

LEADING THE WAY **CampusEnergy**2022

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SCR Performance Anomaly at UMMS CHP

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Problem

CEMs DAHS “Rate” Alarms!

- Never seen before in ten+ years of nearly continuous operation!
- MassDEP Air Permit includes an enforceable limit on NH₃ 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 NH₃ to NOx converter
- New NH₃ Flow Meter + Metering Valve Design
- Rebuilt NH₃ flow curves
- Covid 19 Complicates Operations, Support and Service

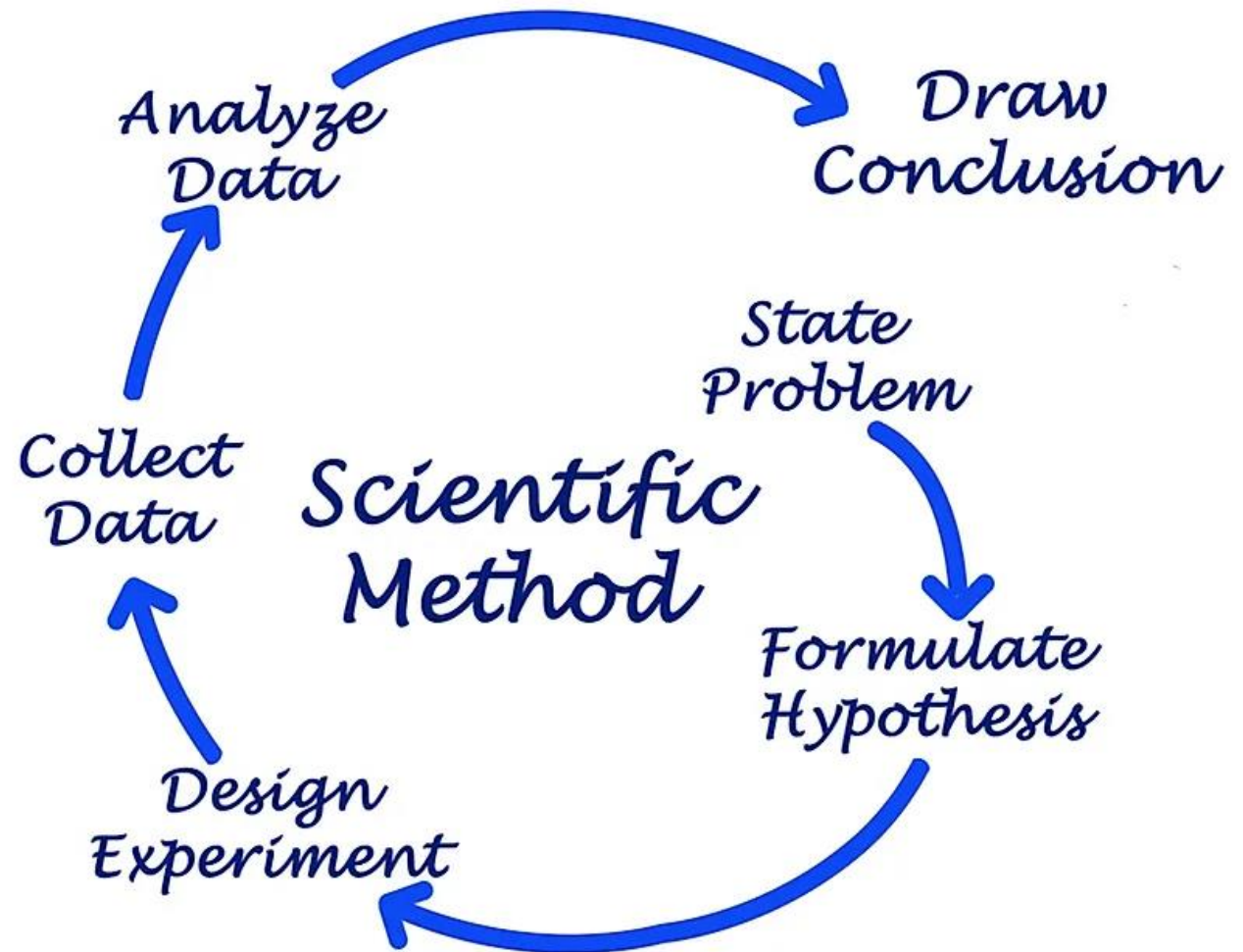


Aristotle; 300 BCE; Father of Scientific Inquiry

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 NOx emitter than the former turbine
2. Duct burner NOx has dramatically changed
3. SCR catalyst spent, needs to be replaced
4. New NH₃ flow meter/control valve not functioning properly
5. Bad NH₃ to NOx sampling system / converter
6. False CEMs readings or wiring / DAHs software
7. NH₃:NOx SCR catalyst maldistribution

Test Hypotheses

1. The replacement engine was a higher NO_x emitter than the former turbine

Disproved - Solar installation tuning report showed < 6 ppm

2. Duct burner NO_x has dramatically changed

Disproved - Hand-held NO_x/CO/O₂ 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 NH₃ flow meter/control valve not functioning properly

Doubtful - NH₃ control curves re-programmed – 2-3X former NH₃ feed rate now required to maintain 2 ppm NO_x; why?

Disproved - Flow meter calibrated correctly

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

5. Bad NH₃ to NO_x 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. $\text{NH}_3:\text{NO}_x$ 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_x average will require higher overall injection rates to achieve. Catalyst OEM suggests internal inspection of NH_3 distribution Grid and catalyst bed

Shutdown and third-party initial inspection - No significant NH_3 injection grid or catalyst block failures observed



Re-test Hypothesis (cont.)

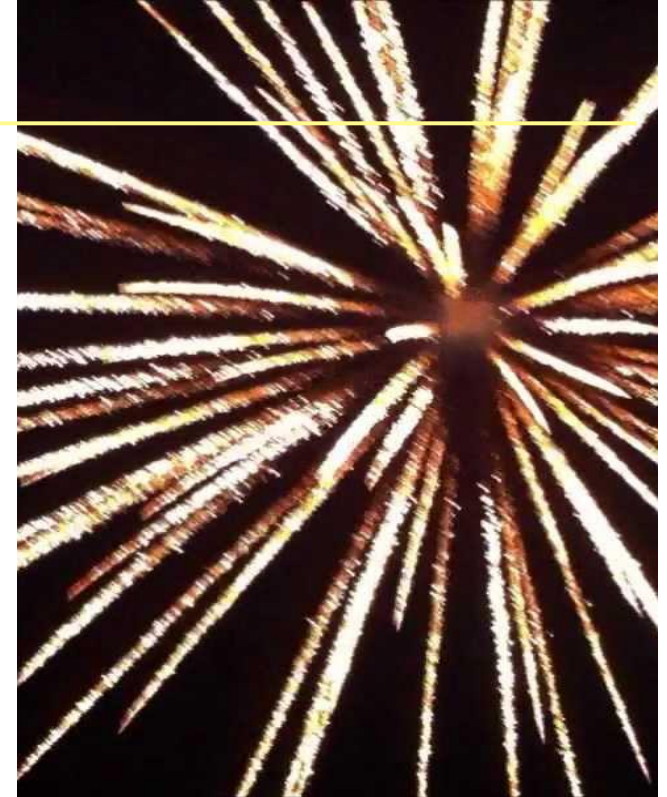
7. NH₃:NO_x Catalyst Maldistribution (must be - no remaining hypothesis!)

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 - $\text{NH}_3\text{:NO}_x$ 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

**$\text{NH}_3\text{:NO}_x$ 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_3 /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!



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