# °Catalytic Stripper

## Oxidation Efficiency Measurement with Propane

Vinicius Berger

Catalytic Instruments GmbH & Co. KG

PMP Meeting

Geneva, 09.01.2023

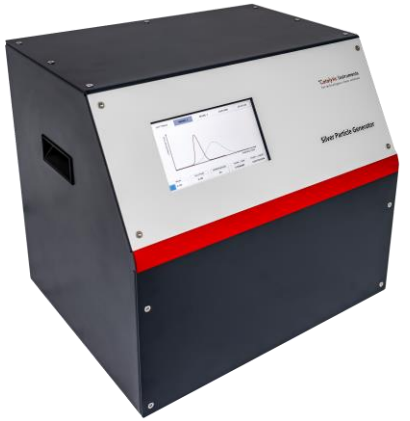
# Motivation

State of the art:

- °Catalytic **Stripper** is checked with tetracontane particles as defined by PMP
  - ✓ > 99.0% vaporisation of 30 nm tetracontane particles with an inlet concentration of ≥ 10,000 $cm^{-3}$ ✓ (23 nm GTR)
  - ✓ > 99.9% vaporisation of tetracontane particles with a CMD > 50 nm and a mass above 1 $mg/m^3$ (10 nm / Brakes GTR)

- Aerosol measurement equipment[+] and know-how necessary to perform this check

*[+]we use our SPG as Tetracontane Generator – at a touch of a button*



Wanted:

- Quick,
  - easy and
    - reliable method

to check if °Catalytic **Stripper** is operational as designed and meets the above criteria

# Approach

## Oxidation efficiency measurement with propane

- Use a gaseous hydrocarbon
  - Propane is a low-cost gaseous hydrocarbon
  - Propane-in-air is easily available as calibration gas bottle
  - Propane concentration in bottle is constant
  - Propane is easy to detect with an FID

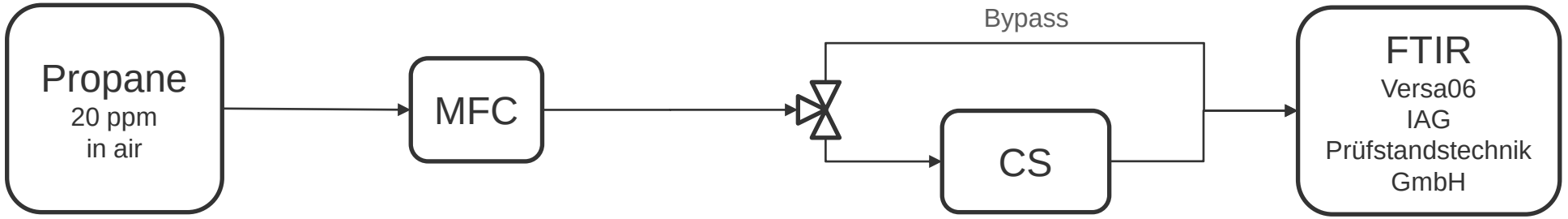
- Propane ($C_3H_8$) shows different oxidation behavior than tetracontane ($C_{40}H_{82}$)
  - A shorter chain of C-C bonds is more difficult to break up
  - Oxidation efficiency numbers will be lower than the typical >99.0% PMP threshold
  - not a problem because it is a different & additional method

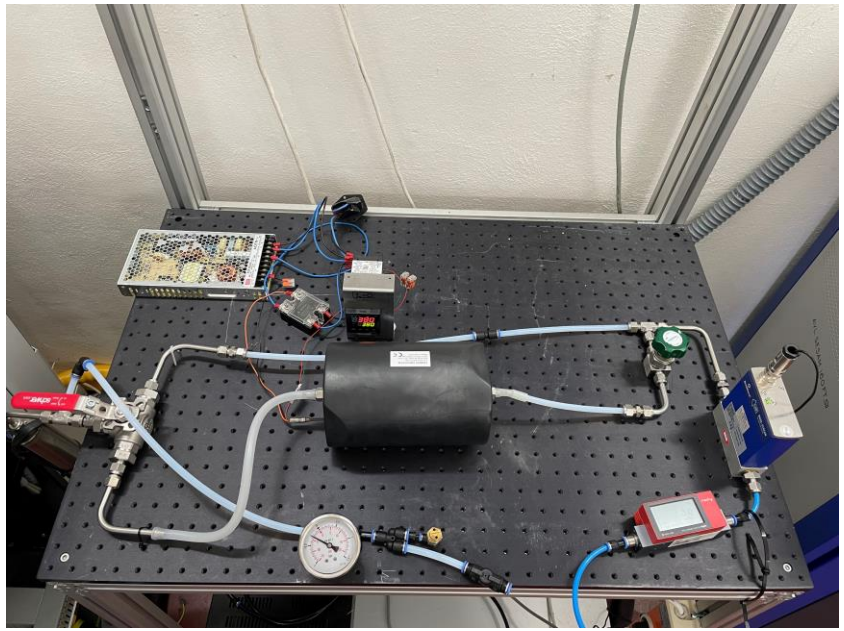
# Tasks

Oxidation efficiency measurement with propane

- Find suitable propane concentration
- Characterise new °Catalytic Stripper
- Load °Catalytic Stripper with sulphur
- Evaluate sulphur-loaded °Catalytic Stripper

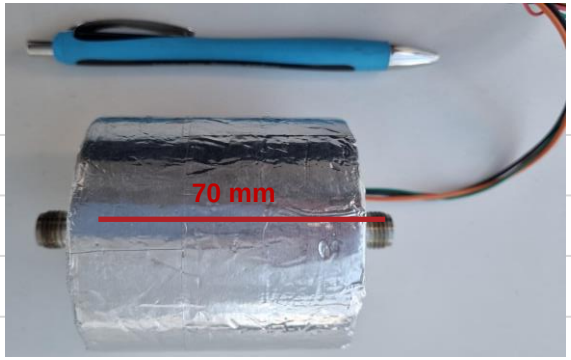
# Experimental Setup



# Results

Compact Catalytic Core
0.2 to 0.8 lpm



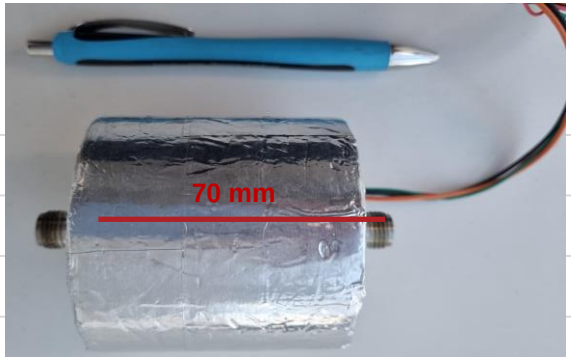

Catalytic Core
0.5 to 1.0 lpm


Catalytic Core
1.0 to 2.8 lpm


Catalytic Core
3 to 20 lpm

# Results

Compact Catalytic Core
0.2 to 0.8 lpm




Catalytic Core
0.5 to 1.0 lpm


Catalytic Core
1.0 to 2.8 lpm


Catalytic Core
3 to 20 lpm

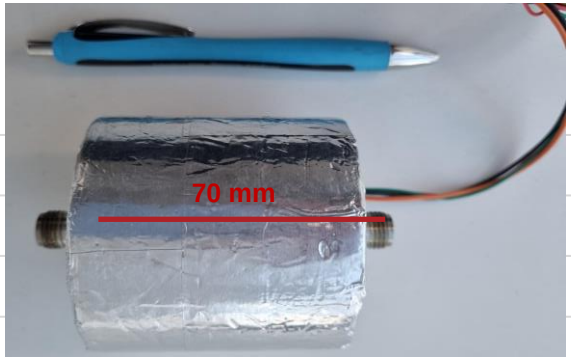




- ✓ All devices perform well
- ✓ Variations are small
- ✓ Propane concentration is suitable for this method

# Results

Compact Catalytic Core
0.2 to 0.8 lpm



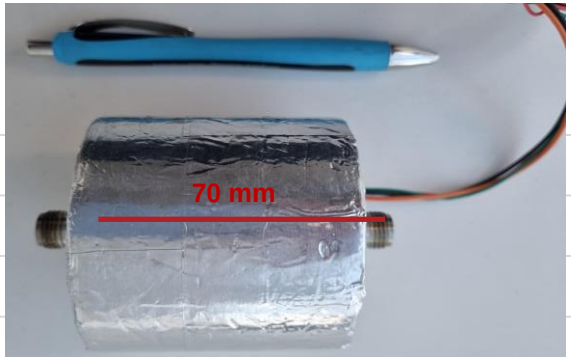

Catalytic Core
0.5 to 1.0 lpm


Catalytic Core
1.0 to 2.8 lpm


Catalytic Core
3 to 20 lpm

# Results

Compact Catalytic Core
0.2 to 0.8 lpm




Catalytic Core
0.5 to 1.0 lpm


Catalytic Core
1.0 to 2.8 lpm


Catalytic Core
3 to 20 lpm





- ✓ Method shows good repeatability, better than ± 5 %
- ✓ Similar devices show similar performance
- ✓ High level of production quality

# Sulphur Poisoning

°**Catalytic Stripper** impairment by sulphur poisoning of the catalytic material?

- Fuels with very high sulphur content (HFO) can reduce the catalytic surface
- Sulphur is stored in the catalyst
- Regeneration is possible

Method:

- Load the °**Catalytic Stripper** with sulphur from $SO_2$ gas (10 ppm $SO_2$ in air)
- Calculate sulphur mass with known concentration and flow rate of SO2
- Calculate emulated operating time with assumptions regarding fuel, engine operating point, dilution

Current results:

- Oxidation efficiency decreased from 95% to 90% after loading 2 g/L [$V_{catalyst}$] of sulphur
  ⇒ °**Catalytic Stripper** is very robust regarding sulphur poisoning
  ⇒ Propane oxidation efficiency method proves effective

- no ash buildup or clogging observed (would be noticed during annual PCRF evaluation)

# Summary

- ✓ Propane oxidation efficiency measurement is
  - ✓ Quick → *15 min measurement*
  - ✓ Easy → *Gas bottle, MFC, valve, sensor*
  - ✓ Robust → *e. g. no instabilities in source*
  - ✓ Good repeatability → ± 5 %

- ✓ $SO_2$-loading to emulate fuel with high sulphur content
  - ✓ Propane method can detect sulphur-poisoned catalyst

- ✓ °**Catalytic Stripper** proves very robust

# Outlook

Comparison of propane oxidation efficiency results with tetracontane of a sulphur-loaded °Catalytic Stripper

Use FID as detector

- Better stability
- Higher sensitivity at low concentrations

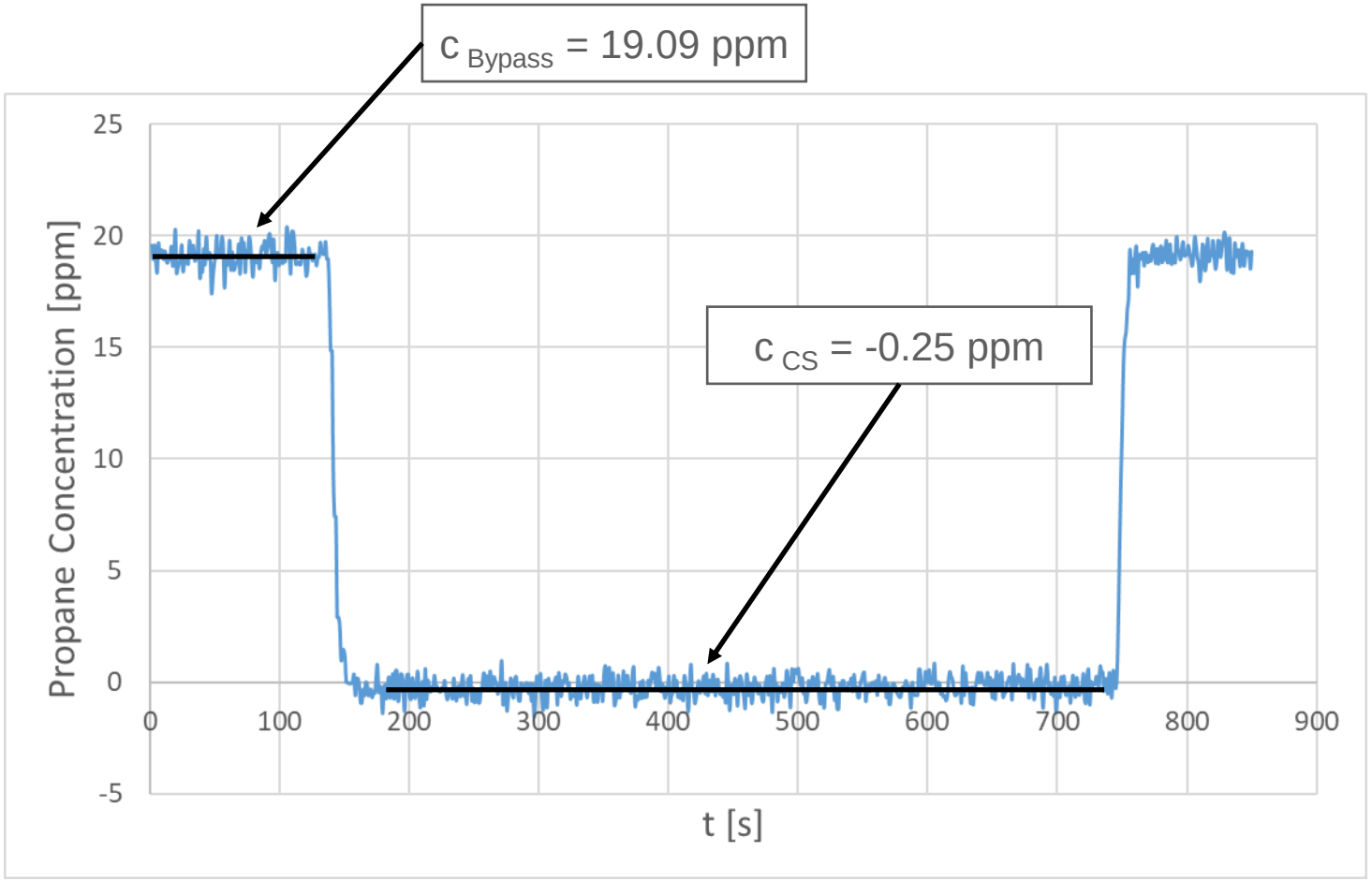
More detailed investigation of sulphur poisoning of °Catalytic Stripper

- Publication planned this year

Investigation whether PN emissions occur from a sulphur-poisoned °Catalytic Stripper running at elevated temperatures (= partially regenerating)

# Appendix

# Results Propane Measurement




e. g. Catalytic Stripper 008CX16

0.75 LPM flow rate

$$\eta = 1 - \frac{c_{CS}}{c_{Bypass}}$$

Error calculation:

Mean + SD → Error Propagation → ± σ