WINTERHAWK WELL ABANDONMENT

EMISSIONS REDUCTION ALBERTA ("ERA")

FINAL PUBLIC OUTCOMES REPORT

Project - F0160860

Title - Casing Expansion for Annual Wellbore Methane Leakage

Project Advisor – Bruce Duong

Start Date – December 1, 2020

Completion Date – November 30, 2022

TRL at Start - 7

TRL at Completion – 8/9

Total ERA Funds Received/Requested - $349,951.54

Total Project Costs - $1,197,105.40

Eligible/Ineligible - $1,157,105.40/$20,377.50

Submission Date – January 30, 2023

Summary

Multi-well field trial program in existing oil and gas wellbores with known Surface Casing Vent Flows (SCVF)/wellbore annular methane leaks to determine the performance of the Winterhawk Casing Expansion Technology (CET) in actual wellbore conditions and its effectiveness in reducing or mitigating SCVFs.

The CET is a new and proprietary oil tool conveyed into and from the wellbore on jointed tubing using a conventional well servicing rig and related equipment such as vacuum trucks, water trucks and pressure pumps. With the exception of the CET, it is part of a conventional wellbore intervention operation.

The performance of the CET was excellent defined as when it was placed in the desired location in the wellbore and activated, it performed as planned. Post intervention multi-finger wireline caliper logs revealed the existence of casing expansions where the tool was placed. It released when required. It never failed and came out of the hole intact every time without leaving parts or debris in the wellbore.

The CET is designed to change the physical properties of the wellbore annulus without perforating or otherwise puncturing the casing, thereby avoiding permanently reducing wellbore integrity. Once production casing is cemented to surface, prior to casing expansion there was no other way to materially change the properties or behavior of the annulus without puncturing the production casing by one means or another, most commonly perforating.

When the CET is used in conjunction with a modern digital pressure/flow meter on the SCFV valve, in many cases the CET had a material and measurable impact on pressure and flow. In the first well in the ERA program, casing expansion shut off the methane flow. This well has subsequently been cut and capped.

In the other wells annular pressure and flow characteristics were changed, but didn't always result in a complete shutoff. This is due to a variety of factors including the depth at which the operations took place relative to all the sources of methane leakage in the test wells.

For casing expansion to seal the annulus and stop methane leakage where the casing is expanded and the properties of the annulus at that interval are critical.

What the Winterhawk/ERA test program also revealed is that current diagnostic methods of analysing the wellbore outside the casing from inside the casing are limited or from surface are limited.

The CET proved to be a valuable diagnostic tool in three ways:

1. Ability to identify the depth from which the methane was flowing by monitoring surface performance during and after expansion.
2. Ability to identify the properties of annulus at a given depth including "cap rock" or a good place for a permanent seal by the size of the expansions relative to other available data such as open hole logs, cement bond logs and compensated neutron logs.
3. Ability to provide a vertical barrier above or below remedial cementing thus ensuring cement squeezes to "re-cement" the annulus are more likely to be successful by confining the cement flow outside the casing to the desired interval.

Considering the Winterhawk CET was the first oil tool of its type using this design to achieve this outcome, the ERA test program was very effective.

As a result, when oil and gas producing companies ask if it works, the answer is “yes.” The tool expands casing when and where required and during this program came out of the wellbore intact.

Failure to release and retrieve is not uncommon in the oil tool business.

The bigger question is where do operators want to expand the casing, and what is the desired outcome? The ERA test program has given Winterhawk and Alberta’s oil and gas industry a new foundation for environmental leadership – another tool in the toolbox – to deal with wellbore integrity and remediation for multiple applications, including Alberta and the world’s growing number of existing wellbores with annular methane leaks.

Table of Contents

1) Executive Summary
2) History
3) The Wellbore Methane Leak Challenge
4) Winterhawk Casing Expansion Tool
5) Wellbore Behavior of Casing Expansion
6) Project Objectives
7) Performance Targets and Outcomes
8) Technology Advancements During ERA Program
9) Technology Risks
10) Commercialization
11) Lessons Learned
12) Emissions Reduction Impact
13) Scientific Achievements
14) Conclusions/Next Steps For Winterhawk
15) Non-Confidential Final Outcomes Report

1 - Executive Summary – Solving The World Petroleum Industry's Largest Environmental Challenge

Casing expansion is the process of expanding production casing in an existing oil and gas wellbore in order to change the behavior of the outside of the casing between the pipe and the wellbore. The trade term for this space is "annulus."

When oil and gas wells are drilled and the production casing is cemented into place, the common belief is that the cement will provide a permanent between the inside and outside of the wellbore. This cement sheath or seal is intended to ensure that the only place oil, gas or water can travel from underground to surface is through the inside of the steel production casing.

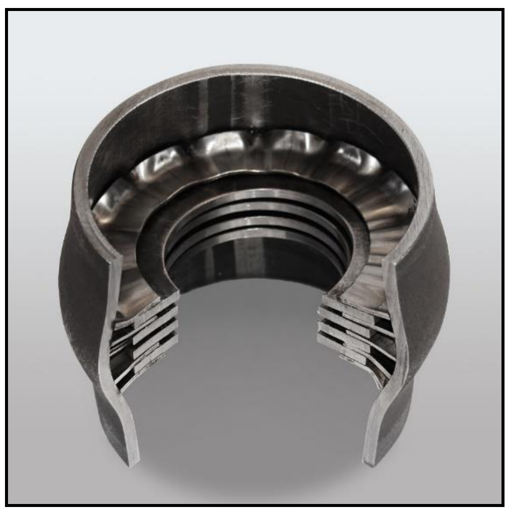
When this is the case, the flow can be controlled and contained.

Cementing techniques have improved considerably in the past 100 years as millions of wellbores were drilled all over the world. However there are several factors emerging today that were not considered when the wells were drilled.

- Many wells were drilled with primitive cementing techniques compared to today
- Many wells were not cemented all the way to surface
- Getting a good cement seal across porous zones or aquifers is difficult if not impossible
- Cement contracts over time creating leakage paths
- There are 10,000 reported Surface Casing Vent Flows in Alberta. The actual number is higher. Globally there are hundreds of thousands of wells leaking methane from the outside of the production casing
- This is the most difficult methane source for the petroleum industry to seal. The costs are high and the success rate is low
- This is the world petroleum's industry largest challenge as defined by the number of leaking assets
- Casing expansion in the way the Winterhawk tool is designed to deliver is one of the most significant advancements in the restoration of annular wellbore integrity in decades.
- The ERA program has revealed that the current industry methods of determining annular wellbore characteristics have not advanced in many years.
- Combined with other tools and techniques, Winterhawk CET is a material advancement in cost-effectively mitigating this significant and growing source of methane emissions.

2 – History

Winterhawk began work on its casing expansion technologies in 2015 using an expanded steel ring method originally designed as a steel-on-steel seal for high temperature thermal recoveries for Imperial Oil at Cold Lake.



However, setting this assembly in the wellbore then releasing from its proved difficult. It was finally concluded after significant field trials that a preferable assembly would be retractable, then retrievable. In 2018 the pleated steel ring was replaced with an expandable elastomer element.

The first test well using this assembly was conducted near Lloydminster in a test well for a major operator in the summer of 2018. However, post-test multi-finger casing caliper logs revealed that the tool did not have sufficient power to expand the wellbore casing against cement at 100 tons of force. The operator had committed to funding a five-well testing and development program.

In the fall of 2018 the output power of the setting tool was doubled to 200 tons. However, in fourth quarter of 2018 the price of heavy oil collapsed. However, the program was cancelled as part of a broader cost reduction strategy.

In the summer of 2019 Winterhawk conducted shop demonstrations to secure development funding from the Natural Gas Innovation Fund and Emissions Reductions Alberta. There was interest by both parties.

In early 2020 the company was restructured and refinanced. A test well was secured with Winterhawk paying the bulks of costs. The purpose was to see if the 200-ton tool would expand casing and be easily recovered from the well.

From March 2020 to November 2020 Winterhawk returned to the test well five times to improve and test the performance and behavior of the 200-ton tool. In total, 34 expansions were performed in this well. Expansions took place in a variety of wellbore conditions to see how the tool performed inside the well and, by monitoring the flow and pressure at surface, the annulus. Material changes in flow and pressure at surface were created by the expansions.

At the same time, Winterhawk began discussions with ERA about funding.

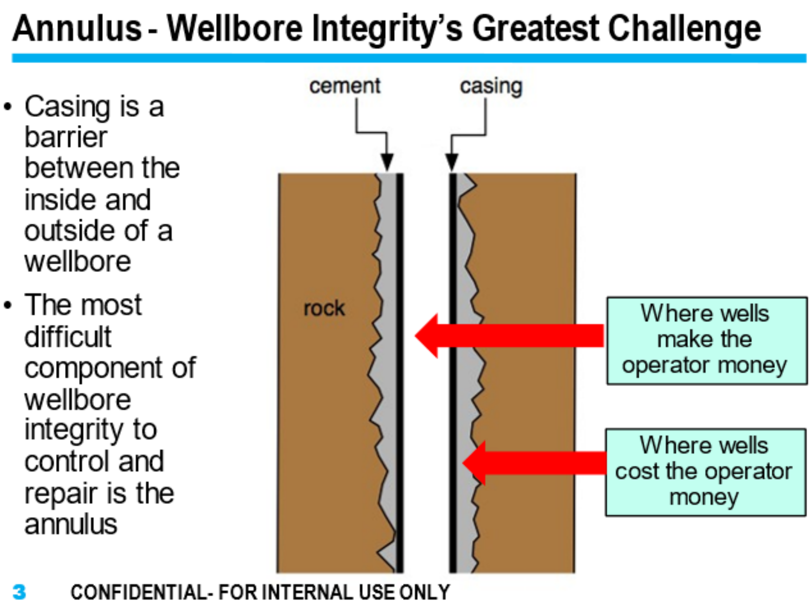
In March of 2020 the global COVID-19 pandemic shut down the industry. Winterhawk was unable to find a single sponsor for the traditional ERA funding model. However, after extensive negotiations ERA was persuaded to pursue a modified sponsorship model considering of multiple industry participants in multiple wells. This was accepted by ERA September 9, 2020.

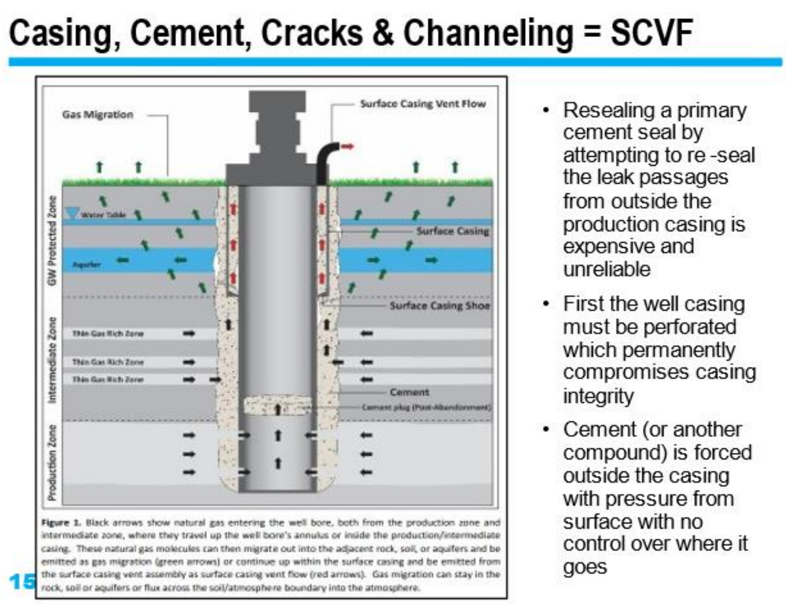
In December of 2020 Winterhawk was contracted by Tervita Corporation to supply casing expansion services for a problem well west of Edmonton. This job was successful and the well has been cut and capped.

ERA recognized this well as Milestone 1 even though the final FPP was not signed until February 28, 2021. At that time Winterhawk had commitment letters for multiple tests wells including three from CNRL and one from Husky Energy.

3 – The Wellbore Methane Leak Challenge

What is not commonly understood is that the Society of Petroleum Engineers definition of wellbore integrity includes the annulus – the space between the inside of the rock formation and the outside of the production casing. These illustrations explain the problem.





The most common method of alleviating SCVFs is a “cement squeeze,” or cement repair in the annulus from inside the wellbore. This involves perforating the casing, thus permanently reducing casing integrity, then attempting to inject cement from surface into the leak paths outside the casing.

The cement squeeze technique was originally developed to help control high pressure oil and gas production flowing up outside the casing. It is used for low volume methane leaks because, until recently, it was the only tool available.

According to Natural Resources Canada, cement squeezes have a success rate of only about 30%. This is because persuading cement from surface to ooze into cracks nobody has been seen hundreds or thousands of metres below the ground is complex and expensive and often takes place in the wrong location in the wellbore.

4 – Winterhawk Casing Expansion Tool

The Winterhawk CET uses pressure from surface and series of hydraulic rams to exert compression force on an elastomer element in a confined location in the wellbore. With nowhere else to go, the power from the setting tool forces the elastomer and casing outwards.

The 4.20” OD tool for 7” (177.8 mm) casing converts 4,000 psi of hydraulic pressure into an outward force of 440,000#. This illustration is the setting tool with a piece of test casing ready for expansion.

This is the same piece of test casing a few minutes later. Here the 7” casing has been expanded to over 8.5” OD. Before the CET is deployed in a wellbore, Winterhawk secures a piece of casing of the same size, thickness and grade as that in the well to determine whether or not the tool has the power to expand against cement and the anticipated performance in a that casing in the wellbore.

In the past three years the CET has been expanded and released over 130 times in eight wellbores. In the shop the behavior of the process has been tested and determined in hundreds of times more. The performance of the tool has become predictable, as has its behavior from surface as indicated by expansion pressure, release time, and string weight behavior.

The purpose of casing expansion is what Winterhawk calls a “mechanical cement squeeze,” a process by which the small cracks and fissures in the cement that are allowing methane to leak are physically squeezed shut by reducing the cross-sectional area of the annulus at that interval.

It is the same process as squeezing a garden hose to reduce or stop flow, except in reverse.

To determine the best place to achieve a mechanical cement squeeze Winterhawk and the well owner examine:

- Wellbore size
- Geological properties
- Casing weight and grade
- Cement properties, if available
- Cement quality via a Radial Cement Bond log
- Compensated neutron log to detect gas storage if possible
- Geological and production history if available

In simple physics, for this process to succeed there must be cement of sufficient volume and density to compress; the expansion location must be above the source of the methane; the wellbore must be as small as possible (no washouts); and the wellbore and geological formations must be of sufficient strength such that the cement will compress, and casing expansion will not simply push the problem further into the side of the wellbore.

When depth intervals for expansion are selected, Winterhawk and the wellbore owner discuss setting depths based on open hole logs, cement bond logs, and recent through-casing compensated neutron logs if they are available. Often oil company geologists are engaged in order to determine the geological properties of the rock formations against which expansion will take place.

Early in 2021 Winterhawk and partner Tier 1 Energy Solutions Inc. began research and testing into using a multi-element assembly to increase the surface area of casing expanded in a single setting activation of the tool in the wellbore. This began with a two-element assembly then progressed to a three-element assembly. This was originally conducted on a vertical press.

Further testing continued including vertical press shop testing, test elements, test casing, machining, and extensive shop testing using the CET itself. These expenses are included under “In Kind” contributions on the Milestone 3 Expense Report.

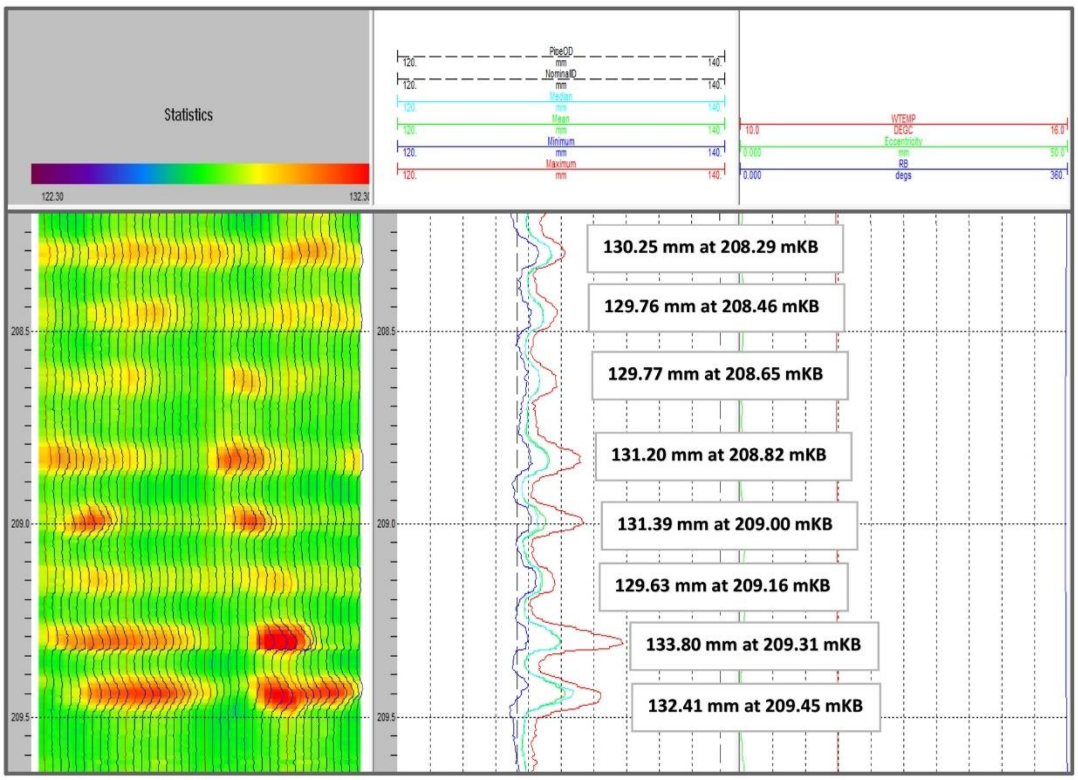
Due to client demand CET for 4 ½” (139.7mm) casing was developed. . In terms of the numbers of wells with SCVFs in Alberta, this would serve the largest number.

5 – Wellbore Behavior of Casing Expansion

The expansion behavior of the CET inside cemented casing is materially different from that on surface. It varies depending upon casing properties, cement quality, borehole diameter, and the resistance of the rock formations at that depth dependent upon geology and compressive strength.

For example, this casing caliper log from the same wellbore within a 2-meter interval illustrates the difference. This log is from Milestone 5.

Casing Expansion from 208.15 mKB to 209.52 mKB



This is called a "tapered" expansion where the pressure is increased as the test moves uphole. The first expansion at 209.45m was done at 3,000 psi. The second, the largest at 209.31 m, at 3,250 psi. The third, at 209.16 m and 3,500 psi, was the smallest. The fourth, at 209.00 m at 3,750 psi, was still smaller than the two at 3,000 and 3,250 psi. The top of the first five (five per run) at 4,000 psi at 208.82 m, was only 131.2 mm.

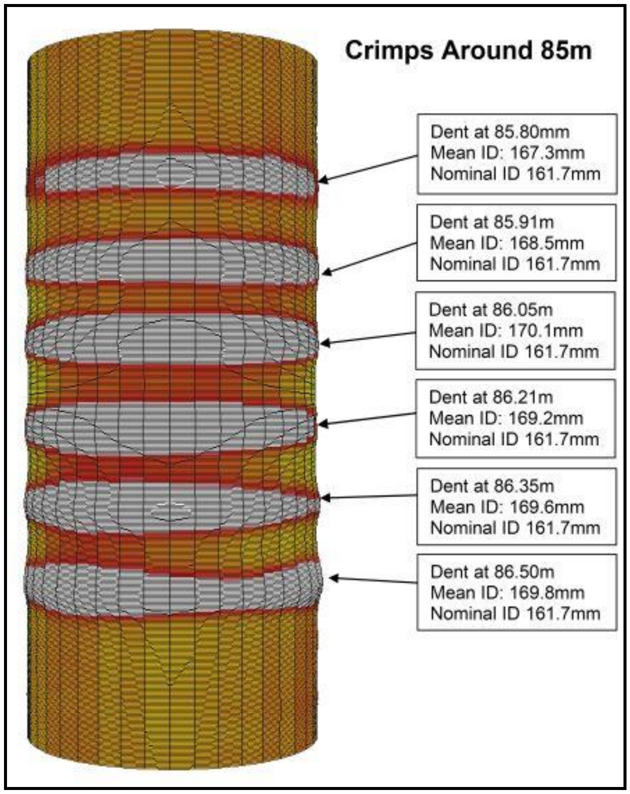
When depth intervals for expansion are selected, Winterhawk and the wellbore owner discuss setting depths based on open hole logs, cement bond logs, and recent through-casing compensated neutron logs if they are available. Often the oil company geologists are engaged in order to determine the geological properties of the rock formations against which expansion will take place.

What Winterhawk and the industry are learning from the post-expansion analysis of the well is the tools used for examination of the annulus are not that well suited to the assignment.

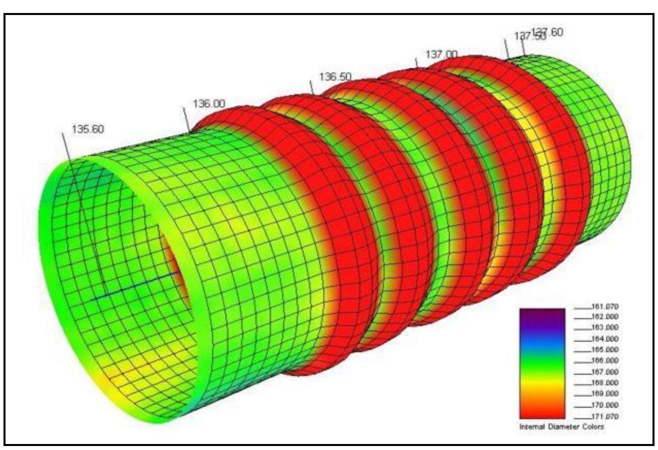
The through-casing electronic logs that provide the best information are also the most expensive. Well owners are loath to spend more money than they have to on assets that cost money, not make money.

Logs like the one above are showing that cement properties change over very short distances in some wells.

This log is of a successful vent flow shutoff in Milestone 1. Six small "dents" did the job.



This log image is of five two-elements expansions closer to surface in Milestone 3.



6 – Project Objectives

There were two primary objectives of the ERA test program.

1) Determine the suitability, reliability and performance of the CET equipment in a variety of wellbores.
2) Learn from first hand experience the wellbore information required and the intervals in which casing expansion is employed to achieve the best possible outcome.

7 – Performance Targets and Outcomes

1.	Success Metric	Commercialization target	Project Target	Achievements to date
	Casing Expansion	> 90%	> 75%	77% in 35 wellbore test expansions 57% exceeded 6+% annulus area reduction
	Gas Flow Reduction	>90%	>70%	100% in expansions exceeding 6+% annulus area reduction, 57% overall
	Tool Functionality	>90%	>75%	100%, current 220-ton force tool has never failed to unset, release and be retrieved from the well in 35 downhole expansions

The original performance targets in Schedule A of the FPP are reproduced above.

After 7 wells in Milestones 1, 3, 4, 5 and 6, Winterhawk reports the following.

- Casing Expansion > 90% commercialization confirmed.
- Gas Flow Reduction > 70% project target confirmed. The commercialization target of > 90% has not been achieved for reasons explained below.
- Tool Functionality > 90% for commercialization confirmed.

The unexpected outcome was restricting the use of casing expansion to the lower sections of the wellbore by the AER. Because casing expansion is new, SCVF shutoffs using this method are considered a "non-routine" abandonment. This means the AER puts restrictions on the intervals at which casing expansion can be deployed.

When Winterhawk is asked by a well owner to identify the zones where casing expansion is most likely to shut off the gas, our project geologist/engineer/log analysts identify all the intervals that meet the above mechanical cement squeeze characteristics above the know sources of either gas sources or stored gas.

Stored gas is methane accumulating in porous formations above the source of the gas. This is caused by what is often many years of leakage. The well in Milestone 3 first reported a vent flow in 1972.

However, when the AER approves a non-routine abandonment, they want to see if casing expansion can have the same impact as a cement squeeze above the most likely source of the gas at the bottom of the well.

While this regulation is an ideal solution, when the casing expansion is done there is very often gas stored above the interval at which casing expansion takes place and the flow continues. Success of the expansions is not immediately known.

Vent flow shutoff experts know that it can take a year for stored gas to bleed off even when the source gas is isolated.

One of the places where casing expansion can be the most effective is in the surface casing. This is important because a common area for stored gas to accumulate over the years is the washout (over gauge hole) just below the surface casing shoe. In central Alberta, coal seams that either store or leak gas often appear at or just below the bottom of the surface casing.

The AER view is that shutting off uphole gas in the surface casing could cause a gas migration problem around the surface casing.

The industry is of the view that well owners should be able to “cut and cap” the surface casing with nominal pressure and flow so long as the formation breakdown pressure below the surface casing is lower than the annular pressure. A common term for this is the “frac gradient.”

Further, the AER will not declare a vent flow fixed unless a surface casing leak test (hose in a pail of water) reveals there is not a single bubble of methane emitted over a 10-minute period.

This reluctance of the industry to tackle vent flows because of unknown costs and outcomes and the rigid nature of current regulations has created a situation where the full potential of the Winterhawk CET remains undetermined.

8 – Technology Advancements During ERA Program

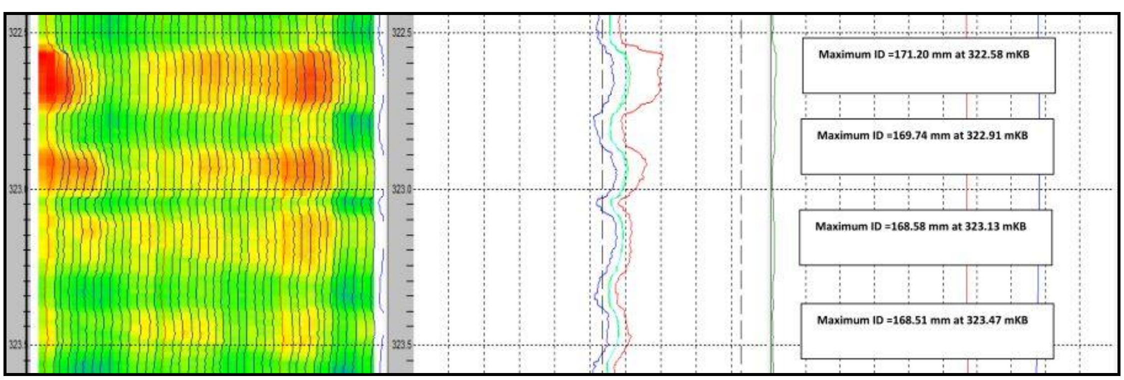
Winterhawk invested heavily in advancements to the CET during the ERA program.

The first was the three-element expansion assembly, pictured below. This was not conceived until early 2021.

Winterhawk's project engineer wanted more surface area of expanded casing for enhanced cement compression.

Shop tests in a vertical test press revealed that three elements would behave in essentially the same way as one in the wellbore. Field tests had confirmed that for each run, the elements could do from 4 to 6 expansions on one trip in the well before tripping out to replace the element. This meant that instead of a single expansion with the tool in the well, this could be increased from 12 to 18 depending on conditions.

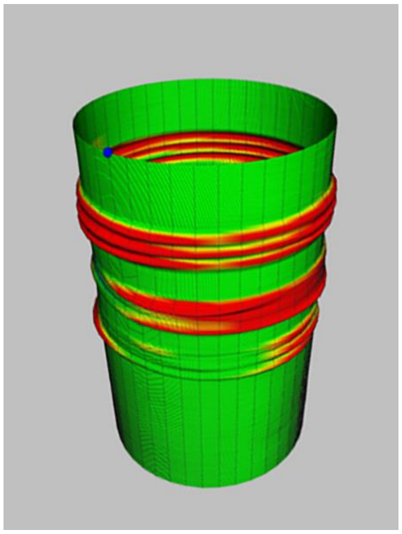
No other oil tool in the world has this capability.



This is a casing caliper log using the two-element assembly. The distortions in circularity are evident by the shape of the graph at the right and the different colors showing off-centre expansion.

Winterhawk went “back to the shop” and developed a by-pass assembly allowing fluid to pass through the tool while running in the hole prevent pressure buildup during expansion.

The three-element assembly was used again for in 177.8mm casing in Milestone 6. This caliper log shows that the expansions were uniform, and the tool performance as planned. No operational issues go into or out of the well were encountered.



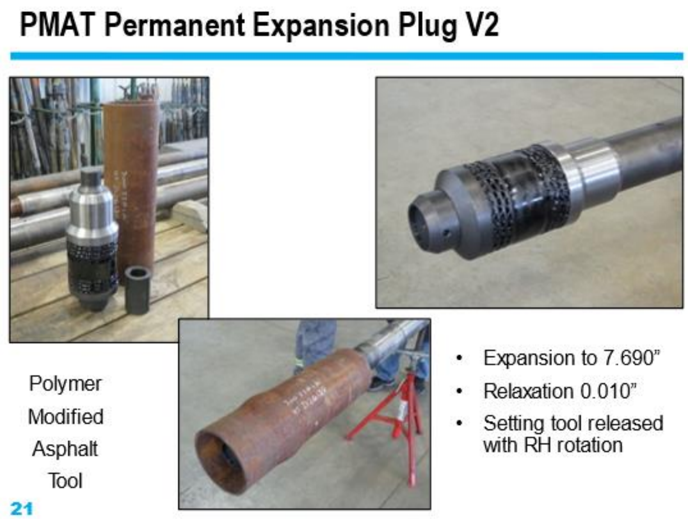
Because of deteriorated casing and poor wellbore conditions, only three sets of three-element expansions were conducted. This casing caliper log of nine expansions with a one-meter vertical interval is major technical milestone for the global petroleum industry.

In 2021 Winterhawk also developed a new tool for 5 ½” (139.7mm) casing. This involved a material redesign. The same power was required except the tool had to be 0.50” smaller in diameter to ensure recovery should the tool get stuck in the hole. The redesign resulted in a tool that was lighter, shorter and less expensive to manufacture.

This new tool was used in Milestone 5 which involved 30 expansions in two wells.

The third advancement was the creation of the modified PMAT plug, or Polymer Modified Asphalt Tool. This was a new design of internal and external well abandonment plug that sealed the inside and annulus of the casing simultaneously. This was developed specifically for Milestone 4 after previous casing expansions had detected the ability to shut off gas when the tool was fully expanded, but not hold the expansion after pressure was released.

The use of pleated rings also required the development of a new right-hand release mechanism to leave the plug in the hole. The PMAT required the same setting force to expand the casing, but was not meant to come out of the well once pressure was released.



In total, Winterhawk invested $192,678.37 cash in these three technologies during the project period. None was claimed for ERA funding. They were essential to the complete of the program, and were the major contributor to the total program coming in $197,105.40 over original budget.

9 – Technology Risks

Winterhawk sees three areas of technology risk.

The first is using casing expansion in corroded casing. The wells in which CET was employed in Milestones 5 and 6 had poor casing. In Milestone 1, the casing was of a lower strength grade that identified by owner. One of the wells in Milestone 5 had a collapsed casing interval in the surface casing that had to be drilled out to get into the well. The casing in Milestone 6 was so badly corroded that the well "leaked" during pressure tests due to holes in the casing.

The risk of rupturing corroded casing during vent flow mitigation efforts is not as serious as it sounds. To introduce cement into the annulus, the casing must be punctured one way or another. Some methods of sealing vent flows with cement involve removing the casing entirely with a section mill.

As the industry searches for a "silver bullet" to be able to shut off vent flows at the lowest possible cost, the default behavior in the ERA program was to give Winterhawk the problem wells that had not responded to other shutoff methods.

The second is the lack of information, or reluctance to spend money on gathering more information, on "end of life" assets with SCVFs. The best analysis tools to determine where annular repair operations should occur are also the most expensive. It is not intuitive for well owners to spend more money on assets with a negative value due to their decommissioning liability.

Older wells with multiple owners do not always have complete or accurate well files.

The industry must join Winterhawk in advancing the suite of technologies to better understand the conditions of the wellbore annulus to help make the most cost-effective remediation decisions.

The third is investing heavily in helping the industry solve a problem that it doesn't really want to solve because of current methods and costs. The risk is investing in a technology that the industry needs in the absence of the regulatory conditions that would persuade them to employ it.

Alberta's regulations on SCVFs are very rigid. The cost of shutting off this source of methane leakage under current regulations make it the most expensive methane leakage to shut off of all methane leakage and fugitive sources.

Lower cost methods are essential. Winterhawk can be a major contributor.

Given the number of leaking wells and the unknown mitigation cost, regulatory reform is essential to get the cost of mitigating this source of methane comparable to other, better-known sources of methane.

10 – Commercialization

The ability to use casing expansion to solve wellbore problems is not confined to vent flows. Winterhawk is attracting interest from producers of bitumen in heavy oil thermal projects to improve wellbore integrity, and from producers with extended reach horizontal wells to use casing expansion to repair distorted casing caused by hydraulic fracturing.

Inquiries from other oil and gas producers in other counties is growing. Winterhawk hopes to establish some form of long-term commercial partnership outside of Canada in 2023.]

11 – Lessons Learned

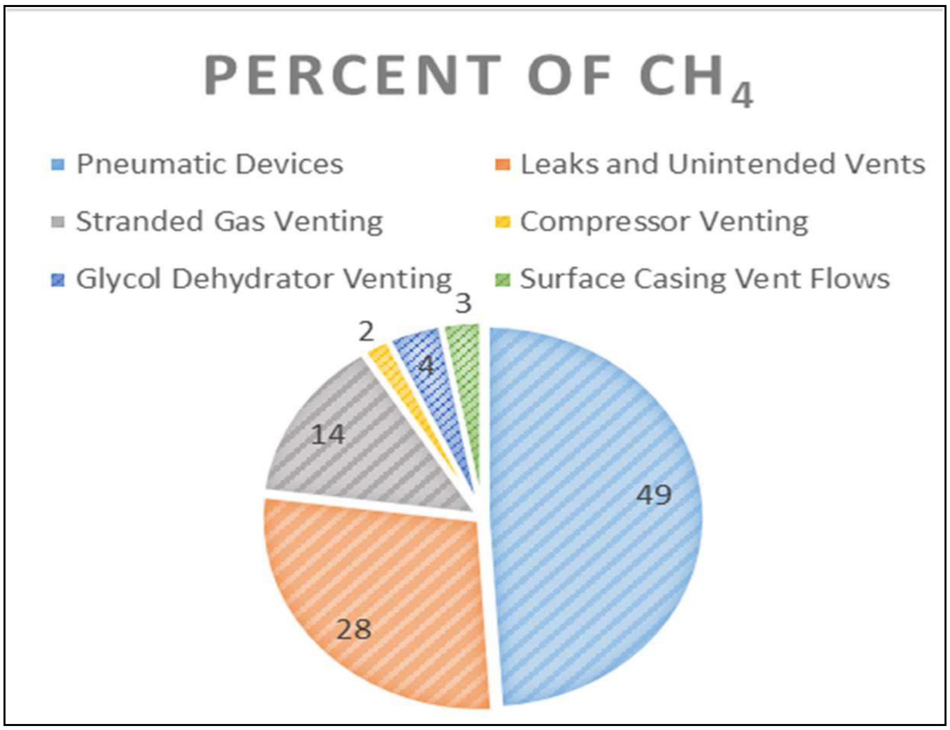
Two years after executing the FPP with ERA Winterhawk offers the following:

1) The industry puts no priority on shutting off methane emissions from leaking wellbores in Alberta at this time. Winterhawk has determined that without regulatory reform or enhanced enforcement, expenditures in this are being intentionally avoided.
2) Undertaking this project with ERA during and in the post-pandemic period resulted in operating challenges not anticipated. But when prices picked up and labor and supply shortage became evident, the focus of finite resources went to generating cash flow instead.
3) The Site Reclamation Program, the $1 billion in provincial funding resulting from the federal COVID relief program of April 2020, avoided SCVF wells. The objective was to do the greatest number of simple internal wellbore abandonments as cheaply as possible. This directed finite oil company and oil services resources away from SCVF activity.
4) ERA was very flexible as test well partners came and went. Thank you.

12 – Emission Reduction Impact

With only seven wells completed in the program – and none of them high volume "leakers" – Winterhawk cannot report any material impact on methane emissions reduction.

This report from the AER indicates that SCVFs are only about 3% of total methane emissions. But as noted in this report several times, they are the most expensive to shut off and are spread over 10,000 individual assets. The other 97% of methane emissions can be shut off on surface, making them easier to detect and less expensive to repair.



At the present time the AER classifies "serious" SCVFs as those emitting 300 cubic meters per day of methane or more. The leakage from the highest emitters in the program – Milestone 3 – was about 15 to 18 cubic meters per day. Milestones 1, 4, 5 and 6 had rates of 1 cubic meter per day or less.

In terms of enforcement, the AER does not differentiate between wells leaking one bubble of gas every 10 minutes on "hose in water" flow test and a well leaking 299 cubic meters of gas per day.

Milestone 6 was only leaking one liter of methane per week. It appeared to less after the Winterhawk intervention. But because it cannot not pass the AER ten minutes without a single bubble test, the owner is forced to keep trying. Repeated cement squeezes had failed and the wellbore could not support the pressures of cement squeezes.

The only way that a material reduction in methane emissions from this source will be executed is if regulators relax excessively restrictive requirements, the industry accepts more diagnostic tools and investments are essential, and that casing expansion is given the opportunity to work on many more wells to learn the best and most economical application of the process.

This cannot be done with the eight wells that Winterhawk has worked on in the past three years.

And many of the ones we did work on had terrible wellbore conditions that were not conducive to success.

13 - Scientific Achievements

At this point Winterhawk is confident that it is the world leader in the technique of using wellbore casing as a wellbore integrity and remedial tool instead of a barrier between the outside and inside of the casing. Winterhawk has learned a lot on the behavior of steel and cement and wellbores that it remains confident will be of great value to the industry in the future.

14 – Conclusions/Next Steps For Winterhawk

The timing of the Winterhawk/ERA test project and the COVID 19 pandemic created highly volatile business conditions that have made it difficult to assess the success of the program and the long-term commercial viability of casing expansion for wellbore methane leak mitigation.

When Winterhawk started the ERA application process, because of the pandemic the industry was experiencing a period of economic downturn and uncertainty of historic proportions.

By the time the program began in 2021, the industry has recovered somewhat but most producers were focused on repairing their balance sheets and returning their operations to normal. Alberta's Site Reclamation Program was underway but it moved resources to other aspects of mature asset retirement besides SCVF.

In 2022, the spectacular and unplanned increase in oil and gas prices then sent finite resources to reactivating wells and maximizing cash flow. A key proponent of the ERA project couldn't find the time to get to our wells. This is highly regrettable because no company had done as much work in specifically selecting three test wells from a large inventory of suspended and leaking wellbores in which casing expansion was most likely to succeed.

That said, the work was done and the tool works great. The AER has increased the industry's minimum spend on Asset Retirement Obligations for 2023 to $700 million. Producers have been avoiding their vents flows for years.

In 2022 Winterhawk funded the development of a CET for 4 ½" casing which can be deployed in the greatest number of leaking wellbores, the mature gas producing areas of central and southeast Alberta.

15 – Non-Confidential Outcomes Report

In the two years from December 1, 2020, to November 30, 2022, Winterhawk, ERA and five operators of oil and gas wells in Alberta combined to conduct a multi-well field trial program in existing oil and gas wellbores with known Surface Casing Vent Flows (SCVF)/wellbore annular methane leaks to determine the performance of the Winterhawk Casing Expansion Technology (CET) in actual wellbore conditions and its effectiveness in reducing or arresting SCVFs.

The CET is an oil tool conveyed into and from the wellbore on jointed tubing using a well servicing rig and related equipment such as vacuum trucks, water trucks and pressure pumps. The CET is part of a typical wellbore intervention operation.

The performance of the CET was excellent defined as when the tool was placed in the desired location in the wellbore and activated it performed as planned. Post intervention multi-finger wireline caliper logs revealed the existence of casing expansions where the tool was placed. It released when required. It never failed and came out of the hole complete and intact. No debris was left in any wellbore.

The CET is designed to change the physical properties of the wellbore annulus without perforating the casing, thus permanently reduced wellbore integrity. It does this by reducing the cross-sectional area of the annual.

Once production casing is cemented to surface, prior to casing expansion there was no other way to materially change the area, properties or behavior of the annuals without puncturing the production casing by one means or another, most commonly perforating.

When the CET is used in conjunction with a modern digital pressure/flow meter on the SCFV valve, in most cases the CET has a material and measurable impact on pressure and flow. In the first well in the ERA program casing expansion shut off the methane flow. This well has subsequently been cut and capped.

In most of the other wells annular pressure and flow characteristics were reduced, although true impact on the zones of interest is not always determinable at that time because of the existence of stored gas in uphole zones.

But the relationship between casing expansion and annular pressure and flow in real time is measurable and valuable.

For casing expansion to seal the annulus and stop methane leakage the properties of the annulus at that interval are critical. Casing expansion is a form of “mechanical cement squeeze” which compresses the methane flow paths in the cement from inside the casing.

Characteristics such as casing grade and weight, cement quality, and the wellbore conditions against which the cement is compressed are critical.

What the Winterhawk/ERA test program also revealed is that current diagnostic methods of analysing the wellbore outside the casing from inside the casing or from surface are limited.

The CET proved to be a valuable diagnostic tool in three ways:

1) In wells with higher volume flows, ability to identify the depth from which the methane was flowing by monitoring surface performance during expansion. If flow changes when expansion pressure is held, it is confirmation that the expansion is above the gas source.
2) Ability to identify the properties of annulus at a given depth including “cap rock” or a good place for a permanent seal by the size of the expansions relative to other available data such as open hole logs, cement bond logs and compensated neutron logs.
3) Ability to provide a vertical barrier above or below remedial cementing thus ensuring cement squeezes to “re-cement” the annulus are more likely to be successful by confining the cement flow outside the casing to the desired interval.

Considering the Winterhawk CET was the first oil tool of its type using this design to achieve this outcome, the ERA test program was very effective.

As a result, when oil and gas producing companies ask if it works, the answer is “yes.” The tool expands casing when and where required and comes out of the wellbore in one piece with no debris left in the wellbore.

The bigger questions for wellbore owners with casing expansion is where do you want to expand the casing, and what is the desired outcome?

The ERA program has given Winterhawk and Alberta’s oil and gas industry a new environmental and emissions reduction leadership foundation – another tool in the toolbox – to deal with wellbore integrity and remediation for multiple applications, including Alberta and the world's growing number of existing wellbores with annular methane leaks.

EMISSIONS REDUCTION ALBERTA	Project Emissions Reductions	ID: F0160860

Recipient Organization	Winterhawk Well Abandonment Ltd.
Title	Casing Expansion for Annular Wellbore Methane Leakage
GHG Emission Reductions (ERs): 2011–2050	
2011	0
2012	0
2013	0
2014	0
2015	0
2016	0
2017	0
2018	0
2019	0
2020	0
2021	0
2022	0
2023	0
2024	0
2025	0
2026	0
2027	0
2028	0
2029	0
2030	0
2031	0
2032	0
2033	0
2034	0
2035	0
2036	0
2037	0
2038	0
2039	0
2040	0
2041	0
2042	0
2043	0
2044	0
2045	0
2046	0
2047	0
2048	0
2049	0
2050	0

Please Refer to ERA’s Website For the Quantification Methodologies
https://www.eralberta.ca/calculating-ghg-emissions-reduction/