BEST PRACTICE

REFINERY FUEL GAS TREATMENT – LOW NOx BURNERS

This outlines the best practices for reducing performance problems related to gas quality in the new class of ultra-low-NOx burners used in process heaters, boilers etc.

The majority of the new ultra-low-NOx burners use gas tip orifices that are significantly smaller than older technology units (1/16" & <). These small orifices are essential to the desired low NOx output but are very sensitive to contamination that is typically present in industrial fuel gas sources.

Sources of contamination include:

> Pipe scale – which include a wide variety of iron oxides formed from exposure to water, H_2S, CO_2, amines, and other hydrocarbons.
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> Catalyst Fines – carried over from upstream processes.
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> Hydrocarbon Aerosols – from upstream processes, compressors and pumps.
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> Water Aerosols – from upstream processes (refinery gases are typically saturated).

Particulate contamination will eventually build up and plug burner tips. Plugging occurs over time and will effect the heat output and the flame shape – which ultimately causes higher NOx output.

Aerosols coming in contact with burner tips will cause formations in the orifice and on the ends of the burner tips similar to stalactites. Orifice shape changes will increase NOx and may also cause hot spots or cold spots to occur

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Particulate

Filtration is the only practical method of keeping solid particulate from reaching burner tips. There are two considerations for particle filters. Micron size and filter locaton:

> Particle size of piping contaminant can vary considerably – simple rust and scale is relatively large and can be stopped by a 20 micron or tighter element. If hydrogen sulfide H_2S is present in the gas, it will generate iron sulfate particles which are very difficult to capture with anything but a sub micron filter element. The best practice is to size the element(s) to pick up the smallest particle.
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> Because solid particulate generation in carbon steel piping systems is a continual process the best practice is to locate the particulate filter as close to the protected process as possible (or replace all piping downstream of the filter with piping that will not corrode[1]). The typical approach to particulate retention if a multi-level or multi-layered approach

[1] 304 or 316 stainless steel piping will not stop the corrosion effects of H_2S or chlorides due to the fact the passive film on stainless does not generate itself fast enough in a low oxygen environment to overcome the corrosive effects of these chemicals. Stainless steel is subject to stress corrosion cracking in chloride environments and is often less desirable than steel piping.

with larger micron media with more dirt holding capacity upstream of the tighter, low micron media.

Aerosols

Aerosols consist of water and hydrocarbon compounds that reached particle size. The old approach using knockout drums and vane separators only remove aerosols 5 micron or larger in size. The newer burner designs require that the aerosols below 5 um are also eliminated from the stream . This calls for a coalescing filter (0.3 um or better) which will catch most of these aerosols. A coalescing filter will not, however, stop humidity or fumes. It is essential that once all aerosols have been captured by a good coalescing filter, the dew-point[2] and hydrate zone of the fuel gas should not be permitted to be reached downstream of the coalescing element. There are two conditions that will cause the gas to reach dew-point:

> Radiant heat loss – due to low piping skin temperature in cooler climates. In cool climates piping downstream of the coalescing element should be insulated at minimum and traced if there is significant distance from the coalescing element to the burner.
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> Pressure Drop – pressure drops created by control valves, pressure regulators or poorly designed gas distribution manifolds will almost always cause the gas temperature reduction with dew-point being reached momentarily (Joule-Thomson effect) causing some water and hydrocarbon gas to precipitate out to liquid water and hydrate. There are only two solutions to this:
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> > Eliminate all control valves downstream of the coalescing system **or** adding heat before the fuel gas goes through a control valve (normally it is necessary to add a minimum of 50°F [3]) which will overcome the Joule-Thomson effect. This solution is rarely employed due to the need to pipe steam or other heating method and the associated controls add complication and expense.
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> > Piping distribution headers downstream of the coalescing system should be designed to eliminate pressure drops. Distribution headers should be as short as possible to keep frictional losses to a minimum.

SUMMARY

The proper treatment of refinery grade fuel gas for ultra low NOx burner consumption requires that adequate particulate filtration be combined with a coalescing filter system to remove solid contamination and aerosols. Gas dynamics of aerosol formation requires that the final coalescing filter be located downstream of control valves and that in cold climates downstream piping be insulated and possibly traced.

There are two reasons to locate the final coalescing system as close to the burner as possible – reduction of pipe surface area (corrosion) downstream and condensation problems associated with radiant heat loss and pressure drops due to piping friction loss.

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[2] Dew-point is that temperature when the first droplet (aerosol) is formed. Refinery fuel gas has an organic phase dew-point and an aqueous phase dew-point. As little as 0.7% C_6 & > will have a significant impact on total dew-point of gas stream.

[3] This temperature requirement drops as the % of hydrogen in gas stream increases.