Mining Industry
Engineering Insurance exposure

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Summary

This paper describes the various types and activities of the mining industry and also the main specialised machinery and equipment used. This industry is exposed to specific high hazards and risks and these are highlighted in detail for insurance underwriters’ appreciation when dealing with the typical Engineering insurance coverages for the mining industry. The paper also includes typical loss examples and some essential loss prevention measures to be evaluated by the underwriter. Finally suggestions and methods of PML calculation conclude this paper.
1. What is Mining?

Our earth contains a great number of materials and substances which have been found to be highly valuable to human’s use, and it is difficult to imagine life today without the use of these commodities. The extraction of these substances, in whatever form they exist in their original appearance in the earth is called mining. These valuable substances comprise a great number of minerals and other geological materials, including base metals, precious metals, iron ore, uranium, coal, diamonds, limestone, oil shale, rock salt or potash. They are found in the form of an ore body, vein or (coal) seam. The extraction of liquid or gaseous substances are generally not defined as “mining” as they are usually removed by drilling of wells and pumping. These activities are not the subject of this paper.

Mining of stone and metal has been done since pre-historic times. Modern mining processes involve prospecting for ore bodies, analysis of the profit potential of a proposed mine, extraction of the desired materials and finally reclamation of the land to prepare it for other uses once the mine is closed.

The physical condition of the mineral, the concentration of it in the rock or soil, the depth the mineral is found and the condition and type of overburden, the geology, are all of great important for the decision of what method of mining is to be used, how the location is to be accessed and how to deal with the possible problems of the mining works chosen. The complexities usually grow with the progress of a mine into deeper layers and longer distances below ground.

Minerals can exist in high concentration such as ore bodies but also in very low concentration such as gold, requiring huge amounts of rock to be extracted, crushed, milled and further treated to remove and concentrate the metal; alternatively the substance can be found in a thin but widespread layer.

Depending on the specific circumstances, the required mining method may necessitate accessing and extracting the mineral or coal by either open cast or underground extraction. Underground mining requires shafts, tunnels, roads and working galleries underground and installation of such services as ventilation, air-conditioning, compressed air, power and fresh water supply, dewatering systems, fire protection and communication systems.

Most of the minerals mined are not in a suitable form to be immediately used or transported. For this reason most mining operations are combined with a processing plant to allow for ore concentration and to prepare the mineral for use or transportation. These plants typically involve very rough processes, heavy machinery and various kinds of hazards such as explosion or poisoning from hazardous chemicals. Therefore the discussion of mining operations will include a description of the main processes, the main machinery utilised and the associated risks.

Due to the interference and destabilisation of the geological formation mining can cause severe incidents such as rockslide, subsidence and the collapse of galleries. Also unexpected rush-in of sand, mud or water can occur for this reason. Such occurrences often prove extremely difficult and costly to handle which could lead to the entire mine or a section of the mine being given up. This could also be the case with an underground fire in a coal mine, where access to the fire is impossible and attempts at extinguishing fail, so the fire may go on for months or years.

The Swiss Re publication “Reducing volatility in the mining sector” states quite typically:

“**Mining is a risky business**

This fact is nothing new. Excluding internal costs and cost of capital, the 10 year view (1997 to 2007) from the Swiss Re perspective reveals a technical loss ratio of above 100%. And in 2008 the market was shocked by initial reported losses of USD 3.5 billion and only some USD 600 million in premium income, although some of these losses have since settled at
lower amounts. The question we should now pose is whether current insurance models for the industry, and the manner in which risk is shared between insured and insurer, have kept pace with the scale, complexity and volatility of industry growth and the changing risk environment."

**2005/06 Difficult Year for Mining Underwriters:**

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<th>Significant number of large losses over last 15 months:</th>
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<tr>
<td>- SAG Mill failure</td>
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<td>- Underground fire</td>
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<td>- Shovel fire</td>
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<td>- Cyclone – Mine inundation</td>
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This is a list of occurrences compiled by AON:

The approach insurers may take in respect of what should be insured and what limitations, exclusions or restrictions should apply is therefore geared by the detailed consideration of the risk features, accumulating hazards and kind of machinery/installation and work performed at each point of the mine. The use of explosives is quite common in mining for various kinds of work. Their handling, storage and application must be carefully considered, as must the risk of explosion of gases and coal dust in underground mines or the potential of flooding.

The nature of mining processes often involves the potential of a negative impact on the environment, both during the mining operations and even after the mine is closed. Furthermore, mining in most cases involves hazardous activities, dangerous to the works and people. This includes the safe storage and deposit of chemically hazardous substances or refuse and tailings and the safe construction and maintenance of tailing dams.

The dangers involved in mining and the potential impact has led to most of the world's nations adopting stringent regulations to moderate the negative effects of mining operations. Safety of operation is of great concern. Modern practices have improved safety in mines significantly. Strict adherence to safety and risk management is the best way to profitably and safely recover minerals with minimal negative impact to the works, health and environment.

Certain minerals are becoming scarce. The need of exploration of less productive mines and those requiring more complex methods and technologies make their mining less economic; however prices for minerals and coal are increasing and can make higher efforts in recovering them more worthwhile but at the same time, more demanding for insurers. Nevertheless, the increasing shortage of resources will boost the efforts of recycling metals and other valuable substances which naturally and unfortunately does not apply to coal and similar fossil fuels.
2. Different activities of Mining

2.1. Construction works for establishing a mine

Generally, each project is unique and exists in a new environment. However there are a few main aspects which apply to the construction of mines regardless of their individual setup:

- remote locations, often combined with high altitudes
- multi location - units such as extraction, processing and loading facilities may be located several hundred kilometres from each other
- long distances, requiring access roads, railway, pipelines, power transmission
- heavy transports
- heavy civil construction – earthworks, excavations, foundation works
- open pits, tailing dams, shafts (vertical or diagonal), tunnels
- heavy contractor’s plant and equipment

Long distance transportation to remote areas

Mine development includes, apart from exploration and feasibility studies the design of open pit and underground projects, including mine shafts, ore and waste handling systems, dewatering systems, backfill systems and ventilation schemes.

The main exposures to any mine components during construction may be structured as follows:

2.1.1 Natural hazards

These may cause substantial damage depending on the individual stage of progress of construction.

**Storm** may cause severe damage to stored materials, to silos, tanks (especially if not finished), buildings such as concentration plants, power transmission towers and the camps.

**Rain**, flood and inundation threaten access roads, shafts, tunnels, open pits, any storage and camp facility. Knowing the topography, catchment area, peak rainfall and the return period will help consider each of the individual scenarios and the assessment of flood exposure. Water ingress to any excavation, lower ground level or underground works is a permanent threat during construction and various possible scenarios should be studied.
Depending on the individual location, earthquake will affect all types of civil works, foundations, open trenches and installed equipment. Underground works may also be affected, although surprisingly, to a lesser extent than generally expected.

2.1.2 Hazards involved in the works

Design
The whole mine planning and design should be trusted to highly experienced engineers and
comply with all construction and design standards. It must be controlled and approved by independent engineers and its adequacy surveyed.

No soil investigation is complete; there are always areas which are not or could not be investigated sufficiently. As a consequence sudden earth movements may occur which could cause notable damage requiring extensive repair works, even the reshaping of hang and slope profiles.

The possibility of damage to any pit, excavation (slope, open trench, road body), cut, embankment and backfill must be investigated carefully. Slides of rock or soil, shearing of tailing dams, displacement of piles and foundaions, deviation, collapse of tunnels or directional drillings, inrush of mud, gravel or water are realistic scenarios to be taken into account.

Damage often is caused by design of temporary roads, mining works, retaining walls and support systems being based on inadequate assumptions such as overestimated bearing capacity or geological stability, undetected faults and cracks in rock formation, underestimated storm or rainfall intensity.

Access, storage and transportation
Given the often remote location of certain minerals in undeveloped and frequently mountainous areas, access roads need to be built in these areas for long distance transports of heavy equipment and construction materials, or existing roads river crossings and bridges need to be strengthened and stabilised. Their temporary purpose often requires only the simple design of sand roads which however are more exposed to storm and water damage from heavy rain falls.

Before transportation to the site, storage of high value equipment will be necessary in ports, harbours and other places in the country. Proper protection from climatic and security measures such as fencing and committed guards need to be imposed. Transports have to be assessed carefully as they are an ongoing process during the whole construction period. Heavy trucks will be used, each can reach individual weights of between 300 to 700 tons.

Working methods
Very generally, there is always an increased risk of earth movement, rock slide and collapse during any construction phase, i.e. in areas which have not yet reached their final stability as foreseen in the design.

Hazardous working methods are applied such as tunnelling, drilling of shafts, blasting, welding and installation of heavy components and high structures above ground.

Shafts can be sunk by either blasting 5 to 10 m long shaft benches, excavating and stabilising, reinforcing the walls before proceeding, or by use of shaft boring machines, working from top to bottom or by raise boring in an upward direction usually by pulling up the machine widening a small pre-shaft connecting the machine with the tower on top of the shaft. Besides the main access tunnel or shaft, additional shafts are constructed for transportation of material, ore, waste or personnel or purely for ventilation.

An access tunnel or shaft must be completed and fully equipped and commissioned for an underground mine before any further development can commence. Therefore, whenever great depths are involved, mine owners usually place a premium on rapid tunnelling or shaft sinking progress. These works are hazardous and require highly specialised and experienced contractors. The same applies to many other technically difficult working methods such as pipeline construction and directional drilling.
Complicated erection works, commissioning and testing are also usually awarded to specialised and experienced contractors whilst general civil works are often awarded to local and often less experienced contractors.

For most of the contracts, inexperienced or less experienced workmen are usually locally recruited and trained in support of the specialised and experienced staff of the contractors. The size and type of workforce changes much as the project progresses from one stage of the contract to the next. Undoubtedly and as experience shows, adequate recruiting and training is an essential task for maintaining the quality of the workmanship.

Installation of high structures above ground

Dangerous works and use of heavy plant and equipment such as drilling machines, bulldozers, mobile cranes, pile drivers and heavy trucks in the environment of a mine, may not only cause damage to the works and machinery, but may also cause serious injuries or death to the workers. Constant, thorough control and coordination of works is highly essential in mining works for preventing or minimising serious accidents and losses. Good maintenance and servicing of contractor’s plant in a professionally equipped local workshop is part of this policy. Keeping on stock essential spare parts and material at a remote mining site is very important also, in view of avoiding unnecessary delays.

**Exposure to fire and explosion**

Fire and explosion are hazards more typical to mining projects than to many others. This is due to the use of a large amount of very heavy mobile equipment, trucks, lorries and excavators of giant size. Under the heavy, dusty and noisy working conditions overheating of parts, leakages of oil or diesel fuel and the initiation of fire is not only highly possible but can also occur without being easily detected before it becomes serious.

The assembling of mechanical parts and installation of equipment imply working methods such as welding and flame cutting. Testing and commissioning whether for mining equipment or processing plants involve flammable feedstock and electric power at higher voltages and current. Short-circuits and overheating of parts increase the potential of fire drastically. Whilst fire may occur anywhere, the items most exposed are conveyor belts, cables and fuel tanks and where flammable liquids are used in the processing plant or elsewhere.
Because of the site’s remote location, larger amounts of fuels and other flammable liquids may be stored on site.

The extensive use of explosives and the storage thereof constitute a substantial hazard to be very well controlled.

Usually during construction permanent fire fighting systems are not yet fully operational.

Underground, the situation is specifically serious as uncontrolled explosions cause damage not only at the point of ignition, but their destructive pressure waves continue long ways within the galleries and tunnels before they die down. Fire underground, however caused, is extremely difficult to fight. The place of the fire is generally inaccessible due to smoke and heat aggravated by the flow of air blown through the mine for ventilation. Sources of fire can be manifold: overheated or damaged electric cables, sparking of other electrical equipment, welding works, spillage of flammable liquids (fuels, hydraulic oils or lubricants), explosive gases, overheated parts of machinery, friction of parts on moving conveyor belts, and the like. The possibility of such occurrence is aggravated by the narrow working space where transport and movement of material and machinery take place between cables, pipes, ropes, moving conveyor belts and lots of parts and material lying around whilst the view is bad due to dusty blowing air, insufficient or glaring spots of light and the hearing bad due to dazzling noise.

Here more than anywhere else (except in the petrochemical industry) rules and regulations for explosion / fire protection and prevention concerning the equipment and material used and the operational and working procedures must be observed.

**Existing property**

Mine extensions often mean an exposure to existing facilities, which should be listed with their respective values and their location clarified. Demolition and flame cutting expose existing property; excavation may erode their stability and require the constant measuring of subsidence, settlements and lateral soil movements may need additional stabilisation measures.

**Third Party Liability**

Although mines may be located in remote areas, villages may be in the neighbourhood where third party traffic uses the same access roads. Crops and forests along the access roads, access railways or slurry pipelines and transmission towers are exposed to damage, resulting from the works in close proximity of existing or adjacent property.

Loading facilities in ports and harbours are often close to third parties’ property and conveyor belts often cross third party premises. Wherever excavation is executed near third party property, vibration, removal or weakening of support are scenarios to be taken carefully into account when assessing the TPL exposure.

A specific TPL and environmental risk is involved in separation, concentration and refining processes of ore or mineral processing plants. They require a huge amount of water and the resulting waste or tailings (contaminated by chemical reagents) have to be removed and stored in a tailing disposal where the tailings settle and the excess water has to be treated before returning it to the surrounding environment.

Tailing disposals are usually located downstream of the concentration/refining plant so that the waste can be hauled by gravity through pipelines or channel shaped sewers. Most of the tailing disposals utilize suitable topographical locations like natural geographical depressions or valleys where dams can be constructed using waste rock available from the mine, so that the waste disposals can flow into the tailings dam.
Construction of tailing dams

Breach of a tailing dam

However dams can be overtopped, especially following massive rain falls or weakened by water resulting in partial or total destruction of dam structure, either under construction or during operation. Since the volume of tailings gradually increases over the years, the height of the crest of these dams or the embankment structure is continuously increased according to the level of tailings in the basin. These dam increases can destabilise the strength of the dam and resultant breach of the structure can occur.
2.2 Operational risks

When does the exposure of the construction policy end?
This is often a difficult question to be clarified between the parties concerned, especially if delay in start-up cover is involved.

In larger projects it is not really conceivable that all construction works end at a specific point in time and then the full plant with all its installations is tested and commissioned where after all is handed over to the responsibility of the principal / owner and then be covered by operational insurances.

Mining projects, of necessity, have to be built in sections where the completion of the first one is required to continue with the others. Before the access road is completed, construction works cannot commence on site. Before the heavy mobile machinery is assembled and a service workshop is in operation, the site works will not be possible and before a power supply system or own power plant is in operation no electrically driven plant can work. Underground work will require the precondition of electric power, compressor plant, ventilation plant and access by a fully operational shaft.

Therefore it is normal that sections of the project that have been completed are taken into operation before others are completed or even only started. Subsequent operation of completed plant sections whilst construction is ongoing is an operational risk rather than construction. Sectional hand-over of operational completed plant sections which have been tested and commissioned, is a recommended practice, because operational risks are better insured by operational policies rather than construction project policies where terms and conditions are not well suited.

As for mining risks, it may not be clear when all works are completed and the project policy expires. There will always be construction works going on. It must be noted that only the construction contract to establish a mine until it is ready to take up the intended mining operations is the subject to be covered under a Project policy. The subsequent operation itself with its ongoing construction activities - the character and the conditions of the works may vary as the mining works go on - is part of the overall mining operations. Only a major extension to be built or revamping contract may come under cover of a separate project policy.

The provisional acceptance certificate for commissioned plant or plant sections should include a detailed assessment of all involved machinery and equipment with its properties and working parameters. In many cases the root cause of problems or damage arising later during the maintenance, relies on such additional information and can help to determine whether a loss or damage falls under a maintenance extension of the project policy or the operational cover.

2.2.1 Surface / open cast mining

Ore Extraction
Blasting (often the first process, ore size greater than 1000mm) Equipment used – rock drills and explosives mixer trucks. Most explosives are a mixture of ammonia nitrate and fuel oil, known as ANFO however other more expensive explosives can be used in certain circumstances, e.g. if the ground water level is high. ANFO is best mixed immediately prior to use. Detonators are required to set off the explosives and these must be kept in special magazines, protected by bunds and remote from working and recreational areas. Detonators and explosives must be stored separately.

Perils – Fire and unexpected explosion

Example of an open cast ore mine:
Example of a rock drill for ore extraction:
Dredging (ore size 20 -200mm)
Equipment used
- Suction and bucket dredgers,
- Shovels,
- Wheel excavators and
- Draglines
Example of a dragline with a bucket capacity of 15 m³, boom length of up to 80m, digging depth of 40m, travelling speed 0.2 km/hr, weight 1,150 t

Wheel excavator:
Diesel driven single operator machines (Dump trucks, scrapers, excavators have values up to USD 25,000,000. Large electrically driven or diesel-electric drag lines can have values up to USD 200,000,000.

Perils – sinking, falling, overturning, collision, rupture of ropes, collapse of boom, fire, etc.

Conveying

Equipment used - Diesel driven single operator machines (Dump trucks, scrapers, excavators, drag lines) with values up to USD 5,000,000, semi mobile belt conveyors and hoists
In the case of dredge mining, barges and/or pipelines are used.

Perils – fire, flooding, driver error, sinking, toppling, overturning and mechanical breakdown

2.2.2 Underground mining

Underground mines need at least one access shaft or tunnel and this is often split into multiple compartments and must be equipped with workman transportation, coal or mineral hoisting equipment, emergency cage or stair case, ventilation ducts, fresh water, dewatering, compressed air piping, electric power and communication cabling. Additional shafts for transportation of material, workmen or for ventilation may also be installed at different areas of the mine, sometimes much later as part of an extension project.
Classical shaft tower where the winders are in separate buildings

Rope winder with electric drive and hydraulic brakes:

Underground, a **system of tunnels and roads** connects the shaft with the various coal or ore bodies at various depths or levels, but the roads may not always be level following the shape of coal layers or ore bodies or connecting different mining levels or to allow flow of accumulating water in the direction of a sump or shaft from where it will be pumped to the surface. The main tunnels will have, mostly near the shaft, chambers or galleries housing switch and transformer stations, underground air conditioning plants, rest rooms with first aid facilities, fire stations, tool and spare parts magazines and buffer storage facilities for coal or minerals awaiting haulage to the surface. Tunnels and roadways are usually driven by drilling and blasting followed by haulage of rock material by mechanical shovels feeding a conveyor system for rock removal. After each step the profile of the tunnel is graded and the roof and wall support extended. Alternatively tunnels are driven by road headers operating an arm with a rotating head fitted with cutting bits.
The drilling arm is moved by manual or automatic control over the surface of the head of the tunnel, taking away the rock material according to the desired profile of the tunnel and moving ahead in increments after each cutting cycle.

For illustration the **situation for work and equipment underground**, one has to imagine that there are permanent tunnels, road and galleries designed for a longer period of use, generally those near the shaft access, and temporary roads being used only for the time a certain area is being mined. The permanent installations are built in reinforced and if required anchored concrete lining with walls strong enough to resist the build up of pressure with only negligible deformation or they are built in solid and faultless rock of adequate strength. The temporary roads are equipped with only a grid of supporting steel structure and, where required, anchoring and mesh wire lining preventing collapse and rock fall during the period of use. Timber is rarely used nowadays. This simple type of support allows gradual yielding to the rock pressure by friction yielding or deformation of the supporting structure. The diameter of the roads gradually reduces and once they become too small, the roads can be widened again by removal of rock material and reinstallation of supports. This is done by progressing metre by metre thus avoiding loss of support and severe rock fall or collapse.

Some of the roads or tunnels must be large enough to allow not only access by workmen or conveyor belt haulage, but also rail and diesel driven machinery for transportation of larger masses or machinery or equipment needed further away at the place of mining. One has to bear in mind that in the tunnels and roadways, a lot of installations of cables, piping, ventilation equipment and other machinery including transformers can be of obstruction to movement of vehicles, men and material. Dust and blowing air make the vision difficult, especially in temporary roadways where installed lighting is very moderate or non-existent and only provided by the worker’s headlamps or vehicles. Underground work is accompanied by much noise and dust, and heat from the rocks deep down make working conditions even less pleasant as do mud and water present on the floor.

This describes the circumstances that make underground mining difficult and costly in many ways and the occurrence of losses or damage very likely and repair or replacement of machinery time consuming and expensive.
Mining techniques and equipment used

Within the coal field or ore body being mined, the type of mining applied depends on the circumstances existing underground for the coal seams or the shape of ore body and the surrounding rock formation, stability of the roof strata etc.

Different circumstances require different methods and type of equipment and these determine the costs involved.

The methods applied are generally either

- **Drilling and blasting** which is an older practice and is done by drilling holes into the ore body or coal by mobile drilling rigs (hand-held drills, hammers or shovels are no longer used except of minor cases of correction or emergency), blasting of explosives filled into the drilled holes and haulage of the broken material accompanied by setting, moving or extending the roof support. Haulage is done by specialised loaders or mobile shovels feeding a conveyor system.

- **Longwall mining** (mostly used for coal mining) is a mechanised system using shearsers with large rotating cutter heads moving along the coal face (long wall of some 100 to 250 metres) mounted on a flexible chain conveyor laid along the cutting face. The shearer moves from one end of the conveyor to the other cutting a slice of half a metre off the face, while the broken material falls onto the conveyor and is hauled to face end and loaded onto other conveying systems.

Whenever the face moves on for the width of one cut, the self-advancing hydraulic roof support units placed side by side along the face behind the conveyor, move on one by one and are pressurised again against the roof hydraulically. Behind the roof supports, where no protection is needed any more (the waste area), the roof is allowed to cave in. Almost the entire process can be automated.
Room-and-pillar mining or continuous mining: Room and pillar mining is commonly done in flat or gently dipping bedded ores. Pillars are left in place in a regular pattern while the rooms are mined out. In many room and pillar mines, the pillars are taken out, starting at the farthest point from the mine haulage exit, retreating, and letting the roof come down upon the floor. Room and pillar methods are well adapted to mechanisation, and are used in deposits such as coal, potash, phosphate, salt, oil shale, and bedded uranium ores.
Underground conveying of the mined mineral or coal is done by diesel or electrically driven lorry trains or, more often, by a conveyor belt system.

Exposures:
For underground mines the following perils have a specific relevance.

- **Mechanical breakdown**
The rough working conditions for man and machinery, the dust, humidity and narrowness require very tough design of machinery and equipment. Nevertheless damage to machinery and equipment is a very frequent and likely thing to happen. Catastrophic machinery damage is not very likely except for cases of cumulated damage, although some of the individual losses can
be serious. This is aggravated by two facts:

a) machinery designed and made adequate for underground conditions and requirements are very costly to procure, i.e. such machinery has surprisingly high new replacement values.

b) due to the very difficult working conditions, repair works are extremely costly underground. Hours for work underground are not only much more costly than on surface, but much more time is required, and time for travelling from surface to the place of work and back adds to the actual working time. Transportation of machinery to surface repair shops and back is also extremely costly, often requiring dismantling to manageable component sizes / weights due to the narrow space and limited underground transportation facilities.

For these reasons, insurers have to expect a high frequency of losses and a multiple of repair / replacement costs for machinery losses above ground.

- Water hazard
In many mines water is used or seeps through the soil or is used for spray cooling. The resultant humidity combined with warm temperatures underground increase the risk of deterioration of material due to corrosion, facilitating failure of material or machinery. Much more serious is the risk of flooding the mine or sections of it due to unexpected water inrush in excess of the installed pumping capacity or due to failure of pumps etc. It is often most difficult or even impossible to cope with such situations. Mines or sections of it have either taken months to be pumped free again or have had to be closed and abandoned, often resulting in accumulated damage or total loss of machinery and equipment and massive business interruption losses.

- Fire and explosion
The potential of fire and explosion depends on the type of mine, mineral / coal mined and the question of gases released from the mined or surrounding soil / rock material. Uncontrolled explosions can cause very serious damage, but fires can be much more of a hazard. This is due to the very difficult or non-existent possibility of fighting an underground fire. Automatic extinguishing systems are rarely installed except for conveyor belt installations in permanent parts of the tunnel system. Again, it may take very long times to fight and extinguish such fire or the respective mine section must be sealed off and abandoned, at least for a lengthy period.

- Collapse of tunnels or galleries
If a collapse of a tunnel, gallery or roof section in the mine occurs this may cause damage to machinery and equipment immediately concerned. It will be costly to stabilise the situation and remove the material to access the machinery and following repair, continue with the work. Sometimes stabilisation is not possible at reasonable costs and measures and the buried machinery will be lost. In addition however it may also be possible that machinery not affected by the collapse becomes inaccessible and must be considered lost although not damaged. This situation may also apply to occurrences of flooding and fire.

Measures to be considered for insurance are discussed under item 5 of this paper.

2.2.3 Mineral processing

The mineral processing that occurs at the mine site is generally the processing of ore to gain concentrated products that are then exported elsewhere for final processing, high temperature smelting and refining (pyro-metallurgy ). Electro winning is used at some mine sites in order to produce pure minerals. Mineral processing at the mine site is required in order to reduce the quantities of ore that have to be transferred to and processed by the energy intensive conversions to pure minerals during the latter refining and/or smelting stages.

Example of a sulphide ore process at a copper mine:
**Size Reduction (comminution)**

The basic premise of comminution is to reduce the ore size to its size of “liberation” where the minerals of interest are liberated from the waste material. Note that this size has reduced as the average grade concentrations have reduced; smaller grain sizes eases processing and transportation. Some processes do not require comminution such as “in-situ” leaching of low grade ores.

**Crushing**

Crushing usually accomplished in steps with larger pieces being passed back for re-crushing after being separated out by screens or other devices and smaller pieces passing forwards for further size reduction or further processing. Typical stages are:

- **Primary Crushing**:
  - Equipment used:
  - Gyratory mills – taking dry run of the mine up to ore up to 1m (ideal particle size between 1000mm and 200mm)
  - Jaw crushers. Grizzlies
  - Cone mills (200mm to 20mm)

Penis, primary crushing and grinding – machinery breakdown; drive motors and gears can be in the 5 to 30MW range and because of the slow drive speeds required these devices are massive in comparison to 50 or 60 Hz machines thus losses can be expensive; fire can result from the leakage of either hydraulic or lubrication oil and/or the overheating of electrical and mechanical components. Care is required to check for any prototype issues.

Some examples of heavy size reduction machinery:
Primary crushers
A Jaw Crusher is mainly used to crush mining stones primarily, and the largest compression resistance of the material is 320MPa. The jaw crusher is widely used in stone mining, metallurgy industry, building material, highway, railway, and chemical industry.

Working Principle of Jaw Crusher:
The motor transmits power through the belt driving the moving jaw to periodic motion towards the fixed jaw by means of an eccentric shaft. As the angle between toggle plate and moving jaw plate increases the moving jaw moves towards the fixed jaw and the ore is. As the angle between toggle plate and moving jaw decreases the moving jaw moves down and the final crushed ore is discharged from the outlet.

This picture shows a mobile hydraulic-release jaw plant with single-toggle design. The plant has hydraulic overload protection. A high-swing jaw can accept large feed. Machine settings change without drawback rod adjustment. It produces up to 400 tons per hour.

Telsmith Inc., an Astec company, introduced its Model SBX Cone Crusher, which is described as an evolution in design from the company's SBS cone crushers. The unit is engineered with new internal components and crushing chamber profiles that allow it to accept larger feed.

It is said to suit secondary crushing circuits that once required larger crushers. The crusher control system is designed to allow operators to monitor crusher operations whilst protecting the crusher from overload, easily make adjustments to crusher settings and collect operational and maintenance data on the same existing plant controls.
The Zenith B series **Vertical Shaft Impact Crusher** is a most advanced impact crusher in the modern world. It introduces high quality roller bearings, which ensure the smooth running of main unit. Hydraulic system used in upper cap, it is easy and convenient to maintain and replace spare parts. The feeding is using central feeding or central feeding with cascade feeding.

Capacity 120 to 500 t/h, double motor power: 110 to 440 kW

**Grinding**

Grinding is the required powdering or pulverizing process when final size of below 2 mm is needed.

Equipment used:

- Tumbling mills, Autogenous (AG) mills, in which the crushing is caused by the ore colliding with itself, and Semi Autogenous (SAG) mills, in which the crushing is caused by the ore colliding with itself and other objects, e.g. steel balls (ideal particle size between 200mm and 2mm)

- Ball Mills in which the crushing is caused by the ore colliding with steel balls (ideal particle size between 5mm and 0.2mm)

- Rod mills in which the crushing is caused by the ore colliding with steel rods (ideal particle size between 20mm and 5mm)

- High pressure grinding mills (ideal particle size between 20mm and 1mm).

- Pebble mills in which the crushing is caused by the ore colliding with pebbles.

High Pressure Mills can provide the proper grinding measure to all kinds of methods and application. They are mainly applied to the powder processing of mineral products in the industries of metallurgy, construction materials, chemical, and mining, etc. It can produce powder from various non-flammable and non-explosive mineral materials.

**Ball Mill**

A ball mill is an efficient tool for fine powder grinding. The Ball Mill is used to grind many kinds of ore and other materials. Ball mills are widely used in building material, chemical industry, etc. There are two ways of grinding: the dry way and the wet way. It can be divided into tabular type and flowing type according to different forms of discharging material.

To use the Ball Mill, the material to be ground is loaded into the Neoprene barrel which contains grinding media. As the barrel rotates, the material is crushed between the individual pieces of grinding media which mix and crush the product into fine powder over a period of several hours.
Obviously, the longer the Ball Mill runs, the smaller the powder will be. Ultimate particle size depends entirely on how hard the ground material is, and how long the Ball Mill runs.

Semi Autogenous (SAG) mills can have diameters of over 10 m and are driven by electric motors up to 8,000 KW for mills using pinion and gear drive and up to 25,000 for gearless drives.

![Image of a Ball Mill](image)

10 m diameter 10,000 KW SAG

Principle of SAG mill operation

SAG mills utilise steel balls in addition to large rocks for grinding. The SAG mills use a minimal ball charge of 6 to 15%. A rotating drum throws large rocks and steel balls in a catacating motion, which causes impact breakage of larger rocks and compressive grinding of finer particles. Attrition in the charge causes grinding of finer particles. SAG mills are characterized by their large diameter and short length. The inside of the mill is lined with lifting plates which lift the material up and around the inside of the mill. The material then falls from the plates and falls back down. SAG mills are primarily used in the gold, copper and platinum industries, with applications also in the lead, zinc, silver, alumina and nickel industries.

**Perils, primary crushing and grinding** – machinery breakdown; drive motors (particularly in the 20 MW or more range) and gears (particularly cracks developing on the teeth of gear rings), due to the slow drive speeds required these devices are massive in comparison to 50 or 60 Hz machines. Consequently losses can be expensive. Fire can result from the leakage of either hydraulic or lubrication oil and/or the overheating of electrical and mechanical components. Care is required to check for any prototype issues. A further issue is wear on the linings of gyratory mills.

**Solid particle conveying systems**

Equipment used: conveyor belts driven by electrical motors. The belts can be several km in length. Changes in direction or longer distances are accommodated by transfer stations.

**Perils:** Dust explosions in enclosed conveyors, fires caused by overheating of motors and idler pulleys, mechanical damage to belts caused by tramp iron if magnetic protection systems are not adequate.

**Separation**

a) **Gravity Concentration**

Gravity concentration is a process in which particles of mixed sizes, shapes and specific gravities are separated from each other in a liquid, by gravity or centrifugal force. Gravity concentration works better for the size range of 0.074 mm (20 mesh gauge) to 130mm. Particle respond to
various concentrating devices depending on certain aspects such as density, size, shape, chemistry, magnetism and porosity. Depending on these properties, one of many separating devices will be chosen.

b) Magnetic and Electrostatic Separation

The Magnetic Separator can separate raw materials with different magnetic rigidities. The machine works under magnetic force and machine force. Magnetic Separators are designed to recover ferromagnetic materials. The separators are available in designs and sizes to provide solutions for all applications. The heart of each separator is the magnetic system with its unique design, which has a proven record of high efficiency. The Magnetic Separators are available in cyclic design with process vessel diameters from 220 mm to 3,050 mm.

The Magnetic Separator is an efficient equipment for processing fine, feebly magnetic minerals, such as hematite, limonite, wolfram, ilmenite, and tantalum-niobium, etc. In recent years, it is also applied more in purifying quartz, feldspar and nephline. Its magnetic system is a ring-shape chain, closed magnetic circuit with energizing coils made of copper tube and cooled internally by water. Grooved plates made of magnetic conductive stainless steel are used as magnetic matrix.

c) Flotation processes

Flotation is a liquid / solid separation process. A plant of the latest design use the circular tank concept and combine the benefits of circular cells with the unique features of the Minerals mechanism to create the ideal conditions to maximize flotation performance for all roughing, cleaning and scavenging duties.

The machine can be used to separate nonferrous metal, ferrous metal, noble metal, non-metallic mine, chemical material and recycle mine. It features: high inhalation, low power. Each chute can inhale gas, sink magma, separate.
Flotation units:

This process depends on differences in the porous nature of particles and is fed with wet paste from the grinding mills. Certain mineral particles are either naturally hydrophobic (e.g. sulphides) or can be made to be hydrophobic by the addition of surface active chemicals. The hydrophobic particles attach themselves to air bubbles which are pumped out of pipes at the bottom of the flotation cells. The air bubbles together with the attached particles are then scraped off the top of the flotation cell and passed on for further processing. Flotation cells are often used in series.

**Perils:** There are no high temperatures or pressures involved and all velocities are low. A large number of chemicals are used in these processes, some of which can be solvents with relatively low flash points and therefore a storage risk exists, however, since the solvents within the flotation tanks are generally mixed with water the flotation liquid usually has a low flash point.

In the thickener plants the extracts are further concentrated:
**Hydrometallurgy**

**Leaching**
Leaching has been developed for the processing of uranium, gold, copper, nickel and other minerals. In its simplest form heap leaching involves rough crushed ore with a particle size of between 10 and 100mm being stacked on specially constructed leach pads which can be up to 20m wide by 100m in length and 10m in height. Depending on the minerals to be leached the leaching solution is determined. Arsenic is a popular solution for many minerals and this is irrigated through a distribution system onto the pile. The solution containing the leach liquid and the leached mineral (pregnant solution) is collected at the bottom of the pad for further processing.

**Perils:** The leach pad is formed from either natural or manmade, non-permeable materials and the puncturing of the non permeable membrane will lead to loss of the leach liquid and pollution which can cause the pad to be shut down. Flooding of the pad from either rain or run-off water could also cause similar problems.

**Pressurised leaching** is a refinement of the above process using either acids (e.g. for nickel extraction from laterite ores) or alkalis (e.g. for uranium or copper extraction). When the maximum amount of the non mineral bearing rock has been removed, the ore is fed into pressure vessels, known as autoclaves, together with the acid or alkali solvent (or in the case of sulphide rocks which produce their own acid with no acid or alkali) and steam and either oxygen or air. The autoclaves are often stirred and after a certain residence time the products are discharged for further processing. The discharged solution will often pass through regenerative heat exchangers where it will heat the autoclave feed.

**Perils:** Autoclaves are often carbon steel pressure vessels to which lining, more exotic steel linings and/or refractories are attached to protect the carbon steel from corrosion, the lining can become detached from the outer pressure vessel and repair if possible can be lengthy and extensive. The discharge or let down systems, which serve to reduce the autoclave discharge to atmospheric pressure, can also cause problems. Explosions in autoclaves as with any pressure vessel are possible and have occurred.

**Solvent Extraction (SX) Plants**
When metals are extracted from ores by dissolution the leach liquor produced often contains more than one type of metal ion. Each one of the metals has to be recovered in turn and some of the processes used for the recovery include electro-winning, ion exchange and solvent extraction. SX plants utilise organic chemicals such as paraffin are to attract one or more of the metal ions from the solution for further processing. Often hydrocarbon chemicals are used in these processes, some of which can be solvents with relatively high flash points and therefore a pronounced high fire risk exists.

**Electro-winning**
Metal ions can be recovered from leach liquor by applying a voltage, which causes positively charged ions to migrate towards a negative pole. Selective deposition at the pole (plating) can be achieved by controlling the voltage and this property is used to plate out copper from a zinc, iron, copper solution. In certain processes the voltage is kept high enough to allow the plating out of more than one metal ion, the “sludge” thus formed, is then sent for further processing. The main hazard associated with this process is the production of hydrogen gas which must be adequately vented in order to prevent fire and/or explosions.

**Biological digesters**
Solar Ponds: These large lagoons are used to concentrate brine and other solutions by evaporation prior to further processing. Cycle time can be up to 2 years.

**Perils:** flooding of the ponds and dilution of the solution.
Bulk Solids Handling
Belt Conveyors are the most common automated method of transporting materials on mine sites. They consist of an endless belt which is driven by an electrical motor and supported by a series of rollers and idlers. The belts require a feed chute and a discharge chute or, if changes in direction are required, a transfer chute to transfer the conveyed material from one belt to another.

Perils: Fire caused by overheating motors, rollers or sabotage. Damage to the belt caused by use of tramp iron.
Other less commonly used bulk conveying systems include:

- Pipelines often used to transport partially processed materials over long distances to a port prior to marine transport.
- Screw conveyor
- Bucket conveyors
- Pneumatic conveying systems

Water extraction
Filters are generally the first stage of water extraction and depending on the slurry to be dewatered, they can remove up to 80% of the liquid present. For the second and often final stage of separation presses (either batch or continuous) and centrifuges are possibilities.

Acid, alkali plants and air separation plants
Due to the need to access the contained minerals in ores by chemically dissolving the containing rock or other material, acid, alkali and air separation plants have become part of the plant equipment. Their hazardous features must be taken into account, and underwriters of mines have to include the exposures of their risk from those hazards.

2.2.4 Power supply
Mining is a highly power-intensive industry. Mines are utilised with electricity by several varying sources. Main sources are either through an existing grid via transmission lines and substation or, for rather remote mine locations or for political reasons quite often through its own power station.

The power demand is usually in the range of 50 MW up to 250 MW for large mines. Before construction of the mining project, an analysis into potential power generation possibilities would be carried out. Renewable energy such as wind or solar power would normally not be the choice. In rare cases hydro power is possible. Power stations for mines will usually be gas or oil fired units (prefabricated Diesel engine or gas turbine driven) as the preferred option. In few cases, a coal fired station requiring a more complex set-up with boilers, coal and ash handling etc. which are more expensive, will be used. The open cycle based solution of gas and Diesel units would be advantageous in terms of capital cost, time and system simplicity as well as minimising water usage. A combined cycle solution could be advantageous in terms of increased efficiency, reducing fuel usage. This would have the added advantage of lowering the greenhouse gas emissions. Thermal power plants using boilers have advantages if steam is also required in the process e.g. for heating or drying.

There is a range of technology options that can be used for a mining power station. The mining company would usually decide on a turbine manufacturer who would provide proven technology to guarantee high reliability of the operation. The mining company would be well advised to install standby units, because downtime of diesel and gas-turbo sets for breakdown or maintenance are quite frequent. For emergency use, black-start diesel generators should be able to provide sufficient power for basic operation of controls and equipment which should not shut down in order to keep a safe condition and economical restart situation.
Substation transformers are stepping down the high transfer voltage to a useful level required for the plant or machine operation. Overhead power lines or cables will supply all mining facilities such as the electrically driven mining machinery, the large and smaller drives of the ore preparation plant, especially primary and secondary crushers, overland conveyors, milling plant, process plant, etc. as well as the accommodation village and auxiliary facilities. Most of the power, up to 95%, is used for the mining and process plant proper.

For underground supply and distribution, the specific high dangers of potential damage in difficult, dusty, dirty and narrow working conditions, existence of heat, humidity and water as well as the strict prevention of arcing, fires and explosions have to be taken into account in the design of the equipment and its installation and protection.

3. Typical losses, loss scenarios

3.1 Gold Mine – Grinding Plant

Coverage: Machinery insurance and Business Interruption
Year: 2000
Loss type: Machinery Breakdown (deformation of SAG Mill)

Circumstances:
The SAG mill was capable of processing a minimum of 500 tonnes of ore per hour at a stated specific gravity and ore hardness. Manufacturing of the SAG mill shell, steel liners, ring gears and gearbox had been sub-contracted. In particular, the shell of the mill was lined internally with 96 steel liners (140 mm thick) secured to the shell with four bolts each. The liners were made of chrome alloy steel and laid inside the shell with the recommended gap in between (formed by rubber widgets) to allow expected thermal expansion during operation of the mill. Expected life of the liners were 6 to 8 months depending on the degree of defacement and considering a normal charge of steel balls applied to smash the ore.

The SAG mill was no-load tested and hot tested in April/May 2000 according to manufacturer’s directives and then put into operation on 1st June 2000, one month ahead of schedule. During operation a number of problems were reported (lubrication system overpressure, lube pulse, water leaks, bearing seals wear, etc.) resulting in a SAG mill shutdown to allow the manufacturer to investigate possible deformations (mill shell bearing faces and flanges). Further to the above inspection it was noted that a considerable part of the expansion gap between the liners had cold welded abnormally, resulting in overstress of the shell and subsequently in deformation of the shell.

Cause:
Consultants agreed that the SAG mill shell had deformed due to excessive stresses caused by over-expansion of the steel liners, resulting from excessive cold welding between the liners themselves.

Different causes were investigated (including a combination of an inordinate ball charge and a lack of ore feed in the mill during operation) and further to laboratory analysis it was found that liner samples were softer than the specified hardness.

Loss extent:
Given that the shell had been reconfigured by means of new steel liners and repositioning the feed end flange, material costs and labour associated with the repair amounted at around USD 500,000 while business interruption resulted in a loss of gross profit of almost USD 2,000,000 following the complete stoppage of the SAG mill during investigations and repair.
3.2 Gold Mine – Refining Plant
Coverage: Operation/MB and Business Interruption
Year: 2000
Loss type: Fire in bullion furnace in gold room
Circumstances:
During smelting of gold concentrate, the crucible (which supports the smelted gold concentrate) became holed, allowing the molten gold slag to flow into the shroud below. As the shroud incorporates the diesel fed burner, the molten gold ignited on contact with the diesel fuel supply for the burner, generating intense heat and smoke.
Cause:
Sudden and accidental failure of the crucible which apparently did not show any particular cause of failure. The crucible was normally used according to its expected life (20 full applications) and the failure happened before the maximum re-use threshold was fixed to 15 times.
Loss extent:
Extensive material damages to equipment in the gold room were reported and in particular to the bullion furnace tilting mechanism, diesel burner, electrical panel and cables running in the shroud and in the adjacent galleries. The stoppage in the gold room smelting operations was extended for the complete replacement of the damaged equipment, and business interruption had been mitigated through a number of emergency measures, resulting in a moderate loss other than the extra expense costs (up to USD 250,000 policy limit).

3.3 Loss Scenario – Flood
Risk: Coal Mine
Coverage: All Risks of physical loss and damage and business interruption (PD+BI)
Location: Bowen Basin, Queensland, Australia
Year: 2008
Loss type: Flood

This is a photograph of an Ensham Resources Pty. dragline submerged in flood waters at the company’s mine site in Queensland, Australia, released to the media on Jan. 22, 2008. Source: Ensham Resources Pty. via Bloomberg News
Circumstances:
Large parts of Queensland’s central inland and northern coast have experienced heavy rain and flooding associated with a monsoonal low. Various coal mines flooded. Run-off containing pesticides and other chemicals from recent flooding in Queensland could damage the Great Barrier Reef.

Cause:
Severe heavy rainfall and record floods across the north-east Australian state of Queensland’s Bowen Basin occurred during January and February 2008.

Loss extent:
The insurance industry may pay up to USD 1,000,000,000 for this mine to the client for material damage and BI. Total insured and uninsured loss is expected to be around USD 18 billion for the affected region. The mine’s property damage loss is expected to be below USD 250,000,000. The business interruption loss reserve is USD 750,000,000.

A relative small property damage respectively flood loss of ¼ of the total can cause an extremely long business interruption time and cause major gross profit loss of ¾ of the total for the client and insurance industry.

3.4 Slope failure in an open-pit mine

Around 2.5 million tonnes of copper and gold ore and waste material slid over 450 meter in one of the biggest copper and gold mines in the world.

The mine is located at a height of 2,900 – 4,300 meter above sea level. It lies just south of the Equator where the climate is tropical with heavy rain falls. In 2003, copper production accounted for around 7% of the world’s production. Following the incident, the price of copper on the London Metal Exchange rose by some 30% overnight.
Extent of the loss
Copper and gold ore and waste had come loose roughly in the middle of the southern slope of the open pit. When the debris slid down in this mine, eight miners lost their lives and another 13 were injured.

The debris slid right down to the bottom of the pit and destroyed five heavy-duty trucks HDTs with a payload of 240 t, one hydraulic shovel, one drilling rig and other mining equipment. Three other HTDs and other mining machines found their way out of the mine blocked, as the access roads were buried or destroyed. Slope failures of this size are quite rare for open-pit operations.

Cause of the loss
The rock on the southern edge of the open pit was friable. The slope angles had originally been created with a safety factor to cater for these difficult geological conditions. As operations changed, however, and the competence of the rock deteriorated – which was not apparent from the outset – the slope angles became steeper, thus increasing the risk of a failure.

Movements in open-pit slopes are closely monitored, in particular in areas with difficult geology. In the days shortly before the slope failure, geologists discovered a ground movement on the southern slope, but this was not considered to be exceptional. Immediately before the loss event, however, the situation was aggravated by rainfall that was unusually heavy, even for this region – a factor that further contributed to the material slipping.

Insurance aspects
Damage to open-pit slopes and benches is generally excluded in all risk policies for mining operations. The restoration of damaged slopes and benches is therefore not covered either. However, this exclusion does not apply to machinery and equipment located within the mine. The destroyed mining machines were therefore indemnifiable, as was the business interruption loss deriving from the destruction of this machinery.
3.5 South African Mine Disaster:

**Underground train jumps tracks and plunges down shaft, crushing crowded elevator**

Some 100 mine workers were crushed to death when a 12-ton underground train engine and carriage plunged down a vertical mine shaft and hit the crowded elevator almost 1 1/2 miles underground.

The elevator cage was packed with workers when the empty locomotive and car apparently jumped the track in a connecting tunnel and tumbled into the shaft falling several hundred feet before crashing into the elevator and snapping its cable.

The massive train and wire-mesh elevator then plummeted 1,650 feet before smashing into the shaft bottom.

The falling train also hit a second, smaller cage used for inspections, but the occupants managed to escape.

The engineer driving the moving train jumped off it. He survived but had suffered from shock. He said the locomotive had entered the wrong tunnel and crashed through steel barriers intended to stop smaller machinery.

4. Some loss prevention / minimisation aspects

The intention of this paper is not to include a comprehensive loss prevention library, but rather some very pertinent points and references are mentioned.

**General fire fighting aspect**

A mine in a remote location means accessibility is difficult and distance from the closest fire station is long. Therefore a fully operational fire station and professionally trained fire fighting teams should be part of the workforce already during the construction of the plant.

**Lifting and positioning** aspects require primarily a careful degree of planning. Furthermore, due to the last tendencies towards larger pre-fabricated units, the use of more than one mobile crane for the same lift has increased. This type of multiple lift operation requires detailed planning to avoid the possibility of the load becoming unstable resulting in a crane and load collapse. There should be detailed multiple lift planning documents in use.

**Pipeline works** for water supply/disposal and for ore’s blend transportation require extensive trench excavation and station construction, sometimes in remote and less accessible areas.

Pipe laying is not a critical issue, but open trenches, partially or completely excavated, are severely exposed to flooding, sandstorm and silting and minimising the length of open trenches should be aimed for.

**Conveyor belt systems** are extensively used in mining plants to haul coal or ore-bearing material within the mine and process plants with often very long runs and high values involved. Protection against conveyor belt cuts by obstructing pieces, overheating of parts by friction of the moving belt and against fire are highly important for avoiding larger losses, especially underground, where automatic sprinkler systems prove highly important for effective fire fighting.

**Large tanks** experience their largest exposure to damage during construction when they are incomplete. Their instability during this stage exposes them to destructive damage by wind, rain storms, flood and earthquake. Measures to improve their stability by temporary towing or other support structures have proven very effective in preventing or minimising such damage. The other potential hazardous risks are fire and explosion in respect of tanks containing flammable liquids or gases or hazardous chemicals. Adequate fire prevention and fire fighting means, as
described in respective regulations are required to be in operation before filling the tanks. During construction, a fire and explosion hazard exists for tanks being lined with rubber or plastic material, especially when flammable glues or solvents are used, requiring special care, supervision and immediately available extinguishers at hand.

**Processing Plants** have their largest exposures usually during testing / commissioning, when feedstock of flammable liquids or chemicals have been introduced and electric power switched on to energise all electric parts of the plant. **Solvent extraction** processes require significant quantities of combustible agents which have to be kept in proper vessels with instantly operational foam protection systems. Electrical faults or overheated pumps can trigger a large fire as the solution is in an easily ignitable form. Gas fired melting furnaces require the construction and controls of respective safety standards. Even if all components of the plant have been tested individually, the overall testing process under the stated conditions is critical, because faults or failures of plant items or operational defaults may cause large explosions or fire. Therefore completion of all pre-commissioning checks and the full operational condition of all controls and fire fighting equipment must be ascertained before.

For **underground works** it is required that all respective rules and regulations and Equipment and procedure standards have been complied with and are in force once underground works are to be carried out, especially if explosives are used or where coal mines are concerned and coal dust and released gases constitute a specific explosion and fire risk. Water sprays and stone dusting are the most common prevention systems to inert coal dust, while stockpiles should present a compacted storage to exclude oxygen and prevent spontaneous combustion. It is a common problem, that during construction and installation of the underground mine the installation and implementation of all safety equipment and measures is only achieved step by step. Therefore these construction works have to be carried out by well experienced specialised contractors and the performance of works must be done under application of all reasonable temporary safety measures and this should be verified. This applies not only in respect of fire and explosion hazards, but also in respect of mine stability, by carrying out adequate geological investigations beforehand and by applying adequate mechanical, constructional or hydraulic supports to prevent collapse, or in respect of dewatering equipment requiring good excess capacity to cater for unexpected water ingress, and in respect of air conditioning and ventilation and implementation of emergency plans to cater for critical situations and accidents.

**Tailing dams**
Rock fill and earth fill dams projects are particularly exposed to natural hazard exposure (e.g. severe rainfalls, flood, earthquake, landslides) while the design aspect for small-medium sized impoundments is not of particular relevance, given that an appropriate grading curve and a careful selection of rock fill material has been put into practice to ensure embankment’s stability. Tailings dams must be designed and constructed in accordance with internationally recognized engineering practices, local seismic conditions and precipitation conditions to grant geotechnical and chemical stability of the tailings.
To prevent seepage of water through the dam or embankment HDPE liners (from 1 up to 3 mm thick) can be placed against the upstream face. These structures are mostly rock fill embankments with wide crests which allow increasing of the height step by step in accordance with the minimum freeboard to be maintained for safety reasons.
Since the embankments can be located at the end of local drainage systems, proper diversion systems (or cut-off drain) have to be built up to prevent flooding and overtopping during both construction and operation. Spillways have to be part of the project to avoid overtopping in case of severe rainfalls which can not be fully drained by the diversion system.

**Third Party exposures**
Mining plants are usually located in remote areas but populated areas or agricultural land or forests may be nearby. Therefore safety measures must be reasonably taken to avoid third party or environmental damage or poisoning of ground water. With regard to prevention of Third Party damage caused by failure of tailing dams and subsequent environmental damage by toxic tailing substances refer to the above.
During construction, massive earth moving works can cause rock or land slides which can affect areas outside the construction site. Careful geological conditions, design features and work measures need to be analysed adequately before and during the works in order to avoid such accidents.

Site security
The sites have to be fenced in and access should be controlled. Watchmen should be put on duty covering 24 hours, seven days a week.

5. Insurance Aspects

In the insurance market mining industry facilities can be generally covered both during construction/erection and during operation phase by different coverage.

Most of the construction/erection projects are covered by CAR/EAR or project insurances based on standard wordings and endorsements (e.g. Munich Re, Swiss Re or other) whilst almost the entirety of the operation coverage is based on All Risks tailor made wordings.

Given that it would be extremely complicated to argue each single wording, all the statements below refer to conditions and exclusions generally used and special clauses applied such as or similar to Munich Re CAR/EAR, CPI (Comprehensive Project Insurance and CMI (Comprehensive Machinery Insurance) wordings. Examples of Standard Engineering Insurance wordings, clauses and endorsements may be viewed on the IMIA webpage [http://www.imia.com](http://www.imia.com), Library, Weblinks.

Furthermore, depending on local conditions (NatCat exposure, topographical situation, greenfield or expansion projects, etc.) and on specific mining processes (underground or open pit mining, smelting and refining process, etc.) it would be necessary to take into consideration only some of the following recommendations, as a number of them could be inappropriate given the actual risk exposure.

Generally speaking, mining industry includes several hazardous activities and most of the equipment is exposed to intensive material stress and fatigue in an aggressive environment which increases the loss frequency so that rates and deductibles have to be adequate to cater for substantially high and frequent repair or replacement costs.

5.1 Construction (CAR/EAR, TPL and DSU)

Disregarding clauses and endorsements normal for most of the construction/erection projects, we focus on some specific clauses (either extensions or restrictions and exclusions) particular to mining industry peculiarities.

5.1.1 CAR/EAR and TPL

Extended Maintenance
In most cases cover of maintenance works is requested and more specifically cover of “Extended Maintenance” as defined e.g. in MRe endorsement 004 for a period of 12, sometimes 24 months, following completion of the contract works including testing / commissioning and hand over of the project. This extension should be carefully evaluated by the underwriter because much of the plant is under severe stress and critical environment and has a short service life. It could be difficult to prove whether a loss or damage arises from operation or from any hazard covered during the construction / testing period.
Serial Losses
Large mining plants with equipment or machinery items that are installed in greater number such as self advancing hydraulic roof supports of a long wall mine, mobile equipment, or electrolysis cells or flotation units which could suffer same kind of loss triggered by the same failure in design or workmanship. Whether faulty design cover corresponds to LEG2/96, DE3 or LEG3, 96 DE 5 (including faulty part damage) or a similar clause has been agreed, the impact may be quite critical but may be controlled by a Serial Loss clause e.g. as per MRe endorsement 011.

Underground works
CAR/EAR insurance should be limited to the construction of permanent tunnels, roads and galleries and other permanent underground structures which are part of the mining plant facilities (power supply equipment, lighting, ventilation and air-conditioning, pipelines, transportation equipment like conveyor belts, etc.). Underground works concerning the actual mining activity, extraction of coal or minerals directly, not coincidently with the establishing of the mine and testing of the equipment (the project), should not be part of the project contract works, as they are operational mining operations to all purposes. The maximum amount payable in case of loss or damage should be limited to the expenses incurred to reinstate the insured property to a standard or condition technically equivalent to that which existed immediately before the occurrence of loss or damage, but not in excess of a reasonable percentage of the original average per-metre construction cost of the immediate damaged area (see e.g. MRe 101 “Special conditions concerning the construction of tunnels, galleries, temporary or permanent subsurface structures or installations” or other similar endorsements).

Tailing Dams and water reservoirs
Tailing disposal facilities are mainly created by means of embankment dams (earth or rock fill) whose cap height can be increased according to the tailings storage level. Hazards during their construction are the same as with water basin embankments and in particular, overtopping of cofferdam or dam body itself could have a considerable impact because of erosion due to the specific construction technology and materials (recommended conditions see e.g. MRe 104 “Dams and water reservoirs” and EPI 56 “Cofferdams” or other similar endorsements).

Faulty Design and Guarantee Covers
Ore and mineral processing plants include a variety of very heavy or specialised machinery adapted or developed for the special local requirements or process parameters. Underwriters need to take care before they extend the cover to include faulty design or even guarantee covers. Some of the machinery may be of prototypical make, design or application. Similarly to the issue outlined for the extended maintenance period, the cause of a loss or damage may be difficult to be clearly proven as either a Guarantee loss or resulting from operational causes. (For inclusion of Guarantee Cover see e.g. MRe 201 or other similar endorsements)

Access Roads
Considering the remote locations of most of the large mine fields, green-field projects usually include the construction of temporary or service access roads which are often used both for the construction and the operation phases. In particular, temporary facilities are frequently built up with lower standards than usual and can be easily damaged especially by atmospheric events. Irrespective of the period of insurance, losses or damages to access roads should be covered under CAR/EAR policies when under construction only. Once they are completed or taken into use for their purpose they should be excluded from CAR/EAR insurance.

Tank farms safety measures
Because of large steel tanks peculiar characteristics, wind storm risks should be controlled by installing scaffolding and temporary support structures during construction. (See also MRe Endorsement CPI 1268 “Special Conditions: erection of storage tanks”).
Open Pit Excavation
Earthworks related to open pit excavation are not covered under CAR/EAR policies instead being part of operational mining activities. Other earthworks related to foundations, access roads and other facilities (e.g. dewatering pumping station, buildings, conveyor belts, etc.) pertaining to the open pit, remain covered, subject to terms and conditions in the policy. In particular, removal of debris cover should be limited to costs of excavating the original material in case of large earthworks (preliminary works for open pit mining) (see e.g. MRe 111 “Removal of debris from landslides” or other similar endorsements).

Pollution and Contamination
The use of chemical solvents (often toxic) for the mineral ore processing and their discharge in tailings disposal are critical exposures for Third Party losses and in particular for soil contamination, affecting crops, forests and cultures. Third Party Liability due to pollution and contamination damages should be covered only if in the course of a sudden and accidental occurrence and decontamination and reclamation costs should preferably be sub-limited. (See e.g. MRe 209 “Crops, Forests and Cultures” or other similar endorsements).

Testing Period
This is a critical risk more specifically to ore processing plants. A high-quality crusher can be heavily damaged in a few days when operational and service practices and procedures are not implemented as per manufacturer’s recommendations. Hot testing should be limited to a reasonable period of up to 6 to 8 weeks.
All the ore/mineral processing equipment has to be run for their trial only once all fire fighting facilities, prevention and monitoring systems has been completed, tested and put into service.

Phased hand-over
For projects progressing in stages completing construction, testing and being taken into use before other parts of the plant still under works haven’t been completed, phased hand-over should be practised. Commonly the ‘Period of Cover’ in CAR/EAR or Project policies is defined in such a way that the Insurers’ liability expires for parts of the insured contract works taken over or put into service (excluding any maintenance cover granted under the policy). If this definition is modified to extend the coverage of any parts of the project up to their hand-over, which could happen later when already in use, then it should be made sure that there is no double-insurance under the operational coverage for these items. The risk of this extension has to be priced adequately.

5.1.2 Delay in Start Up
Increasing consumption of raw materials has the same effect on mineral prices resulting in a constant growth on in the international exchange markets. Attractive mining market conditions and an increasing request of minerals triggered the development of new projects (expansion or green-field) also encouraging the mining companies to buy Delay in Start Up coverage linked to CAR/EAR or Project policies.

The sum insured basically represents the loss of gross profit due to a reduction in turnover and increased cost of working due to delayed completion of the plant as a result of a material damage loss covered under Section I of CAR/EAR / Project policy.

The comparatively high sums insured in the mining business result in high DSU losses, even due to relatively small material damage. Some machinery or critical parts have extremely long replacement periods. Critical spare parts should be available at site during testing and commissioning in order to minimize the repair time in case of loss.
Construction machinery and equipment

Construction machinery, plant and equipment are not part of the construction works and are commonly excluded from DSU cover. They are usually of no great concern as often plenty of machines are at work and replacement is usually not critical. In larger mining projects some heavy machinery is used which is not so easily replaceable. Due to their high degree of stress and wear and tear, high frequency of losses is not unusual and this could erode the time excess within a short time, if the contractor’s plant management is poor. Before considering inclusion of DSU following damage to any contractor’s plant it should rather be verified that the contractor’s monitoring of his plant in respect of servicing, spare parts management etc. is adequate.

Cover for underground works is usually not recommended due to the complexities involved with repair and replacement, extending repair times often in an unforeseeable way far beyond the normal repair time, e.g. in a case of collapse of flooding of galleries and such perils as fire and explosion as described e.g. under item 2.2.2 Underground mining - Exposures.

Contingent Business Interruption

Similar to BI in All Risks policies, DSU can be extended to contingent events like Denial of Access, Public Authorities, Power Supply, Suppliers and Customers. With regard to these specific guarantees, please refer to the IMIA – WGP 55 (08) Contingent BI in engineering Insurance – Relevant risk & underwriting considerations to improve clarity and achieve best practice standards.

Leeway clause and Actual Loss Sustained

Given the high volatility of minerals’ prices, it is rather difficult to know what the actual loss could be in case of delayed start up of a plant which will be put into operation a few years after the policy signing. A leeway clause up to a fixed percentage of the Sum Insured for DSU could be included given that the claim shall always be indemnified on the basis of the actual loss sustained and the maximum indemnity shall not exceed the Sum Insured multiplied for the leeway percentage fixed in the policy. The premium shall be adjusted at the end of the policy period accordingly.

Furthermore, in case of commodities with extreme price volatility it would be appropriate to include a cap or an additional escalation limit for price per tonne or for the actual loss sustained on a monthly basis in respect of values declared in the policy schedule.

Risk Monitoring and Risk Engineering Service

When CAR/EAR or Project coverage includes DSU insurance, adequate risk monitoring activities have to be carried out to be in the position to fulfil the obligations under the policy if any delay would arise. A sound risk engineering service and reporting should be required by the Underwriter.

The appointed Risk Engineer or consultant monitors the project progress by way of:
- gathering and recording works’ progress reports on monthly basis,
- notifying changes in material information during the erection period,
- regular site surveys and following reports drafting (including risk improvement proposals),
- reporting of incidents and loss occurrences without delay as they may have an impact on the progress of the works.

Each of these aspects contributes to the insurer’s knowledge as the project progresses and to the possibility of taking action where there are matters of concern to them.

5.2 Operation (MB, All Risks and BI)

All Risks Covers including Machinery Insurance are widely used. Policies like the Munich Re CMI (Comprehensive Machinery Insurance) provide a very wide and comprehensive protection
against operational material damage (property damage and machinery breakdown on an “All Risks” basis) and business interruption.

More complex variations of cover may be seen. When risks are covered under tailor made wordings or include limits to self retained exposures, the extent of the coverage or underlying conditions have to be carefully analysed and understood. Furthermore, in case of excess of loss layers, these have to be priced with proper tools and their exposure has to be evaluated in light of the risks involved, terms and conditions of underlying primary coverage or layers (e.g. drop down for guarantees with sub-limits in the aggregate per period).

Below we point out some aspects of common extensions or restrictions for operation insurance of mining plants.

5.2.1 MB and All Risks

Underground Machinery and Equipment

Loss or damage to underground machinery and equipment due to flooding, inundation, landslide or rockslide, subsidence, collapse of adits, galleries and tunnels are included in the coverage. Their loss can be substantial, because loss or damage may not be restricted to individual machinery items, as is usually expected in other risk circumstances than underground. The joint loss of a great number of machinery and equipment can be affected by one of such occurrences, and in the case of “All Risks” policies also by fire and explosion, however abandonment remains excluded.

An appropriate aggregate limit of indemnity and a specific deductible are usually agreed in respect of this special exposure of underground machinery and equipment in mining industry. (See e.g. MRe CMI Endorsement 1302 – Underground Machinery and Equipment).

Serial Losses

Large mining plants with equipment or machinery items that are installed in greater numbers such as self advancing hydraulic roof supports of a long wall mine, mobile equipment, or electrolysis cells or flotation units which could suffer the same kind of loss triggered by the same failure or defect in design or workmanship. The impact may be quite critical but may be controlled by a Serial Loss clause e.g. as per MRe CMI endorsement 1360.

Refractory materials and/or masonry

Aggressive working environment and products used during processing operations impair the durability of refractory materials or masonry, parts usually excluded due to their short service life (impaired by deterioration by heat, wear and tear) like refractory materials or masonry in industrial furnaces used in ore processing plants. They can be included in the cover by means of an appropriate endorsement basing indemnity on an annual depreciation rate specified in the policy or by the manufacturer.

Equally loss of refrigerant and lubricating oil caused by an event not excluded in the policy can be indemnified by the insurer subject to a proper depreciation scale according to life expectancy indicated by the manufacturer.

(See e.g. CMI MRe 1361 Refractory materials and/or masonry and CMI MRe 1362 Refrigerant and lubricating oil or other similar clauses).

Conveyor belts and chains

Conveyor belts, steel cables and chains play an important part in the mining industry. They are parts subject to rough working conditions and continuous wear and tear. Machinery insurance excludes damage to these components, but in the mining industry there are high values involved (e.g. with heavy draglines, mine hoists and the miles of conveyor belts). Therefore cover of these components is usually requested. Underwriters should carefully evaluate the risk
of covering these parts when endorsing the policy e.g. by MRe CMI Endorsement 1363 or similar clauses granting cover on basis of an annual depreciation rate.

**Electric machines**
Most of the mining equipment (e.g. SAG mills, crushers, conveyor belts and hoists) are powered by huge electric motors, and electric substations usually situated in the vicinity of the location of power demand include large transformers. Rewinding of such machines is costly and in the case of risks with many large electrical machines, underwriters are recommended to consider endorsing the policy by a clause, basing indemnity on an annual depreciation rate for the electrical windings, considering their fast aging compared to the overall service life of the machine e.g. by Munich Re CMI Endorsement 1365 “Rewinding of electric machines” and 1371 for Overhauling of electric motors and generators.

**Slope stability and pit wall collapse**
Because of uncertainty of pit wall stability and their nature (some of them are only an intermediate stage of the excavation process) material damages to slopes should be excluded. Possible damage to draglines or other mining equipments following pit wall collapse remains covered.

**Mine dewatering and pumping facilities (back-up)**
Both underground and open pit mines can suffer flooding due to rush in of water, heavy rainfalls and/or ground water seepage. Adequate pumping facilities and satisfactory back-up capacity should always be in operative state on site.
The underwriter should consider introducing minimum conditions on basis of potential water inflows.

### 5.2.2 Business Interruption

**Business interruption following Machinery insurance damage**
Considering the high exposure and claims frequency of mining machinery due to intensive material stress and aggressive environment in mining industry, the BI section should require reasonable spare parts availability and an adequate time excess. Cover for underground works is usually not recommended due to the complexities given for repair and replacement, extending repair times often in an unforeseeable way far beyond the normal repair time, e.g. in a case of collapse or flooding of galleries. This applies even more so for All Risks covers including such perils as fire and explosion as described e.g. under item 2.2.2 Underground mining - Exposures.

**Sum insured on unit-price basis and price volatility**
In order to better define indemnities and insurer’s exposure in case of BI losses, the annual sum insured of the operational business interruption section can be defined as a multiple of an agreed unit price which is the number of units produced in one year. The indemnity payable shall be the amount calculated by multiplying the number of units which would be produced but for the material loss or damage with the agreed unit price.
The above does not consider the high volatility of minerals’ prices which could also noticeably vary in relatively short periods. In addition a leeway clause up to a fixed percentage of the Sum Insured for BI should be included given that the claim shall be indemnified on the basis of the actual loss sustained and the maximum indemnity shall not exceed the Sum Insured multiplied for the leeway percentage fixed in the policy. The premium shall be adjusted at the end of the policy period accordingly.
Furthermore, in case of commodities with extreme price volatility it would be appropriate to include a cap or an additional escalation limit for price per tonne, per unit or for the actual loss sustained on a monthly basis in respect of values declared in the policy schedule.
(See e.g. MRe CMI 1374 “Sum insured on unit-price basis” or other similar clauses).
Contingent Business Interruption

Operation Business Interruption can be extended to contingent events like Denial of Access, Public Authorities, Power Supply, Suppliers and Customers. In particular, third party port facilities blockage due to vessels sinking should be carefully evaluated where there are no effective alternatives to deliver the final product because of unfavourable geographical location. With regard to these specific guarantees please refer to the IMIA – WGP 55 (08) Contingent BI in engineering Insurance – Relevant risk & underwriting considerations to improve clarity and achieve best practice standards.

6 PML considerations

6.1 Loss Scenarios

Whilst the exact PML definition varies within the markets, PML for Engineering insurance business is mostly taken as the probable maximum loss as opposed to the maximum possible loss which could for example include planes crashing on the mine site. Some insurers / reinsurers prefer the use of the maximum possible loss for defining their maximum exposure.

The PML must be evaluated in respect of all perils and extensions covered under the insurance policy under consideration. “All Risks” covers usually include fire, explosion and natural hazards.

When calculating the PML, one of the first questions is always “is BI (business interruption) or ALoP (advance loss of profits or delay in start-up) covered?”. If it is and the amount of profits covered is significant, then even small material damage losses must be considered besides major material damage events, if they are likely to involve long repair times.

Considering some of the processes and machinery and their locations described previously, long delay periods due to material damage of comparatively smaller size could result from:

- Damage to the primary crusher or its motor
- Damage to the poles of mill wrap around motors or damage to the girth gears for conventionally driven mills
- Collapse of tunnels used by transportation systems

Under the category of large material damage with or without business interruption insurance the following should be considered:

- Flooding of the process plant or works and equipment of an underground mine or open pit
- Gas explosion and/or fire in underground workings
- Earthquake
- Explosion of the air separation plant
- Fire, explosion at the power plant or disintegration of the turbo set.
- Autoclave rupture
- Fire at a solvent extraction plant
- Hydrogen fire and/or explosion in the electro winning plant
- Explosions on explosive mixing trucks or in explosives or detonator stores
- Collapse of tailings dam
- Fire in fuel storage areas (oil, petroleum, coal)
- Fire in truck maintenance workshops

Please see IMIA WGP19 2002 for further details on definition and assessment procedures.
6.2 Base PML calculation

The PML rationale must embrace the most significant of all possible loss scenarios for a base (or technical) PML estimate of costs on reinstatement basis and, if covered, loss of profits. The aim of this section of the Paper is to provide a guideline template for various loss scenarios due to:

Natural Hazards
Natural hazards are normally defined as ground movement or earthquake water inundation, earthquake, rain, flood, windstorm, frost, and volcanism. These risks are wholly dependent on the actual location of the risk, and are normally evaluated from historical data.

Detailed maps of earthquake, flood and windstorm exposures are in general readily provided by leading reinsurers. Localised hazards such as a dormant fault line bisecting the project site, or nearby seasonally flooding water courses, or ground liquefaction hazards need more careful verification.

The direct hazards of these perils should also be compounded by subsequent scenarios such as “fire following” for earthquake, or collapse with flooding or inundation events.

External Hazards
External hazards normally have a proximate cause beyond the control or influence of the project itself, other than if mitigated against within the scope of a duly rigorous project risk register (or risk management plan). These scenarios include arson, vandalism, or theft. Identifying potentially catastrophic moral hazards affecting the project will inevitably be very subjective. Upstream dam failures (or tailings dam failure), or nearby chemical plants for example or other similar offsite man-made hazards belong to this category and need careful consideration of the project situation.

Construction Method
Please see prior sections of this report regarding construction details and risks for Mining construction.

Design & Materials
The design criteria adopted for the project need to be robust so as to prevent failure beyond the required Critical to Quality specification(s). The risks emanating from defective design and the consequences of failure can be substantial. Material defects and related hazards can also relate to inherent vice being defined as “the tendency of material to deteriorate due to the essential instability of the components or interaction among components”, leading to combustion reactions or failure of coatings or catalysts for example. Such risks are magnified where defective designs or materials are used throughout the project or with repetitive components.

6.3 PML Analysis Process

The schematic below indicated the application of the PML Scenario Template to test each project component and all components collectively for the major perils. Even a large project spread over several 100km can be affected by flood or earthquake, and in particular if “fire following” events are also relevant.
6.4 PML Scenario Template

<table>
<thead>
<tr>
<th>Exc. Method</th>
<th>Effects from</th>
<th>Earthquake &amp; Fire following</th>
<th>Flood</th>
<th>Other</th>
<th>Fire / Explosion</th>
<th>Other</th>
<th>Fire / Explosion</th>
<th>Other</th>
<th>Geo-technical</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Cast Mining</td>
<td></td>
<td>• • •</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td></td>
<td>•</td>
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<td>• • •</td>
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</tr>
<tr>
<td>Underground Mining</td>
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<td>• • • •</td>
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<td>• • •</td>
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<td>• • •</td>
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<td>• • •</td>
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</tr>
<tr>
<td>Processing Plant</td>
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<td>• • •</td>
<td>• • •</td>
<td>• • •</td>
<td>• • •</td>
<td>• • •</td>
<td>• • •</td>
<td></td>
<td>• • •</td>
<td></td>
</tr>
<tr>
<td>Tailings Dam</td>
<td></td>
<td>• • •</td>
<td>• • •</td>
<td>• • •</td>
<td>• • •</td>
<td>•</td>
<td>• • •</td>
<td></td>
<td>• • •</td>
<td></td>
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<tr>
<td>Inland Infrastructure / Balance of Plant</td>
<td></td>
<td>• •</td>
<td>• • •</td>
<td>•</td>
<td>• • •</td>
<td>• • •</td>
<td>• • •</td>
<td></td>
<td>• • •</td>
<td></td>
</tr>
<tr>
<td>Ship loaders / Stackers &amp; Reclaimers</td>
<td></td>
<td>• •</td>
<td>•</td>
<td>•</td>
<td>• • •</td>
<td>• • •</td>
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<td>• • •</td>
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</tr>
<tr>
<td>Jetties</td>
<td></td>
<td>• • Ø</td>
<td></td>
<td></td>
<td>• • •</td>
<td>Ship Impact</td>
<td>•</td>
<td></td>
<td>• • •</td>
<td></td>
</tr>
</tbody>
</table>

**Generic Effects** (a rough guide for PML factors for each scenario / component)

- Ø unaffected, unlikely to suffer damage
- • = damage very unlikely but should be considered.
- • • = low, minor damage, can be repaired
- • • • = medium, significant damages, may require alternative working method for repair
- • • • • = high, catastrophic destruction, failure or collapse.
6.5 Policy PML calculation

The final Policy PML follows the Policy terms and conditions. The policy may allow for an escalation (usually around 15%) in the contract value and an amount for removal of debris and other extensions. These additional limits, as applicable to the chosen loss scenario, will be included in the PML calculation.

**Example**

<table>
<thead>
<tr>
<th></th>
<th>Policy Sum Insured [USD]</th>
<th>PML %</th>
<th>PML [USD]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contract Works</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of Damage (TSI or TCV)</td>
<td>600,000,000</td>
<td>36</td>
<td>216,000,000</td>
</tr>
<tr>
<td>Escalation %</td>
<td>15</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Escalated Replacement Cost</td>
<td>690,000,000</td>
<td></td>
<td>248,400,000</td>
</tr>
<tr>
<td><strong>Policy Extensions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Removal of debris</td>
<td>20,000,000</td>
<td>100</td>
<td>20,000,000</td>
</tr>
<tr>
<td>Professional Fees</td>
<td>5,000,000</td>
<td>100</td>
<td>5,000,000</td>
</tr>
<tr>
<td>Expediting Expenses</td>
<td>2,000,000</td>
<td>100</td>
<td>2,000,000</td>
</tr>
<tr>
<td>Mitigation Expenses</td>
<td>5,000,000</td>
<td>100</td>
<td>5,000,000</td>
</tr>
<tr>
<td>Other</td>
<td>8,000,000</td>
<td>100</td>
<td>8,000,000</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>730,000,000</td>
<td></td>
<td>288,400,000</td>
</tr>
<tr>
<td><strong>Advance Loss of Profits (DSU)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indemnity Period</td>
<td>18 Months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Excess</td>
<td>90 Days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Profit</td>
<td>120,000,000</td>
<td>15/18</td>
<td>100,000,000</td>
</tr>
<tr>
<td>Claims Preparation Costs</td>
<td>250,000</td>
<td></td>
<td>250,000</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>120,250,000</td>
<td></td>
<td>100,250,000</td>
</tr>
<tr>
<td><strong>Combined PML</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contract Works (mat. Damage)</td>
<td></td>
<td></td>
<td>288,400,000</td>
</tr>
<tr>
<td>Advance Loss of Profits (BI)</td>
<td></td>
<td></td>
<td>100,250,000</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td></td>
<td>388,650,000</td>
</tr>
<tr>
<td><strong>Company share</strong></td>
<td></td>
<td>10%</td>
<td>38,865,000</td>
</tr>
</tbody>
</table>

Exchanging figures for the main loss scenarios will show which one results in the highest combined PML.