column of compressed air in the riser, \( L_{rc} \), is 6 Inches

\[ L_{rc} = \frac{V_{rc}}{\pi (Dr)^2} \]
From the calculations above we see that the length of compressed air is approximately 6 inches. If the tool is at the bottom of the riser there would be about 2 feet of cable above the tool and below the grease head. The six inches just below the grease head is where the air would be and it is at this point that the temperatures could approach 1,200°F. The insulating material would quickly melt and the metallurgy of the steel could be altered causing the wire to become brittle. The rapid flow of gas at the same location has been known to result in the severing of the Wireline.

**What can we do to mitigate the problem?**

Although we have spoken of temperature the real culprit here is how much heat energy is available to damage the cable.

\[ Q = \text{Heat Generated} = W a (c_p)(T_2 - T_1) = (9.25)(0.24)(1235 - 75) = 2575 \text{ BTU} \]

The amount of heat available at this high temperature, to damage the cable, increases directly with the height of the air column and the square of the diameter of the lubricator. In essence the amount of air retained after compression. Also keep in mind that the theoretical calculated maximum temperature is based on the condition that the pressure change is so rapid, that there is not enough time for the air to escape through the packer & flow tubes or for heat to be conducted away by the casing. In the real world, some air will escape and some heat will be conducted away but if the valve is opened fast enough, you can reach temperatures high enough to melt cable insulation and affect the armor metal properties.

Having said that in practice to avoid this problem the following points should be considered:

- Filling the lubricator rapidly will result in a condition where the air has nowhere to go and thus compresses resulting in extreme temperatures and high heat energy which can damage the cable permanently
- The more air in the lubricator the more heat can be generated
- Filling the lubricator with fluid prior to equalizing will mitigate much of the air and therefore most of the energy to cause damage
- A by-pass valve can be installed just below the flow tubes to allow the air to escape much faster