Why a Regulator Freezes Up and How to Prevent it!

Form# 1001
Rev A

If all LP-gas regulators have to do is reduce a high pressure to a lower pressure, why do they freeze up? The short answer is "water", but, as you know, nothing is ever quite that simple.

To keep your customer warm and happy, day after day, year after year, your regulator has to do some pretty tricky things. It's got to baby the pilot light, rise to the occasion every time the furnace kicks on and shut off completely when it's supposed to.

In order to do that well, your regulator is a very finely tuned mechanism. Unfortunately, water can really throw a wrench in the works since freezing water can plug up the inlet so no gas flows or even keep a regulator from shutting off completely.

The problem of regulators freezing can be eliminated by using only dry fuel and keeping the fuel free of water until it passes through the regulator. Since that isn't always something you can control, though, it's helpful to know what causes freezing in the first place and what you can do to prevent it.

So where does the water come from? It comes from a variety of sources: Fuel can be water saturated when you get it from underground storage, the gas plant or refinery unless they take care to dehydrate it properly; dry fuel can become saturated with water when transported in tank cars that previously carried wet product; hydrostatic testing can leave water in cylinders and tanks which the dry propane can pick up; and empty cylinders standing in moist atmosphere with the valve open allow air to enter the cylinder where moisture condenses and is trapped.

Well how much water does it take to cause freeze up problems? Table 1 gives some idea of the amount of water that liquid propane can "absorb". It doesn't seem like very much, but it doesn't take very much to cause problems.

Table 1

TEMPERATURE OF THE LIQUID PROPANE	AMOUNT OF WATER IN A FULL 100 POUND (45,4 kg) CYLINDER	AMOUNT OF WATER IN A FULL 500 GALLON (1,893 l) TANK
100 °F	3/4 ounce	16 1/2 ounces
32 °F (water freezes)	1/10 ounce	2 ounces

The warmer the liquid, the more water it can hold. Almost eight times as much at the summertime temperature of 100 °F as at a freezing temperature! If your LP-gas comes to you in a tank car, it could be hiding three pints of water. Let that propane cool to a freezing temperature, however, and all but a part of the water is then free. Free to freeze up regulators.

Unfortunately, it gets even worse once the liquid propane vaporizes, as Table 2 shows.

Table 2

TEMPERATURE OF THE PROPANE VAPOR OR LIQUID	HOW MANY MORE TIMES THE WEIGHT OF WATER CAN BE CARRIED BY VAPOR THAN BY LIQUID PROPANE
100 °F	4.2
40 °F	8.3

While it looks like the ability of propane vapor to carry water increases as things get colder, that isn't the case. Table 2 means that the *liquid* loses its ability to hold water as things get colder *faster* than the *vapor* does. Table 3 shows how much water the vapor can hold. That goes down too, with lower temperatures.

Table 3

TEMPERATURE OF PROPANE VAPOR	AMOUNT OF WATER IN 855 CU. FT. (24,2m^3) OF VAPOR (A 100 POUND (45,4 kg) CYLINDER OF LIQUID EXPANDED INTO GAS)	AMOUNT OF WATER IN 18,240 CU. FT. (516 m^3) OF VAPOR (A 500 GALLON (1,893 l) TANK OF LIQUID EXPANDED INTO GAS)
100 °F	3 1/3 ounces	70 ounces
40 °F	1 ounce	22 1/2 ounces

For instance, take a cylinder of gas, during the fall, with an outside temperature of 60 °F. When a cold spell drops the temperature to freezing, water starts to collect in the bottom of the cylinder because neither the propane liquid nor vapor can "carry" the increased amount of water. It stays cold with the free water at the bottom of the cylinder. As vapor continues to be drawn off, the vapor robs the liquid propane of its water, since vapor can carry much more water than the liquid.

Now let's say that your customer's stove and water heater are connected through a regulator to that same cylinder.
Mrs. Smith starts cooking dinner and Mr. Smith decides to take a long, hot shower. It's cold out – about 35 °F – and propane vapor at that temperature comes out of the cylinder to the regulator inlet at about 57 psi (3,9 bar).

The regulator goes to work maintaining proper appliance pressure, as shown in Figure 1.

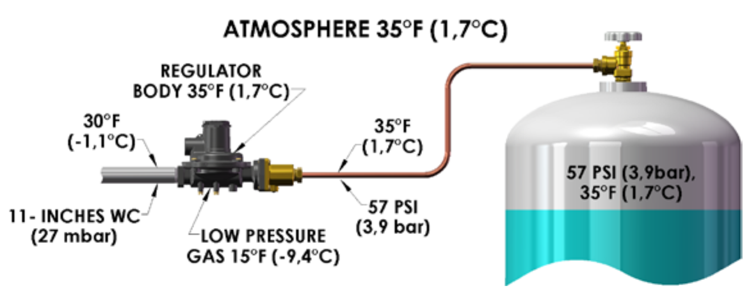

Figure 1

Note that the gas on the low pressure side of the regulator in Figure 1 is only 15 °F. What happened? It takes heat to expand the gas from its compressed volume at 57 psi (3,9 bar) to its enlarged volume at 11-inches WC (27 mbar) for the appliances. This heat comes from the surrounding air through the walls of the regulator. After the gas leaves the regulator and enters the outlet tubing, it goes back up to 30 °F.

Figure 2 shows what can happen during times of long or heavy demand. There have been slight changes in pressure and temperature within the cylinder. This always happens when vapor is drawn off, and 54 psi (3,7 bar) is plenty of pressure to do the job. But look what is happening at the regulator inlet. The expanding gas has pulled the temperature down to 28 °F and propane condense at the inlet. Free water appears because we cool the vapor and reduce its ability to carry water. In Figure 2 the condensate forms just ahead of the regulator orifice.

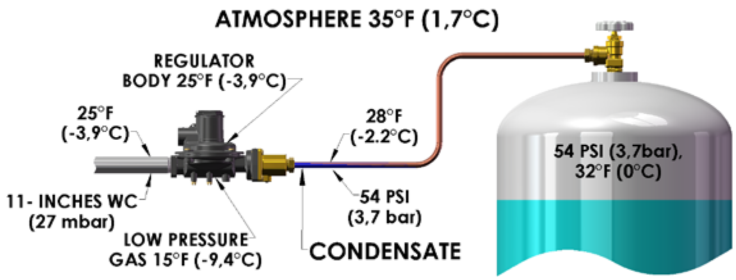

Figure 2

Figure 3 shows where the condensed water turned to ice at the orifice. This is how water causes regulators to freeze up because of their job of reducing pressures.

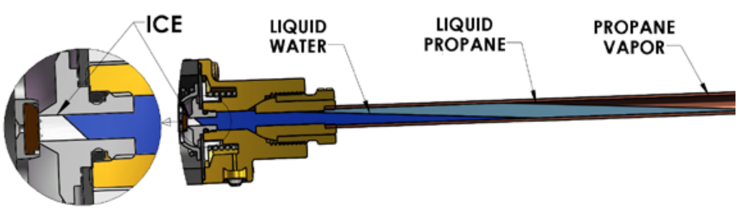

Figure 3

The good news is: There are a number of things you can do to end the painful and expensive freeze up calls and complaints:

Note: The number one solution is to make sure you're using dry LP-gas!

1. Add methanol if you experience freeze ups or suspect water (one pint to a 100 gallons (379 l) fuel). This is by far the most effective way to prevent regulators from freezing.

2. Select a regulator so the typical demand is between roughly 30% and 70% of its rated capacity. Too large a regulator can mean it just barely opens during normal use. That's like an engine that only gets to idle and never really gets to run. MEC offers a full range of regulator capacities, including the cost effective, high flow ¾" outlet compact series specifically designed for mid-range applications with heat-transfer fins to reduce freeze ups (patent pending).

3. In moderate climates with occasional lower temperatures, consider two stages of regulation, i.e., a first stage regulator and a second stage regulator. They're more resistant to freeze ups than integral two stage "twin" units which house both stages in the same body. In very cold climates or when long periods of heavy demand are expected, consider also using an intermediate 2 psi service, or 5 psi regulator. See MEC's LP Gas Service Reference Guide, form #1,000, for more information.

4. Make sure the tank or cylinder is big enough to maintain good vapor pressure. An undersized tank will chill down and frost making freezing worse when demand goes up.

5. Install the regulator and pigtail so that condensate drains back to the cylinder as shown in Figure 4.

6. Keep cylinder valves closed while cylinders are in storage.

These practices should virtually eliminate regulator freeze ups!

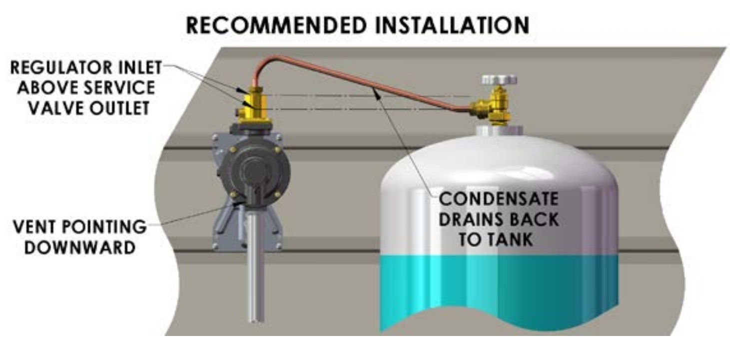

Figure 4

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