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A methodology for assessing underground coal mines for high safety-related risk

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ABSTRACT

In 2008 the authors developed a methodology for assessing underground coal mines for high risk for major-hazard events. It focused on major hazard-related violations of safety standards associated with high-risk conditions. Later using the same stratified pilot sample of 31 mines, injury measures and MSHA citation data were combined into a Safe Performance Index (SPI). Using 2009 data, the database was expanded to 107 mines, which is a 30% sampling of all underground coal mines. The SPI was used to assess the relative safety-related risk of mines, including by mine-size category. The methodology can be used to assist companies, the Mine Safety and Health Administration, or state agencies in targeting mines with high risk for serious injuries and elevated citations for remediation of their violation and/or injury experience.

1. Introduction

Following the underground coal mine disasters of 2006, the U.S. Congress passed the Mine Improvement and New Emergency Response Act (MINER Act, P.L. 109-236). It was enacted primarily to address several shortcomings in emergency preparedness and response, aiding miners in escaping and surviving emergency situations, and to increase the enforcement of safety in mines. An independent, tripartite commission (Mine Safety Technology and Training Commission, 2006) was established by the National Mining Association, which published a consensus report aimed at preventing underground coal mine disasters in the future and targeting the goal of zero fatalities and lost-time accidents. The report specified 75 recommendations that, if implemented, would set safe performance standards for achieving a culture of prevention at mines, including risk assessment, and noted that mines which could not meet the level of safety requirements specified in the report should not be allowed to mine coal.

Post-MINER Act, the Mine Safety and Health Administration (MSHA) increased enforcement of mines in all sectors, and the level of fines was about 3.5 times higher than pre-2006. The provisions of the MINER Act were largely implemented by 2009, with few exceptions, thereby increasing the protection of miners during emergencies and better preparing mines for effective emergency response. Mine safety professionals hoped that major hazard-related disasters would be avoided in the future. However, in spite of many efforts by the Federal government and a number of state governments, the worst underground coal mine disaster in 40 years occurred at the Upper Big Branch-South Mine on April 5, 2010.

Following publication of the Mine Safety Technology and Training Commission (MSTTC) report, the National Institute for Occupational Safety and Health (NIOSH) followed up on the MSTTC recommendation that NIOSH "develop a series of case studies that mines could use as templates (for risk assessment), and that it conduct workshops and seminars to diffuse this approach to safety throughout the industry." NIOSH completed its study, but there was little response by industry to attend workshops to diffuse the major-hazard risk assessment methodology. Thus, a key component of the MSTTC report remained largely unaddressed, and it was critical for establishing a safety culture of prevention founded on systematic risk assessment and follow-up remediation of identified major hazard-related risks.

Beyond ventilation and roof control plans, MSHA has pursued risk management over the years. Stop Look Analyze and Manage (SLAM), the Pattern of Violations (POV) provision, and Rules to Live By are the most recent examples. The two-step POV process was initiated in earnest in June 2007. Today problems persist with the POV process, which depends on final citations, including elevated ones. The process is also not transparent to the mine safety community, is complex with 10 components comprising the calculation, and is cumbersome to enforce, particularly because a significant percentage of significant and substantial (S&S) citations and orders are challenged through the due process that operators exercise via the Mine Safety and Health Review Commission.

In the summer of 2007, the authors initiated a pilot study of 31 underground coal mines, stratified by mine size and state, to analyze the comparative risk among them. One of the tools developed was the Safe Performance Index (SPI), which combines statistics on a mine's injury experience with its citation experience in

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determining its relative level of safety, or risk (Kinilakodi, 2009). Emulating the Environmental Performance Index (Emerson et al., 2010), the SPI was designed to provide a more straight-forward, transparent, and understandable method for determining the relative risk of mines than the POV process. In the calculation, it gives greater weight to the injuries and citations that are more serious. It can be used to benchmark superior safety performance, including by mine size or type of mining, or for screening mines for improvement efforts. The details on the development of the SPI as well as the results of analyses using it will be given next.

2. Pilot-sample study

The 31 pilot-sample mines shown in Table 1 were created for the risk assessment exploratory study by Grayson et al. (2009). The pilot-sample mines were created to study the MSHA citation database and it was the first attempt to use the MSHA citation database for a risk assessment study, other than MSHA using it in POV calculations. The 31 mines in the pilot study were randomly selected and stratified based on mine size and the state in which they are physically located. In 2006, there were 421 active underground coal mines with production greater than or equal to 10,000 tons. Out of 421 mines, 112 were very small mine-size, 143 were small mine-size, 78 were medium mine-size, 49 were large mine-size, and 39 very large mine-size. In the pilot sample there were 8 very small mines, 10 small mines, 6 medium-size mines, 4 large mines, and 3 very large mines which were proportionately representing the various mine-size categories and the nine different states (Alabama, Colorado, Illinois, Indiana, Kentucky, Pennsylvania, Utah, Virginia, West Virginia). Hence, the 31 mines sampled satisfy the size-wise and state-wise representation/distribution. In general, the 31 pilot-sample mines represent the overall industry situation. Final MSHA 2006 injury, employment and citation data were captured on the 31 mines. Three tools were developed for monitoring mine safety performance, as follows:

- Risk assessment for major-hazard conditions using major hazard-related citation data – the calculation made for each mine was the product of the frequency of occurrence of citations and the penalties (in dollars) assessed on them (Grayson et al., 2009).
- The reliability of not getting an MSHA citation on an inspector visit (Kinilakodi and Grayson, 2011).
- The Safe Performance Index.

The remainder of this paper focuses on the details of the development of the Safe Performance Index and the results from using it.

3. Safe Performance Index calculations from pilot study

MSHA data for 2006 on the 31 mines in the stratified, random sample was used in this pilot study. When the project was begun, 2007 data was not yet available. The basic safety data on the sample mines is given in Table 1. The 'inspector hours' field contains total inspector hours, primarily because the Pattern of Violation process (Smith, 2010) was not yet implemented. In the pilot study data there were no fatalities, which indicate the low probability for an underground coal mine to have a fatality in a given year (approximately 4% chance).

The measures used in calculating the Performance Index (PI), and later the SPI, for 2006 data included standard injury measures, i.e. the No Days Lost Incidence Rate (NDL IR), the Non-Fatal Days Lost Incidence Rate (NFDL IR), and the Severity Measure (SM), and citation-related measures, i.e. Citations per 100 Inspector Hours (C/100 IH), Significant and Substantial Citations per 100 Inspector Hours (SS/100 IH), and withdrawal Orders and unwarrantable failures per 100 Inspector Hours (O/100 IH). They are shown in Table 2 for the 31-mine sample.

As the first step in calculating the SPI, the PI is calculated as the summation of the safety measures. The PI thus gives a combined

Table 1
MSHA safety data on pilot study mines.

Mine ID	No. Empl.	No. NLT accidents	No. LT accidents	Restricted and lost work days	Empl. hrs	No. citations	No. S&S	No. orders	Insp. hrs
1	15	0	0	0	36,004	16	3	0	237.50
2	13	0	0	0	8429	11	6	0	101.50
3	7	0	0	0	12,285	11	4	0	307.75
4	20	7	3	8	54,692	51	15	0	740.50
5	20	0	1	354	38,214	150	84	0	518.00
6	15	2	2	162	36,060	65	27	2	435.00
7	14	0	0	0	27,067	7	1	0	212.25
8	15	0	1	120	14,608	13	1	0	156.50
9	49	8	2	146	135,414	512	228	76	2740.50
10	35	2	2	51	79,853	54	23	1	434.00
11	21	0	2	60	36,708	46	18	0	301.75
12	25	2	2	6	40,880	47	20	0	356.75
13	21	0	0	0	38,274	73	39	1	408.25
14	30	2	0	0	67,958	55	11	2	1092.80
15	36	2	4	326	69,822	9	5	0	181.50
16	42	0	1	9	106,095	48	27	2	445.75
17	22	0	0	0	29,166	84	32	3	416.00
18	37	2	5	384	93,419	72	28	0	681.75
19	67	1	0	0	178,226	107	53	0	825.75
20	72	4	2	16	71,977	48	9	0	492.00
21	56	5	2	229	122,416	65	20	0	364.00
22	72	15	11	1435	170,692	96	41	4	619.75
23	63	6	23	1188	152,847	141	45	1	1162.30
24	58	7	1	62	169,469	86	57	10	588.00
25	142	10	5	47	278,557	133	31	8	1556.50
26	107	13	3	165	257,958	154	53	2	858.75
27	103	19	10	176	309,759	167	92	2	845.00
28	231	10	4	428	499,328	196	69	12	2088.00
29	390	30	8	658	894,791	370	100	5	2861.50
30	303	13	12	392	655,104	103	33	1	1706.50
31	383	29	16	1541	794,802	517	128	5	2969.00