Reducing respirable dust liberation during the bulk loading of haul trucks

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Presentation outline:

- Research goal
- Dust suppression hopper (DSH) description
- Test sites
  - Plant A
  - Plant B
- Sampling methods
- Data analysis
- Conclusions
- Acknowledgements
NIOSH research goal

• Reduce mine worker exposure to respirable dust
• Evaluate control technologies and disseminate findings to industry
• NIOSH and IMA-NA worked together to publish the Dust Control Handbook for Industrial Minerals Mining and Processing in 2012

• Chapter 7 - Bulk loading
  – telescoping loading spouts
  – cascading loading spouts
  – enclosed load-outs
  – control rooms
  – dust suppression hopper

• DSH installations in US provided an opportunity for case-study evaluations at two plants
Dust suppression hopper (DSH)

- Originally developed in New Zealand
- Cone-shaped hopper forces product into solid stream prior to discharge from unit
- Equipped with a stationary central plug inside hopper
- Hopper is suspended from top frame by multiple springs which hold hopper closed against central plug
- Hopper loads until mass is sufficient to extend springs and discharge product
- Design principle proposes two benefits
  - mass buildup in hopper forces entrapped air out of product
  - product flows in a condensed column when discharged
- H1 Model used at both plants (200 – 310 tph for bulk density of 100 lb/ft³)
Plant A test site

- Multiple storage silos fitted with rigid loading spouts
- Fines generated as a byproduct during processing stored in one silo
- Mine-owned truck loaded with fines and transported back to mine
- After baseline testing, DSH and bucket lift system installed
Plant B test site

- Enclosed conveyor transported sand from plant to telescoping spout at load-out... spout remained retracted entire time
- Loaded over-the-road commercial trucks or an articulated mine truck
- Six different product sizes loaded during NIOSH sampling
  - 20/40 - Baseline survey blend (60% 30/50 & 40% 20/40)
  - 30/50 - DSH survey blend (50% 30/50 & 50% 40/70)
  - 40/70 - Fines
Respirable dust sampling instruments

- Gravimetric and light-scattering instruments collected area samples
- Each sampling package contained:
  - 3 Zefon Escort ELF pumps @ 1.7 lpm with Dorr-Oliver cyclones
  - 1 Thermo Scientific personal DataRAM 1000-AN (pDR); dust measurement recorded every 2 seconds
- Gravimetric-to-pDR ratio used to adjust pDR measurements
- Sampling packages located at four points around truck bed
- Start and stop loading times recorded for each truck
- Average concentration calculated for each fully-loaded truck (wind)
Sampling locations

Plant A

Plant B
pDR data for truck being loaded with fines

Driver front average = 18.8 mg/m³

Driver back average = 14.4 mg/m³

Passenger front average = 43.8 mg/m³

Passenger back average = 13.8 mg/m³

Truck average = 22.7 mg/m³
Data analysis – Plant A

• Compare dust levels with rigid loading spout to levels with DSH
• Sampling sequence
  • 11 trucks loaded with fines during baseline sampling (rigid spout)
  • DSH and bucket lift installed
  • 11 trucks loaded with fines (DSH1)
  • 11 trucks loaded with fines 6 weeks later (DSH2)
• New equipment approximately doubled loading time
• Prior research shows loading rate impacts dust levels so direct comparison was not appropriate
• Dust concentration data normalized for loading time
• Normalized dust concentration = average truck dust concentration * (individual loading time/average baseline loading time)
Normalized dust levels for each truck sampled at Plant A

Respirable dust concentration, mg/m³

Trucks loaded for each test condition

Baseline  DSH1  DSH2
### Average respirable dust concentrations at Plant A

<table>
<thead>
<tr>
<th></th>
<th>Normalized dust concentrations, mg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
</tr>
<tr>
<td>Mean</td>
<td>107.4</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>29.4</td>
</tr>
<tr>
<td>Number of trucks</td>
<td>11</td>
</tr>
<tr>
<td>95% UCL</td>
<td>127.1</td>
</tr>
<tr>
<td>95% LCL</td>
<td>87.6</td>
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</tbody>
</table>

UCL – upper confidence limit; LCL – lower confidence limit

* Statistically significant difference from baseline at 95% confidence level

Average respirable dust concentration during loading reduced by 88%
Data analysis – Plant B

- Compare dust levels with retracted telescopic spout to levels with DSH
- Sampling sequence
  - 32 trucks sampled during baseline
  - DSH installed….no additional changes
  - 42 trucks sampled with DSH
- Different product sizes loaded during each survey
- Truck loading times nearly equal so data not normalized

<table>
<thead>
<tr>
<th>Product size loaded</th>
<th>Baseline survey</th>
<th>DSH survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>20/40</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>30/50</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>40/70</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Blend (60% 30/50 &amp; 40% 20/40)</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Blend (50% 30/50 &amp; 50% 40/70)</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Fines</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
# Average respirable dust concentration for loading at Plant B

<table>
<thead>
<tr>
<th>Product</th>
<th>Baseline concentrations, mg/m³</th>
<th>DSH concentrations, mg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20/40</td>
<td>40/70</td>
</tr>
<tr>
<td>Mean</td>
<td>8.92</td>
<td>3.19</td>
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<tr>
<td>Standard deviation</td>
<td>2.36</td>
<td>1.22</td>
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<tr>
<td>Number of trucks</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>95% UCL</td>
<td>na</td>
<td>3.97</td>
</tr>
<tr>
<td>95% LCL</td>
<td>na</td>
<td>2.41</td>
</tr>
</tbody>
</table>

UCL – upper confidence limit; LCL – lower confidence limit

* Statistically significant difference from baseline at a 95% confidence interval
Dust reductions for different product sizes

• Statistically significant direct comparison
  – $40/70 = 39\%$
  – Fines = $84\%$

• Limited data direct comparison (only 2 trucks during baseline)
  – $20/40 = 85\%$

• Calculated blend to compare to baseline blend
  – Baseline blend = 60% 30/50 & 40% 20/40
  – DSH individual data: 30/50 = 1.15 mg/m$^3$ & 20/40 = 1.36 mg/m$^3$
  – Calculated blend concentration = $(0.6\times1.15 + 0.4\times1.36) = 1.23$ mg/m$^3$
  – Calculated blend reduction = 70%
Average dust reduction with DSH loading at Plant B

- **Fines**: 83.7% reduction
- **40/70**: 39.5% reduction
- **30/50**: 84.8% reduction
- **20/40**: 69.7% reduction

Respirable dust concentration, mg/m³

Product loaded: Fines, 40/70, 30/50, 20/40, Blend*
Silica sand discharging from DSH as loading ends
Conclusions

• DSH reduced area dust levels at the bed of open trucks during bulk loading of silica sand when compared to existing load-out methods at two plants

• Dust reductions were dependent upon product size and ranged from approximately 40 to 88%

• DSH performance only tested against fixed discharge spouts. An operating telescoping spout was not tested in either case study

• A dust plume was released from DSH after loading is completed until hopper seals against internal stationary plug
Acknowledgements

- Industrial sand producers – providing access to test sites
- Plant personnel & truck drivers – assisting during sampling
- NIOSH personnel
  - Jim Noll – assisted during sampling at Plant A
  - Joe Archer – designed and assembled portable sampling stands
  - Emily Haas – assisted during sampling at Plant B
Thank you for your attention.

Questions???

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