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## Effect of Intake Air with Methane on Diesel Engine Emissions with Control Technologies

**13<sup>th</sup> Annual MDEC Conference**  
**Sheraton Parkway, Toronto North**  
**October 1 – 5, 2007**  
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**N. Paas (Dry Systems Technologies)**  
**T. Robson (Quinsam Coal)**

#07-143



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## Gassy Mine Environment


- Characterized by explosive atmosphere
- May contain methane gas and combustible dust
- Diesel equipment conforms to flameproof, electrical, fuel, safety shutdown etc. requirements
- Equipment surface temperature below 150°C
- Monitoring of gas levels
- Ventilation requirement

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## Ventilation Air Requirement (National Standard of Canada)

- Non-Gassy U/G Mines (CAN/CSA-M424.2-M90)
  - Sample engine testing on a dynamometer
  - Fuel conforms to CGSB standard 3.16
  - $\text{CO} < 2500 \text{ ppm}$ ,  $\text{NO}_x < 1500 \text{ ppm}$ ,  $\text{PM} < 150 \text{ mg/m}^3$
  - Exhaust treatment devices allowed
  - Suitable procedures to maintain devices
  - Vent rate pertains to worst operating conditions
  - Local conditions may change the vent rates

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## Ventilation Air Requirement (National Standard of Canada)

- Gassy U/G Coal Mines (CAN/CSA-M424.1-88)
  - As in for non-gassy underground mines
  - Flameproof requirements
  - Testing with intake air mixture of 1.25% methane
  - Engine shutdown at 1.25% methane
  - Maximum surface temperature of  $150^\circ\text{C}$

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## Equipment Tested

- Diesel Engine
  - Isuzu 6BG1-MAP
- Flameproof package (DST®)
  - Water cooled exhaust manifold
  - Flame arresters
  - Heat exchanger
- Emission control devices (DST®)
  - Catalyst
  - Low temperature particulate filter

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## Schematic Diagram of DST® Exhaust System

The diagram illustrates the flow of exhaust gases through the DST® system. It starts with an Exhaust Manifold, which leads to a Catalyst. From the Catalyst, the exhaust passes through a Heat Exchanger, and finally through a Filter. The components are represented by 3D blocks: a blue rectangular block for the Exhaust Manifold, a red-outlined rectangular block for the Catalyst, a blue rectangular block for the Heat Exchanger, and a blue cylindrical block for the Filter. A curved arrow indicates the direction of flow from the manifold through the catalyst, heat exchanger, and filter.

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**DST®  
Model M150  
Diesel Power  
Package**

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## Engine Dynamometer Testing

- Test Lab: NRCan, CANMET-MMSL, Ottawa
- Accreditation: ISO 9001-2000, ISO/IEC 17025
- Test method: ISO 8178-1
- Test data: 8-modes of ISO 8178-C1
- Baseline test: With clean engine intake air
- Methane test: With intake air mixture of 1.25% methane
- Fuel: Mining diesel CGSB-3.16, 310 ppm sulphur

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## ISO 8178-C, 8 Mode Test Cycle With Weighing Factors

Mode Number	1	2	3	4	5	6	7	8
Speed, rpm	2500				1500			735
Torque, %	100	75	50	10	100	75	50	0
Weighing factor	0.15	0.15	0.15	0.1	0.1	0.1	0.1	0.15

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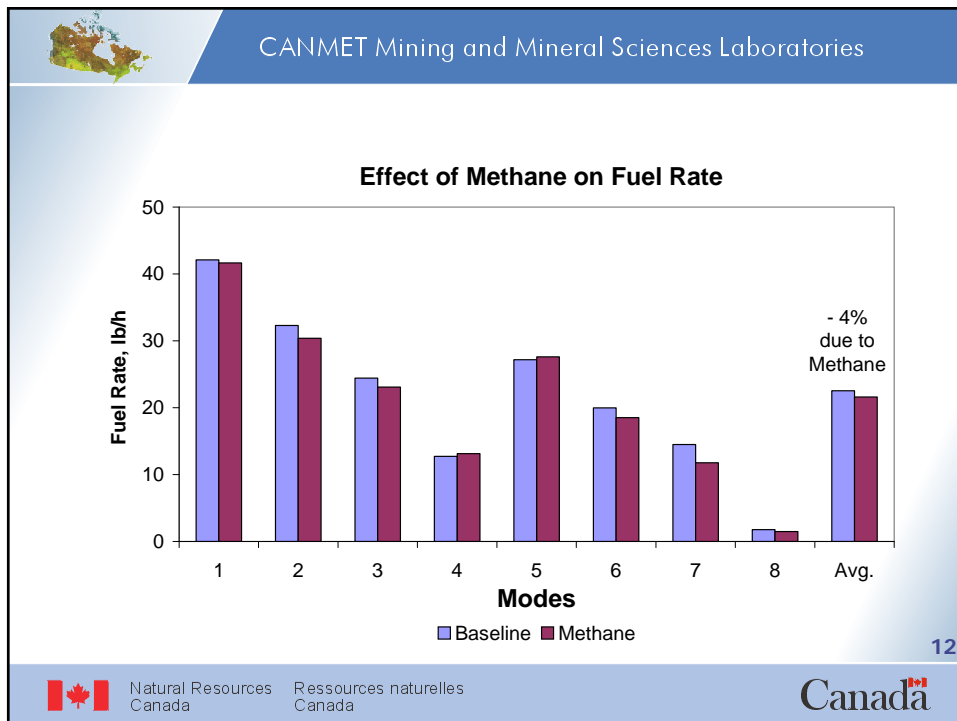
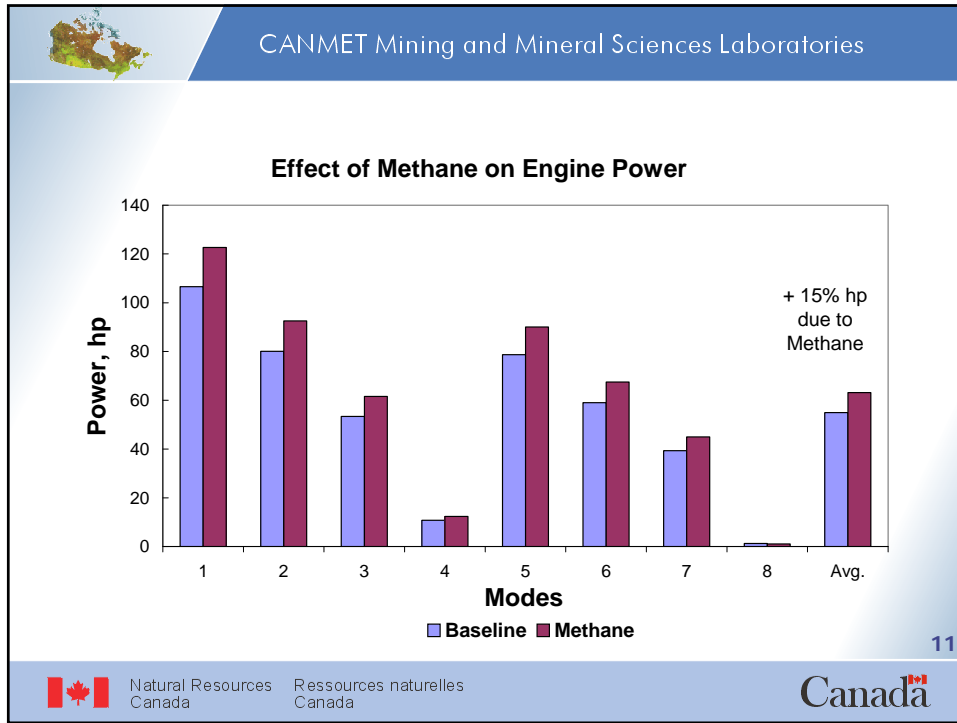
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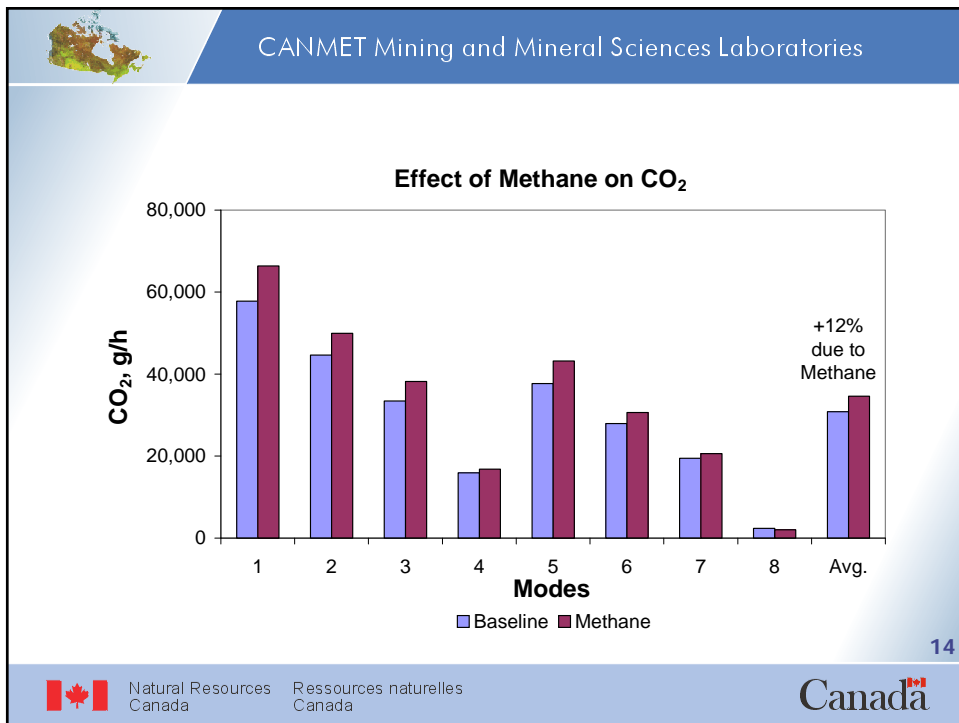
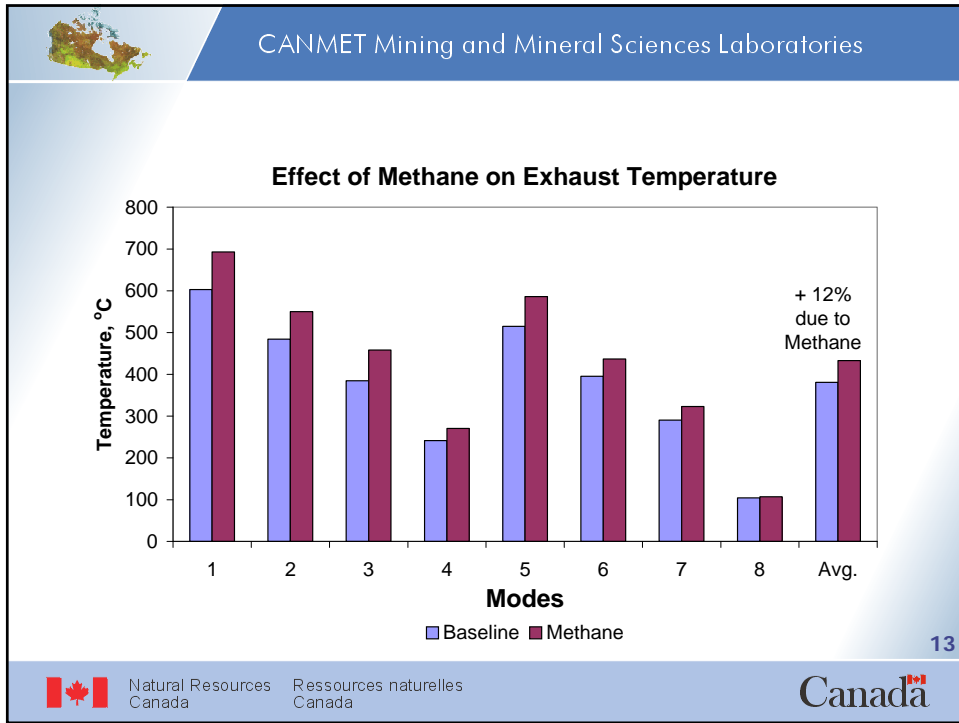
## Test Measurements

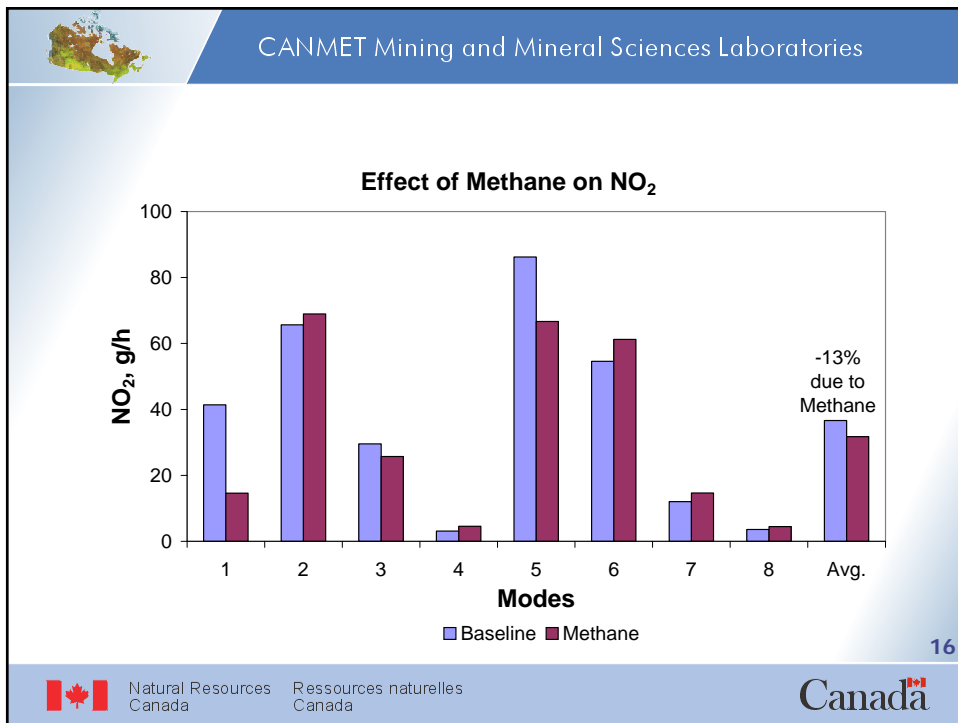
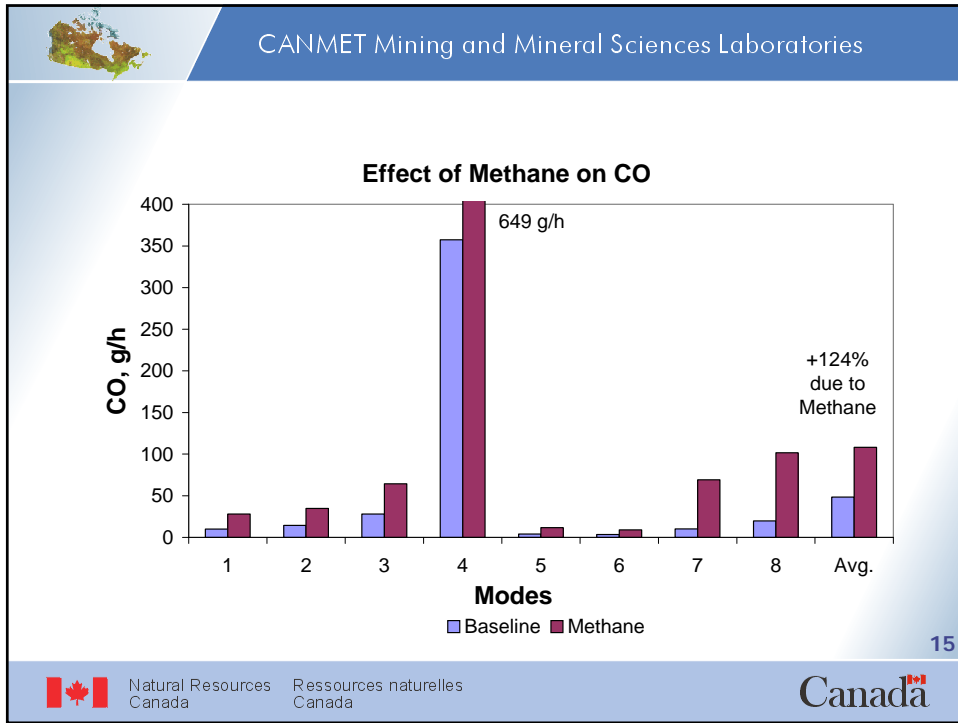
- Engine parameters
  - Speed, torque, power, fuel rate
- Exhaust gases
  - CO, CO<sub>2</sub>, NO, NO<sub>x</sub>, O<sub>2</sub>, THC
  - Particulates (DPM)
- Calculations
  - Emission rate in g/h
- Measurements were taken after the DST® exhaust treatment

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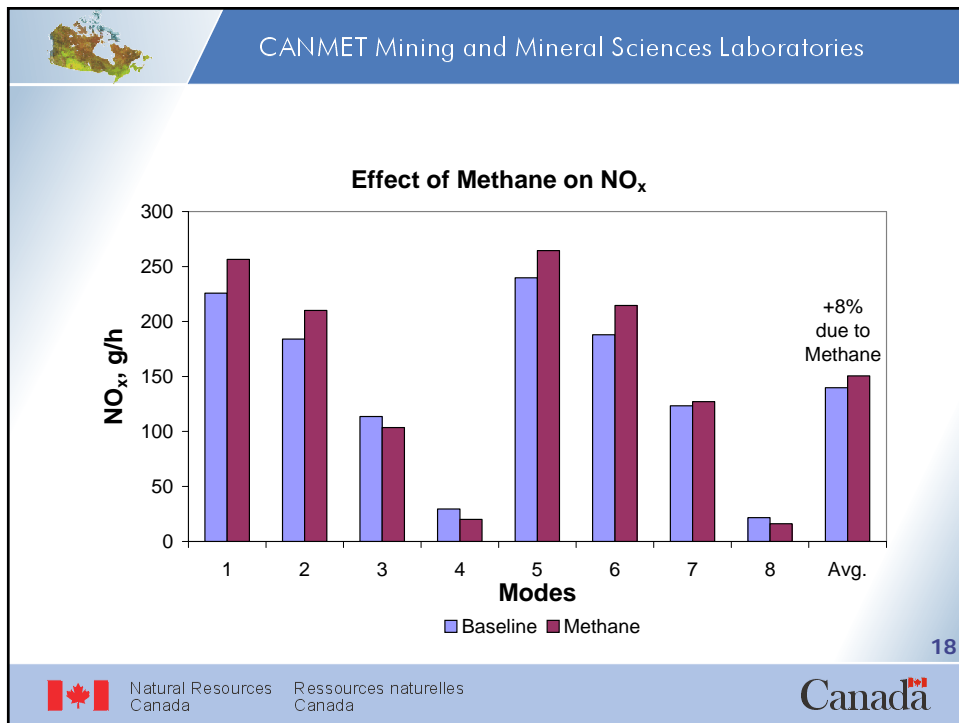
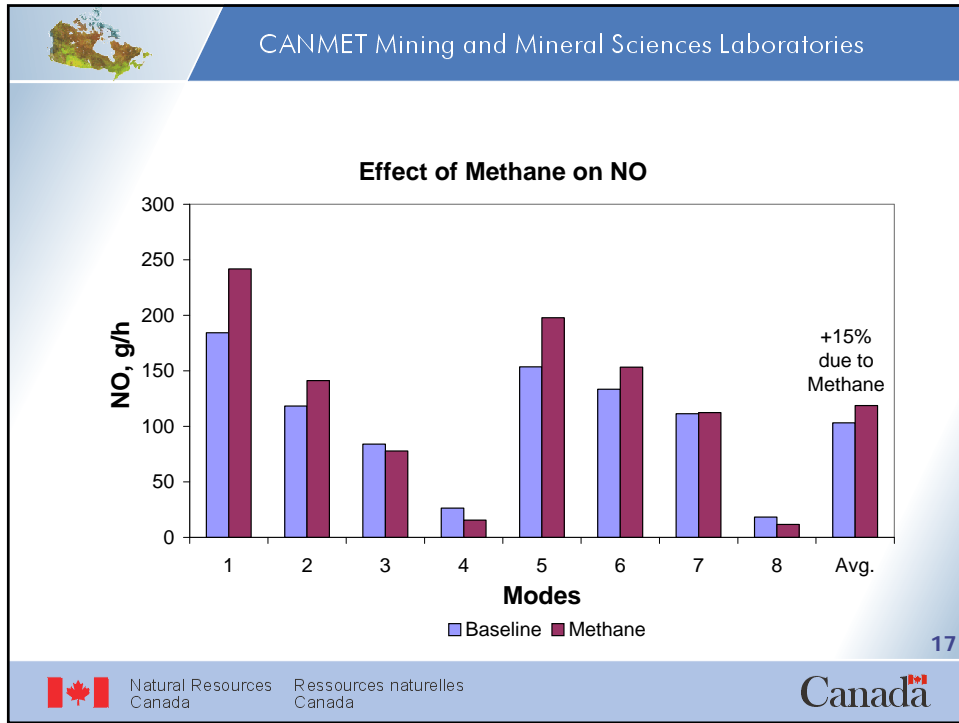

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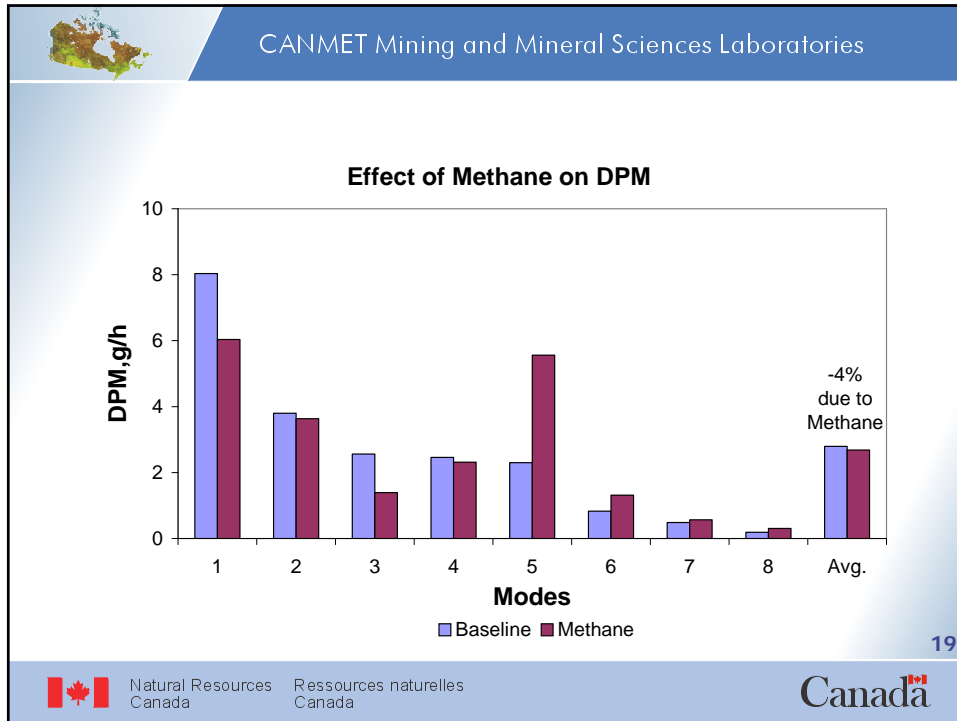












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**Effect of Methane on Power & Emissions (8-Mode Integrated Value)**

	Baseline g/h	With Methane g/h	Change %
HP	55	63	15
CO <sub>2</sub>	30812	34599	12
CO	48	108	124
NO <sub>2</sub>	37	32	- 13
NO	103	119	15
NO <sub>x</sub>	140	151	8
DPM	2.8	2.7	- 4

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## Comments

- 1.25% of methane mixture in engine intake air
  - increased power, CO<sub>2</sub>, and CO at all modes, by an average value of 15%, 12%, and 124% respectively.
  - reduced NO<sub>2</sub> by 13%, and increased NO by 15%.
  - reduced fuel consumption and DPM by an average value of 4% each.
  - decreased DPM at all 4 modes at rated speed, but increased DPM at other modes.

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## Comments

- The tested DST® power package system incorporating a low temperature particulate filter with exhaust gas cooling and catalyst could also be applied in non gassy hardrock mines.
- Application of DST® low exhaust temperature filtration would be beneficial where DPF regeneration is difficult to obtain.

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