

# Cold-acclimatised pipelines

Maintaining flow and pressure when the temperature is low can present serious but

manageable challenges. Field instrumentation can help, but it must be deployed and maintained correctly, **explains Wally Baker (Rosemount, USA) and Mark Menezes (Rosemount Measurement, Canada), from Emerson Process Management.**

**A** long-standing challenge for oil and gas production is difficult locations or environments. The weather can be unco-operative, drilling sites can be far offshore, and some areas are subject to extremes of both hot and cold. Extraction has a lot of moving parts, literally and figuratively, and keeping everything going year round presents a variety of obstacles to those responsible for production and performance.

Places where the temperature is consistent, even if it is very hot or cold, are easier to deal with in many respects than those where climate is highly variable. Equipment can be optimised to specifically work best in one type of environment, but it becomes more of a challenge to perform well across a wide range of





temperatures because many operational and maintenance elements come into play.

This article will focus on environments where ambient temperatures cycle from very cold to moderately hot over the course of a year, ranging from -40°C (-40°F) to over 35°C (95°F). Ambient temperature is a critical consideration because of the effect it has on many substances.

Metal, concrete and other materials used in production and pipeline equipment have to handle these temperature extremes. Factors such as expansion and contraction of piping and mechanical structural

supports, and automation equipment operation, all need to be taken into account. Some of the most challenging temperature measurements relate to dealing with liquids that can freeze.

Water becomes a solid at 0°C (32°F) and the long molecules found in oil become more viscous as it becomes colder. In some cases, this can increase viscosity and make substances more difficult to move through a pipe. For measurement applications, water can become lodged in impulse lines that can freeze, causing blockages or worse yet, expanding to the point of rupture. In addition, mechanical devices may become sluggish in cold climates as lubricants get thicker, and if moisture gets inside a sensitive mechanism it can freeze and keep it from moving as needed.

For those responsible for keeping product flowing, low temperatures often cause problems in two areas: instrumentation and pumps. In many situations, both areas are inextricably connected and affected by many of the same considerations.

### Pumps in pipeline service

There are two instrumentation systems connected with pumps (Figure 1). The first group monitors product moving through the pump. The second watches over the condition of the pump and motor itself. Some areas overlap where a single device serves both purposes. Basic product-related sensors include:

- ▶ Pump intake pressure: ensures an adequate supply flow so the pump does not experience cavitation or run dry.
- ▶ Pump discharge pressure: verifies the pump is running and ensures the desired pipeline pressure is maintained.
- ▶ Differential pressure between intake and discharge: verifies correct operation and helps optimise pump running speed. Can provide a rough flowrate calculation and an indication of product viscosity when flow is compared to pump speed and current draw.

If transported product viscosity increases due to declining temperatures, these measurement devices will recognise it. The pump motor will have to work harder, drawing more current to maintain the speed necessary to keep product moving at desired flowrates. Lower ambient temperature will allow a motor to dissipate more heat, so running harder won't generally be a problem outside of increased energy consumption.

The motor and pump can be outfitted with a second group of sensors to diagnose equipment condition:

- ▶ Pump motor temperature: indicates when a pump motor is running hot.
- ▶ Pump bearing temperature: indicates when a bearing is exceeding safe temperature.

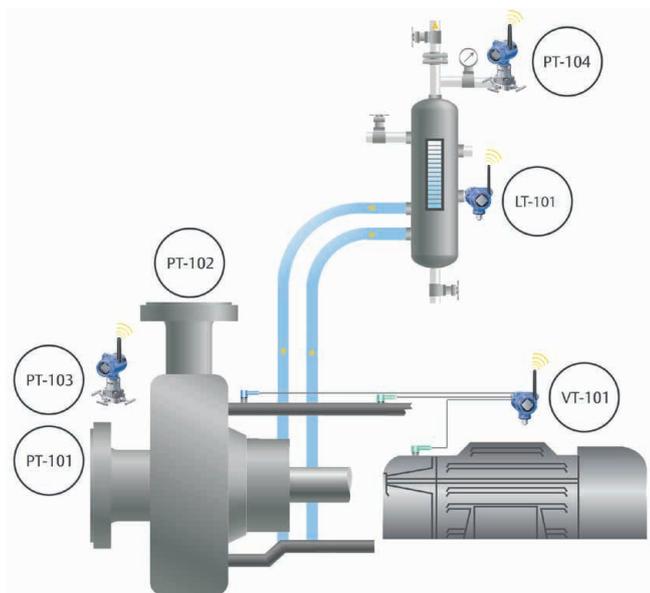


Figure 1. A motor and pump unit usually has a variety of different sensors installed to monitor flow and other parameters, along with the mechanical condition of the equipment itself; courtesy of Emerson Process Management.



Figure 2. Instrumentation suppliers have improved the electronics used in transmitters, expanding the range of temperatures in which they can operate without problems; courtesy of Emerson Process Management.

- Pump vibration: a good indicator of mechanical health, particularly when tracked over time and compared to a baseline.
- Pump seal system reservoir level: indicates buffer fluid level, now recommended by API-682 instead of a level switch.
- Pump seal system vapour vent pressure: indicates high pressure, normally a result of process liquids leaking into the buffer system and flashing to the vapour phase in the seal reservoir, now recommended by API-682 instead of a pressure switch.

API-682 offers specific recommendations on how the pump seal system should be monitored. The pump's lubrication system may circulate oil through an external reservoir where it can cool significantly, changing its viscosity when it is reintroduced to the pump. This doesn't have to be a problem since it can be controlled, and a low ambient temperature can be beneficial in some circumstances.

### Field instrumentation in cold weather

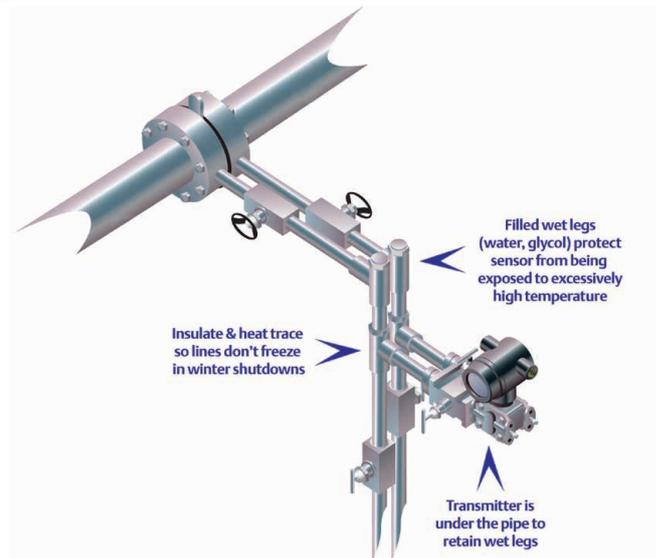
Electrical devices that generate lots of heat, like motors and drives, can actually work better in cold weather due to improved heat dissipation. But with the sensors and transmitters that make up instruments, problems can occur with sophisticated devices such as the A/D converters and other signal processing elements. The electrical characteristics of semiconductors are not always the same at low temperatures, and combinations of dissimilar metals within the circuits can create microscopic thermocouples, with results not always predictable or consistent.

In response, electrical designers have built better circuits, and the components have improved so the characteristics are better understood and their effects reduced (Figure 2). Moreover, most pressure instruments and flowmeters have one or more temperature sensors built-in already to provide compensation for temperature effects, and vendors have found ways to widen the effective operating range in both directions on the temperature scale. A sophisticated pressure instrument is probably monitoring ambient temperature via its built-in sensor and using this value to compensate the pressure reading, and might also measure the temperature of the transmitter's electronics, as both can affect reading accuracy.

### Slower response

Plant owners in areas where the seasons change drastically from summer to winter often find a common problem related to impulse lines; those small tubes (capillaries) leading from the process penetration point to a pressure instrument, carrying either the process liquid or some other filler material to transmit pressure to the sensor

Fill fluid	Boiling point (°C)	Viscosity at 25°C (cSt)	Viscosity at 0°C (cSt)	Viscosity at -25°C (cSt)
Syltherm XLT	149	1.6	2.1	3.5
Silicone DC200	205	9.5	16.1	30.7
Silicone DC704	315	39	183	Solid
Silicone DC705	370	175	Solid	Solid



**Figure 3.** One of the most persistent problem areas in cold environments is frozen impulse lines between the process penetration and transmitter; courtesy of Emerson Process Management.

(Figure 3). Those lines allow the sensor and its associated transmitter to be mounted in a location easier to reach than the actual process penetration, or allow one sensor to connect to multiple measurement points some distance apart.

In a pipeline environment, a pressure instrument might be performing various tasks. It could be measuring the actual pipeline pressure; it could be using a differential measurement to calculate flow; or it might be using pressure to measure level in a tank. Those impulse lines are often filled with a gas or liquid, and are described as dry legs or wet legs, respectively. If there is a steam generator to heat product or equipment, there will be pressure instruments at various points around the installation.

Differential pressure flowmeters are commonly used for measuring steam flow. The impulse lines are wet legs because steam condenses in them, filling them with condensate. Maintenance technicians often expect these to be impervious to cold weather because they are connected to the steam line, which transfers heat down the metal tubing. They are also normally insulated, at least to some extent. Still, it's an unhappy surprise if the first hard freeze disables the instrument and maybe ruptures the lines.

These problems often cause maintenance technicians to replace wet legs with oil-filled capillaries or remote seals. The fluid product in the tubes has a higher

molecular weight than water so it can operate at the full steam temperature without boiling off. Some silicone-based products have boiling points well beyond 300°C. Unfortunately, the colder end of the line can be a problem. Viscosity becomes an issue with these fill fluids at lower temperatures. The Table gives examples of common products and their temperature versus viscosity characteristics.

When viscosity increases, response time slows down. A 5 m long capillary tube with an internal diameter of 10 mm filled with fluid with a viscosity <5 CentiStokes (cSt) slows response time by 1 - 2 sec. The same system with a fluid viscosity of >150 cSt slows response time by >30 sec. If the fill fluid solidifies, it provides no response at all.

One common but expensive alternative is adding thermostatically controlled heat tracing on the impulse lines. Usually these systems only add heat during the winter and can avoid overheating in the summer, however they can double or triple the cost of adding a pressure instrument, require energy to operate and complicate maintenance tasks.

Newer capillary systems are designed to eliminate the need for impulse line heating without slowing response time. As shown in the instrument depicted in Figure 4, the seal is directly connected to the vessel or pipe containing hot fluid. The design of the seal and its internal copper tubing are optimised to conduct the right amount of heat so the oil remains in a liquid phase with low viscosity for best responsiveness during the winter, but does not conduct so much heat as to damage the transmitter during the summer.

Another new alternative is a thermal range expander, which utilises two different fill fluids. The first is a high temperature fill fluid that can tolerate high process temperatures, with a secondary fill fluid suitable for colder ambient temperatures, thus eliminating the slow response times traditionally seen in this type of application.

### Flowmeter considerations

Flowmeters monitor product moving through the pipeline for accounting purposes, and may also close control loops regulating pump speed and/or control valve operation. They can be installed at various points starting at pump output and continuing downstream. The most common pipeline flowmeter technologies are ultrasonic and Coriolis



**Figure 4. Pressure instruments with internal, oil-filled capillaries are more reliable than those with impulse lines; courtesy of Emerson Process Management.**

because they provide straight-through product movement.

The sensors for both types of flowmeters take on the temperature of the product in the pipeline, although their transmitters may be mounted some distance away. As a result, in cold areas the sensor can be warmer than the transmitter. Most designs can compensate appropriately.

In some other flow applications, a version of a differential pressure flowmeter may be used, but these are less common in direct pipeline service because they require an intrusion into the flow path.

### Information management

The output from flow and pressure instruments can be sent to control systems using analog signals, or high-speed two-way digital data links such as FOUNDATION Fieldbus, Profibus PA, EtherNet/IP or WirelessHART. These links allow the control system to use not only the process data, but also the diagnostic information from smart devices for troubleshooting and detecting problems before they occur.

This is especially important given the remote locations of pipeline pumping stations and the difficulty of reaching them

in cold weather. If a technician does need to visit the site, the diagnostic information provided by smart sensors to the control system will allow him or her to bring the needed tools and parts to complete a repair in one trip.

The control system uses process variable information received from flow sensors to optimise pump operation and product movement. Flow sensors installed downstream of pumping stations provide critical data to the control system, which is processed internally to yield actionable information to operators and engineers. For example, comparing flows at various points in the pipeline can show if a major leak has occurred.

### Conclusion

Regardless of the environment, the basic considerations of flow management in pipelines don't change. Accurate and reliable measurement of various process parameters is required throughout the pumping and pipeline system. The greatest advances these days relate to field devices with many improvements in performance and self-diagnostics. Networking protocols are also improving to move information across the long distances involved in pipeline applications. These improvements help facilitate oil and gas extraction in increasingly challenging formations and locations. 