REMEDIATION SERVICE, INT'L

RSI's proprietary internal combustion engine (ICE) used as an air pollution control device to eliminate flaring at a natural gas production site in Pinedale Wyoming area.

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ABSTRACT

Vapor control and abatement of volatile and semi-volatile organic compounds (VOC and SVOC) including (but not limited to) methane , benzene, toluene, ethyl benzene, and xylene that are produced during the operation of natural gas wells and related tank batteries is becoming mandatory for public health and safety. Abatement of these vapors, using a technology with destruction removal efficiency (DRE) of greater than 99% would be beneficial, while using the abatement process energy to convert waste flare gas to electricity/power for use on and/or off site. Combining off-gas abatement with power generation will reduce the amount of the waste gas generated, allow for more of the resources to be sent down stream as sellable gas, and diminish the carbon footprint by reducing greenhouse gas emissions. Providing superior air pollution control and reduced greenhouse gas emissions as compared to flaring is of benefit to all concerned.

DESCRIPTION OF EXISTING PROCESS (P&ID-ATTACHED)

Vapors and liquids are delivered under pressure from production gas wells drilled to varying depths below ground surface. The liquid product produced during these operations consists primarily of "oily" water, referred to as natural gas condensate. The gas/vapor fraction also contains trace amounts of oily water as well (i.e. wet vapors), all of which are separated in a three phase separator located on site. All water and separated liquid gases collected during these operations are directed to a tank battery where they are stored for future disposal. The "wet" vapors are then "conditioned" using a glycol bath process and sent down the pipeline for further treatment and eventual sale.

The "wet" gas vapor stream is directed to a glycol "bath" process using Tri-ethylene Glycol (TEG) to strip the trapped water from the "wet" gas. During the treatment process, a portion of the petroleum hydrocarbons along with the water are adsorbed into the glycol mixture. The glycol mixture is then recycled by heating it to approximately 350 degrees F , causing the dissolved VOC and SVOC in the glycol mixture to be converted to its vapor state, and then vented to atmosphere or oxidized in a flare, as is the case of the demonstration site.

In addition to the VOC/SVOC vapors from the glycol bath process, the tank batteries that store the produced water and petroleum liquid condensate also produce fugitive vapors that are vented to atmosphere, or flared as is the case with this demonstration site. One source of these gasses is from "flashing" operations. Flashing occurs when the petroleum gas condensate is transferred under pressure to storage tanks that are maintained at relatively atmospheric pressure. During this operation, a certain fraction of the liquid "flashes" to the vapor state. The vapor produced is then released through a controlled pressure relief valve on the tank(s), and then at this production facility, the produce vapors are treated by a 2^{nd}, much larger flare.

Another source of vapors from the tank battery is from a portion of the pressurized methane gas stream that would normally be sent down the pipeline for distribution, but instead the pressure from the gas stream is used to operate pneumatic pumps for the glycol "bath" and the separate glycol recirculation heating system used to keep lines from freezing during winter operations. Once the gas pressure is used for this purpose, the gas must be directed to the tank battery for future venting and/or abatement because the line pressure will have dropped below the delivery line pressure of the main distribution line. The flow rate to the pneumatic pumps was estimated at 8 SCFM each, for a total of 16 SCFM. Estimating the BTU value of this diverted vapor stream to be 1000 BTU/cubic foot, therefore approximately 960,000 BTU/hr, less what is used in the "heating" process as described below, requires abatement. .

Some(if not a majority) of the vented gas used for the pneumatic pumps is also used to "fuel" and heat the boilers that are part of the glycol heating and glycol bath systems. A 125,000 BTU rated natural gas heater runs 24/7, 12 months a year to operate the glycol bath system, while a 750,000 BTU/hr burner also uses a portion of this waste gas stream to operate a heat trace system that is used during winter months. Actual energy use is dependent on ambient temperature.

ELIMINATION OF THE FLARE(S) USING RSI'S INTERNAL COMBUSTION ENGINE TECHNOLOGY (P&ID –PROPOSED ATTACHED-PATENTS PENDING)

On November 11, 2008, FSI/RSI was invited to a gas production site to demonstrate how its internal combustion engine (ICE) technology might replace certain flare processes, while also producing usable power/electricity on site. The production of electricity or direct power would operate a natural gas compressor to recapture the tank battery vapors for sale down stream.

There was one gas production well on this demonstration site. There were two flares being used, one was burning a stream of low pressure VOCs at a process rate of approximately 300,000 BTU/hr from the Glycol treatment process; and another flare that was receiving a process flow estimated to be 1,800,000 BTU/hr with bursts up to two times that amount during liquid transfer into the tanks where "flashing" occurs. The site where the demonstration took place was smaller in size when compared to others; however this site was chosen for ease of access and that the RSI technology being demonstrated is scalable.

Based on what we witnessed at this demonstration site, we estimate that the tank battery vapor control system is using at least a 3.6 million BTU/hr rated flare, which is oversized to deal with "flashing" events" as previously described. It is estimated that it normally operates at 1.8 million BTU/hr, and then can increase to more than 3 million BTU/hr during a flashing event in order to control the momentary increase in vapor emissions. Once the flash event is completed, the flare would go back to the 1.8 BTU per hour rate to only consume the energy produced during the normal process flow from the tank battery. The glycol bath flare is estimated to operate at approximately 300,000 BTU/hr. Please refer to attached piping and instrumentation diagram (P&ID) labeled existing for further definition of existing operation.

RSI arrived on site with its 500,000 BTU/hr rated internal combustion engine (ICE) system for demonstration purposes. For the first test, the RSI ICE system was connected to the tank battery. Using RSI's proprietary O2 air/fuel controller and emissions tracking carburetor, the system was able to extract a portion (estimated at 30%) of the gas feed from the tank battery to the associated flare. The engine ran on 500,000 BTU/hr fuel from the flare stream with no disruption of the air fuel ratio control loop to the engine, even during "flashing" events. Although the engine was connected to an alternate fuel source (propane), practically none was used, except of initial system start-up. The RSI ICE system's generator produced 30 kW of energy during the demonstration. The energy produced was consumed by an electrical load bank connected to the system (also brought to the site by RSI).

After the initial demonstration, the ICE was then connected to the waste gas generated by the glycol bath system. This second test was conducted using the same 500,000 BTU/hr rated RSI

ICE, although operated at a reduced load of approximately 300,000 BTU/hr. The objective of the second test was to determine if the less stable waste stream from the second flare on site could be used as the primary fuel source for the ICE system instead of propane or sellable natural gas.

The RSI ICE system was able to "turn off" the glycol bath flare, meaning the engine consumed all the energy generated by the glycol process normally vented to flare. The ICE system was also generating electrical power, which a portion of the generated electricity would be used to power a natural gas compressor to capture sellable gas from the waste streams from the tank battery (including the waste energy from the pneumatic pumps after the glycol heaters used their toll). It is our proposal that both flares could be replaced only with one RSI engine/generator (its fuel source being the vapor stream currently directed to the glycol flare), using the generated power to operate one compressor to eliminate the need for the tank battery flare.. The gas from tank battery (including flash events) would be captured at the tank battery, pressurized, and put into the distribution line for sale.

For this particular site it is estimated that during the winter months of operation, using the RSI ICE as the air pollution control device would save a minimum of 1.5 million BTU/hr of gas that can be sold down stream. During the summer months, the savings would increase. The net result would also lower greenhouse gas emissions because of the reduced oxidation, as well as the elimination of the flares that operate bteween65% to 98% efficient in favor of the ICE that is always operated at greater than 99% destruction rate efficiency (DRE). In other words, a more favorable approach would be to eliminate oxidizing the vapors from the tank battery in favor of using the electricity produced from the ICE unit (air pollution control device as used for the glycol wash system) to operate a natural gas compressor whereas the tank battery vapors can be compressed and put back into the pipe line for sale. This concept is illustrated in the attached piping and instrumentation diagrams (P&ID Proposed).

RSI would propose to supply two systems for the Pinedale facility. One (1) 500,000 BTU/hr rated ICE unit (actual BTU/hr usage will be site specific and automatic to fit the need) to be used for eliminating the flare used for the waste gas stream from the glycol bath process. This engine would generate up to 30 kW of energy to be used to operate a natural gas compressor station, and also have additional power available to do whatever other "work" that may be needed onsite.

ESTIMATED REDUCTION OF GREENHOUSE GAS EMISSIONS TO ATMOSPHERE:
Emissions for the RSI ICE operated at 300,000 BTU/hr are estimated to be .007lb/hr for VOC, .003lb/hr for CO and .006 lb/hr of NO_x (based on source test data attached). The unit used for this demonstration, as well as the unit we would propose for this site to replace the glycol bath flare is rated at 500,000/BTU/hr, therefore the emissions would increase proportionately depending upon engine load demand from the natural gas compressor module..

With RSI's ICE, VOC reduction will always be greater than 99% (source test data reports 99.9%) as compared to flares that operate a much lower efficiencies than our engines. According to the South Coast Air Quality Management District (SCAQMD), when one pound of unburned methane is vented to atmosphere, that would equal 21 lbs of greenhouse gas emission emitted, therefore the greater the DRE of the oxidizing device the less greenhouse gasses are released to atmosphere.

Obviously reduced oxidation in favor of recapture of the usable gas is quite remarkable as far as reduction of green house gases is concerned. CO_2 (also greenhouse gas) would be considerably less (as much as <u>3 tons per day</u>) as compared to the existing flares on site. Please refer to the following tables for reference:

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Existing (tank battery flare, (not including flash events) and glycol bath flare:

Flow (SCFM-Estimated for both flares)	300	(appr. 1.8 million BTU/hr Flare(s))		
(fuel, dilution air and process air)		(not including flash events)		
	TPH (CH_4)	CO	NO_x	CO_2
Measured ppmv (Estmated)	200	14.23	18.47	140000
Lbs/Hr Emitted[1]	0.151	0.019	0.04	292.6
Lbs/Day Emitted	3.647	0.454	0.968	7021
Greenhouse Gas Emissons (approx)	76.587	0	300.08	7021
Total/lbs/day of greenhouse gas emmissions[2]				**7398**

[1](SCFM) *(PPMV)*(mole weight)*(3.7995)*(10^ -6)/24 = lbs/hr
[2]assuming CH_4 contributes 21 times its weight and NO_x 310 times its weight

Proposed (one engine replace two flares at Pinedale demonstration site):

Flow (SCFM)	50	(approx .3M BTU/hr engine)		
(fuel, dilution air and process air)				
	TPH (CH_4)	CO	NO_x	CO_2
Measured ppmv (Source Test Data)	55.4	14.23	18.47	140000
Lbs/Hr Emitted[1]	0.007	0.003	0.007	48.7
Lbs/Day Emitted	0.168	0.076	0.161	1170
Greenhouse Gas Emissons (approx)	3.528	0	49.91	1170
Total/lbs/day of greenhouse gas emmissions[2]				**1223**

[1](SCFM) *(PPMV)*(mole weight)*(3.7995)*(10^ -6)/24 = lbs/hr
[2]assuming CH_4 contributes 21 times its weight and NO_x 310 times its weight

SUMMARY

Using the RSI vapor control system as compared to flaring to reduce oxidation and recover sellable gas vapor will result in a significant reduction of green house gas emission and generate additional profits because of increased sales. Also, the destruction efficiency of the ICE (greater than 99% DRE) as compared to the flare is remarkable and will reduce greenhouse gas emission even further. In general, the power generated by the RSI air pollution control device (fuel source is the vapors/VOC generated by the glycol “bath” system) to operate a natural gas compressor to capture and sell waste gas from the tank battery currently being flared, 1.5 million BTU/hr of energy at this Pinedale facility would be recovered. Again, during the summer months, this would increase. Green house gas emissions would decrease dramatically in all cases. .

Additional generated energy may be used for other useful purposes, such as processing the produced water on site using electro coagulation or other useful work that may be required.

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RSI air pollution control systems are scalable to fit larger or smaller applications.

Attachments:

- P&ID Current
- P&ID Proposed
- Source Test Data for VOC, CO, CO2 and NOx