A FIELD ASSESSMENT OF AN SIUC INNOVATIVE SPRAY SYSTEM FOR CONTINUOUS MINERS

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SME 2012

Seattle, Washington

February 20, 2012

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Thank you!

- Illinois Dept. of Commerce and Economic Opportunity
- Illinois Clean Coal Institute
- Knight Hawk Coal Company, LLC
- JOY Mining Machinery
- SME

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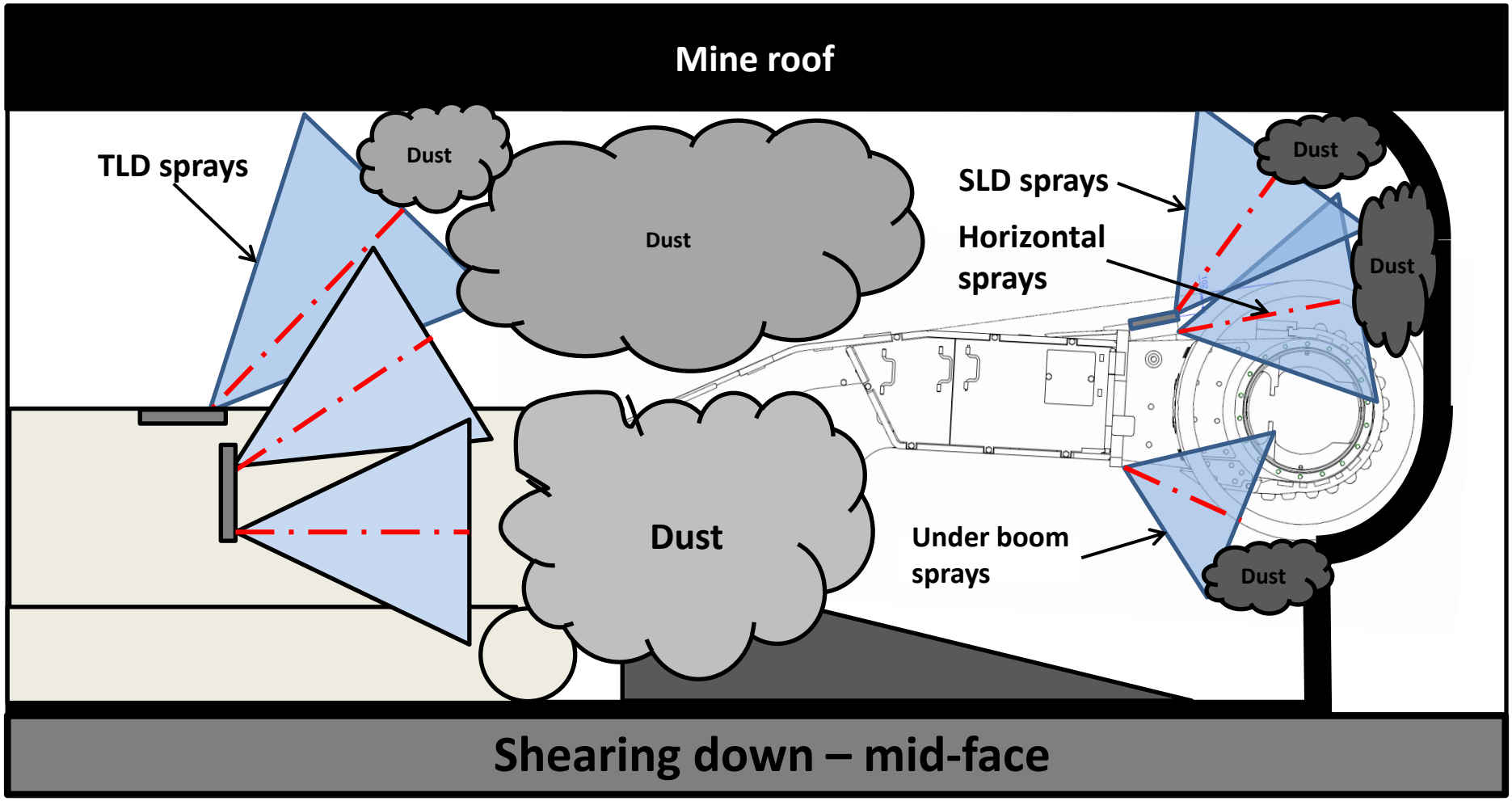
Foundations of Concept

- **Improve wetting of the material as it is mined. Wetter loaded material – less fugitive dust.**
- **Keep the dust at or near the face, don't let it escape. Create multiple check points to confine it.**
- **Increase residence time of the dust in the face area allowing the dust more time to be wetted and to be pulled into scrubber.**
- **Keep dust concentrated in a small volume to improve scrubber efficiency.**
- **Prevent roll-back over the top and along the sides of the CM chassis toward miner operator (CMO) and haulage unit operator (HUO).**
- **Minimize spray cone interaction near their origin or spray nozzle to lessen agglomeration of water droplets. Keep water droplets small as long as possible.**

Some concepts of SIUC spray system



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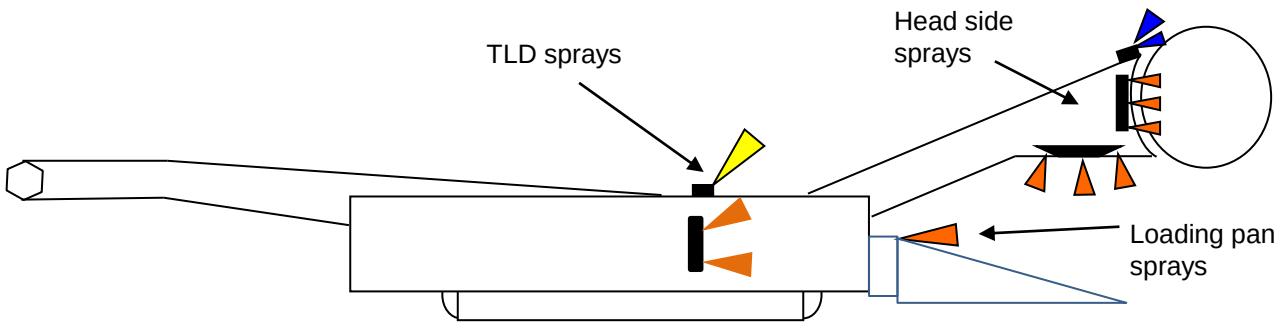
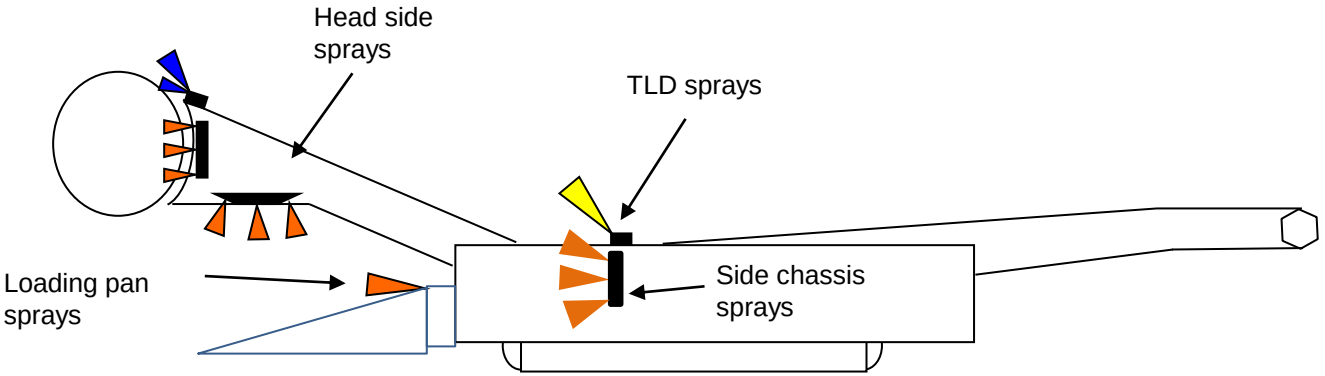
Current spray block design

Multiple spray orientations with minimal spacing – spray cone intersect near the spray nozzles.

Modified spray system elevation views

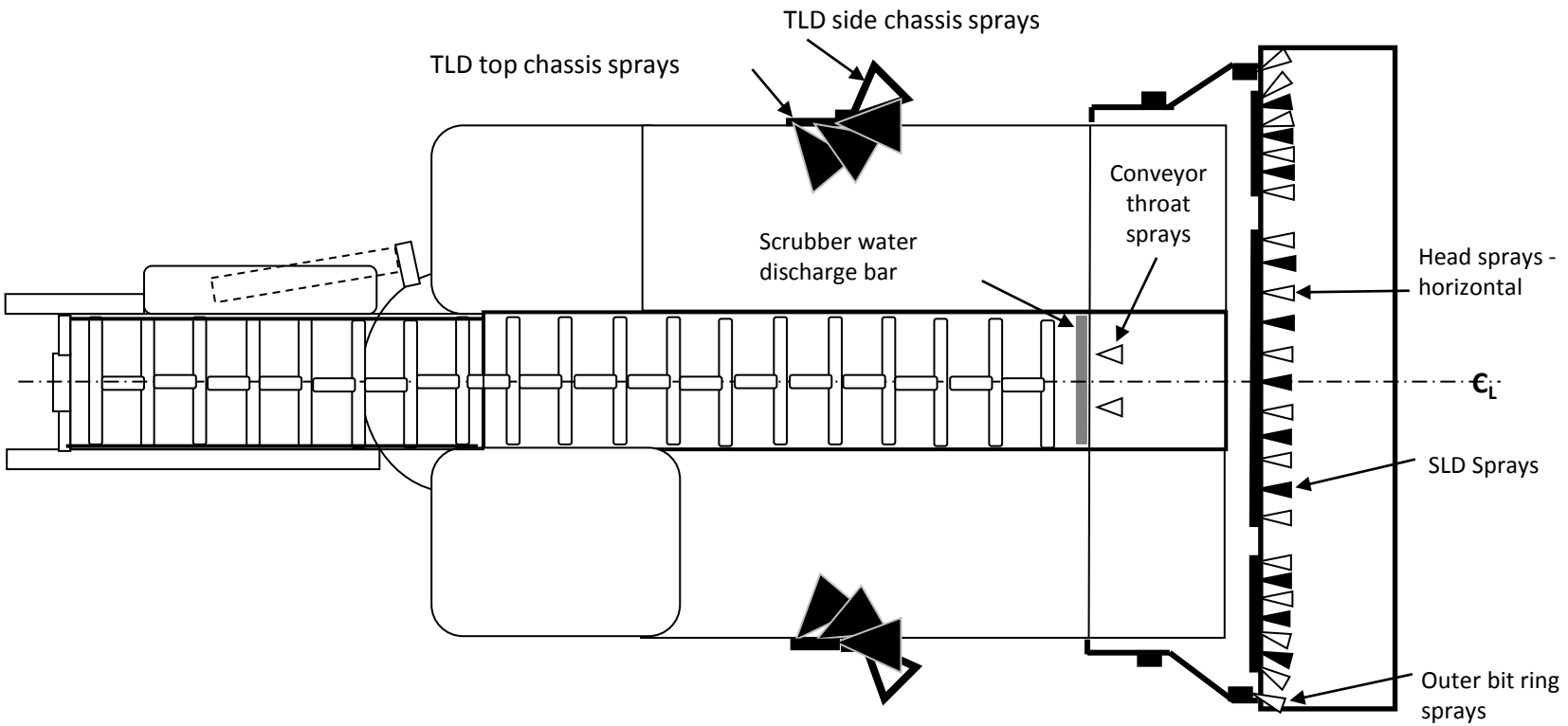


Operator side elevation



Scrubber side elevation

Modified spray system plan view



Plan view (not to scale)

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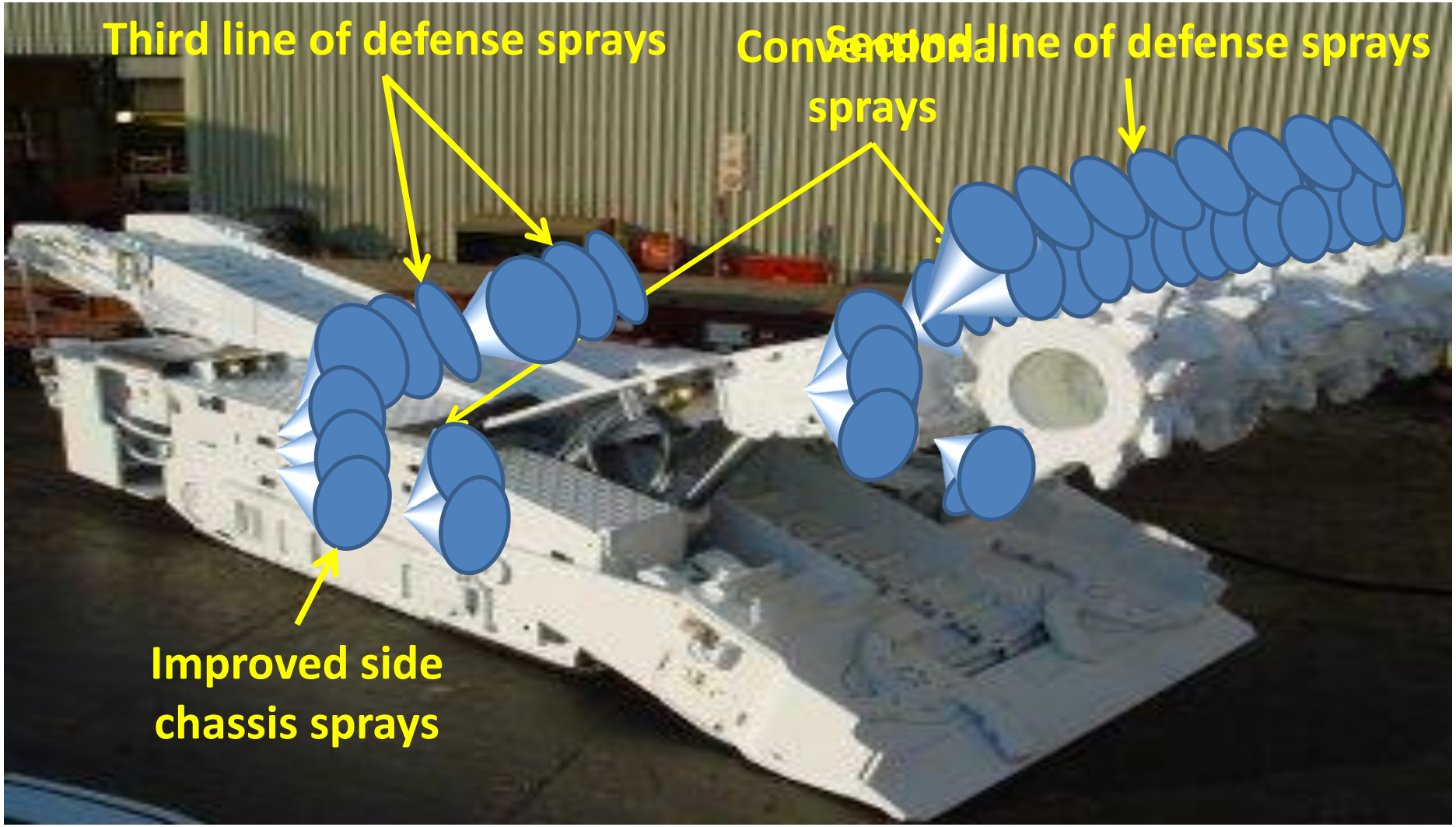
SIUC spray system - isometric view



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Spray System Comparison

Spray location	Conventional spray system	SIUC Innovative spray system
Across top of cutter head	14	17
Under cutter head	8	6
Outer bit rings	4	4
Side cutter boom	6	6
Side chassis	6	5
TLD	0	5
Conveyor throat	4	4
Total number of sprays	**42**	**47**
Total water volume (GPM)	**25.2**	**28.2**

Note: All sprays used were Spraying Systems BD-2 operating at 85-90psi.
(Above water volume based on BD-2 @ 90 psi = 0.6 gpm)

Design and installation of SIUC spray system

Engineering the sprays system at Knight Hawk mine before shipping the CM to rebuild

Installation of sprays at JOY rebuild center – SLD sprays

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Designation codes for sampling locations during field study

- **<u>Intake:</u> Upwind or out-by in the last open crosscut or main intake entry.**
- **<u>CMO:</u> Continuous miner operator *(moved the dust sampling package as the operator extended/retracted the line curtain)***
- **<u>HUO:</u> Haulage unit operator *(moved the dust sampling package as the HUO advanced/retreated with the cut)***
- **<u>Return:</u> Immediately downwind of the continuous miner in the last open crosscut or main return entry. RTI – in-by side, RTO – out-by side of entry/crosscut.**

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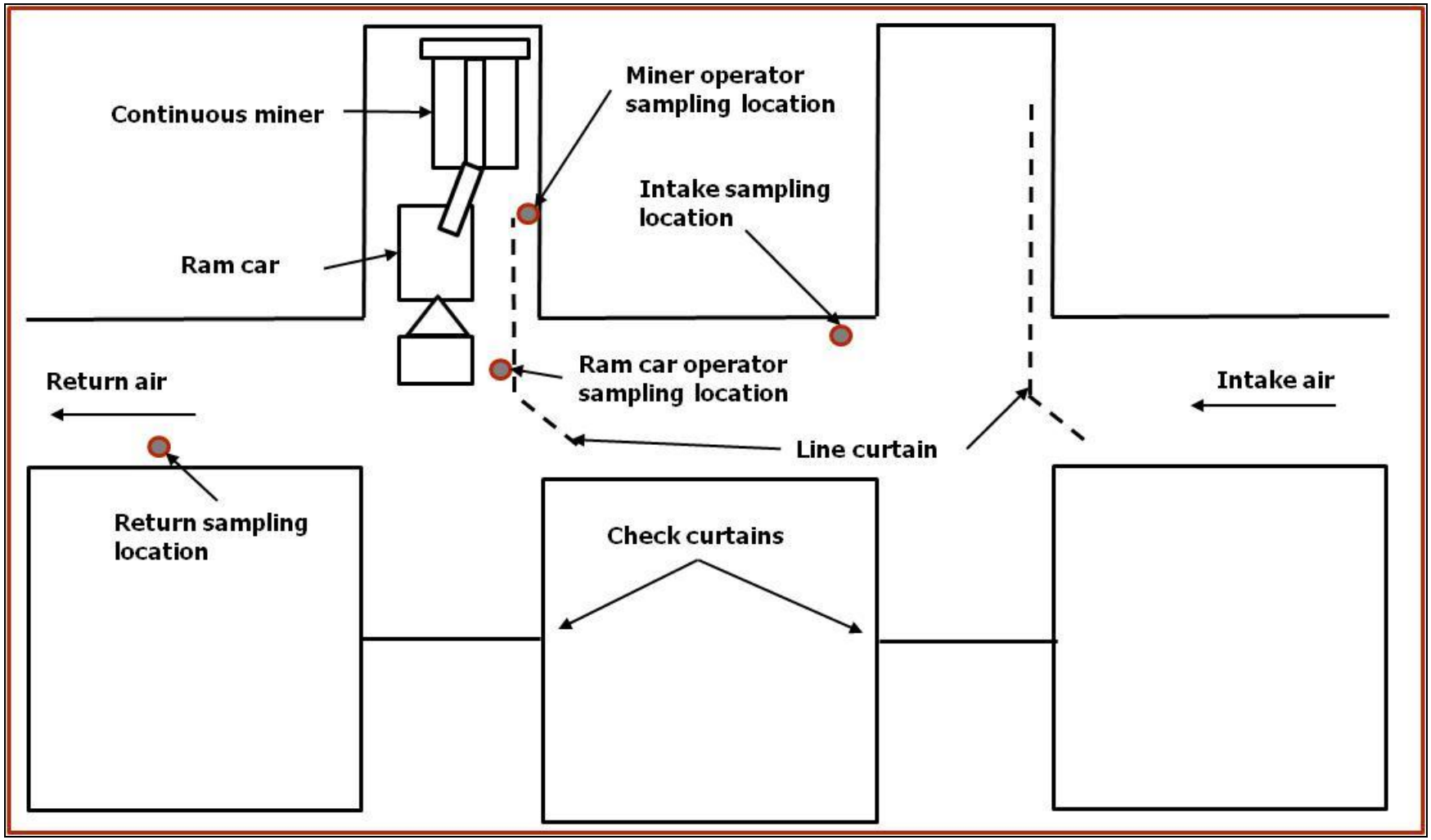
Typical dust sampling locations



Data collected during each cut – Air Volume

- End of line curtain (LC) air volume – running and idle
- LOXC intake air volume – running and idle
- LOXC return air volume – running and idle
- Air volume passing the LC in the LOXC
- Air volume entering the LC at the corner in LOXC
- Dust samples collected using ELF Escort dust pumps and real-time dust concentrations using Thermo Scientific PDr 1000an PDMs

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Data collected during each cut – Production Rate

- **Conveyor “on” and conveyor “off” times and number of haulage units loaded**
- **HU haulage routes and staging location/s**
- **Mining sequence – box cut, slab cut, clean up, delays, line curtain extension, etc.**
- **Cut type and mining geometry – straight, turn crosscut, etc.**

Data collected during each cut – Cut Geometry

- **Distance from LOXC to face at start of cut**
- **Depth of cut**
- **At the beginning and end of each cut:**
  - **Total height – right and left side**
  - **Width of cut**
  - **Roof – right and left side**
  - **Floor – right and left side**

Data collected each shift and checks before each cut

- **Water spray pressures (checked 2 to 3 times per shift)**
- **Vacuum (in/$h_2$0) at scrubber suction inlets (twice per shift)**
- **Scrubber volume (pitot tube)**
- **Cleaned scrubber screen**
- **Checked that all water sprays were operational**
- **Set cutting bits**

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Designation codes for CMs

- **CM-CON**: Return side continuous miner using conventional spray system.
- **CM-SIUC MOD-NIS**: Intake side continuous miner equipped with SIUC innovative sprays – innovative sprays not operating.
- **CM-SIUC MOD-IS**: Intake side continuous miner equipped with SIUC innovative sprays with operation of SLD (Second Line of Defense) and TLD (Third Line of Defense) sprays.

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Summary of Dust Control Comparison Data for SIUC Innovative Sprays

(gravimetric sampling – all cuts sampled)

Location	Miner	Percent (%) improvement CM-SIUC MOD-IS vs. CM-SIUC MOD-NIS	Percent (%) improvement CM-SIUC MOD-IS vs. CM-CON
CMO	CM-NIS	28.5	33.9
	CM-IS		
	CM-CON		
HUO	CM-NIS	-13.0	17.8
	CM-IS		
	CM-CON		
RTI	CM-NIS	22.4	5.9
	CM-IS		
	CM-CON		
RTO	CM-NIS	29.1	-14.2
	CM-IS		
	CM-CON		

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Summary comparison of production rate for all cuts

Miner	HUs loaded	Load time (seconds)	Wait time (seconds)	Load rate face advance (tons/min)	Tons per HU	Percent OSD (%)	Mean load rate entire cut (tons/min)
CM-NIS	18.8	48.5	68.5	13.65	10.81	10.26	5.63
CM-IS	17.9	46.2	58.3	14.19	11.21	7.98	6.15
CM-CON	16.9	47.3	57.0	14.14	11.04	7.41	6.28

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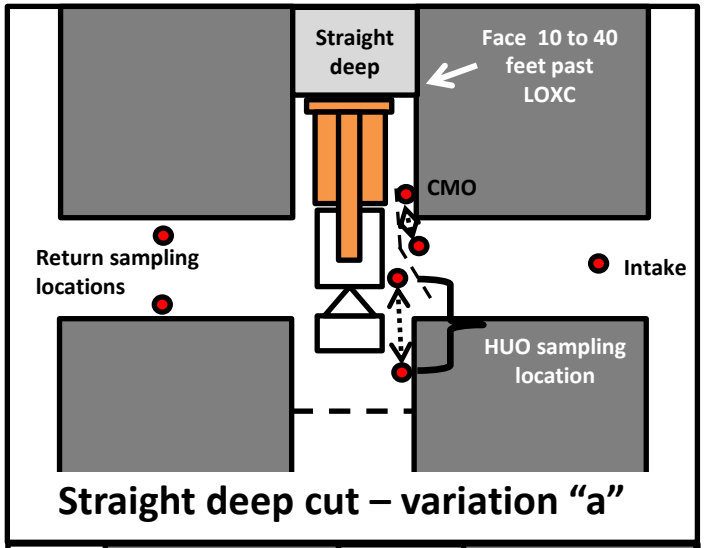
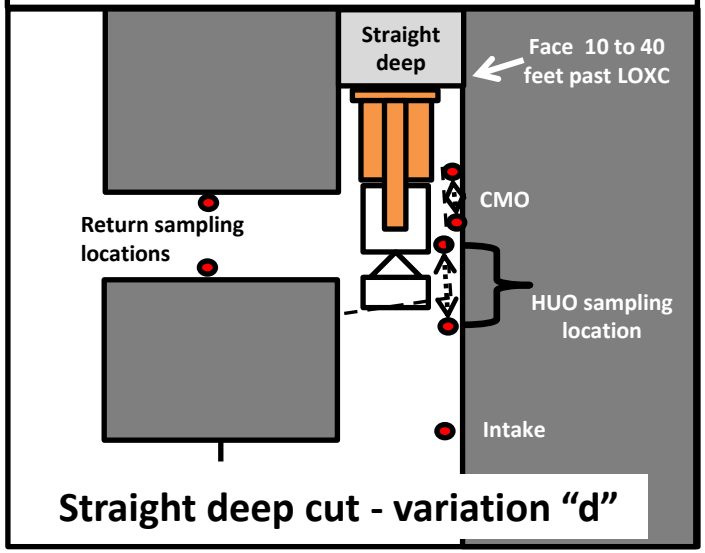
Performance comparison for "straight deep and deepest" cut types

- HUO inby LOXC and sees only air from line curtain during all deepest cuts and some deep cuts
- HUO not influenced by air leakage at LOXC end of line curtain during deepest cuts
- CMO not influenced by shorter length of line curtain – more controlled air flow during cut
- Return locations not influenced by scrubber exhaust
- Using these two cut types for comparison minimizes variables and is more consistent

Straight deep cut type dust comparison



Straight deep cut – variation "a"



Straight deep cut - variation "d"

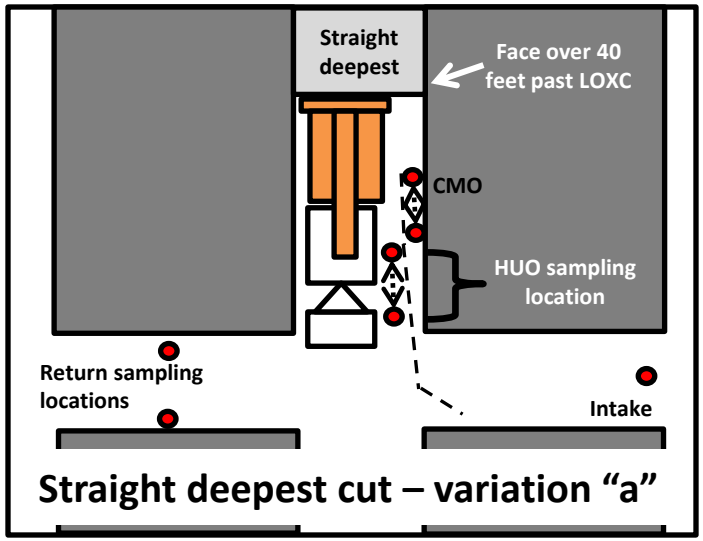
Location	Concentration (mg/m³)			Percent (%) improvement	
	CM-IS (4)	CM-NIS (5)	CM-CON (6)	IS vs. NIS	IS vs. CON
CMO	**0.06**	**0.14**	**0.25**	**60.4**	**78.1**
	0.086	*0.1719*	*0.418*		
HUO	**0.80**	**0.62**	**1.08**	**-27.9**	**26.5**
	0.676	*0.4589*	*1.072*		
RTI	**1.35**	**1.64**	**1.53**	**17.9**	**11.9**
	0.193	*0.2300*	*0.570*		
RTO	**0.88**	**1.22**	**1.53**	**27.9**	**42.2**
	0.394	*0.1735*	*0.736*		

Location	Concentration (mg/m³)			Percent (%) improvement	
	CM-IS (5)	CM-NIS (5)	CM-CON (0)	IS vs. NIS	IS vs. CON
CMO	**0.25**	**0.57**	n/a	**55.9**	n/a
	0.229	*0.5983*			
HUO	**1.53**	**2.36**		**35.5**	
	0.805	*2.4321*			
RTI	**1.21**	**2.43**		**50.2**	
	0.531	*1.1497*			
RTO	**0.95**	**1.76**		**46.0**	
	0.257	*0.8443*			

Straight deep cut type dust comparison – all cuts

Location	Concentration (mg/m³)			Percentage (%) improvement	
	CM-IS (9)	CM-NIS (13)	CM-CON (7)	IS vs. NIS	IS vs. CON
CMO	**0.17**	**0.33**	**0.31**	**50.4**	**46.0**
	0.199	*0.197*	*0.374*		
HUO	**1.20**	**1.04**	**1.70**	**-15.6**	**29.2**
	0.802	*0.790*	*1.210*		
RTI	**1.27**	**1.65**	**1.48**	**22.9**	**14.3**
	0.236	*0.589*	*0.564*		
RTO	**1.00**	**1.44**	**1.30**	**31.0**	**23.6**
	0.304	*0.625*	*0.738*		

Straight deepest cut type dust comparison



Location	Concentration (mg/m³)			Percent (%) improvement	
	CM-IS (3)	CM-NIS (3)	CM-CON (5)	IS vs. NIS	IS vs. CON
CMO	**0.20**	**1.02**	**0.27**	**79.8**	**25.2**
	0.244	*1.200*	*0.330*		
HUO	**1.74**	**3.48**	**2.54**	**49.8**	**31.4**
	0.969	*2.067*	*0.536*		
RTI	**0.80**	**2.52**	**1.55**	**68.1**	**48.1**
	0.723	*1.395*	*0.856*		
RTO	**0.82**	**1.77**	**1.08**	**53.7**	**23.9**
	0.187	*1.224*	*1.058*		

Straight deepest cut type – *all cuts*

Location	Concentration (mg/m³)			Percent (%) improvement	
	CM-IS (5)	CM-NIS (4)	CM-CON (6)	IS vs. NIS	IS vs. CON
CMO	**0.20**	**0.83**	**0.37**	**76.3**	**47.6**
	0.199	*1.047*	*0.386*		
HUO	**1.98**	**3.02**	**2.46**	**34.3**	**19.3**
	0.768	*1.918*	*0.523*		
RTI	**1.02**	**2.12**	**1.56**	**51.8**	**34.5**
	0.632	*1.398*	*0.766*		
RTO	**0.79**	**1.54**	**0.98**	**48.9**	**19.5**
	0.160	*1.096*	*0.975*		

Quartz sampling

- Sampling conducted two consecutive days, one production shift for each CM-NIS and CM-IS
- Sampling locations same as during respirable dust sampling

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Cut data during quartz sampling

CM	Cut #	Cut type	Length (ft)	Height (in)	Width (in)	Roof (in)	Floor (in)
CM-NIS	1	XC right - straight on	40	83.5	237	1.5	2.5
	2	XC left - straight on	40	84	235	1.5	11
	3	Straight deep	38	81.5	224	1	8
	4	XC left - straight on	40	84	218	1	10.5
	5	Straight initial	38	85	228	2.5	6
		Mean	**39.2**	**83.6**	**228.4**	**1.5**	**7.6**
CM-IS	1	Straight initial	39	80	229	4	4
	2	Straight deepest	39	82	220	2	4
	3	XC right - partial	26	92	219	5.5	7
	4	XC right hole thru	14	88	228	3.5	7
	5	Straight deep	25	93	224	13	6
		Mean	**28.6**	**87**	**224**	**5.6**	**5.6**

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Results from quartz sampling

- 4.8% reduction in quartz concentration during CM-IS sampling
- CM-IS - 11.2 inches out-of-seam dilution
- CM-NIS - 9.1 inches out-of-seam dilution
- CM-NIS made deeper cuts

Intellectual Property Protection

- Provisional application filed in July 2010.
- Final application filed in July 2011.
- Current experimental manufactured parts have marked “SIU Patent Pending”.
- The patent application is generic and covers all fields.

Field Assessment
'The Operator's Viewpoint'

Tom Hasenstab

- What they said? A Report from the Working Face!
- Productivity Enhancements / Drawbacks
- Where it Matters! The Safety and Health of the Miner!
- Overall Operator Assessment

What they said?
A Report from the Working Face

- Continuous Miner Operator

- Coal Hauler Operator

- Roof Bolter Operator

Comments from Knight Hawk

- Let's get right to it and go directly to the true testing grounds – the working face! The Face Boss, miner operator, roof bolters, and the entire crew are again confronted with something new. What is it this time? We all tend to associate coal miners with the pre-conceived notion of their unwillingness to change. The Innovative Spray System, however, was very well received by the entire working section. Quite possibly it was the fact that the system is not intrusive to any specific individual, does not require anybody to necessarily perform their duties in any different manner, and the benefits are readily visible.

Comments from Knight Hawk

- First of all, let's talk to the miner operator. There was concern the visibility of the miner operator would be impaired due specifically to the addition of the TLD Sprays. Of the four CM operators who ran the machine with the Innovative Spray System none discounted the system based upon that concern. Rather, the miner operators felt the system performed very well and stated they visibly noticed less dust in the air throughout their shifts. Each of the miner operators did indicate their visibility may be slightly hampered but this did not negatively impact their performance or productivity. Although a little more difficult to trim the top with the Innovative Spray System, the majority of the miner operators turn their sprays off in order to accomplish this activity.

Comments from Knight Hawk

- Moving on to the Coal Hauler Operators we find the impact becomes even more positive. Many of the CH Operators expressed they quickly and visibly noticed a positive change in the amount of dust present in the air. The rollover dust was minimal and allowed the CH Operators a cleaner and more readily visible environment while under the tail of the miner and being loaded. The CH Operators were in agreement with the CM Operators that the new spray configuration was a step in the right direction.
- Finally, the Roof Bolter operators; specifically the downwind roof bolters. Although the impact was less recognizable, they were in agreement that their environment was cleaner. The LOXC showed a reasonable amount of less dust concentration resulting in a positive impact on the roof bolter operators downwind of the CM.

Comments by Knight Hawk

- Let me conclude the assessment of the innovative spray system from an Operator's point of view by making just a few statements. First, the prototype machine which was equipped with the innovative spray system - a Joy 14CM15 miner which was out for rebuild – returned and put back in service during June of this year. Since then, 1 more machine has been sent for rebuild and an additional new 14CM15 machine is being built. Both of these machines are being equipped with the innovative spray system. Until such time as newer technology emerges, Knight Hawk Coal intends to equip the remainder of their fleet with the innovative spray system throughout their rebuild schedule.

Where it Matters!
Safety & Health of the Miners

- Lowering Miners' Exposure to Respirable Coal Mine Dust
  (Is 1 mg/m^3 standard close?)
- Explore Alternatives, Proactive, Protect our Livelihood
- MSHA Approval

Overall Assessment

- Prototype 14CM15 back from Rebuild in June 2011 with Innovative Spray System Installed
- New 14Cm15 was Received September 2011 with Innovative Spray System Installed
- Rebuild 14CM15 was Received October 2011 with Innovative Spray System Installed
- Remaining Fleet to be equipped with Innovative Spray System at Rebuild and/or Original Manufacture Date

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Thank You!

Questions??