Barrick Hemlo – Williams Mine

DPM Management Strategy and Results

MDEC 2017

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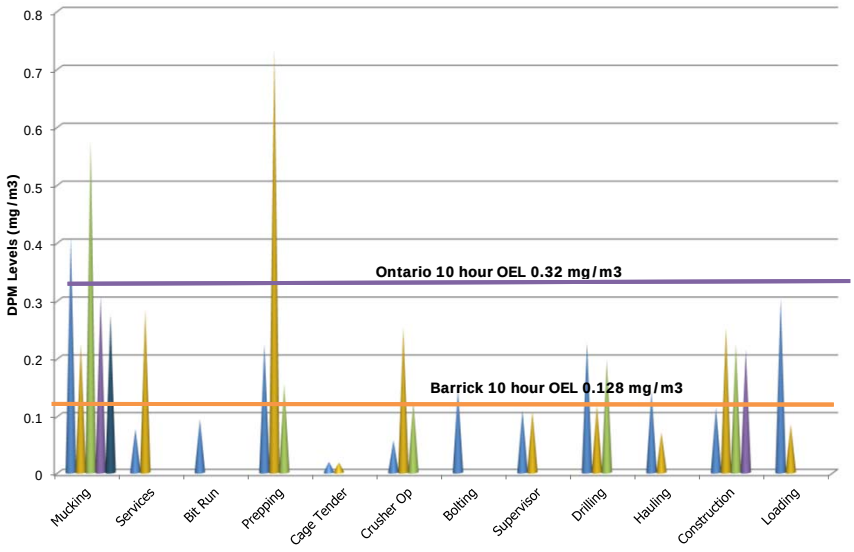
Barrick IH Monitoring Standard

- Required to adhere to all Barrick Occupational Exposure Limits (OELs) unless a more stringent legal limit exists
- Ontario: 0.4mg/m^3
- Barrick: 0.16mg/m^3
- Initial sampling completed to determine baseline in the underground

DPM Personal Monitoring – 2013-14



Considerations

- Multi-faceted, interdepartmental approach
- Emissions Based Maintenance
- Biofuel
- Filtration of equipment
- Ventilation changes/upgrades

Emissions Based Maintenance

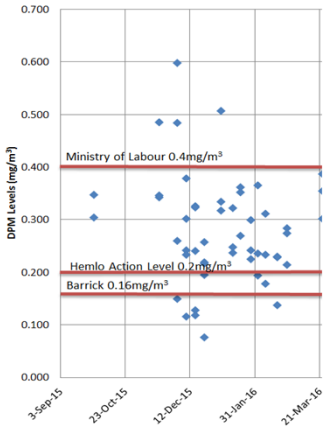
BARRICK

- Setting baseline standards for engine performance
- Base level emissions control at the source
- Intercept issues before they become problems
- Critical for success with DPF technology
- Ecom analyzers / DEEMS interface

Biofuel

BARRICK

- Supplier out of Thunder Bay, ON
  - Provided a higher quality diesel fuel as well as biofuel options
  - B5 blend put into underground December 2015. Weekly area samples taken underground starting in September 2015



Biodiesel Ramp Up

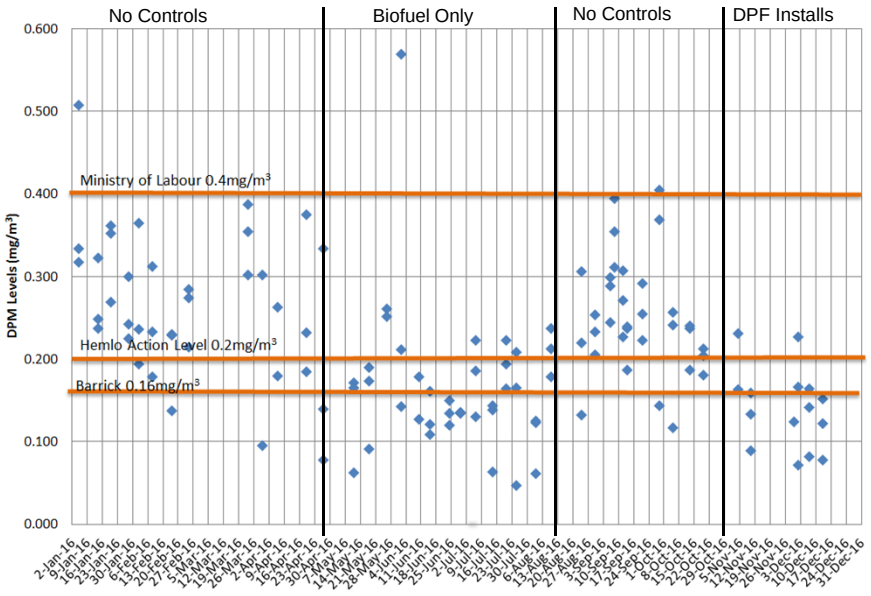
- As biofuel will clean out all fuel tanks and lines of any build-up, a ramp-up plan was put into place in spring of 2016 (temperature dependent) with increases ranging from 5-15% every 2 weeks – reaching B50 by June 3rd

- Extra fuel filters were brought on site, but no issues were had during the ramp up

Winter Preparation

- Due to cold temperature constraints on biofuel, supplier will not provide high blends during winter months, as well as challenges on site:
  - No heated fuel tanks or transfer system
  - Emergency egress is via portal ramp – equipment may have to come to surface
- In order to have a better idea of the increase in DPM with a reduction in biofuel for winter, the blend was reduced to B5 on August 12th
- Filter installations fleet-wide began in November 2016

Area Sampling Results – Biofuel 2016



Equipment Filtration

- Where to start?
  - Auxiliary equipment (personnel carriers, tractors etc.) vs. Heavy mining equipment (scoop trams, haul trucks)
- Auxiliary Equipment
  - Large percentage of fleet
  - Lots of movement – locations not easily accounted for
- Heavy Equipment
  - Approximately 72% of the fleet horsepower
    - Therefore largest emissions volume
  - Working in close proximity

Heavy Equipment Filtration

- CAT R1700G Scoops, CAT AD30 Haul Trucks
  - 9 units of each – both company and contractor units
- Considerations:
  - Passive vs. Active DPF regeneration systems
  - Passive: ceramic vs. silicon carbide
  - Ease of changing on equipment (“plug and play”)
  - Cleaning options/locations
- **Conclusion:**
  - Passive regeneration, wallflow, silicon carbide filters
    - Test filters installed and run end of 2015-2016
    - Fleet wide installation began November 2016 – contractor equipment completed February 2017

DPF Installations

- Emissions testing on all scoops and trucks at engine outlet and exhaust outlet, includes CO, CO_2, NO, NO_2 and smoke dot test capabilities
- Mechanics monitor backpressure with Magnehelic precision gauges
- Installation of data loggers to indicate engine back pressure levels – will alarm in operator’s cab
- Backpressure Rule – 40 / 60 / 80 iwg

R1700Gs

- Minimal issues with installation – Plug and play
  - Crane and cables to remove/replace filter

AD30 Haul Trucks

- Difficult installation location
- High backpressures upon installation and plugging quickly – some within 2-3 days of installation
- Not achieving passive regeneration – low duty cycles (not achieving the required 400°C over 30% of the shift)
- **Difficult Installations/Removals + Frequent changes = PRODUCTION LOSS**

Filter Installation Challenges

- Minimal room to maneuver filter
- Must go in on a tight angle
- Risk of injury and filter damage

Solution – Installation from Beneath

- Remove a section of the undercarriage and create a removable “belly plate” that the filter will clamp onto

Removal of Belly Plate

- With exception of initial prototype all plates were manufactured and installed onsite with company personnel

Removal/Replacement of Filter

Filter Placement Locations/Transport

Backpressures

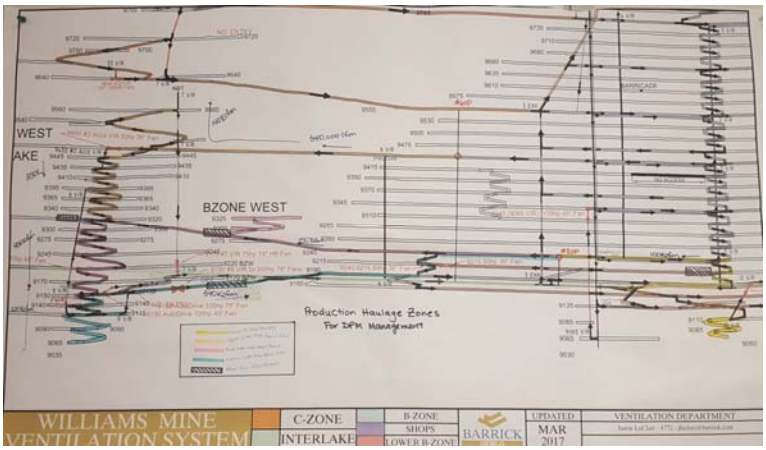
- Initial pressure tests after installation were in range of 30-35 iwg for some trucks
  - Adjustment made to outlet area to reduce restriction provided approximately 10-15 iwg reduction in pressure

Before

After

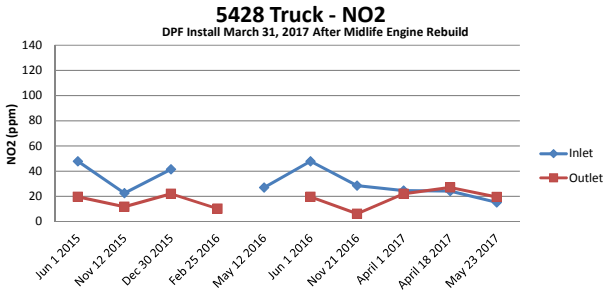
Improving Duty Cycle

- Creation of designated haulage routes, forcing up-ramp haul with designated waiting zones to prevent overloading of ventilation zones.



Catalyzed DPF

- Low duty cycles (exh. temp) created passive regen challenge
  - Low NO_2 results at outlet showed opportunity to change DOC catalyst formulation – raise NO_2 slightly to improve regen
  - Target NO_2 @ 50 ppm max. outlet side – significantly improved passive regen



Results

- As of the end of August 28 Truck has had 2 filter changes – 1st was over 500 hours, the second was at 490 hours
- In comparison 32 truck has had 7 filter changes in the same time frame (compare changing filters 2x weekly to once every 3-4 weeks)
  - Positive side to so many filter changes is that the maintenance department has become very efficient with it – change out time down to approximately **35 minutes**

DPF Cleaning

- Cleaning done by shop in Thunder Bay – logistics and delays
- Partnership with local shop in Marathon, ON and installation of FSX DPF cleaning system – no delays and simple logistics

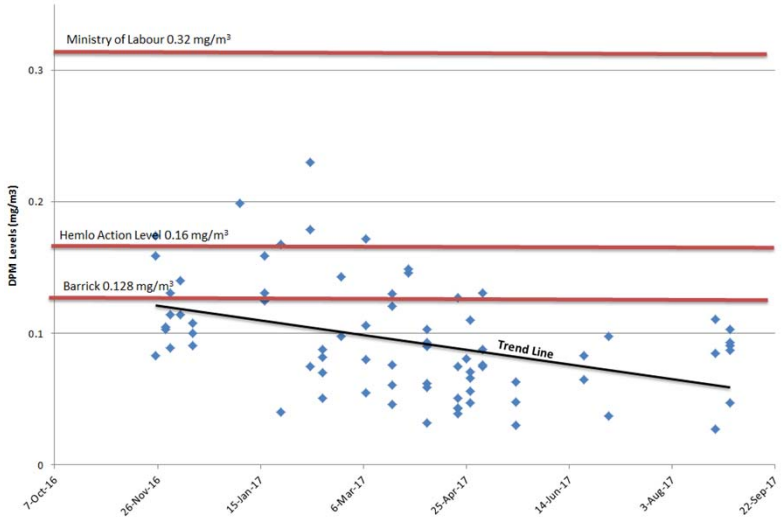
Ventilation Changes/Upgrades

- 3 new vent raises in lower mining zones increased flows and exhaust capacities (2014-2015)
- David Bell Heat Optimization Project:
  - 2014 – closure of David Bell Mine – free flowing vent through DBM & Golden Giant into Williams added approximately 200Kcfm to vent flows
  - 2015 – added 2 x 100hp fans adding another approximately 100Kcfm
  - 2016 – replaced 100hp fan with 2 x 200hp fans increasing flows to 400kcfm
  - 2017 – large vent hood installed on DBM shaft – lowered overall system resistance – decreased from 4”WG to 3”WG

Ventilation Upgrades – moving forward

- Ventilation On Demand – Phases I-III completed
  - VFD’s in place to better direct air flows where needed
  - Phase IV – more communication between surface and UG systems for better control – CO monitors installed UG in each ventilation zone
- Adding parallel #9 vent raise, replacing 3 fans (combination of 600hp) with 1050hp worth of fans – projected completion Dec. 2017 – additional 150-200Kcfm
- Ventsim 3D modeling software project – assist with modeling heat distribution, DPM levels (ability to add in equipment)
- Ongoing raise development in lower mining areas – allow for better flow control to active mining blocks

DPM UG Personal Sampling Results



- Biofuel increase started at the end of March, 2017.
- Maximum B20 as of June 9th with respect to potential warranty issues with some new equipment

Going Forward

- Auxiliary Equipment:
  - Difficult to passively filter as would not achieve required engine temperatures
  - Electric Vehicles
    - Scissor lifts, bolters, fuel truck, anfo loader – Q3 2018
    - Potential to move forward with grader, cement hauler and long hole drills in the future