

# *LEADING THE WAY* **CampusEnergy**2022

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# SCR Performance Anomaly at UMMS CHP

Bob Fraser QEP, Consultant

Joseph Collins, Director Energy Services

Bruce Hjort, Assistant Director

# Problem

## CEMs DAHS “Rate” Alarms!

- Never seen before in ten+ years of nearly continuous operation!
- MassDEP Air Permit includes an enforceable limit on NH<sub>3</sub> feed, lb/MMBtu, 1-hr average
- Control Room Operators need to back down CT to about ½ load to recover compliant hourly averages - output made up via less efficient steam boilers and purchased electricity
- Why? What has changed?

# What has Changed? Nearly Everything! (2019-2020 Major Outage)

- Solar Taurus 60 Turbine Swap
- SCR controls CT + DB NOx
- CEMs Replaced; Software Updated
- New NH<sub>3</sub> to NOx converter
- New NH<sub>3</sub> Flow Meter + Metering Valve Design
- Rebuilt NH<sub>3</sub> flow curves
- Covid 19 Complicates Operations, Support and Service

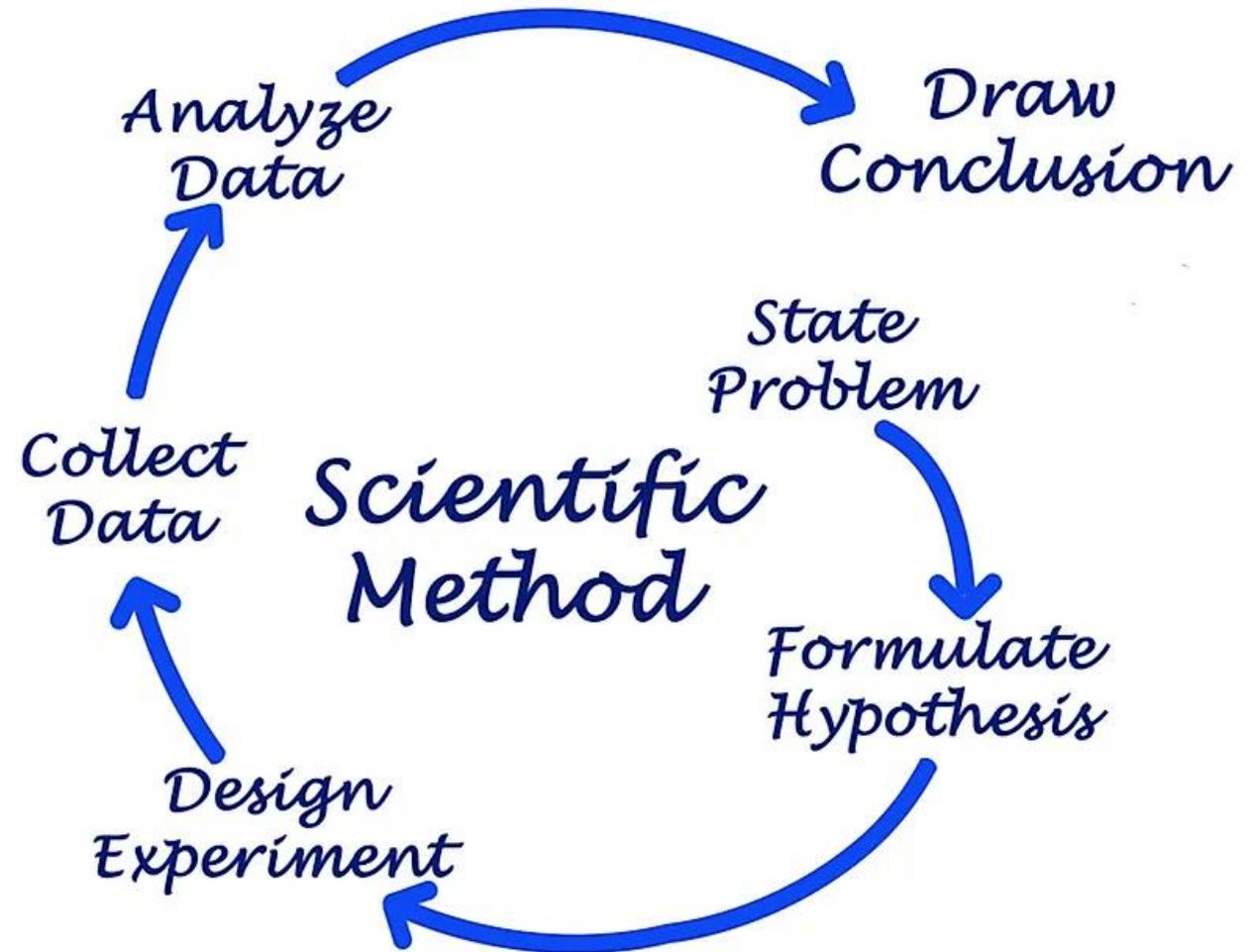


# Aristotle; 300 BCE; Father of Scientific Inquiry

Science is the process of thinking critically, using observations, inferring, comparing, contrasting and seeking understanding of cause and effect.



# The Scientific Method



# Formulate Hypotheses

1. The replacement engine was a higher NO<sub>x</sub> emitter than the former turbine
2. Duct burner NO<sub>x</sub> has dramatically changed
3. SCR catalyst spent, needs to be replaced
4. New NH<sub>3</sub> flow meter/control valve not functioning properly
5. Bad NH<sub>3</sub> to NO<sub>x</sub> sampling system / converter
6. False CEMs readings or wiring / DAHs software
7. NH<sub>3</sub>:NO<sub>x</sub> SCR catalyst maldistribution

# Test Hypotheses

1. The replacement engine was a higher NO<sub>x</sub> emitter than the former turbine

Disproved - Solar installation tuning report showed < 6 ppm

2. Duct burner NO<sub>x</sub> has dramatically changed

Disproved - Hand-held NO<sub>x</sub>/CO/O<sub>2</sub> analyzer showed no change

3. SCR catalyst spent

Doubtful - Catalyst reactivity normally decreases gradually over time; the “rate alarm” problem was never observed before the outage; cause must be due to a step change over that period

Disproved – test coupon removed and normal reactivity verified via lab analysis

# Test Hypotheses (cont.)

## 4. New NH<sub>3</sub> flow meter/control valve not functioning properly

Doubtful - NH<sub>3</sub> control curves re-programmed – 2-3X former NH<sub>3</sub> feed rate now required to maintain 2 ppm NO<sub>x</sub>; why?

Disproved - Flow meter calibrated correctly

Disproved - Ammonia purchase records 2-3X rate prior to outage

## 5. Bad NH<sub>3</sub> to NO<sub>x</sub> sampling system / converter

Disproved - Changed out converter

## 6. False CEMs readings or wiring / DAHs software

Disproved - All CEMs calibrate from stack, local readings same as inputs

Disproved - CEMS Vendor audited software, connections, logic

# Test Hypothesis (cont.)

## 7. NH<sub>3</sub>:NO<sub>x</sub> SCR catalyst maldistribution (all others already eliminated)

Clue - SCR performance occurs at a molar ratio of just over 1:1 – however, that ratio must be achieved across the entire catalyst surface area. If not, 2 ppm NO<sub>x</sub> average will require higher overall injection rates to achieve. Catalyst OEM suggests internal inspection of NH<sub>3</sub> distribution Grid and catalyst bed

Shutdown and third-party initial inspection - No significant NH<sub>3</sub> injection grid or catalyst block failures observed



# Re-test Hypothesis (cont.)

7. NH<sub>3</sub>:NO<sub>x</sub> Catalyst Maldistribution (must be - no remaining hypothesis!)

Test – compare present condition with original HRSG drawings

Observation 1 – SCR catalyst shown as two rows of SCR catalyst blocks with a void between

Observation 2 – “back row” of blocks cannot be inspected from the only HRSG access port!

**Re-inspection - Operators commissioned to perform a needle-in-a-haystack re-inspection (viewports, fiber optic camera, extreme patience)**



# Solution

- ✓ Bruce Hjort infers that something has been missed. Re-tests Hypothesis 7 - NH<sub>3</sub>:NO<sub>x</sub> SCR catalyst maldistribution
  - Eureka Moment - a 3/8-inch gap by about 4 linear ft of insulation was found missing between a row of catalyst blocks, in an area that is difficult to observe.
  - The gap in the front layer “blew out” a similar gap in the row behind
  - As a test, UMMS welded a plate over the gap from the front (accessible side) and returned the system to normal operation

**NH<sub>3</sub>:NO<sub>x</sub> curves re-programmed similar to normal;  
NO MORE RATE ALARMS SINCE!**

# Lessons Learned

As tempting as it may be to perform all needed system upgrades during a single outage, doing so easily confounds future diagnoses

When SCR performance suddenly changes, suspect NH<sub>3</sub>/flue gas maldistribution

Insist on a 100% catalyst gaskets inspection – one small area that is not readily inspectable should never be skipped over as “probably OK”

If two layers of catalyst are present, both sides must be accessible (the UMMS HRSG was equipped with a single manway, upstream)

Many confounding factors muddled the single cause/solution

Methodical application of the *Scientific Method* solved the Problem

# Thank you!



**Bob Fraser, QEP**

[bob@fraseraircompliance.com](mailto:bob@fraseraircompliance.com)

**Bruce Hjort**

[bruce.hjort@umassmed.edu](mailto:bruce.hjort@umassmed.edu)



**Joseph Collins**

[Joseph.collins@umassmed.edu](mailto:Joseph.collins@umassmed.edu)

