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Effect of Various Impurities on the Hydrogen Absorption on SAES ST198

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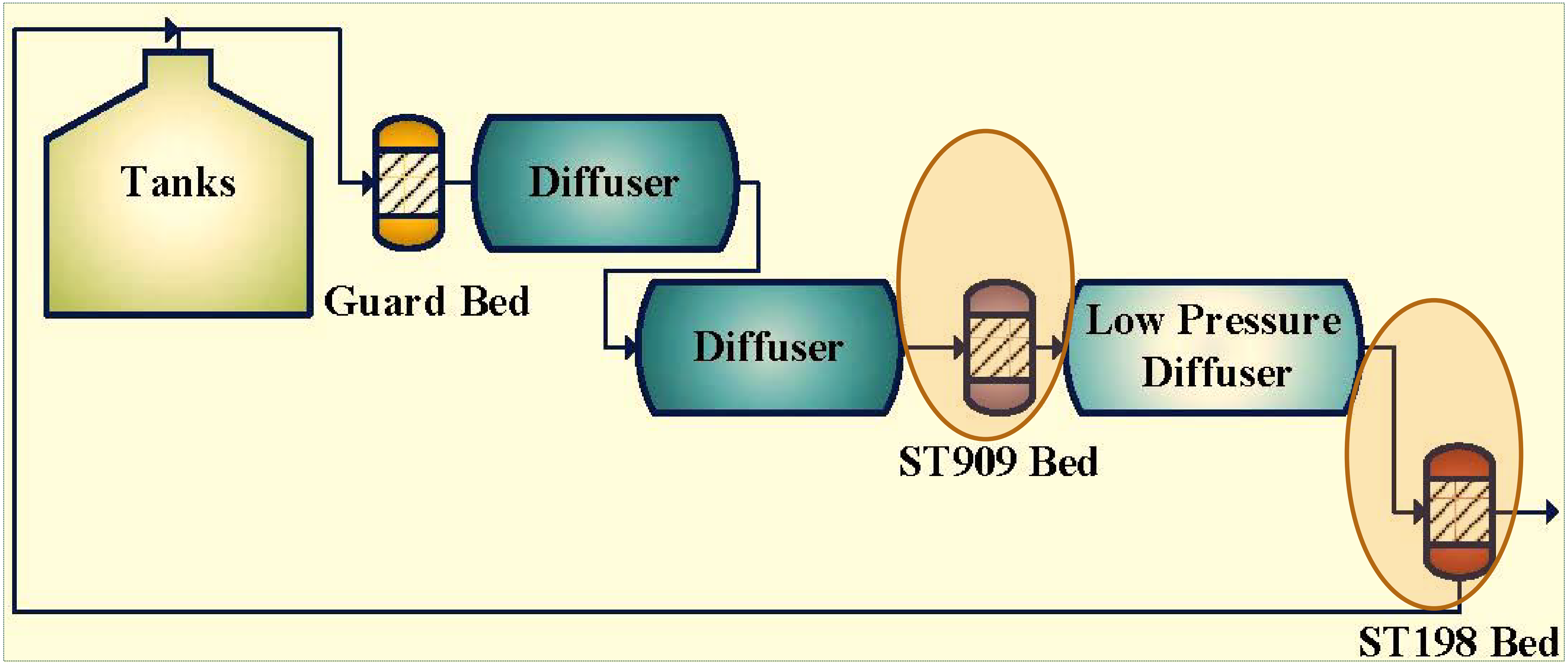
Overview

- Tritium Purification System
- ST909
- ST198
- Results of ST198 Impurity Testing
- Conclusions/Summary

TPS Overview

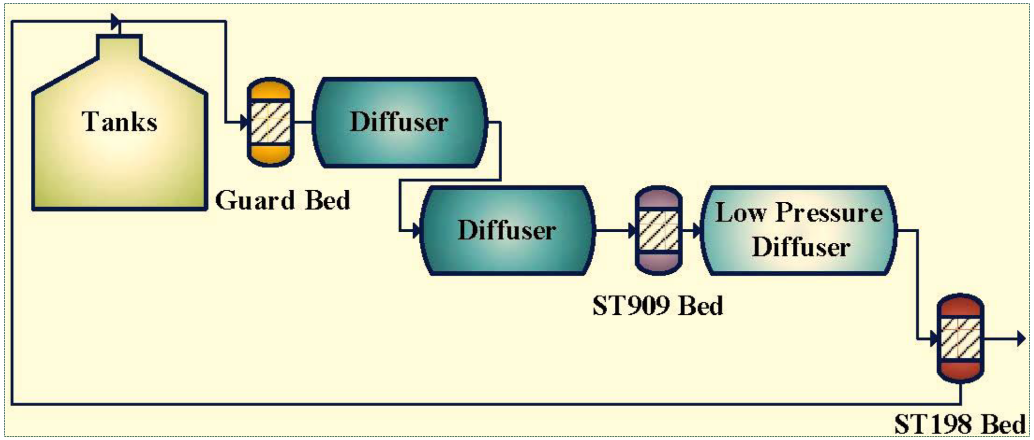


ST909 Characteristics

- **$Zr(Mn_{0.5}Fe_{0.5})_2$ or Zr-Mn-Fe (40.5% Zr, 24.5% Mn, 25.0% Fe, 10% Al)**
- **Manganese and iron – catalytic active sites for decomposition**
  - CH_4
  - NH_3
  - CO
  - CO_2
  - Q_2O
- **Zirconium - active sites for the gettering of elements**
  - O
  - N
  - C
- **Literature tells us**
  - Other getter materials, may have better methane cracking performance than ST909,
  - No other single material was best for use in helium, hydrogen, or nitrogen carrier gas streams

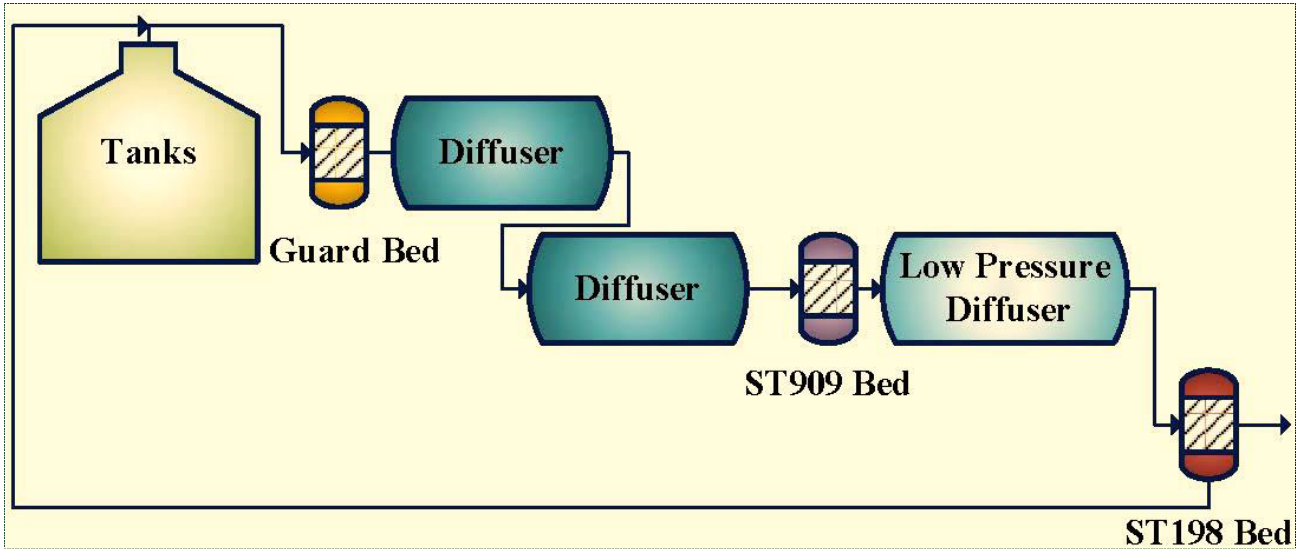
Challenges with ST909

- **SAES ST909 is expensive**
  - (~$4200-5300/kg, depending on the quantity of the material requested)
- **Consumable material**
- **Foreign sole source supplier**
- **Difficult to Obtain – Special Order**



What does ST909 have to do with ST198

- **Downstream effects if ST909 did not perform**
- **ST198 Impurity Testing**
- **Baseline Testing**
- **Impurity Effects**
  - CH_4
  - CO
  - NH_3



- **Effect of Temperature in relationship to Impurities**

Properties and Characteristics of ST198

- **ST198 is a metal alloy getter manufactured by SAES**
  - Nominal composition of 76.5% Zr and 23.5% Fe
  - Primary phase is Zr_2Fe

- **ST198 reacts with:**
  - hydrogen isotopes, oxygen, water, and other gases
  - unreactive towards nitrogen.

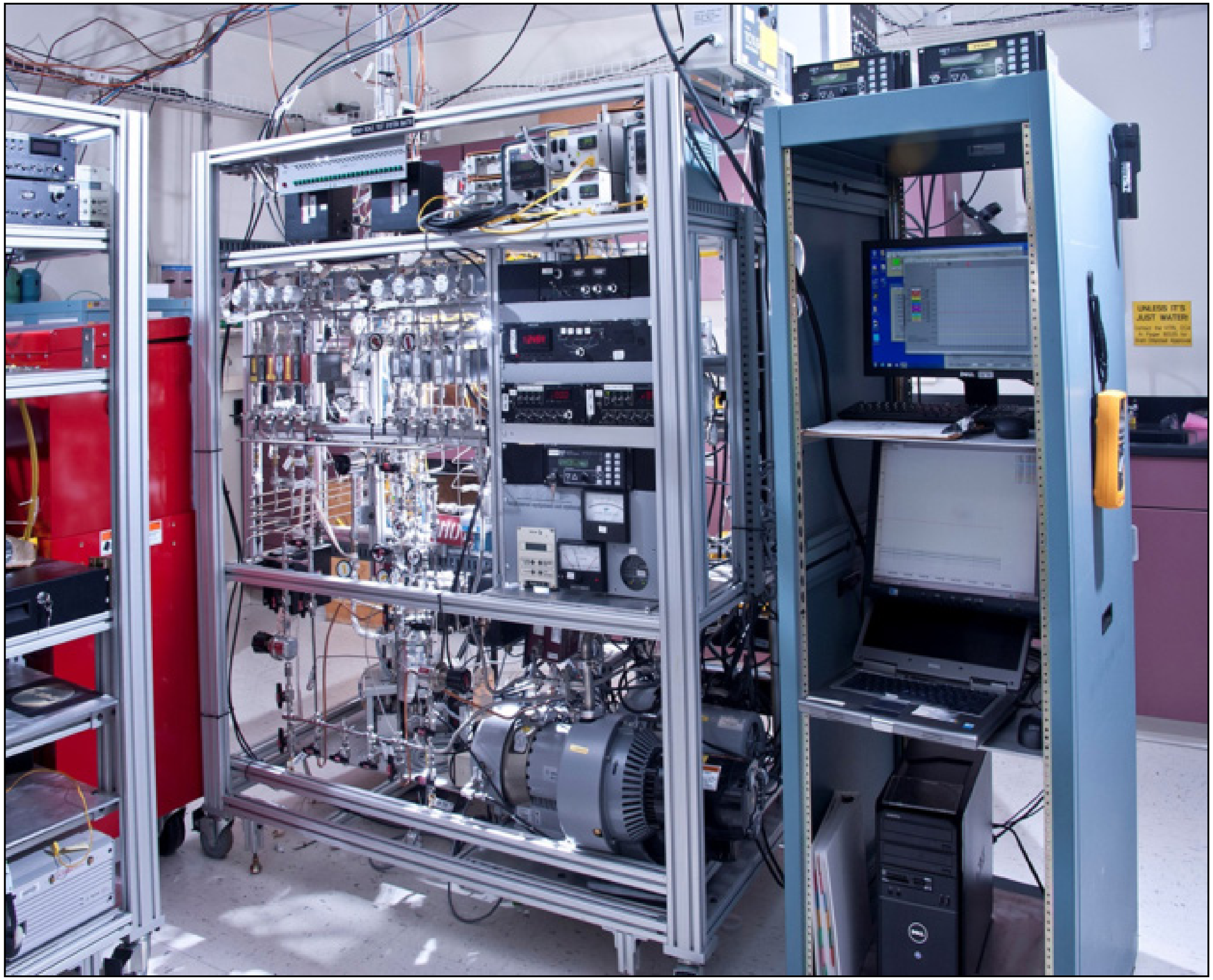
- **Each pellet is roughly 0.6 grams with a density of 5.3 g/cm_3**

- **Useful for tritium removal from process gas streams with low tritium concentrations.**
  - Removes tritium without the formation of tritiated water
  - Tritium is unrecoverable

Experimental Apparatus

Experimental Test System

- Pressure transducers
- MKS Flow Controllers
- Gas supplies of Ar, N_2, and H_2
- 2 Residual Gas Analyzers
- 1 Inficon micro GC
- Flow through testing

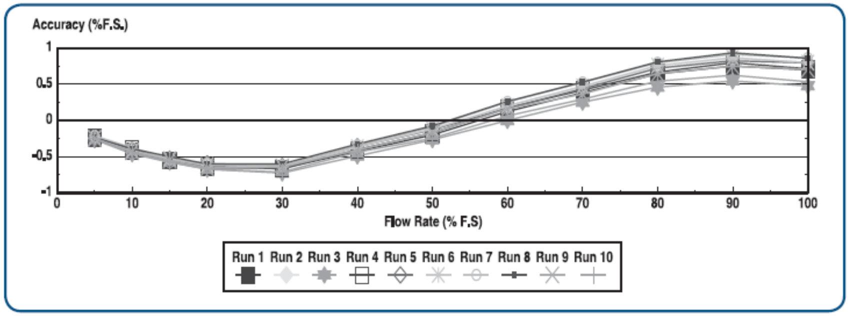


ST198 Test Matrix

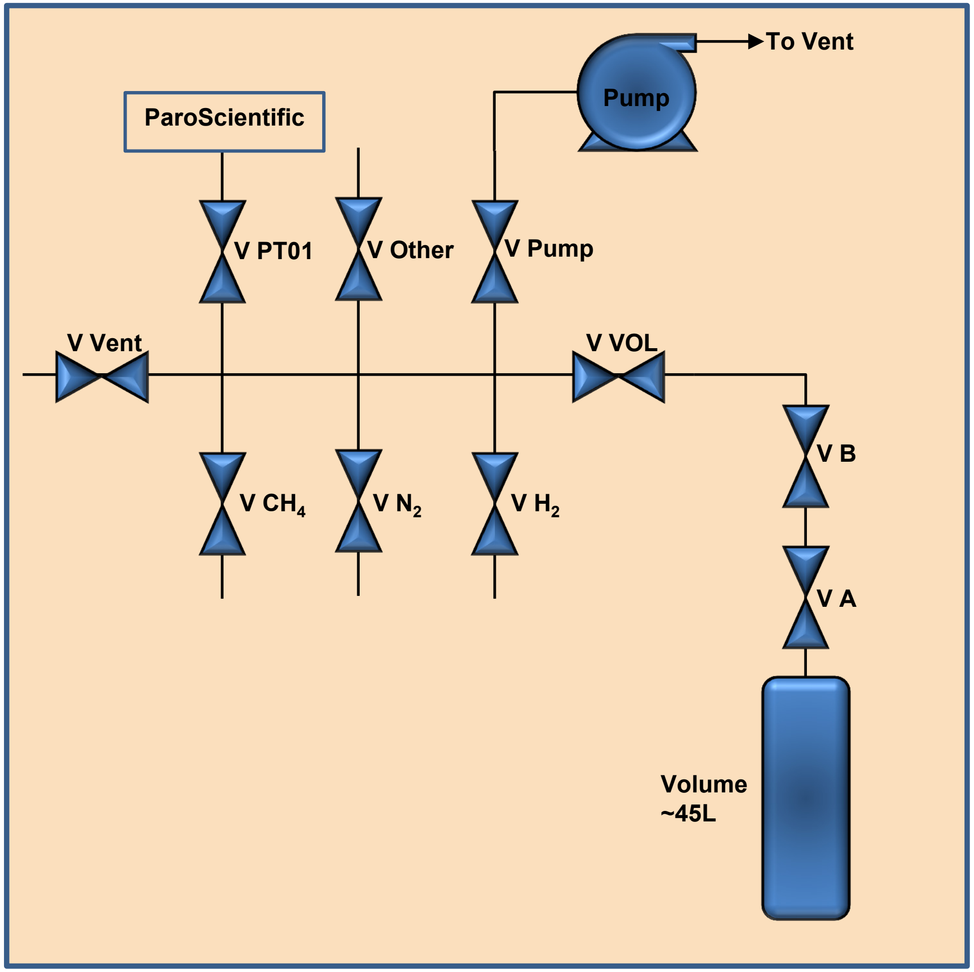
ST198 Test	Gas Constituents (percent by volume)	Test Cell Temperature (°C)
1	1% H_2, 99% N_2	350
2	1% H_2, 99% N_2	24
3	0.1% H_2, 99.9% N_2	350
4	0.1% H_2, 99.9% N_2	24
5	0.1% H_2, 0.1% CH_4, 99.8% N_2	350
6	0.13% H_2, 0.1% $CH_{4,}$ 0.1% NH_3, 99.67% N_2	350
7	0.13% H_2, 0.1% $CH_{4,}$ 0.1% NH_3, 99.67% N_2	350
8	0.13% H_2, 0.1% $CH_{4,}$ 0.1% NH_3, 99.67% N_2	24
9	0.1% H_2, 0.1% $CH_{4,}$ 0.05% NH_3, 99.75% N_2	350
10	0.1% H_2, 0.1% $CH_{4,}$ 0.05% NH_3, 99.75% N_2	24
11	0.1% H_2, 0.1% CO, 99.8% N_2	350
12	0.1% H_2, 0.1% CO, 99.8% N_2	24
13	0.1% H_2, 0.1% CO, 99.8% N_2	24
14	0.1% H_2, 0.1% CO, 99.8% N_2	350
15	0.1% H_2, 0.1% CH_4, 99.8% N_2	24

Preparation of Gas Mixtures

- Low concentration of impurities could not be reliably controlled with flow controllers at low flow rates

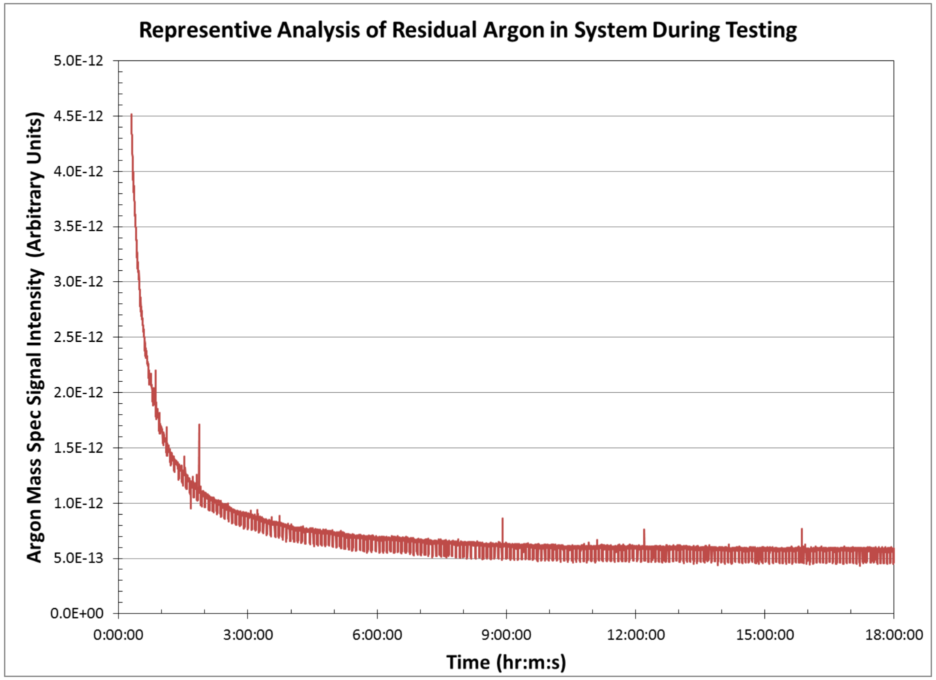


- Assembled a gas mixing manifold to prepare gas mixtures with low levels of H_2 and various impurities.



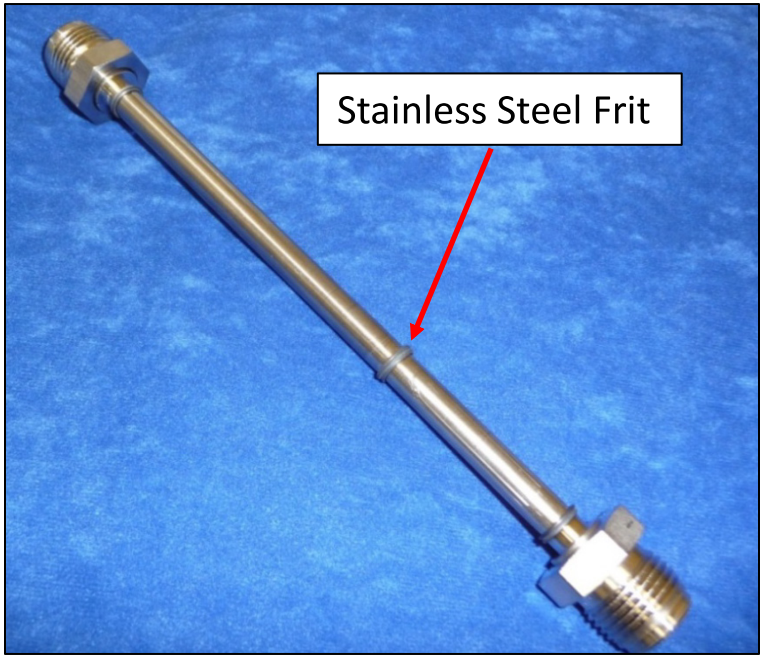
Activation Protocol

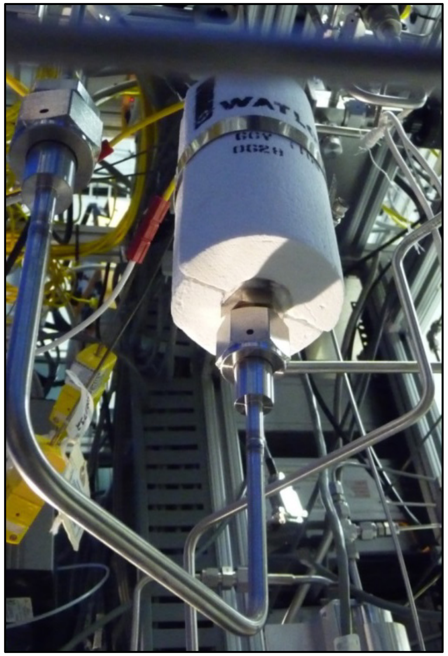
- **Argon purge at ambient temperature to displace the residual air after activation**
  - 30 sccm and ~1875 torr
- **Nominal temperature ramp to 450°C for 4 hours**
- **Evacuation of the system for 1-2 hours to remove the residual argon**

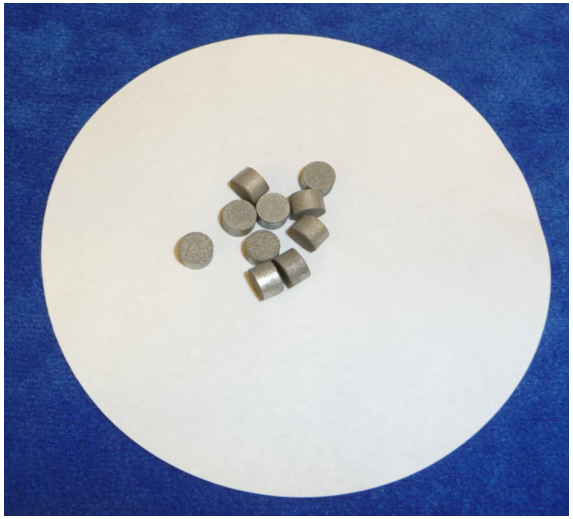


- **Upon completion of the activation the sample temperature was lowered to 350°C or 24°C depending on the test protocol.**

Test Cell Configuration



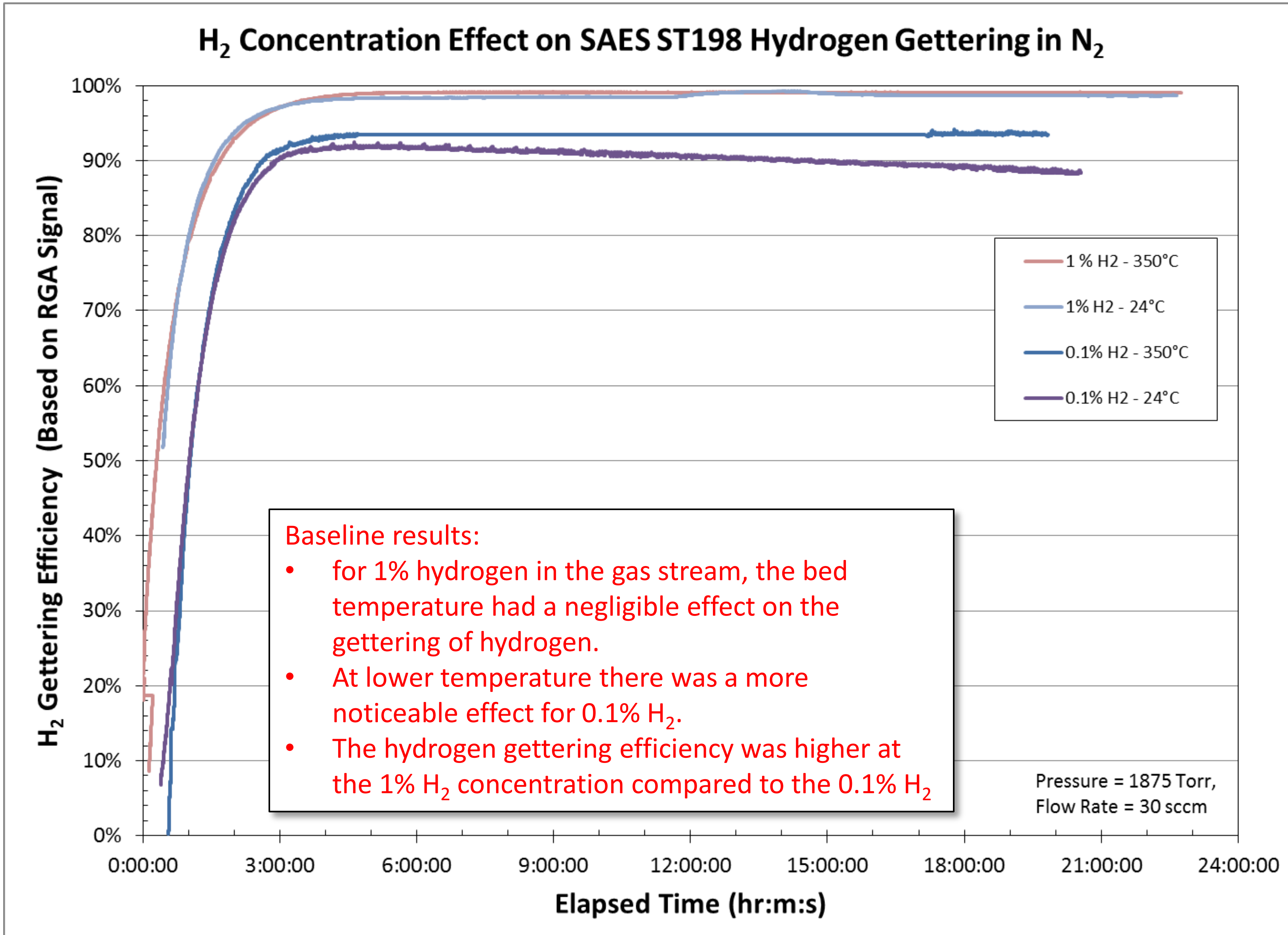




- ¼" diameter tubing 9" long
- VCR #8 fittings
- Welded Fritted Disk up about 1/3 of the way
- Vertical Configuration

- Approximately 6 grams total
- 10 Pellets
  - Right cylinder pellets
  - 6 mm diameter x 4 mm tall
- Stacked configuration

Effect of H_2 Concentration on Gettering



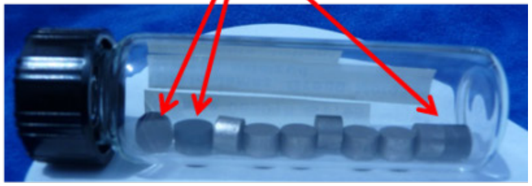
Baseline results:

- for 1% hydrogen in the gas stream, the bed temperature had a negligible effect on the gettering of hydrogen.
- At lower temperature there was a more noticeable effect for 0.1% H_2.
- The hydrogen gettering efficiency was higher at the 1% H_2 concentration compared to the 0.1% H_2

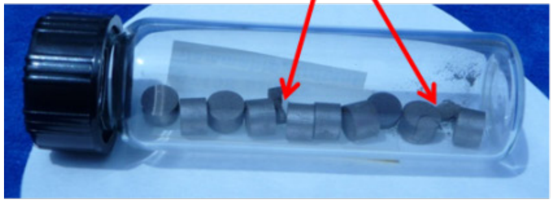
ST198 Decrepitation

Virgin ST198 Pellets

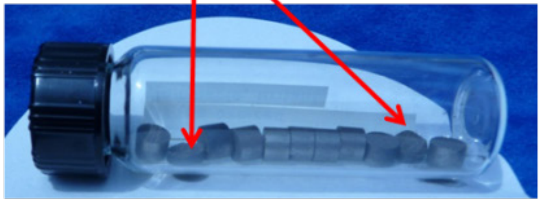
1% H_2
350°C



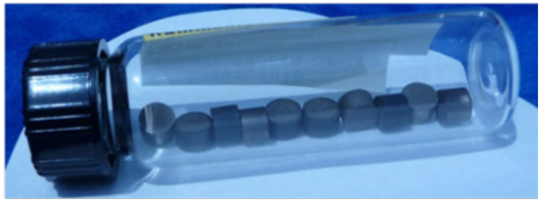
0.1% H_2
350°C



0.1% H_2
24°C

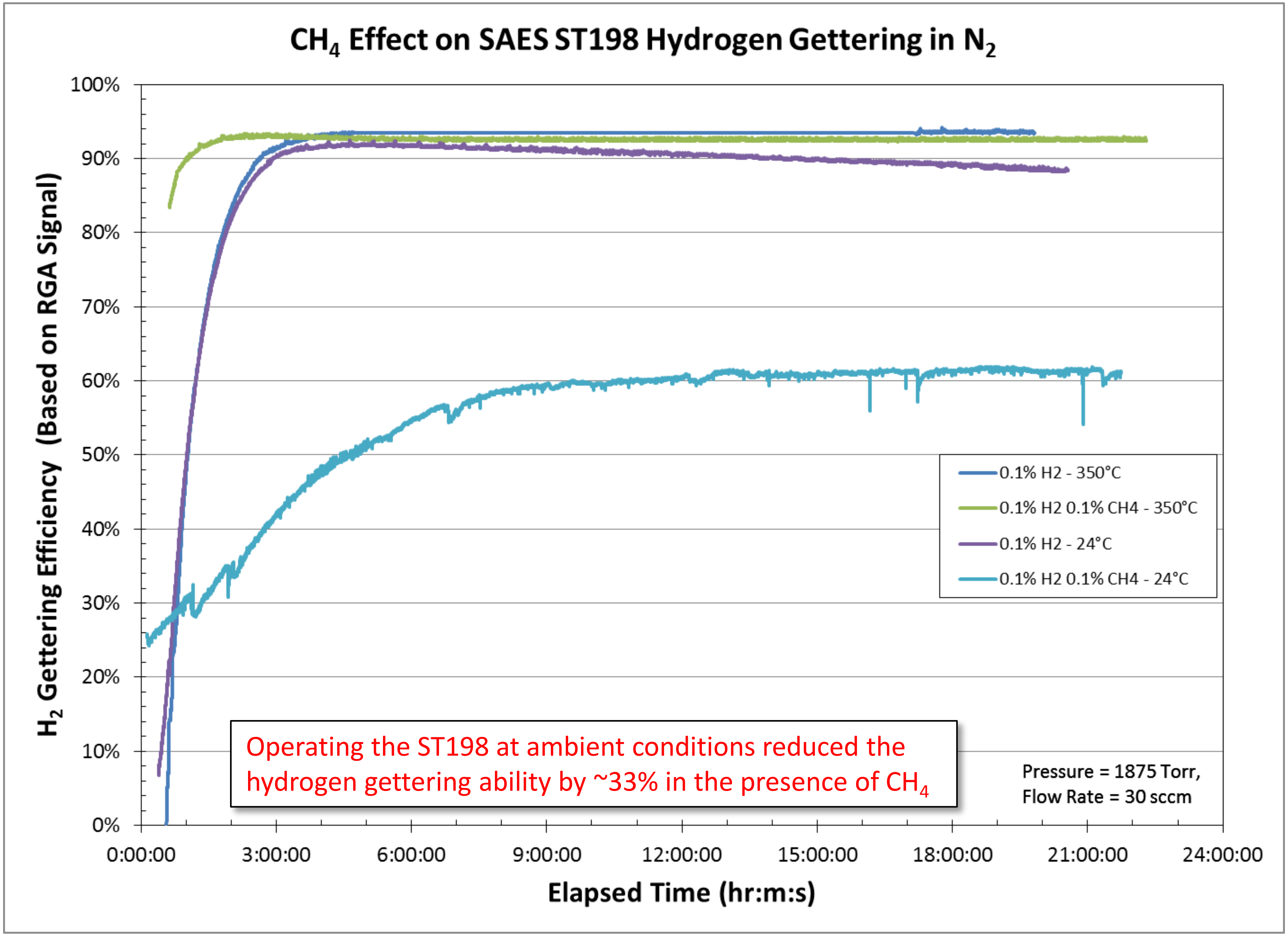


0.1% H_2, 0.1% CH_4
350°C

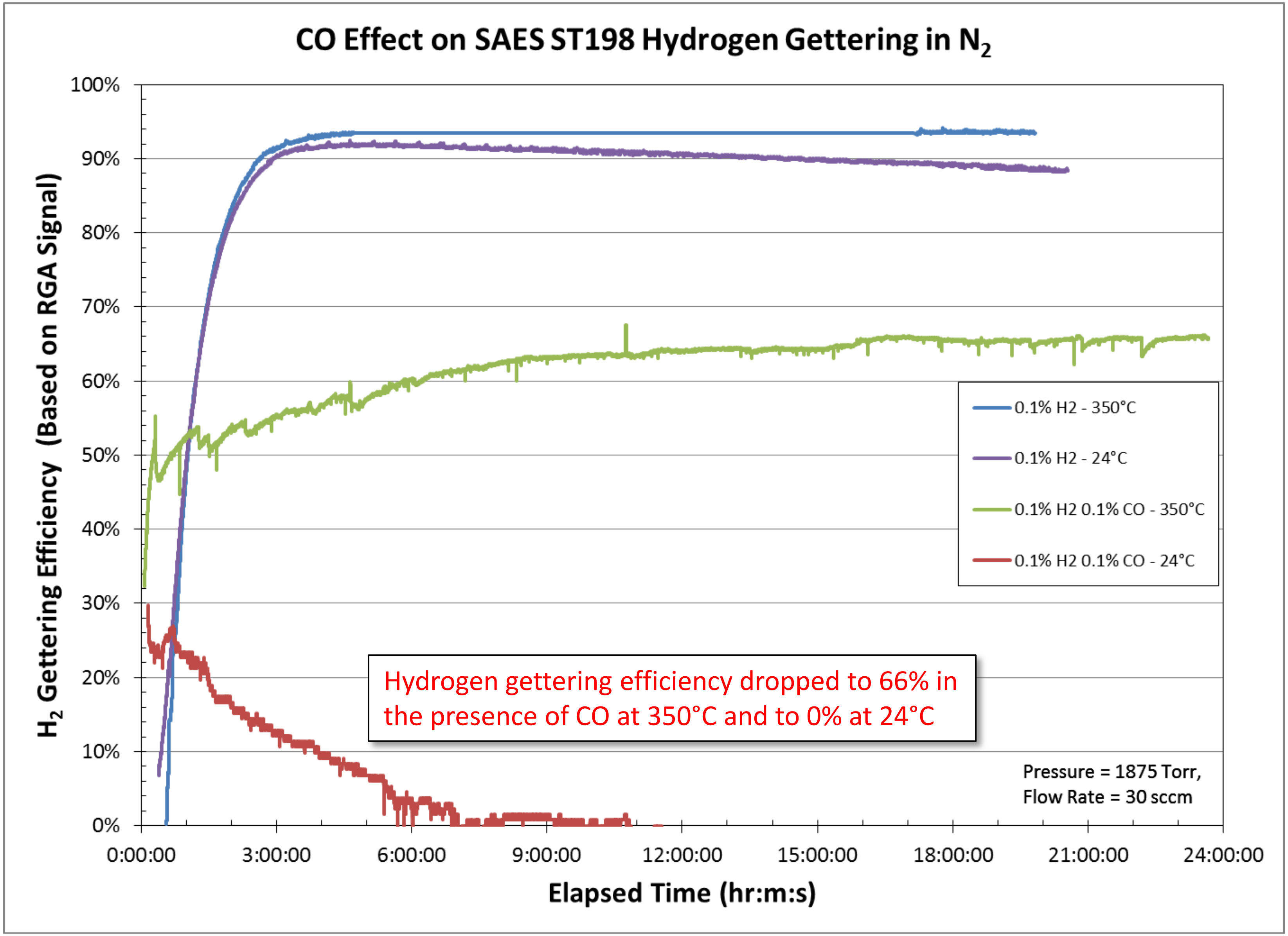


0.1% H_2, 0.1% CH_4 0.1% NH_3
350°C

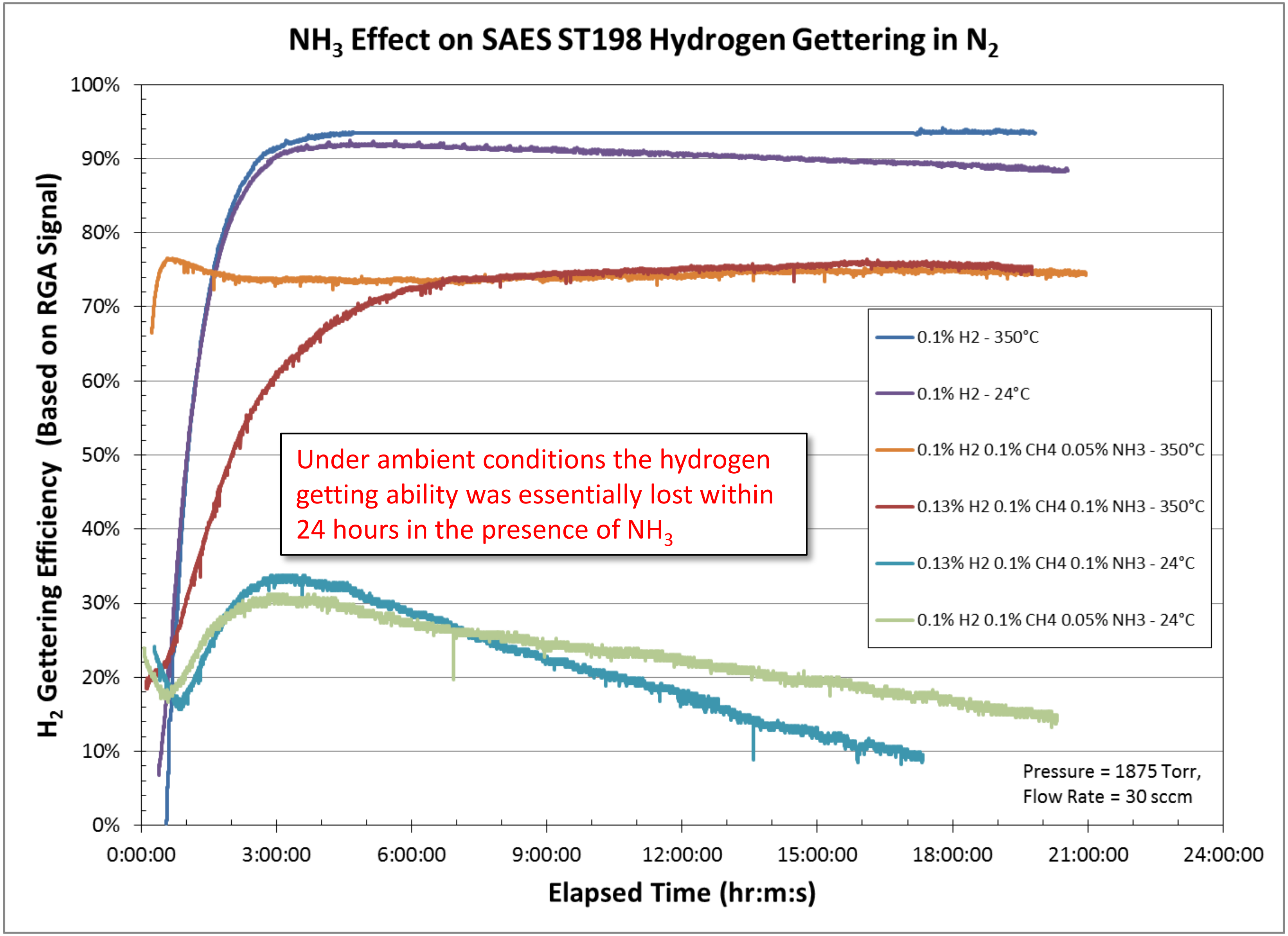
Effect of CH_4 on H_2 Gettering Ability of ST198



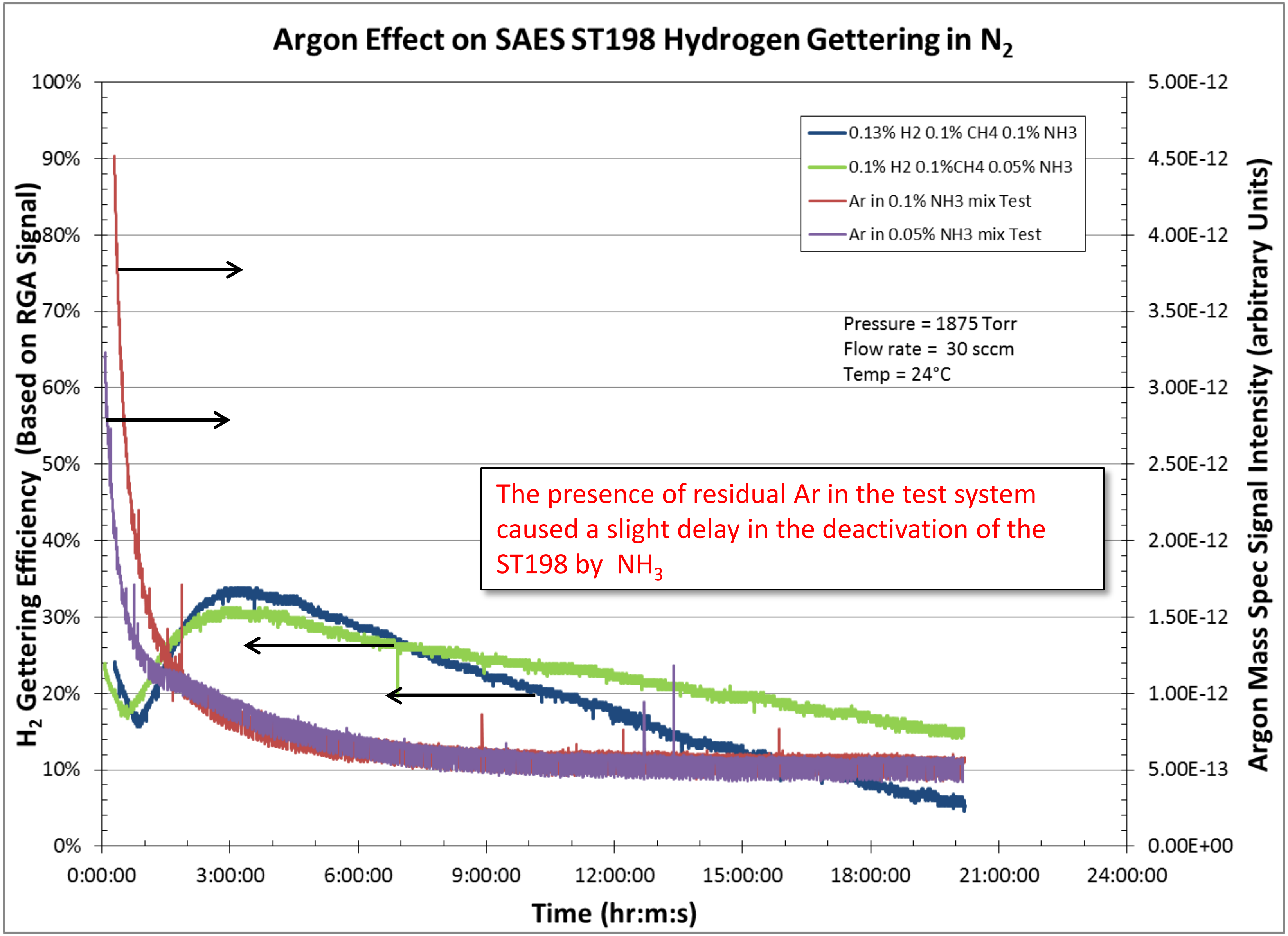
Effect of CO on H_2 Gettering Ability of ST198



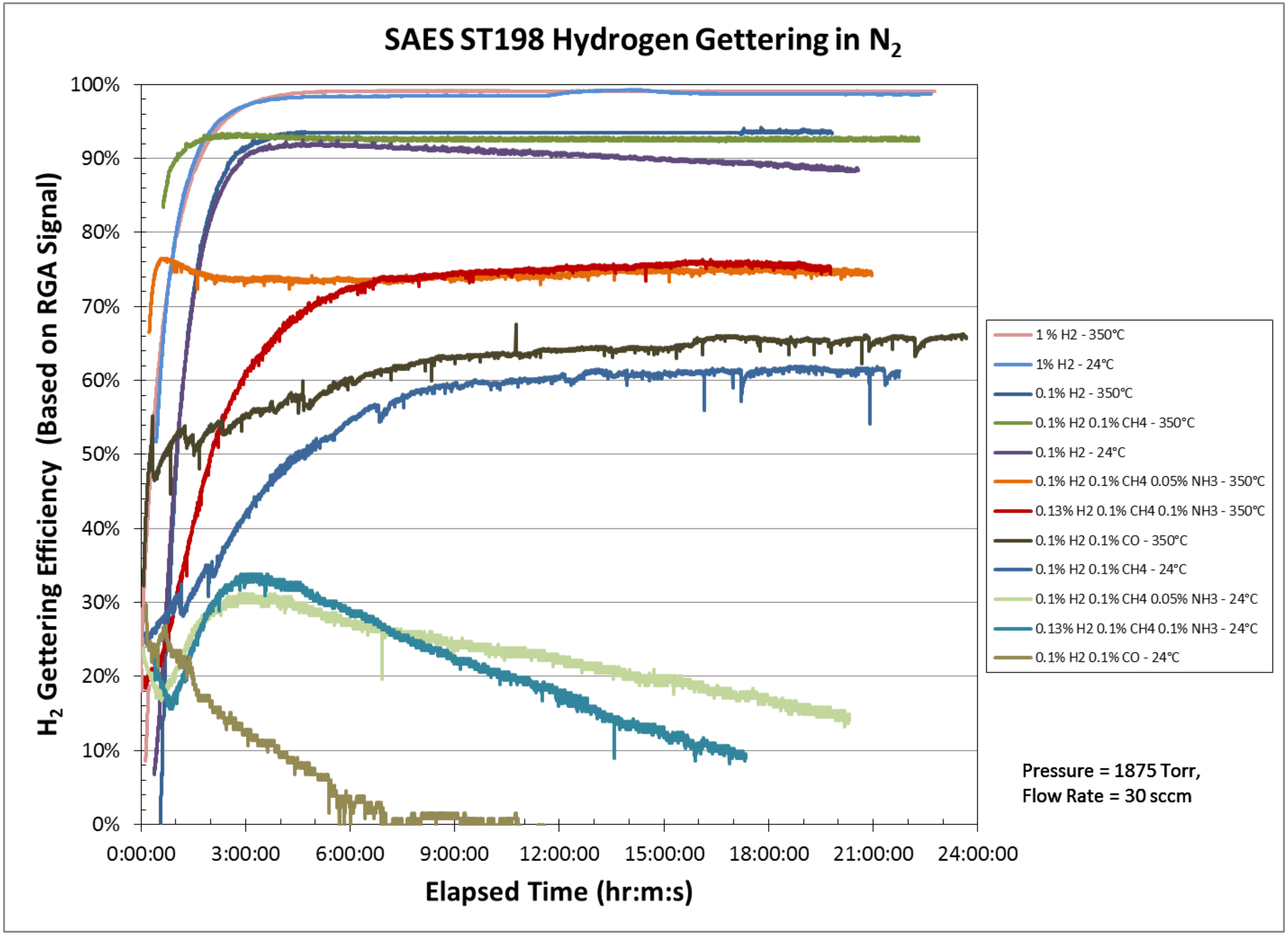
Effect of NH_3 on H_2 Gettering Ability of ST198



Effect of NH_3 on H_2 Gettering Ability of ST198



Alternative Getter Materials - Summary



Conclusions

- **1% hydrogen in the gas stream bed temperature negligible effect**
- **At ambient conditions impurities compromised ST198 hydrogen gettering ability to a greater extent than at higher temperatures.**
- **Experiments showed only a slight reduction of gettering ability with the addition of methane (CH_4) at 350°C.**
- **At ambient temperature conditions, the hydrogen gettering efficiency was reduced by 33% in the presence of CH_4.**
- **Reduction of hydrogen gettering with carbon monoxide at both temperatures.**
  - Reduction of hydrogen gettering capability dropped ~29% for the tests at 350°C (compared to baseline capabilities as related to the reduction of the RGA signal from the mass spectrometer).
  - At ambient conditions, the hydrogen gettering effectiveness was reduced to zero within 10 hours upon contact with CO.
- **At ambient temperature, ammonia also reduced the hydrogen gettering efficiency but to a lesser extent than the CO.**

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Thanks for your attention!!