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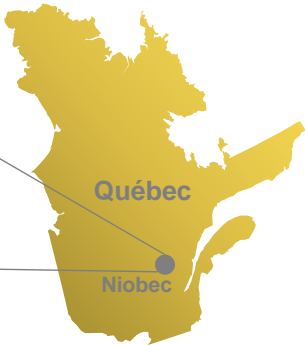
Study of Diesel Emissions Relating to Ramp Air Quality at Niobec Mine

Sean McGinn, MKNIZD Factors Inc. and Éric Côté, Niobec Mine
MDEC Conference – October 9th, 2013

 **MKNIZD** | Factors



Niobec Niobium Mine

- Located in St-Honoré de Chicoutimi, 200 km north of Québec City
- Integrated site : mine, concentrator and FeNb converter
- Will produce 5Mkg of Nb metal in 2013
- In operation for 37+ years, operated by IAMGOLD since 2006

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Only major niobium producer in North America; 1 of 3 globally

2

Niobium: Scarce Metal with Unique Properties

Using **niobium**
to enhance steel has many benefits:

- Adds strength
- Lightens weight
- Enhances flexibility
- Improves durability
- Reduces costs



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Niobium Provides Significant Cost Benefits



Øresund Bridge




Sweden - Denmark



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Niobium is used to produce
high-quality steel

4




Problem Description

- Air quality complaints in ramp areas of the underground mine
- Physical Description: Burning of eyes, foul odour, smoke
- Physical Description: Momentary peak levels of NO₂ surpassing TWA-TLV limits of 3 ppm

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5



Hypothesis

- High levels of hydrocarbon (HC) emissions – unburned fuel
- High levels of NOx emissions (NO + NO₂)
- Contributing factor – engine operating modes, idling and descending ramp
- Contributing factor – engine condition compared to baseline
- Contributing factor – ventilation in ramp – downcast intake air configuration

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6

Project Goal

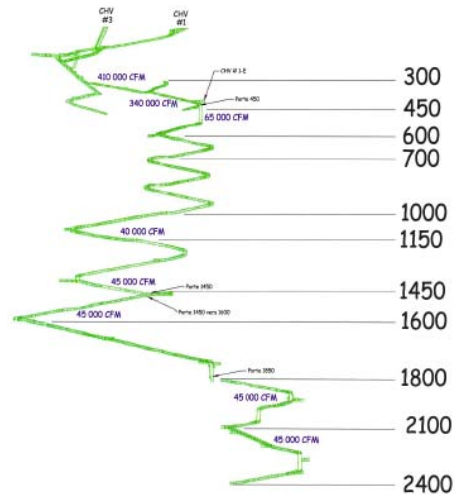
- Precise quantification on five hypothetical points
- Precise in-use measurement of raw emissions particularly HC and static raw emissions (condition)
- Parallel ambient measurements – CO, NO₂, DPM, CFM
- Comparison analysis of engine operating modes
- Comparison analysis of engine and machine types
- Establish root causes – respond to each “why?”
- Provide concrete recommendations and solutions

Scope

- Five day field testing – June 3rd -7th, 2013
- Four vehicles and different engine types
- Kubota tractor, MacLean BT3, MTI and Atlas Copco LHDs
- Structured mine out and back circuit with operating modes within the circuit
- Circuit duration 90-120 minutes depending on traffic
- Testing and Start/End base at surface garage
- MEASURE – MEASURE - MEASURE

Mine Test Circuit and Operating Test Modes

- Down Ramp
 - + throttle
 - - throttle
- Up Ramp
- Idling
- On Level



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Instrumentation

- Semtech DS and technician from Sensors Inc.
- Certified by U.S. EPA for in-use field verification
- O₂, CO₂, CO, NO, NO₂, Temp and **HC using FID**



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10

Instrumentation

- Ecom EN2 4-gas analyzer with DEEM6S interface
- Developed for condition-based comparison against as-certified baselines
- Diagnostic and maintenance tool for mine shops

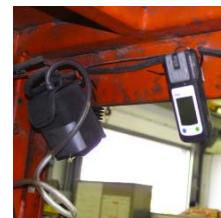


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Instrumentation

- Ambient DPM sampling and analysis – RCD / NIOSH 5040
- CO and NO₂ using Drager X-em 5000
- Synchronized start/stop with mine test circuit



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12

Kubota L5740

- Unit #7661 – V2403 @ 59 hp
- Hydrostatic transmission
- Test modes – upramp, downramp, on level
- 85 minutes sampling duration



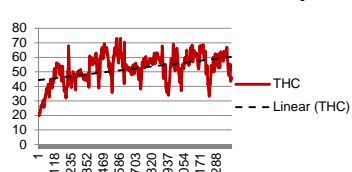
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13

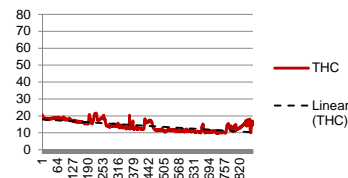
Kubota L5740 Results

- HC emissions 50 ppm downramp
- HC emissions 15 ppm upramp

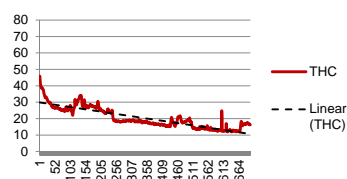
THC Kubota Downramp



THC Kubota Upramp



THC Kubota On Level



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MacLean BT3 Boom Truck

- Unit #7514 – Mercedes OM906 @ 201 hp
- Two days of testing – three circuits in total
- Comparisons downramp with and without throttle
- Second day was with weekly explosives convoy transport



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15

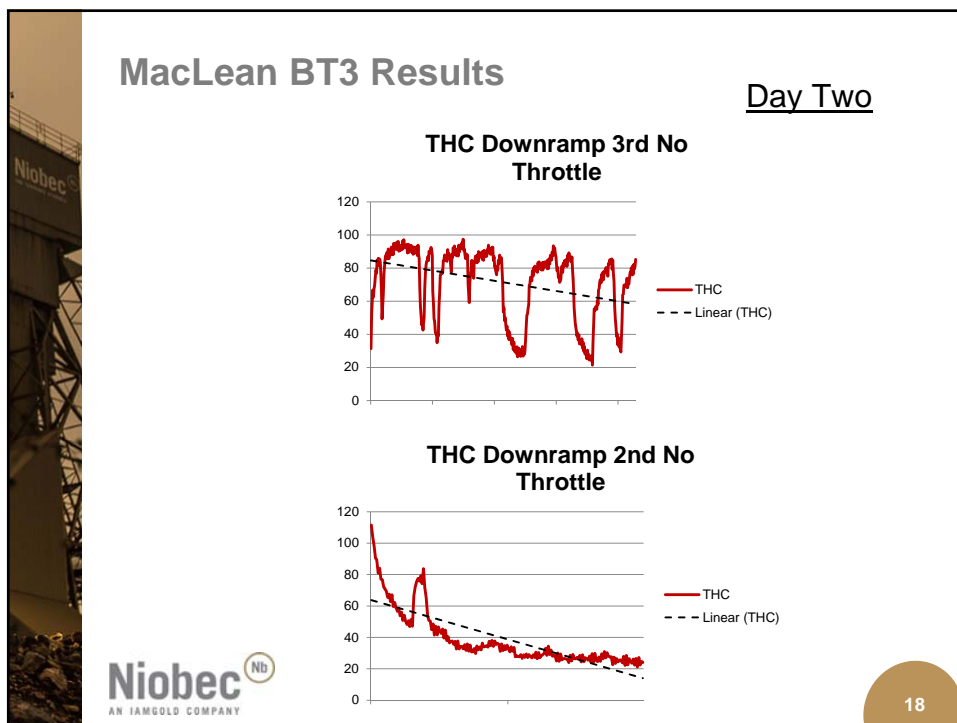
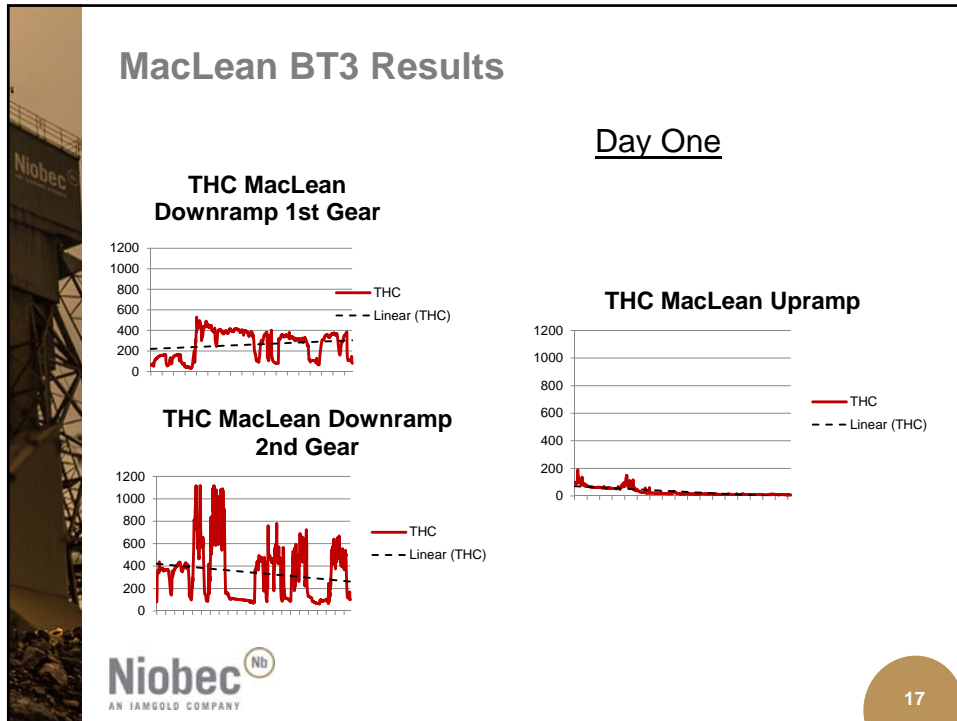
MacLean BT3 Ecom Results

Engine Speed	Test Location	Sample Value	Min. Value	Max. Value	Parameter Name
1985	Inlet DOC	8	0	0	SMOKE
1985	Inlet DOC	10.9	10.9	10.9	O2
1985	Inlet DOC	na	na	na	CO
1985	Inlet DOC	324.8	313	332	NO
1985	Inlet DOC	7.8	7	9	NO2
1985	Inlet DOC	7.4	7.4	7.4	CO2
1985	Inlet DOC	793.6	770.4	811.3	T.GAS
1985	Inlet DOC	332.6	322	339	NOx
1985	Outlet DOC	8	0	0	SMOKE
1985	Outlet DOC	10.7	10.6	10.7	O2
1985	Outlet DOC	158.4	123	307	CO
1985	Outlet DOC	312	289	322	NO
1985	Outlet DOC	8.6	8	10	NO2
1985	Outlet DOC	7.6	7.6	7.6	CO2
1985	Outlet DOC	730.1	687.5	759.3	T.GAS
1985	Outlet DOC	320.6	299	330	NOx

- @ full torque stall full power
- Problems with CO sensor
- CO values indicate above baseline
- Performance otherwise all OK

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16



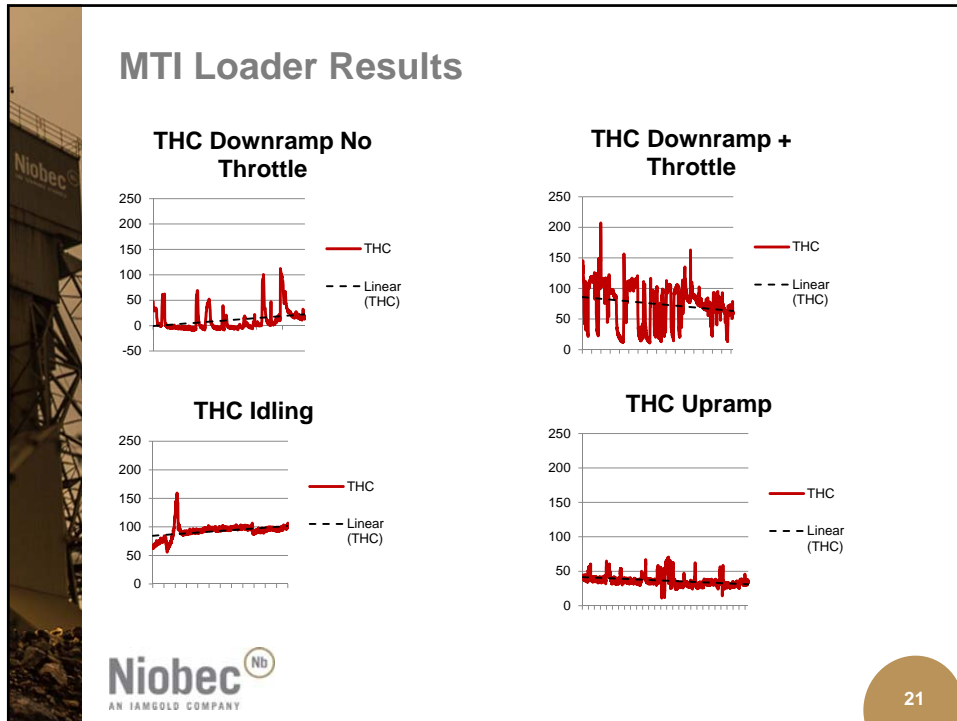
MacLean BT3 Results

- HC peaks above 1000 ppm downramp with throttle
- **HC average values with no throttle are five times less than with throttle**
- HC values upramp, on level and idling were all below 100 ppm avg

MTI LT350 Loader

- Unit #7127 – Perkins 1106C E60TA @ 175 hp
- Test modes downramp with and without throttle, upramp, on level and idle
- Full circuit duration 135 minutes





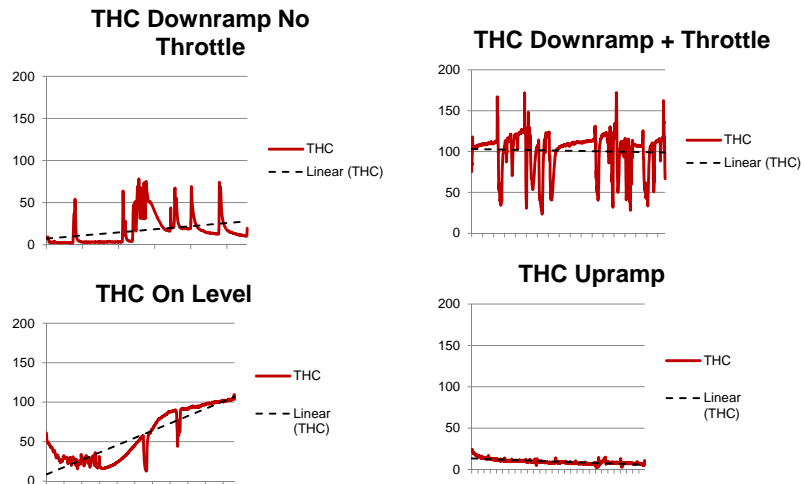
Atlas Copco ST1010 Loader

- Unit #7162 – Cummins QSL9 @ 250 hp
- Test modes downramp with and without throttle, upramp and on level
- Total circuit duration 125 minutes

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22

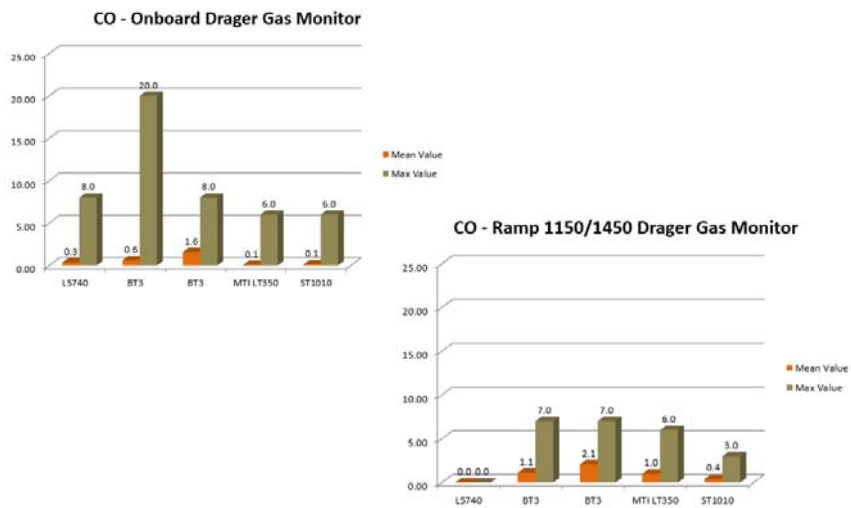
Atlas Copco Loader Results



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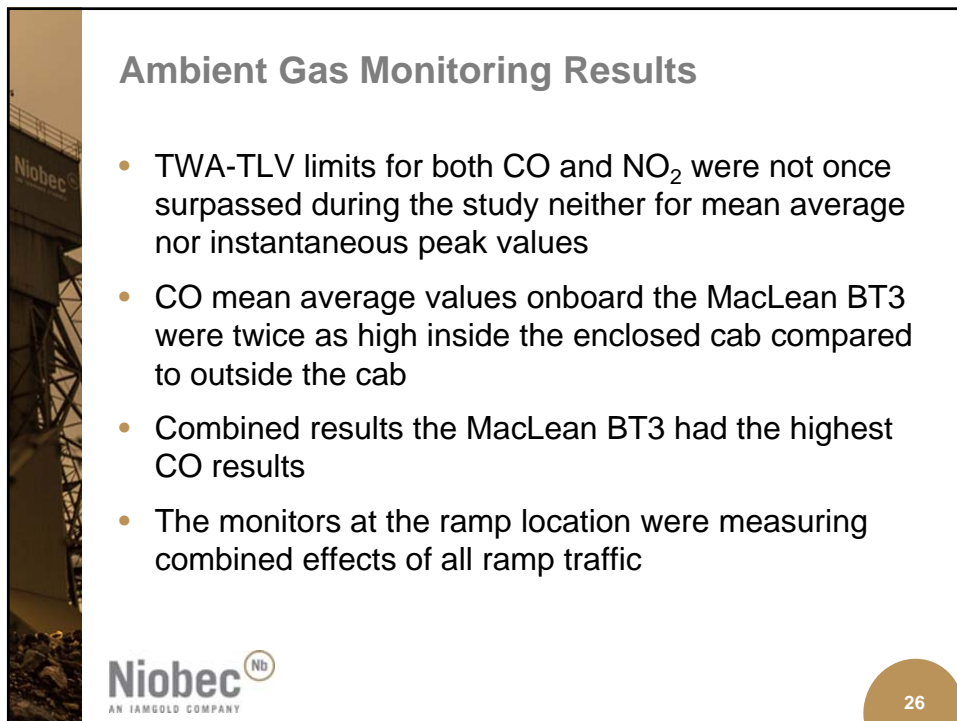
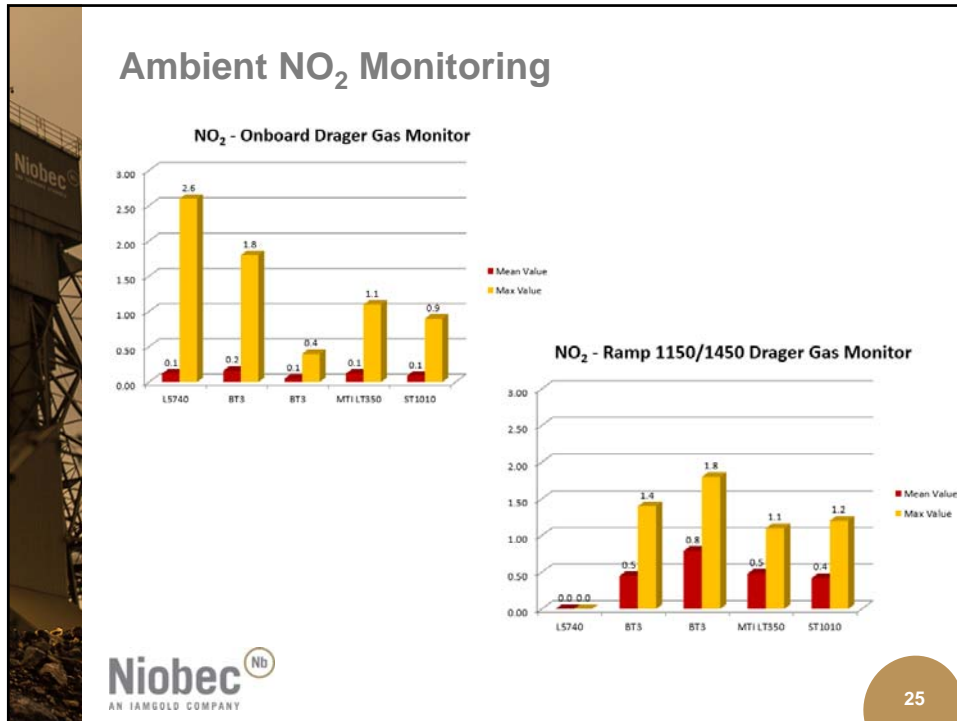
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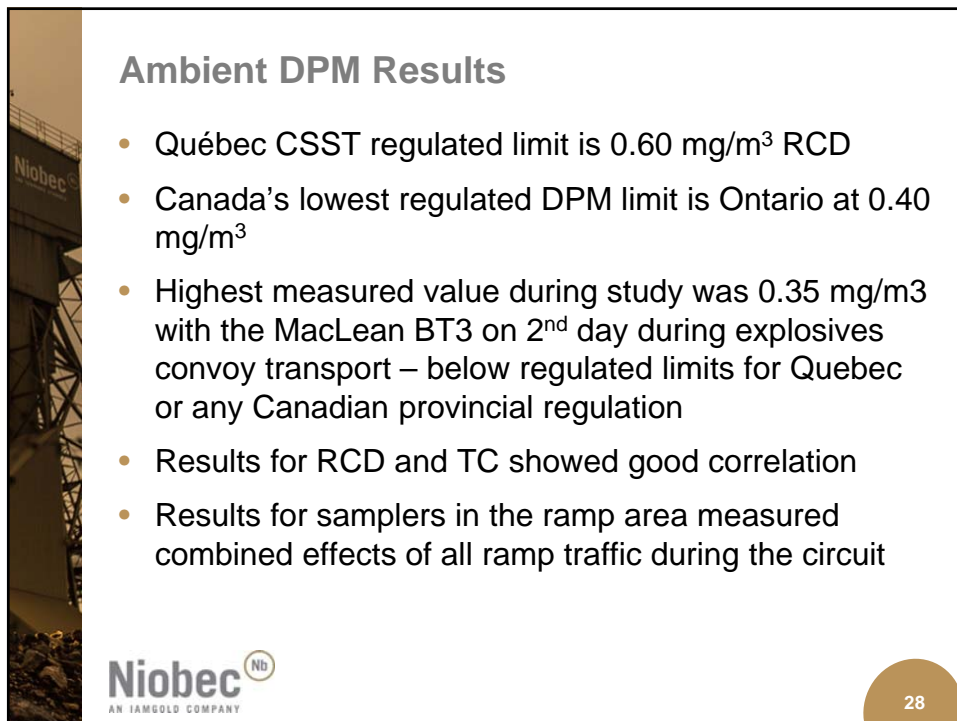
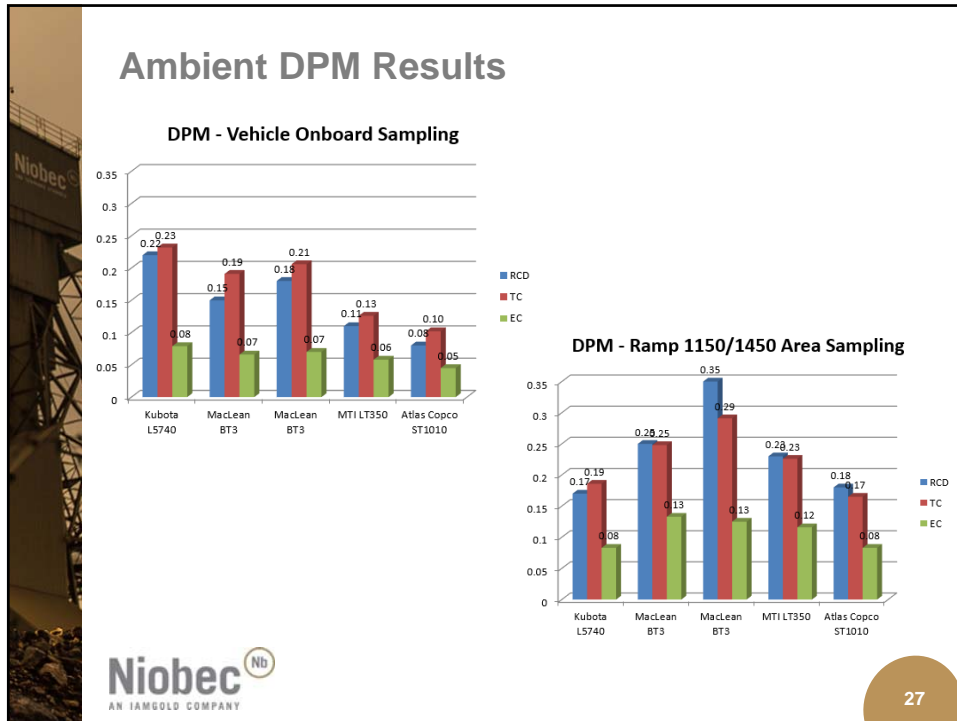
Ambient CO Monitoring



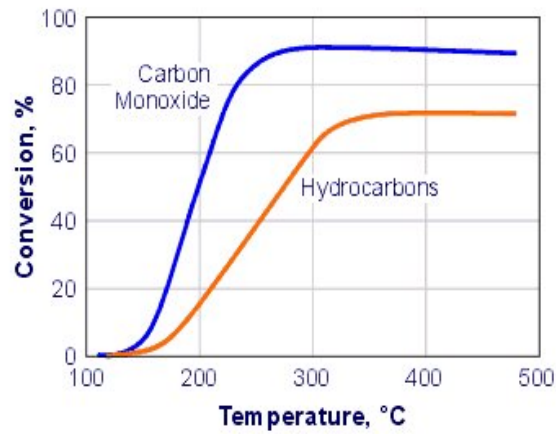
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24





Diesel Oxidation Catalyst Effect



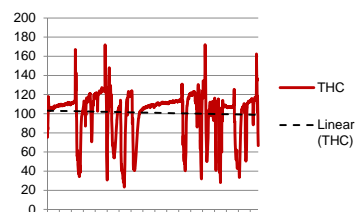
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29

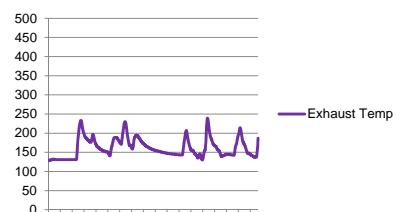
Diesel Oxidation Catalyst Effect

- Downramp operation has the highest levels of HC emissions
- There is insufficient exhaust temperature to support oxidation

THC Downramp + Throttle



Exhaust Temp Downramp + Throttle

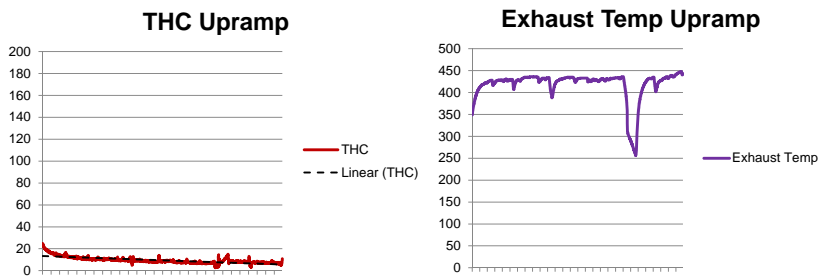


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Diesel Oxidation Catalyst Effect

- Upramp operation has the lowest levels of HC emissions
- There is more than sufficient exhaust temperature to support oxidation



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31

Recommendations – HC Reduction

- Standard Operating Procedure – when operating in downramp mode allow the vehicle to descend in 2nd gear with no throttle or as near to as possible
- Standard Operating Procedure – minimize vehicle idling as low as reasonably achievable (ALARA), objective not more than 60 seconds

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32

Recommendation – Vehicle/Engine

- Initiate project with manufacturers and suppliers to resolve issues discovered with Mercedes OM906 engine
- Review of diesel inventory underground to ensure that all are certified and approved to CSA Canmet and/or MSHA as per current Niobec policy
- Establish performance baseline for all diesel engines against as-certified and implement condition based - emissions based engine maintenance

Recommendation – Enclosed Cabs

- Validate with vehicle manufacturers for enclosed cab filtration and air quality performance standards
- Ensure that vehicles with enclosed cabs are maintained based on and meet the performance standards on a scheduled basis



Recommendation - Ventilation

- Investigate the possibility of modifying the ventilation circuit to have the ramp as an upcast / exhaust configuration

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35



QUESTIONS

Thank You!

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 **MKNIZD** | Factors

36