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Benefits of Multi-Pollutant Catalyst Technology for Combustion Turbine Power Plants

Chris Bertole, Ph.D.

Cormetech, Inc.

VGB WORKSHOP "FLUE GAS CLEANING 2016"

Cormetech, Inc.

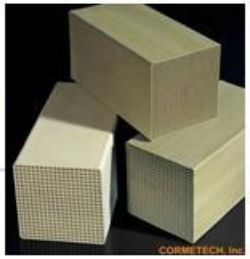
- **SCR catalyst design, manufacturing and testing:**

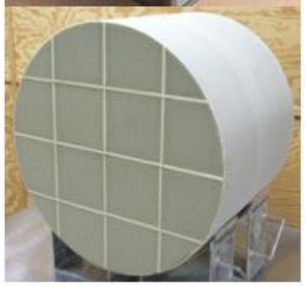
Coal
Gas
Diesel
Fuel Oil

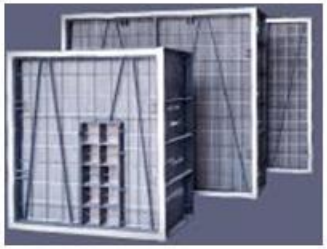
Stationary Power
Refinery & Process
Marine

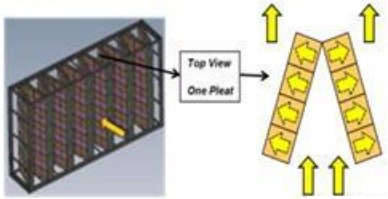
CORMETECH COMET™

Hg Oxidation Catalyst

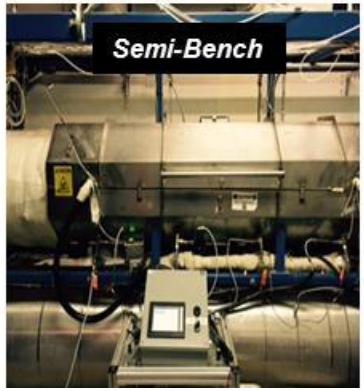


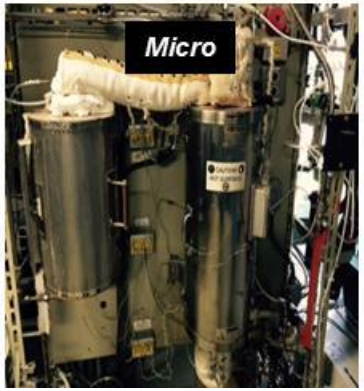






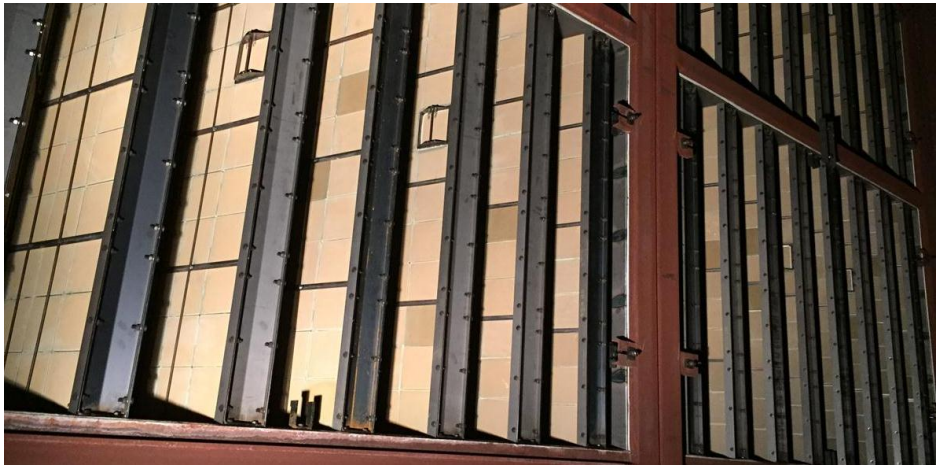
CORMETECH METEOR™





Presentation Overview

- **Multi-Pollutant Catalyst (METEOR™)**
  - Concept
  - Data and Validation
  - Full-Scale Installation



CORMETECH METEOR™

Traditional HRSG Catalyst Layout

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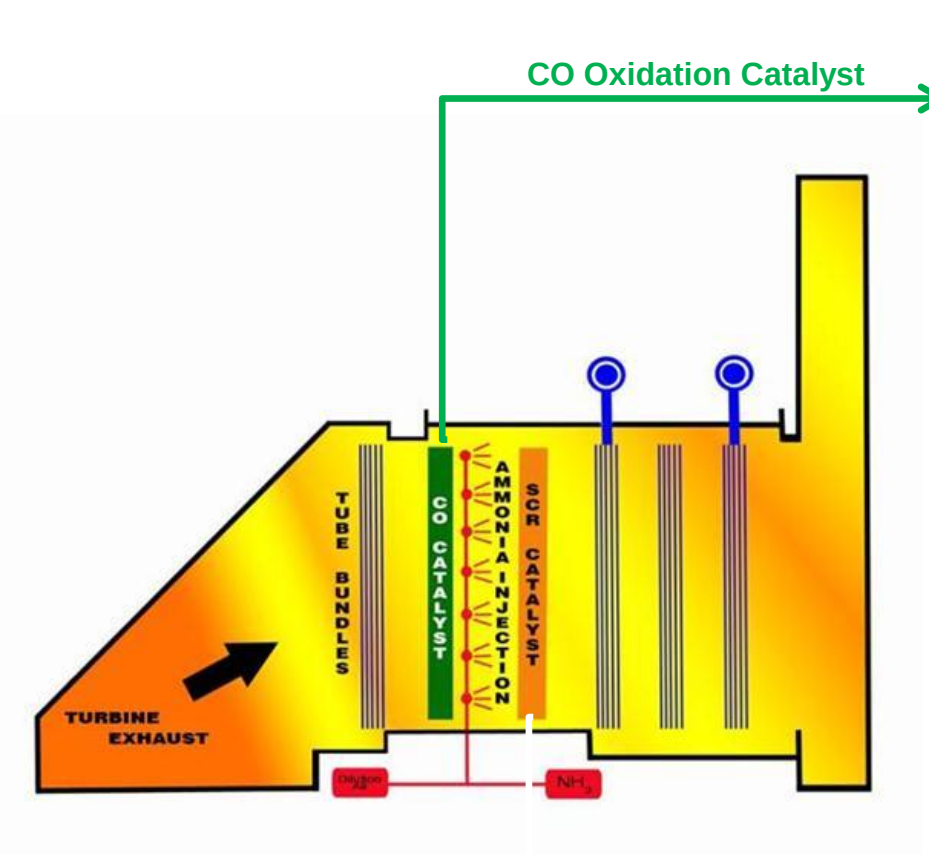

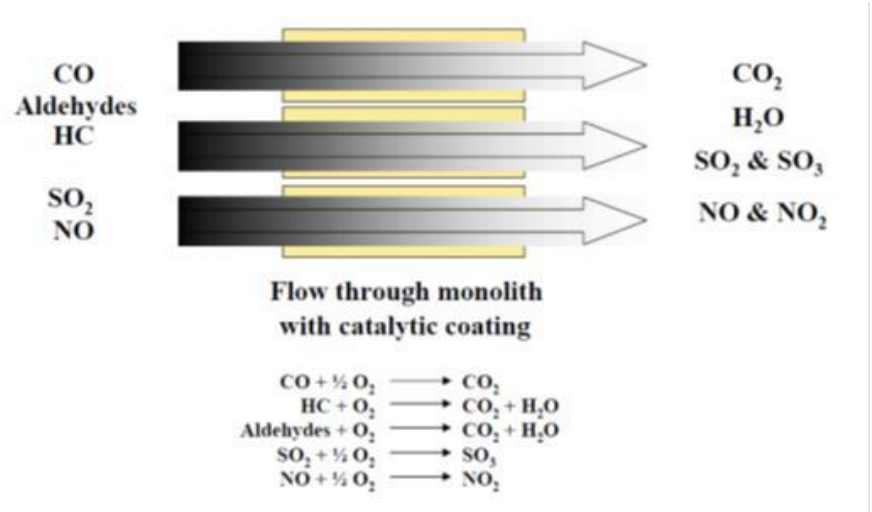

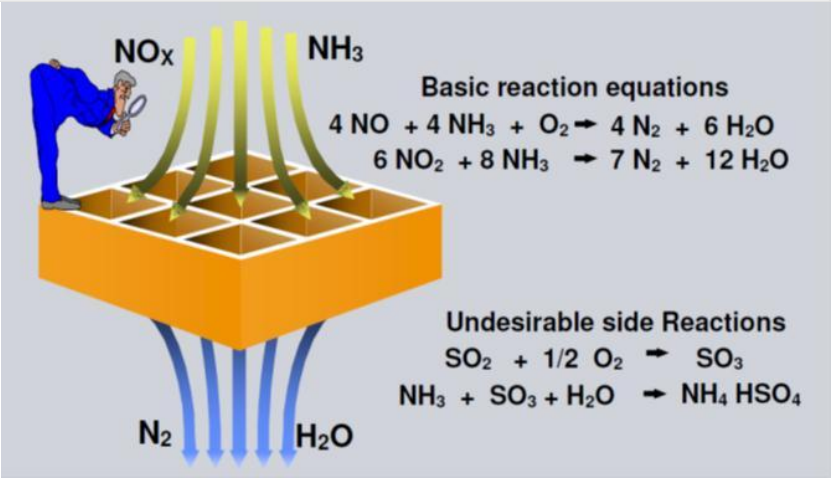

Multi-Pollutant Catalyst: METEOR™

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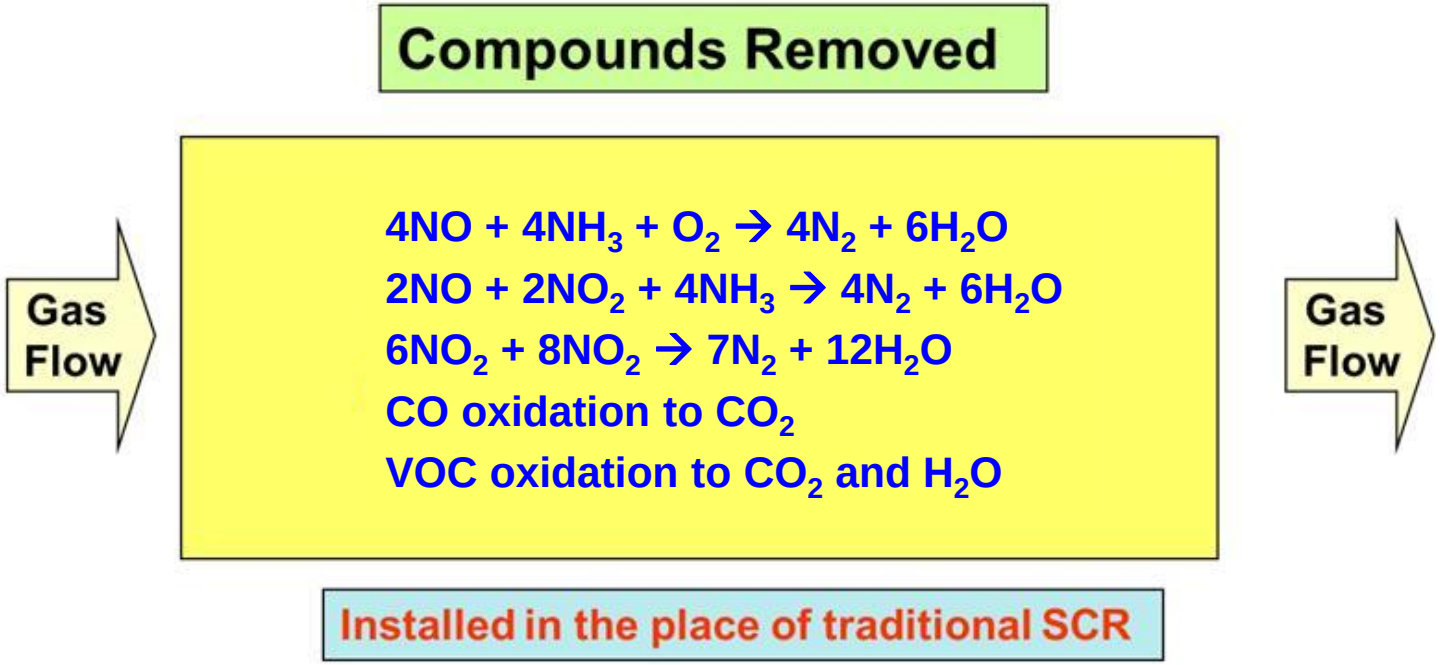
- Homogeneously extruded honeycomb catalyst (1 layer)
- **SCR** functionality → V_2O_5-WO_3/TiO_2
- **Oxidation** functionality → PGM (Pd and/or Pt)
- Initially developed and patented by **Siemens Energy** (US 7,390,471)
- Optimized and fully developed into commercial production by **Cormetech**



New HRSG Catalyst Layout

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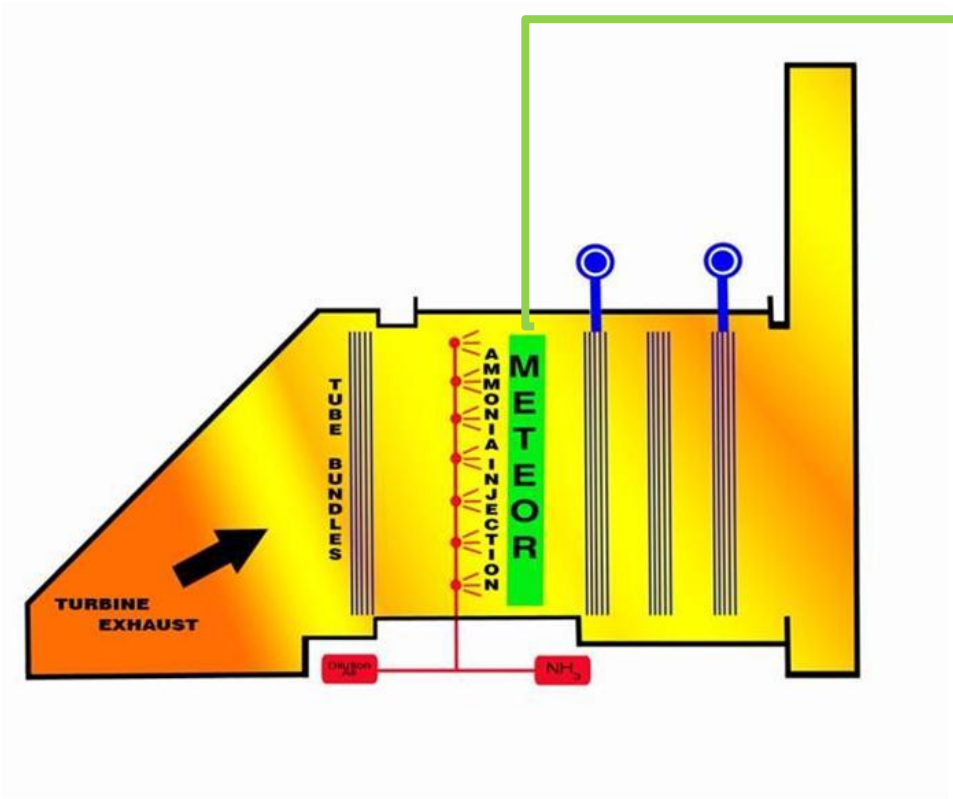
CORMETECH METEOR™



Oxidizing Function:

CO oxidation to CO_2

VOC oxidation to CO_2 and H_2O

Reduction Function:

$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$

$2NO + 2NO_2 + 4NH_3 \rightarrow 4N_2 + 6H_2O$

$6NO_2 + 8NO_2 \rightarrow 7N_2 + 12H_2O$

METEOR™ Catalyst Performance

DeNOx and CO Oxidation (GT Exhaust Condition)

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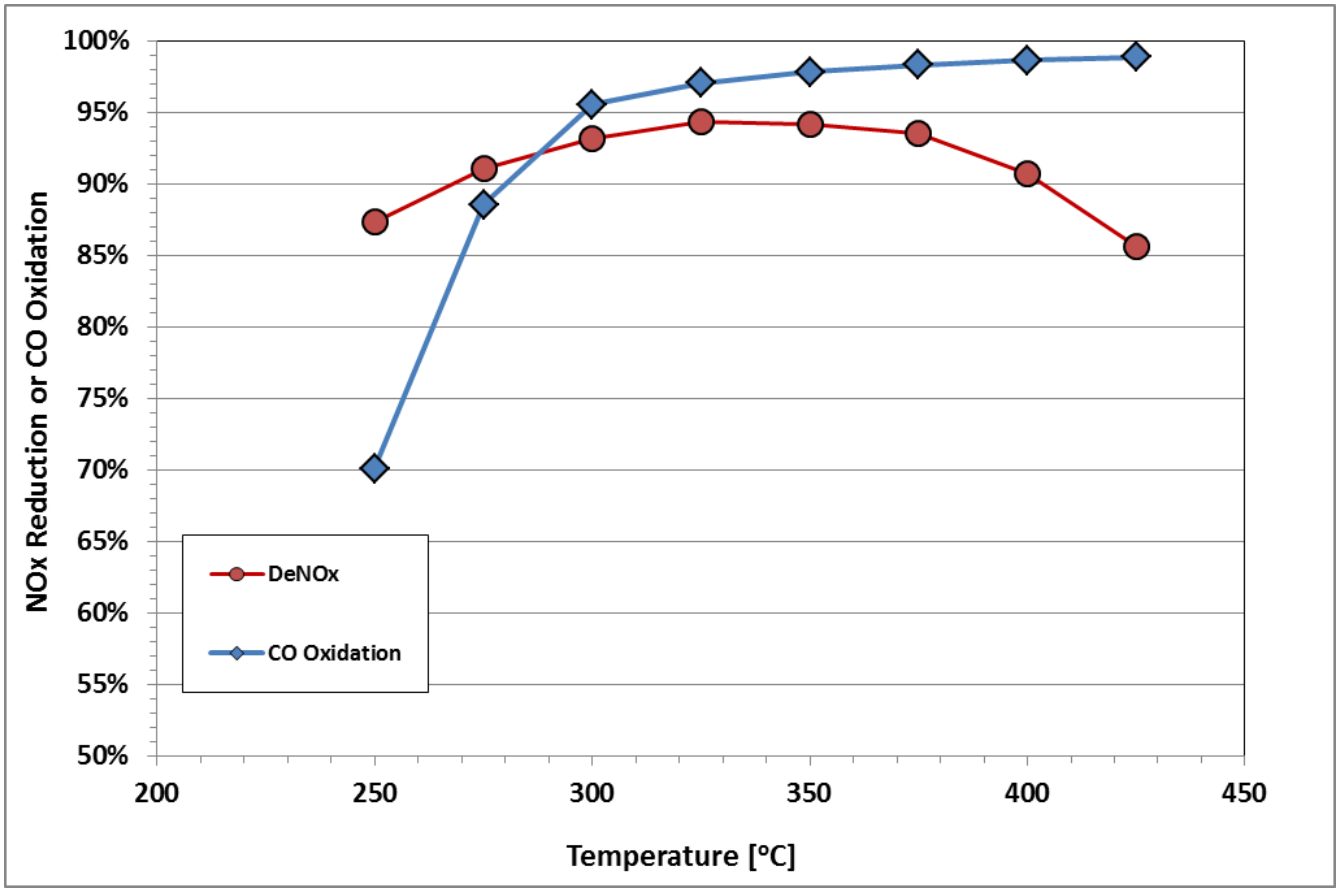
- DeNOx and CO oxidation → **high conversion rates** over wide temperature range.
- PGM loading can be adjusted to optimize performance at low/high temperature.



Test Conditions

NOx = 25 ppm
CO = 25 ppm
O_2 = 15%
H_2O = 7%
NH_3 slip 3 - 7 ppm
Constant SV

METEOR™ Catalyst Performance

VOC Oxidation (GT Exhaust Condition)

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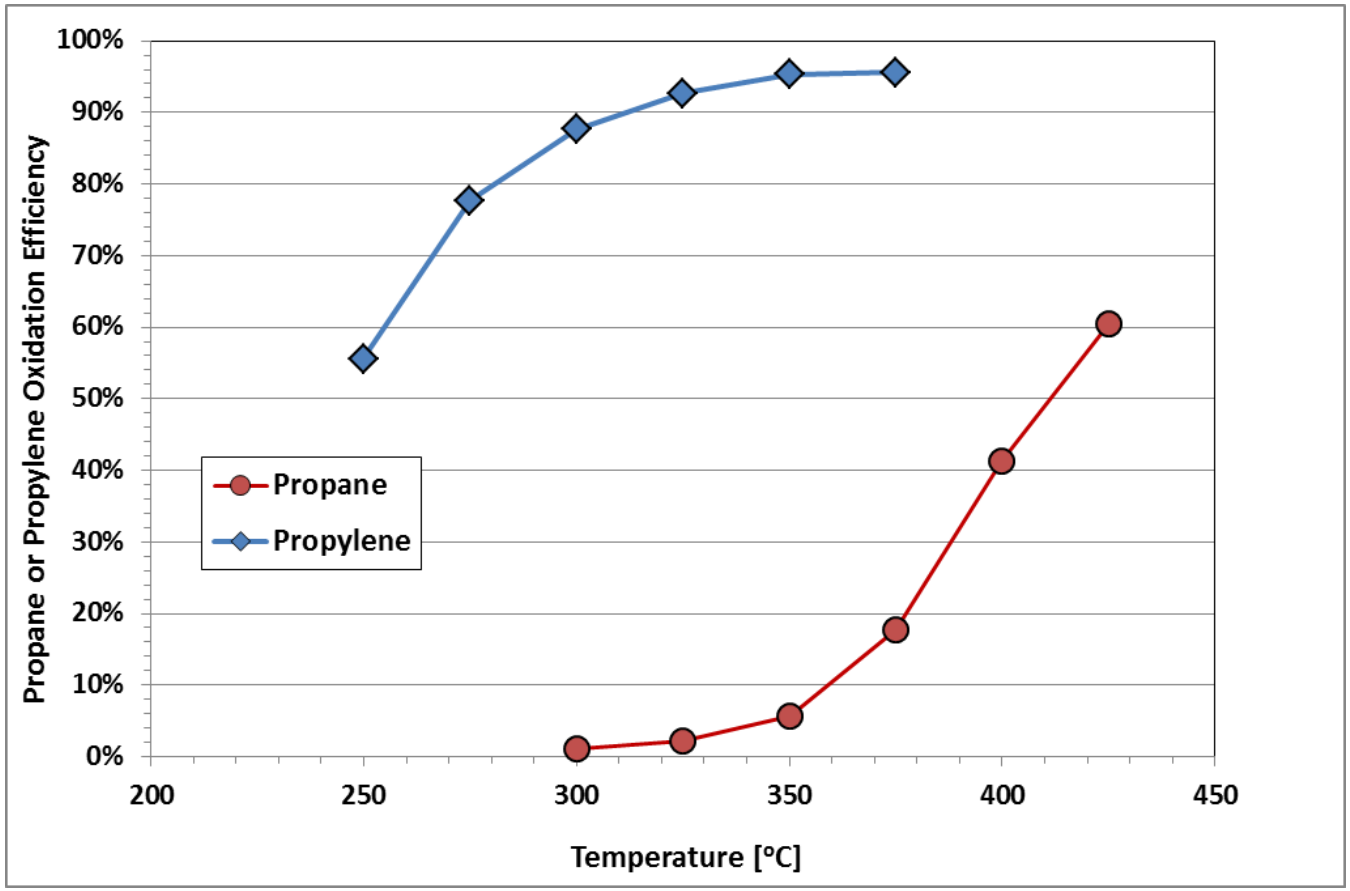
Active for VOC oxidation → rate depends on hydrocarbon speciation.



Test Conditions

NOx = 25 ppm
O_2 = 15%
H_2O = 7%
[C_3H_8 = 20 ppm, or
C_3H_6 = 20 ppm]
NH_3 slip 3 - 7 ppm
Constant SV

METEOR™ Catalyst Performance

DeNOx and CO Oxidation (Diesel Engine Exhaust Condition)

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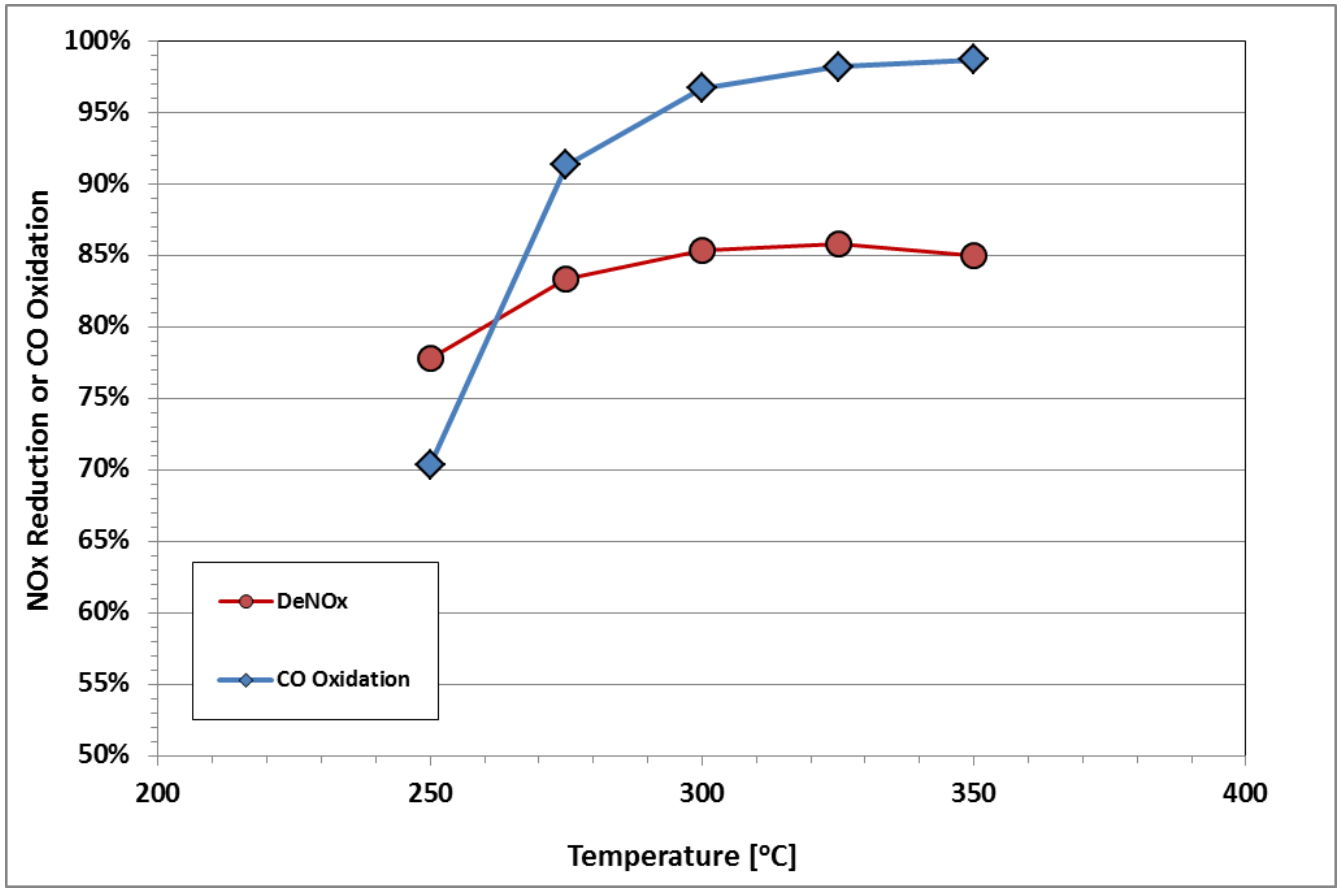
- **Effective DeNOx and CO oxidation** for high inlet NOx & CO concentration cases.
- PGM loading can be adjusted to optimize performance at low/high temperature.



Test Conditions

NOx = 1000 ppm
CO = 1000 ppm
O_2 = 8%
H_2O = 8%
C_3H_8 = 50 ppm
C_3H_6 = 50 ppm
NH_3/NOx = 0.91
Constant SV

METEOR™ Catalyst Performance

VOC Oxidation (Diesel Engine Exhaust Condition)

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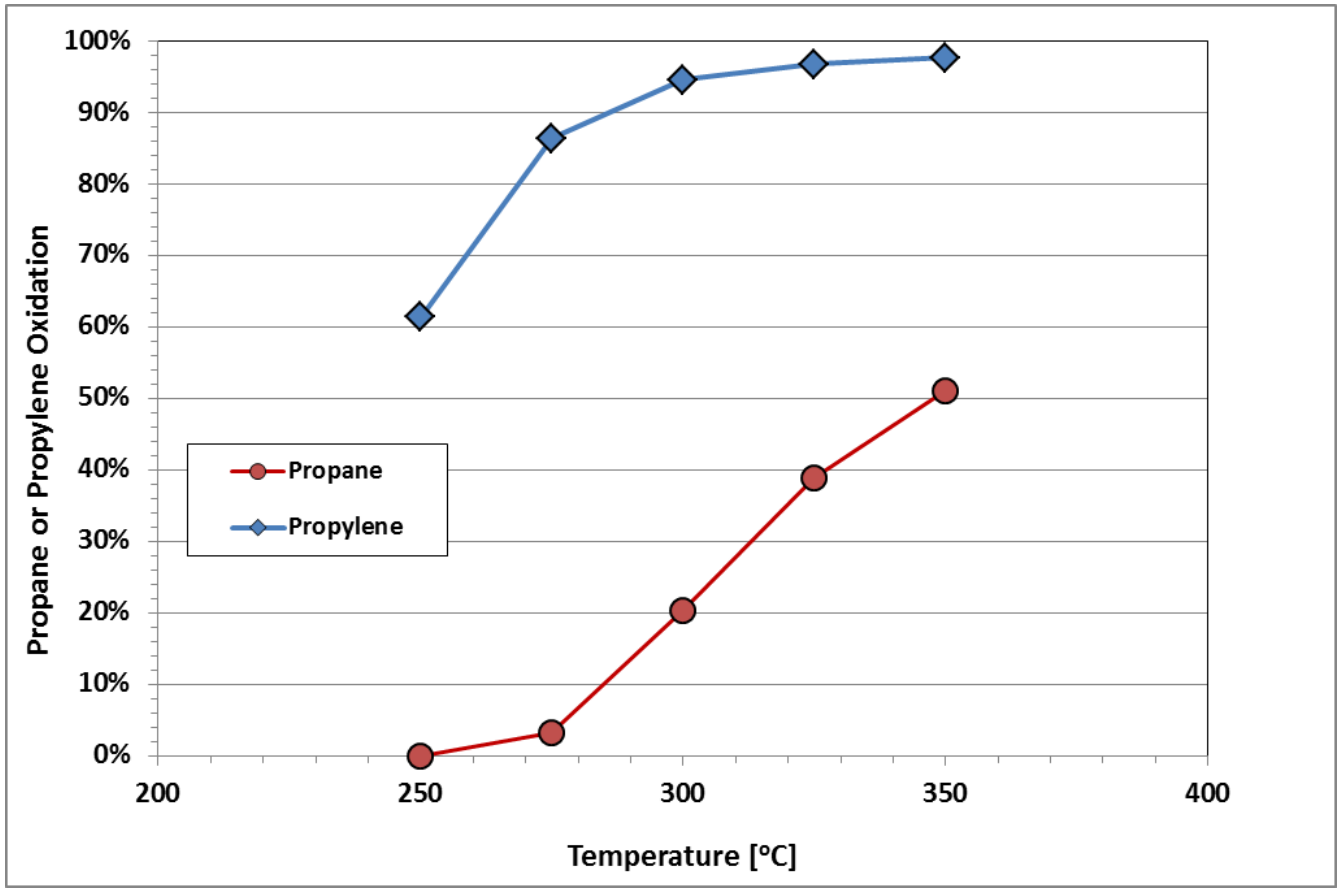
Active for VOC oxidation → rate depends on hydrocarbon speciation.



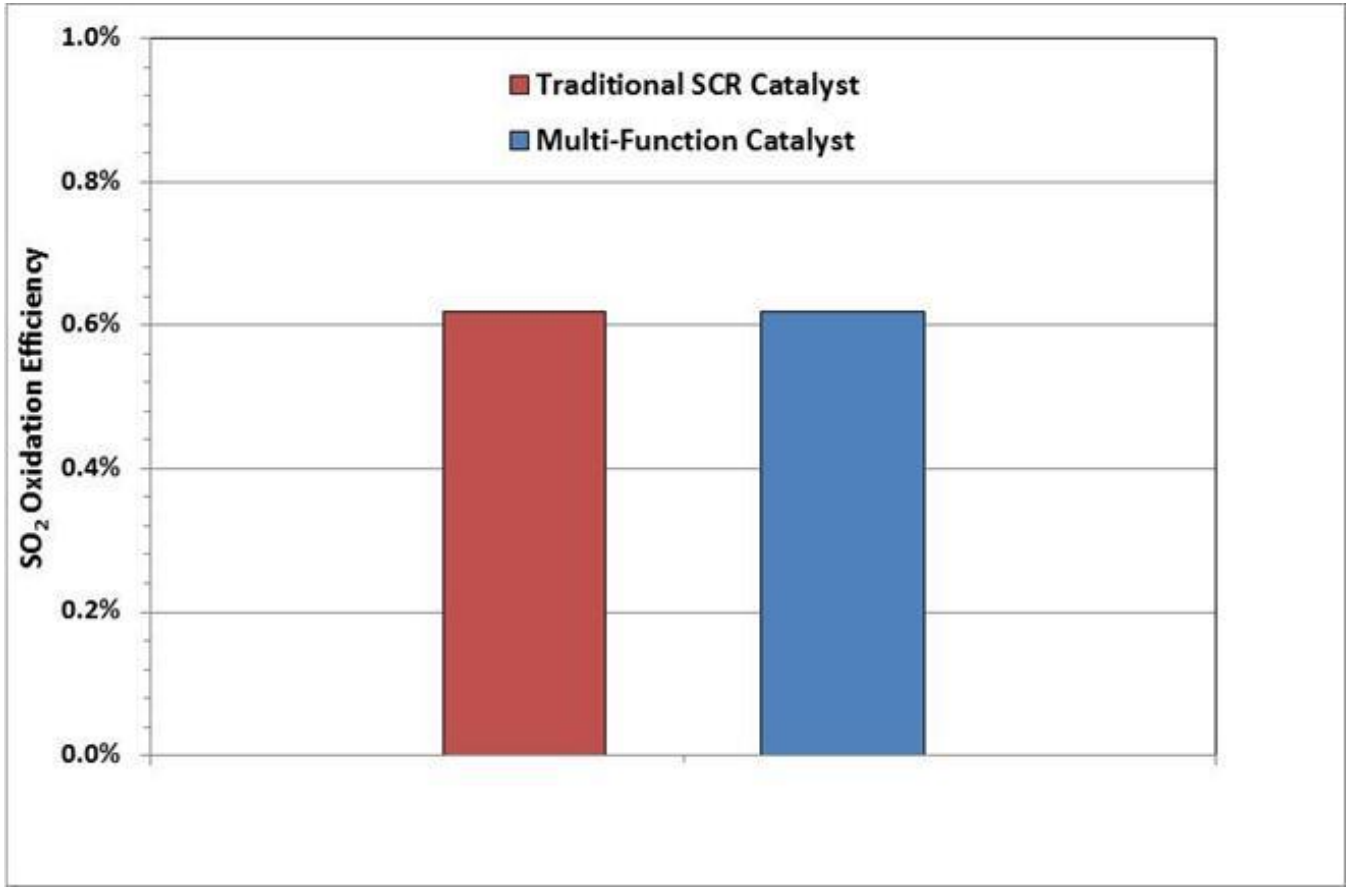
Test Conditions

NOx = 1000 ppm
CO = 1000 ppm
O_2 = 8%
H_2O = 8%
C_3H_8 = 50 ppm
C_3H_6 = 50 ppm
NH_3/NOx = 0.91
Constant SV

METEOR™ Catalyst Performance

SO_2 Oxidation

Similar SO_2 oxidation rate as traditional SCR catalyst.



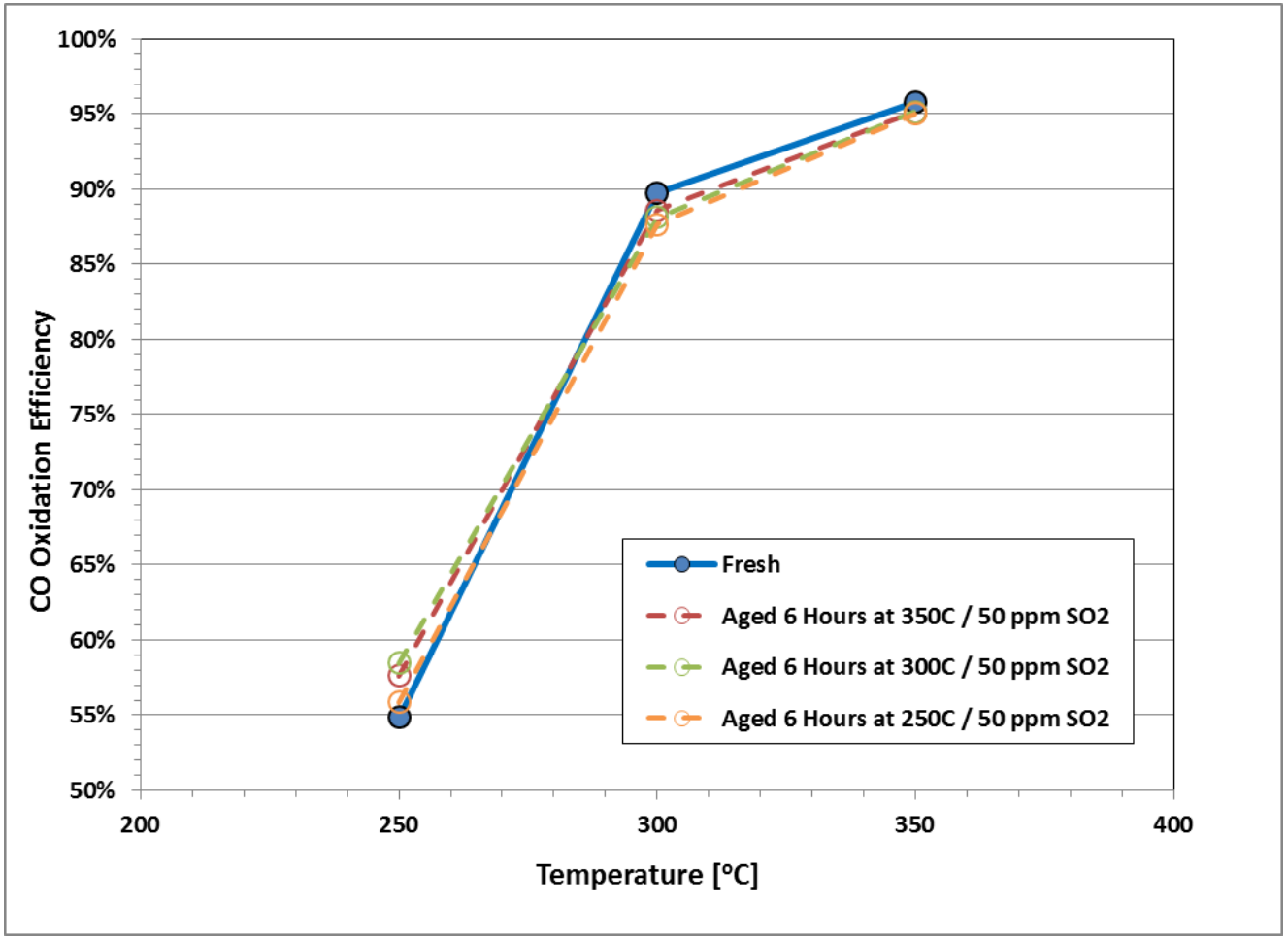
Test Conditions

T = 350°C
NOx = 35 ppm
Inlet MR = 1.1
O_2 = 15%
H_2O = 8%
CO = 100 ppm
SO_2 = 500 ppm
Constant SV

METEOR™ Catalyst Performance

SO_2 Durability

Short-term exposure to **50 ppm SO_2** has **no significant impact** on CO oxidation.

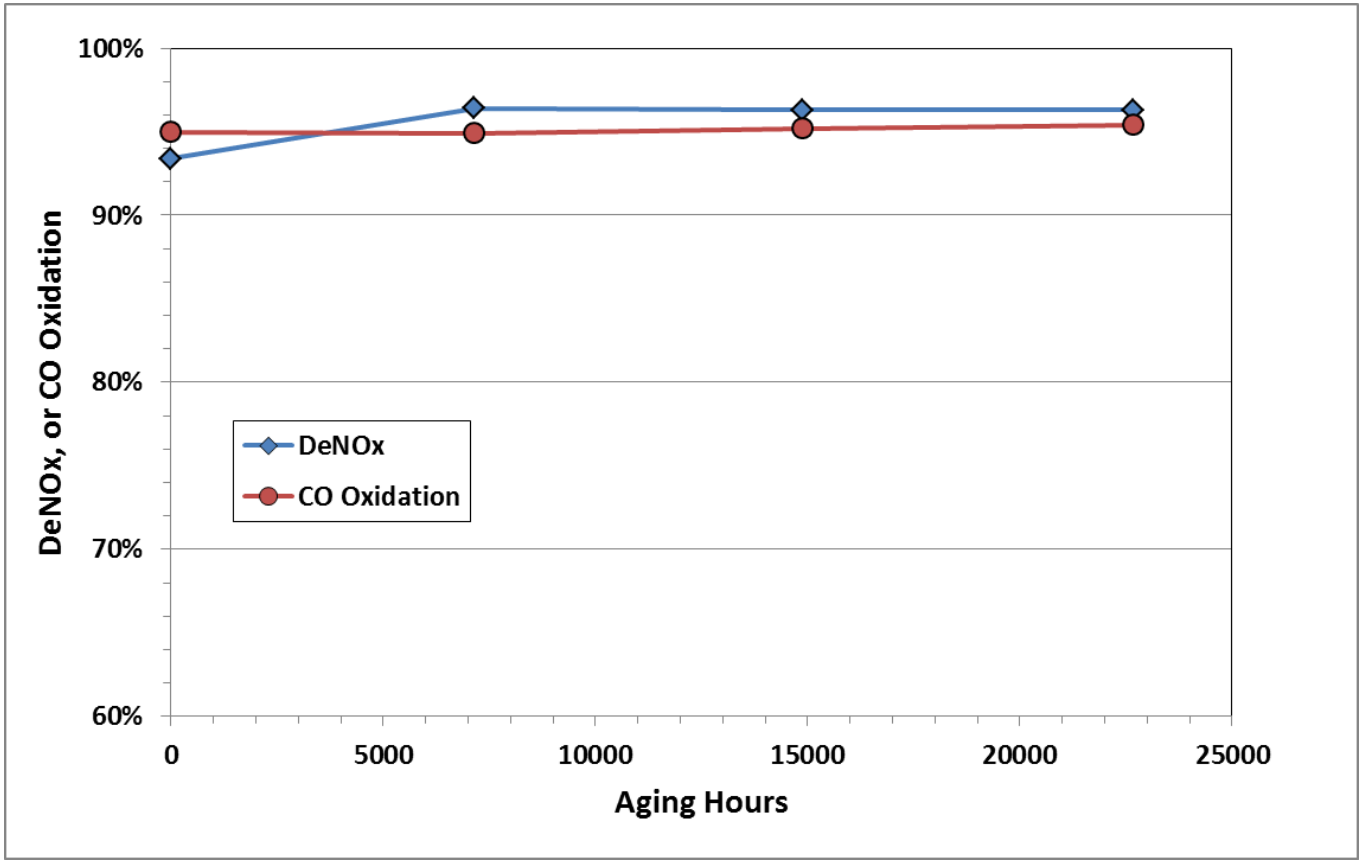


Test Conditions

NOx = 25 ppm
Inlet MR = 1.1
O_2 = 15%
H_2O = 5%
CO = 100 ppm
Constant SV

Long Term Durability Field Test

- Full size element was **installed in an existing SCR catalyst layer** within a HRSG.
- Performance was periodically assessed → **good durability** after 22,660 hours.



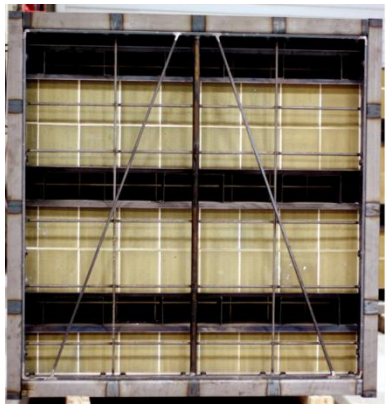
METEOR™ Benefits Summary

- **Simplicity:** *one catalyst layer vs. two*.
  - Smaller footprint in HRSG.
  - Lower pressure drop.
  - Lower O&M costs.
- **Flexibility:** applicable to new units, retrofits, and replacements.
- **Lower SO_2 oxidation rate,** relative to the traditional two catalyst layout.
  - Potential for reduced backend fouling.
- **Highly resistant to sulfur** compounds in the flue gas.

Module Options for Lower DP

Traditional Horizontal Flow "Standard Module"

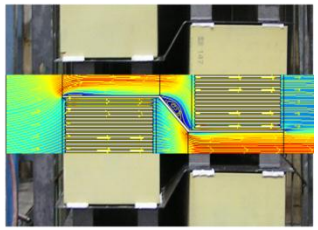
Patented "Advanced Module" for Gas-Fired SCR Units



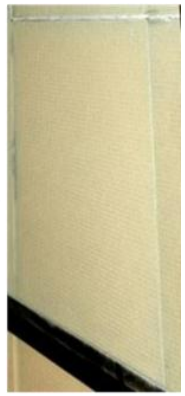
50% more frontal area in same space results in >30% Lower Pressure Loss!

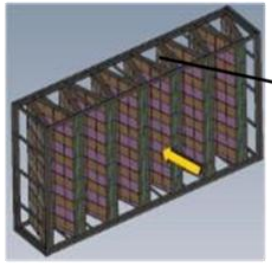
OR

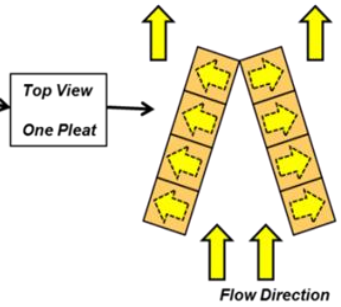
Same Catalyst frontal cross-section in ~ 2/3 the space



Patent Pending "Elite™" Ultra-High Surface Area Module for Deeper Reduction in Pressure Drop for Gas-Fired SCR Units







METEOR™ Full-Scale Installation

- Plant location = Texas.
- Westinghouse 501G unit combustion turbine (~**300MW** electrical generation).
- **METEOR™** fully replaced the existing SCR catalyst layer in November 2015.
- **Guaranteed emission reductions** of NOx, NH_3 slip, CO and VOC.
- **Successful** unit startup. Greater **operating load flexibility** during off-peak hours.

Increased CO Emissions at Low GT Load

Limited Operational Flexibility for Load Turndown

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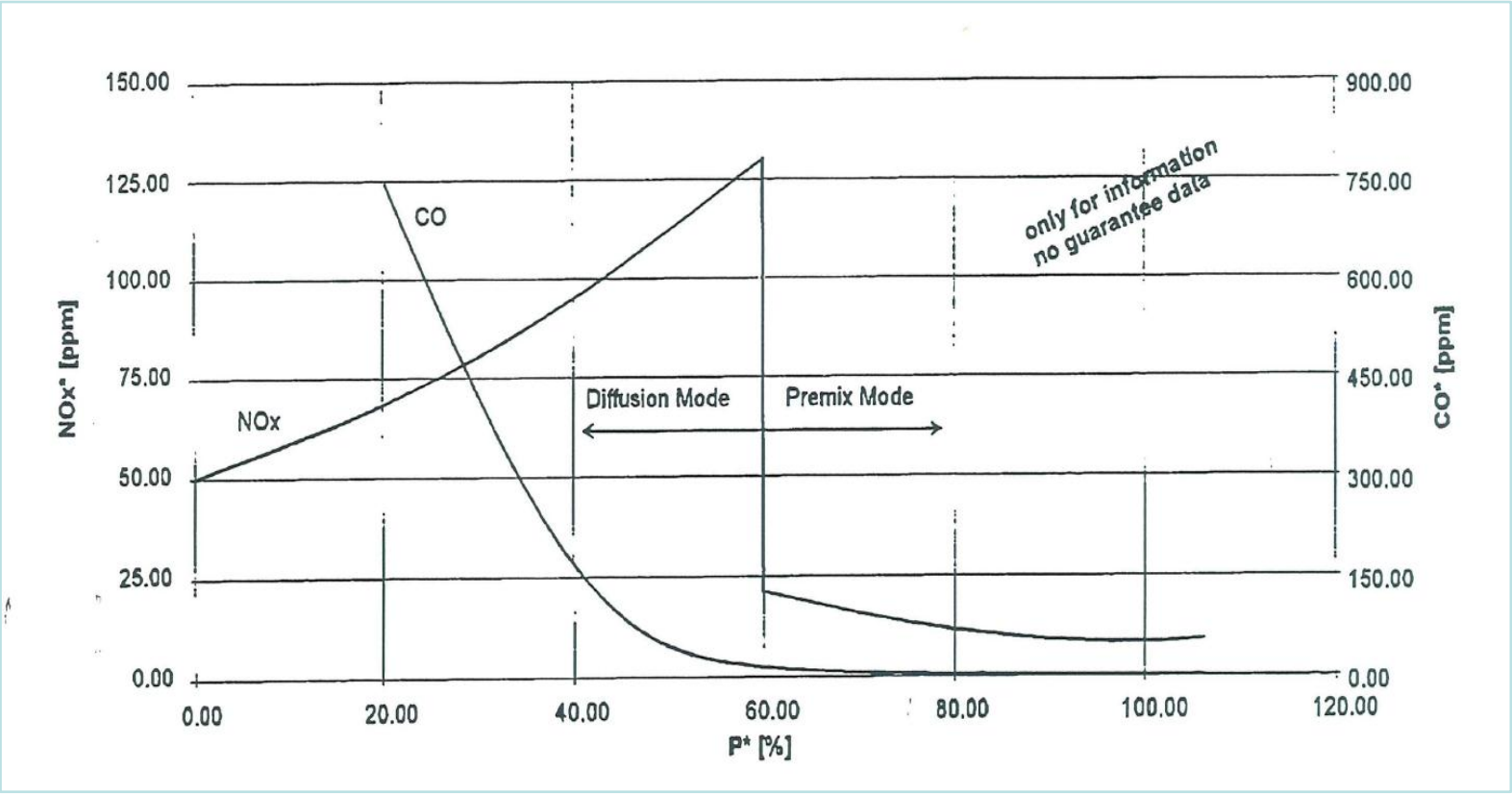
Replacement of existing SCR layer with a new METEOR™ catalyst layer enabled:

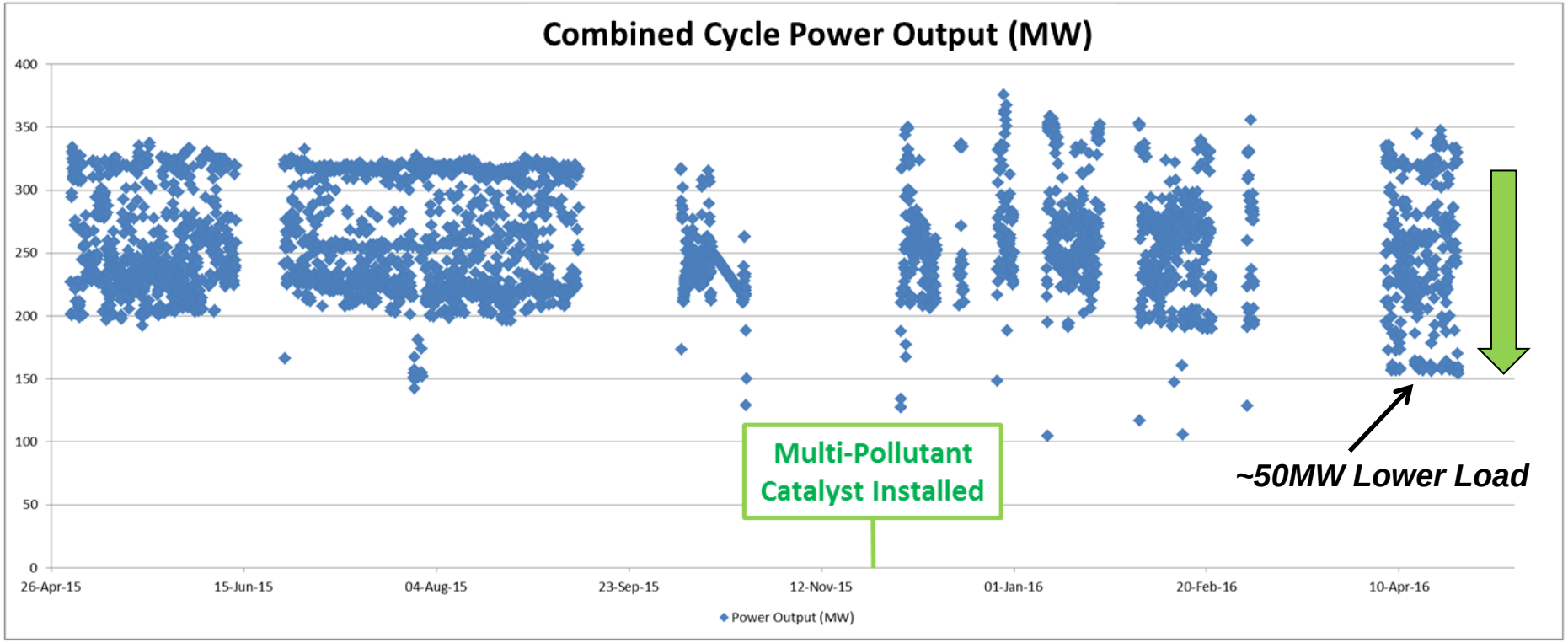
(1) Capability to operate at lower loads while maintaining CO emission compliance.

(2) Faster compliance of CO emissions during unit startup.



METEOR™ Full-Scale Installation

Increased Unit Turndown Capability = ~50MW



METEOR™ Full-Scale Installation

Lowest SCR Temperatures Decreased by ~10°C

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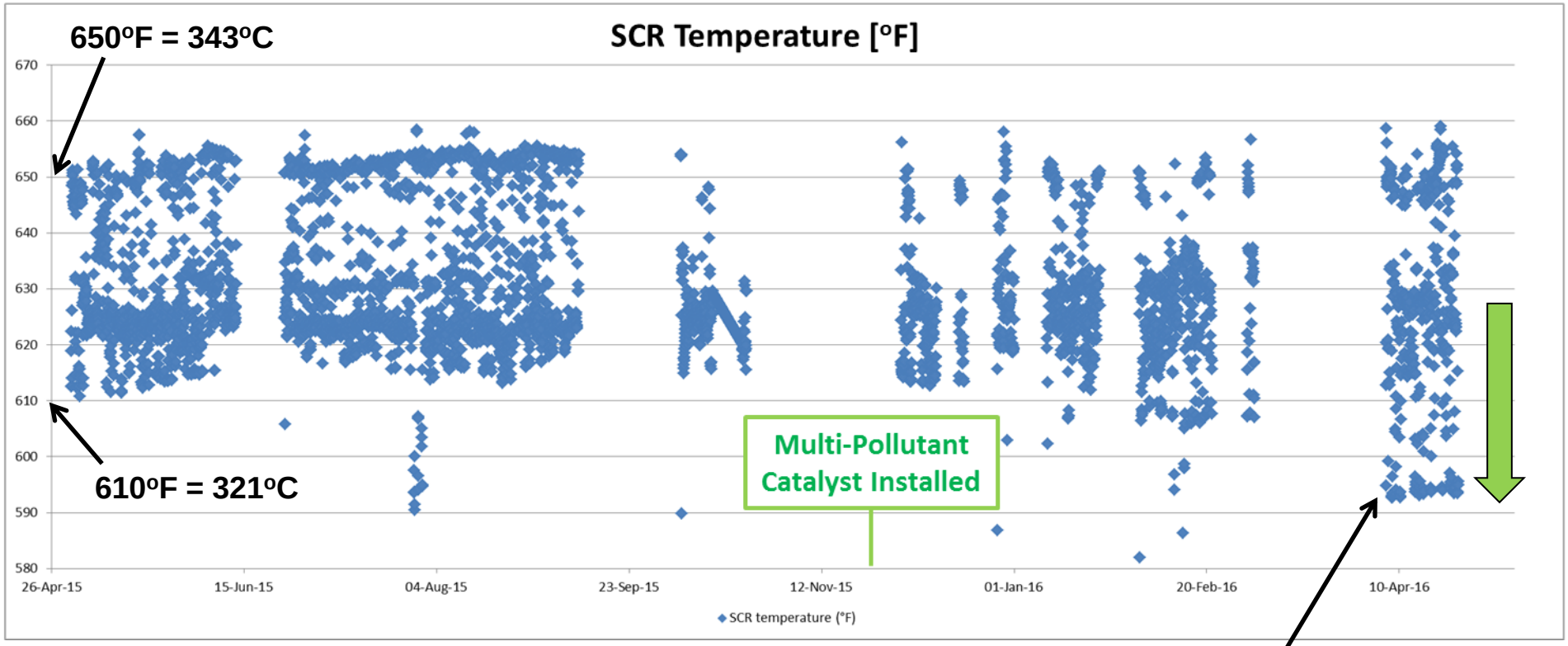
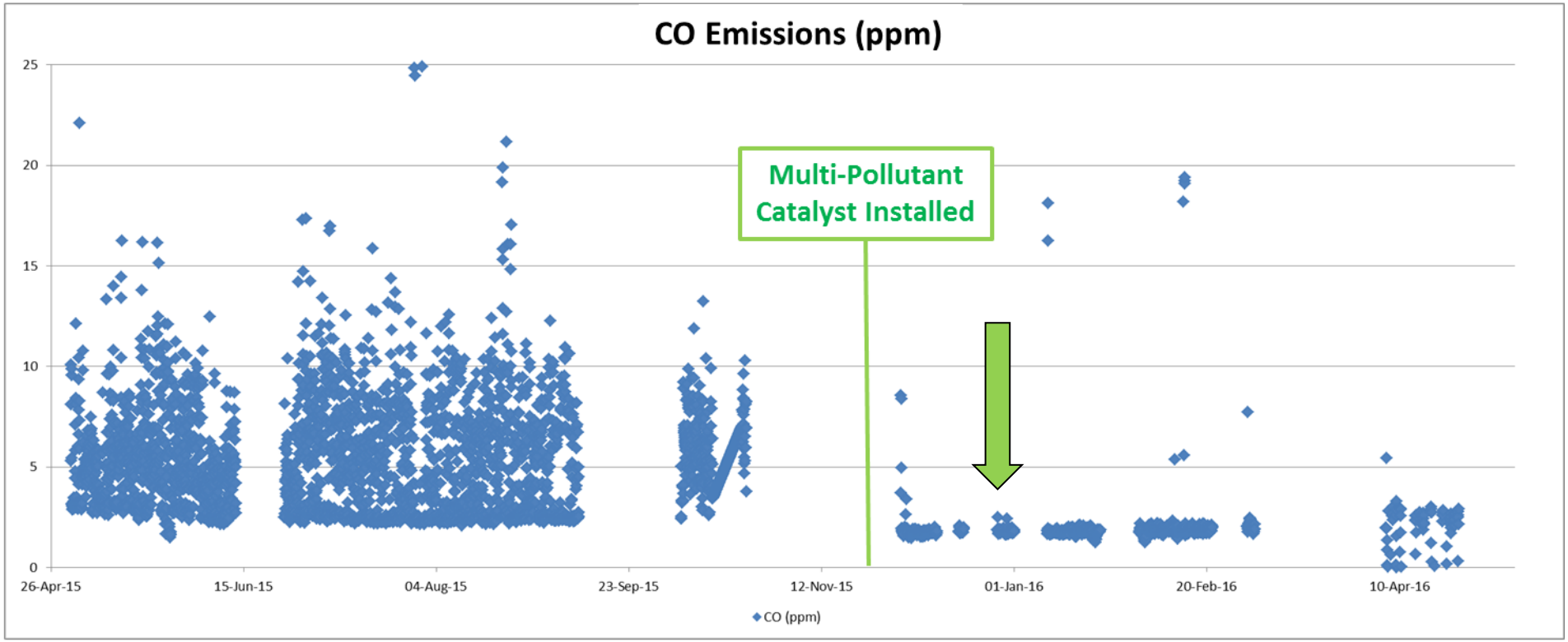


~50MW Lower Load
T_{SCR} ~ 311°C

METEOR™ Full-Scale Installation

CO Emissions Reduced After New Catalyst Installed



METEOR™ Full-Scale Installation

Same NOx Emissions (Per Design)

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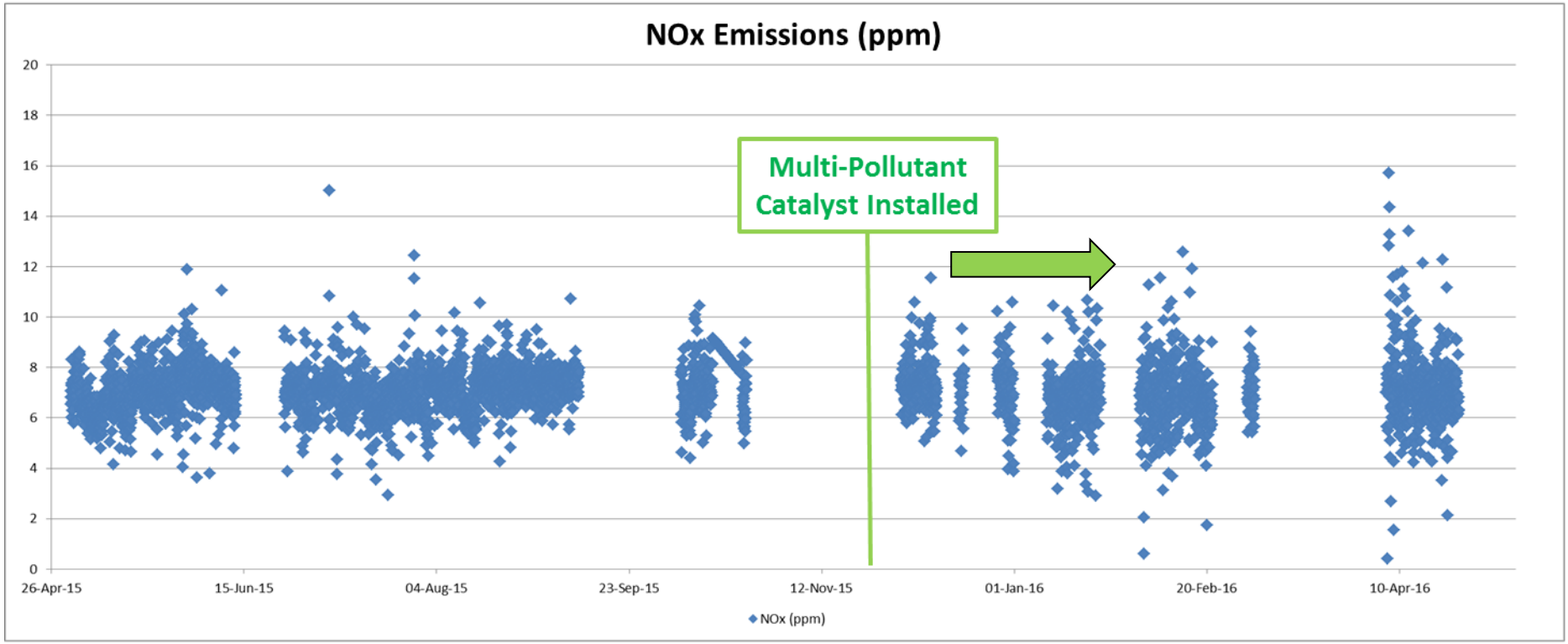

METEOR™ Full-Scale Installation

Lower NH_3 Slip Emissions (Fresh Catalyst)

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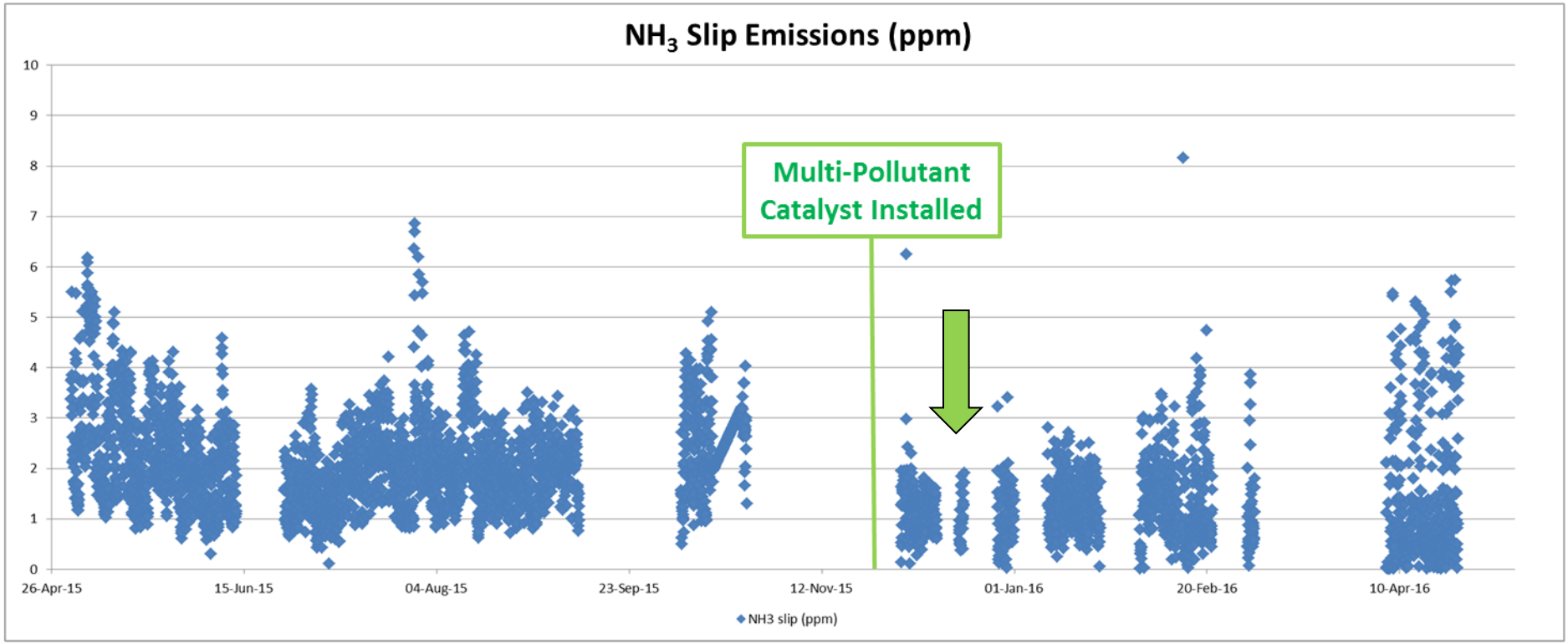

METEOR™ Full-Scale Installation
Field Test Validation

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- **Plant's motivation for METEOR™ installation:**
  - Greater **operating load flexibility** during off-peak hours.
- **Field testing validation:** measured SCR inlet and outlet gas composition
  - SCR inlet = GT exhaust gas.
  - **Fresh catalyst** achieved **~99% CO oxidation** at **36% GT load point**.
  - DeNOx achieving target value. NH_3 slip is very low due to the fresh catalyst state.

		GT Exhaust Gas Composition		SCR Outlet Gas Composition		Meteor SCR Catalyst Performance		
GT Load	SCR Temperature (°C)	GT Exhaust CO (ppm)	GT Exhaust NOx (ppm)	SCR Outlet CO (ppm)	SCR Outlet NOx (ppm)	SCR CO Oxidation	SCR DeNOx	SCR Outlet NH_3 Slip (ppm)
98%	342	0.5	29.4	0.0	7.8	100%	74%	0.7
76%	334	0.6	32.8	0.0	6.7	100%	80%	0.7
36%	322	**172**	44.0	**2.2**	6.7	**98.8%**	85%	0.5

Summary
METEOR™ Multi-Pollutant Catalyst

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- **Simultaneously reduces** NOx, CO, VOCs and NH_3 slip to compliance levels in one catalyst layer located at the traditional SCR catalyst location.
  - Lower system pressure drop.
- Provides **benefits**:
  - Total emissions regulation compliance.
  - Extended operating flexibility by extending the unit load operating range.
  - Reduction of corrosion of the HRSG section downstream of the SCR.
  - Lower O&M costs.
- **Applicable** to new units, retrofits, and replacements.
- Has been **successfully deployed** at a full-scale combined cycle HRSG unit.

CORMETECH METEOR™