Surface MNM Fatal accidents - Causes & Appropriate Counter-Actions

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(Conclusions presented in this document are based on the authors' understanding and interpretation of the accidents analyzed, and should not be considered MSHA canon.)

Introduction.

Current Mine Fatalities

In surface M/NM fatalities data studied for 2003 and 2004 each had about 24. Data studied through July, 2005 indicate that fatalities are actually likely to increase in 2005. Thus, in spite of the profound efforts MSHA and the states are making, little year-to-year progress is currently being achieved. The question "why is it so difficult to make further improvements?" is answered in part by the commonly-known "law of diminishing returns" which states "The closer to perfection, the greater the effort required to make incremental improvements".

Our Analysis Objective

It could easily be concluded from the data above that any future efforts to reduce fatalities will require substantial increases in funding and other resources. However, before that occurs, current resources should be focused on determining the causes of these recent fatal accidents. Once the causes are understood, they can be prioritized, and focus can be placed on controlling these causes. This was the objective of our data analysis. To determine the most important causes of current fatal surface M/NM mine accidents in the U.S, we analyzed MSHA surface M/NM fatalgrams and their accident reports from January 2003 through July, 2005.

Table 1 lists the total numbers of mine fatalities in that time period by MSHA category.

Listing Fatal Accidents by Causes

We examined the causes of 61 fatal surface metal/nonmetal mine accidents over the past 2 ½ years. Then, we listed each fatal accident by type, with each type, to the extent possible, representing a manageable control. For example, if a 7-step lockout procedure would have eliminated an accident, the accident was categorized under "lockout". Causes are not always clear, and some fatal accidents occur simply due to insufficient task training or lack of a risk analysis prior to performing a new or non-routine task (as emphasized in MSHA's new SLAM initiative).

Table 2 lists the surface M/NM fatal accident numbers by type for 2003, 2004 and through July of 2005. Six primary types are listed. 1) lockout, 2) cranes and rigging, 3) mobile equipment, 4) fall protection, 5) sliding product/earth, & 6) maintenance/cleanup. The other two fatalities were classified as "Other". Tables 3A-3G provide additional details on all 61 accidents.

Analysis Conclusions - Accident Categories

Lockout (21) (Table 3A)

Following a 7-step lockout procedure would have eliminated 21 of the 61 or roughly 1/3rd of the surface metal/nonmetal fatalities during the period analyzed. A 7-step lockout program is not mandated by 30CFR. However, our training program for Michigan mines currently follows a 3-year annual refresher training lesson plan which introduces the 7-step lockout process which includes:

1) Prepare to shut down equipment
2) Shut down equipment
3) Isolate equipment from energy sources
4) Apply locks
5) Control stored energy
6) Verify isolation from energy sources
7) Prepare for startup (account for all tools and clear all personnel)

The lockout-related fatalities which occurred during the period were due to:

Failure to Shut Down Equipment – step 2 above (6 failures)
Failure to Isolate/Verify Isolation – steps 3 & 6 above (6 failures)
Failure to Control Stored Energy – step 5 above (8 failures)
Failure to prepare to restart equipment – remove tools – step 7 above (1 failure)

Every miner should learn to consider each of the seven steps when performing any type of maintenance which exposes him to moving parts on equipment (unplugging, cleanup, adjustments, repairs, etc.). We plan to continue to emphasize the use of this 7-step procedure in all future training.

Our Jepardy game introduces the 7-step lockout process in two of the three years of our 3-year annual refresher training lesson plan. Videos and power point presentations are used during the third year. The above analysis suggests that a greater effort toward training miners to use this process has the potential to eliminate about 1/3rd or roughly 33 % of current surface metal-nonmetal mine fatalities. We plan is to continue using our Mine Safety Jepardy game and PowerPoint presentations, and to include a discussion of these fatal accident data as well as information on any future fatal accident that would have been eliminated by implementation of the 7-step lockout process. We also plan to discuss real-world lockout scenarios encountered in mining such as would be encountered when, for example, working on a crusher or front-end loader or when cleaning under a conveyor belt to assist miners in learning how to apply the 7-step lockout process in their daily work activities.

Cranes and rigging (13) (Table 3B)

These 13 fatalities would have been eliminated by using correct operating procedures. This indicates the importance of task training that focuses on the following causes.

Rigger or Helper Position (8) -- Eight out of the 13 crane-related fatalities involved riggers or helpers standing in the wrong place when they or the operator made a mistake. Positioning the rigger/helper in a safe location would significantly reduce crane-related fatalities. Contributing factors to these fatalities included rigging failures where loads shifted or were dropped, operators running into energized overhead lines, mobile crane 2-block, a boat capsizing when assisting a crane to free a dredge anchor, and misunderstood hand signals between the operator and rigger.

Crane Operator Training - Tip-Over (3) -- Crane tip-over killed a rigger/helper who was hit by the swinging load. This fatal accident could hardly be attributed to incorrect rigger position, although riggers/helpers should remain on guard. Crane tip-over also killed one operator when the cab was crushed by the impact. Failure to set the track brakes on a dragline resulted in an operator drowning when the dragline rolled into a water-filled excavation. All three of these can be attributed to not using safe operating procedures - most likely a result of task training deficiencies and failure to stop, look, analyze and manage (SLAM) risks.

Man-Lift Operator Training and Risk Assessment (2) -- Two man-lift operators were killed. One was crushed against a steel structure when using the man-lift as a crane. The other was fatally burned when the men on the man-lift using welding machines started a fire. Contributing factors were failure to assess the fire hazard prior to using the welding machine, failure to move the man-lift away before fire damaged its movement controls, and not knowing how to safely escape from the damaged man-lift. Task training and risk assessment (SLAM risks) could have prevented this fatality.

Specific procedures that need to be considered in task training include the following. 1) Rigger/helpers must determine a safe location to stand to avoid being struck by the load if rigging fails, or the load shifts, 2) the crane operator must be task trained and required to follow safe procedures to avoid tipping over, including knowing how to determine load capacities under various conditions using a load chart and how to ensure that the crane is stable (outrigger pads on stable footing etc.), 3) both the rigger and operator must be aware of the need to take extra precautions when working around overhead power lines including maintaining safe distances or de-energizing the lines (lockout isolation and verification steps) where there is a danger of getting too close to them, as well as requiring the rigger/helper to remain out of electrical contact with the load by using insulated gloves, boots and tag lines if it is necessary to guide the load, 4) making sure the track brakes on a dragline are always locked when in use to avoid rolling into an excavation, 5) using a man-lift only as a man-lift, not as a crane, and being extra careful to ensure that there is no possibility for a fire to start when welding (or air gouging) from a man-lift, moving the man-lift away from the area immediately upon any indication of a fire, and having a safe procedure to escape when man-lift controls become disabled, 6) knowing how to inspect rigging to minimize the possibility of rigging failure and how to rig loads to minimize the potential for dropped loads, and 7) making sure the communication system used between the operator and rigger/helpers is clearly understood by all personnel.

Our current 3-year annual refresher training plan does not specifically address the subject of cranes, although our Program has purchased and uses a number of excellent videos dealing with the subject and we have developed tests for use with some of these videos. The above data suggest that each year's annual refresher training address the hazards and correct operating procedures associated with the use of cranes and these data along with future fatal accident reports will form the basis for future training.

Mobile equipment (12) (Table 3C)

Traveling over edges (4) -- The four over-edge accidents occurred primarily because the operator got too close to an edge and either the edge caved (excavator, forklift), or the operator misjudged and drove over (dozer, scraper). Contributing factors include the scraper operator jumping out where he would most likely not have been killed if he had remained in the cab with a seatbelt on. Methods for assessing the ground conditions when approaching excavations and guidelines for determining safe working distances from edges are needed to eliminate these fatal accidents.

Runaways (4) – These fatal accidents would have been prevented by: (1) controlling speed and downshifting at the proper speed and location at the tops of grades, (2) task training on the procedures used to avoid brake failure due to overuse on long grades, and (3) taking steps to ensure that brakes are working properly. Contributing factors include not wearing a seatbelt and operators not knowing the steps to take in the event of a runaway.

Blind spots (3) – All of these accidents would have been prevented by pedestrians and truck drivers following the rule of "never entering mobile equipment work areas without operator approval". Properly-working backup alarms and the use of horns accompanied by short delays prior to moving parked vehicles may also have prevented one or more of these fatalities.

Seatbelt (1) – Skidsteers tend to tip-over easily. Although skidsteers have a lap bar that provides some support and must be down to operate, a tip-over can still eject an operator who isn't wearing a seatbelt as in this fatal accident. Operators must be taught how to avoid tip-overs and the importance of always wearing a seatbelt.

The above data will form the basis of future mobile equipment training which will include the use of MSHA videos and tests developed by our Program. Each of the four topic areas responsible for the above fatalities needs to be emphasized.

Fall Protection (7) (Table 3D)

Fall Prevention Integrity (1) – One fatal accident would have been eliminated if the fall prevention chain had been tested to see if it could be bumped off the hook before leaning against it. Miners must learn not to blindly rely on fall prevention chains, rails, etc., but to inspect them continually to ensure that they are functional. Any device that is fabricated or installed as a fall prevention device should be tested to determine that it will serve the purpose for which it is intended.

Missing Barriers (1) -- Another fatality would have been prevented by having a barrier around or over a skylight on a roof that a worker needed to walk on. Failure to do an inspection prior to entering the work area may have contributed to this fatal accident.

Failure to Use Fall Prevention/Arrest Systems (5) – The other 5 fatalities would have been prevented by the use of personal fall prevention or fall arrest systems, or having built-in fall-prevention systems in place.

These data emphasize the importance of inspecting fall prevention chains, rails etc., and avoiding false reliance on potentially-defective equipment – also the need for inspection of elevated work areas for fall hazards before working on them, and the need for and correct use of fall prevention and fall arrest systems. Fall arrest systems are covered in our mine safety Jepardy game during one year of our 3-year annual refresher training lesson plan. The above data analysis demonstrates the need for additional emphasis and these data will be used as a basis for discussing this topic in each year's annual refresher training.

Sliding Product/Earth (5) (Table 3E)

Highwall Failure – Slope/Height (1) -- One of these fatalities was a highwall failure where a loader was working at the toe of a highwall that was higher than the reach of the loader bucket and steeper than the angle of repose. Either a properly benched highwall or a properly sloped highwall would have prevented this accident.

Trench Support (2) – Two fatal accidents would have been prevented by supporting trench walls to keep them from caving before entry of personnel.

Entering Bins/Hoppers (2) – Two fatal accidents would have been prevented if workers hadn't entered hoppers/bins to unplug them without an attendant and a lifeline.

These data will be used to emphasize the importance of maintaining bench height or sloping highwalls to the angle of repose before loading out at the toe, to emphasize the need to stay out of bins and hoppers, and to never enter trenches with unsupported walls.

Maintenance/cleanup (3) (Table 3F)

Worker Position During Cleanup/Maintenance and Danger of Falling Materials (2) –These two fatal accidents would not have occurred if maintenance/cleanup workers had not been directly under areas where material could fall on them. One victim was hit by a rock which rolled off from an overhead conveyor as he hosed spillage from the concrete pad beneath. The other was hit by a chunk of material he hydro-blasted from an overhead tank wall.

Worker Position/Procedures -- The third would have been prevented by a worker standing back when using a hydraulic ram with a pipe extension when the pipe slipped out and struck the worker.

The above data will be used to emphasize the need for a SLAM risk assessment prior to taking on maintenance work. Workers must assess their work areas and learn to position themselves so that they are not exposed to an unexpected release of stored energy (gravity – rock and slab falling on worker, pipe under compression by hydraulic ram, etc.) in the event of a failure.

Other (2) (Table 3G)

Entry into danger zone -- One fatal accident would have been prevented if a worker had been prevented from walking into a danger zone. The worker walked into a duct in a cement plant and caved into the hot cement dust receiving fatal burns.

Blocked Fuel Hose Explosion – One fatal accident would have been prevented if a fuel truck driver had been warned that his hose was blocked when transferring fuel oil into a tank. The fuel oil, recirculating through the pressure relief valve, heated up and the hot fuel oil combined with high pressure caused a separation between the hose and coupling, spraying hot fuel oil onto the worker.

These data will be used to make miners and mine operators aware of the need to restrict personnel from entering dangerous areas and the threat of temperature and pressure related explosions. Mine operators will be encouraged to make fuel delivery companies aware of the need for sensors or other procedures to detect blocked lines.

Non-fatal Accidents

Non-fatal accidents reported for the State of Michigan during 2003 and 2004 indicate that handling of materials continues to be the most frequent while slip or fall of person is second, and these are followed by hand tools, machinery, and powered haulage.

Material handling accidents, the largest type of nonfatal accident reported in Michigan, are addressed in our Program's Powerlift training which is available to the State's mines at a small fraction of the normal cost as part of annual refresher training. The data on nonfatal accidents in the State's mines indicate that there is a need to convince these mines to take advantage of this Program as a part of annual refresher training. Slips, trips and falls are thought to be largely due to housekeeping. Our Program will attempt to get up-to-date information on housekeeping to present in annual refresher training. The Program has videos on the correct use of handtools and will attempt to obtain updates. Machinery and Powered haulage will be covered by going over the above-mentioned 2003-2005 fatal accidents.

Table 1. Total Numbers, By Major Category, of Surface Metal/Nonmetal Mine Fatal Accidents for 2003, 2004 and 2005 to end of July				
Category	2003	2004	2005 to Aug 1	Total
Machinery	7	5	6	18
Powered Haulage	6	6	4	16
Fall/Slide of Material (Some are Lockout/ Blocking)	3	5	2	10
Slip/Fall of Person	2	5	0	7
Electrical	2	1	1	4
Explosions	1	1		2
Drowning (other than those under machinery)	0	1	0	1
Other/Handtools (Should all be Lockout /Blocking)	3	0	0	3
Total in all categories	**24**	**24**	**13**	**61**

Table 2. Accident Numbers by Type for 2003, 2004 and Through July 2005

		Report Number			
Type	Sub-Type	2003	2004	2005	Total
Lockout	Failure to shut down	8, 25	7,14	1, 18	6
	Isolation/Verification	4,10,13*,23	21*	6	6
	Control of stored energy – blocking	6,12,26	2,18,22&23	14	8
	Preparation for startup – account for tools			17	1
	Total				21
Cranes & Rigging	Rigger or Helper Position	9, 13*, 17	6, 9, 21*	5, 11	8
	Operator Training -- Tip Over	19, 24	10		3
	Manlift -- Poor training & risk assessment	1		4	2
	Total				13
Mobile Equipment	Over edge	7,20		15,16	4
	Runaway	15,21	12,20		4
	Blind Spots/Miner Position	18,22	15		3
	Seatbelt (skidsteer tip-over)			9	1
	Total				12
Fall Protection	Fall prevention integrity (chain off hook)	2			1
	Fall prevention (missing barrier)	14			1
	Fall prevention/arrest		4,8,13,16,27		5
	Total				7
Sliding Product/Earth	Highwall failure		24		1
	Trench Support	11, 16			2
	Entering Bins/Hoppers		11	3	2
	Total				5
Maintenance/Cleanup	Worker position/falling cleaned materials		19,25		2
	Worker position/procedures -- Hydraulic ram extension slip- out			7	1
	Total				3
Other	Entry into danger zones		1		1
	Blocked fuel hose explosion		26		1
	Total				2
	Total (all types)				**61***

* Total adds to 63, but numbers 2003-13 and 2004-21 are used twice in this table, so total is 61 as shown.

Table 3A – Lockout – Failure to Follow 7-Step Procedure

Category	2003	2004	2005 to End of July
(failure to shut down)	8-On crossover trying to unplug jaw crusher – leg crushed	7-Threading new drill steel – clothes caught in rotating drill head.	1-Victim caught in conveyor return idler.
(failure to shut down)	25-Unplugging impact crusher with bar – crusher propelled bar into victim's neck.	14- Victim crushed between Bobcat lift-arm cross brace & front of ROPs. Tried to operate foot controls to position bucket to replace a hinge pin while reaching over the cross brace to access pin.	18- Caught in tail pulley adjusting conveyor belt.
(isolation/verification)	4- Cleanup inside reaction tank. Automatic-activated steam injection line control had not been locked out, nor had manual gate valve been closed and locked.		6-Victim contacted energized component while performing repairs inside electrical box.
(isolation/verification)	10-Contacted live wire while removing insulation to repair 480 volt cable powering water pump.		
(isolation/verification)	23-Repairing pipeline valve gasket for roaster; left area. Victim walked by and hot calcine dust released through open pipeline. Victim fell 30 feet, to the concrete floor		
(isolation/verification) ***(also crane – operator error & rigger location – rigger died)***	13-Positioning conveyor with rubber-tired crane. Victim w/both hands on conveyor electrocuted when hoist cable contacted high-voltage line.	21-Positioning conveyor with rubber-tired crane. Victim touching conveyor electrocuted when hoist cable contacted high-voltage line.	
(lockout – control stored energy – blocking)	6 - Victim on conveyor underneath crusher preparing to remove shim plate. Nuts removed & shim- toggle block rest fell and struck victim.	2- 15x8-ft metal plate tipped onto victim while retaining cable loosened to adjust it.	14 - Jaw crusher pitman repair – failed to block; pitman moved crushing mechanic.
(lockout – control stored energy – blocking)	12- Jaw crusher upper liner plate fell on victim while positioning wedge bar to secure it.	18-Floor jack shifted and Forklift fell onto mechanic.	
(lockout – control stored energy – blocking)	26-Truck operator struck by falling dump box.	22&23 - Failure to block (welded brace) during bucket repairs. **(2 fatals)**	
(lockout – prepare for startup – account for tools)			17-Ratchet handle forgotten on pump shaft bolt. Hit mechanic's head when pump started.

Table 3B – Crane Operation/Rigging/Rigger Location Fatalities			
Category	**2003**	**2004**	**2005 to End of July**
(Rigger or Helper Positioning)	9-Rigger hit by falling load when load shifted while attaching lift chain.	6-Mobile Crane – two-block, ball fell on victim.	5-Freeing Dredge Anchor - Boat and crane connected; crane moved, boat capsized.
(Rigger or Helper Positioning)	17– Rigging slipped off and haul truck wheel crushed rigger.	9-Hoisting conveyor – Hit by conveyor motor when hoist broke support.	11-Rigging failed when lifting steel plate from truck, victim and plate fell off truck bed – victim crushed by plate
(Rigger or Helper Positioning) ***(also lockout -- isolation/verification)***	13-Positioning conveyor with rubber-tired crane. Victim touching conveyor electrocuted when hoist cable contacted high-voltage line.	21-Positioning conveyor with rubber-tired crane. Victim touching conveyor electrocuted when hoist cable contacted high-voltage line.	
(Operator Error -- Tip Over)	19-Operating Crane on soft ground – tipped over pinning operator in cab.	10-Dragline rolled into water (track brake not locked)	
(Operator Error -- Tip Over)	24-Dismantling conveyor, helper struck by boom of tipped over crane.		
(Man-lift - improper Training & Risk Assessment)	1 - Men working from two man lifts on opposite sides of 16-ft dia metal duct connected to scrubber. Using welding machines to air gouge metal flange. Slag fell & ignited filter membrane. Cables on highlift damaged. 3 escaped; one jumped or fell; death due to burns.		4-Manlift overloaded, operator crushed himself against beam.

Table 3C – Mobile Equipment Fatalities			
Category	**2003**	**2004**	**2005 to End of July**
(over edge)	7-Edge caved – excavator rolled onto side crushing cab		15-Scraper tip over – wheel over edge of stockpile (victim jumped out – ended up under scraper)
(over edge)	20-Forklift too near pond edge – edge sloughs & oper. drowns.		16-Dozer backed over 45 ft highwall while cleaning bench.
(runaway)	15-Forklift run-away rollover on mine roadway (not equipped with seatbelt.	12-Water Truck runaway, victim ejected or jumped & struck.	
(runaway)	21-Pickup crashed into weigh house killing weigh master.	20-Driving haul truck w/bad brakes down grade -- over edge – overturned.	
(blind spots)	18-Loader backed over miner on ramp to hopper	15-Switchman run over by rail car.	
(blind spots)	22-Loader backed over pickup (guys trapping on edge of mine)		
(seatbelt)			9-Skid loader tip over (oper. ejected & crushed – no seat belt).

Table 3D – Fall Protection Fatalities			
Category	**2003**	**2004**	**2005 to End of July**
(fall prevention integrity)	2- Fall-prevention chain slipped off hook and victim fell 9 feet.		
Fall prevention (missing barrier)	14-Victim walking on roof fell through skylight 29 feet.		
(fall prevention/ arrest)		4-Lowered pipe from 56 ft screening building & fell out access door.	
(fall prevention/ arrest)		8-Opening truck hatches and fell 12 ft to ground.	
(fall prevention/ arrest)		13-Driller trainee fell from top of highwall while threading drill steel in vertical drill.	
(fall prevention/ arrest)		16-Installing new conveyor belt standing on conveyor support structure pulling rope. Fell 12 feet when rope came loose from belt.	
(fall prevention/ arrest)		27- Victim fell into water tank on concrete decanting structure.	

Table 3E -- Sliding Product/Earth			
Category	**2003**	**2004**	**2005 to End of July**
(highwall failure)		24-Loader buried while at toe of 65 ft highwall when matl sloughed trapping victim inside cab.	
(trench support)	11- A 9-ft trench wall caved onto victim.		
(trench support)	16-Bank of 15 foot deep hole being dug by backhoe caved onto victim.		
(entering bins & hoppers)		11-Engulfment in hopper entered to dislodge material.	3-Victim engulfed while in bin to dislodge plugging material.

Table 3F – Maintenance/Cleanup Procedures			
Category	**2003**	**2004**	**2005 to End of July**
(Maintenance/cleanup – worker position/ falling cleaned materials)		19-Larger rock rolls off conveyor killing worker cleaning under conveyor.	
(Maintenance/cleanup – worker position --hit by falling materials)		25-Hydroblasting lime crust from surge tank, victim buried in falling crust material.	
(Maintenance – worker position/procedures – hydraulic ram extension slip-out.			7-Replacing Fan housing – hydraulic ram w/pipe extension; against concrete wall; pipe slipped out and struck victim.

Table 3G – Other Fatalities			
Category	**2003**	**2004**	**2005 to End of July**
(entry into danger zones)		1-Victim walking in cement duct, caved to waist height at transfer point – Hot cement/fatal burns.	
(explosion –Blocked fuel hose explosion)		26 - Diesel fuel heated by high pressure (blocked hose & recirculation through relief valve). Hose connecting pump and mine storage tank separated spraying miner with hot fuel.	