

Maintenance Based Emissions Test Protocols

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The Goal

- To be able to detect operating faults in diesel engines working at underground operations using emissions measurement
- To be able to maintain diesel engines working at underground operations to as-certified levels (CAN/CSA & MSHA)
- To be able to respect regulations, standards and recommendations for loading engines to steady-state stall conditions without compromising equipment condition

The Challenge

- Engines are certified to CAN/CSA and MSHA standards in accredited laboratories using dynamometers for steady-state engine loading
- In order to maintain against certified values in-use engines must use a combination of vehicle parasitic load systems such as torque converter and hydraulics to reproduce the load condition



Background

- USBM Study - 1985
- NIOSH Emissions-assisted Maintenance Program (EAMP)
- MSHA
- Australia NSW – Coal Services
- NRCan CANMET Effects of Simulated Faults
- DEEP Maintenance Project – 1999
- Noranda Technology Centre – 1996 to 2002

Background

- Noranda Technology Centre consultations with NRCan CANMET in 1996
- Dr. Mahe Gangal recommendations for development of emissions verification tool development:
 - Steady-state sampling for minimum 60 seconds at rated speed and power
 - Baseline individual emissions and combine to use as surrogate for EQI formula ($CO/25 + NO/25 + NO_2/3$) for verification against engine certification
 - Use of EC cell gas analyzer with heated condensate trap capability
 - UGAS System - United States patent 6,079,271

Test Mode – Where and How?

Field Emissions Testing of Engines and Aftertreatment: Best Practices, Methods and Maintenance

Brent Rubeli, Natural Resources Canada

How to test - Loading

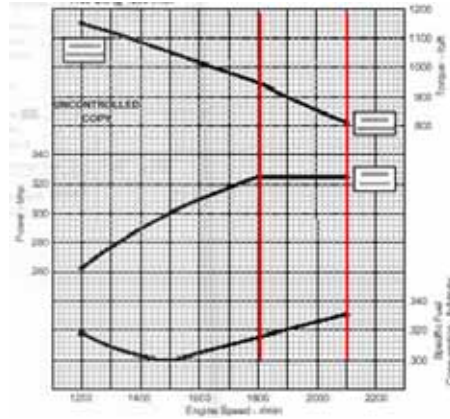
- Meaningful data is only obtained with engine under loaded conditions.
- Torque converter/hydraulic stall procedure.
- Idle does not have significant fuel delivery of temperature.
- Snap acceleration test does achieve full fuel but only briefly.



CANMET MINING AND MINERAL SCIENCES

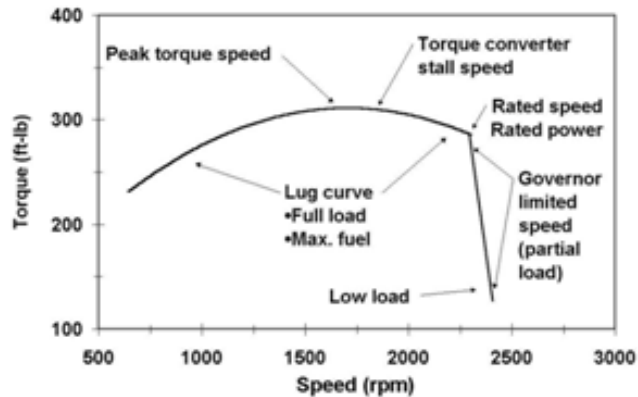
Test Mode – Where?

Rated – 100% load – steady state



Test Mode – Where?

Rated – 100% load – steady state



Test Mode – How?

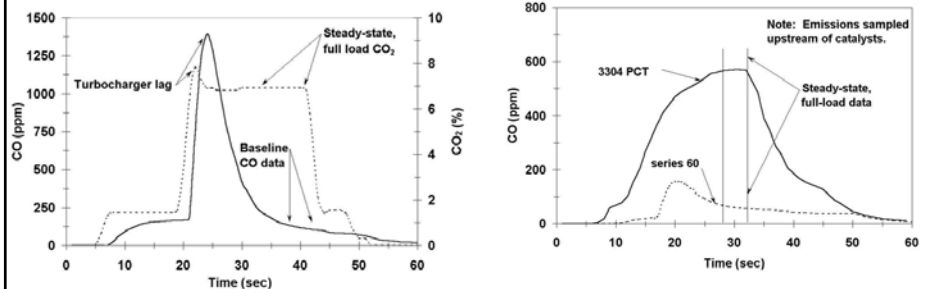
Rated – 100% load – steady state

- Torque converter stall
- Hydraulic stall
- Torque + Hydraulic combined stall
- « Emissions must be at steady state to be repeatable »
Brent Rubeli, Natural Resources Canada

Test Mode – How Long?

Rated – 100% load – steady state

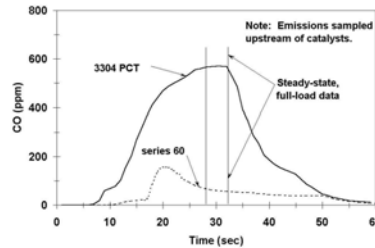
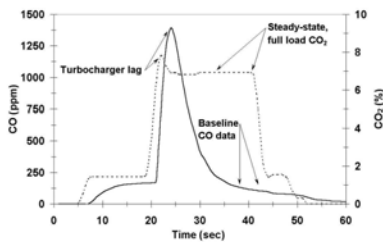
- Minimum 60 second sampling period
- Avg / Min / Max
- Std deviation



Test Mode – How Long?

Rated – 100% load – steady state

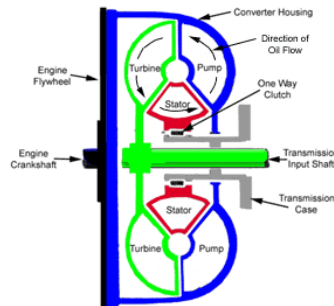
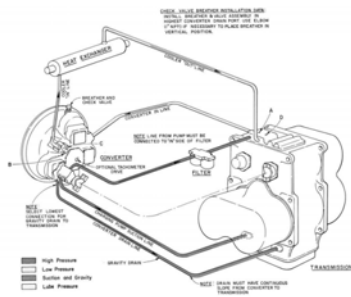
- Instantaneous value (compliance) versus avg/min/max values (maintenance)
- Not exactly clear to the mechanic taking the test!
- What is acceptable and not – what is the truth??



Test Mode – Constraints

Torque Converter

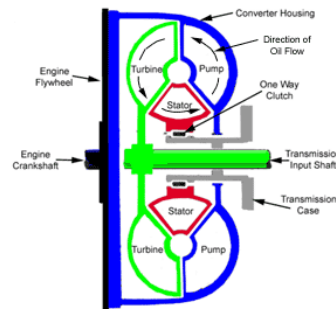
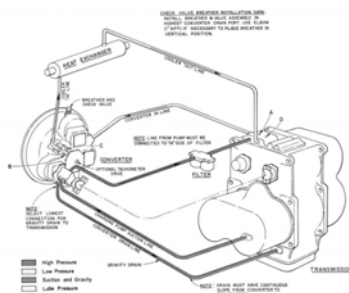
- Heat dissipation – degradation of seals
- Varying types – planetary transverters, etc.
- Contradicting evidence



Test Mode – Constraints

Torque Converter

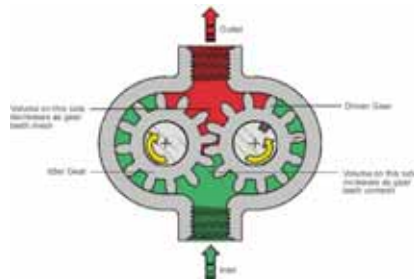
- Safety – braking systems and stationary assurance
- Transmission shift modulation and interlocks



Test Mode – Constraints

Hydraulic System

- Fixed displacement – gear pump
- Variable displacement – load sense pressure compensated



Test Mode – Advantage

Performance Standard

- Use available engine certification data such as MSHA lug curve for CO and CO₂
- Ability to maintain « as certified »

TORQUE CURVE TEST ALL TESTS AT FULL THROTTLE		
MSHA # :	7E-B090	
Engine:	Deutz F3L 1011F	
Engine Rating:	44 HP @ 3000 RPM	
Engine Speed, RPM	CO, ppm	CO ₂ , %
3000	982	10.9
1800	1834	11.7

TORQUE CURVE TEST - ALL TESTS AT FULL THROTTLE		
MSHA # :	7E-B098-0	
Engine:	DaimlerChrysler OM 904LA	
Engine Rating:	174 HP @ 2200 RPM	
Engine Speed, RPM	CO, ppm	CO ₂ , %
1200	1341	11.81
1400	318	10.32
1600	335	10.1
1800	299	10.09
2000	267	9.94
2200	222	9.58

Test Mode – Future

- Hydraulic stall with gear pump is preference #1
- Torque converter stall with precautions is preference #2
- Engineered solutions from manufacturers is what is required: Example J.H. Fletcher Tow Tractor
- Solution using variable displacement hydraulics
- Solution using supplementary cooling for torque converters
- Customers need to include requirement in equipment specs
- Will Tier IV technology require less maintenance????

Light Duty Vehicles

- Toyota Landcruiser, John Deere Gator, etc.

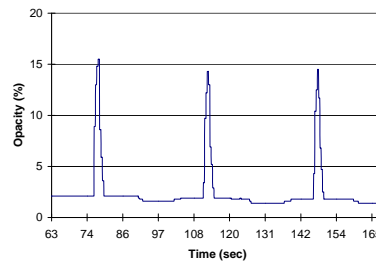
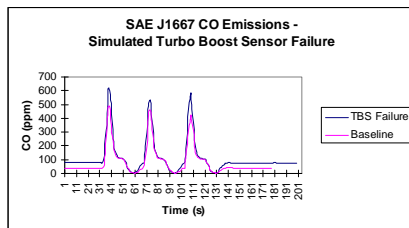


Light Duty Vehicles

- No on-board parasitic load with manual transmissions
- No possibility for stalling engine without chassis dyno
- SAE J1667 – snap acceleration X 3 – provincial drive clean programs
- Adjusts fuel system to full fuel momentarily until governor compensates
- Best available surrogate for non-load capable vehicles

Light Duty Vehicles

- Written for use with light extinction (opacity) instrumentation
- Can be adapted using gases and other smoke density
- Interpreting results in a standard manner is an issue



Summary

- The requirement for steady-state emissions testing at rated power is a long-accepted and acknowledged practice
- A steady-state testing period of 60 seconds is required to account for transient cycling and sampling system delay
- Selection of on-board system(s) for applying load to the engine must consider safety and reliability factors
- Manufacturers should become more actively involved in providing engine load solutions
- Light duty vehicles require an adapted standard for emissions testing and cannot be ignored

Acknowledgements

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Questions?

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