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Interpreting MSHA Citations Through the Lens of Occupational Health and Safety Management Systems: Investigating Their Impact on Mine Injuries and Illnesses 2003–2010

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Since the late 1980s, the U.S. Department of Labor has considered regulating a systems approach to occupational health and safety management. Recently, a health and safety management systems (HSMS) standard has returned to the regulatory agenda of both the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA). Because a mandated standard has implications for both industry and regulating bodies alike, it is imperative to gain a greater understanding of the potential effects that an HSMS regulatory approach can have on establishment-level injuries and illnesses. Through the lens of MSHA's regulatory framework, we first explore how current enforcement activities align with HSMS elements. Using MSHA data for the years 2003–2010, we then analyze the relationship between various types of enforcement activities (e.g., total number of citations, total penalty amount, and HSMS-aligned citations) and mine reportable injuries. Our findings show that the reduction in mine reportable injuries predicted by increases in MSHA enforcement ranges from negligible to 18%. The results suggest that the type and focus of the enforcement activity may be more important for accident reduction than the total number of citations issued and the associated penalty amount.

KEY WORDS: Health and safety management systems; public policy; regulatory impact

1. INTRODUCTION

In the United States, during the first decade of the 21st century approximately 60,000 people were fatally injured in accident events that originated during the course of work.(1) These occupational fatalities produce substantial ethical, social, and economic strain absorbed by organizations, communities, families, and the U.S. economy in general.(2) Most would agree, however, that even one occupational fatality is an unacceptable event. Given the need to preserve and protect human resources, finding ways to prevent fatalities, injuries, and illnesses that occur during the course of employment is a collective endeavor—one that encompasses efforts from businesses, workers, and the regulatory environment.

Over the past century in the United States, there has been an increasing federal government initiative to regulate worker safety in all major industrial sectors. Significant pieces of U.S. federal safety legislation came in the form of the Occupational Safety and Health Act (1970) and the Federal Coal Mine Health

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and Safety Act (1969). Although the scope and regulatory framework differs between them, these acts of Congress allow the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA) to develop safety rules and regulations that govern a business's operations for the benefit of worker safety.

The ultimate goal of safety legislation and the accompanying enforcement activities is to facilitate and/or assist employers in the process of promoting a safe and healthful workplace. In the United States, federal safety regulating bodies and the businesses subjected to their regulations are involved in a continuous exchange of ideas and interactions regarding existing and proposed safety regulations. These interactions and exchanges have historically revolved around interpretations of existing regulations, potential adverse consequences of existing and new regulations, and enforcement feasibility issues resulting from proposed regulations.

Recently, there has been an increased international emphasis on a regulatory approach to health and safety management systems (HSMS). Occupational standard setting bodies both within the United States (e.g., OSHA, MSHA, the U.S. Department of Energy, and the U.S. Department of Defense) and outside of the United States (e.g., the International Labor Organization, Canada, Australia, and the European Union) have made efforts toward systems-related standards. These efforts have been emphasized primarily because of the potentially important role that HSMS play in occupational injury and illness prevention. The ideas behind an HSMS standard have relied on empirical studies revealing that a systems approach to safety management can significantly decrease workplace injuries and illnesses.[3,4]

Despite the above assertions, within the United States, federally proposed standards for HSMS have not been received well by industry. Beginning in the late 1980s, OSHA considered adopting a mandatory standard requiring worksites to develop and implement a safety and health program. Based on industry feedback, OSHA made the decision to publish the safety and health program standard as a voluntary guideline, reserving the right to undertake regulatory action at a later date. Industry objections to a mandated standard include the cost of compliance, ambiguity of language in the proposed rule, and the difficulty of regulating the elements of management commitment and employee involvement.[5] More recently, a regulatory approach to health and safety management programs has returned to both OSHA's and MSHA's regulatory agenda.[6,7] Thus, research that can shed light on the potential effectiveness of such a mandated approach is increasingly important.

Numerous previous studies have explored the effect of OSHA regulatory activities on establishment-level injuries and illnesses.[8–15] These studies report that, depending on the time period in question, OSHA's regulatory efforts have been associated with an approximately null to 24% decrease in establishment-level injuries and illnesses. In contrast, we were able to locate only one study that explored the relationship of MSHA enforcement activity on mine-level injuries and illnesses. Using MSHA data for the years 1983–1997, Kniesner and Leeth[16] found a positive effect of MSHA enforcement activity on mine injuries and illnesses in terms of a cost of enforcement to benefit of injury prevention comparison.

Using MSHA data for the years 2003–2010, the primary goal of this study was to investigate the impact of MSHA regulatory effort on mine-level occupational injuries and illnesses through an HSMS-integrated perspective. By aligning MSHA's current regulatory framework with the HSMS elements, we were able to determine which management-system-element-aligned citations are most beneficial to injury and illness reduction. To that end, we first define and explore the elements of an HSMS using the prominent consensus standards as a guide. We next impose the management system elements onto the current regulatory framework utilized by MSHA. We follow with an analysis exploring the effect of distinct types of MSHA citations and enforcement activities on mine-level reportable injuries for the years 2003–2010. We then conclude with a discussion of our findings.

2. HSMS ELEMENTS

Multiple efforts have been undertaken to operationalize a generalizable approach to an organizational HSMS (e.g., OHSAS 18001:2007; ANSI/AIHA Z-10:2005; U.S. Federal Register, 1989; ILO:2001). These guidelines refer to "occupational health and safety management systems," "injury and illness prevention programs," and "safety and health program management guidelines" as having the same general meaning. For consistency, we use the phrase "health and safety management systems" to align with the language of OHSAS 18001:2007 and ANSI/AIHA Z-10:2005, which underpin the U.S. regulatory perspective.[7]

Based on a review of the published consensus standards, and consistent with the International Labor Organization's definition, we define an HSMS as a set of institutionalized interrelated and interacting elements designed to establish and achieve occupational safety goals and objectives. Redinger and Levine[17] reviewed numerous HSMS models, standards, and guidelines and identified 27 different elements that might be included in a comprehensive HSMS. Distinct from this approach, we sought to include HSMS elements for the purpose of generalizability. In other words, our goal in identifying HSMS elements was to include those consistent across the published standards and government guidelines. Based on a review of the prominent HSMS-related publications, we conceptualize the following elements as being critical to a generalized HSMS: management commitment, employee involvement, planning, implementation and operation, proactive checking and corrective action, reactive checking and corrective action, and management review.

In the following paragraphs, we highlight how each of the identified HSMS elements theoretically operates to reduce occupational safety incidents.

2.1. Management Commitment

Decision-making authority and control of organizational assets reside in the hands of organizational management. Without a management team that is committed to the idea of risk mitigation, accident prevention, and compliance with applicable laws and regulations, as well as continuous improvement in organizational safety performance, there is little hope that an organization can achieve safety excellence. Management commitment to safety is consistently identified in all published HSMS guidelines, and its impact on occupational injuries and illnesses in the workplace has been researched extensively through different measures of safety culture and climate.[18–21]

Commitment is articulated by management in the form of spoken and written statements regarding the value and priority of workplace safety. These statements provide workers with initial information regarding the value and priority of safety in the workplace thereby facilitating role-relevant safety motivation and behavior. These statements, however, will have limited impact on safety unless management's commitment is expressed in the form of resource allocation action. In other words, commitment is ultimately reflected in the time and monetary resources that management provides toward the overall safety effort. The resources it provides should be initially and continually focused on: involving employees in the organization's safety effort (i.e., employee involvement); hazard identification, assessment, and control planning (i.e., the planning element); safe operations (i.e., the implementation and operation phase); proactively checking its operations and correcting physical and other safety issues related to the human factor (i.e., proactive checking and corrective action); investigating safety incidents and correcting the primary causes that started the chain of events that led to the incident (i.e., reactive checking and corrective action); reviewing all of the safety management activities and their interactions to ensure continuous improvement in the effort (i.e., management review); as well as other context-specific HSMS-related activities.

2.2. Employee Involvement

Based on a review of the existing management system guidelines, there are two primary reasons for the employee involvement emphasis. First, because employees have intimate knowledge of the work within an organization, their input will allow for a more thorough identification, assessment, and control of risks and hazards related to the production processes utilized. Second, involvement provides a mechanism to facilitate intrinsic safety motivation through a number of theoretical processes (e.g., justice perceptions, value congruence, employee engagement, identification, and commitment) that can lead to enhanced attitudinal and behavioral adoption of various management practices and employee safety procedures, and ownership of the outcomes relevant to practices and decisions.[22] These employee-level motivational processes are critical to safety-incident prevention in which behavioral elements play a substantial role.[23–25] Similar to the management commitment element, employee involvement would ideally be displayed in all management system elements (i.e., planning, implementation and operation, proactive and reactive checking, and review).

2.3. Planning

The planning element includes the organization's activities related to hazard identification, risk assessment, and the development of hazard and risk control plans. Ideally, these efforts lead to a thorough understanding of all of the hardware and human safety risks the organization is faced with along with a plan to mitigate them.[26–29] Safety-relevant information is used to feed the planning phase and includes information on production processes, machines and equipment, chemicals, workspace layout, personnel jobs and current knowledge/skills/abilities, laws and applicable regulations, lessons learned, etc. Various analytical techniques (e.g., systems safety studies, job hazard analyses, educational needs assessments, etc.) can be used to prioritize a list of actions needed to control hazards and risks. The end product, or output, based on a comprehensive planning process is a written course of action to be undertaken, which, if followed properly, will ensure that hazards and risks are minimized and that regulatory compliance objectives have been satisfied.

2.4. Implementation and Operation

After the planning phase has been completed, the organization implements work plans accordingly. This HSMS element represents the "doing" of the system (ANSI/AIHA Z-10:2005). The goal of the implementation and operation phase of the safety management system is to precisely and fully implement the developed plan(s). This includes, for example, all risk mitigation activities associated with the installation of machinery and equipment, preventative and predictive maintenance, and the utilization of proper tools and procedures, as well as the education and motivation of employees. In order to successfully implement the control plans, adequate communication and coordination mechanisms, organizational structure, and resources are necessary (ANSI/AIHA Z-10:2005; OHSAS 18001:2007).

2.5. Proactive Checking and Corrective Action

This element is designed to uncover hazards and risks prior to a safety incident that have passed through the planning and implementation and operation phases. Activities used to support this element consist of, for example, safety audits and walkthroughs, industrial hygiene monitoring to determine the effectiveness of controls, record-keeping reviews, and interviews with employees to determine the effectiveness of education and motivation efforts (ANSI/AIHA Z-10:2005; OHSAS 18001:2007). These types of proactive checking and corrective action activities have been empirically linked to occupational accident prevention.[30–32] Once a hazard or risk is identified during the proactive checking process, proper corrective actions are then implemented in an effort to correct the control plans or their improper implementation.

2.6. Reactive Checking and Corrective Action

Similar to the proactive checking and corrective action element, the reactive checking and corrective action element is used to uncover the primary causes of the hazards and risks that have passed through the previous phases. Distinct from the proactive checking and corrective action element, this activity is undertaken after a hazard or risk has resulted in a safety incident.[28] Investigations are a common practice across major industries and should be conducted for every serious accident as well as near-accidents.[33] The ultimate goal of an incident investigation is to identify and correct the human and hardware root causes that reside in other elements of the HSMS.[34] The process of incident investigation begins first with identification of the incident subject to investigation through individual or group reporting mechanisms, and ends with dissemination of the findings and a resolution of its causes.[33]

2.7. Management Review

This element is the last phase in the HSMS cycle. As the cycle starts with management commitment, it ends with management review. This element is designed to assess the effectiveness of the other individual elements of the system, as well as their interconnected effectiveness in relation to the organizational health and safety goals initially established. The review is a formally undertaken study using documented outputs from across HSMS elements in order to answer the ultimate question "how is the system performing?" and reports the following types of specific information: progress of risk reduction efforts; effectiveness of the planning element; effectiveness of proactive and reactive checking and corrective action processes; any changes needed to the existing overall system; and the extent to which HSMS goals have been met (ANSI/AIHA Z-10:2005; OHSAS 18001:2007). The output from this activity is evidenced in the form of written documents that report the methodology utilized for the study, its results, and the interventions that will be conducted in an effort to continually improve each HSMS element and the system as a whole.

The complexity of the HSMS elements may, on their face, seem difficult to enforce. However, there is evidence to suggest that MSHA's enforcement activities are reflective of an HSMS approach. The North American Industry Classification System defines the mining sector as "establishments that extract naturally occurring mineral solids, such as coal and ores; liquid minerals, such as crude petroleum; and gases, such as natural gas."[3,(1)] Mining has historically been one of the world's most dangerous occupations. The fatal work injury rate (based on 100,000 full-time equivalent workers) for all U.S. workers in 2010 was 3.6, while the U.S. mining industry's 2010 comparable rate was 19.9.[(1)]

The modern age of regulation and enforcement of mining health and safety originated in the Federal Coal Mine Health and Safety Act of 1969, which was a response to the deaths of 78 miners in Farmington, WV, the year before. The U.S. MSHA traces its inception to the Federal Mine Safety and Health Act (or the Mine Act) of 1977, which extended the 1969 Coal Act and consolidated regulation of all U.S. mining under its jurisdiction.[(35)] MSHA's mission is stated as follows: "The purpose of the Mine Safety and Health Administration is to prevent death, disease, and injury from mining and to promote safe and healthful workplaces for the Nation's miners." The MSHA regulatory framework currently oversees the health and safety of approximately 380,000 U.S. mine workers at roughly 14,000 U.S. mines.[(36)]

Distinct from OSHA's inspection program in which a federal safety and health inspection is possible but not certain, the Mine Act requires MSHA inspectors to inspect each established mine at least twice annually (twice for surface mines, four times for underground mines). Also, distinct from OSHA's regulatory framework, MSHA does not allow for states to substitute jurisdiction over mine workplace safety. In other words, MSHA effectively operates and has jurisdiction over mining operations in all U.S. states. During the course of each inspection and investigation, MSHA can issue citations to mines for violations of the established regulatory standards. To that end, MSHA issues a citation categorized in distinct ways that reflect the gravity and circumstances surrounding the citation.

[3]Although the BLS definition is inclusive of numerous types of mining related activities, the scope of this research includes only the commodities of coal, metal, nonmetal, stone, sand and gravel mining.

3. METHODS

3.1. Representations of HSMS in MSHA's Current Regulatory Framework

In order to code each MSHA standard according to a corresponding HSMS element, we adopted strict rules of inclusion for each element based on its objective and its measures of effectiveness as discussed above. For the purpose of this integration, we pull primarily from the content of the standards, but also incorporate MSHA's "degree of negligence" classification as a proxy for the management commitment element (discussed below). The authors first worked independently then collectively to code the standards. After an initial, individual coding effort, each standard's coded classification was discussed among the authors and discrepancies were resolved. The Appendix includes a list of the MSHA standards that were included under each element. In the following paragraphs, we report each of the management system element's rules for inclusion and provide examples of standards we coded to represent the element.

3.1.1. Management Commitment Criteria for Inclusion: Any Standard that Reflects a Lack of Commitment by Management to Any Other Element of the HSMS

As a proxy for the HSMS element of management commitment, we used MSHA's "degree of negligence" classification system. MSHA assigns a degree of mine operator negligence to each citation: low, moderate, high, or reckless disregard. High negligence and reckless disregard citations can be fixed to any existing MSHA standard and reflect a mine operator's unwarrantable failure to comply with established regulations. When MSHA classifies a citation as high negligence or reckless disregard, it considers, for example, whether there is a history of violation of a particular standard, whether the violation was a result of a deliberate activity, and/or whether the operator knew or had reason to know that its action(s) violated a standard. Our inclusion rule is consistent with the premise that management commitment should be reflected and measured in all aspects of the HSMS (i.e., employee involvement, planning, implementation and operation, proactive and reactive checking and corrective action, and management review).

3.1.2. Employee Involvement Criteria for Inclusion: Any Standard that Reflects a Lack of Involvement by Employees in Other Elements of the HSMS

Based on a thorough review of the MSHA regulations, we were unable to find any standard referencing a requirement of employee involvement.

3.1.3. Planning Criteria for Inclusion: Any Standard that Requires Mines to Develop and Maintain (or Submit for Approval) a Hazard or Risk Control Plan

Standards included within this management system element require only the development of the written plan. Any citation written for one of these standards necessarily cites an operator's failure to develop a plan or failure to include all required elements in a plan. Within the MSHA standards there are numerous citations that meet the criteria for this HSMS element. MSHA requires, for example, that mines develop training, emergency preparedness, roof, ventilation, electrical, ground control, slopes and shaft, dust control, and auger mining plans. More specifically, 30 CFR 46.3 (titled "Training plans") requires operators to develop a written plan for the delivery of effective training programs for new miners, newly hired experienced miners, experienced miners conducting new tasks, annual training, and site-specific hazard awareness training. MSHA requires the operator to submit a copy of this plan for approval as well as maintain and communicate a copy of the plan to internal stakeholders. Further, 30 CFR 75.370 (titled "Mine ventilation plan; submission and approval) requires mine operators to develop and submit a ventilation plan that defines the methods of control for methane and respirable dust. Using our planning criteria of inclusion, we coded 27 MSHA standards that specifically require a hazard or risk control plan to be developed and either submitted or maintained.

3.1.4. Implementation and Operation Criteria for Inclusion: Any Standard that Requires the Proper Execution of an Established Plan or Requires a Specific Workplace Condition

In some instances, the MSHA standards require that a mine's established plan be implemented according to the plan. Thus within our HSMS model framework, it is our perspective that MSHA clearly differentiates between the planning and implementation and operation phases of the management system. For example, MSHA requires in 30 CFR 46.4 (titled "Training plan implementation") that each training program is conducted in accordance with the training plan, is presented by a competent person, and is presented in a language understood by all miners. Also, for example, 30 CFR 77.1900-1 (titled "Compliance with approved slope and shaft sinking plans") requires that once a slope or shaft sinking plan has been developed and approved, the operator must adopt and follow the plan. The majority of standards included within this element, however, require a specific workplace condition. For example, 30 CFR 56.20003 (titled "Housekeeping") requires that all workplaces, passageways, storerooms, and service rooms be kept clean and orderly. Further, 30 CFR 57.14107 (titled "Moving machine parts") requires that moving machine parts shall be guarded to protect persons from contacting moving parts (e.g., gears, sprockets, chains, drives, flywheels, fan blades, etc.). The MSHA standards in the preceding two examples refer to a specific workplace condition that is objectively observable during the time of an inspection. By citing an observed unsafe workplace condition, rather than some type of plan to address the workplace condition, MSHA places no direct emphasis on whether or not a hazard or risk control plan was in place or if a proactive checking and corrective action process was faulty. Rather, based on our coding schema, we contend that MSHA is citing an existing workplace safety hazard or risk that has gone unchecked and has surfaced during the implementation and operation phase. In our analysis, the majority of MSHA standards fall into this category, and within the MSHA regulatory text there are hundreds of standards that meet these criteria.

3.1.5. Proactive Checking and Corrective Action Criteria for Inclusion: Any Standard that Requires a Process of Proactively Checking for Physical Hazards and Risk Factors and Correcting Those Identified Deficiencies

MSHA has numerous standards that meet the criteria for this element. All site safety inspections, process safety checks, and industrial hygiene monitoring for control effectiveness fit into this category. In these instances, the standard (and corresponding citation resulting from these standards) places no direct emphasis on the existence of a hazardous condition; rather, the emphasis is directly focused on the process of proactively checking and correcting within the workplace. These MSHA requirements are designed to facilitate the process of determining hazards and risks that have passed through the planning phase as well as the implementation and operation phase and have the possibility to cause workplace injuries and illnesses. To illustrate, 30 CFR 70.201 (titled "Sampling; general requirements") requires that each operator takes respirable dust samples during active workings of the mine. In this instance, the process of proactively conducting industrial hygiene sampling for respirable dust is the requirement. As such, when a mine operator is cited for this standard, it is for not effectively conducting proactive monitoring for respirable dust in the workplace. As another example, 30 CFR 57.7003 (titled "Drill area inspection") states that "the drilling area shall be inspected for hazards before starting the drilling operations." Again, a citation resulting from this standard places emphasis on the process of inspecting drilling areas prior to commencing operations, and satisfactory compliance with this preceding standard is evidenced by written reports indicating that hazard inspections were conducted. Based on a review of the MSHA regulations according to our HSMS generalized model, we were able to code 165 standards that require a similar proactive checking and corrective action requirement.

3.1.6. *Reactive Checking and Corrective Action Criteria for Inclusion: Any Standard that Requires the Process of Reactively Checking and Correcting Hazards or Risk Factors that Caused a Safety Incident to Occur*

We were able to identify only two standards within the MSHA citations that meet these criteria. MSHA requires in 30 CFR 50.11 (titled "Investigation") that mine operators investigate each safety incident and identify relevant steps taken to prevent similar occurrences in the future. Similarly, 30 CFR 62.174 (titled "Follow-up corrective measures when a standard threshold shift is detected") requires mine operators to review the effectiveness of any engineering and administrative controls related to hearing protection and to correct any deficiencies. Citations in these instances have little direct emphasis on the safety incident itself; rather, the standard points directly to the premise that a follow-up investigation or corrective action was either not completed or not executed according to the standard's criteria.

3.1.7. *Management Review Criteria for Inclusion: Any Standard that Requires Mine Management to Review the Overall Effectiveness of the Elements Within the HSMS*

Similar to the reactive checking and corrective action element, we were able to identify only two standards within the MSHA regulations that met these criteria. In 30 CFR 77.216-4 (titled "Water, sediment or slurry impoundments and impounding structures; reporting requirements; certification"), MSHA requires that, following the approval of an initial safety plan, the mine operator must annually submit a review of that plan that addresses, for example, any change that may have affected the stability or operation of the impounding structure. In 30 CFR 75.223 (titled "Evaluation and revision of roof control plan"), MSHA requires that roof control plans be reviewed and revised every six months or when conditions warrant such revision. In the preceding two standards, MSHA directly requires that mine operators review the effectiveness of established courses of action and make revisions to the overall safety strategy.

In an effort to be comprehensive, we explored how 10 different types of MSHA enforcement activities in a given year impact mine-level reportable injuries in a subsequent year. In addition to standards and associated citations corresponding to the six management system elements we were able to include in the analysis (i.e., all elements but the "employee involvement" HSMS element), we also explored the impact of the total number of citations, withdraw orders, serious and substantial (S & S) classified citations, and the amount of monetary penalty. Withdraw orders can be issued by MSHA when a hazard exists in a mine that must be immediately corrected. MSHA can issue a withdraw order linked to specific pieces of equipment or parts of the mine affected by the violation. When operators receive a withdraw order, they are required to remove the equipment or all people from the affected area until the violation has been corrected by authorized personnel. The S & S classification is linked to an observed hazard or risk for which there is a reasonable likelihood that a serious injury or illness could occur. Finally, MSHA can assign different monetary penalty amounts to each citation. The monetary penalty for each citation has considerable variance, with higher penalty amounts attached to more aggravated health and safety infractions.

3.2. Data and Analytical Approach and Control Variables

In order to explore how these different types of enforcement activities impact mine-level reportable injuries, data sets had to be created and two publicly available databases were used: the Mine Address and Employment (AE) and the MSHA violations databases. The AE database is a list of all mines throughout the United States and is created through a Quarterly Mine Employment and Coal Production Report (MSHA-required Form 7000-2). The database is organized by a unique mine identification code and contains information on the location of the mine, the mine's status (active, inactive, etc.), and employment statistics. The AE database also includes the outcome of interest (the total number of mine reportable injuries and illnesses).[4] Each mine, through Form 7000-2, must report each safety incident that results in a miner fatality, medication treatment beyond first aid, loss of consciousness, restricted duty or job transfer, or diagnosed occupational illness. Each line in this database corresponds to a unique mine ID for a given year. The MSHA violations database maintains a list of each citation provided to each mine throughout the course of a given year. The database includes information on the exact standard violated, its associated penalty amount, its MSHA enforcement classification, and the owner of the mine (through a controller name and ID). Mine controllers may own multiple mines and thus numerous mine IDs can be associated with a single controller ID. Because the MSHA databases are dynamic (i.e., subject to change), we report an approximate date when these two databases were downloaded for the analyses (~June 15, 2012).

Similarly situated previous research[9] has noted the importance of considering changes in the regulatory environment and relevant industrial events that may impact the effect of enforcement activity on mine reportable injuries. Numerous mining events occurred between 2000 and 2010 that are noteworthy.[5] Two major incidents took place prior to 2003. During the year 2006, several mine incidents took place, resulting in the U.S. Mine Improvement and New Emergency Response Act (MINER Act). Thus, following Gray and Mendeloff's[9] advice, we used the time periods 2003–2005 and 2006–2010 and created two data sets to derive results for this study.

In order to create the two data sets, each citation in the MSHA violations database was first coded according to each HSMS element. Within the MSHA violations database, citations issued to contractors are nested within the mine ID. However, in the AE database, injuries associated with a particular mine ID include only those experienced by the mine operator. In order to eliminate this potential confounding effect of the relationship between citations issued to and injuries experienced by the operator, contractors were eliminated from the MSHA violations database. This elimination resulted in the removal of approximately 7% of the total citations issued for each year 2003–2010. Next the MSHA violations database was aggregated by year and mine ID to create variables reflecting the total number of each citation type for each year corresponding to a specific mine. For each year individually, the violations data sets were merged with the AE databases based on the unique mine ID code. These steps created unique data sets for each year from 2003 to 2010 that included, for example, the mine ID, the controller ID, the number of reportable injuries experienced by the mine, and numbers of types of MSHA citations issued to that mine. These individual data sets were then merged again based on mine ID, creating two data sets: the first included relevant variables for the

[4]In addition to the AE database, MSHA also provides the Accident/Injury/Illness (AII) database, populated through the completion of the 7000-1 form, which is submitted 10 days after the occurrence of a reportable injury or illness. The AII database maintains individual records of reportable injuries and illnesses experienced by the mine throughout the course of a given year. Because of the possibility of reporting discrepancies when dealing with such large numbers, we conducted a study to determine that the outcome of interest was consistent between the two databases. We derived a sufficiently large sample (>13,000 mines for each year in the 2003–2010 time period) from the AE database and then correlated the reportable injuries and illnesses with the aggregated total from the AII database. The correlations were found to range from 0.902 to 0.943 for all years 2003–2010. These findings suggest a consistent rank ordering of mine reportable injuries and illnesses between the two databases.

[5]In 2001, a mine explosion occurred at Brookwood Mine in Tuscaloosa County, Alabama, killing 13 miners. In 2002, nine miners were trapped as a result of a water inundation for 78 hours but subsequently rescued at the Quecreek Mine in Somerset, Pennsylvania. Three notable mining incidents occurred during the year of 2006: the Sago Mine explosion in Sago, West Virginia, which killed 12 miners; the Darby Mine #1 explosion in Holmes Mill, Kentucky, which killed five miners; and a belt fire at the Aracoma Alma Mine in Melville, West Virginia, resulting in two deaths. In 2006, the U.S. MINER Act was also implemented.

2003–2005 time period and the second for the 2006–2010 time period. Mines that were inactive or originated during the course of the time period in question were eliminated from the data set such that only mines that were active for each year within the time period were included in the final data sets. The final data sets included 13,241 mines for 2003–2005, and 13,712 mines for 2006–2010.

Within the final sample of mines, the total number of MSHA citations issued during 2003–2005 was 294,423, and the total number of MSHA citations issued during 2006–2010 was 645,340. There were a total of 29,979 mine reportable injuries for the years of 2003–2005 and 39,014 for the years 2006–2010.

In their exploration of the impact of OSHA inspections on establishment injuries, Gray and Mendeloff[(9)] identified control variables that are also relevant to the current study. For the current study we incorporate the following three theoretically derived control variables: the total number of employees; average number of hours worked by employees within the mine; and the number of reportable injuries and illnesses in the preceding year.

Gray and Mendeloff[(9)] identified a number of reasons why the size of the total number of employees (i.e., establishment size) should be used as a control variable when they modeled the impact of OSHA inspections on establishment-level injuries. Larger establishments have more resources available to allocate toward accident prevention and are subject to greater media scrutiny and therefore may have a strong motivation to be socially responsible.[(9)] For these reasons we included the number of employees working within a mine during the same year of the outcome as a control variable.

Gray and Mendeloff[(9)] also discuss the need to account for the potential effect of injuries in a given year on the subsequent year's number of injuries. A high number of injuries experienced by an organization, and their direct and indirect associated costs, may prompt increased attention to safety issues within the establishment. Thus, because there is potential variability in mine-level reportable injuries and illnesses due to previous levels of the same measure, we account for this potential influence by creating a lagged reportable cases variable and controlling for the influence of mine reportable injuries and illnesses in time $t-1$.

Statistically accounting for an estimate of worker fatigue within the establishment has also been noted as an important consideration. As worker fatigue increases there is a potential increase in human error and safety incidents, and the degree of miner fatigue within a mine is suspected to increase as the number of hours miners are required to work throughout the year also increases.[(9)] As such, we control for the potential effect of worker fatigue by creating a variable reflecting the average number of hours employees within the establishment worked during the year in question (total number of mine hours worked in a given year/total number of mine employees).

As mentioned, the primary research concern in this study is exploring the effect of HSMS-aligned MSHA enforcement activities in a given year on mine-level reportable injuries in a subsequent year. As such the citation counts for each type were lagged so that the prediction of mine-level reportable injuries for a given year could be predicted by MSHA citation counts in a previous year. Thus, within the 2003–2005 data set, for example, we allowed the 2003 citations to predict the 2004 reportable cases and the 2004 citations to predict the 2005 reportable cases. The same analysis approach was used to analyze the 2006–2010 data independent from the 2003–2005 analysis. Therefore, citations that mines received during the years of 2005 and 2010 were not used in the analysis. Because of the nature of such a data set and the desire to obtain one estimate of the effect (for each different type of citation on the mine injuries and illnesses) for each data set, we nested time within each mine and executed the analysis using a three-level, random effects, HLM strategy.[(37)]

Table I reports the descriptive statistics for the variables used in the data set corresponding to both the 2003–2005 and 2006–2010 data sets.[6] The table shows that the mean number of citations for a single mine per year in the 2003–2005 data set was 11.03 ($SD = 33.04$) and the mean number of citations per year for the 2006–2010 data set was 14.47 ($SD = 49.04$).

As can be seen from Table I, the outcome of interest (the count of mine-level reportable injuries and illnesses) is positively skewed, suggesting that a Poisson analysis was appropriate.[7] Thus, we executed

[6]The mean number of citations and the types of citations for each data set does not factor in mine citations received in the years 2005 and 2010.

[7]Within the HLM framework, we tested the efficacy of using the random effects, hierarchical Poisson model in the current analysis by first assessing the overdispersion parameter in the three-level, fixed effects models for both the 2003–2005 and 2006–2010 time periods. We found that the data were slightly

Table I. Descriptive Statistics for Each Mine and for Each Year Within the Designated Time Period

Variable	2003–2005 Mean	2003–2005 *SD*	2006–2010 Mean	2006–2010 *SD*
Mine injuries and illnesses	0.81	5.68	0.67	2.95
Number of employees	18.94	54.49	19.96	63.78
Average hours per employee	1,645.25	782.01	1,572.58	778.87
Monetary penalty	$2,248.72	$13,428.27	$10,673.83	$81,937.56
Total number of citations	11.03	33.04	14.47	49.04
Total number of orders	0.29	1.42	0.43	2.28
Total number of S & S violations	3.42	13.26	4.12	15.91
Management commitment coded citations	0.59	2.32	0.92	4.32
Planning coded citations	0.51	3.26	0.68	4.55
Proactive checking and correction coded citations	1.51	4.10	2.13	6.64
Implementation coded citations	8.42	25.43	10.75	36.11
Reactive checking and correction coded citations	0.02	0.06	0.02	0.08
Management review coded citations	0.01	0.04	0.01	0.09

Poisson models within the hierarchical linear modeling (HLM) framework and report and interpret the incident rate ratio as the effect of MSHA citations on mine injuries and illnesses. The incident rate ratio expresses the ratio of the expected count of injuries (μ) due to the predictor variable (x) in the form of $\log(\mu_{x+1}/\mu_x)$. In this form, the ratio reflects the change in the expected number of injuries due to a one unit increase in the predictor variable (e.g., citations). The incident rate ratio, in the context of the current research, should then be interpreted as the multiplicative effect for a one unit increase in MSHA enforcement activity in a given year on mine-level injuries and illnesses in a subsequent year. We report and interpret the estimates derived using robust standard errors from the linear Poisson models and allow for the intercept and the slope of the predictor of interest to be random.[8] In the three-level model, time was nested within mines, and mines were nested within a controller.

4. RESULTS

HLM results are reported in Table II for 2003–2005 and Table III for 2006–2010. For ease of interpretation, in both tables we report the incident rate ratio rather than the estimated regression coefficient.

As can be seen from the results, because of the sheer number of observations in the data sets, very small effects are significant. As such, interpretation of the actual effect size, as opposed to its significance level, is important. Both Tables II and III report the base model first, Model 0, in which only the control variables were imposed on the outcome, followed by Models 1 through 10, in which the predictors of interest are included individually. Tables II and III also report the estimated variance components for the random intercepts and slopes for

underdispersed as opposed to overdispersed (for both time periods the overdispersion parameter, σ^2, was slightly below 1). In contrast to inflation of Type I error associated with overdispersion, underdispersion can result in an inflation of Type II error, thus providing more conservative estimates of the effect. We also conducted a sensitivity analysis between fixed effects, negative binomial approximated distributions within HLM, and the current analysis and found the pattern of results to be consistent. Based on these analyses, we report the results for the random effects, Poisson-distributed models.

[8]The assumption of linearity was examined. In order to ensure the results were robust and the linear interpretation was reasonable, numerous additional models were explored with categorized, dummy-coded citations based on different ranges relative to the scale of the citation type. Each of these dummy-coded variables was then entered into the hierarchical model uncentered and regressed simultaneously on the injury outcome (with the lower category as the reference group) along with the covariates. This process was repeated across the different citation categories (i.e., management commitment, planning, proactive checking, implementation and operations, reactive checking and corrective action, and management review) and, where appropriate, for different, reasonable ranges of citation count categories. Although some fluctuation was apparent depending on the categorized range of citations, we found support for the linear interpretation in that an expected proportionate decrease in injuries was generally found for each categorical increase in citation range. Based on these results we conclude that the interpretation of the linear models is appropriate.

Table II. 2003-2005: Incident Rate Ratio of Control and Independent Variables Predicting Mine-Level Reportable Injuries and Illnesses

	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Intercept	.200*	.291*	.291*	.291*	.291*	.280*	.281*	.275*	.291*	.277*	.294*
Employee Count	1.001*	1.002	1.003*	1.003*	1.001	1.002	1.004*	1.003*	1.003*	1.003*	1.004*
Avg. Hours Per Employee	1.001*	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Previous Year Injuries	.988*	.964*	.965*	.962*	.975*	.968*	.966*	.969*	.957*	.968*	.967*
Total Number of Citations	–	.985*	–	–	–	–	–	–	–	–	–
Orders	–	–	.992*	–	–	–	–	–	–	–	–
S & S	–	–	–	.992*	–	–	–	–	–	–	–
Monetary Penalty	–	–	–	–	.999*	–	–	–	–	–	–
Management Commitment	–	–	–	–	–	.990*	–	–	–	–	–
Planning	–	–	–	–	–	–	.955*	–	–	–	–
Proactive Checking	–	–	–	–	–	–	–	.956*	–	–	–
Implementation	–	–	–	–	–	–	–	–	.992*	–	–
Reactive Checking	–	–	–	–	–	–	–	–	–	.815*	–
Management Review	–	–	–	–	–	–	–	–	–	–	.965*
Variance Components											
Variance between mines (Level 2)	.96	1.11	1.11	1.11	1.11	1.09	1.03	.86	1.11	.82	1.14
Variance between controllers (Level 3)	1.74	1.14	1.14	1.15	1.15	1.20	1.36	1.59	1.15	1.61	1.08
Slope											
σ^2	–	.013	.042	.013	.012	.014	.471*	.300*	.001	.557*	.214*

Note: $^*p < .05$. Total number of mines in the sample = 13,241. The incident rate ratio of interest in each model reflects the average effect of that particular type of citation recorded in the previous year on reported mine-level injuries and illnesses in the following year during the 2003-2005 time period. These effects are derived controlling for employee count, average number of employee hours per year, and previous year injuries.

each model.[9] For both 2003–2005 and 2006–2010, the intercept fluctuates across models but shows that there is a significant decrease in the average mine injuries and illnesses over time. The effect of the control variables also fluctuates across Models 0–10 as the additional MSHA-enforcement predictor is entered into the model. In the base model, all three adjustments are significant for both time periods. For 2003–2005 and 2006–2010, as a mine's number of employees increases there is an associated 0.1–0.4% increase in mine reportable injuries and illnesses. Similarly, as the average number of employee hours increases within each mine, there is a slight increase or negligible effect on mine reportable injuries and illnesses for the two time periods. As expected, when a mine experiences a higher number of injuries, those injuries are likely to decrease by approximately 1–4% in a subsequent year.

Model 1 reports the impact of one citation on subsequent year mine reportable injuries and illnesses. The results show that as one additional citation (any/all types) is issued to a mine, a reduction in that mine's number of injuries and illnesses in the following year is negligible to approximately 1.5% depending on the time period in question. Similarly, as the number of withdraw orders and S & S citations increases by one for a given year, there is little to no effect on the number of subsequent year mine-level injuries and illnesses (Models 2 and 3). In a similar fashion, across the two time periods, as the penalty amount associated with the issued citations increases, there is a negligible effect on mine injuries and illnesses the following year (Model 4).

There are some notable differences, however, across the effects of management-system-aligned citation types. The effect of a one increase in management commitment coded citations (i.e., those

[9]For a Poisson model, the total level-1 variance for the intercept is fixed at ($\pi^2/3$). As reflected in Tables II and III, for the 2003–2005 Model 0, the variance in mine-level injuries was as distributed into the following components: level 1 (due to time) was 55%; level 2 (mine level) was 16%; and level 3 (controller level) was 29%. Similarly, for 2006–2010, the variance components for Model 0 were 53% for level 1; 15% for level 2; and 32% for level 3. Where significant, the variance component for the slope of the predictor of interest, σ^2, indicates that there is significant variability among the mine-level regression slopes. Where not significant, the effect reported does not vary significantly.

Table III. 2006–2010: Incident Rate Ratio of Control and Independent Variables Predicting Mine-Level Reportable Injuries and Illnesses

	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Intercept	.134*	.181*	.180*	.180*	.181*	.180*	.186*	.184*	.180*	.190*	.177*
Employee Count	1.001*	1.002*	1.002*	1.001*	1.002*	1.002*	1.001*	1.001*	1.001*	1.001*	1.001*
Avg. Hours Per Employee	1.001*	1.001*	1.001*	1.001*	1.001*	1.000	1.000	1.000	1.000	1.000	1.000
Previous Year Injuries	.995*	.997*	.991*	.995*	.995*	.994*	.994*	.994*	.997*	1.000*	.995*
Total Number of Citations	–	.998*	–	–	–	–	–	–	–	–	–
Orders	–	–	.998*	–	–	–	–	–	–	–	–
S & S	–	–	–	.997*	–	–	–	–	–	–	–
Monetary Penalty	–	–	–	–	.999*	–	–	–	–	–	–
Management Commitment	–	–	–	–	–	.997*	–	–	–	–	–
Planning	–	–	–	–	–	–	.952*	–	–	–	–
Proactive Checking	–	–	–	–	–	–	–	.942*	–	–	–
Implementation	–	–	–	–	–	–	–	–	.998*	–	–
Reactive Checking	–	–	–	–	–	–	–	–	–	.899*	–
Management Review	–	–	–	–	–	–	–	–	–	–	.996*
Variance Components											
Variance between mines (Level 2)	.95	.90	.90	.90	.90	.90	1.10	1.09	.90	1.11	.87
Variance between controllers (Level 3)	2.01	1.76	1.76	1.76	1.76	1.76	1.38	1.39	1.76	1.37	1.77
Slope											
σ^2	–	.001	.003	.001	.001	.001	.214*	.314*	.001	.371*	.185*

Note: *p < .05. Total number of mines in the sample = 13,686. The incident rate ratio of interest in each model reflects the average effect of that particular type of citation recorded in the previous year on reported mine-level injuries and illnesses in the following year during the 2006–2010 time period. These effects are derived controlling for employee count, average number of employee hours per year, and previous year injuries.

citations classified as either high negligence or reckless disregard) had little impact on the following year's level of mine injuries and illnesses for both time periods (Model 5). For both 2003–2005 and 2006–2010, for each planning coded citations there was an approximate 4.5–5% decrease in a mine's injuries and illnesses the following year (Model 6). Each proactive checking and corrective action coded citation was associated with a 4% reduction in mine injuries and illnesses during 2003–2005 and a 6% reduction for 2006–2010 (Model 7). For both time periods, each implementation coded citation was associated with a negligible impact on mine injuries and illnesses (Model 8). The reactive checking and corrective action coded citations displayed the greatest effect on a mine's following year injuries and illnesses (Model 9). For each coded reactive checking and corrective action citation in a given year, there was an approximately 18% decrease in mine injuries and illnesses the following year for 2003–2005. This decrease (still the largest for the time period) dropped to approximately 10% during 2006–2010. Management review coded citations displayed a small effect on the following year mine injuries and illnesses during 2003–2005 (3.5%) and a negligible effect during 2006–2010 (Model 10).[10]

5. DISCUSSION

The primary goal of this research was to understand the relationship between different HSMS-aligned MSHA enforcement activities and mine injuries and illnesses. Through the lens of an HSMS's generalized elements, we interpreted the

[10] As a follow-up to these main effects, we conducted a moderator analysis using the dummy-coded variables for mine commodity and the MSHA district having jurisdiction over the mine. In order to execute the moderator analysis, we imposed the dummy-coded variables (4 for commodity; 16 for MSHA district) in the HLM level-2 (mine level) equation. We entered these moderators on to both the level-2 intercept and slope for the overall MSHA citations category only. Neither of the two moderators significantly altered the prediction of mine injuries and illnesses in a given year by MSHA citations.

current MSHA standards and enforcement activities and then tested their impact on subsequent year mine-level injuries and illnesses. By studying the impact of citations on subsequent year injuries and illnesses across multiple years, we hoped to decrease the potential bias associated with subjective interpretations by federal safety inspectors of noncompliant workplace conditions in lieu of the written MSHA standards.[8]

Through an extensive coding effort, we found that MSHA's current regulatory standards align well with a generalized system of health and safety management. Perhaps our most interesting finding is that different *types* of citations categorized based on the elements of an HSMS have a differential effect on mine injuries and illnesses. The greatest decreases in subsequent year mine-level injuries and illnesses for both time periods resulted from the planning, proactive checking, and reactive checking coded citations (albeit still objectively small for planning and proactive checking). This suggests that the types of citations, rather than the sheer number of citations and associated penalty, may be a more salient regulatory consideration for the purpose of accident prevention. Although an interpretation of these results is subject to debate and future research, we offer an insight as follows.

Mendeloff and Gray[38] theorized that safety enforcement can effectively decrease employee injuries through three distinct processes. First, when hazardous conditions are cited, employers are forced to abate the hazard, thereby reducing the likelihood that an injury will result from the particular hazard that resulted in a violation. Second, employers may seek to improve their overall compliance effort as opposed to just those noncompliance aspects revealed during an inspection. Third, safety inspections that identify serious safety concerns may focus management attention on general safety issues outside of the scope of those addressed by existing standards.

Through the results of the current research effort, we are able to offer a fourth possible theoretical process through which safety enforcement activities work to influence establishment-level injuries and illnesses. We suggest that safety standards development and related enforcement activities can also work to *teach* employers how to prevent accidents. This is especially true with the HSMS-aligned citations that specifically require management to execute activities necessary to prevent accidents from occurring. In a sense, then, HSMS-aligned citations *teach* an organization which management-prompted activities effectively prevent accidents. Through HSMS-aligned citations, organizations may then better understand the steps they need to carry out to actually prevent hazards and risk factors that lead to the incidents. As opposed to pointing out the manifestations of the system's failure (e.g., observable hazards), this teaching-related alternative regulatory approach offers a potentially flexible and/or customizable intervention.

6. LIMITATIONS AND CONCLUSION

One significant limitation to this study is our inability to truly understand the impact of how a comprehensive enforced HSMS standard would impact mine-level injuries and illnesses. As noted, gaps exist between a comprehensive HSMS and the existing standards currently enforced by MSHA. Based on the sheer number of standards that cite specific workplace hazardous conditions and risk factors, MSHA's recent enforcement emphasis appears to focus on targeting workplace conditions related to implementation and operation, rather than, for example, the planning actions necessary to control those hazards. Further, as a proxy for the HSMS system element of management commitment, we coded each citation according to MSHA's "degree of negligence" classification. One particularly important point to note is that while high negligence and reckless disregard classifications do reflect a lack of commitment on the part of mine management, they do not fully capture an enforcement approach that could be utilized in regulating the element. Voluntary HSMS guidelines published by the U.S. Department of Labor in the late 1980s[39] detail numerous management activities that might be enforced under a mandated HSMS approach. These include, for example, a clearly stated written health and safety policy, recorded and communicated health and safety goals, health and safety accountability systems along with an appropriate organizational structure, and visible top management involvement in all aspects of the complete HSMS. These gaps could prospectively be closed through the incorporation of a regulated HSMS approach.

An additional limitation is the potential underreporting by mines of the actual number of injuries and illnesses they experience throughout the course of a given year. Indeed, we explicitly acknowledge that additional work exploring the impact of MSHA enforcement activity is warranted given the dynamic nature of the publicly available data sets, slight discrepancies between multiple databases that report on the same outcome (i.e., differences in reportable injuries between the AE vs. AII database), and the mine-level operational and managerial idiosyncrasies that may moderate the effect of enforcement activity on important mine-level outcomes.

Even with the noted limitations of this study, we found evidence that the existing MSHA regulatory framework can be mapped onto current conceptualizations of a generalized HSMS model. Through a hierarchical linear modeling effort, we found that the total number of citations, orders, increases in penalty amount, and S & S citations had a negligible effect on subsequent year mine reportable injuries and illnesses. This negligible effect may indicate that MSHA is correctly fixing citations to mines that display low motivation toward health and safety efforts. However, this effect also suggests, in part, that increases in these types of enforcement activities do little to change a mine's attention to its health and safety efforts.

Consistent with the work of Poplin *et al.*,[40] the results also suggest that different regulatory structures and enforcement activity can influence accident prevention differentially. The results further suggest that it may be more important to teach an organization how to prevent accidents than to simply point out the products of its observable system failures. This wisdom may be in line with the anonymous proverb: "If you give a man a fish you feed him for a day. If you teach a man to fish you feed him for a lifetime."

With this perspective, our analysis is also insightful in situating the activities of mining workplace practices inherent in the implementation of an HSMS approach. This knowledge then serves as a useful reference point to situate discussions among political, regulatory, and industry stakeholders regarding the use of an HSMS approach in the United States, as well as in the international mining industry.

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APPENDIX

In the following tables, the MSHA standards included or classification scheme utilized to represent each management system element is listed.

Table A1. 2006–2010: Incident Rate Ratio of Control and Independent Variables Predicting Mine-Level Reportable Injuries and Illnesses

Management Commitment
High negligence and reckless disregard citations

Employee Involvement
MSHA currently has no standards enforcing employee involvement in safety-related processes

Planning Coded Standards							
49.9	71.300	75.222	75.517-2	75.161	77.1101	77.1702	77.1900-1
46.3	71.301	75.370	77.107-1	77.216-2	75.220	77.1900	90.300
48.3	75.1713-1	75.371	77.216	77.1000-1	77.1500	75.221	90.301
48.23	57.11053	57.8520					

Implementation and Operation
All other standards not classified as planning, proactive checking and corrective action, reactive checking and corrective action, or management review

Proactive Checking and Corrective Action Coded Standards							
70.201	71.702	77.211	56.3401	75.1432	75.800-3	57.22228	56.13015
70.202	75.100	77.309	56.4201	75.1433	75.705-8	57.22226	56.12030
70.203	75.150	77.311	56.5002	75.1508	75.705-7	57.22204	56.12028
70.204	75.151	77.312	56.6301	77.1004	75.705-6	57.19129	56.10003
70.205	75.211	77.314	56.6407	77.1110	57.22309	57.19120	56.10002
70.206	75.312	77.315	56.7002	77.1403	57.22308	57.19023	75.1001-1
70.207	75.323	77.502	56.7003	77.1404	57.22307	57.18002	75.1100-3
70.208	75.336	77.704	57.3200	77.1432	57.22306	57.14100	75.1107-4
70.209	75.342	77.800	57.3401	77.1433	57.22301	57.13015	75.1400-2
70.210	75.351	77.900	57.4201	77.1501	57.22240	57.12030	75.1400-3
71.201	75.352	90.201	57.5002	77.1606	57.22239	57.12028	75.1400-4
71.202	75.362	90.202	57.5005	77.1713	57.22238	57.10003	75.1402-2
71.203	75.363	90.203	57.6301	77.1901	57.22237	57.10002	75.1714-7
71.204	75.364	90.204	57.6407	77.1906	57.22236	56.19129	75.1101-11
71.205	75.512	90.205	57.7002	77.704-8	57.22235	56.19121	75.1101-22
71.206	75.812	90.206	57.7003	77.704-7	57.22234	56.19120	75.1103-11
71.207	75.821	90.207	57.8527	77.704-6	57.22233	56.19023	75.1107-16
71.208	75.832	90.208	75.1103	77.216-3	57.22232	56.19022	75.1400(d)
71.209	77.100	90.209	75.1106	75.900-4	57.22231	56.19022	
71.210	77.101	90.210	75.1324	75.900-3	57.22230	56.18002	
71.701	77.102	56.3200	75.1326	75.800-4	57.22229	56.14100	

Reactive Checking and Corrective Action	
50.11	62.174

Management Review	
77.216-4	75.223

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