Development and Field Testing of a Dynamically Spiked Controlled Condensation Train

Presented at SSSAAP
Stationary Source Sampling and Analysis for Air Pollutants Conference
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Presented by
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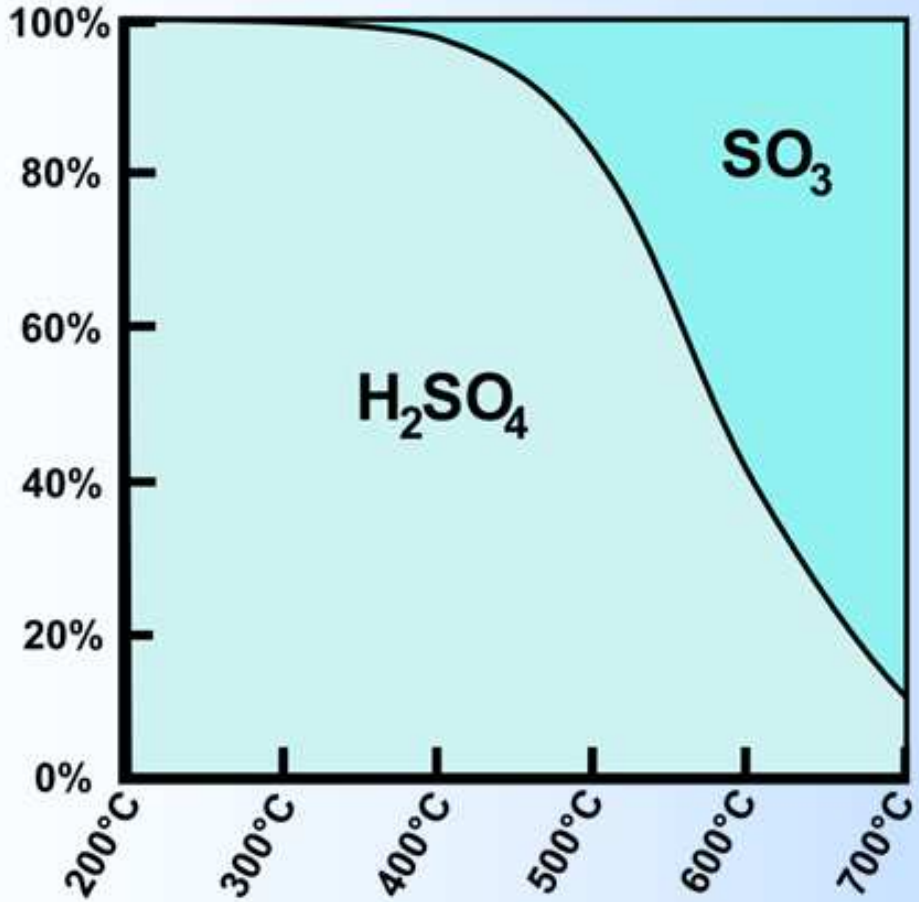
Why Spike?

SO_3 ➡ H_2SO_4 (vapor) ➡ H_2SO_4 (mist)



- SO_3/H_2SO_4 difficult to measure
- SO_3/H_2SO_4 validation sources don't exist
- Measurement Techniques
  - Based on theory
  - Have not been validated
  - May contain biases for common situations

Dale A. Lundgren, Paul Urone and Thomas Gundersn, "A Stack Gas Sulfate Aerosol Measurement Problem", In Workshop Proceedings on Primary Sulfate Emissions from Combustion Sources, Volume 1, EPA-600/9-78-02tia, (August 1978), pp. 161-178

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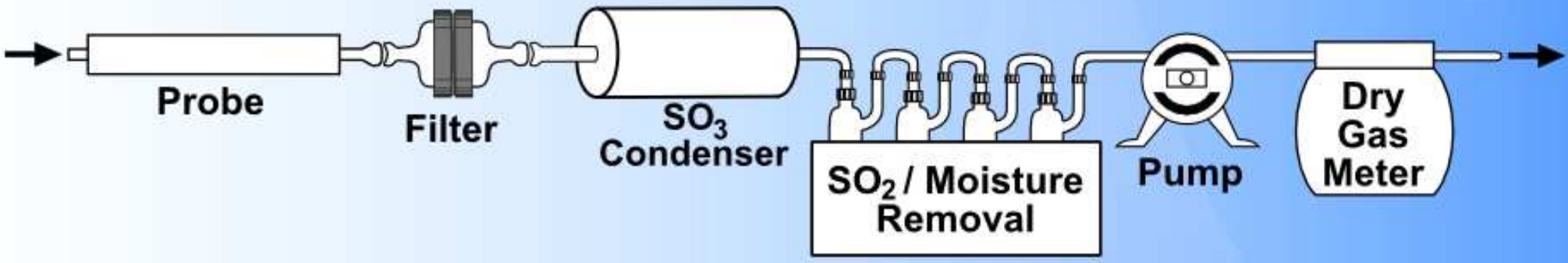
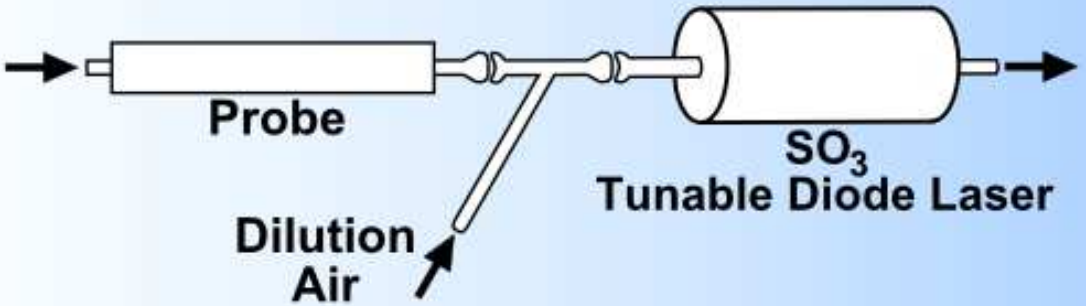
Measurement Techniques

Manual Methods, Including Controlled Condensation (Method 8 and Various CCMs)



Continuous Methods, Still Under Development (QCL/TDL, FTIR, etc.)



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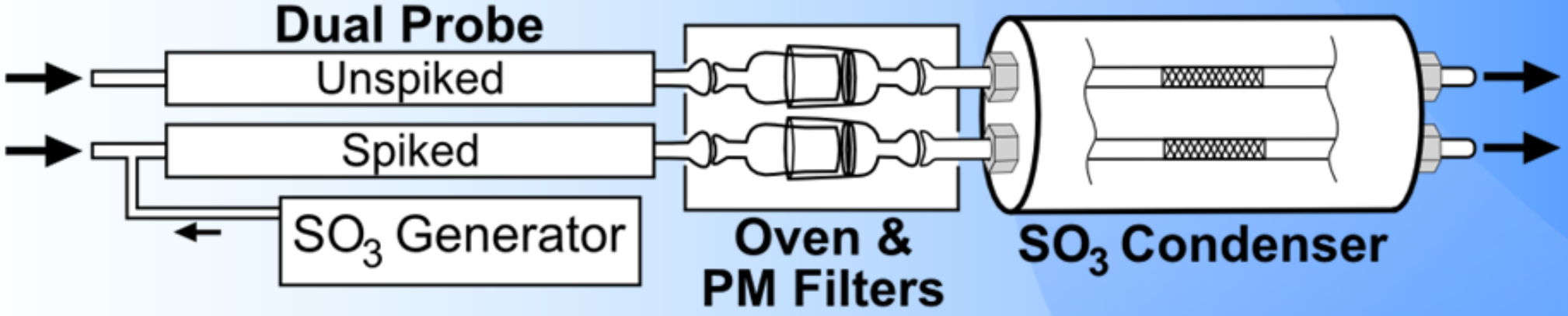
Dynamic Spiking Concept

- Dual controlled condensation sampling trains:
  - One Spiked
  - One Unspiked
- Generate SO_3 on demand using platinum catalyst
- Inject a known amount of SO_3 into spiked train probe tip
- Compare spiked train recovery to unspiked train recovery
- Determine method bias based on spike recovery



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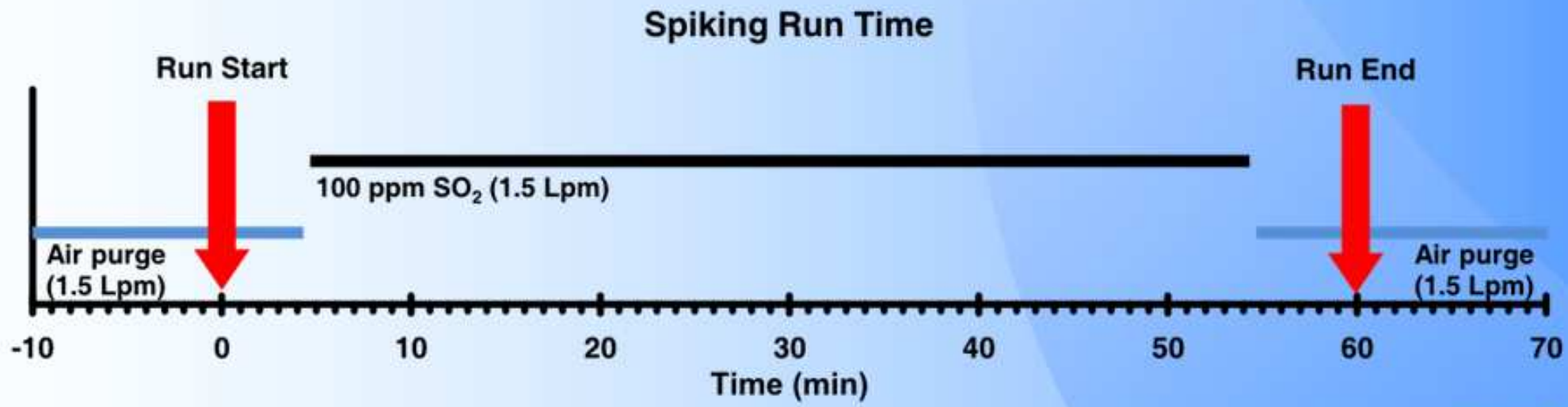
Dynamic Spiking Run

- Constant rate of spike (20% of sample rate)
- Batch collection of spike in condenser
- Spike measured in mg sulfate

$$m_{spike} = MW_{SO_4^{-2}} \cdot x_{conv.} \cdot \frac{C_{spike} \cdot P \cdot Q_{spike} \cdot t_{spike}}{R \cdot T \cdot 1{,}000{,}000}$$



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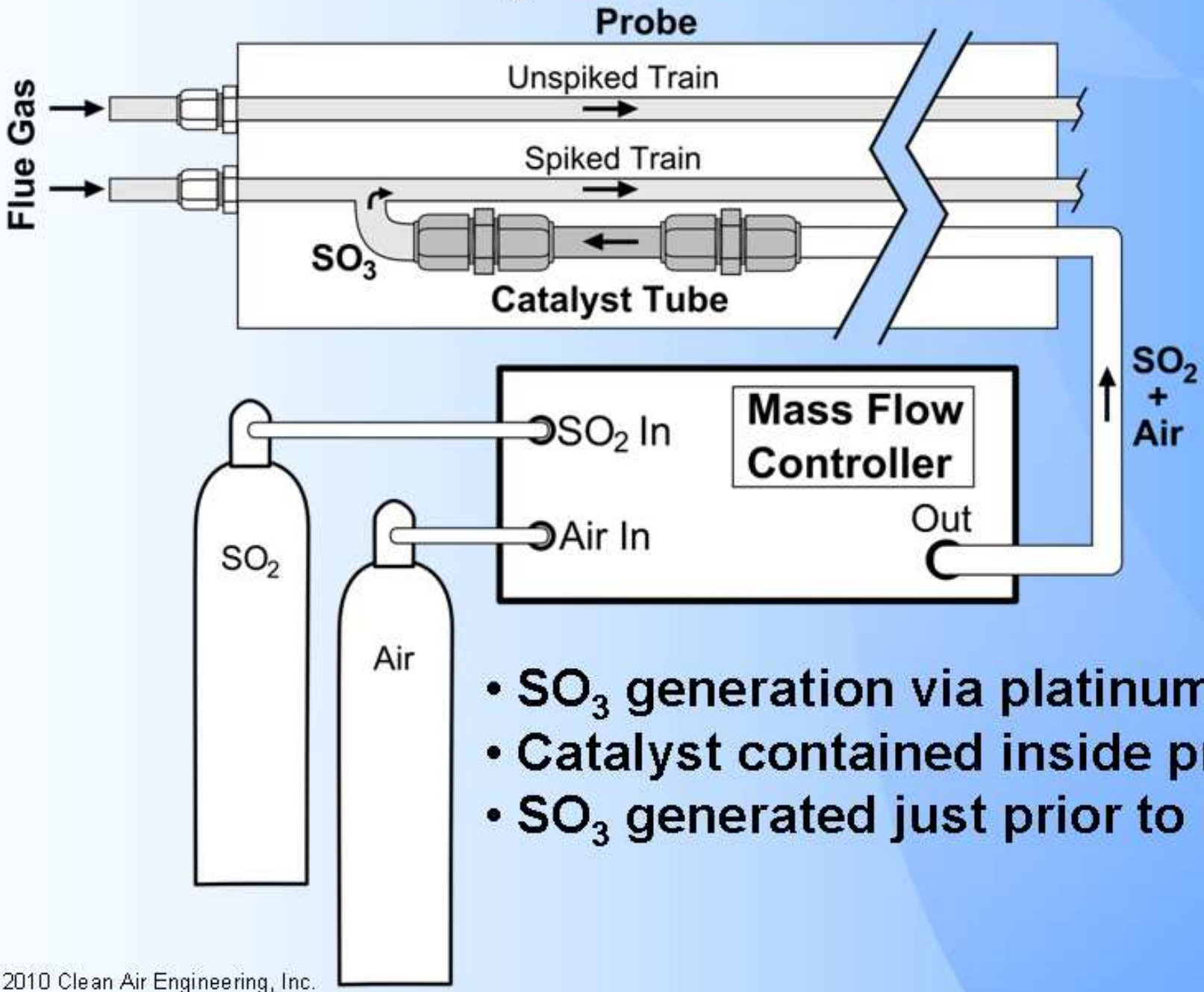
SO_3 Generation



- SO_3 generation via platinum catalyst
- Catalyst contained inside probe
- SO_3 generated just prior to injection

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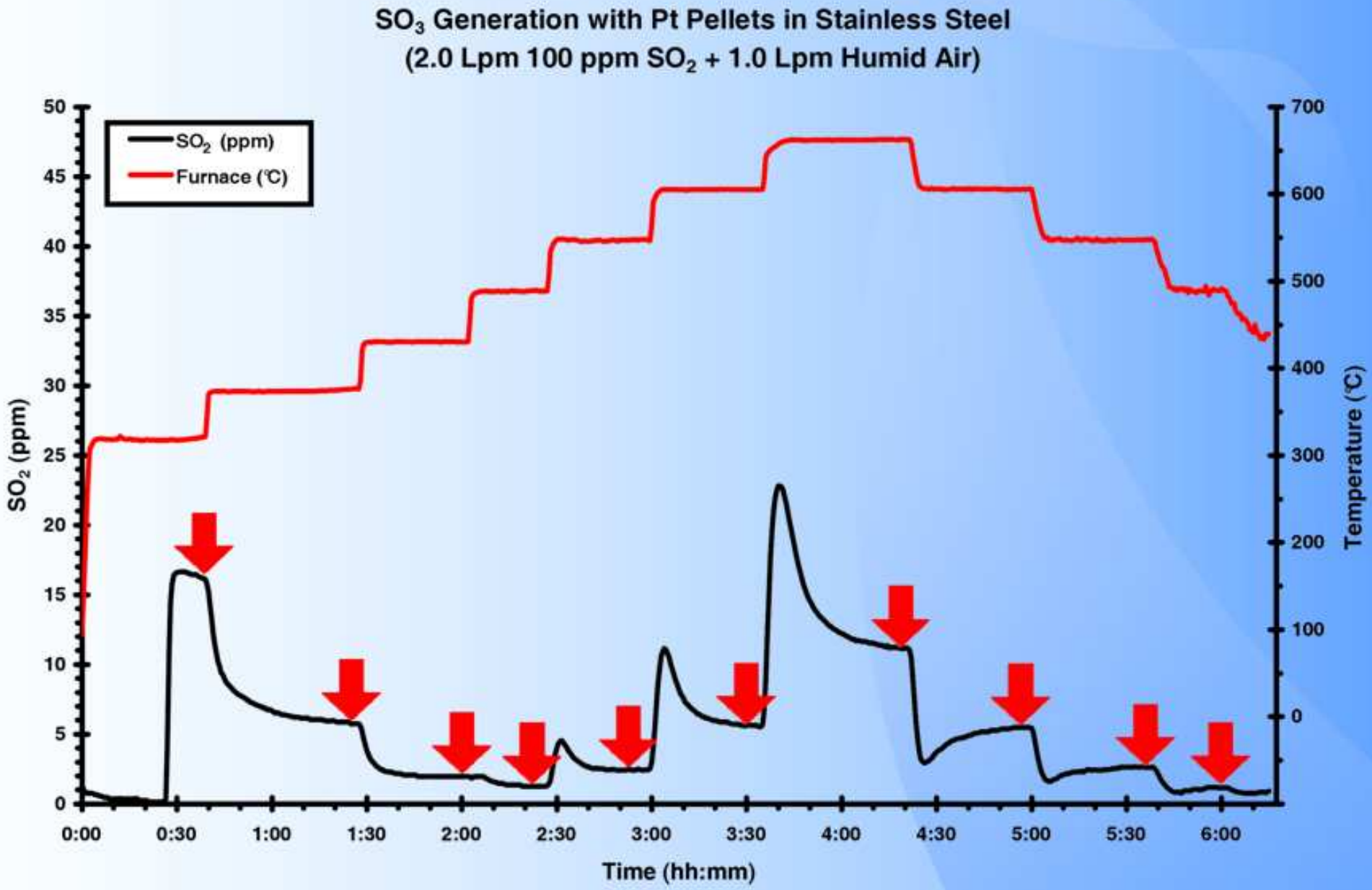
SO_3 Generation Testing



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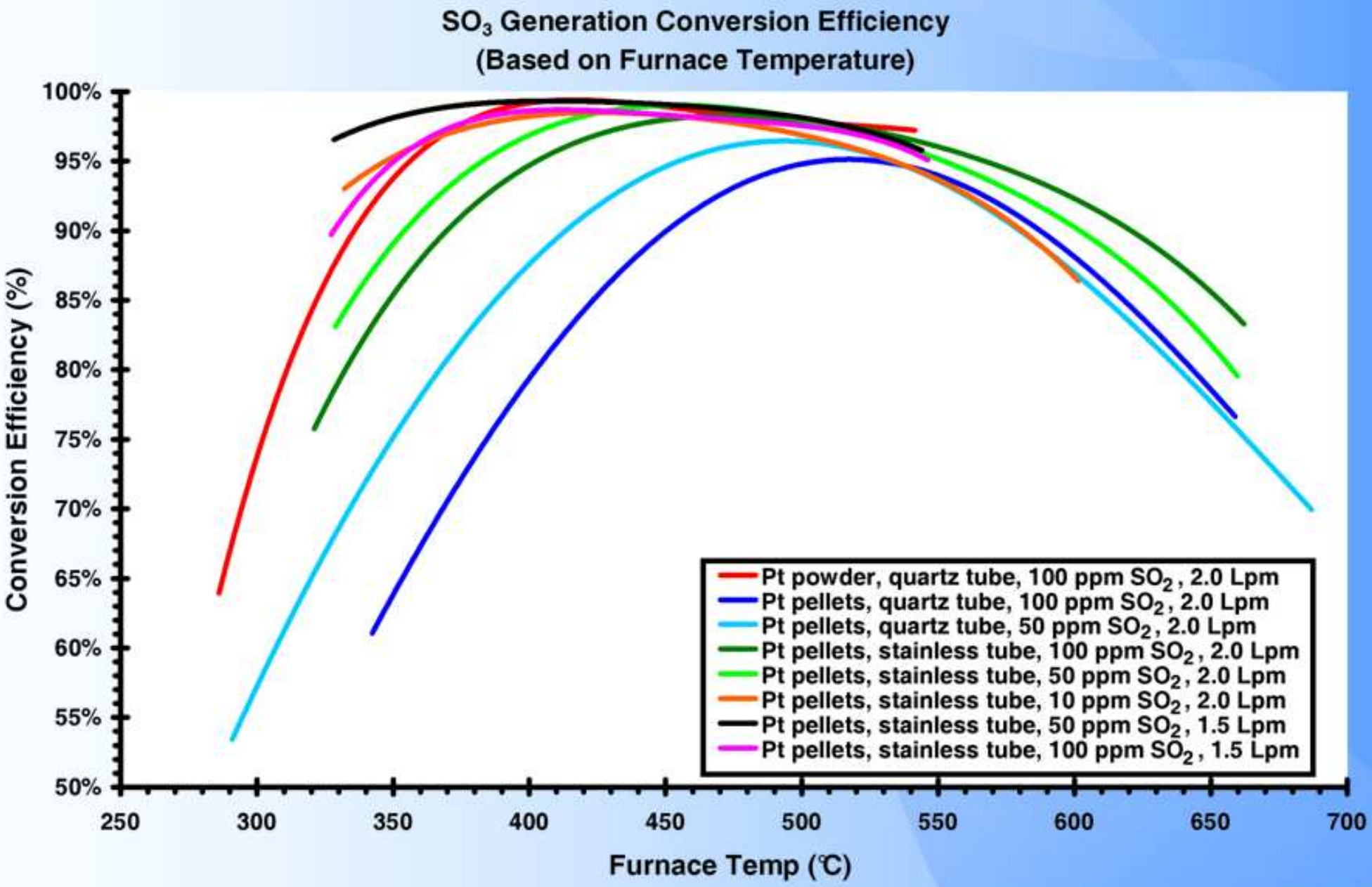
SO_3 Generation Conditions



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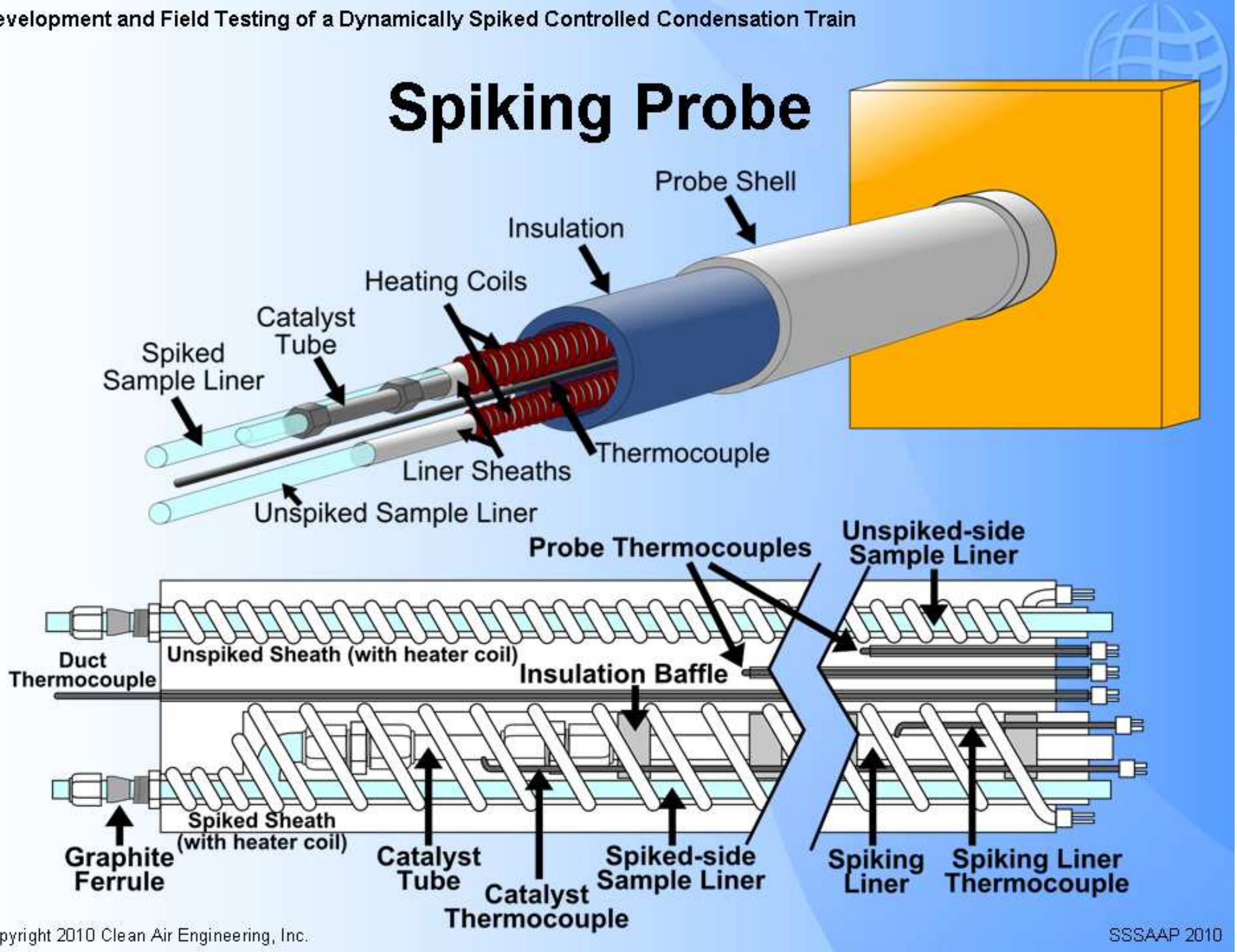

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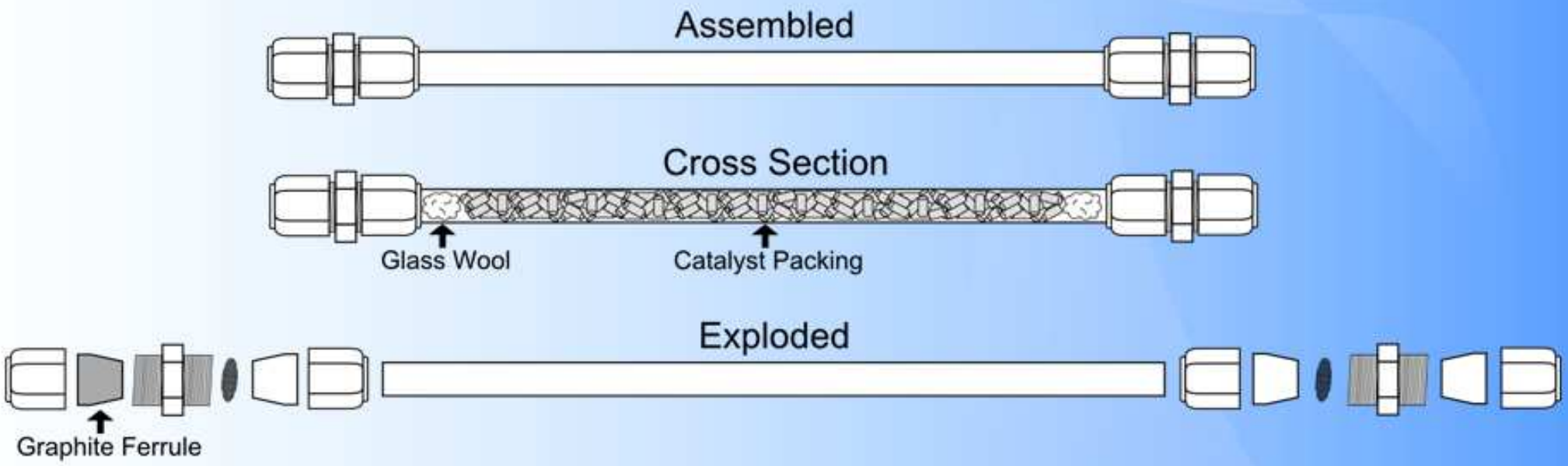
Catalyst Tube



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Picture – Spiking Probe (new)

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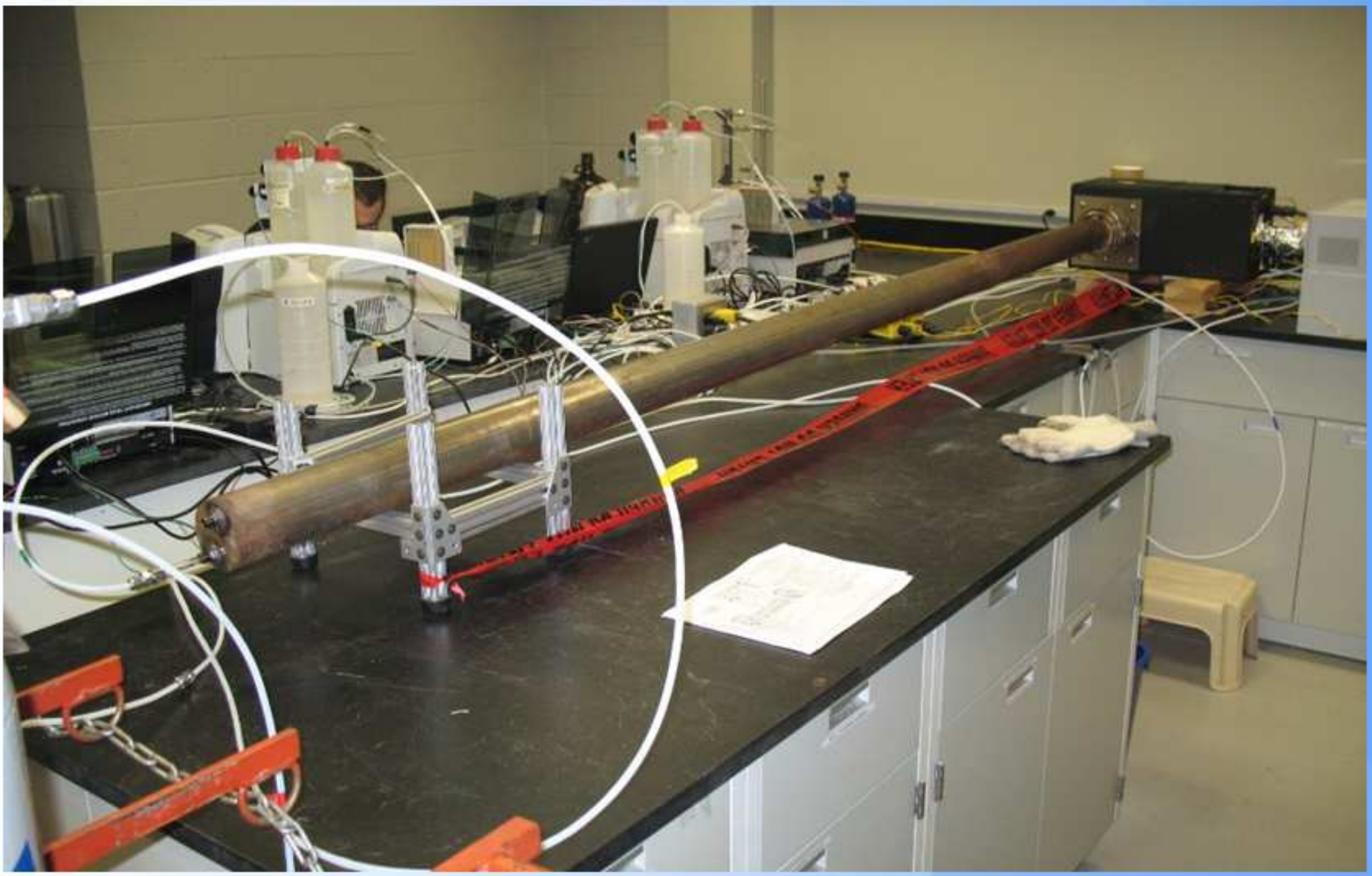
Picture – Spiking Probe (used)



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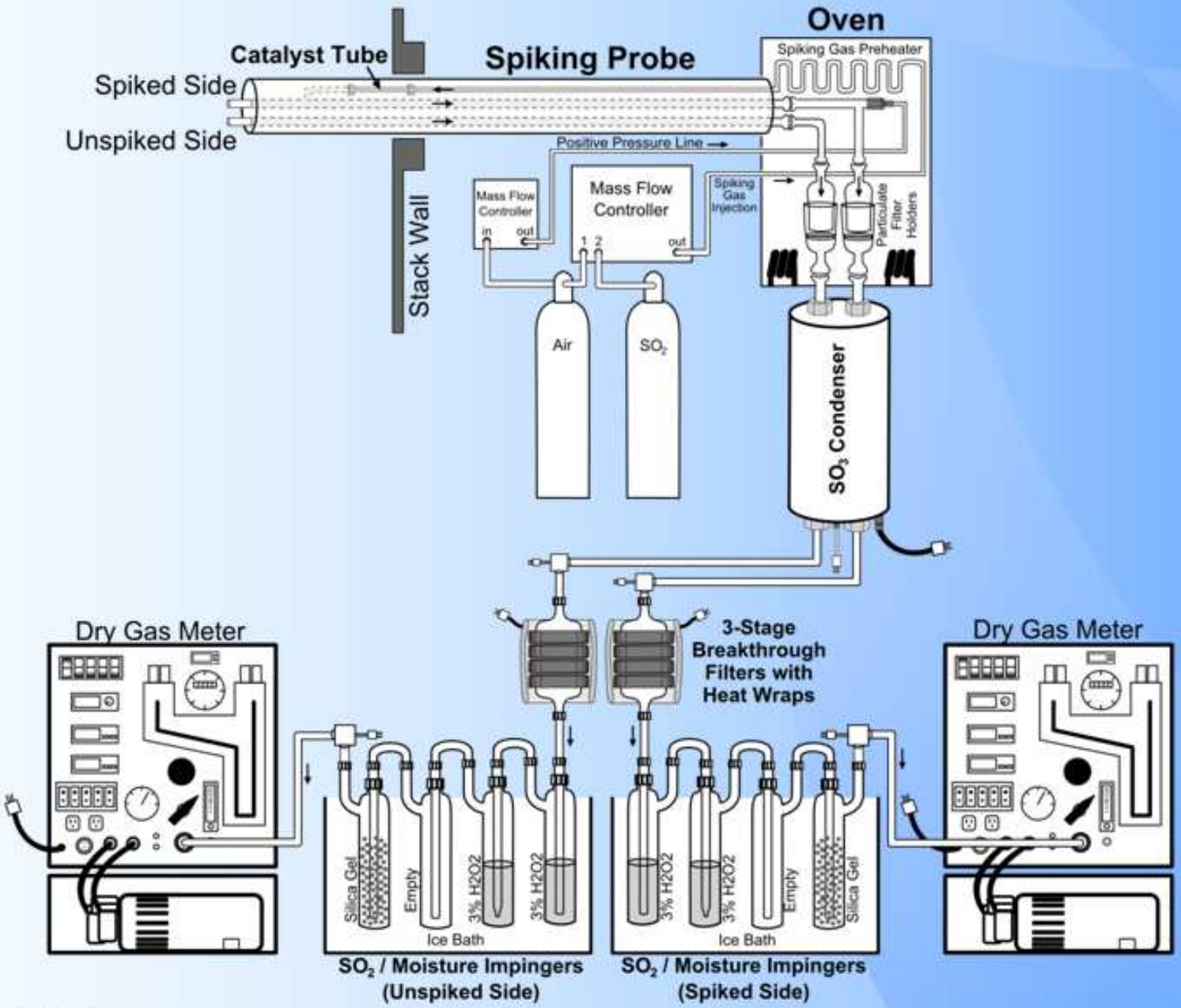
Spiking System Setup



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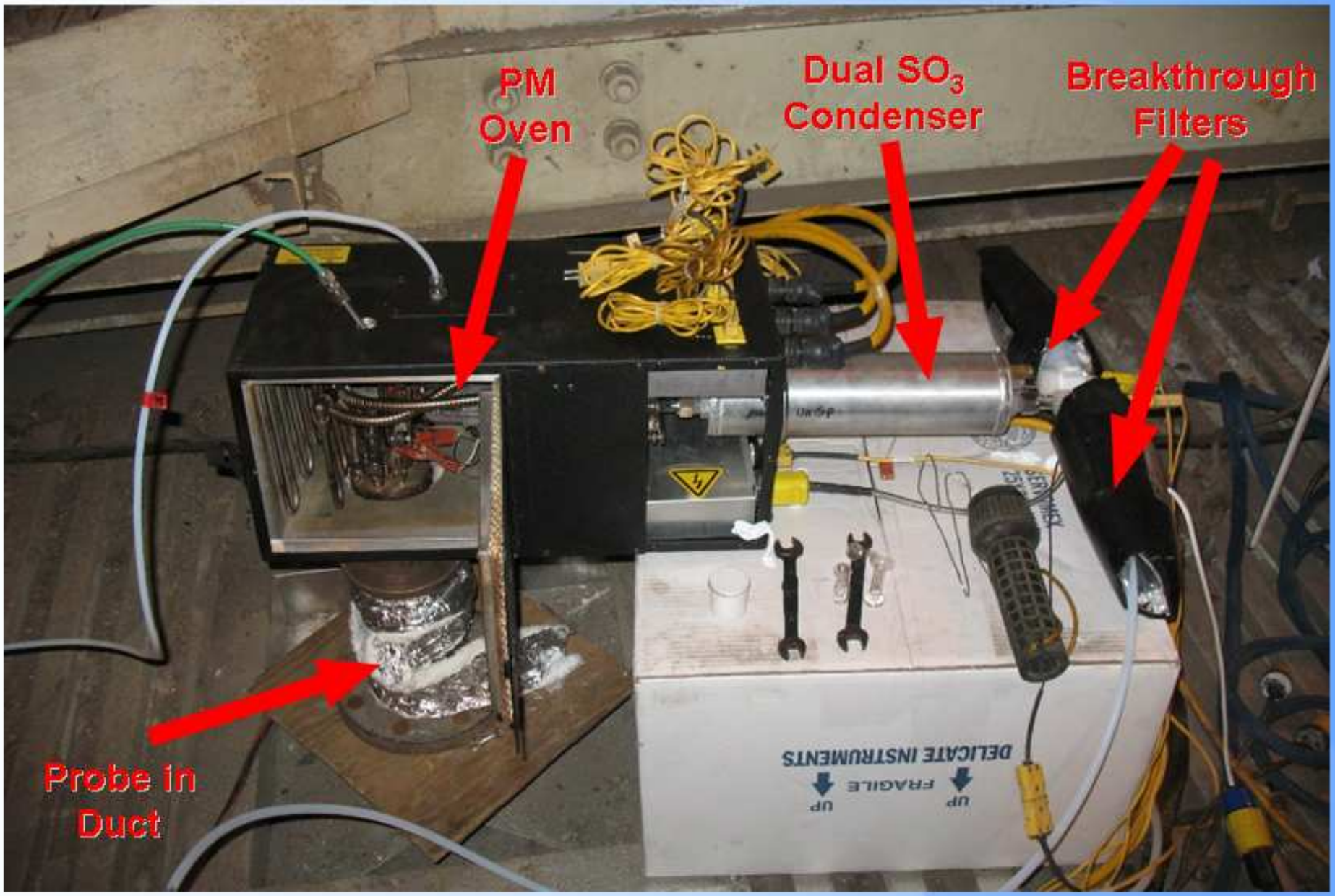
Picture – Location Setup



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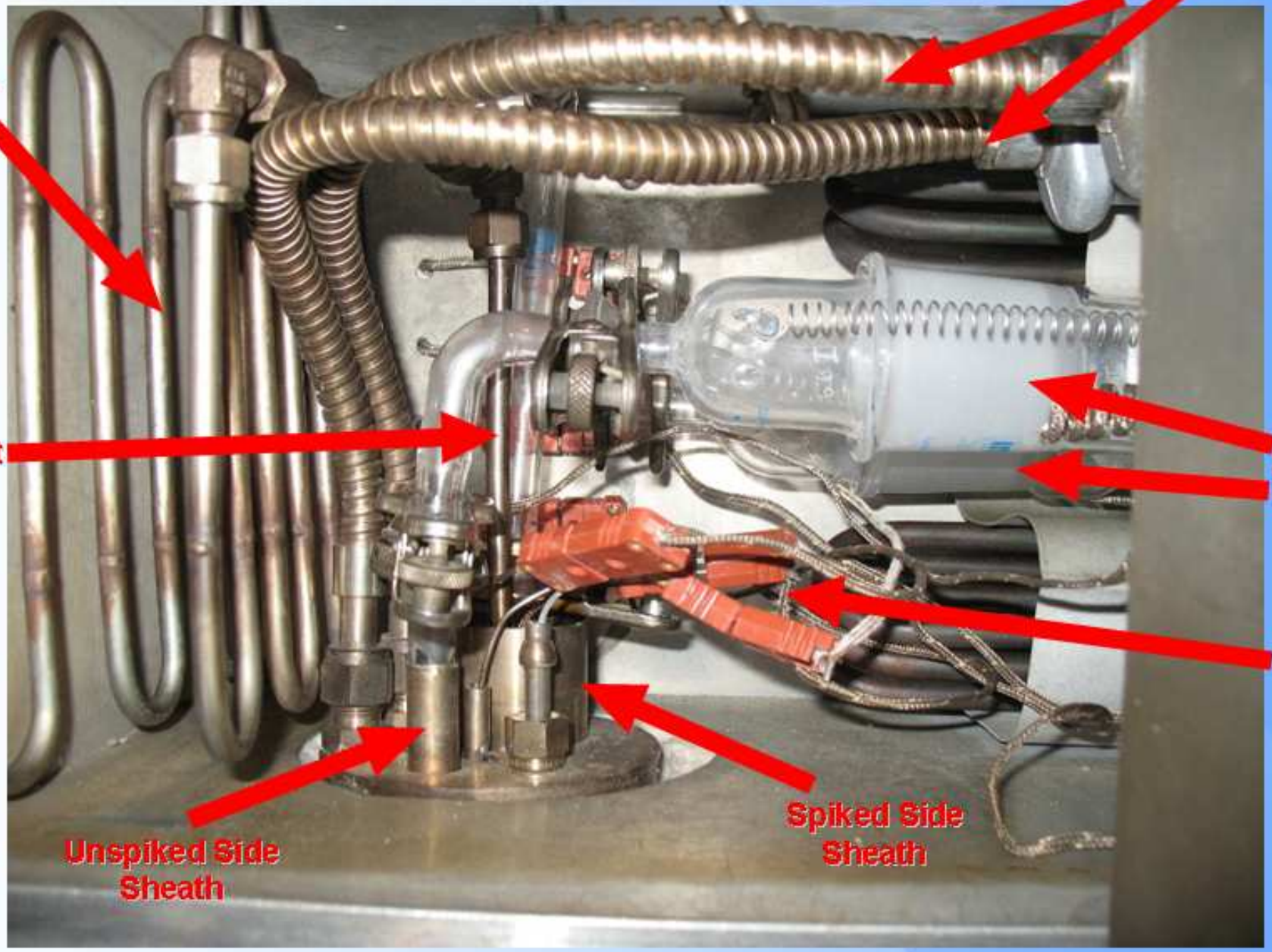
Picture – Inside Oven



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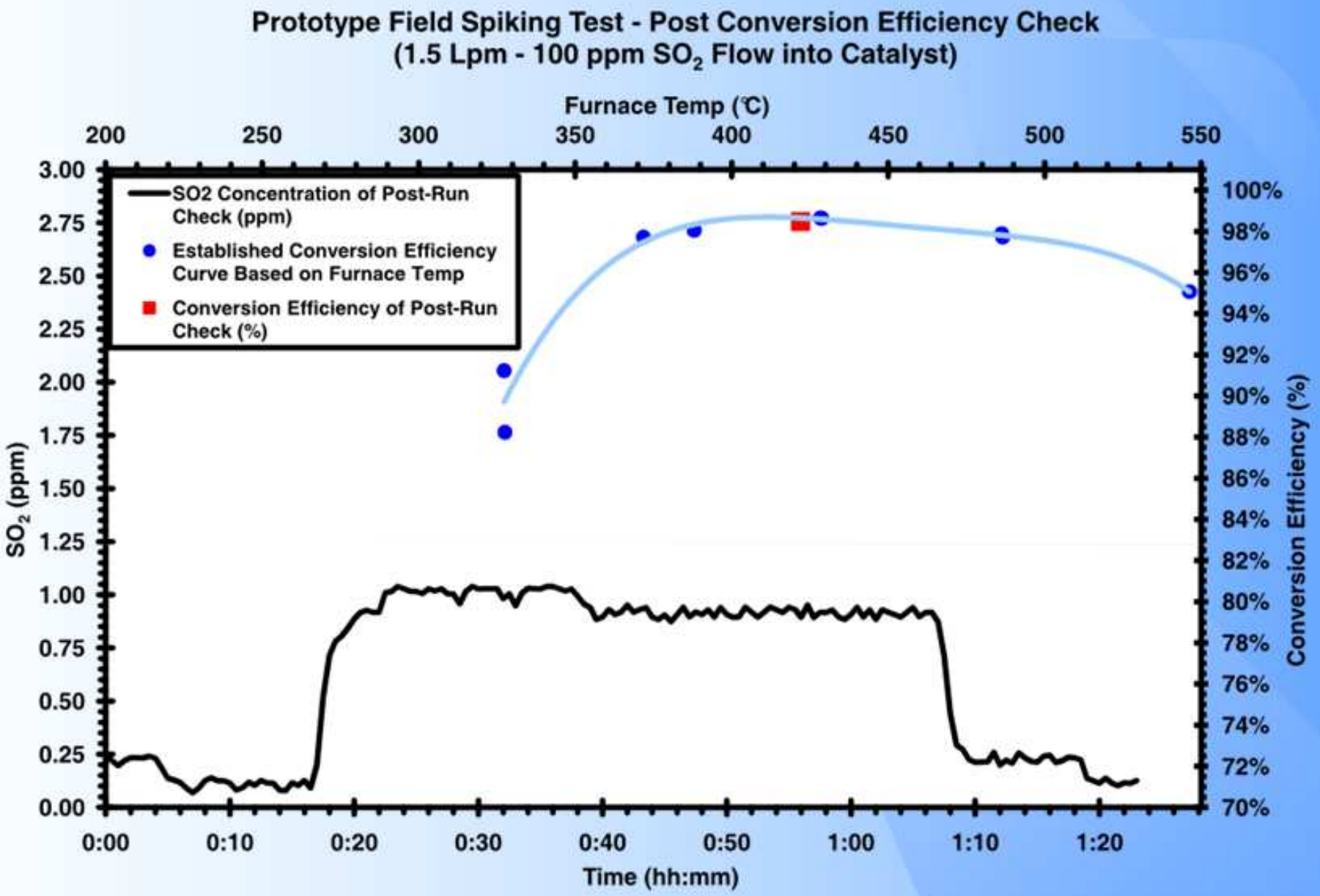
Conversion Efficiency Check



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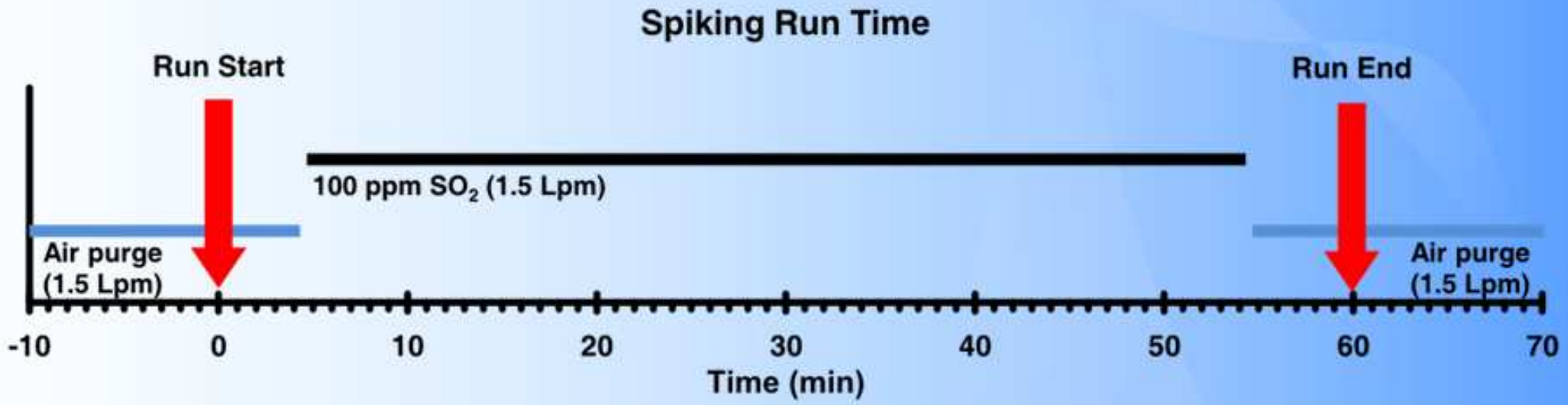
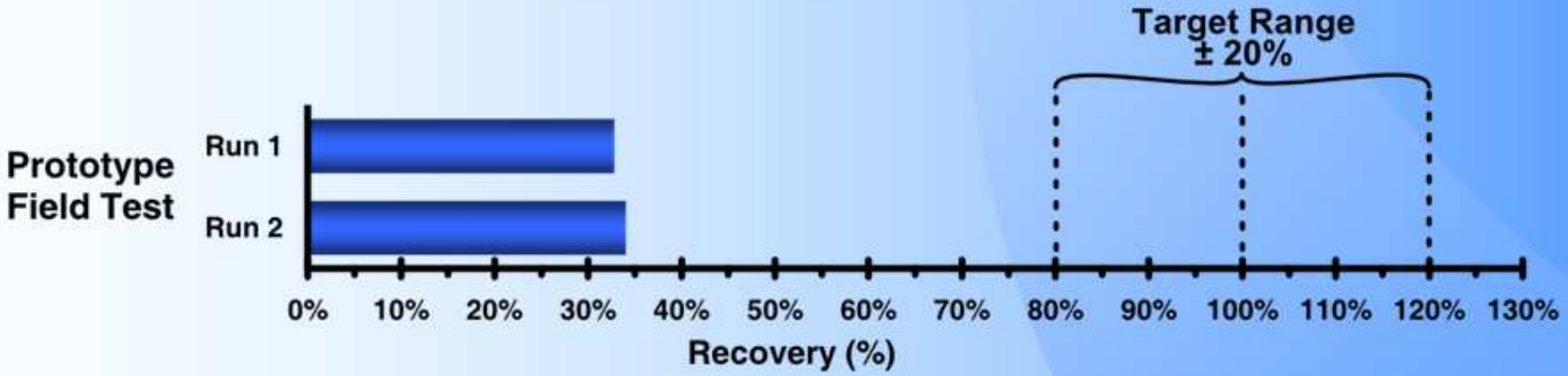
1st Prototype Results



Prototype Field Spike Recovery



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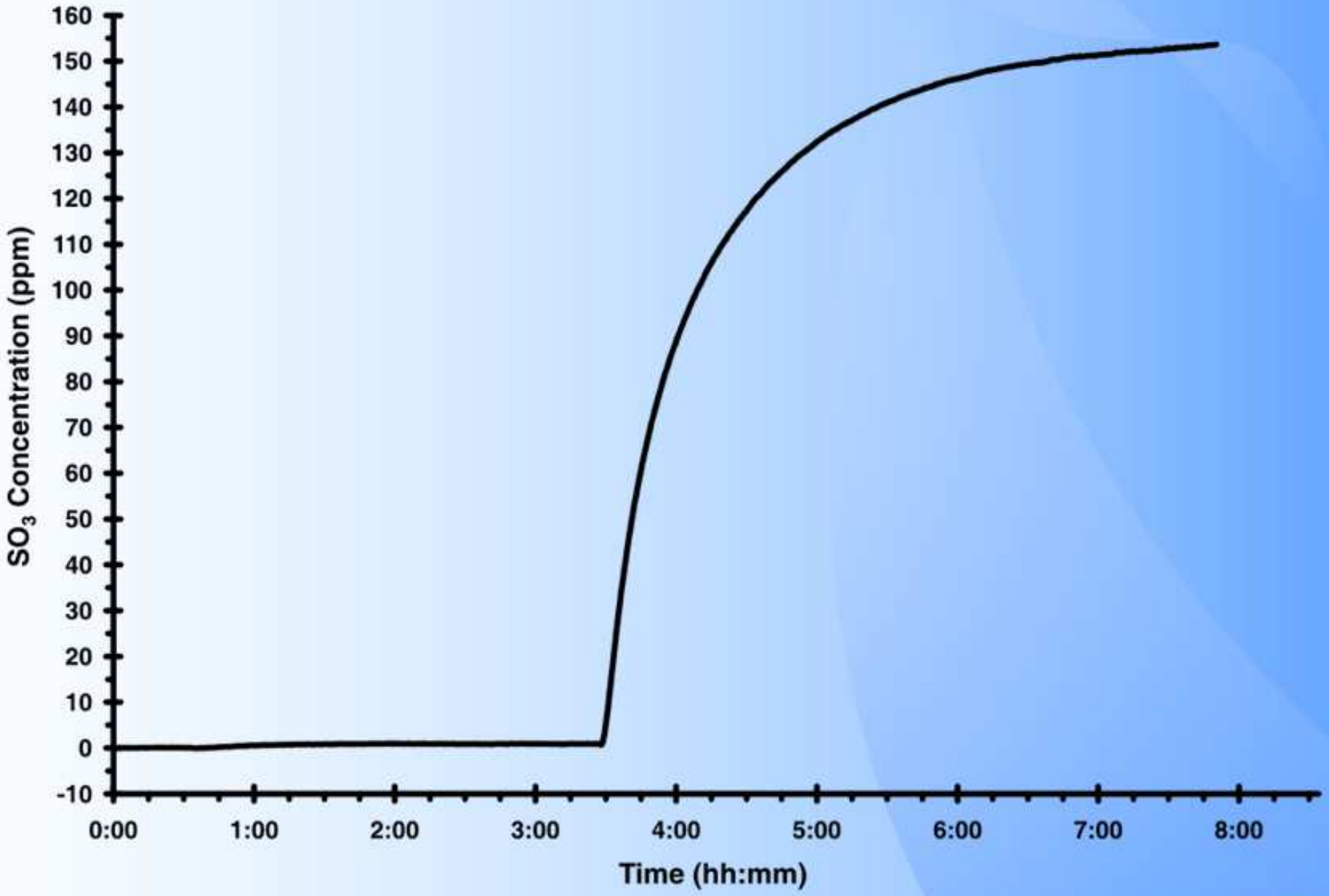
SO_3 Ramping



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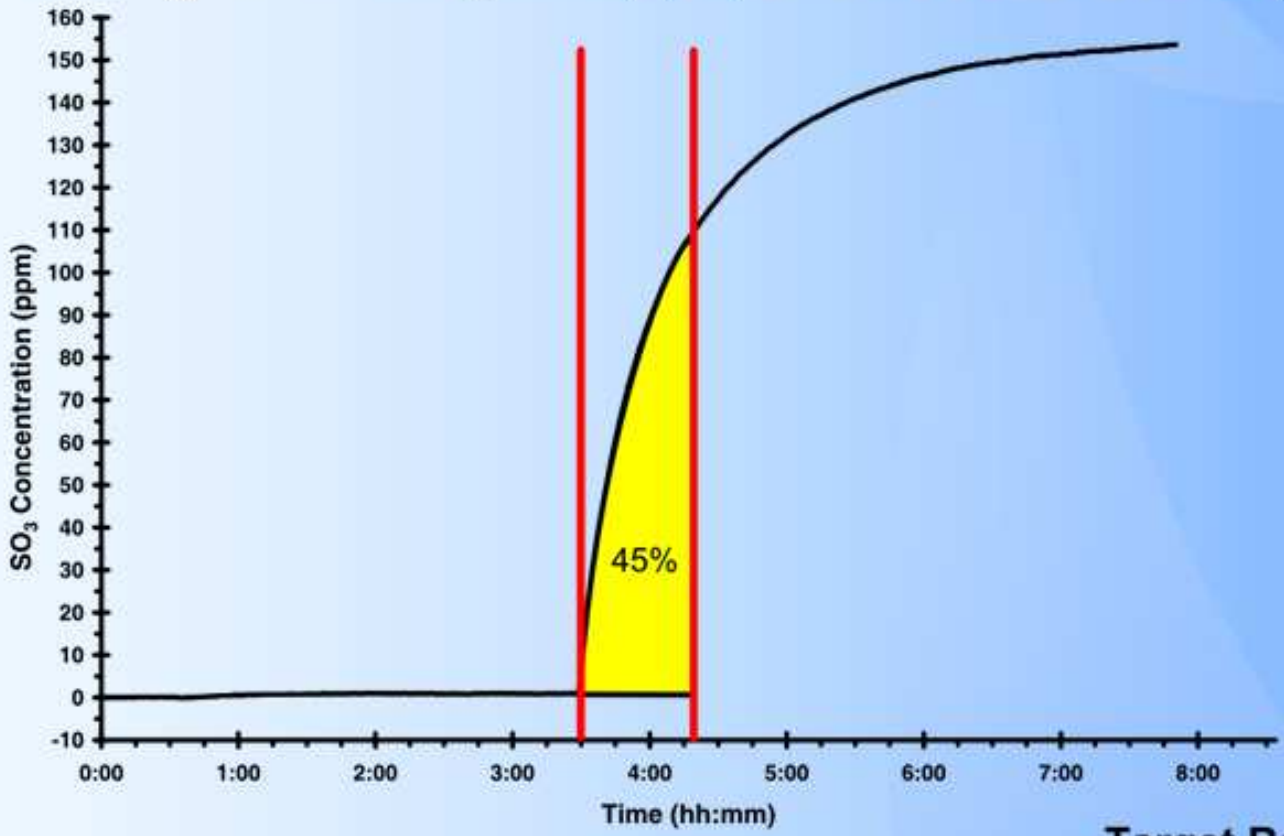
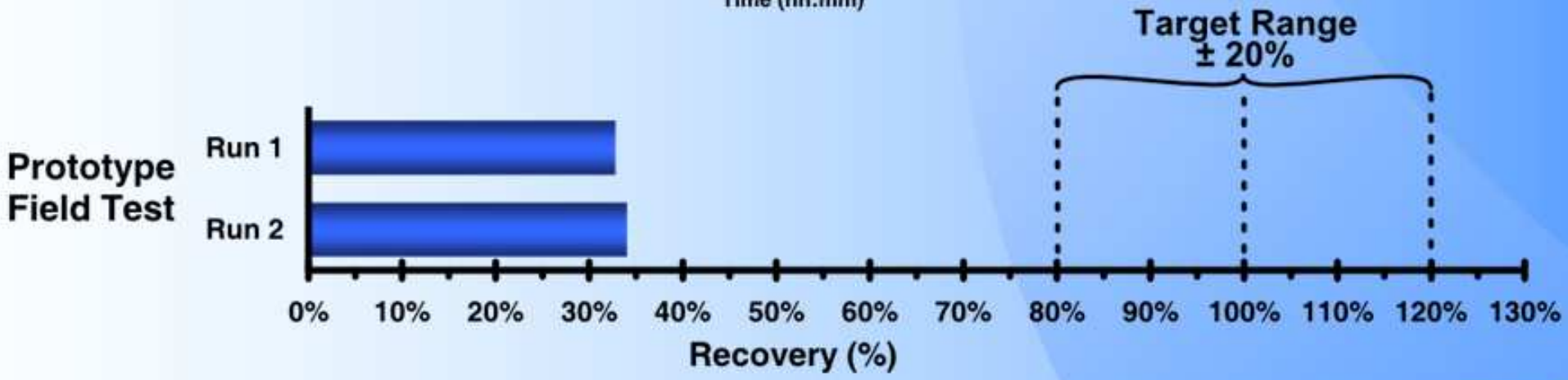
SO_3 Ramping (Continued)





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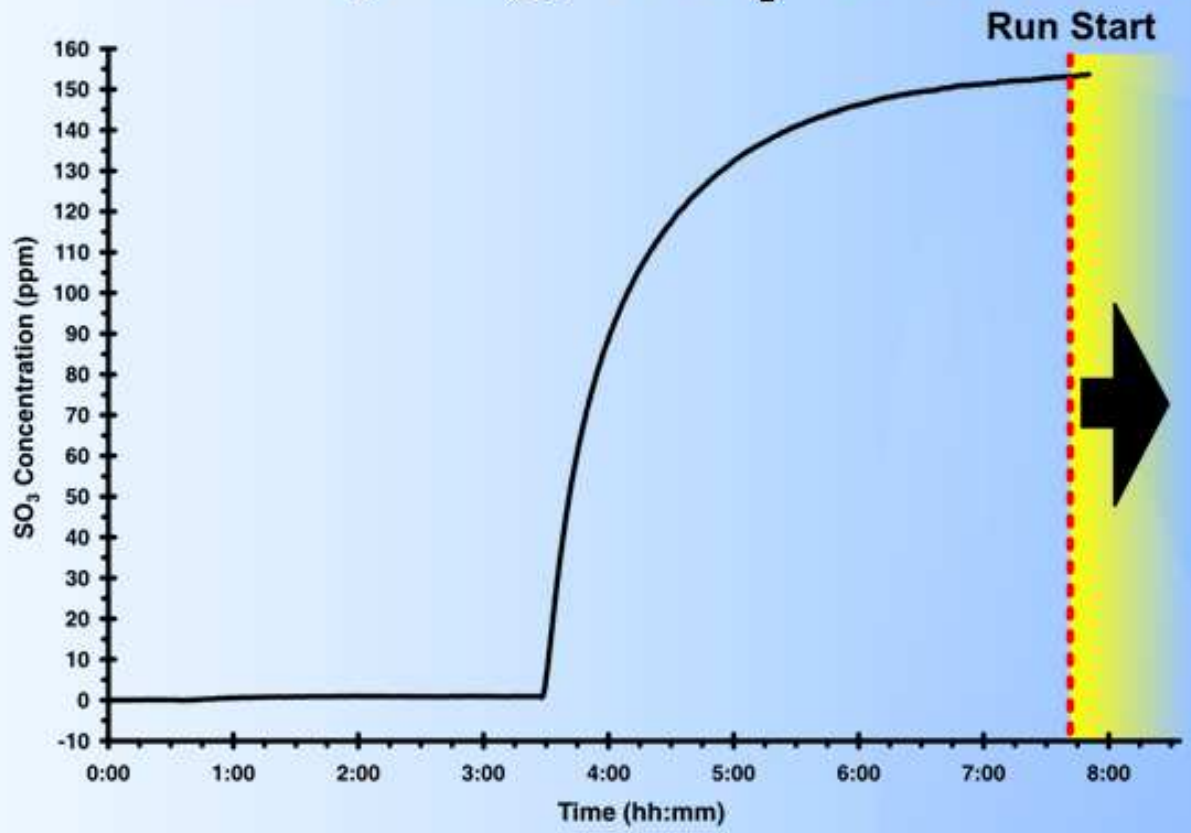
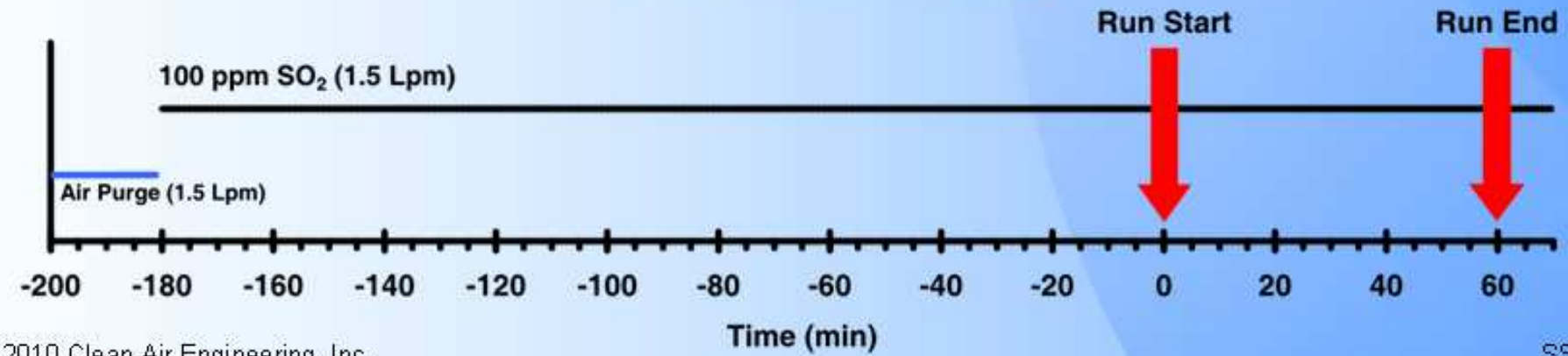
Pre-Ramping SO_3 Generation



Spiking Run Time (with Pre-Ramp)



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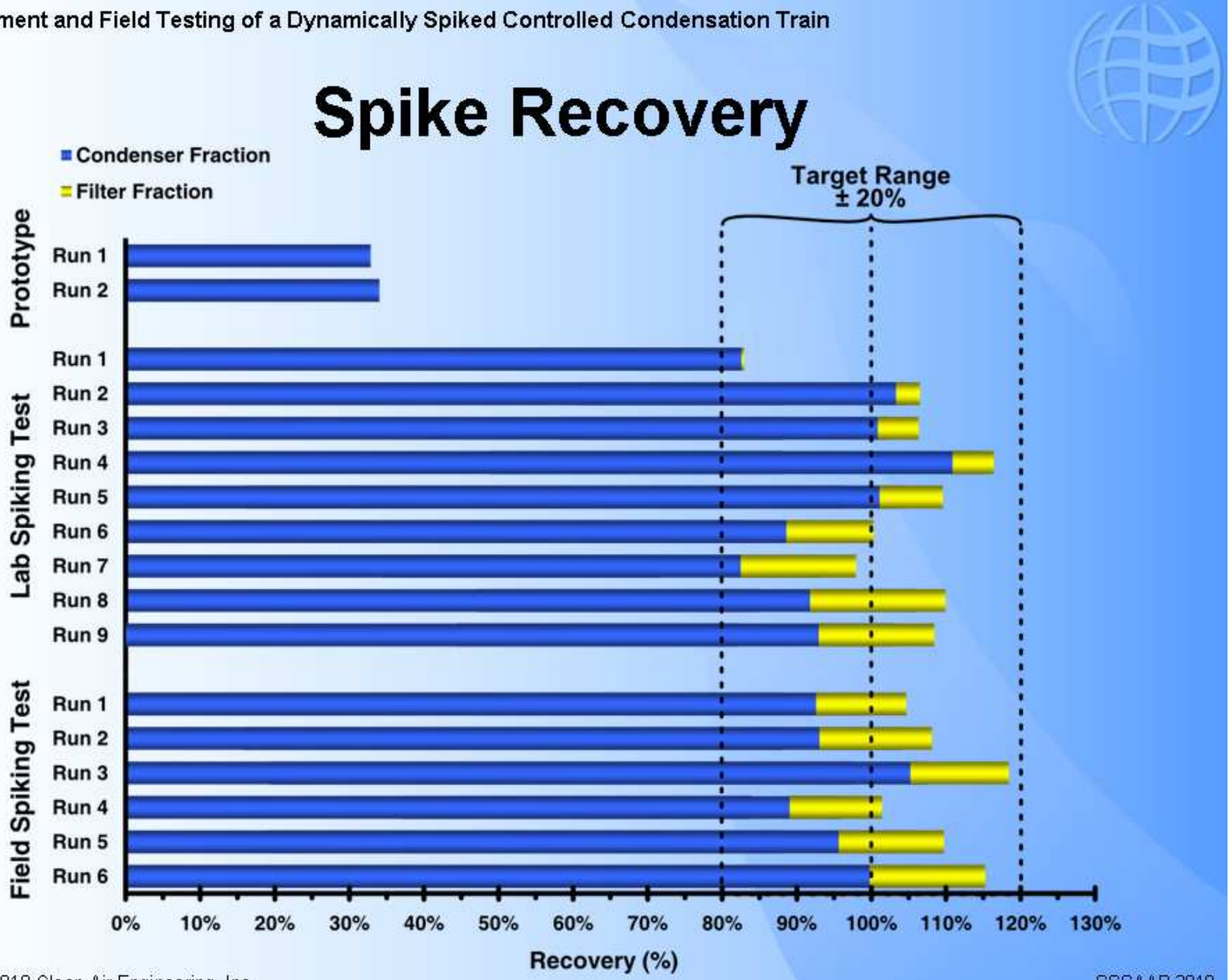

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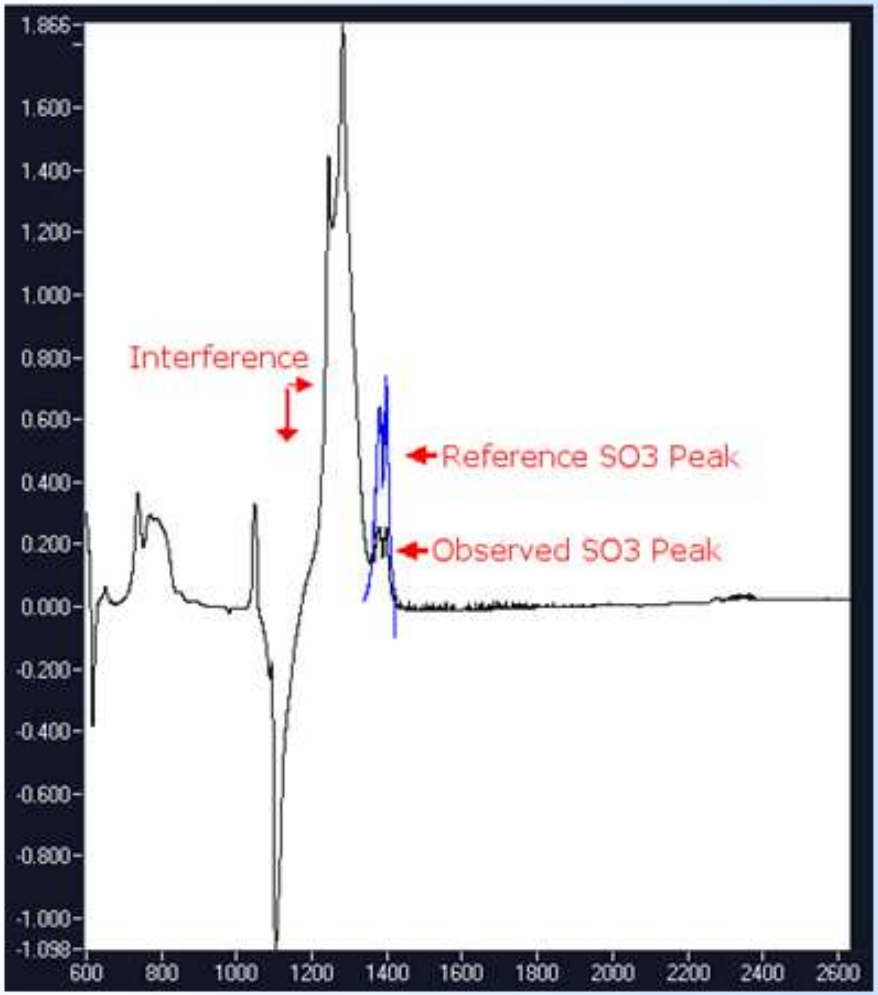
FTIR Detection of SO_3

- SO_3/H_2SO_4 reacted with FTIR windows, creating buildup of interference that overshadowed SO_2 and SO_3 peaks



- Only relative accuracy and stability measurements
- Lacked reference spectra for low concentrations of SO_3

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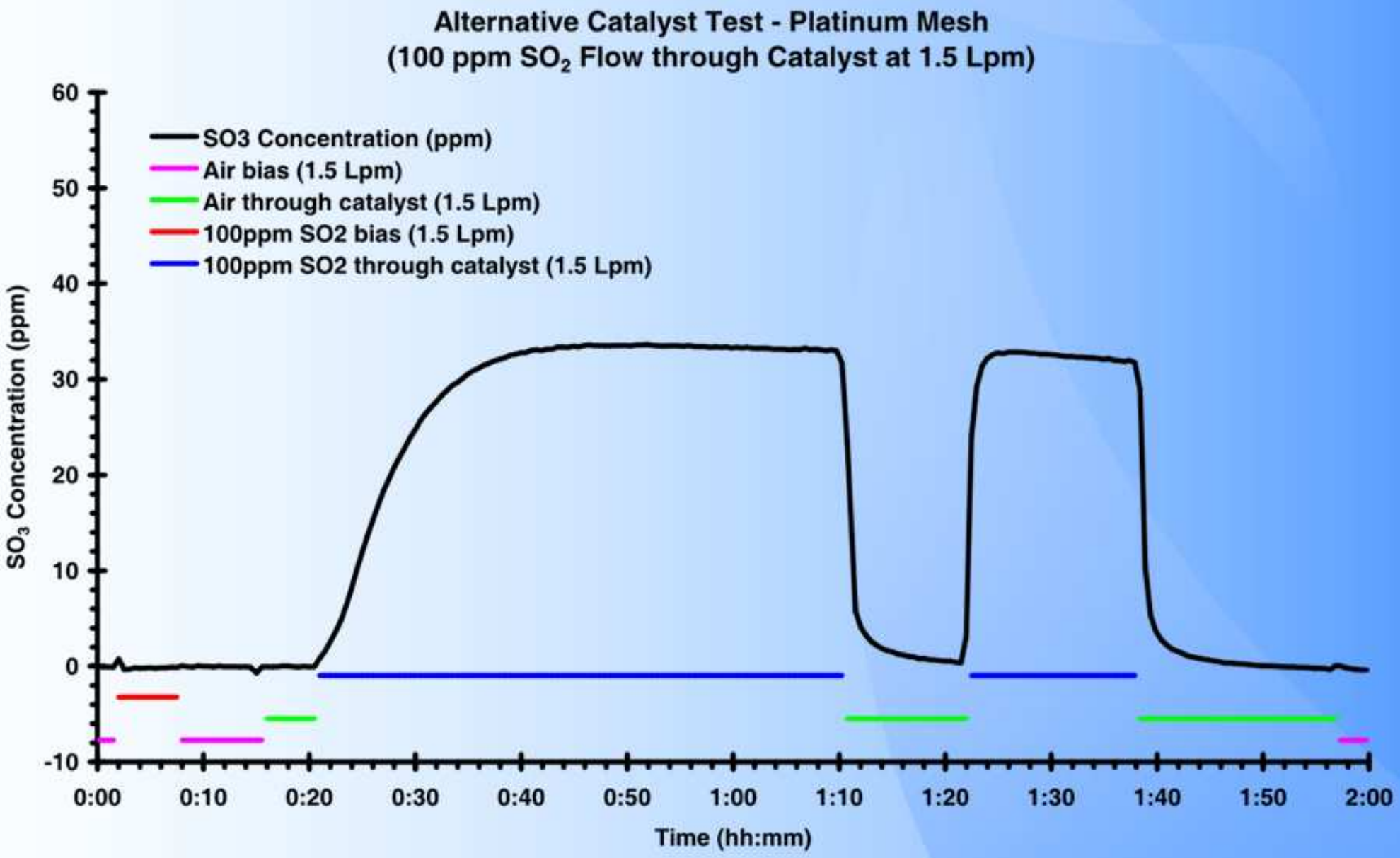
Alternative Catalyst



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Conclusion

Yes!

We can reliably generate a known amount of SO_3 spike within a ±20% range.

Yes!

We can capture that SO_3 spike using controlled condensation in a field setting.

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What's Next

- Make dynamic spiking available for SO_3/H_2SO_4 testing (patent pending)
- Further develop alternative catalyst
  - Shrink the ±20% recovery range to ±5%
  - Remove the need for seasoning and pre-ramping
- Create low level SO_3 reference spectra for FTIR
- Validate other SO_3/H_2SO_4 measurement techniques using SO_3 generation and spiking system, such as new ASTM SO_3/H_2SO_4 method

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Questions?

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