Melting or parting of electro-mechanical wireline during pump downs and pressure work

By TERRY MOFFATT
Quality Wireline and Cable Inc.

BILL BOWERS
Specialist Consultant Engineer

On pump downs and other pressure jobs, the wellhead is equipped with a lubricator and flow tubes as shown in Figure 1, to maintain well control while 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 of 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 quickly because there is very little room past the flow tubes for the gas to escape. A typical grease head which contains the flow tubes is depicted in Figure 2. This rapid compression causes an extreme increase in air temperature because the timeframe does not permit significant heat loss. The formula to calculate this “adiabatic” (zero heat loss) temperature rise is as follows:

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

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

**Figure 1 – Pressure job. Photo courtesy of Wood Group Logging Services**
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 inches similar to the riser depicted in Figure 3. In the riser is a 24-foot tool that is 3.125 inches in diameter. The volume, \( V_r \) filled with air at 15 psia would be 16,000 cubic inches.

\[
V_r = \pi (Dr)^2 L_r - \pi (Dt)^2 L_t
\]

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

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

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 6 inches just below the grease head is where the air would be and it is at this point that the temperatures could

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?

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

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

The amount of heat available to damage the cable at this high temperature 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, there is not enough time for the air to escape through the packer and 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.
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 that 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 eliminate most of the air and therefore most of the energy that can cause damage.
- A by-pass valve can be installed just below the flow tubes to allow the air to escape much faster.

In conclusion it is possible to melt conductors and even burn through a cable during the equalization process. The first step to eliminate this problem is to create awareness of the cause of the cable damage, then train and educate to prevent a reoccurrence. The above list of “best practices” can be used to help mitigate the problem.

**ABOUT THE AUTHORS:**

Terry Moffatt, P.Eng., ME, PET, is president of Quality Wireline and Cable Inc. His experience includes co-founder and president of Wireline Works Inc.; and president and founder of PROMORE Engineering Inc. He has 20 years experience in the design and installation of permanent monitoring systems using wireline, and in the manufacture of electro-mechanical wireline.

Bill Bowers, P.E., EE, MS, currently acts as a specialist consultant engineer to the wireline industry. His experience includes manager of the Cable Engineering Department for Schlumberger, vice president of Vector Cables, director of operations for ITT Cable-Hydrospace and president of Camesa Inc.