Emissions Solutions for the Natural Gas Industry

As domestic natural gas production continues to grow, the industry faces unique air pollution control challenges that require custom-designed solutions. This White Paper examines two aspects of the natural gas exploration and production industry: Production of "frac sand" used in hydraulic fracturing and operation of dehydration units.

A Catalytic Products International White Paper
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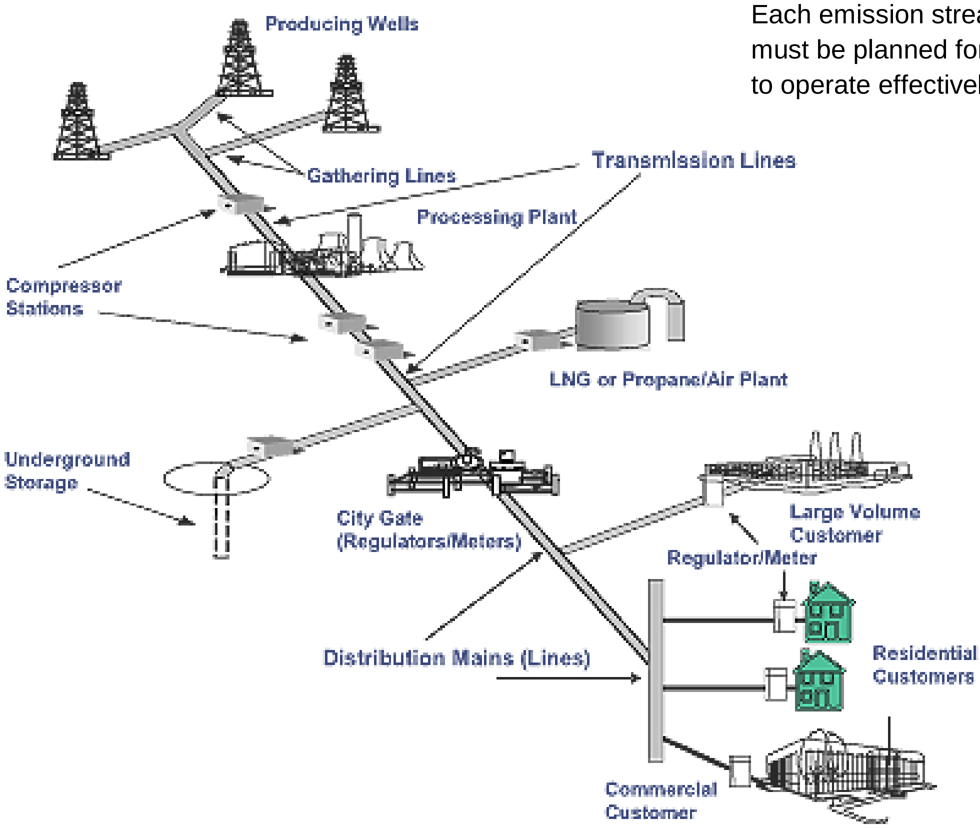
Introduction

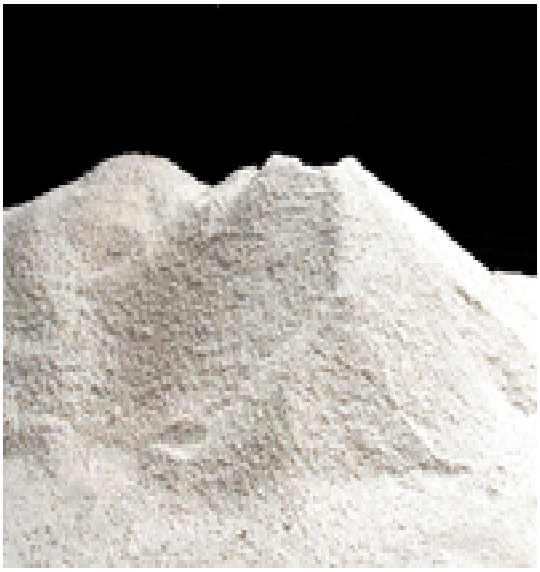
America's natural gas industry continues to thrive, providing a bright spot for the nation's economy. Innovations in drilling and extraction methods has drastically improved the efficiency of gas wells. Our ability to tap into the vast reserves of natural gas contained in shale formations is fueling the boom and it's clear that shale gas production will continue to grow. As domestic natural gas production continues to ramp up, the industry faces unique air pollution control challenges that require custom-designed solutions.

In this White Paper, we'll examine two aspects of the natural gas exploration and production industry: production of "frac sand" used in hydraulic fracturing and operation of dehydration units. Both processes typically require the use of control devices in order to reduce emissions of volatile organic compounds (VOCs), hazardous air pollutants (HAPs) and other air pollutants. Each emission stream presents challenges that must be planned for if the control device is going to operate effectively over the long term.



Introduction

What is hydraulic fracturing?



Hydraulic fracturing is a method used by gas and oil producers to stimulate production of shale gas wells. Shale gas wells are less porous than other types of wells. When combined with horizontal drilling techniques, hydraulic fracturing (fracking) has un-covered vastly more gas reserves. These reserves are wide spread across the country and range from Texas to New York. These reserves are estimated to provide a century of energy for the United States.

Fracking techniques have been in use for more than 60 years, but recently has grown more common because of the economical advantages described above. Fracking involves injecting water mixed with specialized coated sand into the shale or rock formations to displace trapped gas. The injected mixture is done at very high pressures and creates fractures with the rock. These fractures provides the gas a path to flow to the wellhead.

Given the wide spread use of hydraulic fracturing, many companies that have traditionally supplied coated sand products to the foundry industries have responded with new coating recipes and production methods to keep pace with the needs of the gas producers. The following sections discuss the frac coating process and challenges.

Frac Sand Production

The Process

Frac sand is very similar to foundry sands. Like foundry sand, frac sand is coated with resin and other solvent ingredients, although the type of resin(s) used in each formulation is unique to each sand manufacturer and is almost always carefully guarded proprietary information. Emissions from the sand coating process will contain VOCs and other emissions, some of which will be HAPs. Finally, a significant amount of particulate will be emitted in the form of coated sand that escapes from the process.

In simple terms, the sand coating process starts with preheated sand. Once heated the sand is fed to a specialized mixing system. Combinations of ingredients are added at very precise quantities to form the specific coating on the sand and achieve the desired end product. The sand is mixed until the product is thoroughly blended. Once the batch is complete the coated sand will gravity feed to another mixer where it is allowed to cool so it can be conveyed and finally packaged or stored. It is during the ingredient addition phases and cross linking stages where hydrocarbon fumes are generated. These vapors need to be collected and conveyed to the pollution control device. These fumes typically not only include process vapors and reaction off gases, but partially cross linked resins & product dust. This combination of constituents in the exhaust has an affinity to build up on all surfaces they come into contact with, thus requiring special expertise to effectively collect, capture, and destroy.

Frac Sand Production
The Process Continued

A variety of equipment and processes have been developed that help the sand coater provide safe equipment designs and that work to minimize the maintenance associated with coated sand products.

Traditionally, wet scrubbers have been used to control emissions from sand coating processes, whether coating is done in a mix mill or in some other type of specially-designed equipment. Wet scrubbers work basically by using water (in some cases with chemical additives) as a scrubbing media to absorb water soluble organic pollutants into the water.

While wet scrubbers are reasonably effective in controlling particulate matter, they are far from ideal in terms of VOC and HAP emission control.

Organic compounds that have higher vapor pressures tend not be absorbed in a wet scrubber and a significant portion of lower vapor pressure organic compounds will pass through a wet scrubber as well. The residual water left over in the process, referred to as blow down, must often be treated before final disposal, and operating wet scrubbers consistently during the winter in cold climates can be a challenge.

Finally, wet scrubbers do little to reduce the strong odor associated with the use of sand coating resins and do very little to minimize opacity (sometimes called blue haze). If a sand coating production facility is located near a residential area, or if the facility's industrial neighbors are bothered by visible emissions and the smell, these complaints can force the local regulatory authority to investigate.

Technology Terms:
Types of Oxidizers

There are three types of oxidizers commonly used in the industry. These are:

1. ***Recuperative Thermal Oxidizers** – These oxidizers use traditional shell and tube exchangers to preheat the air stream and save energy. These units can achieve 99.9 percent removal of VOC and HAP pollutants.*

2. ***Regenerative Thermal Oxidizers** – Generically known as "RTOs," these oxidizers usually use a special ceramic media to recover energy. They are very thermally efficient and are usually the best choice for air streams that have low to medium VOC concentrations.*

3. ***Catalytic Oxidizers** – These oxidizers use a precious metal catalyst to oxidize VOCs at a lower temperature than thermal oxidizers. Care is needed when choosing a catalytic oxidizer, because certain chemicals can degrade catalyst efficiency over time.*

Frac Sand Production

New Solutions

As the EPA continues to clamp down on VOC and HAP emissions, the use of wet scrubbers to control emissions from sand coating production processes is becoming less and less viable. Thermal oxidizers, which are commonly used in other industries to control VOCs and organic HAPs, would appear to be the ideal solution, but traditional thermal oxidizers are not designed to deal with the particulate part of the equation. Sand in the air stream would quickly clog up the catalyst used in a catalytic oxidizer, and would clog up the ceramic media used in a regenerative thermal oxidizer. A recuperative thermal oxidizer offers better resistance to high particulate loading conditions, but recuperative units are not nearly as energy efficient as catalytic or regenerative units.

A combination of a dry particulate removal system to pull sand out of the air stream prior to combustion and an energy efficient recuperative thermal oxidizer is the ideal solution. Dry particulate removal eliminates the need to dispose of the much larger volume of waste water associated with a wet scrubber. In most cases, the particulate removed will minimize the maintenance associated with conveying the exhaust and help to insure a safe and reliable operation. The VOC fumes that pass through the particulate removal system are then controlled by the recuperative thermal oxidizer. Lastly, a specialized heat recovery system that uses waste heat from the recuperative thermal oxidizer can return valuable heat to front end of the process and lower the overall operating cost of the system

Catalytic Products International proprietary “Frac Sand Control Solution” uses additional technologies and engineering practice to ensure that particulate matter does not contaminate or clog the thermal oxidizer. Thus, today’s frac sand and coated sand producers can have the best of both worlds: high efficiency minimization of particulate matter and high destruction of VOCs and organic HAPs in a safe and economical pollution control circuit.

Natural Gas Dehydration

The Process

Whether it's being extracted from a newly drilled well (that may have used frac sand) or pumped out a storage field, natural gas requires dehydration or 'sweetening' before it can be introduced into a pipeline. Glycol and amine dehydrators are commonly used for this purpose. No matter what type of reagent is used for dehydration, VOC and organic HAP emissions are generated when the dehydration fluid is recovered in a reboiler.

The concentration and amount of VOC and organic HAP emissions generated can vary substantially, depending on characteristics of the natural gas field and dehydrator. Fields that yield higher levels of condensate will usually tend to generate more VOC and organic HAP emissions during dehydration, while fields that yield lower amounts of condensate typically generate less.

Other factors contribute to the final characteristics of the vent gas that needs treatment. Amine treatment units typically contain very high percentage of CO2 and when CO2 and water combine, carbonic acid, a corrosive gas will be formed. Glycol treatment units routinely contain much less CO2 and some amount of the glycol fluid itself volatizes in the reboiler. In each case, a significant portion of the VOC emissions generated are benzene, toluene and xylene (BTX), all of which are HAPs. While the vapor pressures of the glycols and amines used in dehydration are relatively low, the volume of the fluids re-circulated means that the dehydration fluids themselves can be significant sources of VOC emissions.

Natural Gas Dehydration
The Process Continued

By definition, *dehydration involves the removal of moisture from the gas stream*. The amount of water contained it the gas stream can vary substantially, even in a given well. While the moisture is sometimes present only in the gas phase, concentrations can often be supersaturated, forcing liquid water through the system.

HAP emissions from dehydration units are EPA regulated under Title 40, Part 63, Subpart HH. These rules allow dehydrator operators to use different control technologies, including oxidizers, carbon absorbers and flares to control emissions of organic HAPs from dehydrators.

Traditionally, flares have been the control technology of choice for many operators, for a couple of reasons.

- First, installing a flare involves the lowest capital cost of any approved control technology.
- Secondly, EPA rules that apply to flares are extremely generous.

For example, Subpart HH does not require dehydrator operators to determine a flare's efficiency through an emissions test when one is used to control a dehydration unit's efficiency. Instead, compliance is assumed if certain flare design criteria are met.

However, flares are not usually designed with worst-case conditions in mind, because there aren't any regulatory requirements that demand that they are so designed. Flares frequently fail or underperform, simply because they aren't actually designed with environmental regulatory requirements in mind. This is particularly the case when facilities are located in the frost belt. In that case, the special strains that freezing weather places upon a VOC control system can render a flare virtually ineffective in very short order.

Though the EPA rules don't require testing of flares, state requirements can be more stringent and – if a flare breaks down – odor complaints can provide the impetus for more effective control. While the capital cost to install a flare are low relative to other forms of control, operating costs are relatively high because there is no heat recovery and thus more fuel is used. As example, most flares are designed to operate efficiently when the off gas contains approximately 300 BTU/ft3. In many dehydrator applications, the vent gas may only contain 20 BTU/ft3 – thus requiring substantial auxiliary fuel, or natural gas, to reach the minimum combustion zone temperatures. Today's thermal (recuperative) oxidizers or regenerative thermal oxidizers offer ROI's of less than 18 months when compared to a traditional enclosed flare system.

Natural Gas Dehydration

New Solutions

The industry's need to find a more reliable way to control VOC emissions at lower operating costs has led more and more natural gas producers and transporters away from flares. Thermal oxidizers and regenerative thermal oxidizers are fast becoming the technology of choice for controlling VOC emissions from dehydrator reboiler vents. Thermal oxidizers offer more reliability and much lower operating costs than flares. And, though the capital costs for a thermal oxidizer will never be as cheap as costs for a flare, advances in technology have reduced thermal oxidizer capital costs and the time it takes to realize a return on investment, relative to flares.

Still, there are challenges associated with designing either the thermal oxidizer or the regenerative thermal oxidizer for service with a dehydrator. The oxidizer must be designed with worst case conditions in mind, not only in terms of VOC loading, but in terms of moisture loading and consideration to the corrosive nature of the vent gas all must be part of the basis of design. Some of the important design considerations are:

- Analysis of vent gas constituents to determine carbonic acid or other acid gas formation potential.
- Pre-heating method that is engineered to ensure that all of the moisture in the gas stream, including liquid water, is in the vapor phase before entering the oxidation system. While it is possible to include a knock out drum to remove excess moisture, most dehydrator operators do not wish to manage the liquid waste stream that is created when a knock out drum is used. The advantage of using a knock out drum is that the size of the thermal oxidizer is proportionally smaller, because it does not have to be designed to handle extreme moisture loads. However, since the gas exhaust rate from most reboiler vents is relatively low to begin with, there's not much difference between the size of a thermal oxidizer that uses a knock out drum and one that does not.
- Accurate identification of peak VOC upset conditions.
- Identification of oxygen content (especially critical in amine tail gas vents). Typically the amine tail gas lacks oxygen and since oxygen is needed to effect "oxidation" of the pollutants (VOC's or HAPs), an accurate method of adding sufficient oxygen is necessary.
- Consideration of secondary heating opportunities. Since not all of the heat generated in combustion is needed to preheat the emissions stream, another portion can be used to heat the reboiler, thus further reducing overall operating costs.

Natural Gas Dehydration
New Solutions Continued

After analysis of the vent gas has been complete, analysis of the appropriate oxidation system needs to be considered. The most appropriate systems to consider are either a Regenerative Thermal Oxidizer or a Thermal (recuperative) Oxidizer. Some of the design features for each are described below:

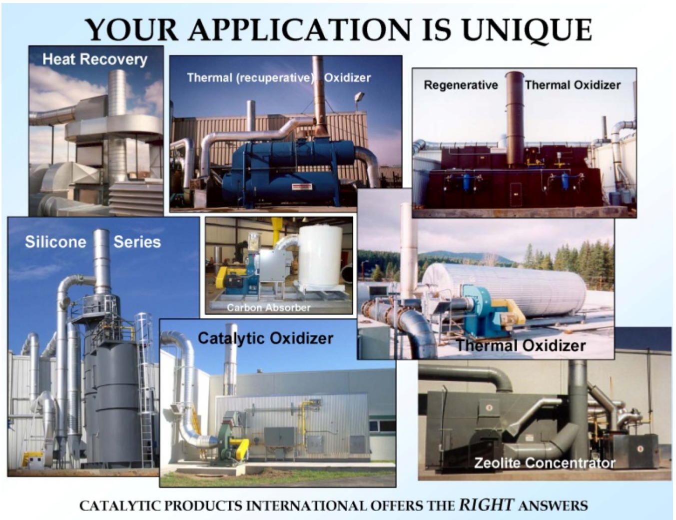
Regenerative Thermal Oxidizers:

- Use directional flow control valves and a ceramic media to provide very low auxiliary fuel use. Usually can operate auto thermal at 3-5 percent LEL
- Cold end corrosion must be considered and materials of construction are upgraded to stainless steel. This inflates the capital cost when compared to a traditional RTO
- Generally provide 98-99 percent VOC/HAP removal efficiency
- Integral condensate recirculation system provides proven method to insure vaporized water prior to entering the oxidizer

Thermal (recuperative) Oxidizers:

- Use a robust primary heat exchanger to lower auxiliary fuel use. Can operate on very wide range VOC loadings (low to very high) without interruption in service.
- All internal components are stainless steel as standard and therefore not a substantial premium in capital cost
- Capable of delivering a consistent +99 to 99.9 percent VOC/HAP removal efficiency
- Integral condensate recirculation system provides proven method to insure vaporized water prior to entering the oxidizer
- Optional heat recovery systems maximize the efficiency of the oxidizer and glycol treatment unit

Conclusion



Catalytic Products International has been helping the oil and natural gas industries find efficient and reliable control solutions for over three decades. Our custom engineered products meet the exacting requirements of these industries and are robust enough to keep operating in the harshest conditions. We understand that productivity is everything in the business. Nobody can afford to shut down a well or interrupt recovery from a storage field because a control device has failed. Our products are designed to ensure that you have one less thing to worry about as you generate the energy that keeps America rolling.

Catalytic Products International is a worldwide leader in the design and manufacture of custom air pollution control systems. Further assistance may be found by consulting Catalytic Products International, Inc., please contact us at:

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