Abstract – This paper shall discuss the effects on mine design, operation and maintenance as a result of the inclusion/use of chemicals that produce explosive atmospheres. A brief discussion in relation to the acceptance of EEHA principles within the mining community – the age old how can it be hazardous when you can eat it argument. Finally, mines are interesting in as much as they may have both dust and gaseous hazardous areas, what is the outcome when the hazardous zones overlap and a piece of equipment must be certified to both dust and gaseous requirements? Is such equipment readily available in the market?

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1. Introduction

The mining process facility differs from the typical Oil & Gas process facility in a very simple way, with O&G facilities the “product” is the hazard causing material whereas with mining it is typically the reagents required to implement the process that can cause the hazardous areas. As such the typical mining hazardous area is significantly smaller than that of an O&G facility and can even be separated from the majority of the process to reduce potential impacts. These areas are typically confined to the reagents facility and reagents storage areas of a mine site, however this is not always the case.

This simple fact is probably the main reason why for a historical period the mining industry trailed the O&G industry in as much as understanding the requirements for EEHA.

There is a further differentiator between the two industries, mining reagents facilities will quite regularly contain hazardous dust areas in close proximity to the gaseous hazardous areas. In fact in some instances these will overlap with the resultant conundrum of either requiring dual certified equipment OR specifying for one zone and ignoring the other? Not something any competent EEHA designer would comfortably do.

Finally, as is well known in the O&G industry there are significant costs that are directly related to operating and maintaining EEHA areas and equipment. These costs need to be adequately determined at all stages of a mines life, it may even be more cost effective to design now for future reagents requirements due to a changing ore body and the resultant chemical process changes.
1.1 Who is Responsible?

AS/NZS 3000:2007 Clause 7.7.2.1 clearly states that it this the party that is “in control” of the installation who is responsible for the classification and maintenance of hazardous areas.

HB 13 Section 2.1 states that it is the Owner/Occupiers responsibility with the emphasis being on the Occupier as the Owner may not be present on sight in any meaningful capacity. Section 2.3 (a) reinforces the above statement and goes on to mention specific states of Australia where this is “more enforceable” than in others due to the implementation of OH&S legislation.

2. Relevant Standards

The below list of standards contain the relevant gaseous and dust hazardous area standards:

- AS3000:2007 Wiring Rules
- AS/NZS 4745 Code of Practice for Handling Combustible Dusts
- AS/NZS 4761 Competencies for working with electrical equipment for hazardous areas
- AS/NZS 60079 Series of standards for hazardous areas
- AS/NZS 60079.10.1 Gas classification
- AS/NZS 60079.10.2 Dust classification
- AS/NZS 60079.20 Data for flammable gases and vapours

What is evident from detailed inspection of these standards is that, without an exhaustive list of discrepancies, the standards refer to superseded standards. The process of change through standards appears to be gradual and can confuse the inexperienced EEHA engineer at times.

3. Regulatory Requirements

Mines Safety and Inspections Act (Regulations) 1995 essentially governs the manner in which mines in Australia are to be operated, managed and reported to the relevant state authority. In relation to hazardous areas Clause 5.4 refers to complying with AS2380. This further accentuates the point made in the section immediately above, Acts need to be made current to reflect the changing requirements of Australian Standards.

4. Reagents Facilities

Reagent facilities in mines contain the chemistry which makes the process viable and is dictated by the type of mineral being processed and the chemical composition of the raw ore. Reagent applications within a process can be identified as providing the following functions:
(i) Leaching – the process by which a material is removed from a solid into a water based solution.

(ii) Flotation – process by which mineral particles cling to bubbles in the solution on the addition of blown air. The mineral particle rich bubbles float to the surface of the solution and are skimmed off.

(iii) pH modifiers – as the name suggests control the pH of the process stream as required, an alkaline or acidic solution may be required.

(iv) Dewatering aids – removal of excess water such as in filter presses, some reagents aid this process.

(v) Cyanide detoxification – removal of cyanide from the gold tails stream to meet international environmental requirements.

(vi) Solvent extraction (SX) – moving of selected minerals from one aqueous solution containing the minerals to another solution to further the purification and recovery process.

4.1 Typical Reagents

There is a seriously large number of reagents used, especially in flotation. Furthermore many of the flotation and solvent extraction reagents are proprietary mixes thus whilst they are based on a certain chemical they have their own twist which may change the characteristics of the base chemical from hazardous to non-hazardous or vice-versa. Trying to summarise this in a couple of paragraphs or tables is difficult. See Appendix A. (1)

4.2 The MSDS

The Material Safety Data Sheet is typically the first reference point to determine hazardous properties of chemicals/substances onsite in the mining environment. As stated previously in the O&G industry the process product is the main source of hazardous areas so the potential for hazardous areas is understood at the outset of the project, whereas for the mining industry this can develop during project definition as understanding of the ore body grows and subsequent process chemicals are determined.

MSDS are required to provide information on the explosive nature of the product they cover so that those handling the material can readily determine if a product has explosive properties. The definition of the flammability, chemical composition for liquids/gases and therefore gaseous hazardous area variables such as flash point are well defined and if in doubt AS/NZS 60079.20 is readily available for reference. However, when combustible dusts are mentioned it is not so easy to determine the relevant hazardous area properties nor is there a ready reference standard available to look up “typical” properties.

4.2.1 AS60079.20 – Gaseous

Appendix B contains the MSDS for Methyl Isobutyl Carbinol (MIBC) which as discussed in section 4.1 above is a common frothing agent in flotation processing plants. The datasheets states flammable or EEHA relevant properties as follows:
Section 3 Hazard Identification – Flammable.

Section 5 Fire-fighting Measures – Flammable liquid... Avoid ignition sources...

Section 8 Exposure controls – Engineering Controls. Vapour heavier than air – prevent concentration in hollows or sumps.

Section 9 Physical and Chemical Properties;
   a. Molecular formula,
   b. Specific gravity,
   c. Relative vapour density,
   d. Flash point, and
   e. Flammability limits.

Section 14 Transport Information – Class-primary 3 Flammable Liquid.

Section 15 Regulatory Information – R10 Flammable.

From the above it should be clear that a significant amount of EEHA information is immediately presented to the reader of this MSDS. Further due to the inclusion of the molecular formula in section 9 quick reference to AS/NZS 60079.20 will show the remaining properties required for classification and design.

4.2.2 Properties of Dusts

Appendix C contains the MSDS for Magnafloc which as discussed in section 4.1 above is a common thickening reagent in many mining process plants.

Section 5 Fire-fighting Measures – Dust may form explosive mixture with air. Avoid heat, flames and ignition sources.

The above limited information is not sufficient to adequately classify and design areas of a plant where Magnafloc is present. Further specific omissions from the MSDS are below:

Section 8 – Exposure Controls/Personal Protection – Engineering Controls, nothing stated that references the need to consider explosive hazardous areas.

Section 9 Physical and Chemical Properties;
   a. Cloud ignition temperature,
   b. Layer ignition temperature,
   c. Minimum concentration g/m³,
   d. Electrical resistivity,
   e. Particle size, and
   f. Minimum ignition energy (kJ).

In relation to dust HA properties and MSDS' on initial reading you may consider the above a one off, not so, see below and Appendix D for MaxiFlox:
(i) Hazard Classification – Nil data.

(ii) Chemical Properties – Nil relevant data shown.

(iii) Precautions for Use – Flammability…flammable dust clouds may be formed.

(iv) Safe Handling Information – Fire/Explosion Hazard…refer to flammability info.

The reference in (iii) immediately above should present a red flag to the astute HA classifier and should result in an immediate search for the required information. Unfortunately there is no AS/NZS 60079.20 to quickly refer too to determine the required properties. However, HB13:2007 Table 8.8 does give some guidance limited though that is.

It should be evident from the above that the MSDS is NOT adequately conveying the required data for the classification and design of Dust explosive hazardous areas. The question must be asked:

Are the requirements on manufacturers to present MSDS information for potentially combustible dusts not strict enough?

With the lack of information for the correct classification and design as a result of the use of these products as reagents, it is incumbent on the classifier to have the material tested to determine the required properties in accordance with AS/NZS 61241.2.1/2/3. These tests can cost $30,000 and is therefore a considerable burden on the engineer (project) which should be the responsibility of the manufacturer to provide.

4.2.3 Materials Handling Plant Materials

Some process plants fall under the Mining Regulations and Act although not strictly speaking being mines, Arc Furnaces for example. These types of plants have significant materials handling operations and it is not unforeseeable that one or more of the required materials may form combustible dusts.

As such it is probably not immediately apparent if such materials have the potential to form explosive dust atmospheres. It is therefore incumbent on the original design engineer (engineering company), or for later upgrades process modifications for the operations engineering manager, to ensure materials are suitably tested to ensure combustible dusts cannot be formed.

An example of such a material is coal, which an entire industry is built around. The process of transporting coal from stockpile to the process point will cause fine particle dust. As it is a known combustible material, and hence assumed to be capable of creating explosive dust atmospheres, the specific coal in question needs to be tested to AS/NZS 61241.2.1/2/3 to determine all of the relevant characteristics.

Later it will be shown, Case Study 2 that in some cases even when this initial testing is done correctly, plant management and subsequently a brownfields engineering companies can fail to adequately classify and manage the risk. In this particular
instance it was evident that all parties were not suitably experienced with EEHA principles and subsequently made incorrect decisions OR ignored such advice.

4.3 Gaseous Hazardous Areas & Classification

Gaseous hazardous area classification and design for mines follows the same principles as for the Oil & Gas industry, AS/NZS 60079.10.1. As has been stated previously it is just the locations that would differ such as storerooms, reagents facilities and in some cases a tun dish.

This later location does pose an interesting question as the volume of the tun dish typically sits below the minimum volume prescribed in AS/NZS 60079.10.1. The classifier is therefore required to inspect IP 15 and API505 for appropriate classification techniques. Case study 1 covers this problem in detail.

For completeness gaseous zones are described below:

(i) **Zone 0**: An area in which an explosive gas atmosphere is present continually or for long periods or frequently.

(ii) **Zone 1**: An area in which an explosive gas atmosphere is likely to occur in normal operation occasionally.

(iii) **Zone 2**: An area in which an gas atmosphere is not likely to occur in normal operation but, if it does occur, it will exist for a short period only.

The classification of areas, as above, necessitates the designing of equipment to operate within these hazardous areas. Specialised equipment is required to be installed, equipment certified to either ANZEx or IECEx certification schemes and belonging to various Ex protection techniques. Equipment is given a protection level grouping to identify which zones it is allowed to be installed in, these are indicated below:

(i) **EPL Ga**: Equipment for explosive gas atmospheres, having a “very high” level of protection, which is not a source of ignition in normal operation, during expected faults malfunctions or during rare malfunctions.

   *Suitable for Zone 0.*

(ii) **EPL Gb**: Equipment for explosive gas atmospheres, having a “high” level of protection, which is not a source of ignition in normal operation or during expected malfunctions.

   *Suitable for Zone 1.*

(iii) **EPL Gc**: Equipment for explosive gas atmospheres, having an “enhanced” level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences (for example failure of a lamp).

   *Suitable for Zone 2.*

*See the tables below which are extracts from the standards.*
### Table 2.1 – Gases and vapours—Relationship between EPLs and types of protection and applicable Standards

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NOTE: For protection by ventilation, Ex 'V' in accordance with AS 1482, refer to 19.
4.4 Dust Hazardous Areas & Classification

Dust hazardous area classification follows the principles of AS/NZS 60079.10.2, much like AS/NZS 60079.10.1. As such classification and design for such areas is relatively straightforward and does not present many challenging technical concerns with the exception of combined gaseous and dust hazardous area zones. This is discussed in section 4.5 below.

The principal concerns with dust classification are the formation of dust clouds, which due to the suspended particles in oxygen rich air can be explosive, and the formation of dust layers which can burn and then ignite dust clouds. Dust layers are extremely dangerous in as much as if a cloud were to explode a pressure wave will cause all available dust in a successive expanding ring to become explosive dust clouds. In this manner ignition of dust layers can be catastrophic.

Dust hazardous areas are roughly analogous with gas areas, for clarity they are listed below:

(i) **Zone 20**: A place in which an explosive dust atmosphere, in the form of a cloud of dust in air, is present continuously, or for long periods frequently.

(ii) **Zone 21**: A place in which an explosive dust atmosphere, in the form of a cloud of dust in air, is likely to occur in normal operation occasionally.

(iii) **Zone 22**: A place in which an explosive dust atmosphere, in the form of a cloud of dust in air, is not likely to occur in normal operation but, if it does occur, will persist for a short period only.\(^4\)

Similar equipment to that available for gaseous hazardous areas is also available, certified to the same schemes but suitable for dust hazardous areas. The protection level descriptions are indicated below:

(i) **EPL Da**: Equipment for combustible dust atmospheres, having a “very high” level of protection, which is not a source of ignition in normal operation, during expected faults malfunctions or during rare malfunctions. 

   *Suitable for Zone 20.*

(ii) **EPL Db**: Equipment for combustible dust atmospheres, having a “high” level of protection, which is not a source of ignition in normal operation or during expected malfunctions.

   *Suitable for Zone 21.*

(iii) **EPL Dc**: Equipment for combustible dust atmospheres, having an “enhanced” level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences (for example failure of a lamp).\(^5\)
4.5 When Dust & Gas HA’s Overlap

Reagent facilities are typically isolated away from other sections of a mining processing facility for several reasons:

(i) Isolation of potentially dangerous hazardous areas,

(ii) Access for replenishment of reagents.

For these two reasons quite often dust and gaseous hazardous areas overlap. Most equipment is certified for a single EPL type, gases or dusts, some equipment is dual
certified, however, despite dual certification some gaseous protection techniques are not allowed in dust zones and vice versa. AS/NZS 60079.14 Tables 2.1 & 2.2 detail the approved equipment per zone, included as Appendices B & C respectively.\(^{(5)}\)

By inspection of these tables it should be clear that the implementation of one technique for gaseous requirements does not immediately satisfy the requirements for the dust hazardous area. Astute engineers recognize this issue early in the design and can respond appropriately by separating the areas, unfortunately this is not often the case or it is not possible.

For the unfortunate incidences where separation cannot be achieved there does not appear to be an acceptable mechanism to adequately alleviate the risk, or so it would appear. Section 5 below introduces a risk assessment approach available to “management” by which dust hazardous areas after suitable classification can be deemed of a manageable or acceptable risk level such that measures are not implemented for dust hazardous areas. In some cases, very high ignition temperatures combined with a high g/m\(^3\) and large particle size material, this is an acceptable approach but in many it is not.

### 5. Risk Management

AS 4745 Code of Practice for handling combustible dusts, provides plant operators a risk management process by which they can identify, analyse and control the risks by their company risk policy. In some instances this even includes ignoring the hazard altogether, Case Study 2 will discuss this at length.

To qualify the above Clause 4.2 (g) requires that personnel at all operational and maintenance levels involved with the combustible dust areas are competent. Further the risk management process specified in this standard, specifically Clause 2.2.5 (e), provides a mechanism for management to introduce a “procedure” as a means of managing the risk. A typical procedure implemented is a “housekeeping” procedure to reduce the occurrence of dust layers and clouds.

The risk to the above process is that inadvertently, managers without adequate knowledge of the potential risks associated with hazardous areas, can be involved in and conduct a risk assessment that results in no actions or an action which will not adequately address the risk for the long term. Remember identification and management of hazardous areas is not a core mining skill set.

### 6. Capital, Operation & Maintenance Costs as a Result of EEHA

#### 6.1 Capital

Equipment for hazardous areas is more expensive than that for normal environments, this is well known, the factor by which the costs differ vary depending on the protection technique employed and the type of instrument technology required. As reagent facilities for mines do not form a large part of the process equipment the incremental cost of having hazardous reagent facility areas is not overly burdensome from a capital cost perspective.
If the ore body changes through the life of the mine this may require a change in the chemical reagents. Careful consideration should be given to the required reagents as some new reagents may cause hazardous areas where previously there were none. Upgrading a previously non-hazardous facility to be compliant with EEHA equipment requirements can be capital intensive.

Such upgrades can require the complete replacement of all electrical and instrumentation equipment within the reagent facility. In some cases it is found that the reagents MCC is within a hazardous zone, all of a sudden the costs have tripled if not more. Further, if there were no previous hazardous areas, engineering and maintenance now have to become competent to operating and maintaining equipment for hazardous areas.

Case Study 2 shall discuss costs of upgrading a plant.

6.2 Operation & Maintenance

Operation and maintenance of equipment for hazardous areas is more expensive than that for normal environments due to:

(i) The requirements of ensuring personnel competence to AS/NZS 4761,
(ii) Isolations and permit works requiring additional precautions to ensure gas/dust free,
(iii) The need to maintain a hazardous area verification dossier (HAVD), and
(iv) Equipment costs more.

When a site is first commissioned and there are hazardous areas to operate and maintain the constructor/commissioning company are typically required to hand over the HAVD and provide operational training to personnel. Further, operations and maintenance procedures are also developed and handed over to the plant operator (normally the client). As such for this type of project in most instances the operations and maintenance team are well equipped to adequately deal with hazardous areas.

For process plants were the reagents facility is upgraded and as a result hazardous areas now form a part of the regular operations and maintenance framework, the level of expertise of the operations and maintenance personnel may vary. Further, management level EEHA experience will and often is most probably lacking.

As EEHA is not a core skill in the mining environment and managers and maintenance staff typically do not have past experience in the field, it is common practice for mines to outsource their EEHA works to a contractor. In this way the mine site may pay a premium for the EEHA works but they also do not have to pay for training expenses for their maintenance and supervisors. Given the nature of the trade workforce, that is the ability and willingness to move, the training cost saving can be significant due to the ongoing training need.

7. Case Study 1 – Copper Mine Reagents Facility
The Copper Mine in this study was very typical in as much as it had the following areas:

(i) Crushing and material handling – 1st, 2nd and sometimes 3rd stage of material sizing, typically reporting to a stockpile. No reagents used in this process.

(ii) Grinding – as the name suggests this process consists of grinding the ore down to micron level particles for classification by hydro-cyclones, potentially regrinding and then on to the flotation circuit. PH conditioning can take place during the grinding process but typically that is all.

(iii) Flotation – multi-stage process of mineral extraction by collecting the mineral in solution then applying a frothing agent with air injection such that the agitation process and air injection cause the mineral to “bubble” to the surface so it can be skimmed off the top. Collectors and frothing agents are used in this process, this particular mine used MIBC as a frothing agent which is a flammable liquid.

(iv) Tails Thickening – process of de-watering the ore waste such that the process water requirements of the mine are reduced. Typical tails densities range from 60-75% and it is therefore pumped to the tails dam as a thick slurry. Flocculants are used in this process which can form combustible dusts.

(v) Concentrate storage and belt filter (de-watering) – second de-watering process but using a belt and compression to drive out the retained liquid. No reagents used in this process.

7.1 MIBC Area

The MIBC area for this plant was located away from the other reagents and main process plant, this was done to limit the impact of the hazardous area. The MIBC vapour is heavier than air with a vapour density of 3.5. As such any zone which extends into a sump or bund would be considered for extension of the zone 2 to a height of 1m. See Appendix E.

The classification and design for the main MIBC area is relatively straightforward with very little if any departure from AS/NZS 60079.10.1. The final distribution of MIBC is somewhat more problematic.

Firstly the idea of locating the MIBC reagent area away from all other plant had the intent of reducing the impact of the hazardous areas. However, the reagent was still required to be distributed through the flotation building. This was completed by way of a fully welded pipe spool to ensure gaskets were not installed and subsequently small HA zones did not result. This pipe spool delivered the MIBC to the Tun dish. See Appendix F & G.

The Tun dish is the final mechanism by which the MIBC is distributed through the process plant, its job is to drip feed the flotation cells to ensure the right amount of frothing (bubble formation) is correct for the process. As such the tun dish is a small local storage facility of MIBC, it stores approximately 20L of MIBC.
AS/NZS 60079.10.1 clause ZA 5.1 (a) states that the standard zonings shown within the standard are only relevant for flammable liquid capacities greater than 100L in closed containers or (b) greater than 25L for decanting purposes. As the tun dish volume is less than both of these limits the engineer was required to step outside Australian Standards in accordance with clause 5.4.6.

IP15 table 1.1 states the threshold above which hazardous area classification is required for flammable liquids stored above their flashpoint is >25L, section 1.2.1 goes on to clarify this as “classification may not be needed” for quantities below that stated in Table 1.1.

As the flashpoint of MIBC per the MSDS is 39°C and the ambient design temperature was stated as 42°C, the engineer could reasonably conclude that for this instance classification was not required. However, some laboratory test work was completed to determine the rate of vapour evolution from a 20L container with the tun dish surface area and at the design temperature.

The test work showed the evolution of MIBC vapour was very small and the engineer by calculation determined that a small Ex “e” vent fan could be used to dissipate what vapour was produced. The vent fan “not running” indication was alarmed on the plant control system for investigation. Given the standards requirements and this further investigation the area was deemed non-hazardous with the vent fan running. The plant operator in conjunction with the engineer conducted a risk assessment and determined this was an appropriate outcome.

7.2 Flocculant Area

The Flocculant area is a straightforward dust classification to AS/NZS 60079.10.2 with not combined gas a dust areas. The only issue in classifying this area is the availability of combustible dust data. In this instance the manufacturer was able to provide adequate information when requested.

An interesting point for this classification was the repeated statements by process engineers and operations staff that “you can eat it, how can it be dangerous?” That might be the case but it does not detract from the fact that the granulized dust can form an explosive dust atmosphere. If the operations manager so chooses they can conduct a risk assessment, post classification and design, and decide that they are willing to accept the risk as it sits within the companies risk profile.

The important thing to note from the risk assessment process in AS/NZS 4745 is that it demands a compliant classification and design be completed and that “competent” persons sit in on the risk assessment to advise those making the decision. Case study 2 really highlights this point.

7.3 Reagents Area

Appendix F shows the reagents facility of the copper mine. Recent queries from the mine indicate that they intend to transfer to using Xanthates (a collector) as a reagent for the process. Initial inspection of the reagents facility and the proposed xanthate locations indicates that the entire facility will need to be re-engineered to ensure compliance with standards. Further the MCC will fall within the HA zones and therefore need to be moved.
These works have not been estimated yet but the expectation is that this will be a significant expense, certainly one that if considered during the original design would not have been as significant now.

8. Case Study 2 – Materials Handling (Name Removed)

This case study is an example of both the client and several engineering organizations not having sufficient experience in EEHA principles and as such ignoring the requirements until it was almost too late. All names of organizations have been removed from this paper and from the associated drawings as the author does not have approval from the companies in question to advertise these failings.

Let it be stated though that the client had been operating the facility for 20 years prior to the events and that the two engineering organizations concerned could be considered Tier One firms.

The below lists the events in chronological order:

(i) Client operating the existing plant equipment, no change of materials required to be handled and no change to the proposed process. The plant had been operated for 20 years without incident.

(ii) Engineering and design company starts the process of scoping the work and determining project risks. HAZOP is conducted and action item #1 identifies due to the process using coal a hazardous area classification and design needs to be completed.

(iii) Design continues without consideration to EEHA classification and design. HAZID is conducted where it was noted again as action item #2 that due to the process using coal a hazardous area classification and design needs to be completed.

(iv) Design and construction continues without consideration for EEHA design.

(v) Commissioning documentation starts to be produced, no consideration given to EEHA as it is not part of the design until such time as it was mentioned in passing that the materials handling plant handles coal.

(vi) An experienced commissioning consultant immediately raised the question as to compliant EEHA design and requested the existing Hazardous Area Verification Dossier as the operating plant must have one – none was ever sighted.

(vii) Hazardous area classification and design commenced and was completed within 3 weeks. Material and installation costs were assessed as $500k.

(viii) All material provided to the client who was advised of the requirements and may or may not have implemented the design.

Note: The author was engaged on this project from (v) through (vii) and had no say in the final decision making process of implementation. In all instances the HA consultant should be read as referring to the author.

8.1 Initial Discovery & Investigations - (v & vi)
The process of developing commissioning documentation for a large upgrade project to a plant can be quite time consuming when just dealing with electrical, instrumentation and control. The documentation required for this project extended to full structural, mechanical and piping systems as well. During the development of the commissioning system it was noted that a function of the materials handling system was to transport coal and store for ready use.

It was noted by the commissioning team at this point that coal is a combustible material and capable of forming explosive dust clouds and as such there must be a project specific classification report and an existing operations HAVD.

The project team, which consisted of two “Tier One” engineering companies, were unable to show evidence of any design consideration for hazardous areas. Both indicated that this must have been missed despite the references to the requirement for such in both the HAZOP and HAZID. The principle engineering company immediately commissioned a full hazardous area classification and design.

As a result of the initial investigations, the HA consultant requested the client’s existing classification report and associated drawings. Further a request was made for inspection of the site’s HAVD. None of these documents were ever presented for inspection although an initial laboratory test of the coal dust was provided and can be seen at Appendix H.

Failing the provision of the required information the HA consultant inspected the existing operational plant to determine the state and extent of potential zones in an operational capacity. The inspection revealed that throughout the operational plant almost all horizontal surfaces had a minimum of 5mm of fine dust on them, in some cases it was as thick as 50mm and when walked upon a fine dust cloud was formed. The inspection was conducted with no personally mobile ignition sources as a precaution.

Further, during the process of classification and design, the HA consultant was very particular in project meetings in regards to the requirement for the client to have an existing HAVD complete with Classification Report. The client refused to provide the required documentation and asserted that in accordance with AS/NZS 4745 Clause 2.2 they had conducted a “risk assessment” and deemed the risk to be acceptable by implementation of a strict “house-keeping procedure”. The risk assessment was also never sighted by the principle engineering company nor was the house-keeping procedure.

The HA consultant advised the principle engineering company that despite the client’s assertion proper application of the AS/NZS 4745 risk assessment process was not followed as a core input to the risk assessment process would be a compliant HA classification report. As such the HA consultant further advised that the principle must advise the client of their understanding of the standards requirements and that the principle believed the “in control” party, in this case the client, had not met its obligations.

It was not clear at the time whether this message was conveyed.

8.2 HA Classification & Design - (vii)
The HA consultant at this point advised the principle engineering company to continue with the classification and design regardless of any contractual discussions – these were taking place in the background.

Appendix I shows the Overall Hazardous Area Classification Drawing for the materials handling area. It should be clear from this drawing that the dust hazardous area for the new plant is quite considerable, as the existing plant is of similar manufacture it can be assumed that similar zones may be required on the existing plant. This last part was deemed outside the scope of the projects classification battery limits.

The hazardous areas can be seen to affect multiple levels of the facility and multiple open conveyors and chutes. As such, despite the application of a dust collection system, the plan views (not provided) of each level show considerable zone 22’s through the structure. Given the amount and extent of the dust zones a large quantity of instrumentation was identified as required to be removed and replaced with suitably rated Ex equipment. This included the design and installation of IS circuits.

The final assessment of de-construction and implementation of the compliant design was estimated at $500,000. It was on completion and delivery of the HA classification report and design that the HA consultant was removed from the project.

9. EEHA, A Short History

Hazardous area classification in the early 2000’s was an emerging industry in the mining environment although having been a requirement for some time. At the time not all mine management teams understood the requirements for hazardous area classification of reagents facilities, given Case Study 2 above, that could still be argued to be true today.

As time moved forward to 2010 electrical engineering in mines has had to react to the greater reliance by process engineers on potentially hazardous materials. Certainly it appears that more and more potentially hazardous reagents are being used or at least are on the market for use by process plants. As such today it is quite common to find EEHA competent electrical engineers in a mine design office. In fact the skill set in some instances is the differentiator when a design office is reducing numbers as to who remains on the books and who does not. Twenty years ago I do not believe this would have been the case.

It should be noted that in the mining environment due to the prevalence of potentially explosive reagents hazardous area classification should be completed by process engineers due to their greater understanding of the chemicals. That said electrical engineers can and should continue to act in this capacity, in close consultation with process engineers, when there are no EEHA competent process engineering resources available.

In comparison to the operation and maintenance of the rest of a process plant the hazardous areas associated with reagents facilities is small and necessarily EEHA for mines remains a niche field. Along with the electrical engineers, engineering and operations managers have been required to upskill in relation to their understanding of operations, engineering and maintenance in and of EEHA environments. Generally they have not necessarily themselves become competent to AS/NZS
4761, however, have at the minimum improved their understanding of what it takes to operate in these environments.

Further reagent facility equipment supplies or facility designers are now expected to provide EEHA compliant equipment/facilities where in the past this has not always been specified. Again these companies are in some instances outsourcing the EEHA component of these works to electrical companies who specialize in this field.

This section may be removed pending my research of identifiable dates for a more consolidated timeline of EEHA in the mining environment.

10. Summary

Hazardous area classification for mine reagent facilities and materials handling facilities of combustible materials is a challenging field for the classification engineer. The challenges do not just consist of interpretation or implementation of “pre-approved” examples, although this does often occur, but on into managements lack of understand of the requirements of not just the classification but of operating such facilities.

Reagents facilities commonly consist of both gaseous and dust hazardous areas and it is the latter which often require classification by first principles and judgement. Further the Code of Practice for handling combustible dusts, AS/NZS 4745, allows management to conduct a risk assessment to determine if the mines management team is prepared to accept the risk of operating the dust HA, without installing suitably rated equipment.

A common mechanism employed by management teams is to implement a strict house-keeping procedure. If the procedure is followed then there should be no problem, however, this is not always the case as was evident in Case Study 2.

Design of reagents facilities for mines is essentially the same for designing for an oil & gas plant with the exception dusts zones may be present. Therefore consideration must be given to implementing the appropriate protection techniques for dust environments. In addition in some instances dust and gaseous hazardous areas may overlap and result in the inability to apply either dust or gaseous compliant equipment installations. In these situations the classification and design engineer must use their experience to implement a safe design.

References:

(1) Mineral Processing, Mr Tony Weeks.
(2) AS/NZS 60079.10.1:2009 Clauses 3.6, 3.7 and 3.8.
(3) AS/NZS 60079.10.2:2009 Clause D.3.2.
(4) AS/NZS 60079.10.2:2011 Clause 6.2.
(5) AS/NZS 60079.10.2:2009 Clause D.3.3.
(6) AS/NZS 60079.14. Table 2.1 & 2.2.
Hazardous Reagents in the Mineral Processing Industry

The mineral processing industry differs from the oil and gas industry. Oil or gas is intrinsically hazardous from extraction through to the production of final products. In contrast, the ores mined and the products produced in mineral processing are generally nonhazardous, but many of the chemicals used to extract the minerals or metals of interest from the ore are hazardous.

Common hazards that must be dealt with during the extraction process include use of explosives, flammable gases and hazards associated with storage and use of reagents. Many of the reagents used are classified as dangerous goods with classification classes including corrosive, toxic, flammable, spontaneously combustible and environmentally hazardous.

Regulations and Guidelines

Transport requirements for dangerous goods are defined by State Government regulations. State Government regulations are generally aligned with the Australian Dangerous Goods (ADG) Code which in turn is based on the United Nations, Recommendations on the Transport of Dangerous Goods Model Regulations which is revised approximately every two years.

The current ADG Code\(^1\) is Edition 7.3 which was last revised in August 2014. This revision is based on the Seventeenth Edition of the UN recommendations\(^2\). Australian State regulations normally follow UN recommendations and the ADG code closely. However, minor variations, can and do occur. In Western Australia sulphur is defined as a Class 4.1, PG III (Flammable Solid) irrespective of form\(^3\) whereas under the ADG code there is a special provision for sulphur whereby sulphur is not subject to the code when it has been formed to a specific shape (e.g. prills, granules, pellets, pastilles or flakes)\(^1\).

Hazardous goods covering the majority of the hazardous classes are used throughout the mine. Emulsion explosives and detonators (Class 1 Explosives) are used in the mine. The mine fleet and light vehicles require a combination diesel (Class C1 Combustible) and petrol (Class 3 Flammable) fuel farm. The mineral processing plant can require a wide variety of reagents (Table 1). Laboratories require a wide variety of reagents including LPG (Class 2.1 Flammable Gases) for the furnaces.
Table 1 Hazardous Classification of Reagents Commonly used in Mineral Processing

<table>
<thead>
<tr>
<th>Class</th>
<th>Flash Point</th>
<th>Dangerous Goods</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 3</td>
<td>&lt; 60.5°C</td>
<td>Yes</td>
<td>A liquid having a flash point below 60.5°C</td>
</tr>
<tr>
<td>Flammable Liquid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class C1</td>
<td>60.5 to &lt;150°C</td>
<td>DG only for storage purposes</td>
<td>A liquid having a flash point greater than 60.5°C but less than 150°C.</td>
</tr>
<tr>
<td>Combustible Liquid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class C2</td>
<td>&gt;150°C</td>
<td>DG only for storage purposes</td>
<td>A liquid having a flash point greater than 150°C.</td>
</tr>
<tr>
<td>Combustible Liquid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 4.2</td>
<td>Not applicable</td>
<td>Yes</td>
<td>A self-heating material that can ignite without an external ignition source.</td>
</tr>
<tr>
<td>Spontaneously Combustible Solids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 5.1</td>
<td>Not applicable</td>
<td>Yes</td>
<td>Substances which, while in themselves are not necessarily combustible, may cause or contribute to the combustion of other material by yielding oxygen.</td>
</tr>
<tr>
<td>Oxidising Agents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 6.1</td>
<td>Not applicable</td>
<td>Yes</td>
<td>Substances that can either cause death, serious injury or harm to human health if swallowed or inhaled or by skin contact:</td>
</tr>
<tr>
<td>Toxic Substances</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 8</td>
<td>Not applicable</td>
<td>Yes</td>
<td>A liquid or solid that is capable of causing the degradation and destruction of living tissue, steel and other materials on contact.</td>
</tr>
<tr>
<td>Corrosive Substance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class 9</td>
<td>Not applicable</td>
<td>Yes</td>
<td>Substances which during transport present a danger not covered by other classes. Amongst others, includes; asbestos, lithium batteries; electrical double layer capacitors, genetically modified organisms and substances toxic to marine life</td>
</tr>
<tr>
<td>Miscellaneous including Environmentally Hazardous Substances</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The primary focus of the ADG code is on the safe transportation of hazardous materials by road and rail. It does not contain any provisions relating to usage, storage or security of these goods. Other publications such as the EC BAT Guidelines can provide guidance relating to storage (Table 2).

The EC BAT Guidelines are not regulatory requirements. The guidelines emphasise the importance of risk assessments and risk management plans. They can provide a framework for designers and operators but ultimately the design and use must be subject to risk assessments and comply with relevant Local, State or Federal regulations.

The packing group as designated in the UN Recommendations on the Transport of Dangerous Goods can be used as a further indicator of risk within a hazardous class. The UN has assigned 3 different levels of packing for hazardous goods.

<table>
<thead>
<tr>
<th>Packing Group</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (PG I)</td>
<td>High Danger</td>
</tr>
<tr>
<td>II (PG II)</td>
<td>Medium Danger</td>
</tr>
<tr>
<td>III (PG III)</td>
<td>Low Danger</td>
</tr>
</tbody>
</table>
The criteria used to define the packing group requirement for specific reagents are dependent on the severity of the outcome if the reagent is released or the ease with which the hazard can be triggered (Table 3).

Table 3 Package Group Classification Criteria

<table>
<thead>
<tr>
<th>Packing Group</th>
<th>Hazard Class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Class 3 Flammable Liquids</strong></td>
</tr>
<tr>
<td>PG I</td>
<td>Boiling point or initial boiling point lower than or equal to 35°C</td>
</tr>
<tr>
<td>PG II</td>
<td>Boiling point or initial boiling point greater than 35°C and flashpoint below 23°C</td>
</tr>
<tr>
<td>PG III</td>
<td>Boiling point or initial boiling point greater than 35°C and flashpoint equal to or greater than 23°C and less than or equal to 60°C. However, such liquids with a flashpoint of more than 35°C which do not sustain combustion may not have been classified as flammable liquids i.e. if they are water miscible with a water content of more than 90% by mass.</td>
</tr>
<tr>
<td></td>
<td><strong>Class 4.2 Spontaneously Combustible Solids</strong></td>
</tr>
<tr>
<td>Definition</td>
<td>Self-heating of dangerous goods, leading to spontaneous combustion, is caused by reaction of the substance with oxygen and the heat developed not being conducted away rapidly enough to the surroundings. Spontaneous combustion occurs when the rate of heat production exceeds the rate of heat loss and the auto-ignition temperature is reached. Classification differentiates hazards based on whether the material is pyrophoric or self-heating</td>
</tr>
<tr>
<td>PG I</td>
<td>Pyrophoric substances are liquid or solid dangerous goods which even in small quantities ignite within five minutes of coming into contact with air. These are liable to spontaneous combustion</td>
</tr>
<tr>
<td>PG II</td>
<td>Self-heating substances are liquid or solid dangerous goods, other than pyrophoric substances, which in contact with air without energy supply are liable to self-heating. These substances will ignite only when in large amounts (kilograms) and after long periods of time (hours or days) and are called self-heating substances.</td>
</tr>
<tr>
<td>PG III</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Class 8 Corrosive</strong></td>
</tr>
<tr>
<td>PG I</td>
<td>Is assigned to substances that cause full thickness destruction of intact skin tissue within an observation period up to 60 minutes starting after the exposure time of three minutes or less</td>
</tr>
<tr>
<td>PG II</td>
<td>Is assigned to substances that cause full thickness destruction of intact skin tissue within an observation period up to 14 days starting after the exposure time of more than three minutes but not more than 60 minutes</td>
</tr>
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<td>--------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| PG III | Is assigned to substances that cause full thickness destruction of intact skin tissue within an observation period up to 14 days starting after the exposure time of more than 60 minutes but not more than 4 hours.  
  Or
  Corrosion rate on either steel or aluminium surfaces exceeding 6.25mm a year at a test temperature of 55C when tested on both materials |
Table 2 Compatibility of Hazardous Substances

<table>
<thead>
<tr>
<th>CLASS</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPRESSED GASES</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
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</tr>
<tr>
<td>2.1 Flammable</td>
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<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
</tr>
<tr>
<td>2.2 Non-Flammable, non-toxic</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
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<tr>
<td>2.3 Toxic</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
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<tr>
<td>FLAMMABLE LIQUIDS</td>
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<td>KEEP APART</td>
<td>KEEP APART</td>
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<tr>
<td>FLAMMABLE SOLIDS</td>
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<td>KEEP APART</td>
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<tr>
<td>4.1 Readily combustible</td>
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<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
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<tr>
<td>4.2 Spontaneously combustible</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
</tr>
<tr>
<td>4.3 Dangerous when wet</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
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<tr>
<td>OXIDISING SUBSTANCES</td>
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<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
<td>KEEP APART</td>
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</tr>
<tr>
<td>5.1 Oxidising substances</td>
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<td>KEEP APART</td>
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</tr>
<tr>
<td>5.2 Organic peroxides</td>
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<td>KEEP APART</td>
<td>KEEP APART</td>
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<tr>
<td>TOXIC SUBSTANCES</td>
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<tr>
<td>CORROSIVE SUBSTANCES</td>
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</table>
Reagent Uses and Design Considerations

In order to correctly design reagent handling and distribution systems it is important to understand how and where the reagent is used. Some reagents have multiple associated hazards such as some of the flotation reagents which are classified as flammable and corrosive. In other instances, the hazard can differ depending on the form of the reagent. Xanthates, which are used in flotation, are classified as Class 4.2 (Spontaneously Combustible) in their solid form but in their liquid form are classified as Class 3 (Flammable).

Many different reagents are used (Table 4). The choice of reagent depends on the characteristics of the ore being treated and the combination of processes needed to extract the mineral or metal of interest. Unit processes within the mineral processing industry include:

(vii) Leaching
(viii) Flotation
(ix) pH modification
(x) Dewatering
(xi) Cyanide detoxification
(xii) Solvent extraction (SX)

In many instances the same chemical can be used in multiple applications i.e.

- Lead nitrate can be used as a leach aid to accelerate leaching of gold ores and as an activator in flotation to assist with flotation of antimony sulphide minerals
- Sulphuric acid can be used; to leach copper from copper oxide ores; to lower the pH in a flotation circuit and as one of the chemical reactants used to destroy cyanide in gold tailings

The wide variety of reagents used, dictate that ultimately the hazards must be assessed at an individual reagent level. However, the reagents used for a particular unit process often have similar properties and the hazards for the chemicals used for a particular unit process can be grouped.

**Leach Chemicals**

The classes of hazardous chemicals used in leaching are normally:

- Class 5.1 Oxidising
- Class 6.1 Toxic
- Class 8 Corrosive

**Flotation Chemicals**

The choice of chemicals is largely driven by process considerations relating to the recovery of the valuable mineral and the quality needed for sale of the concentrate to the end user. There is some scope for substituting cheaper or less hazardous chemical for another but generally process considerations trump cost and design considerations. Classes of hazardous chemicals used in flotation include:

- Class 3 Flammable
- Class 4.2 Spontaneously Combustible
- Class 5.1 Oxidising
• Class 6.1 Toxic
• Class 8 Corrosive
• Class 9 Environmentally Hazardous Substances

Whilst it is possible to substitute non-hazardous chemicals for hazardous chemicals it is unlikely to happen in practice. Furthermore, even if non-hazardous chemicals were chosen in the initial design, changes in the composition of the ore body over time may require substitution of hazardous chemicals for non-hazardous chemicals sometime after the operation has commenced.

It is prudent to group flotation reagents into their own area which is physically separated from other reagent areas. The entire flotation reagent area should be designed on a worst case basis.

• Materials of construction should be carefully selected for resistance to corrosion
• Motors and electrical apparatus should be specified as explosion proof capable of being used for Class 4.2 chemicals regardless of chemicals being pumped
• Power requirements should be carefully considered. The dose rates for frother are often low and fine control over the dose rate is needed. The dosage requirements can often be met by use of single phase positive displacement ‘lab’ style pumps. It can be difficult to obtain these types of pumps with explosion proof rated motors.

Flotation chemicals are generally subdivided into:

Frothers
These are used in every flotation circuit. They are generally combustible liquids which are added neat at low dose rates. Frothers are normally delivered in 200L drums or 1000L Intermediate Bulk Containers (IBCs) and are often pumped directly from the delivery container to the dosing point, especially on smaller throughput plants.

Collectors
These are used in every flotation circuit. The most common collectors are the xanthates. Xanthate is normally delivered as a solid and mixed with water to site. Solid xanthate is classified as Class 4.2 Spontaneously Combustible. Liquid xanthate decomposes to form carbon bisulphide (CS₂) which is a Class 3 Flammable Liquid. The decomposition rate is affected by the concentration of the initial mix, the temperature, the type of xanthate and time.

There are many alternates to xanthate that are not classified as Class 4.2 chemicals but many of the alternatives are classified as Class 8 Corrosives. Alternatives include:

• Xanthates
  o All of the xanthates (PAX, SIBX, SIPX, SEX) are classified as Class 4.2 spontaneously combustible under the dangerous goods code.
• Dithiophosphates (DTP)
  o All the DTPs are classified as Class 8 corrosive liquids under the dangerous goods code.
• Thionocarbamates (TNC)
○ Pure TNCs are mostly non-dangerous goods. However, some of the products in the TNC range may be classified as Class 3 dangerous goods dependent on the residual alcohol content. Unfortunately TNCs are often mixed with DTPs and NaMBTs and take on the dangerous goods classification of these classes of chemicals.

○ Sodium mercaptobenzothiazole (NaMBT)

○ All the NaMBTs are classified as Class 8 corrosive liquids under the dangerous goods code.

Activators and Depressants
Activators, also known as promoters, and depressants are generally, but not always used. They are used to improve recovery of the valuable mineral or to improve the quality of the concentrate. The choice of reagent is very ore specific and there is little room for substitution. Many of the reagents are classified as hazardous. Hazard classes include:

- Class 4.2 Spontaneously Combustible
- Class 5.1 Oxidising
- Class 6.1 Toxic
- Class 8 Corrosive
- Class 9 Environmentally Hazardous Substances

pH modifiers
pH modifiers are generally Class 8 Corrosives. The exception is sodium carbonate (soda ash) which is sometimes used in flotation circuits.

Dewatering aids
Flocculants and coagulants are not classified as dangerous goods. Some surfactants can be classified as Class 9 Environmentally Hazardous Substances.

Cyanide detoxification
Two main processes are used for cyanide detoxification; Caro’s acid and the SO2/air (Inco) system. Most of the chemicals used in these processes are classified as dangerous.

- Sulphuric acid
- Hydrogen Peroxide
- Sodium metabisulphite (SMBS)
- Sodium bisulphite (an alternative to SMBS)
- Copper sulphate
- Lime

Class 8 Corrosive
Class 5.1 Oxidising
Not a dangerous good
Class 8 Corrosive
Class 9 Environmentally Hazardous
Class 8 Corrosive

Solvent extraction (SX)
The solvent extraction process has all the hazards associated with a diesel fuel farm with the added complications of corrosiveness and high evaporation rates.

The SX process uses proprietary organic solvents to selectively extract the metals of interest from the leach solution. The leach solution is generally acidic.
A common application of the solvent extraction process is removal of dissolved copper from an acidic solution.

The high cost organic solvents are mixed with a low cost diluent (solvent). The diluent is high flash point, (typically >75°C), kerosene. (The flash point of normal kerosene is 38°C). Diluent is classified in the same category as diesel. It is a Class C1 combustible which is not classified as dangerous goods for the purposes of transport but is classified as dangerous goods for storage purposes.

Special care is needed with the design of SX plants. Separation of the organic solvent from the acidic liquor occurs in settling tanks which have a very large surface area to depth ratio and correspondingly high evaporation and fume rates.

Materials of construction, protection from stray currents, static electricity discharge, lightning and potential ignition sources amongst others all have to be taken into consideration during the design.

Table 4 Typical Reagents used in Mineral Processing Plants

<table>
<thead>
<tr>
<th>Application</th>
<th>Reagent</th>
<th>Formula / Application / Comments</th>
<th>ADG Class / Packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaching</td>
<td>Cyanide (Solid or liquid)</td>
<td>NaCN or KCN. Used to leach gold. Generally mixed and added to slurry streams as 20-30% w/w solution. Also used in flotation circuits as a depressant to stop flotation of iron and zinc sulphides.</td>
<td>Class 6.1 Toxic / PG I (solid) / PG II (liquid)</td>
</tr>
<tr>
<td></td>
<td>Sulphuric acid</td>
<td>H2SO4. Generally supplied as a 98% liquid. Also used in flotation circuits as a pH modifier</td>
<td>Class 8 / PG III</td>
</tr>
<tr>
<td>Leach aid</td>
<td>Peroxide</td>
<td>H2O2. Sometimes used in leach applications as a source of oxygen. Most commonly used as an oxidant in cyanide destruction applications. Generally supplied as a 30 – 70% liquid. Peroxide is acidic (pH2).</td>
<td>Class 5.1 / PG I Subrisk: Class 8</td>
</tr>
<tr>
<td>Leach aid</td>
<td>Lead Nitrate (Solid or liquid)</td>
<td>Pb(NO3). Generally supplied as a solid crystal or powder. Typically mixed with water on site to form a 20% w/w solution. Solution pH 3-4. Also used in flotation as an activator.</td>
<td>Class 5.1 (oxidising agent) / PG II Subrisk : Class 6.1 Toxic</td>
</tr>
<tr>
<td>Flotation</td>
<td>Frother Methyl Isobutyl Carbinol (MIBC)</td>
<td>Widely used – weak frother prized for its selectivity and “drainability”. Flash point 43°C. Ignition point 327°C. Heavier than air (vapour density =3.5 cf air =1)</td>
<td>Class 3 / PG III</td>
</tr>
<tr>
<td></td>
<td>Frother DSF 004A</td>
<td>Proprietary chemical supplied by Orica. Contains 10-30% ethyl hexanol. Claimed to be a rival for MIBC. Classified as Category 4 Flammable liquid by Safe Work Australia</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
</tr>
<tr>
<td></td>
<td>Frother Interfroth 50</td>
<td>Proprietary chemical supplied by Chemical &amp; Mining Services. Blend of alcohols and esters. Flash point 66°C. Fumes heavier than air. Combustible liquid (Category C1). Classified as DG for storage purposes.</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
</tr>
</tbody>
</table>
### Application

<table>
<thead>
<tr>
<th>Reagent</th>
<th>Formula / Application / Comments</th>
<th>ADG Class / Packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frother</td>
<td>Interfroth 604 Proprietary chemical supplied by Chemical &amp; Mining Services. Blend of alcohols and esters. Flash point &gt;70C. Combustible liquid (Category C1). Classified as DG for storage purposes.</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
</tr>
<tr>
<td>Frother</td>
<td>Betafroth FMM 180 Proprietary chemical supplied by Betachem. Glycol butyl ether. Flash point 76C. Combustible liquid (Category C1). Classified as DG for storage purposes.</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
</tr>
<tr>
<td>Collector</td>
<td>Xanthate (Solid) Xanthates are the most common of the collectors. They decompose over time. Decomposition is accelerated by heat. The decomposition product is carbon bisulphide. (CS2). Pure CS2 liquid is classified as highly flammable and dangerous to the environment under EU classification system. CS2 auto ignition 90C. Lower explosive limit = 0.6% v/v. Upper explosive limit 61% v/v.</td>
<td>Class 4.2 / PG II</td>
</tr>
<tr>
<td>Collector</td>
<td>Xanthate (Liquid) Proprietary chemical supplied by Orica. Contains 10-30% MIBC &amp; 30-80% NaMBT. Used for nickel flotation. Flash point 42C</td>
<td>Class 3 / PG II Subsidiary Risk: Class 8</td>
</tr>
<tr>
<td>Collector</td>
<td>DSP 432 Proprietary chemical supplied by Orica. Contains 10-30% MIBC &amp; 10-30% DTP. Used for nickel flotation.</td>
<td>Class 8 / PG II Subsidiary Risk: Class 3</td>
</tr>
<tr>
<td>Collector</td>
<td>DSP 413 Proprietary chemical supplied by Orica. Contains 10-30% NaMBT &amp; 10-30% DTP. Used for nickel flotation.</td>
<td>Class 8 / PG II</td>
</tr>
<tr>
<td>Collector</td>
<td>DSP 330 Proprietary chemical supplied by Orica. Contains 30-60% NaMBT. Used for lead flotation. Less corrosive than DSP 413</td>
<td>Class 8 / PG III</td>
</tr>
<tr>
<td>Collector</td>
<td>DSP 007 Proprietary chemical supplied by Orica. Contains 30-60% DTP, remainder H2O. Used for gold flotation.</td>
<td>Class 8 / PG II</td>
</tr>
<tr>
<td>Collector</td>
<td>DSP 009 Proprietary chemical supplied by Orica. Contains &gt;95% TNC. Flash point 91C. Used for Cu-Zn flotation. Combustible liquid (Category C1). Classified as DG for storage purposes.</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
</tr>
<tr>
<td>Collector</td>
<td>RTD1339 Liquid Proprietary chemical supplied by Tall-Bennet. Alkyl thiocarbamic acid ester. Flash point &gt;82C. Used for Cu-Zn flotation. Combustible liquid (Category C1). Classified as DG for storage purposes.</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
</tr>
<tr>
<td>Collector</td>
<td>X-23 Liquid Proprietary chemical supplied by Hostaflot. Contains &gt;95% isopropyl ethyl thionocarbamate (TNC). Flash point 95C. Used for Cu-Au flotation. Combustible liquid (Category C1). Classified as DG for storage purposes.</td>
<td>Class 9 (Environmentally Hazardous Substance) / PG II</td>
</tr>
<tr>
<td>Activator</td>
<td>Copper Sulphate CuSO4.5H2O Personnel protection exposure (dust) limit (as Cu) 1.0 mg/m3 Time Weighted Average (TWA)</td>
<td>Class 9 (Environmentally Hazardous Substance) / PG III</td>
</tr>
<tr>
<td>Activator</td>
<td>Lead nitrate (solid or liquid) PbNO3 used as an activator to assist with flotation of antimony sulphides and copper sulphides depressed</td>
<td>Class 5.1 (oxidising agent) / PG II</td>
</tr>
</tbody>
</table>
### Explosive Hazardous Areas – In the Mining Environment

<table>
<thead>
<tr>
<th>Application</th>
<th>Reagent</th>
<th>Formula / Application / Comments</th>
<th>ADG Class / Packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activator or</td>
<td>Sodium Sulphide (Na₂S)</td>
<td>Typically added as a 15-25% solution strength. The choice of whether to use Na₂S or NaHS depends on the pH required. (Na₂S is more alkaline). At medium dose rates can be used as an activator for oxidised or tarnished minerals. At low dose rates (less than 500 g/t) can be used to depress Zn and Fe sulphides. At high dose rates can be used to depress all sulphides (reverse flotation) allowing gangue to be floated and removed.</td>
<td>Subrisk : Class 6.1 Toxic</td>
</tr>
<tr>
<td>Depressant</td>
<td>Sodium hydrosulphide (NaHS)</td>
<td></td>
<td>Class 8 / PG II</td>
</tr>
<tr>
<td>Activator or</td>
<td>Cyanide</td>
<td>Can be used to activate lead sulphide minerals Strong sulphide depressant for Fe and Zn sulphides</td>
<td>Class 6.1 Toxic / PG I (solid) / PG II (liquid)</td>
</tr>
<tr>
<td>Depressant</td>
<td>Sodium Metabisulphite (SMBS solid)</td>
<td>SMBS (Na₂S₂O₃) solid: Personnel protection exposure (dust) limit 5.0 mg/m³ TWA. Classified as Hazardous Substance (acute oral toxicity) by Safe Work Australia. Generally mixed to 10 – 30% w/w. solution with pH 4-5. Depressant for Zn and Fe sulphides. Also used to produce as a reactant in cyanide detoxification</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
</tr>
<tr>
<td>Depressant</td>
<td>Carboxymethyl cellulose (CMC)</td>
<td>Depressant for talc. Often used in nickel flotation circuits. Not classified as Hazardous Substance by Safe Work Australia. Solution pH 6.5 – 8.5</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
</tr>
<tr>
<td>Depressant</td>
<td>Guar</td>
<td>Alternative to CMC. Flash point &gt;93°C</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
</tr>
<tr>
<td>Depressant</td>
<td>Zinc sulphate</td>
<td>Supplied as mono or hepta hydrate (ZnSO₄·H₂O or ZnSO₄·7H₂O). Depressant for zinc sulphide minerals in a base metal (Cu/Pb/Zn) circuit. Classified as Hazardous Substance (acute oral toxicity) by Safe Work Australia</td>
<td>Class 9 (Environmentally Hazardous Substance) / PG III</td>
</tr>
<tr>
<td>Depressant</td>
<td>Dextrin</td>
<td>C₆H₁₀O₅ Dextrin &amp; Maltodextrin. Generally used to depress carbon minerals during sulphide flotation.</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
</tr>
<tr>
<td><strong>Dewatering Aids</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flocculants</td>
<td>Anionic or cationic polymer. Used to settle fine particles. Supplied as a powder. Slip hazard when mixed. (Solution is viscous and slippery).</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
<td></td>
</tr>
<tr>
<td>Coagulants</td>
<td>Mix of inorganic and organic polymers. Used to settle fine particles</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
<td></td>
</tr>
<tr>
<td>Surfactants /</td>
<td>Alkane sulphonates or Alcohol ethoxylates</td>
<td>May be classified as</td>
<td></td>
</tr>
<tr>
<td>Application</td>
<td>Reagent</td>
<td>Formula / Application / Comments</td>
<td>ADG Class / Packaging</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
<td>----------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>Detergents</td>
<td></td>
<td>Environmental impacts: Due to their surface active nature surfactants may have toxic effects on some (aquatic) organisms.</td>
<td>Class 9 Environmentally Hazardous Substance</td>
</tr>
<tr>
<td>pH modifiers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>H₂SO₄</td>
<td>Generally supplied as a 98% liquid</td>
<td>Class 8 / PG III</td>
</tr>
<tr>
<td>Caustic soda</td>
<td>pH 12.7</td>
<td></td>
<td>Class 8 / PG II</td>
</tr>
<tr>
<td>Lime</td>
<td>CaO. Reacts vigorously with water generating heat and steam. pH 13</td>
<td>Class 8 (for air transport only) / PG III</td>
<td></td>
</tr>
<tr>
<td>Sodium carbonate</td>
<td></td>
<td>Also known as soda ash. pH 11.5</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
</tr>
<tr>
<td>Cyanide detoxification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMBS (Na₂S₂O₅) solid</td>
<td>SMBS (Na₂S₂O₅) solid: Personnel protection exposure (dust) limit 5.0 mg/m³ TWA. Classified as Hazardous Substance (acute oral toxicity) by Safe Work Australia. Generally mixed to 10 – 30% w/w. Solution pH 4-5. In the presence of water, oxygen and cupric (copper) ions forms sulphur dioxide (SO₂) which reacts with and destroys cyanide</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
<td></td>
</tr>
<tr>
<td>Sodium Metabisulphite (SMBS solid)</td>
<td>Alternative SO₂ source. Generally mixed to 25 – 40% w/w. Solution pH 3.8</td>
<td>Class 8 / PG III</td>
<td></td>
</tr>
<tr>
<td>Copper Sulphate</td>
<td>Used as a catalyst. CuSO₄.5H₂O Personnel protection exposure (dust) limit (as Cu) 1.0 mg/m³ Time Weighted Average (TWA)</td>
<td>Class 9 (Environmentally Hazardous Substance) / PG III</td>
<td></td>
</tr>
<tr>
<td>Caro’s acid detoxification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>H₂SO₄</td>
<td>Generally supplied as a 98% liquid</td>
<td>Class 8 / PG III</td>
</tr>
<tr>
<td>Peroxide</td>
<td>H₂O₂ Reacts with sulphuric acid to form Caro’s acid which reacts with and destroys cyanide. Generally supplied as a 30 – 70% liquid. Solution pH 2.</td>
<td>Class 5.1 / PG I Class 8</td>
<td></td>
</tr>
<tr>
<td>Solvent Extraction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diluent (solvent)</td>
<td></td>
<td>High flashpoint kerosene typically 75C. Combustible liquid (Category C1). Classified as DG for storage purposes. Electrostatic charges may be generated during pumping. Electrostatic discharge may cause fire. In use, may form flammable/explosive vapour-air mix.</td>
<td>ADG: Not classified as dangerous goods for transport purposes</td>
</tr>
</tbody>
</table>
Appendix B – MSDS Methyl IsoButyl Carbinol.

Material Safety Data Sheet

This material is hazardous according to criteria of NOHSC. Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail.

1. Identification of the substance/preparation and of the company/undertaking

Product Name: METHYL ISOBUTYL CARBINOL
Synonyms: Methyl amyl alcohol; 4-Methyl-2-pentanol; Isobutyl methyl carbinol; MIBC.
Supplier: Orica Australia Pty Ltd
ABN: 004 117 826
Street Address: 1 Nicholson Street, Melbourne 3000, Australia
Telephone Number: +61 3 9655 7111
Facsimile: +61 3 9655 7937
Emergency Telephone: 1 800 033 111 (ALL HOURS)

2. Composition/information on ingredients

Product Description: Solvent. mineral flotation agent.

| Methyl isobutyl carbinol 108-11-2 | >=98% | R10, R37 |

3. Hazards identification

Risk Phrases: Flammable. Irritating to respiratory system.
Poisons Schedule: None allocated.

4. First-aid measures

Inhalation: Remove victim from area of exposure - avoid becoming a casualty. Remove contaminated clothing and loosen remaining clothing. Allow patient to assume most comfortable position and keep warm. Keep at rest until fully recovered. If patient finds breathing difficult and develops a bluish discoloration of the skin (which suggests a lack of oxygen in the blood - cyanosis), ensure airways are clear of any obstruction and have a qualified person give oxygen through a face mask. Apply artificial respiration if patient is not breathing. Seek immediate medical advice.

Skin Contact: If skin contact occurs, remove contaminated clothing and wash skin with running water. If irritation occurs seek medical advice.

Eye Contact: If in eyes, wash out immediately with water. In all cases of eye contamination it is a sensible precaution to seek medical advice.

Ingestion: Rinse mouth with water. If swallowed, do NOT induce vomiting. Give a glass of water. Seek immediate medical assistance.

Notes to physician: Treat symptomatically.
Material Safety Data Sheet

5. Fire-fighting measures

Specific Hazards: Flammable liquid. Avoid all ignition sources. All potential sources of ignition (open flames, pilot lights, furnaces, spark producing switches and electrical equipment etc) must be eliminated both in and near the work area. Do NOT smoke. May form flammable vapour mixtures with air. Vapour may travel a considerable distance to source of ignition and flash back.

Fire-fighting advice: On burning will emit toxic fumes, including those of oxides of carbon. Heating can cause expansion or decomposition of the material, which can lead to the containers exploding. If safe to do so, remove containers from the path of fire. Keep containers cool with water spray. If safe to do so, remove containers from path of fire. Fire fighters to wear self-contained breathing apparatus and suitable protective clothing if risk of exposure to vapour or products of combustion.

Suitable Extinguishing Media: Foam, dry agent (carbon dioxide, dry chemical powder).

6. Accidental release measures

Shut off all possible sources of ignition. Clear area of all unprotected personnel. Slippery when split. Avoid accidents, clean up immediately. Wear protective equipment to prevent skin and eye contact and breathing in vapours. Work up wind or increase ventilation. Contain - prevent run off into drains and waterways. Use absorbent (soil, sand or other inert material). Use a spark-free shovel. Collect and seal in properly labelled containers or drums for disposal. If contamination of sewers or waterways has occurred advise local emergency services.

7. Handling and storage

Handling advice: Avoid skin and eye contact and breathing in vapour.

Storage advice: Store in a cool, dry, well ventilated place and out of direct sunlight. Store away from sources of heat or ignition. Store away from incompatible materials described in Section 10. Keep containers closed when not in use - check regularly for leaks.

8. Exposure controls/personal protection

Methyl isobutyl carbinol: 8hr TWA = 104 mg/m³ (25 ppm), 15 min STEL = 167 mg/m³ (40 ppm), Sk

As published by the National Occupational Health and Safety Commission.

TWA - The time-weighted average airborne concentration over an eight-hour working day, for a five-day working week over an entire working life.

STEL (Short Term Exposure Limit) – the average airborne concentration over a 15 minute period which should not be exceeded at any time during a normal eight hour work day. According to current knowledge this concentration should neither impair the health or, not cause undue discomfort to, nearly all workers.

'SK' Notice – absorption through the skin may be a significant source of exposure. The exposure standard is invalidated if such contact should occur.

These Exposure Standards are guides to be used in the control of occupational health hazards. All atmospheric contamination should be kept to as low a level as is workable. These exposure standards should not be used as fine dividing lines between safe and dangerous concentrations of chemicals. They are not a measure of relative toxicity.
Material Safety Data Sheet

Engineering Control Measures:
Ensure ventilation is adequate and that air concentrations of components are controlled below quoted Exposure Standards. Vapour heavier than air - prevent concentration in hollows or sumps. DO NOT enter confined spaces where vapour may have collected. If inhalation risk exists: Use with local exhaust ventilation or while wearing organic vapour respirator. Keep containers closed when not in use.

Personal Protective Equipment:
Orica Personal Protection Guide No. 1, 1998: G - OVERALLS, SAFETY SHOES, SAFETY GLASSES, GLOVES, RESPIRATOR.

Wear overalls, safety glasses and impervious gloves. Use with adequate ventilation. If inhalation risk exists wear organic vapour respirator meeting the requirements of AS/NZS 1715 and AS/NZS 1716. Always wash hands before smoking, eating, drinking or using the toilet. Wash contaminated clothing and other protective equipment before storage or re-use.

9. Physical and chemical properties

<table>
<thead>
<tr>
<th>Physical state:</th>
<th>Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour:</td>
<td>Colourless</td>
</tr>
<tr>
<td>Odour:</td>
<td>Mild</td>
</tr>
<tr>
<td>Molecular Formula:</td>
<td>(CH₃)₂CH₂CH₂OH₂CH₃</td>
</tr>
<tr>
<td>Solubility:</td>
<td>Slightly soluble in water.</td>
</tr>
<tr>
<td>Specific Gravity:</td>
<td>0.8075</td>
</tr>
<tr>
<td>Relative Vapour Density (air=1):</td>
<td>3.5</td>
</tr>
<tr>
<td>Vapour Pressure (20 °C):</td>
<td>3.7 mm Hg</td>
</tr>
<tr>
<td>Flash Point (°C):</td>
<td>39 (TCC)</td>
</tr>
<tr>
<td>Flammability Limits (%):</td>
<td>1-5.5</td>
</tr>
<tr>
<td>% Volatile by Weight:</td>
<td>100</td>
</tr>
<tr>
<td>Boiling Point/Range (°C):</td>
<td>131.7</td>
</tr>
<tr>
<td>Freezing Point/Range (°C):</td>
<td>-90 (Sets to glass)</td>
</tr>
</tbody>
</table>

10. Stability and reactivity

Stability: Incompatible with strong acids, and alkalis.

11. Toxicological information

No adverse health effects expected if the product is handled in accordance with this Safety Data Sheet and the product label. Symptoms or effects that may arise if the product is mishandled and overexposure occurs are:

- Ingestion: Swallowing can result in nausea, vomiting and central nervous system depression. If the victim is showing signs of central system depression (like those of drunkenness) there is greater likelihood of the patient breathing in vomit and causing damage to the lungs.
- Eye contact: May be an eye irritant.
- Skin contact: Contact with skin may result in irritation. Will have a degrading action on the skin. Repeated or prolonged skin contact may lead to irritant contact dermatitis. Can be absorbed through the skin with resultant adverse effects.
- Inhalation: Material is irritant to the mucous membranes of the respiratory tract (airways). Breathing in vapour can result in headaches, dizziness, drowsiness, and possible nausea. Breathing in high concentrations can

Product Name: METHYL ISOBUTYL CARBINOL
Substance No: 000031314201
Issued: 04/07/2003
Version: 2
Material Safety Data Sheet

produce central nervous system depression, which can lead to loss of co-ordination, impaired judgement and if exposure is prolonged, unconsciousness.

Long Term Effects:
No information available for the product.

Toxicological Data:

Oral LD50 (rat): 2590 mg/kg. (1)

12. Ecotoxicological information

Avoid contaminating waterways.

13. Disposal considerations

Refer to Waste Management Authority. Dispose of material through a licensed waste contractor. Advise flammable nature. Normally suitable for incineration by an approved agent.

14. Transport information

Road and Rail Transport
Classified as Dangerous Goods by the criteria of the Australian Dangerous Goods Code (ADG Code) for Transport by Road and Rail.

UN No: 2063
Class-primary: 3 Flammable Liquid
Packing Group: III
Proper Shipping Name: METHYL ISOBUTYL CARBINOL
Hazchem Code: 3[Y]

Marine Transport
Classified as Dangerous Goods by the criteria of the International Maritime Dangerous Goods Code (IMDG Code) for transport by sea.

UN No: 2053
Class-primary: 3 Flammable Liquid
Packing Group: III
Proper Shipping Name: METHYL ISOBUTYL CARBINOL

Air Transport
Classified as Dangerous Goods by the criteria of the International Air Transport Association (IATA) Dangerous Goods Regulations for transport by air.

UN No: 2053
Product Name: METHYL ISOBUTYL CARBINOL
Substance No: 000031314201
Issued: 04/07/2003
Version: 2
Material Safety Data Sheet

Class-primary: 3 Flammable Liquid
Packing Group: III
Proper Shipping Name: METHYL ISOBUTYL CARBINOL

15. Regulatory information

Classification: This material is hazardous according to criteria of NOHSC.
X1: Irritant

Risk Phrase(s): R10: Flammable.
R37: Irritating to respiratory system.

Safety Phrase(s): S23: Do not breathe vapour/mist.
S24/25: Avoid contact with skin and eyes.
S36/37: Wear suitable protective clothing and gloves.

Poisons Schedule: None allocated.

This material is listed on the Australian Inventory of Chemical Substances (AICS).

16. Other information


This material safety data sheet has been prepared by SH&E Shared Services, Orica.

Reason(s) for Issue:
5 Yearly Revised Primary MSDS
Change in Personal Protection Requirements

This MSDS summarises to our best knowledge at the date of issue, the chemical health and safety hazards of the material and general guidance on how to safely handle the material in the workplace. Since Orica Limited cannot anticipate or control the conditions under which the product may be used, each user must, prior to usage, assess and control the risks arising from its use of the material.

If clarification or further information is needed, the user should contact their Orica representative or Orica Limited at the contact details on page 1.

Orica Limited’s responsibility for the material as sold is subject to the terms and conditions of sale, a copy of which is available upon request.
### Appendix C – MSDS Magnafloc

#### 1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

<table>
<thead>
<tr>
<th>PROJECT NAME</th>
<th>Magnafloc, Softloc 950, Magnafloc 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPLICATION</td>
<td>Flocculating Agent</td>
</tr>
<tr>
<td>SUPPLIER</td>
<td>Abbey Chemicals</td>
</tr>
<tr>
<td></td>
<td>27-30 North Rowe Road</td>
</tr>
<tr>
<td></td>
<td>Great Yarmouth</td>
</tr>
<tr>
<td></td>
<td>Norfolk</td>
</tr>
<tr>
<td></td>
<td>NR36 1SH</td>
</tr>
<tr>
<td></td>
<td>Tel. +44 1493 850303</td>
</tr>
<tr>
<td></td>
<td>Fax: +44 1493 330090</td>
</tr>
<tr>
<td></td>
<td><a href="http://www.abbey-chemicals.co.uk">www.abbey-chemicals.co.uk</a></td>
</tr>
</tbody>
</table>

#### 2. HAZARDS IDENTIFICATION

<table>
<thead>
<tr>
<th>CLASSIFICATION</th>
<th></th>
</tr>
</thead>
</table>

#### 3. COMPOSITION/INFORMATION ON INGREDIENTS

**COMPOSITION COMMENTS**

The data shown is in accordance with the latest EC Directives.

#### 4. FIRST-AID MEASURES

**INHALATION**

Move the exposed person to fresh air at once. Rinse nose and mouth with water. Get medical attention if any discomfort continues.

**INGESTION**

Immediately rinse mouth and provide fresh air. Do not induce vomiting. Never give liquid to an unconscious person. Get medical attention if any discomfort continues.

**SKIN CONTACT**

Remove affected person from source of contamination. Remove contaminated clothing. Wash the skin immediately with soap and water. Get medical attention if any discomfort continues.

**EYE CONTACT**

Make sure to remove any contact lenses from the eyes before rinsing. Promptly wash eyes with plenty of water while lifting the eye lids. Continue to rinse for at least 15 minutes. Get medical attention if any discomfort continues.

#### 5. FIRE-FIGHTING MEASURES

**EXTINGUISHING MEDIA**

Use fire-fighting media appropriate for surrounding materials. Extinguish with foam, carbon dioxide or dry powder.

**UNUSUAL FIRE & EXPLOSION HAZARDS**

Do not form explosive mixture with air. Avoid heat, flames and other sources of ignition.
Session 4: Explosive Hazardous Areas – In the Mining Environment

REVISION DATE: 15.07.2009

Magnafloc

SPECIFIC HAZARDS
Toxic gases/vapours/foams of Carbon monoxide (CO). Carbon dioxide (CO2). Nitrous gases (NOx).

PROTECTIVE MEASURES IN FIRE
Self contained breathing apparatus and full protective clothing must be worn in case of fire.

6 ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS
Wear protective clothing as described in Section 8 of this safety data sheet. In case of spills, beware of slippery floors and surfaces.

ENVIRONMENTAL PRECAUTIONS
Do not discharge onto the ground or into water courses.

SPILL CLEAN UP METHODS
Avoid generation and spreading of dust. Shovel into dry containers. Cover and move the containers. Flush the area with water. In case of spills, beware of slippery floors and surfaces.

7 HANDLING AND STORAGE

USAGE PRECAUTIONS
Avoid spilling, skin and eye contact. Avoid handling which leads to dust formation. Mechanical ventilation or local exhaust ventilation is required. Avoid inhalation of dust.

STORAGE PRECAUTIONS
Store in tightly closed original container in a dry, cool and well-ventilated place. Keep in original container. Keep away from heat, sparks and open flame.

8 EXPOSURE CONTROLS/PERSONAL PROTECTION

PROTECTIVE EQUIPMENT

ENGINEERING MEASURES
Provide adequate ventilation. Observe Workplace Exposure Limits and minimise the risk of inhalation of dust.

RESPIRATORY EQUIPMENT
If ventilation is insufficient, suitable respiratory protection must be provided. Use respiratory equipment with particle filter, type P2.

HAND PROTECTION
Use suitable protective gloves if risk of skin contact. PVC or rubber gloves are recommended.

EYE PROTECTION
Wear approved safety goggles.

HYGIENE MEASURES
DO NOT SMOKE IN WORK AREA! Wash at the end of each work shift and before eating, smoking and using the toilet. Wash promptly if skin becomes contaminated. Promptly remove any clothing that becomes contaminated. When using do not eat, drink or smoke.

9 PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE
Powdery, dust

COLOUR
White - off-white

ODOUR
Odourless

SOLUBILITY
Soluble in water

BULK DENSITY
750 kg/m³

10 STABILITY AND REACTIVITY
Session 4: Explosive Hazardous Areas – In the Mining Environment

REVISION DATE: 15.07.2009
MagnaFloc

STABILITY
Stable under normal temperature conditions.
CONDITIONS TO AVOID
Avoid heat, flames and other sources of ignition. Protect from humidity.
HAZARDOUS DECOMPOSITION PRODUCTS
Fire, carbon monoxide (CO), carbon dioxide (CO2).

11 TOXICOLOGICAL INFORMATION

TOXIC DOSE 1. LD 50
>2000 mg/kg (oral rat).

INHALATION
Due to high concentrations may irritate the respiratory system.

INGESTION
May cause discomfort if swallowed.

SKIN CONTACT
Powder may irritate skin.

EYE CONTACT
Particles in the eyes may cause irritation and swelling.

12 ECOLOGICAL INFORMATION

ECOTOXICITY
Not regarded as dangerous for the environment.
LC 50 96 h (Fish) mg/l 317
EC 50 48 h (Daphnia) mg/l 212

MOBILITY
The product is soluble in water.

13 DISPOSAL CONSIDERATIONS

DISPOSAL METHODS
Dispose of waste and residues in accordance with local authority requirements.

14 TRANSPORT INFORMATION

ROAD TRANSPORT NOTES
Not Classified
RAIL TRANSPORT NOTES
Not Classified
SEA TRANSPORT NOTES
Not Classified
AIR TRANSPORT NOTES
Not Classified

15 REGULATORY INFORMATION

RISK PHRASES
NC Not classified.

STATUTORY INSTRUMENTS
Chemicals (Information and Packaging) Regulations.

APPROVED CODE OF PRACTICE
Classification and Labelling of Substances and Preparations: Dangerous for Supply. Safety Data Sheets for Substances and Preparations.

GUIDANCE NOTES
Workplace Exposure Limits (EM) 0.1mg/m3 for everyone (HSE).

16 OTHER INFORMATION

REVISION DATE: 15.07.2009
MagnaFloc

ISSUED BY
Abbey Chemicals

REVISION DATE
15.07.2009

REV. NO. REPL. SDS
05

GENERATED
SDS NO.
M001

SAFETY DATA SHEET STATUS
Approved.

DATE
15.07.2009

SIGNATURE
Thomas Titleford
Appendix D – MSDS MaxiFlox 402

Available on request

Appendix E – Copper Mine MIBC Reagents Area Classification
Appendix F – Copper Mine MIAB Tun Dish GA

Appendix G – Copper Mine – Associated Plant Drawings

Flotation Plant GA
Reagents Facility GA
Appendix H – Explosivity Testing of Charcoal Fines

SAFETY IN MINES TESTING AND RESEARCH STATION

Mining Research Centre

SAMPLE TESTED:
Collie Charcoal Fines

LABORATORY NUMBER:
90003R

RESULTS:

Explosivity Testing:
- Max. Explosion Pressure Pmax = 7.4 bar (g)
- dp/dt max = 223 bars
- kmax = 63 m/s
- St. Classification = 1
- L.E.L. = 40 g/m³
- Median Particle size = 21 μm

DISCUSSION:
The particle size analysis showed that the supplied sample had a large percentage of fines. The sample had a median particle size of 21 μm with 93% of the dust sample less than 64 μm. This presents a dust in a form which is potentially explosive.

The testing in the 20 litre spherical chamber, with a 10kW ignition source, showed that the dust was definitely explosive. The dust was classified as St. 1 with a lower explosive limit, L.E.L., of 40 g/m³.

CONCLUSIONS:
The product as tested has the potential to develop damaging pressures, and is classed as being a strong explosion hazard, with an St 1 classification. Vessels carrying products of this classification can be adequately protected with explosion vents or suppression systems. Explosion vents are the preferred option in regard to installation and maintenance costs provided any subsequent explosion can be vented to a safe area.

RECOMMENDATIONS:
- Further testing be carried out to confirm the product’s ignition sensitivity and hence gain an idea as to what would constitute a possible ignition source. This information would help establish the level of risk involved.
Appendix I – Overall HA Drawing Materials Handling Facility

Material Handling Facility Elevation View - HA

1 Commonwealth of Australia, Australian Code for the Transport of Dangerous Goods by Road or Rail Edition 7.3, August 2014