

Proceeding Paper

Risk Management: An Essential “Tool” for the Extractive Sector †

Petros Maraboutis *, Niki-Iliana Poulimenou and Elena Nikolaou

Eco-Efficiency Technical & Engineering Ltd., G. Papandreou 60A Dasos Haidariou, 12462 Athens, Greece; n.poulimenou@ecoeficiency.gr (N.-I.P.); el.nikolaou@ecoeficiency.gr (E.N.)

* Correspondence: p.maraboutis@ecoeficiency.gr; Tel.: +30-210-5325110

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Abstract: Risk management is a methodology through which industry can proactively manage risks (inclusive of potential opportunities and threats), which is a common practice for operators all over the world. For the extractive industries, due to the highly variable operating parameters, such as site-specific conditions, geographical location, local environmental conditions, behavior and characteristics of the ore, and the geological background of the deposit, Risk management (RM) is an essential tool. Risk management as a management technique has developed significantly over the past 20 years, with an array of different tools and techniques being increasingly used globally to address risks pertinent to the extractive sector. The sustainability of the extractive sector will be guided by the environmental, occupational safety and health, and the societal approval of the extractive operations, including the processing plants. Risk management is a holistic approach that assesses all risks associated with the facility’s construction, operation, and closure. This article attempts to highlight the advantages of the implementation of RM approaches by the extractive sector and intends to promote the idea that RM can act as a vehicle to optimize the overall safety and environmental performance of the extractive sector.

Keywords: risk management; extractive industry; MWEI BREF; safety and environmental performance optimization



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1. Introduction

The extractive sector illustrates highly variable operating parameters, such as site-specific conditions, geographical location, local environmental conditions, behavior and characteristics of the ore and geological background of deposit, which are only some issues that should be managed considering safety aspects and environmental impacts. Potential risks associated with stability issues relating to an extractive facility, including the extractive waste facility, covering the physical and chemical as well as operational, organizational, financial, and management risks must be identified, and facilities must be conceived, designed, constructed, operated, and closed in a manner that effectively manages risks to achieve the objective of “zero” harm. Risks must be re-assessed throughout the life cycle. As the risk profile of the facility changes, the risk management measures shall be updated accordingly.

Risk is a complex concept, and the extractive industry may be associated with a wide variety of risks. Therefore, the evaluation of overall risks requires aggregation to make different practices and scenarios comparable.

One of the objectives of the risk-based considerations is to predict potential risks and impacts from the very beginning (design phase) resulting from the operation of an extractive facility and explore possible solutions to avoid them. Any significant change that may arise at some point during the mining life cycle may lead to a proportional

evaluation of the risk assessment. Indeed, risk management is a procedure that iterates with operational planning and needs to be adapted progressively to changing operational conditions [1].

General and environmental legislation of the EU such as the directives on Environmental Impact Assessment (EIA), Water Framework Directive (WFD), and the Habitats and Birds Directive apply to the extraction of raw materials. In 2006, the Extractive Waste Directive (EWD) was adopted in the EU, providing measures to prevent or reduce as far as possible any adverse effects on the environment and any resulting risk for human health that may result from the management of waste from the extractive industries. These measures shall be based, inter alia, on the best available techniques (BAT) without prescribing the use of any technique or specific technology but considering the technical characteristics of the waste facility, its geographical location, and the local environmental conditions. On 18 December 2018, the Commission published the BAT Reference Document for the Management of Waste from Extractive Industries (MWEI BREF) addressing extractive waste management through the risk assessment. Specifically, the MWEI BREF presents 10 generic and 47 risk-specific BATs. The risk-specific BATs require a proper environmental risk and impact evaluation to determine their applicability and to identify the relevant and appropriate technique among the techniques listed in each BAT. According to BAT 5,

“In order to determine the potential environmental risks and impacts brought about as a result of the management of extractive waste, BAT is to use all of the following techniques: (a) Hazards and risk elements identification and (b) Environmental Risk and Impact Evaluation during the three main life cycle phases of an extractive waste facility (i) planning and design, (ii) operational phase and (iii) closure phase”. [2]

Risk management is a crucial part of the decision-making process, yet it remains a broad term that includes disciplines from engineering to finance [3]. In this article, the scope is limited to environmental and safety risk management (included the health and safety of workers). However, in reality, in the extractive industry it will be important to take into consideration the socio-economic context of an operation, as this can be an important driver for how risks are assessed and managed in practice. Risk management is integrated into business processes to ensure that, on a day-to-day basis, both strategic and operational decisions are risk-based [4]. The advantage of the “risk-based” decisions is that the final choice was made after investigating all the possible actions, identifying the priorities, and selecting the most appropriate action [5]. Furthermore, RM is also linked to terms such as “prevention”, “preparedness” and “response actions”, which are mitigation strategies that are used for the protection of the environment and human health. Specifically, according to the Decision on a Union Civil Protection Mechanism which entered into force on 1 January 2014,

“prevention is of key importance to achieve a higher level of protection and resilience against disasters. It requires further action and an integrated approach to disaster risk management, linking risk prevention, preparedness and response actions”. [6]

The extractive sector needs to perform the RM with the perspective to collect sufficient and detailed data which may lead to a clear indication of the actions and options available, and then give a clear indication of these, their risk reduction and prevention potential, cross media effects, technical considerations relevant to their applicability (e.g., geological context), economics, and driving force for implementation. The article attempts to highlight the necessity of risk identification and risk assessment through the life-cycle of a mineral extraction project (from the exploration phase to post-closure phase) on environmental and Occupations Safety and Health (OSH) issues.

2. Risk-Based Considerations for the Extractive Sector

Risk can be defined as being the effect of uncertainty on the achievement of objectives (ISO 31000:2018) [7]. Risks can therefore be both positive and negative and are viewed as being any potential event or scenario that may impact the achievement of the goals of an

organization, team, or individual. Every human activity has certain risks associated with it. These can include risks to the health and safety at work and health of an individual, risks to the environment posed by human activity, or conversely, risks posed by the environment (e.g., physical disasters) on human activity [8]. Risk management is the process of taking control of risks and therefore reducing the likelihood or impact of a potential negative risk occurring, as well as enhancing the likelihood or impact of a potential positive risk occurring.

The process of risk assessment comprises the following steps [8]: (a) Hazard identification; (b) assess the consequences; (c) assess the likelihood; and (d) allocate the current risk level.

The extractive sector is familiar with risk or impact assessments since they is undertaken as part of the formal Environmental Impact Assessment (EIA) in the pre-licensing process. Within environmental disciplines, risks are often assessed on the basis of the Source-Pathway-Receptor paradigm. One paradigm can be the following: the potential source of environmental impact can be a hazardous waste; the potential pathway can be either air, soil, groundwater, or surface water; and the potential receptors are humans and the environment. The question that arises is how an operator can manage this situation. A risk is only present when these three parameters are present. As a consequence, the risk can be reduced if one of them can be eliminated. The realistic scenario is the removal of the potential source of risk (e.g., hazardous waste) or the potential pathway (e.g., a proper facility to secure the hazardous waste). The removal of the receptor in most cases is not feasible. However other disciplines do not use this language; many forms of enterprise-wide risk management are moving away from using likelihood (or probability) as a core mode of differentiation due to the difficulty encountered when attempting to calculate it accurately. Key concepts and priority areas can therefore be identified in various ways and by a range of criteria. As a consequence, a number of guidelines that have been published for the sector (e.g., in the oil and gas sector [9]), EU Member States, as well as other countries with considerable mining experience (e.g., Australia) structured transversally into particular risk areas, according to elements or activities of the extractive operations that are held or represented.

As regards Occupational Safety and Health (OSH), a large body of EU legislation exists with minimum requirements, whereby Member States are free to adopt more stringent protective measures. The main measure is the Framework Directive 89/391/EEC (Directive 89/391/1989 on the introduction measures to encourage improvements in the safety and health of workers at work) and several related directives have been adopted, including the Extractive Industries Directive 92/104/EEC (Directive 92/104/EEC on the minimum requirements for improving the safety and health protection of workers in surface and underground mineral-extracting industries), which addresses the exploration for and exploitation of minerals in surface or underground mines and quarries. Workers in the extractive sector are likely to be exposed to particularly high levels of risk. Any risk management measures should be in line with these directives, and as it is a high-risk sector, it is likely that several Member States have adopted stricter protective measures.

The mining sector is especially complex due to the geological, geochemical, climatological, and social conditions of the location of each deposit, but also because of the breadth and range of the mining life-cycle, it is very difficult to provide a horizontal solution for all the mines and the quarries in European Union. On the other hand, risk management of a mine or any other extractive facility is a holistic approach that takes into account all risks resulting from the construction and operation of a facility. This approach results from the need to optimise the overall safety and environmental performance of the facility.

Specifically, Environmental and Occupational Safety and Health risk management can be broken down into environmental management and OSH management. Environmental management is certified according to ISO 14001 [10]. Occupational Safety and Health risk management is also a type of risk management. It is certified according to ISO 45001 [11]. The integration between them, with the option to also include quality management (ac-

According to ISO 9001 [12]) is referred to as an Integrated Management System, which is often considered to be the Environmental, Health and Safety component of Integrated Risk Management (or Enterprise Risk Management, ISO 31000 [7]) for an organisation as a whole.

The combination of information on risks and impacts is helpful to develop feasible solutions during the activities of an extractive operation. Each of these possible solutions is reviewed with respect to the risk reduction strategy applied (based on relevant engineering principles) considering risks, impacts, as well as social aspects [13]. The visual representation of the paths and the scenarios during the risk assessment will give the possibility to assess the progress of a certain activity or decision. For example, for the management of extractive waste, the risk assessment will be based on information related to Extractive Waste (EW) and Site characterization. The EW characterization includes the waste's nature, classification, intended handling, geochemical characteristics, and behavior. The Site characterization is related to EW deposition area type (construction methods including basal structure concept design) and deposition technique for ponds, dams, and heaps, as well as placing back extractive waste in excavation voids. As a result, a risk assessment that takes into consideration all the aforementioned facts will provide an improved understanding of the level of risks that could affect the achievement of objectives such as safety of the deposition, environmental precautions, and OSH. Risk-based considerations contribute to setting priorities for environmental and social protection in an objective and scientific way.

3. Key Risks on Environmental as Well as Occupational Safety and Health along the Life-Cycle of an Extractive Operation

The objective of any risk management process is to ensure that significant risks are identified and evaluated to ensure that an appropriate level of risk reduction is applied to mitigate such risks or impacts. Risk evaluation is a key part of the management of all stages in the Life Cycle (LC) of an extractive facility. The size, the complexity, and geographic location of the extractive operation are just some of the parameters that should be included in the risk assessment process [13]. Thus, the complexity and the results of the risk evaluation may vary accordingly for every extractive operation, and no single harmonized scope is appropriate.

As part of the planning of an extractive operation, it is often necessary to make an evaluation of potential environmental impacts (i.e., predictable impacts during normal operation) and potential risks ("i.e., the potential impacts of unplanned events, such as accidents and spills, and the likelihood of such events"). Planning is linked to the process of data gathering and analysis. It may be characterized as a multi-phased, iterative process involving geological, mining, engineering, environmental, social and marketing studies [1]. Planning requires goals, objectives, and programs and is controlled by rules, procedures, and pre-determined results. On the other hand, the design focuses on the nature of a project to conceive a framework for development. The design seeks alternatives and is controlled by principles, product specifications and values. During this phase, all the risks should be identified and prioritized. Integrated planning across all aspects of an extractive operation with a view to minimise risks and avoid risk displacement within the operation should then be developed, taking into consideration management strategies from planning to post-closure [1].

As far as environmental risks are concerned, the overarching planning and management tool is the Environmental Impact Assessment (EIA) according to the EIA Directive [14]. Concerning OSH risk assessments, the relevant minimum requirements in the EU OSH Framework Directive 89/391/EEC as well as Directive 92/104/EEC and other individual and other Directives related to Directive 89/391/EEC plus relevant national legislation transposing these EU Directives must be taken into account. During the design phase, it is very important to prepare a Baseline Report, which assists in determining the state of soil and groundwater contamination to make a quantified comparison with the state upon

definitive cessation of activities. The Baseline Report will act as a tool of monitoring during the operational and closure phase.

The operational phase in an extractive operation can be focused on (a) mining and quarrying and (b) processing of ore. During this phase, to determine potential Environmental, Occupational Health and Safety risks it is necessary to review the hazards and risk elements that have been identified in the planning phase and evaluate the findings from the monitoring. Taking into consideration the BAT 5 of the MWEI BREF [2], even if the MWEI BREF is limited only to waste management, the present article tries to go beyond and make some suggestions on the key areas of concern during the operational phase:

1. Physical/Geotechnical Stability of the mine and the extractive waste facility;
2. Ore, waste rock, and extractive waste characteristics;
3. Emissions to soil and groundwater;
4. Emissions to surface water;
5. Emissions to air;
6. Other parameters considered relevant for the hazards and risk elements identification.

In each of the aforementioned key areas, different risk assessment approaches can ideally work, and a few examples are given below:

- Workplace risk assessment and control (WRAC);
- Hazard and Operability study (HAZOP);
- Baseline assessment of contaminants taking into consideration the Baseline Report that had been prepared in the design phase;
- Risk-based characterization of the waste based on geological and mineralogical characteristics, its geotechnical behavior and geochemical characteristics and the site conditions in accordance with EU Provisions;
- In the area of OSH, Council Directive 89/391/EEC and Council Directive 92/104/EEC article 3.2 require, among other stipulations, that employers of mining operations draw up (before work starts) a health and safety document including an assessment of the risks workers will be exposed to and necessary measures to prevent them, demonstrating that their workplaces and equipment are safe. This relates to all relevant measures mentioned in the articles of the Directives and those related to the minimum requirements in Annexes A and C of Directive 92/104/EEC.

The closure of a mining operation is a complex process and entails a variety of activities. Any closed extractive site and closed and rehabilitated extractive waste facility pose a certain potential risk.

Fundamental criteria for closure processes that are proposed in the MWEI BREF [2] that can also be applied in mines and quarries are the following:

- Physical stability;
- Chemical stability;
- Hydrological and hydrogeological environment;
- Geographical and climatic influences;
- Local sensitivities and opportunities;
- Land use.

During the risk management, the following should be evaluated and investigated: conceptualization of long-term risk reduction, (b) assessment of long-term stability, and (c) strategies to ensure compatible land-uses.

4. Conclusions

The management of risks is not a new concept to the extractive sector. Many significant risks are inherent to the mining value chain, and therefore have been managed formally or informally for many years. For companies to meet permitting, regulatory, financial listing requirements (to name but a few), evidence of risk management need to be provided. The nature of this evidence often varies but typically includes a list of risks and the controls in place to manage them to a tolerable level, together with the accountable persons for the

management of each risk. Risk management of a mine or any other extractive facility is a holistic approach that takes into account all risks resulting from the construction and operation of a facility. This approach results from the need to optimize the overall safety and environmental performance of the facility.

The European Commission has authorized a 3-year project [1] “Study Supporting the Development of Guidelines for Best Risk Management Approaches in the Extractive Sector”. Its objective is to introduce guidelines for risk management within the EU by identifying key activities most relevant to ensure the sustainability of extractive operations. Eco-Efficiency Consulting and Engineering Ltd performs this project in collaboration with the following subcontractors WEFalck (FR), Satarla (UK), Afry Finland Oy (FI), CRS Ingeniería (ES), Geologia e Geotecnia Consultores, Lda (GGC, PT), Ivan Andreev (BG), Mineral and Energy Economy Research Institute of the Polish Academy of Sciences (MEERI, PL) and Total Business Land (TBL, RO).

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