

Design of Impulse Lines for Analysers

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It's often the first place for mistakes to be made when designing an analyser system, as the importance for good design and installation in an impulse line is often overlooked.

Why is it such a problem?

It is absolutely critical that the analyser sees a representative sample of the gas. It must be quick and as free as possible from contamination.

Firstly let's take 'speed of response'. If it takes an hour for a gas molecule to travel from the pipeline to the analyser, even the best measurement in the world is still going to be out of date. Lengthy delays can lead to unstable or hunting systems. If you're always waiting to see response to any system changes then diagnosis becomes very difficult. It's obvious really.

Problems really start to occur with polarised molecules like water or Hydrogen Sulphide. The polarisation makes them sticky, therefore what enters a line doesn't always come out the other end at the same rate. Usually a degree of equilibrium has to be reached before a representative sample can be taken. The speed this is reached is related to the surface area of the tubing.

Keeping the flow rates up or the length of impulse line to a minimum will dramatically reduce these effects.

Poor sampling can lead to liquid entrainment being dragged into the analyser. This is undesirable but a commonly not considered. An installation fault with the same consequences can allow liquids to form in the lines – but we'll come onto that later.

Response Times

Naturally a large volume of gas in an impulse line is going to slow the measurement. Don't forget that impulse lines are often at system pressures, so a litre in the impulse line at 100 Bar expands to litres at atmospheric.

The common mistake is to simply take a sample off from a convenient tapping. This may have a large stand off pipe stub, with a significant valve hung on the end of it. Taking a 300mm stub, 60 mm diameter (50 mm inner diameter) contains about 2.3 Litres of gas. Again take a system pressure of 100 Bar and suddenly you have 230 litres of gas before you even get to your impulse line. At 3 L/min it will take nearly an hour to purge this volume and many times this to reach an equilibrium.

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To avoid this we recommend using a stabbing probe where ever possibly, getting rid of any of that dead space.

Using a stabbing probe also has two other very beneficial effects: reduction of liquids; sampling from pipe centre. A tapping point on the side of a pipe can see liquids running along the side wall entering into the impulse line. This is especially the case if the tapping is on the bottom of the pipe. A stabbing probe can and should be designed to extract a sample from the centre third of the pipe, where the gas velocity is at its highest and the sample most representative.

Large amounts of surface area is equally a problem with polar molecules. The more area the more molecules can get stuck (adsorb) or become unstuck (desorb). Reducing the tubing bore dramatically reduces the surface area. However very small bore tube, ie 3mm or 1/8" is not without it problems as pressure drops may cause liquids to form and any liquids introduced into the pipe will be pushed through, rather than allowed to freely drain back into the pipe.

As a rule of thumb the residence time of gas should be no more than 1 minute, but targeted at less than 30 seconds. This can be achieved in three ways:

- Locate the sample system close to the tapping
- Use fast by-pass
- Reduce bore

If the main sample system cannot be located adjacent to the tapping then a first stage pressure reduction will reduce the pressure and hence the residence time.

Key Points

- Use a stabbing probe
- Sample from the centre third of the pipe
- Reduce the residence time of the sample to a minimum

Genie Probes

Genie probes are manufactured by A+ Corporation and come in two flavours: probes and probe/regulators. The probe is a clever idea, incorporating a coalescing filter on its tip. A balanced pressure insertion device means you can insert and retract these into a pressurised pipe for easy cleaning or replacement. The regulator is another good idea but it comes with a number of caveats. When gases expand they cool, the Joules-Thompson effect. Conventionally electrical heaters have been embedded into regulators to overcome the temperature drop and prevent freezing. The Genie system places the regulator into the probe and the gas stream, using the gas in the main stream and metal of the pipework as a heat sink, keeping the regulator warm.

The issue is not necessarily with freezing, this is easy to overcome. The problem is in condensing out the heavier components, changing the gas matrix. This will kill the accuracy of a

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gas chromatograph, but will also dramatically effect other analysers such as moisture. For example: as liquids form they will attract the water molecule, as with a contactor, drying the gas.

When deciding whether to use a Genie Probe Regulator the gas matrix has to be considered. There is a selection program on the A+ website to help. As a rule of thumb, do not use on upstream processes where you are likely to encounter rich gas.

Key Points

- Consider process conditions when selecting probe / regulators

Wake Frequency Calculations

There is a word of caution when fitting stabbing probes: resonance. If the gas velocity coincides with the resonant frequency of the stabbing probe the resultant oscillations can snap the probe, potentially causing enormous damages to downstream equipment. Be sure to consult the supplier of the probe and ensure it is suitable for the process conditions.

Key Points

- Request Wake Frequency Calculations

Running Impulse Lines

Liquids can always get pulled into impulse lines. It may only be a rare occasion but under plant fault conditions it can happen. It avoid liquid trapped ensure there are no 'swan necks'. The lines should rise vertically up from the stabbing probe, run to the analyser in a near vertical plane (allowing an angle to free drain any liquids) and then down to the analyser.

It may be prudent to start the impulse line run with a section of 6mm / ¼" to allow aerosols to drain back into the line.

Key Points

- Avoid swan necks
- Allow a slight angle to allow liquids to drain

Heating

Trace heating is common on impulse lines. Good and effective trace heating is rare! Trace heating is important for a number of reasons:

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- Prevent heavy hydrocarbons from condensing
- Reduce diurnal effects
- Keep glycol vapour mobile

If at any point along the sample line the temperature falls below the gas dewpoint then liquids will form. These could poison an analyser, or at the very least fundamentally alter the gas you're trying to measure.

As the temperature in the lines varies then so will the energy of the molecules you're trying to measure. As temperature increases the molecules attached to the tube walls will be liberated creating high reading. Of course the opposite is true.

Glycol vapour is common in gas streams. Contactors use large amounts in every day use. The vapour will enter the impulse lines close to its saturation temperature (dewpoint). If the lines are cooled at any point then free glycol forms. Again, as with any liquid contamination, it can poison or damage an analyser.

Good efficient heating, to above the cry-condentherm, is imperative. Lagging must cover all exposed parts. Valves should be lagged and only placed adjacent to the tapping anyway. If at any point the temperature of the impulse lines dips into the phase envelope then liquids will freely form. It can take significant energy to re-vaporise them and so they are only going to enter the sample system. Enough will get through the filters to contaminate the probe.

Many trace heating systems use thermostats to ensure a maintained temperature. These should never be used! Thermostats usually have about a 6 °C dead band. As the impulse lines heat and cool the equilibrium of the gas in the impulse lines with the tubing is constantly effected. In-gassing and out gassing will constantly occur and a saw-toothing on the analyser will be observed, especially at low concentrations.

Key Points

- Size heating tape to ensure correct temperature is maintained
- Use self regulating tape
- Ensure there are no cold spots

Material Selection

When running an impulse line the normal thing to do is to grab some trusty ol' stainless steel. This may not always be the best option. Ignoring chemical attack with incompatible fluids, polarised molecules will be drawn onto the surface, and until a new equilibrium is reached there will be errors in the measurement. On a constantly varying system then equilibrium will never be reached and so the measurement cannot be accurate.

There are a number of manufacturers about offering propriety coatings to tubing, or electro-polished internals. We recommend seeking advice from the analyser manufacturer regarding tube selection, after all they should be the specialist.

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Key Points

- Seek advise on material selection from the analyser vendor

Appendix A
Impulse Line Diameter Effects

D = Diameter large bore
d = Diameter small bore
L = Length large bore
l = Length small bore
S = Surface Area Lge
s = Surface Area sm
V = Volume large bore tube
v = Volume small bore tube

$$S = \pi \times D \times L$$
$$s = \pi \times d \times l$$

$$l = s / \pi \times d$$
$$L = S / \pi \times D$$

Where $l = L$

$$s / d = S / D$$

$$d / D = S / s$$

Directly proportional decrease in diameter to surface area.

Appendix B

Impulse Line Volume Effects

$$V = \pi \times R^2 \times L$$

$$v = \pi \times r^2 \times l$$

$$L = V / \pi \times R^2$$

$$l = v / \pi \times r^2$$

Where $L = l$

$$V / R^2 = v / r^2$$

$$v / V = R^2 / r^2$$

From 6 mm OD to 3 mm OD, 1 mm wall thickness

$$R = 2$$

$$r = 0.5$$

$$v / V = 4 / 0.25$$

$$v / V = 16 \text{ Times volume difference}$$