




**MINING DIESEL**  
**mdec**  
**EMISSIONS COUNCIL**

**22<sup>nd</sup> Annual MDEC Conference**

**On-board Monitoring of Diesel Emissions  
Pilot Project – June 2015 to May 2016  
Results**



Paul Sheremeto, President & CEO  
Pattern Discovery Technologies Inc.

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**On-board Monitoring of Diesel Emissions**

October 7<sup>th</sup>, 2010







Underground Real Time Diesel Exhaust Gas Sampling

D. O'Connor & C. Allen, Vale Canada Ltd, Ontario Operations

Underground Real Time Diesel Exhaust Gas Sampling  
2013 MDEC Conference Up-date

C. Allen, Vale Canada Ltd, Ontario Operations  
D. O'Connor, Doug O'Connor Consulting Limited

Doug O'Connor – 1950-2015

**Continuation of the work spearheaded by Vale beginning in 2010**

**Cheryl Allen and our dear friend Doug O'Connor**

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## The Platform and Vision



*Vision: Build a world class sensing and communications platform for monitoring diesel equipment and ambient conditions using best-in-class technologies combined with advanced analytics to deliver reliable, actionable information in real-time to ensure **safe working conditions**, **streamlined maintenance programs**, **optimized ventilation delivery**, **reduced energy costs** and **increased production throughput**.*



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## Background: Regulation 854, Subsection 183



Occupational Health and Safety Act

R.R.O. 1990, REGULATION 854

MINES AND MINING PLANTS

January 1, 2012

(1.1) The employer shall ensure that the following rules are complied with in relation to tests conducted under paragraph 2 of subsection (1):

1. The employer shall develop and implement testing measures and procedures in consultation with the joint health and safety committee or health and safety representative, if any, and shall take into consideration any recommendations made by the committee or representative.
2. Each individual piece of equipment must be tested under consistent conditions so that results from different tests can be compared.
3. Testing must be carried out, as far as is practical, on equipment under full load. O. Reg. 296/11, s. 14 (2).

(2) The employer shall provide the results of every test conducted under subsection (1) to the joint health and safety committee or the health and safety representative, if any, for the workplace. O. Reg. 779/94, s. 7.

(3) The employer shall record the results of every test conducted under paragraphs 2 and 3 of subsection (1) and shall maintain the record. O. Reg. 779/94, s. 7; O. Reg. 296/11, s. 14 (3).

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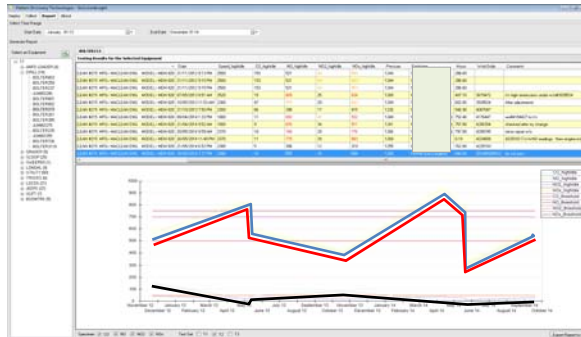
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## EmissionInsight™ 1.0 – January 1, 2012



**Dräger**



**Challenges:**

- Consistent testing procedures
- Safe working conditions for mechanics
- State of operation for measurement – rarely measured under load
- Time out of production for testing
- Number of mechanics tied up for test – wrench time lost

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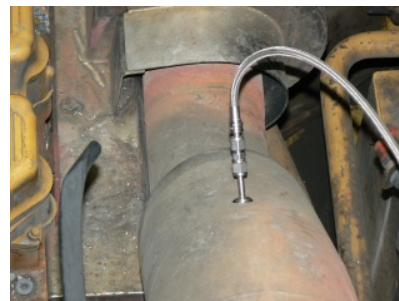
## Evolution: On-board Emissions Measurement Device



**SenzLogic** - Emissions measurement, controller, logging and communications capabilities in one platform



**Dräger**



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### Phase 1 - Pilot – Goals and Objectives



#### 1. Test SenzLogic onboard emissions monitoring unit

- Evaluate reliability and past ruggedization efforts
- Validate operational performance of gas sensors
- Measure both “Pre” and “Post” emissions
- Monitor air filtration and condensate operation



#### 2. Integration with Isaac Instruments

- Emissions data time stamped and recorded with engine telemetry data
- Batch extraction of telemetry and emissions data from Isaac unit



#### 3. Analyze raw data for operational performance – operating as expected?

- Are we seeing gas measurements as expected
- Evaluate error conditions and results

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### Initial Pilot – Goals and Objectives – Phase 1



#### 4. Develop models that reflect various Duty Cycles (Working State)

1. High RPM
2. Load
3. Low RPM
4. Other

“Capture valid emissions readings during identified duty cycles”

#### 5. Develop dashboards for reporting emissions, warnings and violations



- Report 250 engine hour performance intervals (for comparison to manual reporting testing method)
- Drill down to 50 hour and 1 hour intervals
- Drill down to raw data and report on engine parameters

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Parameters Used In Analysis and Defining Working States

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Aug. 24 - Dec. 6, 2015 – 3,184,836 records captured!

Column Name	Minimum	Maximum
row_id	1.00	1880892.00
date	24/08/2015	06/11/2015
measurement_cycle_id	0.00	573.00
channel_group_id	0.00	488.00
segment_id	391.00	829.00
Acc_Lat	-0.25	0.35
Acc_Vert	0.75	1.19
Acc_Long	-0.70	0.33
EngSpeed	0.00	16388.00
EngFuelRate	0.00	112.95
DragerState	0.00	6.00
MeasurementState	0.00	1.00
DragerChannel	0.00	2.00
DragerComState	0.00	3.00
DragerErrorState	0.00	32.00
MeasurementTime	0.00	905.00
COconcentration	0.00	1778.00
NOconcentration	0.00	891.00
NO2concentration	0.00	163.00
NOXconcentration	0.00	963.00
AccelPedalPos1	0.00	100.00
WheelBasedVehicleSpeed	0.00	186.76
EngCoolantTemp	-32766.00	124.00
TransOilTemp	0.00	0.00
TransOilPress	0.00	32761.50

Column Name	Minimum	Maximum
EngOilPress	0.00	16385.00
EngTurboBoostPress	0.00	32767.50
AirFilterRestriction	0.00	4.50
TransCurrentGear	0.00	4.00
TransSelectedDirection	0.00	7.00
BatteryVoltage	0.00	30.50
EngCoolantLevel	0.00	1.00
ActualEngPercentTorque	0.00	100.00
BrakeSwitch_1	0.00	1.00
TransRetarderSwitch	0.00	1.00
TorqueConvOilTemp	-40.00	170.00
BrakeOilCoolingTemp	-40.00	170.00
DumpHoistLeverStatus	0.00	240.00
DumpHoistLeverPos	0.00	100.00
IntakeManifoldAir Temperature	-3276.60	95.90
DumperBedPos	0.00	655.20
TransRetarderControl	0.00	655.20
ParkingBrakeSwitch	0.00	1.00
BoxV	12.42	12.80
BoxT	23.16	60.05
FuelLevel	0.00	100.00
EngTotalFuelUsed	0.00	41238.98
TotalVehicleHours	0.00	17879.26
TotalEngineHours	63.18	627.32

Engine Parameters Captured from Vehicle Telemetry System



Emission Concentration Measurements Captured

Used in defining Working State or Duty Cycles – see next slide

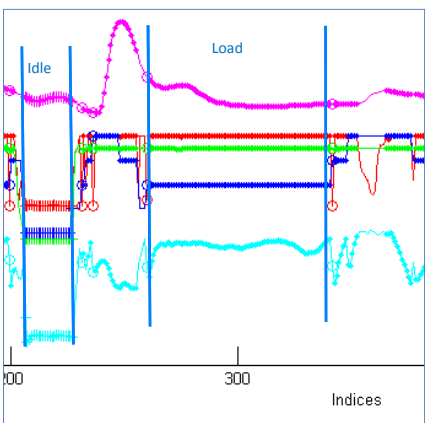
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Graph of raw data – establishing Working State

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Building models for classifying emissions – High RPM, Low RPM (Idle), Load, Other



CO Concentration

% Engine Torque

Accel Pedal

Trans Gear

Engine Speed

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## Valid Emissions Measurements – Update to Dec. 6



Aug. 24, 2015 – Dec. 6, 2015 = 103 days = 242,152 tests at the exhaust (Channel 1)

<b>Total Data Points Captured</b>				
3,184,836				
<b>Valid Emission Measurements Captured</b>				
	<b>Total</b>	<b>Channel 1</b>	<b>Channel 2</b>	
count	304,591	242,152	62,439	
seconds	304,591	242,152	62,439	
minutes	5,077	4,036	1,041	
hours	85	67	17	
<b>Channel 1</b>				
242,152				
<b>Working State</b>	<b>0-250</b>	<b>250-500</b>	<b>500-750</b>	<b>750-949</b> by State
All	63,155	66,531	73,688	38,778
High RPM	6,733	8,032	7,549	5,031
Load	22,029	17,391	22,378	11,925
Low RPM	13,016	13,728	18,367	7,446
Other	21,377	27,380	25,934	14,376
				89,067

Approximate number of manual tests performed in 103 days = 6

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## Visualization in Dashboard of Emissions Measurements



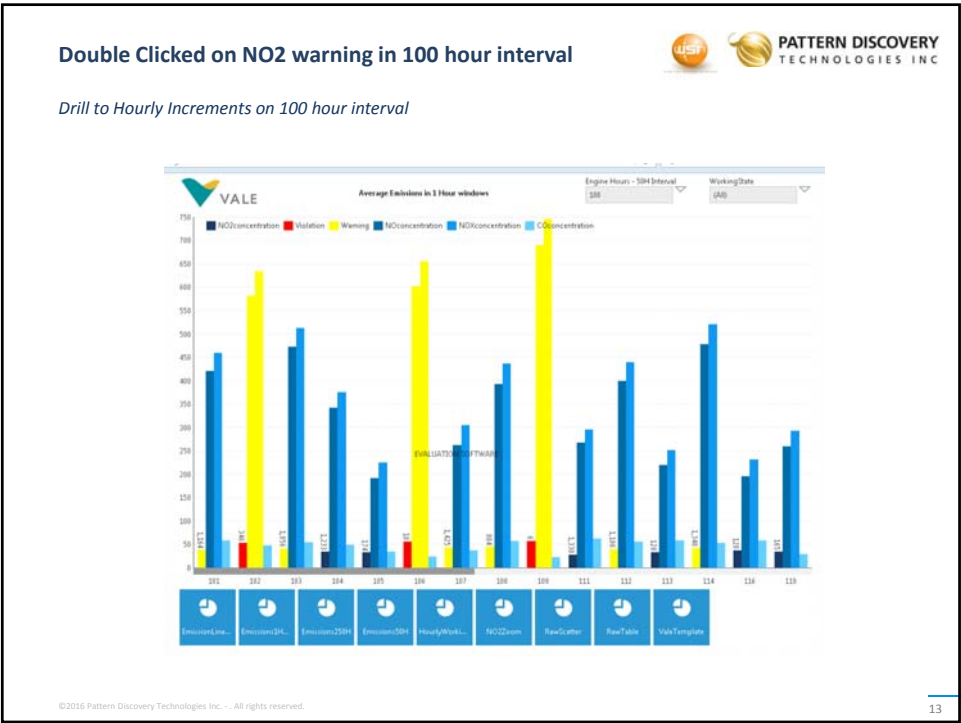
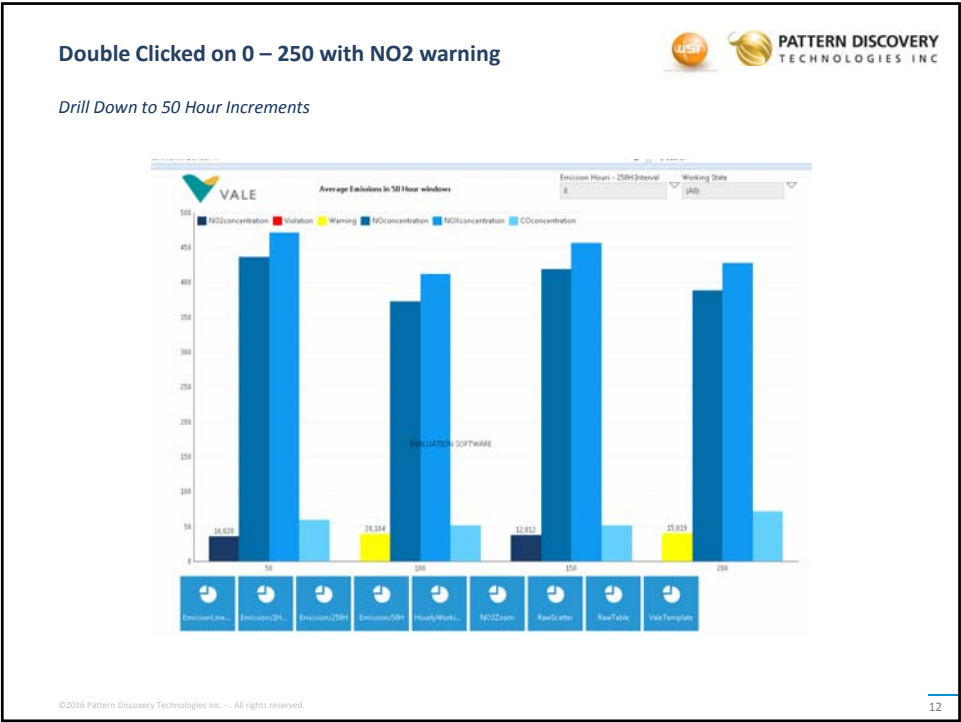
Average of all Working States over 250 hour increment



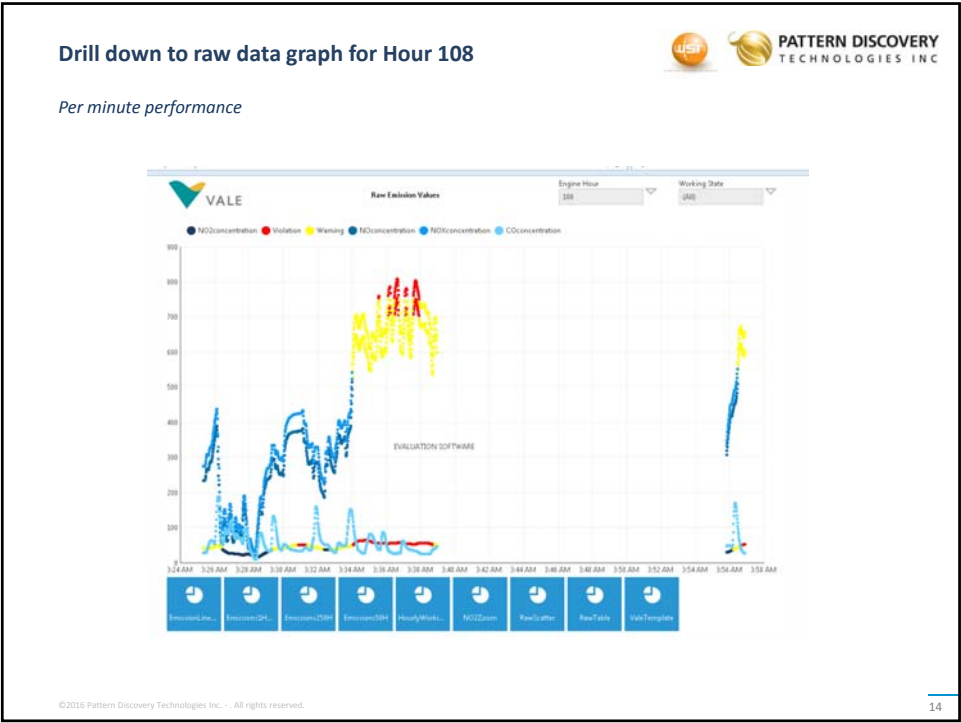
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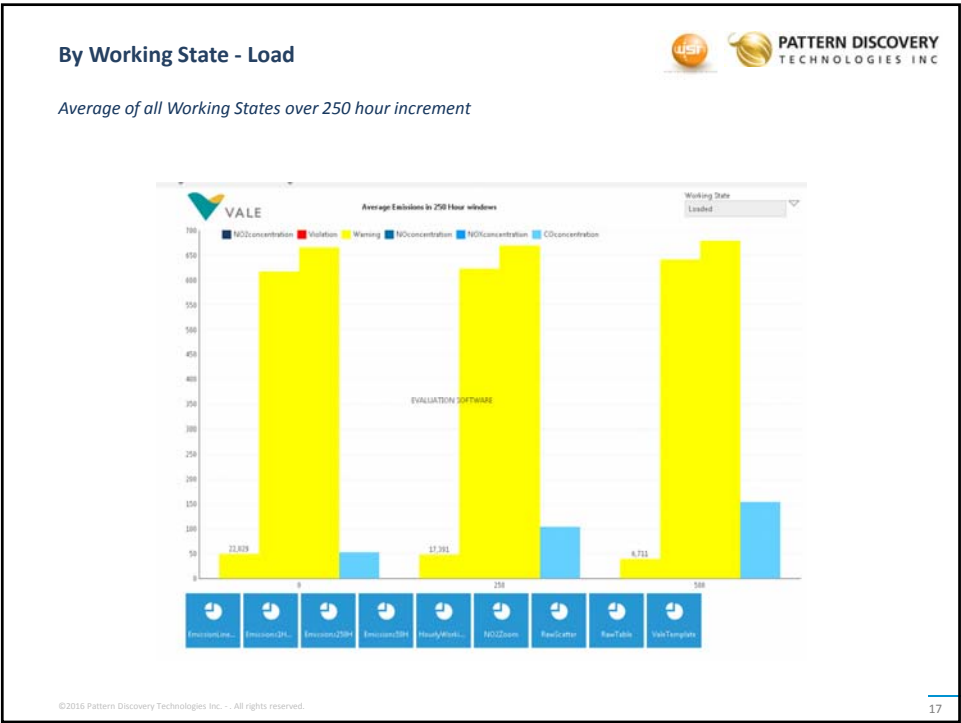
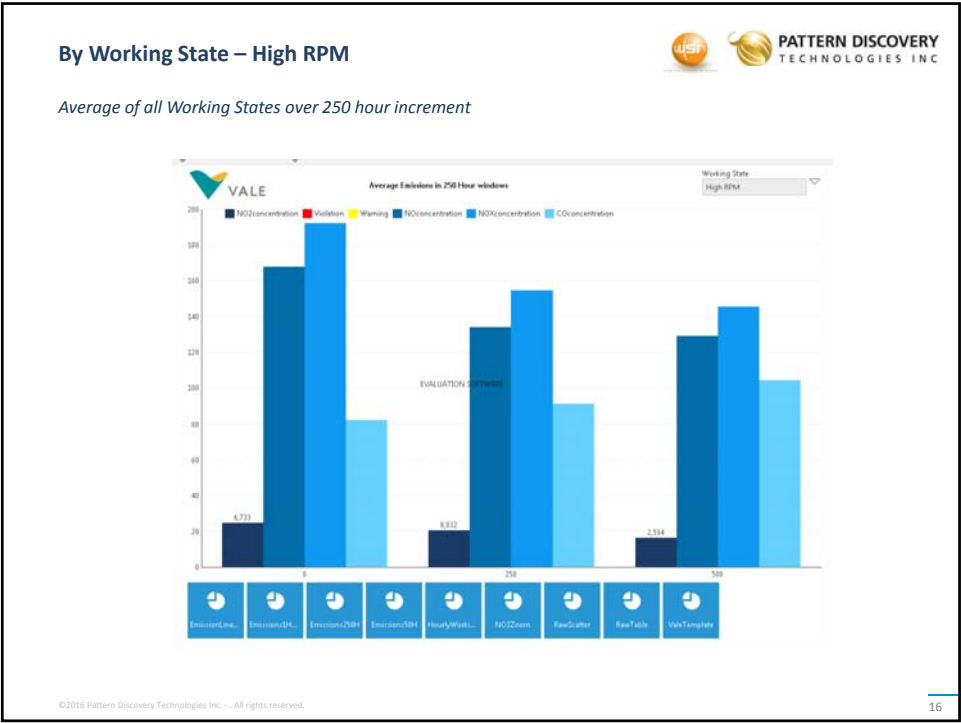




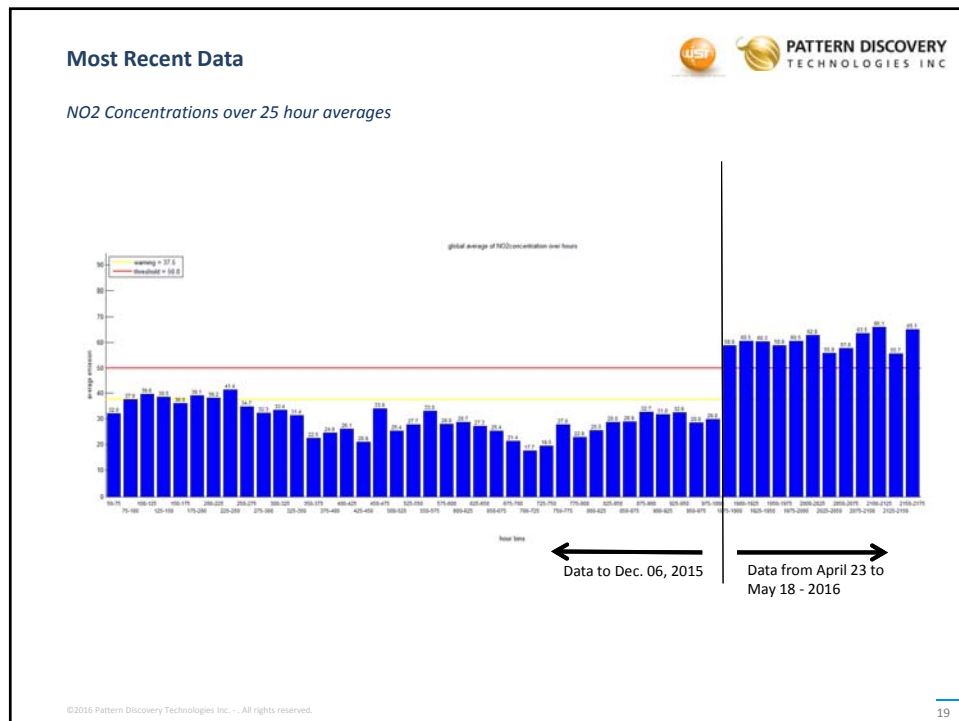
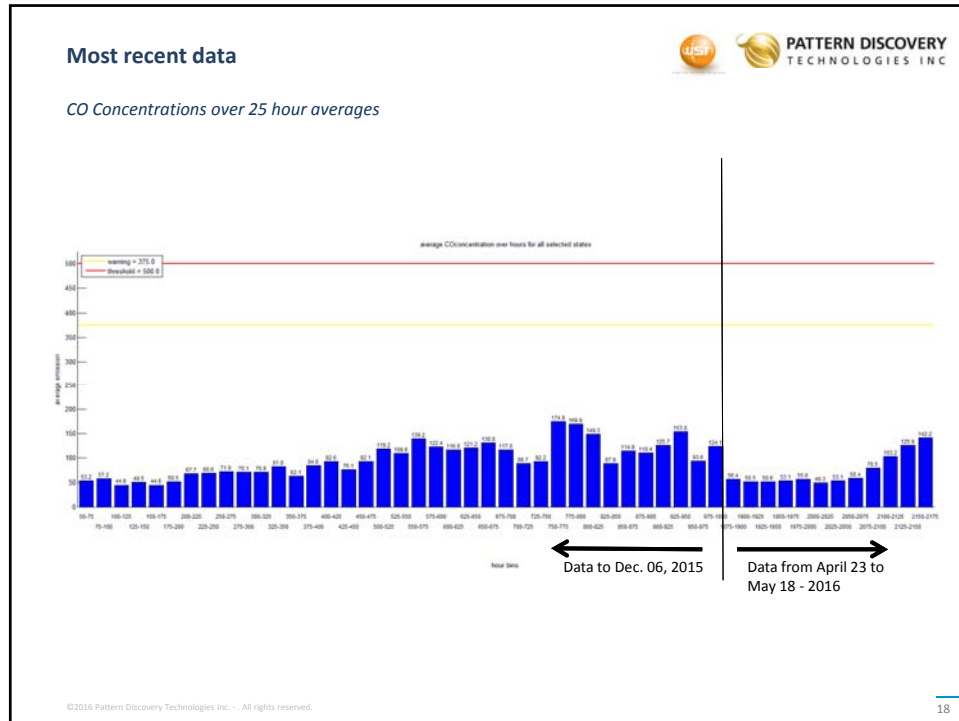




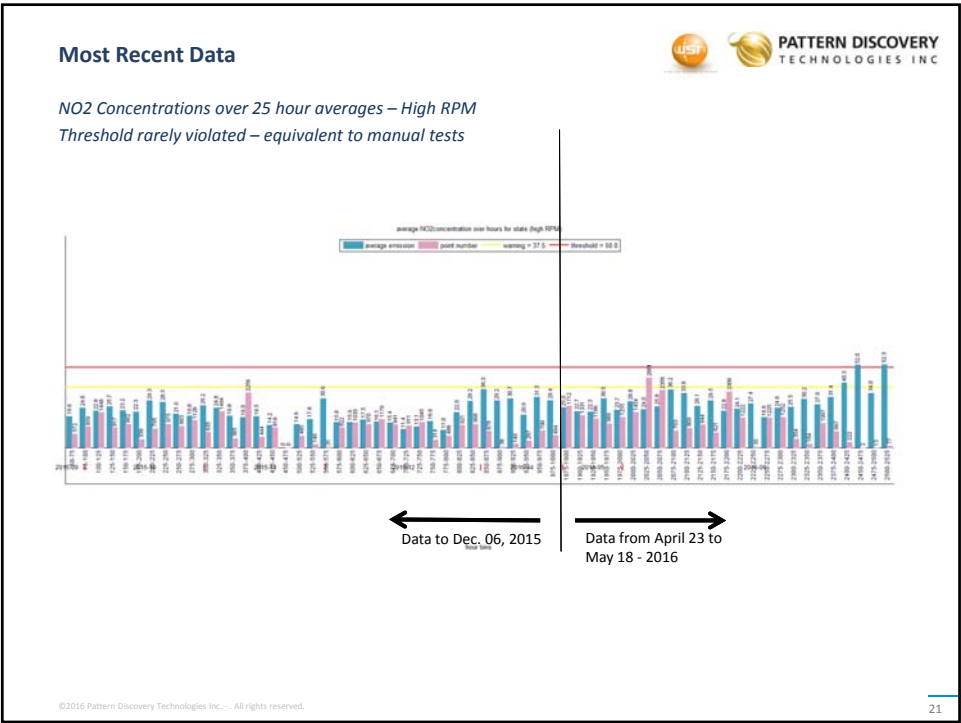
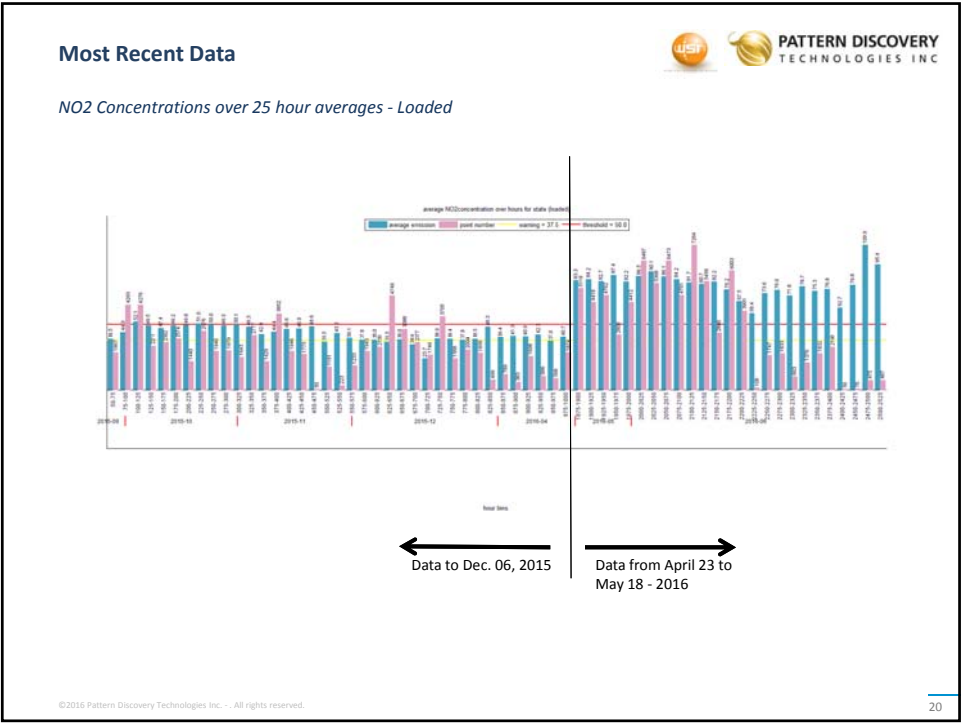




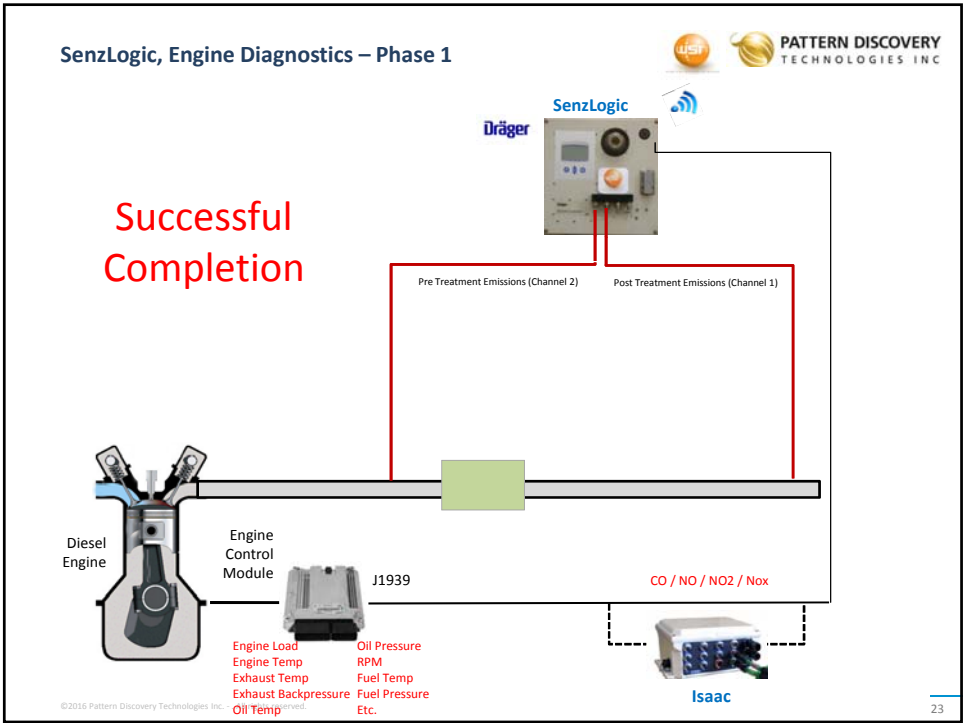
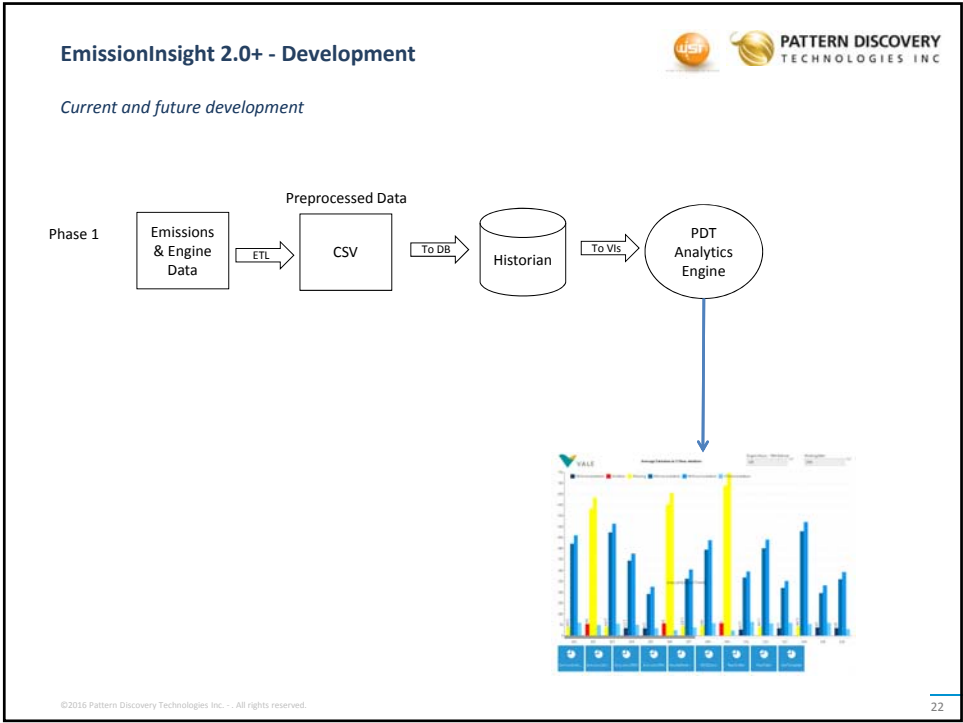




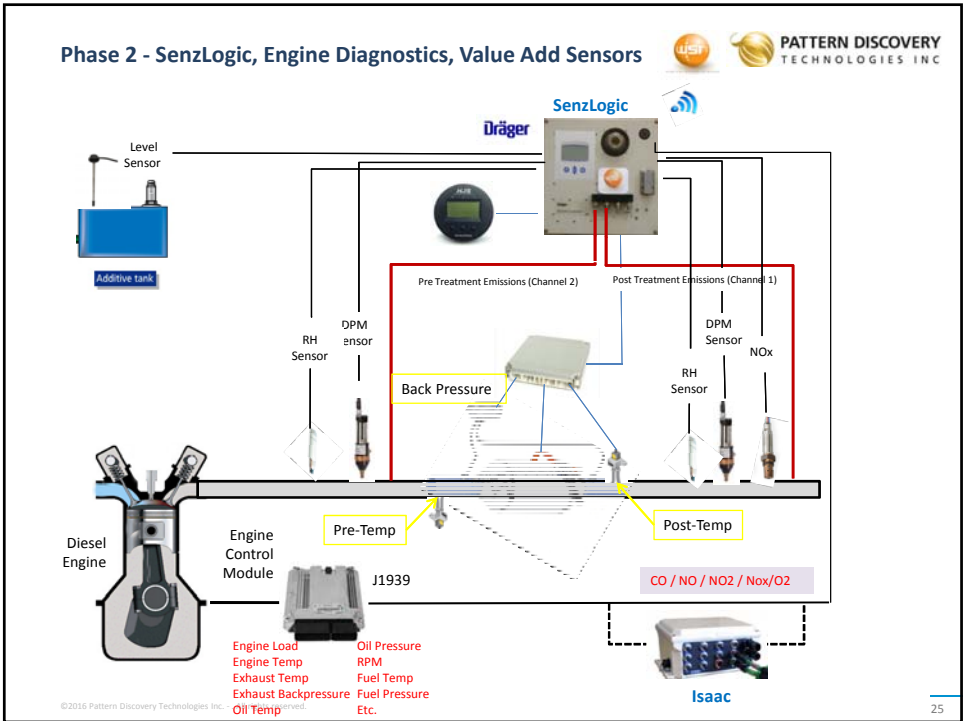
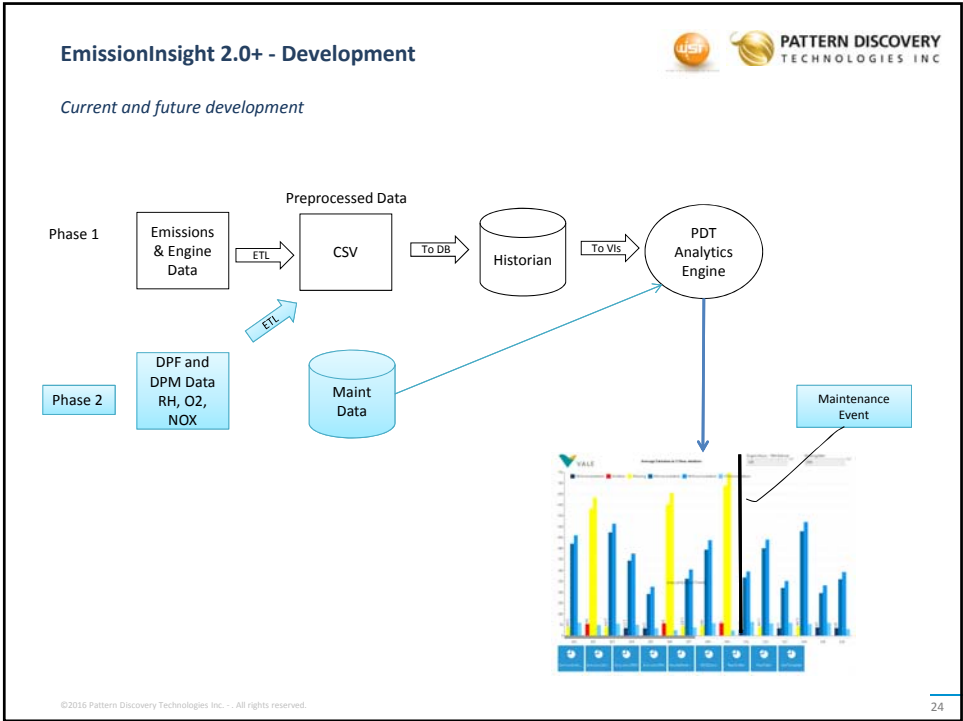




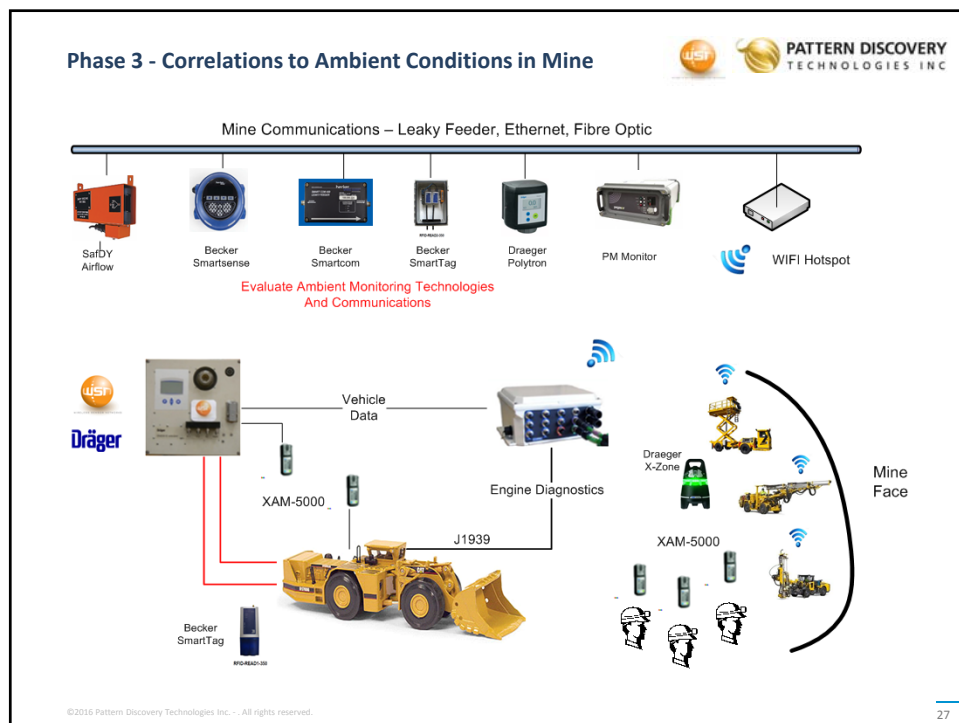
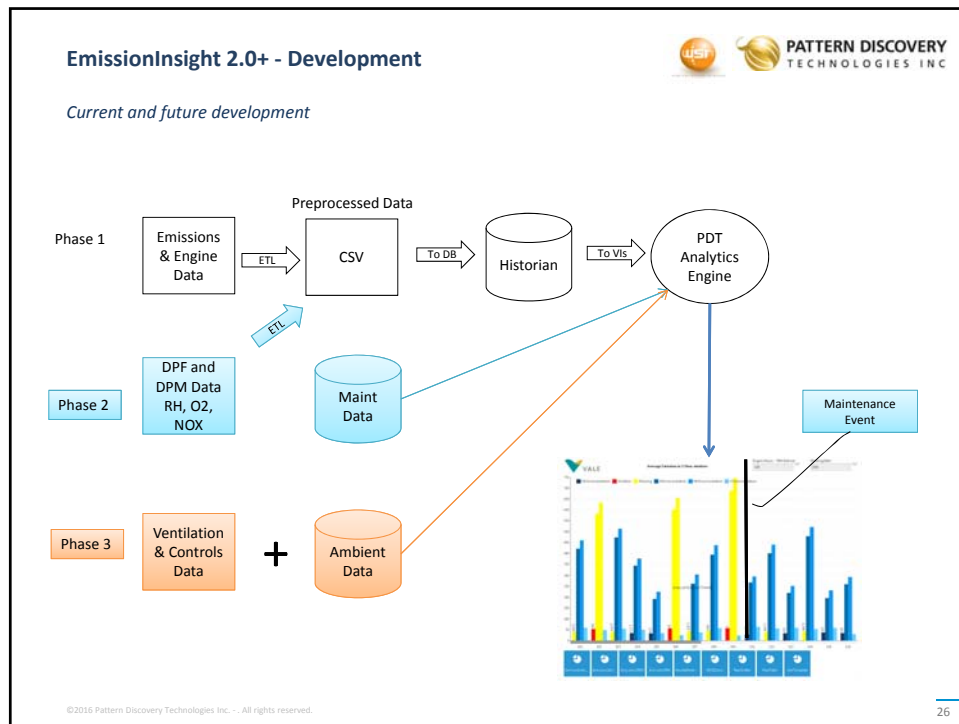














**EmissionInsight™**



## Questions and Answers