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OHS management systems for geotechnical risk

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Abstract

The shortage of experienced site-based mining professionals, particularly mining engineers and geotechnical engineers, means that safe "life of mine" designs and systems of work must be established with site risk management practices to ensure management can meet its duty of care and other occupational health and safety (OHS) obligations. Merging an OHS Management System (OHSMS) certified under International Standard (OHSAS 18001:2007) or Australian Standard (AS/NZS 4801:2001) with technical compliance audits, such as the Department of Mines and Petroleum's high impact function (HIF) audits, can ensure that the mine is optimally designed for safe systems of work, with all possible risks identified and control measures put in place. A merged audit of this nature was performed at La Mancha Resources' Frog's Leg Mine in Western Australia as a case study. The study showed the HIF audits, when merged with the OHSMS audit, are a powerful systems check on project-specific technical risks. To maximise the benefits, the audits should be performed by a "qualified certification assessor", a technical content expert and a site staff team representing all levels (i.e. management to the "coal-face").

1 Introduction

Under the current Mines Safety and Inspection Act (MSIA) (1994) and future mines safety legislation, mine management has a duty of care to ensure the occupation health and safety of workers in Western Australian workplaces. In the Model Workplace Health and Safety Act (Model WHS Act), there is also a requirement for mine sites to compile principal hazard management plans (i.e. site risk registers) and develop more resilient safety cultures.

Management is responsible for so much and yet it is not possible to have direct control over it all. How do you manage that responsibility, and liability, without micro-managing and burning out? In particular, how do you manage technical risks, such as geotechnical risks, when you as a mine manager or site senior executive may be a generalist? How can you be sure that all employees from the ground-floor mining environment to the technical services staff have diligently performed their roles with safety as the top priority?

Some of the biggest risks on a mine site are geotechnical. With a severe shortage of site-based experienced geotechnical engineers and mining engineers, there is an increasing need to ensure site risk management practices are functioning well. It is the responsibility of the mine manager and principle employer (or person conducting business undertaking under the Model WHS Act) to ensure that all risks are identified and assessed, with appropriate controls implemented and resourced (e.g. budget, staff, materials and equipment).

Most mine sites have implemented an OHSMS as part of their risk management strategy to address changing legislation and protect their workforce. An OHSMS promotes a safe and healthy working environment by providing a framework that supports the mine as it continuously and consistently identifies and controls its health and safety risks; reduces the potential for accidents; ensures legislative compliance; and improves overall performance.

An OHSMS audit is often used to obtain accredited third party management system certification. Attainment of this certification is an effective way to prove a company's quality assurance and risk mitigation. This certification is a valuable commodity for contractors during tenders and for mining companies when negotiating new terms for their liability insurance. The benefits of certification generally significantly outweigh the cost of implementing it, and are not just financial and commercial but also legal, in that the process ensures due diligence.

Opportunities exist to better integrate site OHSMS and site geotechnical management systems. Specifically, the audit function of OHSMS provides a mechanism to assess if existing practices are at industry best-practice standards. This paper describes one such audit undertaken in February 2011 to assess the paste fill system at La Mancha Resources' Frog's Leg Mine in Western Australia, which involved the merging of a technical engineering audit and the high level ISOAS 18001:2007 OHSMS audit.

Internal company or risk specific audits could also be combined with the ISOAS 18001:2007 OHSMS audit to obtain accredited third party compliance management system certification for a specific technical risk.

The 'what-who-when' action plans arising from these audits facilitate the filling of 'gaps' incrementally over time. The first audit is most likely to provide a long list of actions required for major non-compliances. Performed annually, these audits will enable continuous improvement of designs, systems of work, resourcing, training, organisation, communication and documentation. This continuous improvement should be tracked by the resulting audit action plans (stating: do what, by whom and by when).

There will come a point where no further large incremental improvements can be made, the system appears to be functioning well and accredited third party compliance management system certification for that technical risk should be possible. In going through this process, mine management can prove it has diligently performed its duty of care, as far as reasonably practicable.

2 Current regulatory framework (2011)

2.1 Geotechnical considerations

Table 1 outlines the current regulatory framework for geotechnical considerations, but this will change with the proposed enactment in 2012 of the Model WHS Act with its accompanying regulations and codes of practice. Geotechnical HIF audits, for use in pits and underground, have been developed by the Resources Safety Division of the Department of Mines and Petroleum (DMP) to facilitate compliance with this regulatory framework.

2.2 Paste and hydraulic fill systems

Table 2 outlines the current regulatory framework for paste and hydraulic fill systems, but this will change when the Model WHS Act is enacted. DMP's underground mine fill HIF audit has been developed to ensure consistency and lift the standards across the Western Australian mining industry with regard to use of paste or hydraulic fill and barricades for this purpose.

Table 1 Applicable standards, codes and Western Australian legislation – geotechnical considerations

Source	Section	
MSIA 1994	s. 9	Duty of care
	s. 78(3)	Reporting of incidents to DMP
Australian Standards	AS/NZS 4801:2001 or OHSAS 18001:2007 (OHSMS)	
Guidelines	Geotechnical considerations in underground mines	
	Geotechnical considerations in open pit mines (DoIR, 1997)	
MSIR 1995	r. 10.28	Underground geotechnical considerations
	r. 13.8	Open pit geotechnical considerations

MSIA 1994 – Mines Safety and Inspection Act (1994); MSIR 1995 – Mines Safety and Inspection Regulations (1995)

Table 2 Applicable standards, codes and Western Australian legislation – underground mine fill systems

Source	Section
MSIA 1994	s. 9 Duty of care s. 78(3) Reporting of incidents to DMP *("inundation" or "potentially serious occurrence")*
Australian Standards	AS 1715 (Cyanide) AS 3778.4.1-1991 (V notch weirs for water mass balancing) AS/NZS 4801:2001 or OHSAS 18001:2007 (OHSMS)
Codes	International Cyanide Code (ICMI, 2011)
Guidelines	Geotechnical considerations in underground mines (DoIR, 1997)
Safety Bulletins	Safety Bulletin No. 64 (31 July 2001) *"Safety issues associated with hydraulic backfill"* (DMPR, 2001) Safety Bulletin No. 55 (29 June 2000) *"Potential hazards associated with mine fill"* (DME, 2000)
Significant Incident Reports	Significant Incident Report No 138 (7 August 2006) *"Paste fill wall failure"* (DoCEP, 2006)
MSIR 1995	r. 10.28 Underground geotechnical considerations r. 13.8 Open pit geotechnical considerations r. 10.28(3)(c) Rationale for stope sequencing and filling r. 13.5 Dumping precautions r. 10.31 Chute and pass safety precautions r. 10.35 Vertical opening safety procedures r. 4.13 Induction and training of employees r. 7.29 Workplace atmospheric contaminant monitoring to be provided r. 9.12 Control of atmospheric contaminants r. 9.26 Tailings filled stopes – atmospheric contaminants r. 9.29 Monitoring of toxic, asphyxiant and explosive gases r. 10.12 Workers to be withdrawn if danger exists r. 4.3 Preparation of emergency plan r. 4.36 Specific emergency precautions required to be taken for underground mines r. 7.27 Risk assessment r. 7.28 Means of reducing risk of exposure to hazardous substances r. 4.30 Risk assessment; preparation of emergency plan r. 4.11 Flood protection r. 10.19(1) Dams and plugs r. 7.16 Stagnant water not to accumulate underground r. 6.2 Plant to be maintained and operated in safe manner r. 6.17 Employer to identify hazards associated with plant and to assess risks r. 6.18 Employer to reduce risks identified (with respect to plant)

3 Integration of site OHS and geotechnical management systems

3.1 OHSAS 18001:2007 OHSMS audit

International Standard OHSAS 18001:2007 and AS/NZS 4801:2001, its Australian equivalent, is the internationally recognised assessment specification for occupational health and safety management systems. The International Standard was developed by a selection of leading trade bodies, international standards and certification bodies to address the gap where no third-party certifiable international standard existed.

OHSAS 18001 is inherently a management standard that is used by a diverse range of industries and organisations to manage their respective safety challenges. The International Standard has therefore been written on a management process simply defined as Plan-Do-Check-Act (PDCA). It is comprehensively aligned with ISO 14001 (Environmental Management System), ISO 9001 (Quality Management System) and a range of other ISO management systems (e.g. ISO 27001, ISO 28001).

The majority of mining companies have adopted these standards as the basis for the development of integrated management systems that define a single organisational management system applicable to significant business aspects such as: safety; environment; operations; information management; training; human resources; and increasingly, geotechnical.

Over the last ten years, the PDCA process (interchange ISO management system) has evolved to be the default model for most mining companies' integrated management systems. The PDCA is a robust model as demonstrated by its wide international acceptance, diversity in application and the regard that external certification is held by senior executives and board members who increasingly communicate their expectation for their companies to gain accredited certification of their management systems if not already certified.

The PDCA and ISO/OHSAS management systems are also susceptible to lacking functional and effective operational focus, as these systems tend to be bureaucratic, are not practicable, have limited workforce ownership, and lack awareness and integration with the operational challenges faced by the operation. This susceptibility to irrelevance poses a major challenge for senior management, which needs to manage the operational challenges and ensure the generally substantive investment in development and implementation leads to a PDCA management system capable of managing the organisation's challenges and demonstrating an effective and tangible value of that investment.

Certification companies and certification auditors also have a responsibility to ensure that the certification audit process provides a robust, challenging and relevant function on a year-on-year basis. As a PDCA system matures and the certification auditors establish a greater appreciation of the organisation and its challenges, opportunities will exist to undertake detailed audits of the organisation's integrated management systems in the context of managing specific high risk aspects associated with the organisation's activities. Examples of high risk mining aspects that lend themselves to a detailed PDCA management system audit include:

- emergency preparedness
- traffic management
- geotechnical
- drill and blast
- working at heights
- confined space
- hazardous materials
- fatigue management.

An opportunity arose to apply the PDCA management system audit process with DMP's recently developed Underground Mine Fill HIF Audit (DMP, 2011). The benefits of the integrated audit are discussed below.

3.2 DMP's HIF audits for geotechnical considerations

Over time, DMP has developed many subject-specific technical audits, based on years of experience investigating many reportable occurrences. DMP's HIF audit templates and guidelines are available for industry use at their website (DMP, 2011). Geotechnical audits are available for:

- underground mine fill
- geotechnical considerations underground
- geotechnical considerations open pit.

3.3 Integration of audits

For the case study at Frog's Leg Mine, the two audits merged were DMP's underground mine HIF audit – a technical engineering audit (DMP, 2011) and ISOAS 18001:2007 OHSMS audit – a high-level management audit).

DMP's underground mine fill HIF audit (DMP, 2011) includes sections on management systems and risk management. The ISOAS 18001:2007 OHSMS audit should be inserted into these sections to merge the two audits.

Adding the OHSMS audit into the HIF audit makes the overall audit more comprehensive in terms of systems, procedures, documentation, organisation and training. These are the areas in which paste and hydraulic fill systems often fail, mainly for the following reasons:

- Hydraulic or paste fill systems are highly technical projects:
  - complex to design, construct and operate safely
  - lack of understanding (inadequate training for all levels of staff)
  - communication difficulties (silos, too technical for operations, poor training).
- Unknown or uncontrollable factors:
  - no safe means of access during and after filling resulting in a loss of ability to validate models and check actual versus calculated fill or water heights, or fill quality parameters
  - possibility of stope failure potentially causing dynamic loading of emplaced fill before it has consolidated or cured, which could cause barricade failure
  - pressure instrumentation difficult to install and may not be robust enough.
- Multi-disciplinary team with individual groups having time and resource constraints, conflicting interests and contradictory technical terms:
  - consultants who specialise in the field of paste or hydraulic fill (the technical nature of paste or hydraulic fill needs to be made mine specific and simple for operational ease-of-use)
  - metallurgists and process plant operators (focus on mill priorities and use metallurgical calculations)
  - mining engineers (focus on mine production)
  - geotechnical engineers (use soil mechanics calculations)
  - underground mine supervision and mining crews (prefer simplicity for operational ease-of-use)
  - occupational health and safety team.

Pressure on mine personnel to achieve production goals often means end-stream processes, such as placement of tailings underground as fill, are placed low on the list of priorities. However, bringing this type of fill material into an active underground mining environment introduces considerable operational risk to underground personnel and the future viability of the mine if there is a major incident, such as the multiple-fatality incident at Bronzewing Mine in 2000 (for further information about this and similar incidents, see safety bulletins and significant incident report available on the DMP website). Management's ability to identify hydraulic or paste fill systems and their barricades as a potentially high risk activity is an important first step towards committing to continuous improvement through auditing.

Technical audits, major incident investigations and project specific risk assessments must be undertaken by skilled and competent teams to ensure they are comprehensive, practical and consider all aspects of the operation. The teams should include:

- experienced professionals who are considered competent in the field
- a range of site personnel including:
  - mine operators
  - service crew
  - paste plant operators
  - mining and geotechnical engineers
  - mine management.

4 Case Study – Frog's Leg Mine, La Mancha Resources

The paste fill system at Frog's Leg Mine was audited by the authors in February 2011 using a merged audit comprising DMP's underground mine fill HIF audit (DMP, 2011) and the ISOAS 18001:2007 OHSMS Audit. The HIF audit drills down to great detail on the topics.

- Fill system design should be holistic, based on site specific numerical modelling in keeping with current life of mine designs and fill strategies.
- Technical specification needs to be clearly defined and site specifically designed by a competent person using recognised modelling tools and methods for:
  - barricade designs
  - paste or hydraulic fill specification
  - reticulation system.
- Quality assurance is undertaken and documented for:
  - barricades:
    - ~ materials used as per design specification
    - ~ built to design specification
    - ~ in Western Australia, fibrecrete sprayed onto prefabricated steel frame kits (Clune kits) are very common and acceptable as long as they are based on site-specific designs. They must not be used as an "off the shelf" kit
    - ~ in Western Australia, a site-specific worst case scenario design is often used for a "one size fits all" approach at the mine (must state: maximum allowable dimensions and standoff from stope brow, arch radius, anchorage, fibrecrete thickness).
  - paste or hydraulic fill:

    - ~ fill specification ex-plant (% solids, % cement, PSD, slump, mineralogy, toxins)
    - ~ fill height, curing or consolidation checks
    - ~ water mass balance if hydraulic fill or wet mine
      Note: If using paste fill in a wet mine, the hazards are as severe as for hydraulic fill.
  - reticulation system:
    - ~ preventative maintenance and monitoring.
- Underground monitoring and documentation**:**
  - observations (CCTV, from outside containment bunds or exclusions zones)
  - measurements (e.g. CMS, pressure probes, probe drilling, water mass balancing where possible).
- Mine management systems need to be formally documented and communicated in a fill management plan, including the following (this is where the ISOAS 18001:2007 OHSMS audit was inserted):

  Section 4.3.1 Risk register
  - team-based multidisciplinary risk assessment on the entire fill system
  - reviewed annually
  - all control measures transferred to action plans, site risk register, standard operating procedures (SOPs), emergency response plans (ERPs) and other relevant designs or documentation.

  Section 4.4.1 Resources
  - organisational charts showing interrelationships, approvals and reporting structures
  - job descriptions clearly defined
  - adequate resourcing:
    - ~ coverage for fly-in fly-out (FIFO) operations' rostered days off
    - ~ clearly define the single point of accountability for fill systems.

  Section 4.4.4 Documented systems of work
  - SOPs (including technical specifications from expert)
  - process driving templates, checklists and forms
  - training and competency assessments and skills matrix for all staff underground and associated with fill plant
  - general awareness training information for all site personnel (e.g. toolbox talk, PowerPoint presentation).

  Section 4.5.3 Incident investigation and documentation
  - incidents investigated, formally documented and reported
  - database of site incidents (historical) is kept updated for back-analysis or validation of models and calculations.

  Section 4.4.7 Emergency preparedness
  - ERPs for all potential fill egress scenarios ("what if's")

- ○ emergency drill schedule ensuring all site personnel receive training.

Section 4.4.6 Documented trigger action plans

- ○ give recovery steps for “off specification” barricades and/or fill, stating acceptable tolerances
- ○ reticulation leaks
- ○ barricade or rock mass fill leaks
- ○ barricade cracks or failures
- ○ exposed fill failures (post barricade failure or after mine adjacent to fill)
- ○ fill height or quality observed does not match calculation or model.

In the opinion of the authors, merging the technical and management system audits provided a basis for substantively improving the quality of both audits and their combined findings. The technical component of the audit provided a horizontal sampling opportunity to test the robustness and effectiveness of the integrated management system in managing a high risk and technical aspect of the operation. In particular, the technical audit was conducted by a technical expert who had subject matter expertise generally absent from most management systems audits. This provided a much higher degree of technical interrogation regarding the quality management system elements (e.g. risk register and incident investigation).

At Frog’s Leg Mine, the above items were audited and a ‘what-who-when’ action plan was generated that will enable mine management to put in place formally documented continuous improvement measures. Repeated annually, it should eventually be possible for the mine to attain accredited third-party management system certification for its paste fill system. The speed at which this accreditation is reached depends on how well actions are completed after each audit ‘gap analysis’.

5 Conclusions and recommendations

Geotechnical risk management is vital to ensuring the safety of mine site personnel and the long-term viability of mining operations. The current professional skills shortage makes management of these geotechnical risks problematic. As site-specific geotechnical risks are assessed and control measures put in place, these should be embedded in site systems and processes through relevant documentation. Personnel must be trained and deemed competent in these. OHSMS audits can be used to ensure this has been done appropriately.

Merged OHSMS and technical audits, such as DMP’s HIF audits, can provide value to mine sites in terms of formally driven and documented continuous improvement and eventually, technically specific accredited third-party management system certification.

Certification auditing is a valuable due diligence tool that can generate financial, commercial and legal benefits and is an effective way to prove a company’s quality assurance and risk mitigation processes. This process is congruent with a resilient safety culture and the proactive risk management approach that is promulgated in the Model WHS Act, expected to be enacted in 2012.

OHSMS accredited certification audits can provide a strategic approach to managing safety and legal obligations. The case study demonstrated the ability to combine HIF audits and PDCA management system audit functions for a site-specific technical aspect (i.e. paste fill) to demonstrate both effectiveness of the site’s integrated management system implementation and the specific management of a high risk aspect. A critical aspect to the success or otherwise of such an integrated audit lies in ensuring the appropriate selection and mix of auditors. Having both a subject matter expert and an experienced management systems auditor is deemed critical to ensuring an effective audit outcome.

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