

Pre-Operational Checklists Reinvented; Data Driven Reliability in Mining

By Dale R. Ekmark, Senior Consultant, IDCON

When was the last time we boarded an airplane and thought about what occurs in the cockpit? The activity that occurs before takeoff is meant to insure that all the steps necessary are accomplished to ensure a safe flight not only for all personnel but also the equipment. It's not that the pilots haven't done it a zillion times before. It is because they have and they also know that one missed step could lead to serious implications. Prior to engine start, the crew has completed, without exception, a Pre-operational Checklist.

In the 2011 seminal work on checklists, The Checklist Manifesto: How to Get Things Right, by Atul Gawande, the following observation by the author, even though he is a surgeon, could have been extracted directly from the mining industry.

“We don't like checklists. They can be painstaking. They're not much fun. But I don't think the issue here is mere laziness. There's something deeper, more visceral going on when people walk away not only from saving lives but from making money. It somehow feels beneath us to use a checklist, an embarrassment. It runs counter to deeply held beliefs about how the truly great among us—those we aspire to be—handle situations of high stakes and complexity. The truly great are daring. They improvise. They do not have protocols and checklists. Maybe our idea of heroism needs updating.”

For those of you with any exposure to mining, or heavy industry for that matter, you will be able to easily relate to Mr. Gawande's previous statement. Pre-operational checklists tended/tend to be “pencil-whipped”, ignored, or sloppily done, with of course the rare exception that is actually completed accurately and with useful notes. Why?

There are two, and probably many more, fundamental reasons. The first one is historically, the equipment was quite basic and fundamental and didn't require extensive pre-operation inspection/tests. Basically it was “kick the tires and light the fires”. Secondly, which was mentioned, human ego got in the way of sound judgment. Without a clear understanding of the value of doing a pre-operational checklist, operators subjugated the task to a menial importance, when the complete opposite was the reality.

With history in mind, in many respects, mining has followed the similar path as aircraft, albeit slower. Instead of a B-17 we are concerned about a Jumbo Bolter, Remote operated Scoop, Scissor bolter etc. Again, Mr. Gawande describes the mining industry at its current stage. (substitute mining for aeronautics)

“Instead, they came up with an ingeniously simple approach: they created a pilot's checklist. Its mere existence indicated how far aeronautics had advanced. In the early years of flight, getting an aircraft into the air might have been nerve-racking but it was hardly complex. Using a checklist for takeoff would no more have occurred to a pilot than to a driver backing a car out of the garage. But flying this new plane was too complicated to be left to the memory of any one person, however expert. The test pilots made their list simple, brief, and to the point—

short enough to fit on an index card, with step-by-step checks for takeoff, flight, landing, and taxiing. It had the kind of stuff that all pilots know to do. They check that the brakes are released, that the instruments are set, that the door and windows are closed, that the elevator controls are unlocked—dumb stuff. You wouldn't think it would make that much difference. But with the checklist in hand, the pilots went on to fly the Model 299 a total of 1.8 million miles without one accident. The army ultimately ordered almost thirteen thousand of the aircraft, which it dubbed the B-17. And, because flying the behemoth was now possible, the army gained a decisive air advantage in the Second World War, enabling its devastating bombing”

A similar scenario is rapidly unfolding in the world of mining and especially mobile equipment. The rate of technological advancement is rapidly outstripping the capacity of operations and maintenance to keep pace. The traditional generic five-minute walk-around, pencil whipped, checklist pre-op of a piece of equipment is no longer valid and, to be honest, likely never was. Below is a classic generic pre-op checklist that probably came into existence in the 1950's and is still used frequently in North America.

PRE-OP FLOW CHART

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graph TD
    A[OPERATOR FILLS OUT PRE-OP SHEET] --> B{EQUIPMENT OK TO OPERATE}
    B -- NO --> C[TAG OUT AND REPORT DEFECT]
    B -- YES --> D[GIVE PRE-OP SHEET TO SUPERVISOR AT END OF SHIFT]
        
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WALKAROUND INCLUDES

BATTERIES BATTERY COMPARTMENTS PHYSICAL DAMAGE WHEELS TIRES STUDS WINDOWS & SEALS MASTER SWITCH OPERATOR COMPARTMENT SAFETY CHAIN	V-BELTS COOLING SYSTEM AIR FILTER EXHAUST SYSTEM FUEL BUCKET / BOX CONDITION SAFETY RESTRAINT CABLE
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ALL MOBILE EQUIPMENT	OK	DEF
1) ENGINE OIL - FILL IF REQUIRED		
2) HYDRAULIC OIL - FILL IF REQUIRED		
3) TRANSMISSION OIL - FILL IF REQUIRED		
4) FIRE EXT. & SUPPRESSION SYSTEM		
5) WHEEL CHOCKS (2)		
6) WALKAROUND INSPECTION (See Inside Cover)		
7) WARNING SYSTEM & HORN		
8) LIGHTS, SWITCHES, GAUGES, CONTROLS		
9) BRAKE TESTS		
10) OPERATION OF STEERING		
11) FILL FUEL TANK		
12) GREASE UNIT		
13) HYDRAULIC HOSES & SAFETY CHAINS		
14) SAFETY INTERLOCK SYSTEMS		
15) CONDITION OF SEAT & SEAT BELTS		
16) CONDITION OF LADDERS & HAND RAILS		
17) TRAILING CABLE, ANCHOR & REEL		
18) AIR HOSES AND WHIPCHECKS		
19) OPERATION OF STABILIZER JACKS		
20) OPERATION & CONDITION OF BOOM(s) & FEED(s)		
21) OPERATION OF REMOTE PENDANT		
22) OPERATION OF REMOTE DRIVE SYSTEM		
23) OPERATION OF DRILL (s)		
24) OPERATION OF HOIST / DUMP CYLINDERS		
25) OPERATION OF AIR CONDITIONING SYSTEMS		
26) VENTILATION PLACARD M ³ /min (check per second)		
REMOTE CONTROL CHECKS		
27) CONDITION OF CONSOLE: STOPE LIGHT AND WATER SPRAYS		
28) STAND CONDITION: GUARDRAILS AND STAND LEVELNESS		
29) REMOTE CONTROL BRAKE TEST		
30) REMOTE CONTROL FUNCTIONS		
31) EMERGENCY SHUTDOWN CONTROLS: TILT & DELAY SHUTOFF PROTECTION		

USE CHECK MARKS ONLY!

T.P.P. 15-0008

Classic Traditional Generic Underground Mining Pre-Operational Checklist

It would be normal to say “Unfortunately, the equipment is becoming so complex” But that is not the case. Instead, “Fortunately” , mining equipment is becoming so complex today that these traditional checklists are truly obsolete; however they are still being used. Importantly, please note that this pre-op checklist is typically turned in at the END of shift. In modern underground mining operations, most shifts are 12 hours and even a small equipment fault that is uncorrected can develop into a major breakdown over a span of a single shift.

However, all is not lost in the world of mining. New leadership is entering the industry and “daring” to rock the pillars of a slow to change culture. One of those mines is Goldcorp’s new underground gold mine in Chapleau, Ontario, the Borden Mine. It is “Disrupting Mining” in a myriad of ways. As Canada’s first totally electric underground mine, it is on the vanguard of both technology and management operating systems (MOS) for the mining industry. The electric mobile mining equipment, in many cases, is just out of the prototype phase and represents a quantum technological leap from traditional diesel powered manual operated equipment.

It is not just the mobile mining equipment that has advanced. The advent of Industrial Internet of Things (IIoT) is now facilitating an enhanced underground asset health and maintenance management revolution. The Borden underground mine, like others, is now completely connected to the surface via high speed Wi-Fi to the “cloud”.

Luc Poulin, the maintenance manager at Borden, astutely recognized the opportunity and his vision is to completely automate and convert operator pre-op inspections from generic paper based pencil whipping exercises, with a time latency of over 12 hours, to real-time data-driven tablet-based checklists. Defects will be noted, prioritized and a SAP notification will be automatically generated for the supervisor/planner to be able to properly plan and schedule the work directly from underground.

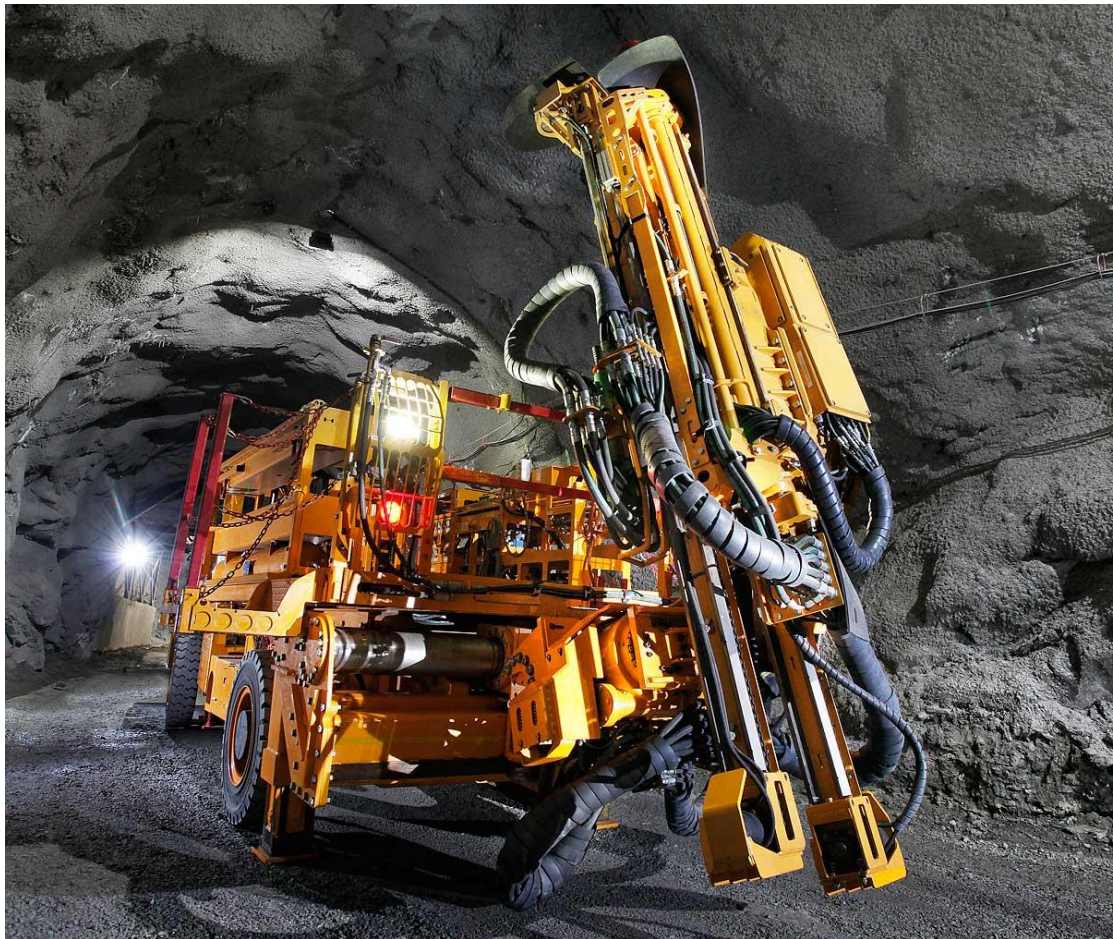
"Here at GoldCorp's Borden mine we are pushing the envelope of technology; we are 'Disrupting Mining'. We are Canada's first completely electric underground mine and are extremely dependent on early detection of defects of our advanced underground mobile fleet, to properly plan, schedule and execute our maintenance to safely and reliably achieve our production goals. Our first line of identification is from our operators during their pre-operational checklists. Together with IDCON, we are creating the next generation of digitally driven, real-time, operational pre-op checklists to drive reliability"

Luc Poulin, Maintenance Manager, GoldCorp Borden Mine

Stepping back to basic reliability, the P-F Curve clearly illustrates the value of early fault detection. Early detection allows for proactive monitoring, proper planning & scheduling and ultimately effective cost effective maintenance which maximizes uptime. The new tablet-based “Borden” underground, pre-operational checks harness not only the value of data driven inspections but also the real time capability of the internet, which not too long ago was not possible underground. With the increasingly complex equipment, real time monitoring of assets and assessing the operator inspections/machine generated data is paramount to early detection of problems for corrective maintenance prior to catastrophic failures.




DD422E (Electric) Sandvik Jumbo Drill



MacLean Omnia 975 Electric Scissor Bolter

Together with IDCON, inc. , the Goldcorp Borden Mine reliability journey commenced in early 2018. Recognizing that in order to capitalize on the opportunity, not only must pre-operational checklists become data-driven, operators also need to be extensively trained to understand what a pre-operational check is and actually why they are doing it. Recognizing that reliability is a shared responsibility between maintenance and operations, the approach undertaken included creating an operator reference guide called “Pre-

operational Condition Monitoring Standards” (CMS). This is a concise operational reference document that doesn’t supersede OEM manuals, but compliments them.







Mobile –MEM OMNIA EV975 SCISSOR BOLTER
Borden EV975 BLO2 CMS300P
Pre-Operational Inspection Condition Monitoring Standards

BASIC PRINCIPLE

The MacLean (MEM) OMNIEA EV Scissor Bolter is a complete and complex bolting and screening vehicle for underground hard rock mining operations. It has been designed to facilitate safe drilling and screening functions during the mine development and rehabilitation services in drift/tunnel headings up to six meters (20 feet) high. The OMNIA is fully equipped as standard for the multi-tasking required in today’s underground trackless mining environment. The Scissor Bolter is a complex machine with many user controls. Powered by a Lithium-Ion Battery Pack, the electric driveline replaces the diesel engine used for tramming producing zero emissions, reducing operating costs and increased productivity. The batteries are charged during the tramming process, leaving the unit with full power to readily move to new work headings.

Benefits:

- Complete drift coverage from a single setup,
- New state-of-the-art Lithium-Ion battery operating system,
- Low cost dependable mine supply vehicle,
- Best of maintenance with electronic diagnostics, accessible grease points
- Superior traction due to four-wheel drive

Applications:

1. Best suited for installation of ventilation ducting, electrical reticulation, and piping for air and water services,
2. Rehabilitation projects are conducted safely and efficiently from the level work deck, elevated to a comfortable work height.

The inspection should be done first, with the loader de-energized and shut off /made safe according to local company and government regulations



Additional pre-operational checks must be performed with unit energized
Due care must be insured to perform this safely.

Disclaimer: Please refer to the current version of the
MacLean OMNIA EV Scissor Bolter Operator Manual that supersedes this document

It is the responsibility and obligation of Goldcorp Borden Mine to ensure compliance to the various sections in Regulation 854 (Mines and Mining Plants) under the Occupational Health and Safety Act (OHSA) of Ontario. In addition, current operations/maintenance manuals of the OEM supersede the CMS and Pre-op Checklists.”
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CMS 300P DRAFT V2

OMNIA EV975 Condition Monitoring Standard (CMS)

The Condition Monitoring Standard is then converted to the new data driven pre-operational checklists that capitalizes on the concept of Operation's led reliability. The following are page excerpts from a new Borden data-driven pre-operational checklist.

GOLDCORP **MEM OMNIA EV975 SCISSOR BOLTER BL01 PRE-OP CHECKLIST**

STOP	ISOLATIONS
1	WITHOUT ENERGY < 1-10 < 12-31 < 84-89 < 92-94 < 99 Ensure Parking Brake is Applied and Wheels are Chocked
2	WITH ENERGY < 11 < 32-83 < 90-91 < 95 < 98 Ensure Parking Brake is Applied and Wheels are Chocked

Pre-Checks	
1	Execute Daily Before Shift
2	If changes or updates are needed to this inspection list, mark them directly on this list so it will be revised when you turn it back in.

Work Scope	
FROM	CMS 300P MacLean EV975 Scissor Bolter Pre-Op

Tools Recommended		
Description	Comment	Quantity
Inspection Light	Bright, 100 Lumens Plus	1
Inspection Mirror	Standard	1
Scraper	1"	1
Wire Brush	Standard, 12-14"	1
Rag	Standard	1

MATERIALS REQUIRED		
Stock No. & Description	Comment	Quantity
N/A		

LABOR REQUIRED (HOURS)		
Description	Quantity	Hours
Trained Employees	1	.25 - .50

IMPORTANT!!!!
IF DURING YOUR PRE-OPERATIONAL INSPECTION YOU DISCOVER ANY SAFETY DEFICIENCIES OR INSIGNIFICANT EQUIPMENT/OPERATIONAL DEFICIENCIES OR LEADS THAT COULD LEAD TO FURTHER EQUIPMENT DAMAGE OR CREATION OF A SAFETY/ENVIRONMENTAL HAZARD, IT IS YOUR RESPONSIBILITY TO NOTE THESE DEFICIENCIES AND TO CONTACT MAINTENANCE IMMEDIATELY AND DO NOT OPERATE THE EQUIPMENT UNTIL CLEARED BY MAINTENANCE!

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GOLDCORP **MEM OMNIA EV975 SCISSOR BOLTER BL01 PRE-OP CHECKLIST**

	Equip. No.	Equipment Description	Component or Task	Task Description (CMS Key)	ENERGIZED Y/N	CMS #	Inspected	Work Required?	Describe Problem - Indicate if you were able to fix it
49	BL01	MEM EV975 SCISSOR BOLTER	ALARMS & INTERLOCKS	Test functional operation of Remote Drive System (RDS) Drive Interlock	Y	304P	<input type="checkbox"/>	<input type="checkbox"/>	
50			ALARMS & INTERLOCKS	Test Deck Bolt Mode Interlock	Y	304P	<input type="checkbox"/>	<input type="checkbox"/>	
51			ALARMS & INTERLOCKS	Test Deck Extension Interlock (Machine Protection)	Y	304P	<input type="checkbox"/>	<input type="checkbox"/>	
52			ALARMS & INTERLOCKS	Test Deck Extension Interlock (Enhanced Operator Protection)	Y	304P	<input type="checkbox"/>	<input type="checkbox"/>	
53			ALARMS & INTERLOCKS	Test Drill Impact, Feed and Rotation Interlocks	Y	304P	<input type="checkbox"/>	<input type="checkbox"/>	
54			ALARMS & INTERLOCKS	Test Drill Impact, Feed and Rotation Locks Interlock with the Tilt Interlock System (TIS)	Y	304P	<input type="checkbox"/>	<input type="checkbox"/>	
55			ALARMS & INTERLOCKS	Test Electrical Power Pak Interlock	Y	304P	<input type="checkbox"/>	<input type="checkbox"/>	
56			ALARMS & INTERLOCKS	Test Face Bolting Mode Interlock (if equipped)	Y	304P	<input type="checkbox"/>	<input type="checkbox"/>	
57			ALARMS & INTERLOCKS	Test Mode Change Interlock	Y	304P	<input type="checkbox"/>	<input type="checkbox"/>	
58			ALARMS & INTERLOCKS	Test Operator Present Bolter Drill Lock/Gate Interlock (if equipped)	Y	304P	<input type="checkbox"/>	<input type="checkbox"/>	
59			ALARMS & INTERLOCKS	Test Outrigger Down Brake Interlock (if equipped)	Y	304P	<input type="checkbox"/>	<input type="checkbox"/>	
60			ALARMS & INTERLOCKS	Test Remote Pendant Interlocked with Tilt Interlock System (TIS)	Y	304P	<input type="checkbox"/>	<input type="checkbox"/>	

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MEM OMNIA EV975 SCISSOR BOLTER BL01 PRE-OP CHECKLIST

	Equip. No.	Equipment Description	Component or Task	Task Description (CMS Key)	ENERGIZED Y/N	CMS #	Inspected	Work Required?	Describe Problem – Indicate if you were able to fix it
39	BL01	MEM EV975 SCISSOR BOLTER	ALARMS & INTERLOCKS	Check motor protection alarm and warning lights are in good working condition.	Y	300P	<input type="checkbox"/>	<input type="checkbox"/> Y	
40			SCISSOR DECK	Raise scissor deck, install scissor lock and lower deck until scissor just touches scissor lock.	Y	300P	<input type="checkbox"/>	<input type="checkbox"/> Y	
41			SCISSOR DECK	Visually inspect scissor condition, rollers, scissor keeper belts. Look for hydraulic leaks, loose or unusual wear.	Y	300P	<input type="checkbox"/>	<input type="checkbox"/> Y	
42			SCISSOR DECK	Raise the scissor deck, store the scissor lock and lower deck. The Descent Alarm must sound.	Y	300P	<input type="checkbox"/>	<input type="checkbox"/> Y	
43			ALARMS & INTERLOCKS	Test Drive Mode: Steering, Throttle, Braking Functions.	Y	300P	<input type="checkbox"/>	<input type="checkbox"/> Y	
44			ALARMS & INTERLOCKS	Test Auxiliary Mode: Boom Manipulation, Drilling, Bolting and Outrigger use.					
45			ALARMS & INTERLOCKS	Test functional operation of Horn/Drive Lights Interlock.	Y	300P	<input type="checkbox"/>	<input type="checkbox"/> Y	
46			ALARMS & INTERLOCKS	Test functional operation of Air Compressor Interlock.	Y	300P	<input type="checkbox"/>	<input type="checkbox"/> Y	
47			ALARMS & INTERLOCKS	Test functional operation of Automatic Brake Application (ABA) Interlock.	Y	300P	<input type="checkbox"/>	<input type="checkbox"/>	
48			ALARMS & INTERLOCKS	Test functional operation of Boom/Deck Scissor Interlock.	Y	300P	<input type="checkbox"/>	<input type="checkbox"/>	

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Excerpts from of “new” Borden expanded Equipment Pre-operational Checklist

In an industry that not too long ago was unfairly labeled as, “Dark, Dirty and Dangerous” and where Maintenance and Operations were “opposing” forces, the leadership of GoldCorp , Borden Mine has recognized that Safe Reliable Operations is actually a powerful shared vision for excellence for the entire organization. The high tech revolution has taken it by storm and not only will it enable dramatically improved reliabilities and cost efficiencies but the collateral benefit is a safe operation. This all begins with leadership and the daily commitment to a thorough and accurately completed pre-operations inspection.

Pre-operational checklists are not “new”, “sexy” or exciting. What they are is the leading foundation of a safe, highly efficient, reliable and cost effective mining operation!