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HYDRIDE BED HELIUM-3 RECOVERY & PARTIAL REGENERATION

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Summary

A bed, operated beyond its design life, was selected to undergo elevated heating to evaluate theorized improvements that could be attained.

- *Bake-out removes portions of trapped hydrogen and helium-3*
- *Preliminary data indicate that elevated temperature bake-outs may partially regenerate* $LaNi_{4.25}Al_{0.75}$ *(LANA.75) beds.*
- *Performing bake-outs results in increasing helium-3 recovery, more efficient end-of-life activities (such as isotopic exchange), and extends the useful life of the bed.*

Introduction

$LaNi_{4.25}Al_{0.75}$ can be used as a hydride storage material. Over time, as tritium stored on the beds decays, its byproduct, helium-3, accumulates. For many years, LANA.75 retains the helium-3 and allows delivery of high-purity hydrogen. However, the helium-3 eventually accumulates to a point where it begins to weep. In addition, helium-3 in-growth traps a portion of the hydrogen (the heel), which reduces reversible storage capacity of beds to approximately by 30% - 40% at the end of a bed's service life.

Complexities associated with replacement may result in a bed being used beyond its recommended service life, requiring additional steps to contend with the reduction in capacity and helium-3 release. To manage helium-3 release, normal desorption temperatures are lowered, which further reduces usable capacity.

To overcome these effects, an aged storage bed underwent elevated temperature testing to determine if capacity could be partially restored.

Methodology

The following methodology was used to perform the bake-out a LANA.75 hydride bed and evaluate its impact on performance:

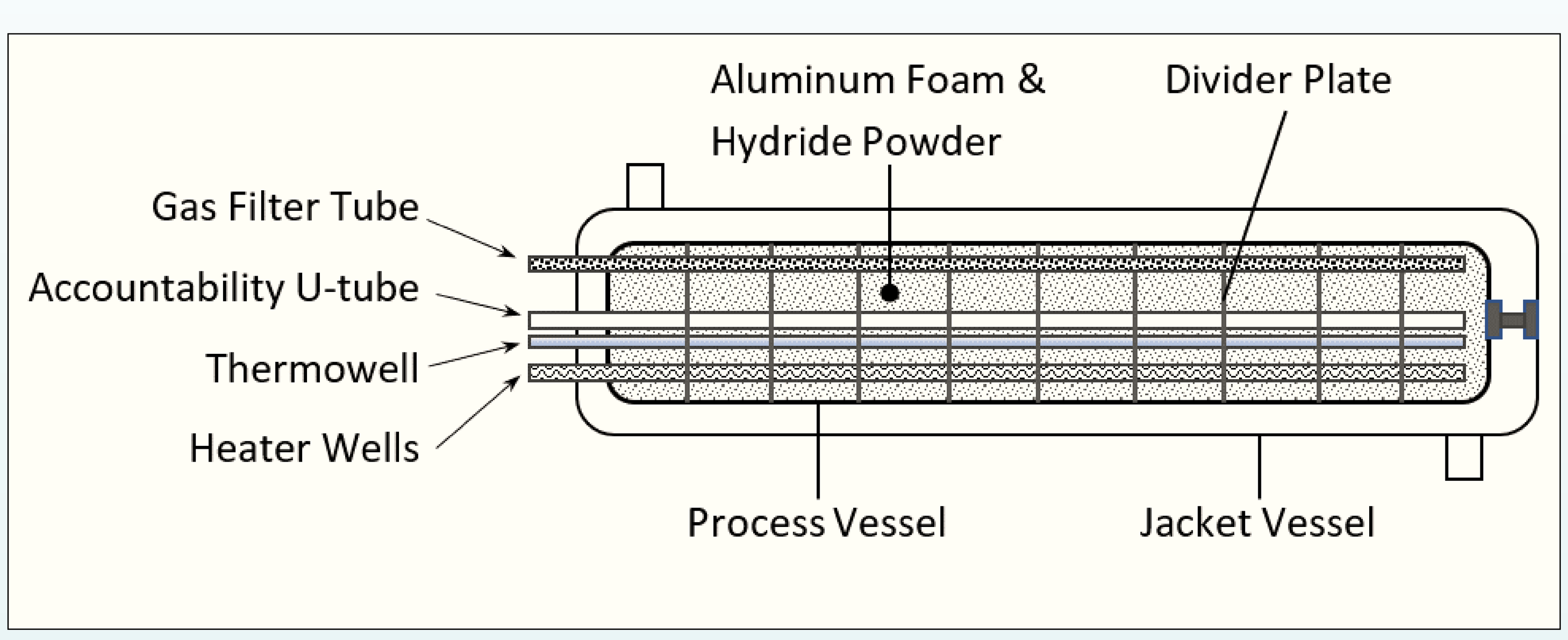

Figure 1. Illustration of example LANA.75 hydride bed components

1. Bed filled to normal operational capacity
2. Hydride bed desorbed to a tank with reduced desorption temperature (to avoid helium-3 release)
3. Gas sent to a calibrated volume for pressure, temperature, and composition measurements to determine quantity.
4. In-bed accountability (IBA) performed – a calorimetric process used to measure quantity of tritium on a hydride bed – to document quantity of tritium remaining on the bed prior to elevated heating [1-4]
5. The bed heated incrementally over 30 hours up to ~320ºC to desorb gas.
6. Desorption terminated and bed allowed to cool.
7. In-bed accountability repeated to measure remaining tritium heel.

Results

Prior to heating above the reduced desorption temperature, 27% of the total gas was desorbed (primarily tritium). Upon heating to normal LANA.75 desorption temperatures, an additional 13% of the gas removed was removed. At elevated temperature, 60% of the gas was desorbed.

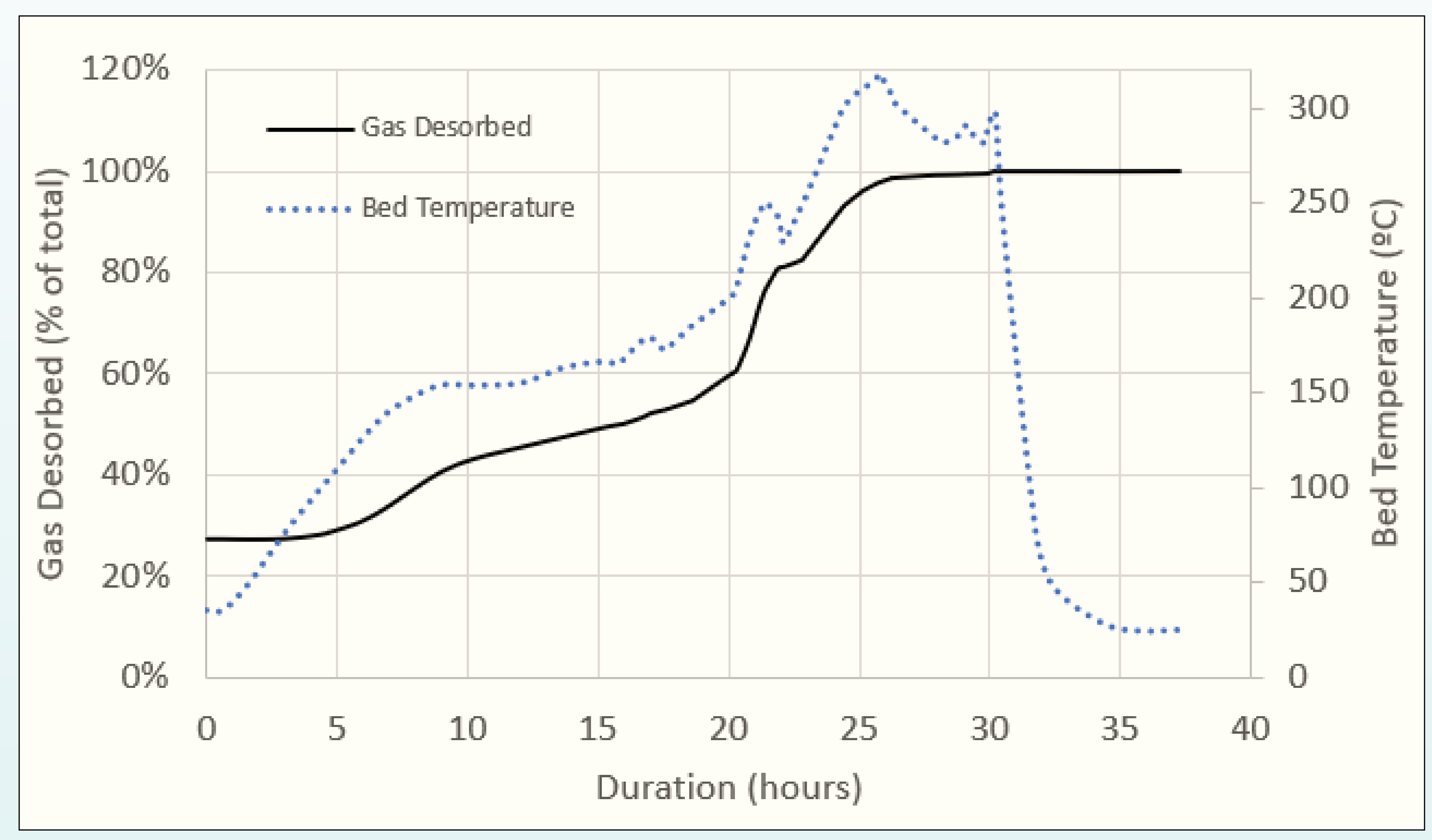

Figure 2. Percentage of total gas desorbed and bed temperature over time

The gas removed above the reduced desorption temperature was a mixture of tritium and over 60% helium-3. **This represents helium-3 and tritium recovered from the bed that would not otherwise been recovered.**

Preliminary data indicate reversible capacity of the bed following bake-out increased by approximately 15% to 90% (average 51%) relative to the reversible capacity immediately prior to the bake-out.

The hydride bed is considered partially regenerated since full (reversible) bed capacity was not achieved.

Conclusions

- A portion of trapped tritium can be recovered without isotopic exchange.
- A portion of previously unrecoverable helium-3 heel is now possible.
- Hydride bed capacity is improved, allowing for larger quantities of gas to be delivered at higher purities.
- Service life potentially increased, leading to a reduction in the frequency of time-intensive and costly outages necessary to replace beds.
- **Partial regeneration of a LANA75 hydride bed achieved.**

References

1. J. E. Klein, M. K. Mallory, and A. Nobile, Jr., "Tritium Measurement Technique Using 'In-Bed' Calorimetry," Fusion Techn., **21**, 401 (1992).
2. J. E. Klein, "In-Bed Accountability of Tritium In Production Scale Metal Hydride Storage Beds," Fusion Techn., **28**, 1026 (1995).
3. J. E. Klein, "A Summary of Tritium In-Bed Accountability for 1500 Liter $LaNi_{4.25}Al_{0.75}$ Storage Beds," Fusion Techn., **41**, 542 (2002).
4. J. E. Klein, "In-Bed Accountability Development for a Passively Cooled, Electrically Heated Hydride (PACE) Bed," Fusion Science and Technology, **48**, 416 (2005).

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