Protecting Magnetic Flow Meters in Vacuum Situations

Background

Collapse damage to non-bonded, unsupported liners such as PTFE is most often caused by vacuum in the process line. Vacuum can be created in process piping by an unanticipated condition or series of events. Most often these upsets or events are not recorded due to limitations of process recording instruments or a complete lack thereof. Some of the common causes of vacuum failure include:

- Liquid withdrawal by pumping or gravity draining. In order for this type of damage to occur, typically the meter is mounted at a point in the process where vacuum potential of one sort or another exists. These would include but not be limited to valves upstream of the tube with a significant amount of pipeline downstream, a tube mounted high in the process piping and exposure to drain back vacuum when the process pumps are shut off or valving is closed, pumps drawing rather than pushing process through the tube.
- Removal of gas vapor by evacuators, declinators, fans, jets, or blowers.
- Siphoning action of liquids.
- Condensation of vapor, cooling of hot vapor or liquid. An example of this would be piping and process heated by the summer heat and sun, then rapidly cooled by clouds and rainfall.
- Maintenance, testing and unusually altered process conditions such as those used during start up verses normal operating conditions.
- Chemical reactions.

Essentially, anything that can create a vacuum inside the pipe, either by design or not, has the potential to collapse an unattached liner. The odds of a liner collapsing under vacuum conditions increase as the diameter of the tube increases and as the temperature of liner/process increases. Applications that are at a greater risk of these types of failures can be found in pulp and paper (high temperature black liquor applications), applications where steam cleaning or SIP is used, and geothermal power (high temperature water applications). In these applications, vacuum is often created by either the draining of the line creating a suction pressure causing vacuum collapse, or the condensing of the hot liquid or air (in an empty line) creating a vacuum and causing the liner to collapse.

Identifying Vacuum Collapse

Vacuum damage has a very distinct and easily identifiable appearance. In all cases the liner will form a linear “lobe” (often times more than one) which protrudes into the tube’s bore and typically runs the length of the tube. In applications where the tube is mounted horizontally, as the liquid level drops, the lobe will form in the void space that is created at the highest point, regardless of the meter’s orientation in the process piping. Generally, in horizontal applications the lobe will not form where the weight of the liquid is still resting on and supporting the liner.

In vertical applications it is not uncommon to see a collapse pattern that has a “tri-lobe” appearance with three almost equally spaced lobes protruding into the bore of the tube. This pattern occurs when the tube empties completely and evenly from one end to the other subjecting the entire liner through the bore of the meter to the vacuum. In either orientation, the vacuum can become so deep that the electrode heads will pull through the liner if a lobe develops through one or both of the electrode plains.

Solving Vacuum Collapse Failures

For applications where vacuum pressure is being intentionally introduced and for applications where a vacuum pressure may be unexpectedly introduced as described above, it is recommended that a vacuum break be installed directly upstream of the meter as a means of protecting the magnetic flowmeter from damage due to the creation of the vacuum.

It is also important to note that these vacuum conditions can be created within the meter despite pressure measurement devices not registering a negative pressure on the pipeline. There are many factors that go into the pressure measurement including relative location of the pressure transmitter to the magnetic flow meter, piping configurations between the magnetic flow meter and pressure transmitter, and sampling rate of the pressure transmitter. Often a vacuum may occur in the magnetic flow meter while the pressure transmitter never registers a negative pressure value.

Allowable Vacuum/Temperature Limits of Teflon (PTFE) in Inches of Mercury

Pipe Size	20 to 100 degF	200 degF	300 degF	350 degF
.5”	FULL	FULL	FULL	FULL
1”	FULL	FULL	FULL	FULL
1.5”	FULL	FULL	FULL	FULL
2”	FULL	FULL	FULL	FULL
3”	FULL	FULL	FULL	FULL
4”	FULL	FULL	FULL	FULL
6”	FULL	FULL	FULL	24
8”	FULL	FULL	24	22
10”	26	24	21	18
12”	24	21	18	15
14”	20	17	–	12
16”	17	14	–	9
18”	13	11	–	6
20”	10	7	–	3
24”	6	3	–	1

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