CERIN
Canadian Emissions Reduction Innovation Network

CANADA EMISSIONS REDUCTION INNOVATION NETWORK (CERIN) PUBLIC REPORT

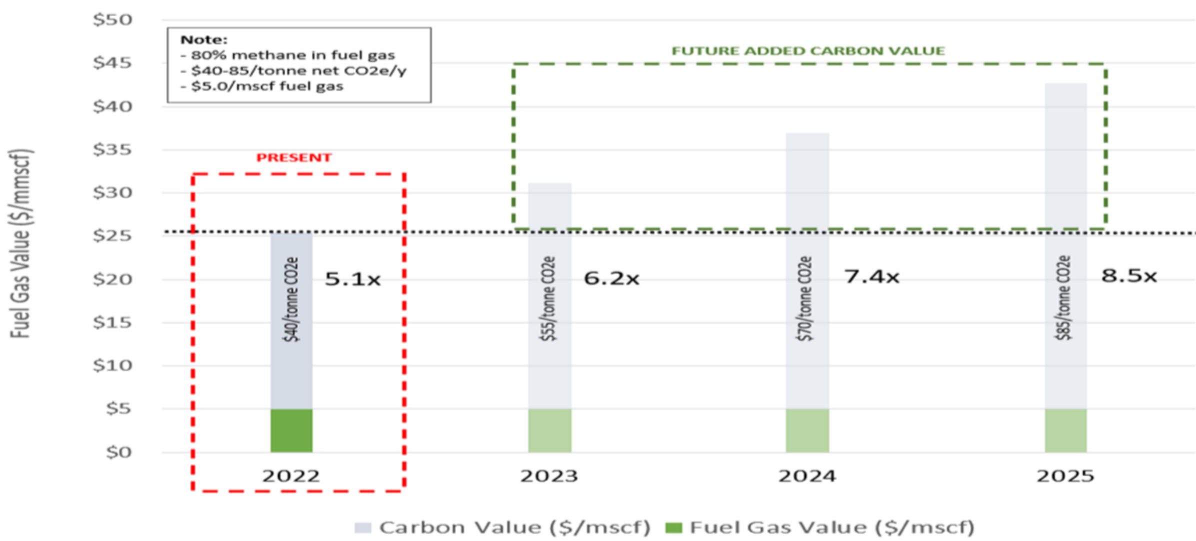
1. PROJECT INFORMATION

Project Title:	**Controlled Tank Investigations**
Emissions Reduction Scope/Description:	Instrumentation to monitor and minimize emissions from controlled production tanks. Fit-for-purpose pressure control equipment and monitoring instrumentation sized, selected and tuned to work in conjunction with the vapor recovery and combustor infrastructure.
Applicant (Organization):	Spartan Controls Ltd.
Project Completion Date:	***Date provided when complete.***

2. EXECUTIVE SUMMARY

Multiple combinations of wired and wireless monitoring of existing controlled tank top equipment, including replacement of some overpressure protection technologies, were deployed to help industry continuously monitor emissions from near atmospheric controlled tanks and to make informed decisions associated with the business impact of lost fugitive and vented emissions. Insights were also gained on their relative contribution towards the total emissions released. Non-intentional (i.e., fugitive) emissions across seals of overpressure protection devices in the closed position typically resulted in lower emissions by relative magnitude than emissions through overpressure protection devices opening to relieve pressure by design.

Focus on reduced emissions in this way provides a means to generate carbon offset credits for Technology Innovation Emission Reduction (TIER) facilities in Alberta through the Environment and Protected Areas (EPA) Vent Gas Reduction protocol. A reduction in fuel gas emissions has a gross value of roughly $31 per mscf or GJ including carbon value at $65/tonne CO2e. That value increases as the book value of $/tonne CO2e increases from $65 to $80 in 2024, and $95+ in the years to come per required Federal minimums.



Quantifying volumes emitted from different controlled atmospheric tank point sources (including Emergency Relief Valves, Pressure Vacuum Relief Valves, Thief Hatches, etc.) cost effectively also provided the data needed to develop a business case for supporting technologies that further mitigate or eliminate that released volume as industries move towards Net-Zero/non-emitting outcomes. This investigation included improved seals when closed, more dead band in operating pressure between overpressure protection devices (vacuum pressures and positive pressures) and ensuring there were no conflicts between overpressure protection reseat points on lifting events. For example, an instance was found where the metered flow to a combustor was much less than it had been trended as earlier. This was a result of a leak through the pressure vacuum relief valve (PVRV). Monitoring the tanks continuously also provided a baseline for steps towards compliance where monitored flow rates in the context of Overall Vent Gas and Defined Vent Gas were above regulated maximums.

3. KEY WORDS

Atmospheric tank, emissions, vent, fugitive

4. APPLICANT & LEAD CONTRIBUTING PARTNER INFORMATION:

Applicant (Organization): Spartan Controls Ltd.

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5. PROJECT PARTNERS

Thanks to the team, which included:

- Bonavista Energy Corp. (Colin Hennel, Des Schwindt, Kendell Esau)
- Cenovus Energy Inc. (Morgan Wrishko, Sean Hiebert)
- Torxen (Chad Northeast, Ian Gabouda, Pascal Bonnet)
- Tourmaline (Carter Bates, Dylan Morrow)
- Spartan Controls (Dave Dallas, Dean St. Amant, Josh Kolenc, Michael Cowan, Sean Kotri, Tanner King)
- PTAC (Brian Spiegelmann, Marc Godin)
- NGIF (Jonathan Bryan)

And supporting companies:

- CDN Controls (Scott Webb, Dan Longtin, Mitchell Best)
- Phoenix Energy Services (Garett Moir)
- Kuva™ (Thomas Mcarthur, Monica Sippola)
    - Cenovus and Tourmaline camera installs that were compared with

A. INTRODUCTION

Oil and Gas Sector

Canada has set goals to achieve 45% methane emission reductions in the upstream oil and gas industry by 2025 and 75% reductions by 2030. To achieve this, oil and gas field venting limits have been applied to upstream assets. Site limits for new infrastructure put in service after Jan 1, 2021 in British Columbia and Jan 1, 2022 in Alberta are now significantly reduced. To achieve reduced emissions, the business-as-usual approach of using fuel gas to operate pneumatic instruments has been a focus area, which has required existing instruments in service to be reduced from high bleed to low bleed (steady state vent rate less than 0.17m3/h fuel gas). New sites need to conserve or control, which means going one step further and collecting remaining emission sources from assets such as atmospheric tanks, pneumatic instruments, pneumatic pumps, compressor packing vents, reducing and eliminating fugitive emission sources, eliminating emissions from surface casing vents, mitigating fuel gas blow-through associated with combusted sources, converting pneumatic systems to be operated on non-GHG media such as air or nitrogen and use of electric and electrohydraulic control loops instead of pneumatic. Through this effort to reduce methane emissions, industry continues to focus on the aforementioned areas and is evaluating the most cost-effective means of reduction by knowing the magnitude of emission source and the cost to eliminate or mitigate it. Not knowing the magnitude of the achievable emission reduction presents a barrier to achieving improved environmental outcomes.

Knowledge or Technology Gaps

Better notification of atmospheric point source emission events and quantification of the volume released provides the information needed to improve outcomes. Atmospheric vent metering presents challenges. Flow meters available to industry today each have strengths and weaknesses. Flow meter accuracy and error are impacted by the following: cost; media phase; wet or dry gas; specific gravity; downstream backpressure; sensor range; meter turndown ratio; upstream and downstream straight pipe length (inlet and outlet runs); laminar or turbulent flow; etc. Flow meters in the conventional sense also need process piping between the flow meter and the point source. There-in lies a signifiant challenge when the point source doesn't have a process connection available nor the means of attaching one cost-effectively.

Atmospheric tank emissions are variable by nature because the tanks "breathe". Liquid flow into a vessel displaces the vapour within that same space and vice versa. Thermal expansion of the vapour space, even with a static liquid volume, within a tank may cause some of the vapour to be emitted from the tank. In combination, through processes called outgassing and flashing, some of the gas that was in solution will be released and some of the liquid will evaporate because the tank pressure is lower than the vapour pressure of the lighter ends of the hydrocarbon mixture within the tank. For this reason, sampling a tank in a specific instance provides a snapshot of emissions associated with that asset, but that may not be representative of daily, monthly, or annual average rates. Installing a cost-effective means of detecting emission events is key to gain insights.

In any closed-loop system, the goal is to ensure the loop in fact stays closed. Any vapour recovery unit (VRU) needs to be properly sized for the forementioned variable flow conditions. Similarly, combustors need to be able to handle that variable emitted flow. Not having a proper closed loop system means volume is leaking where it shouldn't be. If the infrastructure invested in is installed to help mitigate environmental consequences, it is best to ensure the means in place are working as they should be. An alternate flow path to atmosphere is present when volumes leak through emergency relief valves (ERVs), pressure vacuum relief valves (PVRVs) and thief hatches that may not be closed or well-sealed if closed. Consequentially, more atmospheric emissions tend to occur than were sought when the means of control were implemented. Similarly, there are operational benefits to being able to see that installed equipment is working as was intended for confirmation of the positive resulting outcome. For example, a thief hatch may have been opened to get a physical measurement or it may have been opened on purpose for a truck out event to ensure a vacuum pressure didn't develop inside the tank that would compromise its structural integrity. Ensuring that the lid is closed and sealing properly remotely is a good thing just as much as seeing that an open lid was unintentionally left in that position by mistake.

Installing a flow meter on an atmospheric tank also presents challenges. Many of the atmospheric tanks in service today are not rated to pressures above 14.0 kPag (32.5 oz/in^2). The roof of these tanks is often fixed, but not rated to support the load of a person standing on it. For that reason, use of an artificial lift is recommended, but adds another layer of complexity to measurement. Use of an artificial lift doesn't provide a secondary path of regress in the event of an incident. Furthermore, many atmospheric tanks are not connected to vapour recovery units and have just a gooseneck at the top of the tank to allow it to breathe and a thief hatch to allow excess pressure to be relieved from the tank. In the process of metering the volume from the tank, flow will take the path of least resistance. Quantifying the flow through the pipe away vent line provides insight on that flow rate, however it may not be a representative measurement of total flow from a closed system if the thief hatch or other over pressure protection device is leaking.

B. METHODOLOGY

This investigation was focused on controlled tanks. The first step working with industry was to find good sites that had control infrastructure already installed. In Alberta, about one in five tanks have some form of vent gas capture infrastructure already on them. While non-controlled tanks emit to atmosphere freely, they too provide opportunity for improvement in the same way as a controlled loop system installed at a future date. Reducing or eliminating the flow through a PVRV, thief hatch or ERV isn't much help if the flow can freely exit through a different open pipe that is part of the tank envelope. This came up in conversations exploring opportunities for monitoring instrumentation and was a self-imposed limitation for this investigation.

With folks engaged and sites of interests found, the following steps were used:

a) Asset baseline
    i. Review of available engineering details of the production tanks and vapor recovery system(s)
b) Visit to site
    i. Documentation of surface pressure boundary infrastructure including tanks
    ii. AVOID (Audio, Visual, Olfactory, Inspection and Detection) walkdown
    iii. Means of monitoring instrumentation integration
        - Existing RTU and PLC infrastructure or other means?
        - Preference for wired or wireless instrumentation?
        - Cellular and/or radio?
        - Power at site – Voltage and reliability
c) Consideration for operating setpoints
    i. Selection criteria relative to MAWP and other devices
    ii. Record of previous lifting events associated with tank emissions
    iii. Adjustment of setpoint(s) to achieve better performance
d) Plan
    i. Added measurement points to existing assets
    ii. Available hardware to assemble
e) Field installation
    i. Pre and post-performance
        - Wired/wireless pressure monitoring – "under" PVRVs
        - Wired/wireless position monitoring – thief hatches, ERVs, PVRVs
        - Improved seal PVRVs, thief hatches and ERVs
f) Report

Summary of Investigation

This study investigated overpressure protection (OPP) devices being used on atmospheric tanks at 6 different sites as shown in Table 1.

Table 1: Asset Summary

Producer	Site(s)	Tank Quantity Investigated	Tank-top Devices Monitored	Monitoring Approach	Instruments Added
Torxen Energy	1	3	3	Wired Pressure	3
Tourmaline Oil / Perpetual Energy	1	3	3	Wireless limit switches (2) and position monitoring	3
Cenovus	1	2	3	Wireless limit switches (4) and pressure monitoring (2)	6
Bonavista	3	4	6	Wired/wireless limit switches (2) and pressure monitoring (4)	6
Total	**6**	**12**	**15**		**18**

Three (3) Tank Battery – Torxen Energy Ltd.

Pressure vacuum relief valves (PVRVs) were installed on each tank at site. PVRVs were included as part of the tank surface pressure boundary infrastructure to ensure the pressures stay within the min allowable working vacuum (MAWV) and the maximum allowable working pressure (MAWP). As shown in Figure 1, when the tank pressure is within the control pressures of the PVRV it remains closed, but when the pressures get to low or too high, air will be allowed into the vessel or vapour will be emitted from the PVRV to atmosphere or to a pipe away line if the geometry of the PVRV allows for such.

Figure 1: Pressure Vacuum Relief Valve (PVRV) Operation

The PVRVs were retrofit to include pressure monitoring of tank pressure at a battery including three production tanks that received emulsion from a group and test separator (1). Emissions from these tanks were controlled with the vapour recovery unit (2) at site. In Figure 2, future expansions to the site are shown with the dashed lines and represented as future assets: test separator (3); vapour recovery unit (4) and; production tanks (8).

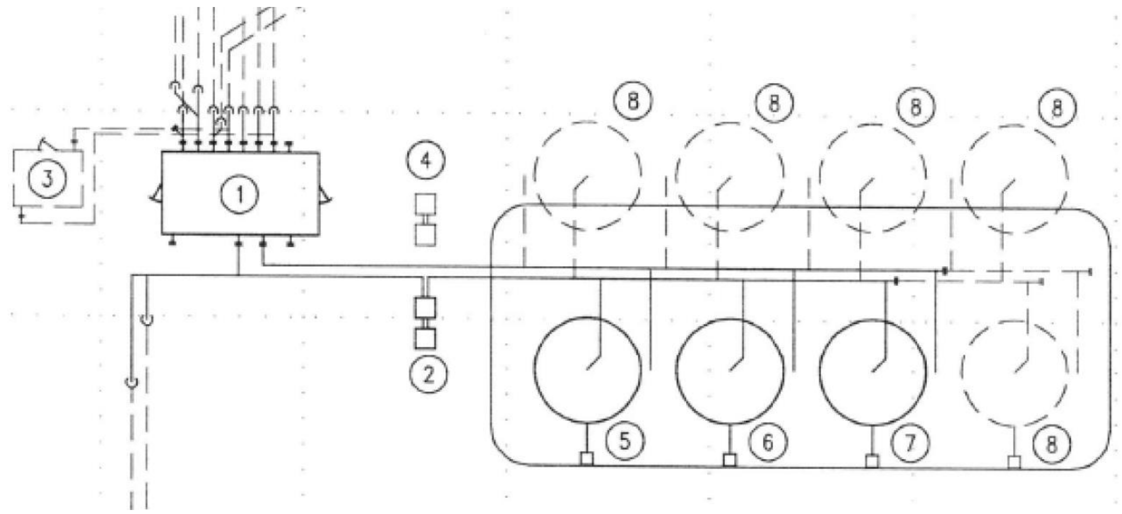


Figure 2: Multiwell Battery Plot Plan

A sensing ring was added between the PVRV and the tank to provide a pressure monitoring sensing location for the pressure transmitter to monitor the pressure acting on the pallet of the PVRV. Pre and post images are provided in Figure 3 for the applied measurements.

Figure 3: PVRV with pressure sensing ring and wired pressure transmitter added

Within the SCADA system at site, the capable flow through the PVRV relative to pressure was added for future trending. Equations were updated from the sizing software as shown in Figure 4 to get flow as an output rather than pressure as shown in Figure 5 (i.e., Figure 5 is an inversion of Figure 4).

Units were converted to Metric for this report as well. Note that 14 oz/in^2 gauge is equivalent to 6 kPag.

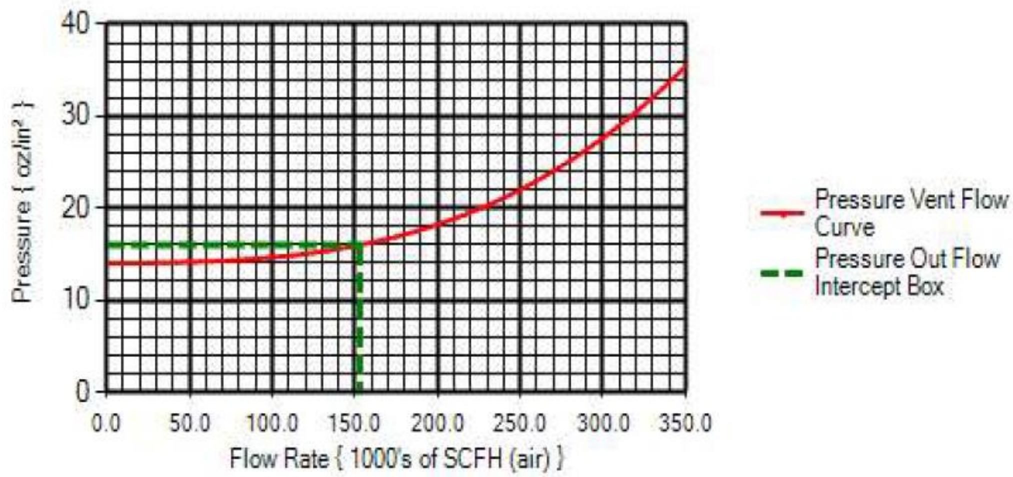


Figure 4: Pressure vs. Flow per Enardo Model 950 sizing software

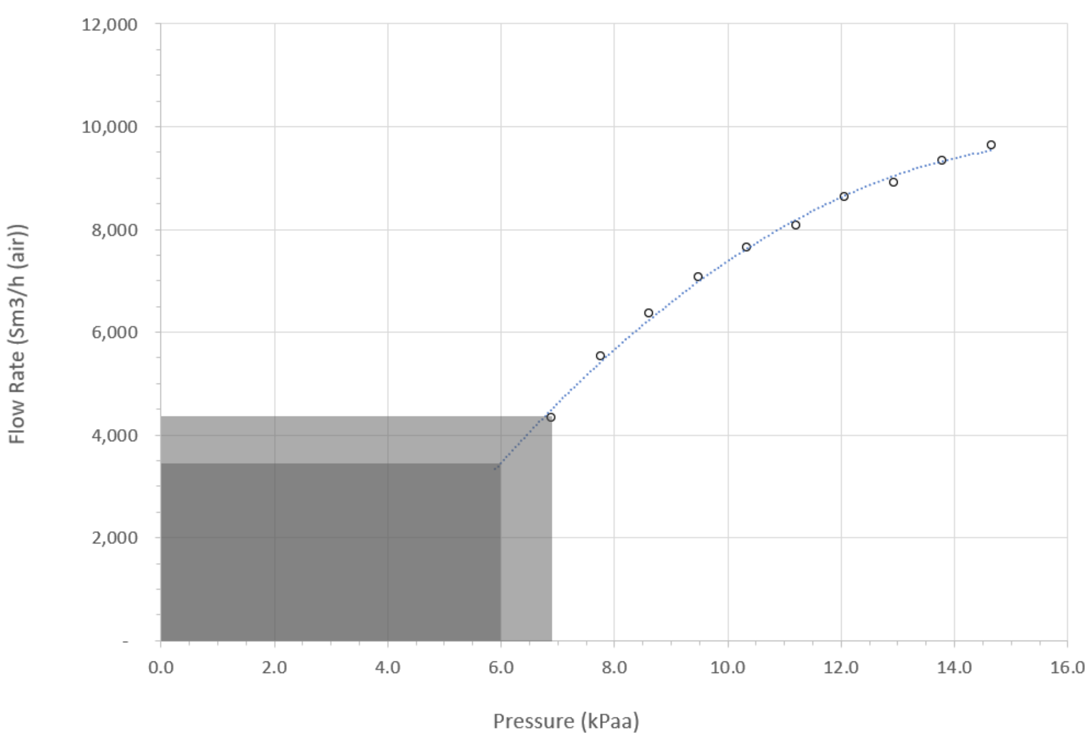


Figure 5: Flow vs. Pressure for Enardo Model 950 - Set at 6 kPag (14 oz/in^2)

Three (3) Tanks at Gas Plant – Tourmaline Oil Corp. / Perpetual Energy Inc.

Figure 6 shows the seven tanks at this site; three of which were equipped with additional monitoring instrumentation for overpressure protection devices. A Kuva^{TM} gas cloud imaging camera was also monitoring emissions from the tanks and is visible in this image on the far right-hand side.

Figure 6: Atmospheric tanks at gas plant

Two thief hatches were retrofit with limit switch monitoring to provide position indication being open or closed as shown in Figure 7.

Figure 7: Thief hatch in open and closed position

One existing thief hatch had the wireless limit switch added to it, one was replaced with an alternate thief hatch with limit switch position monitoring and one was replaced with an ERV with travel sensing as degrees of rotation. Monitoring with the wireless limit switch is shown in Figure 8.

Figure 8: Wireless open/closed position monitoring of thief hatch

In Alberta, reported emissions from thief hatches in the open position are reported as fugitive emissions on controlled tanks and as vents on uncontrolled tanks. If the thief hatch is in the closed position and is relieving pressure as designed, the emissions are reported as a nonroutine vent on controlled tanks and as a routine vent on uncontrolled tanks. Similarly, an ERV relieving pressure on a controlled tank is reported as a non-routine vent and as a routine vent on uncontrolled tanks. Note too that producers may have opted to flip thief hatches open in the winter to help ensure there are fewer operational challenges, which this study serves to provide operational solutions for.

These emission details are summarized in Table 2 from Manual 015 published by the Alberta Energy Regulator (AER).

Table 2. Example of tank emissions characterization summary

Emission source	Uncontrolled tank	Controlled tank
Thief hatch left open*	Vent – routine (DVG)	Fugitive emissions
Thief hatch relieving pressure as designed	Vent – routine (DVG)	Vent – nonroutine (OVG)
VRU / vent control system offline (upset or maintenance)	—	Vent – nonroutine (OVG)
Tank cleaning or de-sanding	Vent – nonroutine (OVG)	Vent – nonroutine (OVG)
Well casing tied into the tank	Vent – routine (DVG)	Vent – nonroutine (OVG)
Produced water tank*	Vent – routine (DVG)	Fugitive emissions
Level gauge seal	Vent – routine (DVG)	Fugitive emissions

* Continuous emissions from either of these sources may be indicative of unintended gas carry-through. These unintentional emissions should be classified as fugitives and the source should be localized as part of a fugitive emission survey and repaired according to *Directive 060*.

It is important to note that position monitoring this way provides the information to report the emission type correctly (as vent or fugitive emission as shown in Table 2), but it does not provide the means to indicate if the thief hatch is relieving pressure while the lid is closed. There are challenges with position monitoring being used to detect relief events in thief hatches because the components that lift are internal to the device itself as shown in Figure 9. While the lid is still latched, the Enardo ES-665 thief hatch allows air into the vessel with vacuum pressures between 0.17 kPag and 0.38 kPag (-0.4 oz/in^2 and -0.9 oz/in^2 respectively) and vapours from the vessel out with positive pressures between 0.25 kPag and 13.79 kPag (4 oz/in^2 and 32 oz/in^2 respectively).

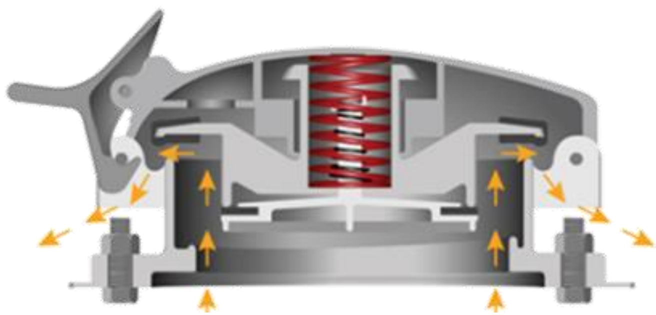


Figure 9: Lifting action on over pressure through a thief hatch

Monitoring the rotation on an ERV as shown in Figure 10 provides more detail regarding how open an overpressure protection device is, which goes one step further than merely identifying that the lid is open. With monitoring like this, there is proportionality between the tank pressure, how open the ERV is and the flowing area that is available to better estimate emission rates.

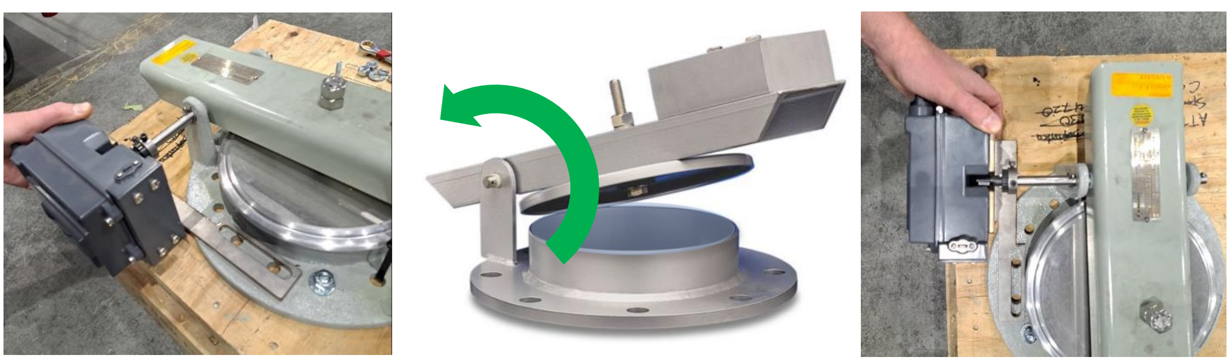


Figure 10: Position monitoring on Emergency Relief Valve

Data from the monitoring devices was brought through to the SCADA infrastructure at site via a wireless gateway and remotely through a secondary data channel in the Empower blue box as shown in Figure 11.

Figure 11: Local and remote data acquisition through wireless gateway

Two (2) Tanks at Gas Plant – Cenovus Energy

Monitoring thief hatches with wireless limit switches and monitoring of PVRVs with limit switches and pressure indication was also implemented on two adjacent tanks as shown in Figure 12. Note the Kuva^{TM} camera just to the right of the south tank in this picture. A view from that camera is also included in Figure 20.

Figure 12: Monitored condensate tanks

Unique at this site was pressure monitoring of the PVRV lift response of the baseline model and the retrofit model shown in Figure 13. The illustration in the top right of Figure 13 is representative of how far the pallet is above the seat similar the photo of a flanged pipe-away model in the bottom right of Figure 13.

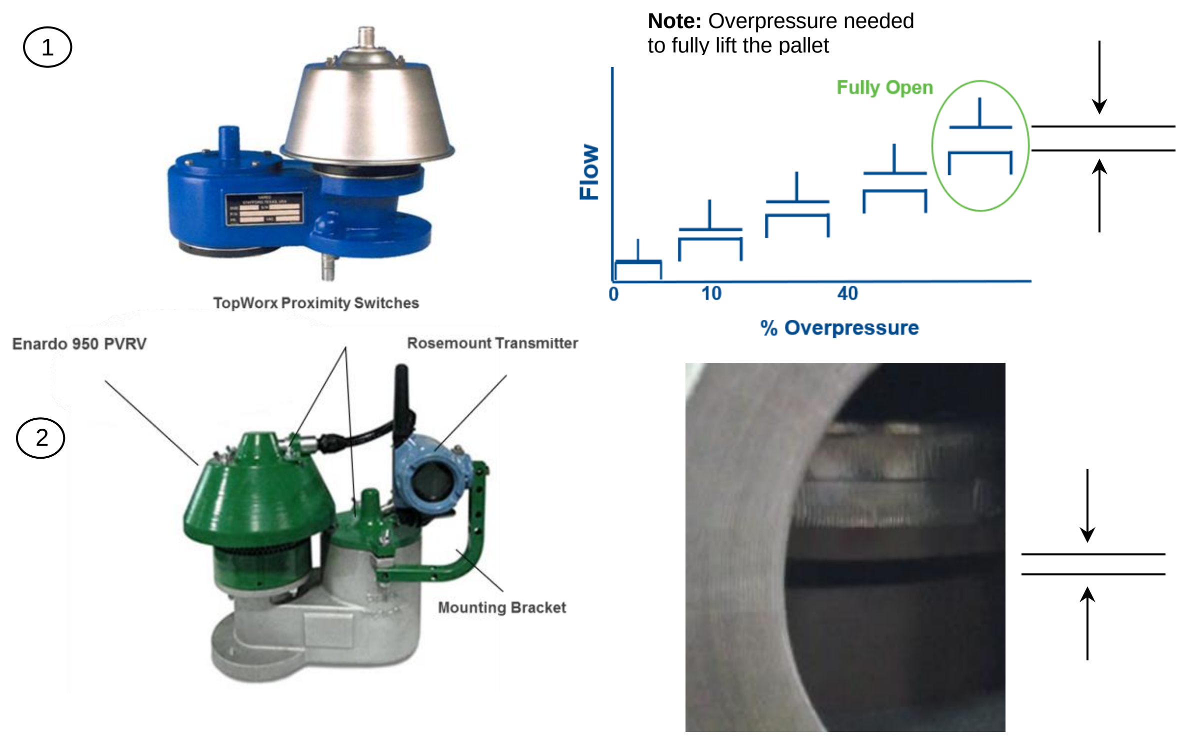


Figure 13: Baseline Varec PVRV model (1) and retrofit Enardo PVRV model (2)

Four (4) Tanks at Three (3) Sites – Bonavista Energy

Position monitoring of six different thief hatches and PVRVs was implemented at three sites in west-central Alberta.

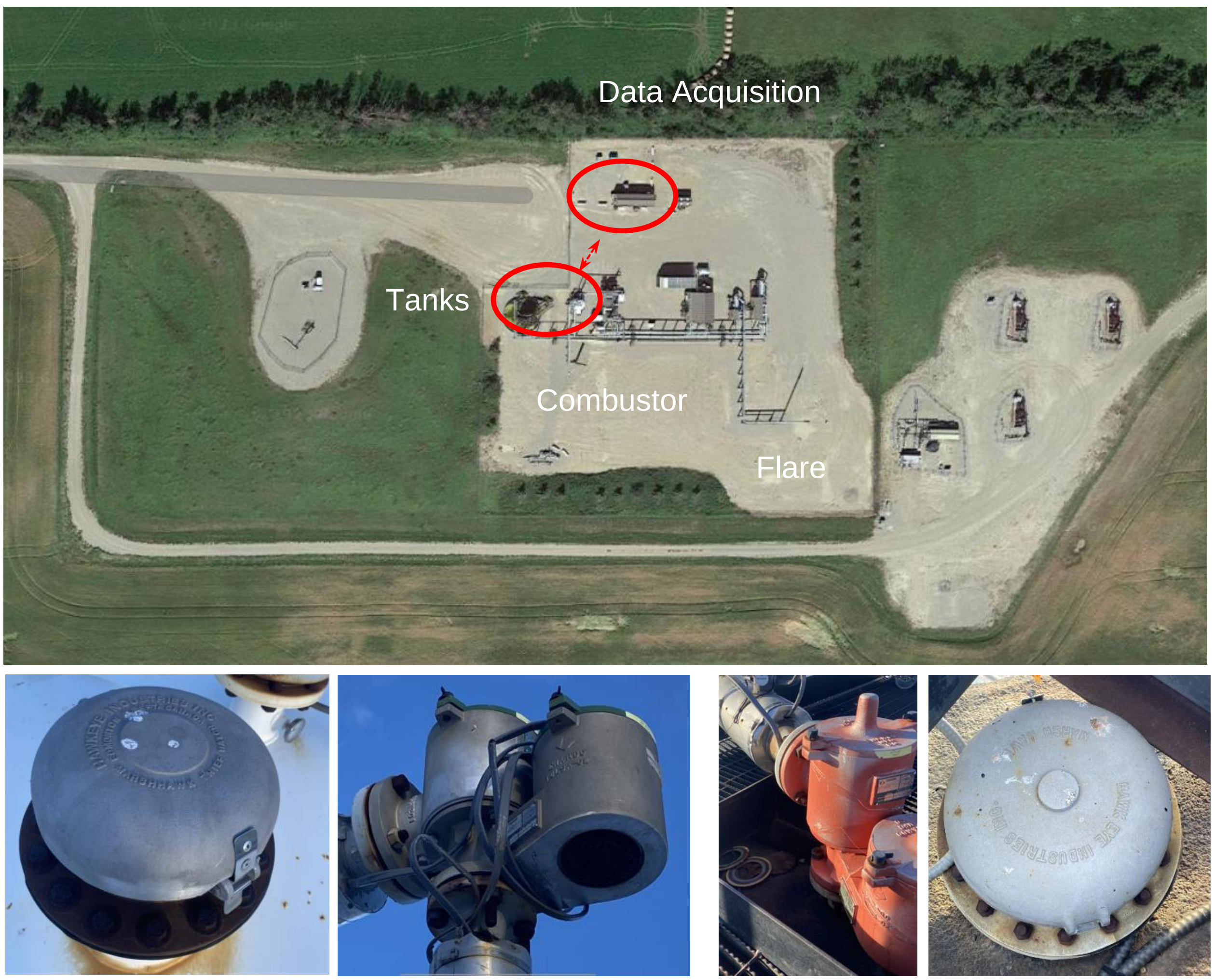
At one site, the gas volume from the production tank was tied into a combustor as shown in Figure 14. The flow to the combustor was also monitored with a Fox thermal mass flow meter. In this case, the volume being captured from the tank was burned to reduce the CO_2e emission impact. Methane has a global warming potential (GWP) of 28 currently in Alberta, where CO_2 has a GWP of 1. Reducing the impact in this way also provided a means to generate carbon offset credits in Alberta using the Vent Gas Reduction protocol. If the PVRV is not closed though, the flow that should only go to the combustor will leak from the PVRV. This site did not have remote power. The instrumentation added needed to be operated on solar and monitored with radio connected SCADA.

Figure 14: Production tank with pipe away to combustor

At the second site there was already a pressure tap and gauge present to monitor the pressure in the tank. With that sensing line already present, it was easier to add the wired pressure transmitter where the gauge was as shown in Figure 15. This also prevented the need to put a flushing ring between the PVRV and the flange on the pipe away vent line.

Figure 15: Production tank with vapour recovery and sensing line for pressure indication

The third location had two atmospheric tanks that were both tied into a combustor and a larger flare line. Each tank had a thief hatch and a PVRV with a flanged discharge that were also tied in as shown in Figure 16 and Figure 17. Having the flanged pipe away on the PVRVs was beneficial because it allowed for overpressure relief events to be tied in too and not emitted to atmosphere. While this form of secondary capture was helpful, it also meant that any backpressure in the pipe-away line was pressure that acted in addition to the weights on the pallet of the PVRV. This could artificially increase the set pressure. Manual level gauges were on these tanks too, which provided another pathway for gases to leak to atmosphere. Properly plugged with grease, those pathways were closed and helped keep the system operating as a closed loop system.



Condensate Tank **Water Tank**

Figure 16: Site layout, thief hatches and pressure vacuum relief valves

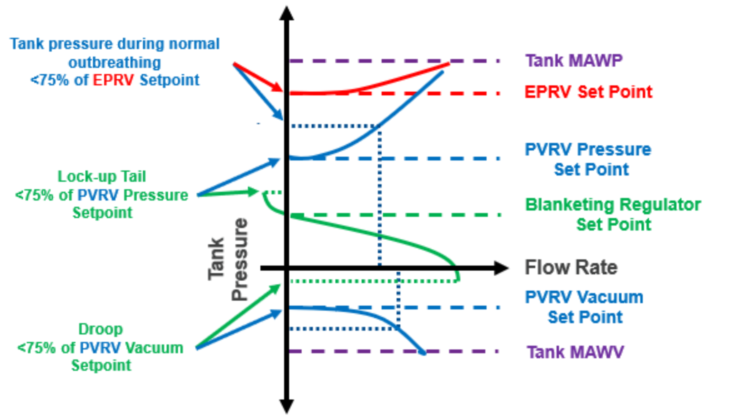
Figure 17: Condensate and water tank with vapour recovery tied into flare and combustor

C. PROJECT RESULTS AND KEY LEARNINGS

Obtaining indication of directly sensed emission events in applications with very low pressures has been challenging for industry to properly detect and quantify. Other detection technologies in this space didn't yet have the same low flow detection capability these wired/wireless technologies did. That made this flexible detection approach more fit-for-purpose in a wider set of field applications. The ability to detect low travel overpressure events and leak rates when tank top controls are closed also provided the insight needed to properly quantify emitting devices as intermittent or continuously emitting.

Enhanced Sealing technology on the Enardo thief hatch and PVRV products was found to have reduced leakage performance consistent with published emission rates of 0.003 Sm3/h (0.1 scfh) @ 90% set pressure.

Care is needed with tank top overpressure protection devices to ensure set points between devices don't interfere with each other both on pressures needed to open and on pressures needed to close again. This is better illustrated in Figure 18. Overpressure protection devices per API 2000 have allowable leakage at 75% of set pressure. API 2000 does not define acceptable leakage as a rate at 90% of set pressure.



API 2000 Table 10 Acceptable Leakage Rate at 75% of device relief setpoint

Vent Size mm (in)	Maximum allowable leak rate m3/h (cfh)
≤ 150 (6)	0.014 (0.5)
200 to 400 (8 to 16)	0.142 (5.0)
> 400 (16)	0.566 (20.0)

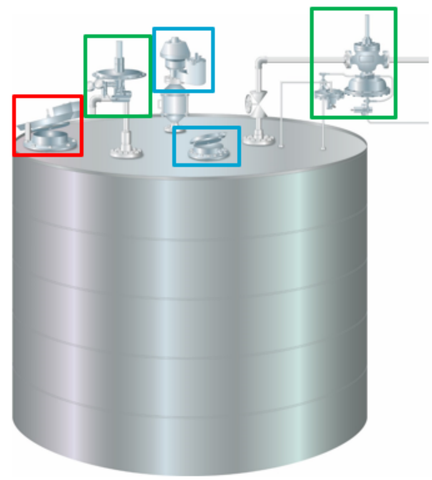


Figure 18: Set point spacing between MAWP, Emergency relief, PVRV and tank blanketing regulators

An improved PVRV, that emits less than 0.003 m3/h (0.1 scfh) at 90% of set pressure in maintained condition, is also able to increase the deadband pressure in the tank such that the overpressure protection thief hatch and PVRV were able to stay closed above operating pressures that would have previously resulted in an emission event. For example, if the PVRV started to leak more at 75% of set pressure instead of 90% of set pressure. A more instantaneous lifting action is shown in Figure 19 to help illustrate this concept. Reductions in emissions were also anticipated because the PVRV didn't need the tank pressure to blowdown as far before the PVRV was able to reseat and be back in the closed position again.

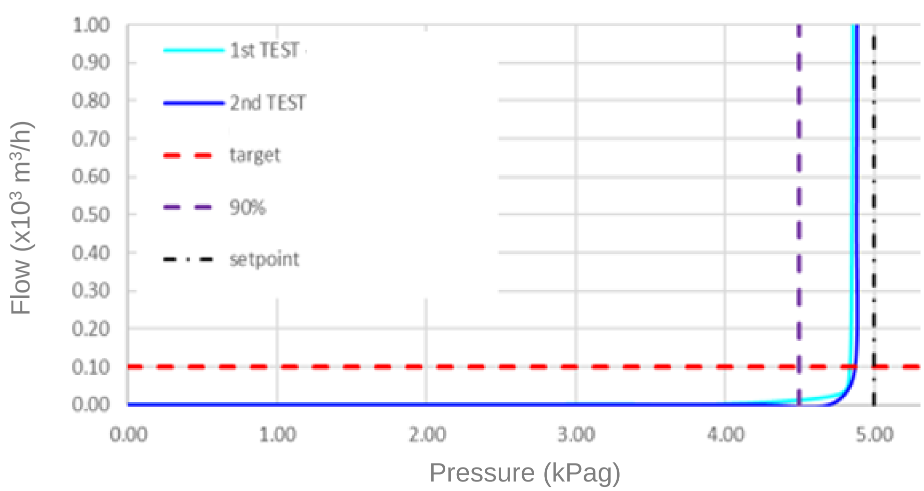


Figure 19: Improved lifting action to reduce overpressure premature relief events

Three (3) Tank Battery – Torxen Energy Ltd.

Without previous continuous monitoring, an indication of emission events, that were previously more challenging to identify and quantify, was captured. With pressure monitoring on the PVRVs, and the relation between overpressure and relief flow rates programmed into the SCADA system at site, there was indication of released volume magnitude. This was helpful for Torxen.

Three (3) Tanks at Gas Plant – Tourmaline Oil Corp. / Perpetual Energy Inc.

Many high-volume liquid dumping events to tank were tracked after retrofit, as was expected in normal operations. Those events were also confirmed audibly when the PVRVs opened several times in the span of a week on site. The increase in vent rates was metered through the pipe away vent lines to the VRU and plotted for visual reference. Through these events, the discrete wireless position monitor indicated that the thief hatch was not operating in the open lid position during that time. That increase in metered vent rate was indicative that the existing tank PVRVs were doing their job in releasing gas at 6 kPag (14 oz/in^2) and were not pressured up to 7 kPag (16 oz/in^2) when the thief hatch would have relief pressure while in the lid closed position to provide secondary overpressure protection.

Through comparison to the Kuva^{TM} gas cloud imaging camera and emission intensity data over a 12-day period of monitoring, emission events were detected on the tank tops that were not collected in the vapour recovery system. The total cumulative duration of those intermittent events was just under 10 hours which was equivalent to 3.3% of the operating run time. There was value ensuring alternate leaks to atmosphere were not present in a system designed to be closed loop.

Two (2) Tanks at Gas Plant – Cenovus Energy

The PVRVs installed in the as found condition were documented to be leaking. This was shown in Figure 20 with the Kuva^{TM} camera.

Figure 20: Baseline emission detection with Kuva^{TM} from south tank (TK-101A)

The improved PVRVs to be installed as retrofits were designed not to start opening until the pressure reached 90% of set pressure. This provided more working pressure variance within the atmospheric tank and wasn't by design to result in premature relief events. That design would also reduce the frequency of intermittent relieving events from the tank top. Efforts are underway to document if there will be a reduced the number of emission events through comparison to trended Kuva™ camera data.

Four (4) Tanks at Three (3) Sites – Bonavista Energy

Efforts are underway to complete retrofits at these sites. Results are learnings for these three locations will be included in an update to this report.

D. PROJECT AND TECHNOLOGY KEY PERFORMANCE INDICATORS

Organization:	Current Study	Commercial Deployment Projection
Project cash and in-kind cost ($)	$885,000	TBD based on scale
Technology Readiness Level (Start / End):	9	9
GHG Emissions Reduction (kt CH4/y):	• N/A for monitoring • Improved seal thief hatches and PVRV is 20+ tonnes CO2e/y per retrofit	
Estimated GHG abatement cost ($/t CH4)	<$65/tonne	<$65/tonne
Jobs created or maintained:	1	5+

E. RECOMMENDATIONS AND NEXT STEPS

This technology was successfully deployed at six different sites with 18 different measurement points to provide indication of device position. When used to detect limit events, it provided an alternate means for emission detection without use of a flow meter or non-contacting camera. Wireless instrument monitoring was opted for where the distance between data logging and/or power supply and the tank was more significant. There was a tradeoff between using the higher cost wireless monitoring points and needing to replace the batteries in the future versus going wired where the distance was shorter and power was readily available. Update rates were also a key parameter to be mindful of per the capability of the existing SCADA system and the impact on battery life.

Next steps and recommendations for further development will be updated after additional field data is received from all sites in this study. For example, the impact of seasonality will be discernable after the data is gathered through a longer period of operation. It may be possible to determine if:

- Emissions are higher in the summer than the winter because more light-end hydrocarbons are flashing off with higher ambient temperatures
- There is greater degree of thermal expansion with larger daily temperature changes
- Vapour collection systems were able to handle that volume without lifting events in overpressure protection systems
- The liquid flow rates into an atmospheric tank need to be reduced to ensure the displaced vapour off the top isn't too much for the vapour recovery system to handle well

The comparison of these measured data points with that of existing flow meters installed at site and/or alternative detection technologies already in use, will improve the correlation of lifting events with the cause.

Further work is needed to help detect relief events from thief hatches that are operated with the lid in the closed position. Coupling position detection with means of emission detection in concentration (ppm or ppb) would provide means of correlating the emission magnitude with the source of the emission.

Applying these approaches to tanks that are presently uncontrolled from other studies, but will be controlled in the future, would be advantageous to ensure those future vapour collection systems are validated to be operating as closed-loop systems and when intermittent lifting events occur. While those vapour collection systems may have flow metering installed, there won't be clear indication if lower metered flow rates or indicative of less liquid volume coming into the tank or if there is a leak elsewhere in the vapour space of the process piping unless monitored.

Use of this technology to validate that tanks primarily storing heavier end hydrocarbons are typically lower volume emitting tanks would also be beneficial. Vapour collection systems used on such storage tanks may be better suited and less prone to being undersized given the more limited range of "breathing" associated with outgassing and flashing vapours from those assets. Monitoring and reporting reduced frequency lifting events from this asset type may also help put focus where larger magnitude emissions are prevalent or if vapour collection systems are needed for a specific type of atmospheric tank or not.