

The Advanced Combustion and Emission Control (ACEC) Technical Team

Low Temperature Aftertreatment (LTAT) working group

Including representatives from:

- FCA, Ford, GM, ORNL, PNNL, & DOE

STEP 1 Low-Temperature Oxidation

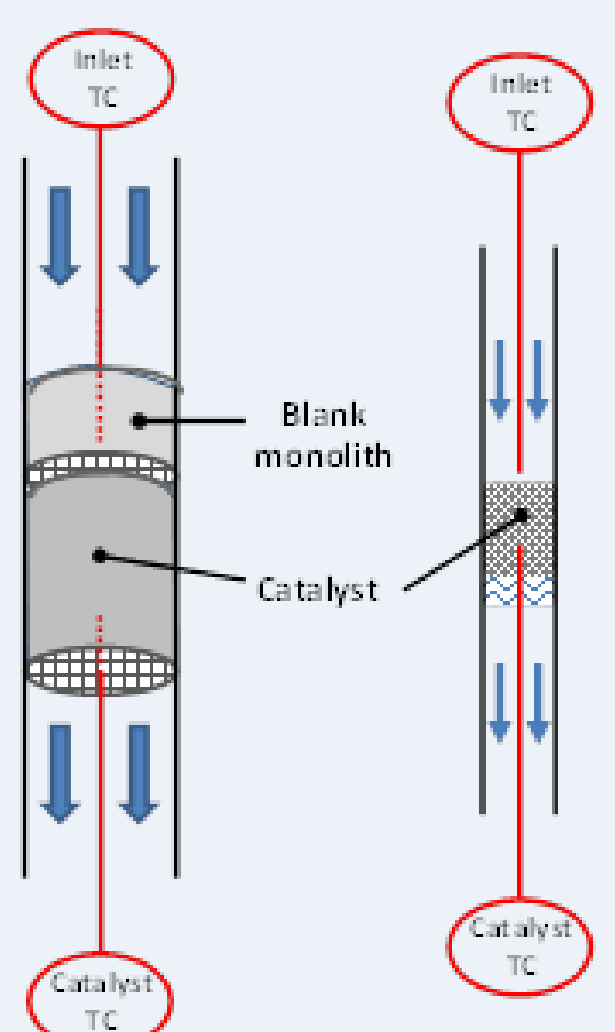


Low Temperature Aftertreatment (LTAT) Test Protocol Development

The Protocol is a document that will be distributed via the **CLEERS** website upon final approval by **USDRIVE** leadership

Reactor Description

Core ↔ Powder



ANALYTICAL

- [CO], [CO₂], total HC, [NO], [NO₂]
- [N₂O], [NH₃], stoich comb. [O₂]

Frequency of Analysis
Sampling every 2°C

Rate of Response
≤ 15 seconds

TEMPERATURE MEASUREMENT

- catalyst inlet, within catalyst powder, inserted into core

REACTOR BASE-LINING

- Ensure reported data dictated solely by material behavior
- One-time blank run per application to base-line without catalyst
- Quantify recovery of reactive species to ensure fate

Aftertreatment Protocols for Catalyst Characterization and Performance Evaluation:
Low-Temperature Oxidation Catalyst Test Protocol

The Advanced Combustion and Emission Control (ACEC) Technical Team
Low-Temperature Aftertreatment Group

March 2015

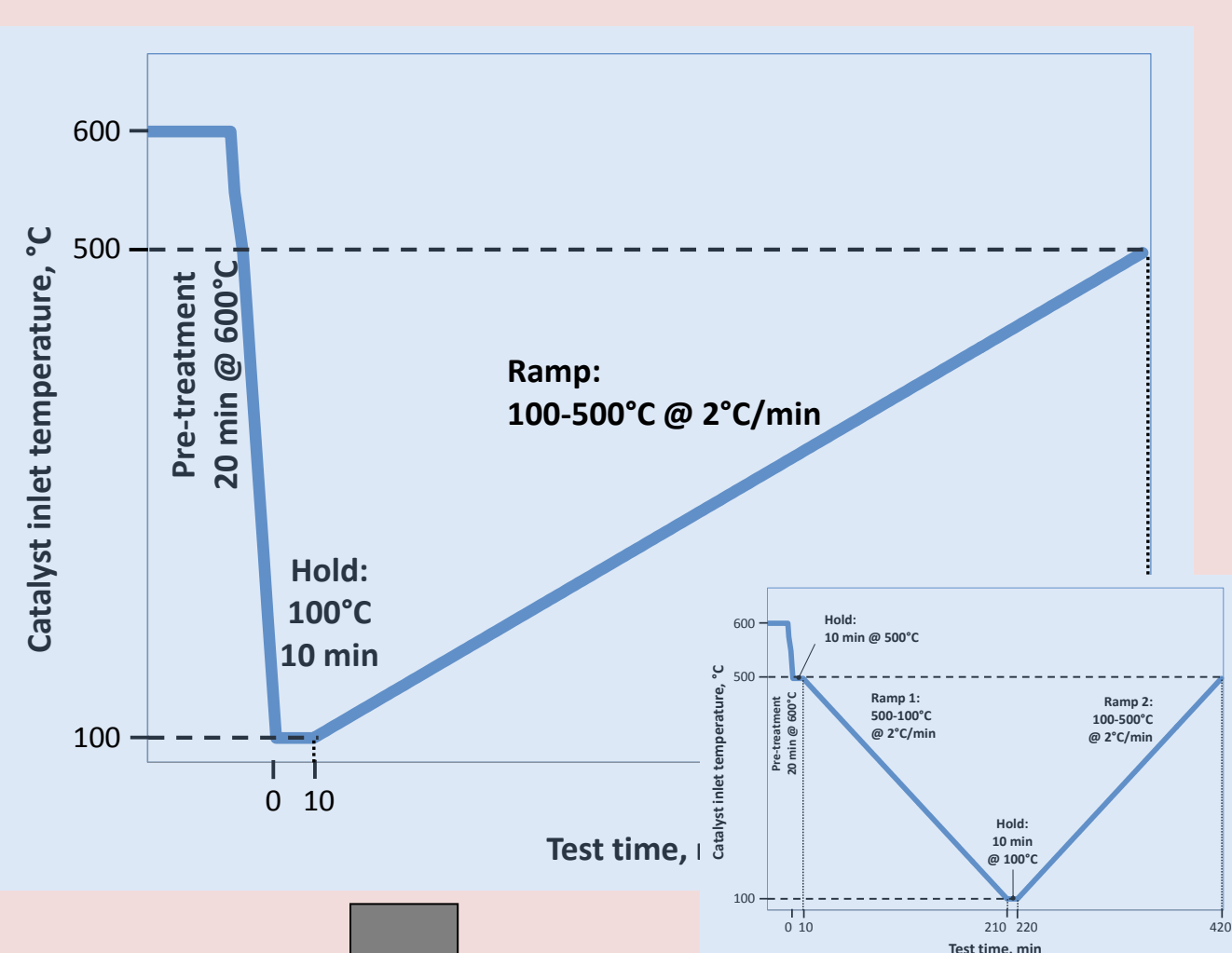


Exhaust Simulation

Constant Components	Stoichiometric GDI [S-GDI]	Clean Diesel Combustion [CDC]	Lean GDI [L-GDI]	Low Temp Combustion of Gasoline [LTC-G]	Low Temp Combustion of Diesel [LTC-D]
[O ₂]	0.74%	12%	9%	12%	12%
[H ₂ O]	13%	6%	8%	6%	6%
[CO ₂]	13%	6%	8%	6%	6%
[H ₂]	1670 ppm	100 ppm	670 ppm	670 ppm	400 ppm
Variable Components	all in [ppm]				
[CO]	5000	500	2000	2000	2000
[NO]	1000	200	500	100	100
Hydrocarbon – [ppm] on C ₁ basis**					
Total [HC]	3000	1400	3000	3000	3000
[C ₂ H ₄]	700 (1050)	500 (778)	700 (1050)	700 (1050)	500 (1667)
[C ₃ H ₆]	1000 (1500)	300 (467)	1000 (1500)	1000 (1500)	300 (1000)
[C ₃ H ₈]	300 (450)	100 (155)	300 (450)	300 (450)	100 (333)
[i-C ₈ H ₁₈]	1000 (0)	-	1000 (0)	1000 (0)	-
[n-C ₁₂ H ₂₆]	-	500 (0)	-	-	2100 (0)

HC C₁ concentrations in parenthesis to be used if the user chooses to omit the liquid HC species

Protocol Execution and Reporting



PRE-TREATMENT 20 min @ 600°C

- CDC, LTC-(D/G), L-GDI
– Lean [O₂, H₂O, CO₂]
- S-GDI
– Neutral [H₂O, CO₂]

ACTIVITY TESTING 2°C/min 100 – 500°C

- 30k GHSV (60k option)
- Full simulated exhaust

REPORTING

Catalyst Sample Details

- Catalyst dimensions (or amount), composition
- Core substrate details (e.g., cell density)

Reactor Configuration

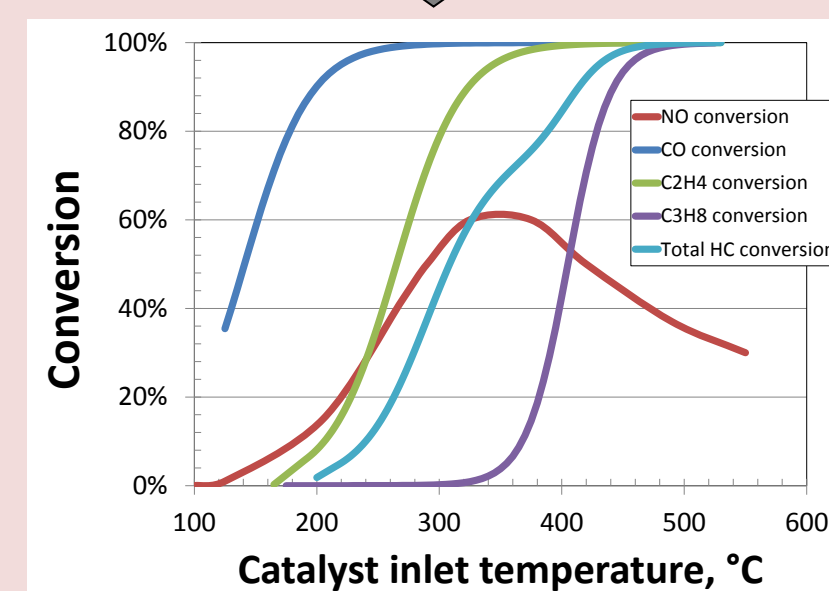
- Reactor and heating details
- Details regarding thermocouple location, chemical analysis, sampling techniques, feed composition, GHSV

Test Conditions

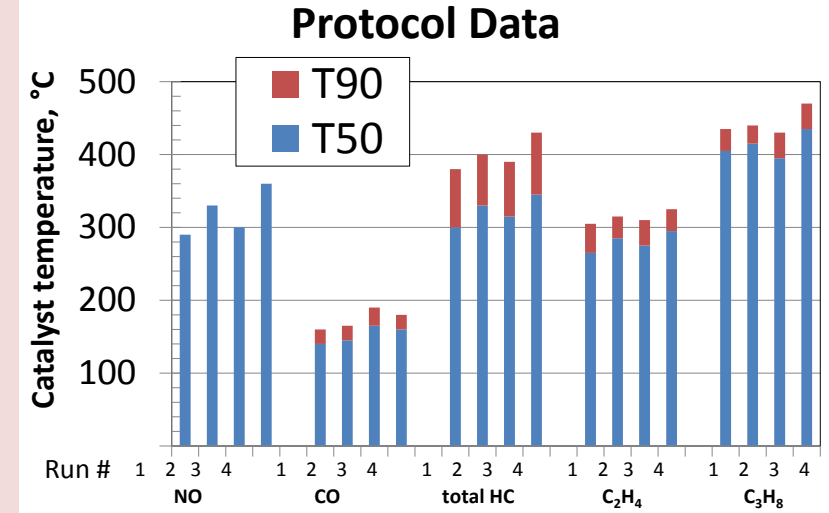
- Intended engine application
- Procedures used for de-greening, aging and/or poisoning, pre-treating & testing (or reference to protocol)

Test Results/Performance Data

- Concentration versus temperature
- Conversion efficiency, T50/T90 determination



Example Data Compilation for Protocol Data



SELECT ENGINE TYPE AND COMBUSTION MODE

DE-GREEN

700°C/4 hours

PERFORMANCE EVALUATION

AGE

800°C/50 hours

PERFORMANCE EVALUATION

LNT only

AGE

800°C/10 hours

PERFORMANCE EVALUATION

POISON

5 ppm SO₂/5 hours

PERFORMANCE EVALUATION

De-greening and Aging

- All catalysts de-greened prior to protocol execution
- De-greening *once* per sample; pre-treatment prior to *each* test
- Aging/poisoning to occur separately from activity testing
- Aged-state unchanged during the course of activity testing

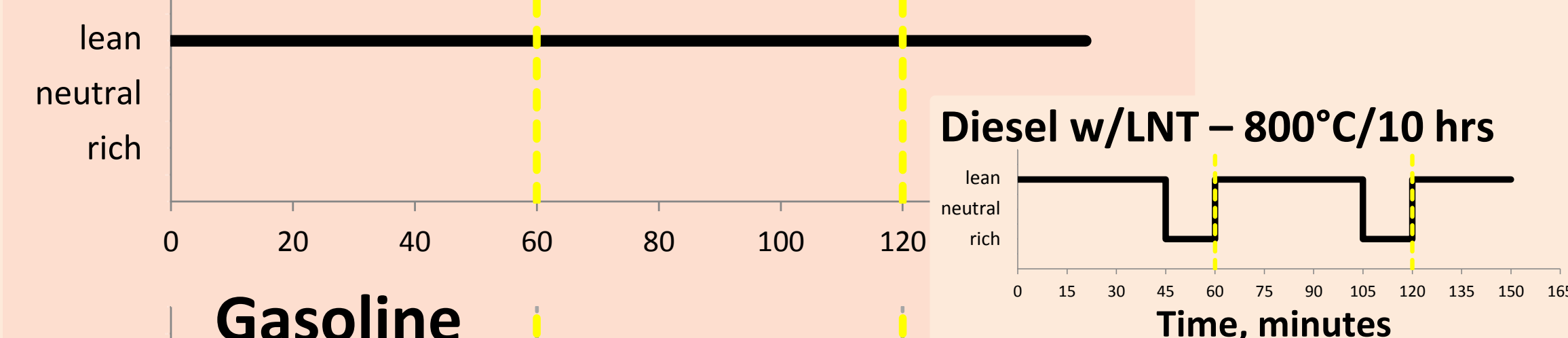
DE-GREENING – 700°C/4 hours

Neutral – gasoline [S-GDI, L-GDI, LTC-G]

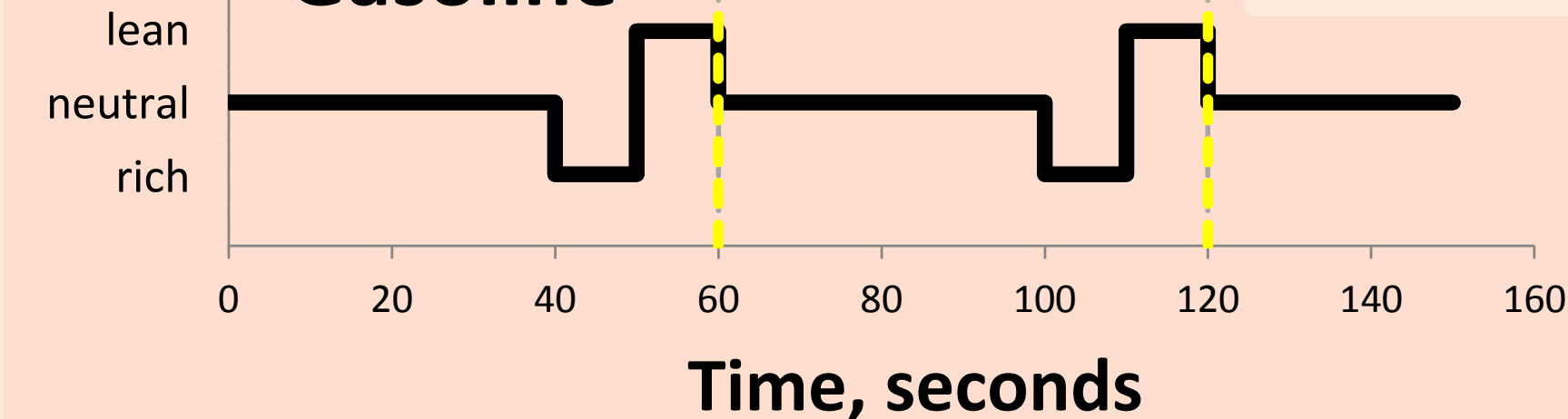
Lean – diesel [CDC, LTC-D]

CATALYST AGING – 800°C/50 hours

Diesel



Gasoline



Sulfur Poisoning

PRE-TREATMENT
20 min @ 600°C

POISON – 5 hrs @ 300°C
Full Simulated Exhaust
+ 5 ppm SO₂

ACTIVITY TESTING