

# Novel Leak Detection Method for Sulfur Recovery Unit Condensers

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## Summary

At a Shell sour-gas processing facility in Alberta, Canada, hydrogen sulfide contained within the natural gas is converted into elemental sulfur by means of a sulfur recovery unit (SRU). Tube leaks present in a water-cooled SRU condenser can lead to a variety of process issues, including corrosion and the oxidative formation of acidic species. Leak indicators, such as loss of sulfur flow in the rundown and a frothy sulfur appearance, were observed. This work devised a novel method to verify such leaks within a SRU condenser. Using basic pump equipment and an inexpensive commodity chemical tracer, lithium hydroxide, a leak was diagnosed without the shutdown of the unit and with a minimal of expenditures and hazards to operators. The unit was inspected and the tube leak plugged, which enabled the resumption of normal operations.

## Introduction

Shell is the majority owner and operator of the Burnt Timber Gas Complex, which is located in the foothills of central Alberta. The complex contains two processing plants separate up to 3.6 million cubic meters of raw natural gas every day into sales gas, natural gas liquids, condensates, and sulfur. Natural gas from the fields feeding the plants contains hydrogen sulfide, which typically ranges from 0 to 28%. Sulfinol-D and MDEA units are used to sweeten the sour gas, and the removed hydrogen sulfide is sent to a SRU, where it is converted into elemental sulfur. This sulfur is transferred to a downstream facility, where it is formed into pellets and transported elsewhere for sales.

## Background

Leaks within a SRU water-cooled condenser can result in operational and maintenance issues. Water flashing into the process side can cause sulfur solidification, with resultant plugging and high rundown pressure. This was evident at Burnt Timber, where the pressure buildup progressively worsened with venting required numerous times each day to prevent plant back up. Loss of flow (freezing) and plugging were also observed in the rundown. The sulfur recovered from the condenser had a frothy/spongy appearance, which would indicate the presence of water and served as a leak indicator. Furthermore, sounds resembling sizzling and cracking were heard from the sulfur pit as the water contained within boiled off.

Other potential indicators that exist for condenser leaks but were not detected at Burnt Timber can include excessive steaming from the seal pot and an increase in water treatment [e.g., boiler feed water (BFW) make-up, chemical make-up, and water-softening chemical usage]. Consequences of water ingress can be severe, be-

cause it can include corrosion of the train equipment, formation of sulfuric acid in the presence of an oxidizing environment, and train shutdown/loss of production for corrective measures.

## Leak Testing

**Approaches.** Because Burnt Timber exhibited a number of the aforementioned leak indicators, it was determined that a testing regime should be applied for verification. Whereas operating procedures can call for a train shutdown to allow an external vendor to employ a radioactive tracer for the detection of any leaks, a desire for cost-effectiveness led to a search for a non-radioactive method that could be performed by in-house operators while the train remained online. Any outside testing by vendors also had to factor in health, safety, and environment (HSE) concerns with regard to the handling of radioactive materials (Nava et al. 2009) and confined space entry, which would require a cooling period before manned entry, and incurs cost in the form of production loss. A method was thus formulated whereby a non-radioactive tracer would be injected into the BFW flowing to the exchanger, where it would disperse with the water through any leaks and into the sulfur (Crevier 2002; Watkins and Mardock 1954). Analysis of the sulfur would reveal the presence of the tracer, if any, and confirm or refute the presence of leaks in the SRU condenser. This detection method uses equipment that is readily available in virtually any gas processing plant and would preclude the involvement of cost-prohibitive external vendors and their associated drawbacks.

**Tracer Selection.** The selection of a suitable tracer for dissemination into the BFW requires that many factors be taken into consideration (Gore and Terry 1956). Because the solvent is BFW, the tracer must be adequately miscible in aqueous environments such that a sufficiently large concentration will be present for detection, especially if the leak is minor. Non-volatility of the tracer must be ensured so that its exit from the system is solely through the leak and not lost with the steam downstream of the condenser; a gaseous tracer would be unsuitable in this case. Elements that have a high tendency for the formation of scales (e.g., Group II elements) are an inappropriate choice, because they would exacerbate any loss of flow or plugging issues. Heavier species would be preferred for their ability to withstand sample preparation (e.g., digestion) would enable lower analysis detection limits, whereas lighter elements would be lost during this process. Non-reactivity and chemical stability must also be taken into account to ensure the lifetime of the species through the system (Asadi et al. 2002). Conversely, transition metals may prove too “noble” for dissolution into the BFW or “exotic” for what is intended as a cost-effective and operationally simple method with readily obtainable material. The use of such species may also necessitate the procurement of cost-prohibitive standards if they are not normally analyzed by the laboratory. In addition to the HSE considerations, radioactive tracers were not considered, because their use would require specialized detection equipment. The tracer should not be commonly present in the BFW

Element	Relative Intensity
Lithium	12,000,000
Rubidium	25,000
Cesium	300

(e.g., sodium and potassium) or as part of the train equipment (e.g., iron, chromium, and zinc) because this will cause difficulty in differentiating between any increases in the signal and the background, especially if the leak is minor.

Because detection of the tracer was to be performed using inductively coupled plasma atomic emission spectroscopy (ICPAES), elements that impart a strong signal with this technique must be employed. This is evident in **Table 1**, where the relative intensity of the lithium signal is 480× that of rubidium and 40,000× that of cesium, even though all three are Group I elements. Finally, the solvent itself used to disseminate the tracer should be free of agents that could interfere with the tracer or analysis. If BFW is used, this should nominally not be an issue. After taking into account all of these criteria, lithium hydroxide was selected as the most suitable tracer, with lithium as the element of interest.

**Procedure.** 1 kg of lithium hydroxide was dissolved in a jockey pump containing 10 L of approximately 20°C BFW. All samples thenceforth were collected using thermally stable glass bottles and cooled under ambient conditions before being sealed off. Approximately 100 ml of sulfur was taken from the rundown as a baseline. The lithium hydroxide solution was then manually pumped into the BFW inlet as rapidly as possible (approximately 15 minutes). 100-ml sampling of the rundown was then taken at the times specified in **Table 2**. Sample preparation for each was performed by mixing approximately 1 g of the solidified sulfur with 20 g of hot water, followed by 60 minutes of sonication, and then standing overnight. The mixture was then filtered using a 0.45-um filter and the filtrate analyzed by ICPAES.

## Results and Discussion

Because of the type of sample preparation employed (i.e., hot water extraction), the detection limit for this method was set at a conser-

Sulfur Sample Number	Time After Injection (min)
1	1
2	4
3	7
4	10
5	13
6	16
7	20
8	25
9	30
10	35
11	40
12	45
13	120

vative level of 2 ppm. As shown in **Fig. 1**, it was determined that lithium was present in the sulfur at above-detectable levels from approximately 10 minutes until approximately 25 minutes after injection. It can be inferred that for approximately the first 10 minutes, the lithium hydroxide tracer solution proceeded with the BFW toward the condenser leak, where it mixed with the sulfur and was recovered at the 10-minute mark. Recovery then continued until the 25-minute mark when the lithium concentration abruptly decreased to below-detectable limits. This indicated that the tracer solution had completely passed through and that standard BFW water was flowing again with no lithium to be detected. The data from this test strongly suggested the presence of a leak in the SRU condenser; it was subsequently shut down and inspected. A tube leak was confirmed and plugged off, which avoided further damage to the condenser.

Further work for the optimization of this method could involve the usage of a different pump because a faster injection rate would give sharper peaks and a higher contrast between it and the detection limit. Similarly, a higher concentration of the tracer may be necessary if future leaks are smaller than the one detected here. The choice of a lithium-based tracer limited sample preparation to extraction; the use of another species that can withstand more ag-

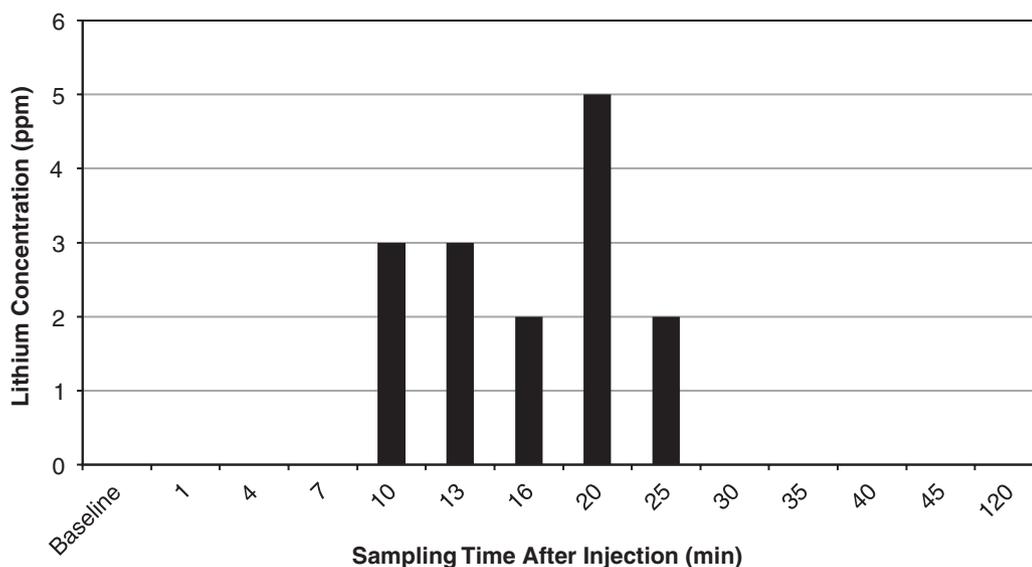


Fig. 1—Lithium content of rundown samples.

gressive preparation techniques may lower the detection limit and enhance results.

## Conclusions

An economical and operationally straightforward method for the detection of leaks in water-cooled SRU condensers was formulated and successfully used to verify leaks present at Shell's Burnt Timber Gas Complex. It involved the novel use of a readily available tracer chemical and basic equipment on hand at virtually any gas processing plant to troubleshoot the issue with a minimum of HSE hazards and without the need for cost-prohibitive external vendors.

## References

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