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t-mass' Heartbeat Monitoring and corrosion prevention in compressed air systems

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The corrosion question

In many compressed air systems, steel piping is used for the air transport. Although there are other material choices for compressed air piping, such as, plastics, aluminum or stainless steel, often carbon steel or galvanized steel is used for cost reasons. In some cases, existing piping, e.g. old galvanized steel water piping, is converted into compressed air networks.

The problem with using steel piping for compressed air, aside from the possibility of scaled inner pipe walls in reconverted water piping, is that steel piping has a potential for corrosion when exposed to condensate. Ambient air always contains a certain amount of water vapor, which forms to condensate when undergoing compression. This is why well-planned compressed air systems will always have built-in condensate removal to ensure that water is removed prior to the air's transport within the compressed air network. Water can be removed by means of cooling systems that cool the air below the pressure dew point to ensure that it forms to condensate and then removing the condensate from the piping system using a knock-out pot. Water can also be removed through chemical adsorption, for example.

These removal systems are placed typically after the compressor and before the receiving tank of the compressed air system. What these systems do not account for, however, is the possibility of renewed entrance of water vapor into the compressed air at other points within the network. This can happen when there are faulty seals, for example, that facilitate the exchange of water vapor between ambient air and compressed air. Also, old condensate removal equipment or equipment in need of repair can foster the presence of water in a compressed air network.

With inadequate condensate removal or excessive leaks in the compressed air network, the potential for corrosion in steel piping increases dramatically. The effects of corrosion on compressed air networks are manifold: shortened lifetime of piping parts, air contamination through the transport of rust particles and wasted energy due to pressure loss coming from corrosion-induced leaks in piping, restricted flow and choked filters from rust build-up.[1]

[1] Air Audit. "Corroded Steel Pipes are Eating your Compressed Air System's Efficiency!", https://airaudit.com.pk/corrosion-in-pipes/ (accessed 19 June 2020)

Figure 1: Corroded steel pipe in a compressed air system. Rough surface leads to restricted air flow and debris in air lines.[2]

Corrosion prevention with Heartbeat Monitoring

t-mass 300/500's Heartbeat Monitoring offers a preventative measure for avoiding the onset of corrosion in steel piping systems. This monitoring feature, known as "Process Stability," utilizes a unique, proprietary software algorithm, which monitors the flow output signal of t-mass for patterns that are typical of applications with wet gas flow.

Wet gas flows are two-phase, meaning that they consist of the main gas phase and a second liquid phase, usually in the form of water. Wet gas represents a difficult obstacle for the measurement success of thermal mass flowmeters, as water has very different heat transfer characteristics than does air, for example. Water has the tendency to strip a much larger amount of heat energy from the thermal sensor than the gas itself. This behavior of water leads to the development of peaks in the flow output signal of thermal mass flowmeters. Typically, the formation of a signal peak is analogue to the formation of a water bead on the thermal mass sensor prong that slowly builds and finds its way along the length of the sensor before finally reaching the sensor tip, where it will increase in size until its weight overcomes the water bead's surface tension and drops off. When the bead drops off the sensor

[2] Photo from: Taylor, Brad (2020). "What Type of Piping Should I Use in My Compressed Air System." *https://fluidairedynamics.com/what-type-of-piping-should-i-use-in-my-compressed-air-system* (accessed 19 June 2020).

tip (this would appear in the output signal as the peak itself), the signal falls back to its original starting point.

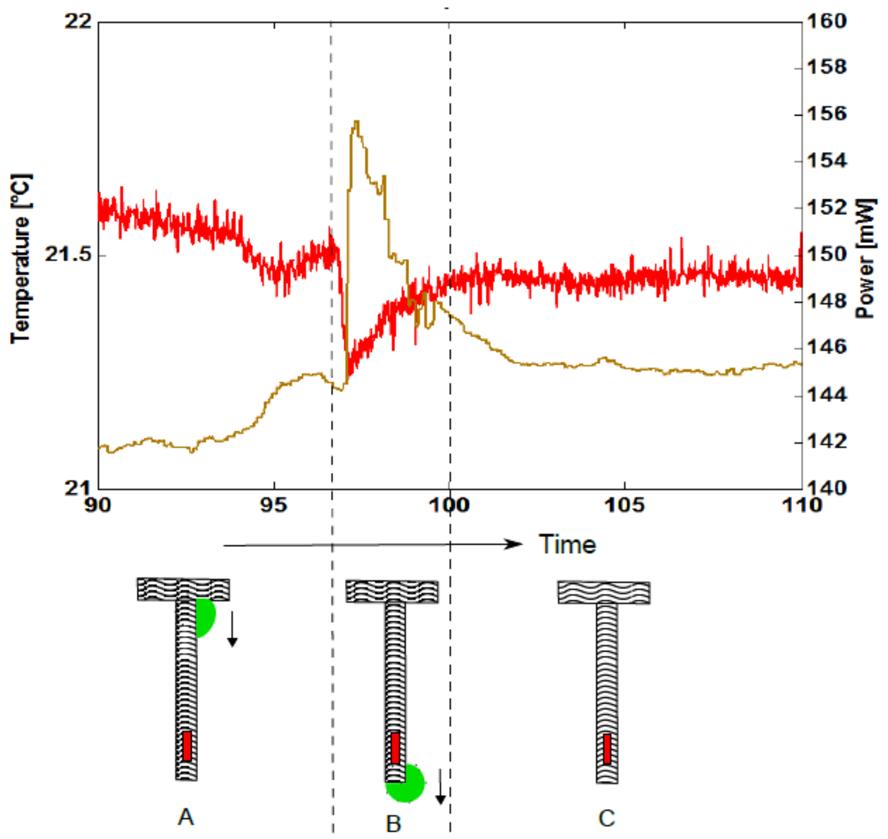

Figure 2: An example signal pattern of droplets which travel from the base to the tip of the sensor with corresponding physical phenomenon.[3]

The formation of droplets on the thermal mass sensor can be categorized into three types:

1. Droplets forming on the tip of the sensor prongs
2. Droplets forming on the base of the prong and traversing the length of the sensor to the tip
3. Bursts of droplet showers[4]

Each of these different types of droplets result in a distinct type of flow output signal which can be detected using the Heartbeat Monitoring algorithm. This algorithm runs continually in the background

[3] Malladi, Krishna Chaitanya (2014). "Development of Algorithms for the Detection and Correction of Error due to Water Droplets in Thermal Mass Flow Meters" (Master's Thesis for Hochschule Karlsruhe Technik und Wirtschaft on behalf of Endress+Hauser), p. 9.
[4] Ibid., p. 7.

during the flow measurement, so that any presence of condensate on the sensors can be detected and then issued as either a warning or alarm. The monitoring functionality can also be turned off if so desired.

Conclusion

By using this unique process monitoring functionality, the customer can constantly monitor his compressed air network for the presence of water condensate and be alerted by t-mass 300/500 when condensate exists. This warning can either be a sign that the existing configuration of the compressed air network must be revamped to achieve more effective condensate removal or that existing water removal equipment is malfunctioning or in need of repair. The proper use of t-mass's "Process Disturbance Monitoring" together with the customer's effective maintenance and repair process can result in a superior corrosion prevention system for users of compressed air.