2006

Confined space fatalities

Ciaran MacCarron
Edith Cowan University

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0985377

DOCTOR OF PHILOSOPHY

Supervisors: A/Prof. Milos Nedved

Dr Janis Jansz

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This study is dedicated to all those who lost their lives in Confined Spaces.

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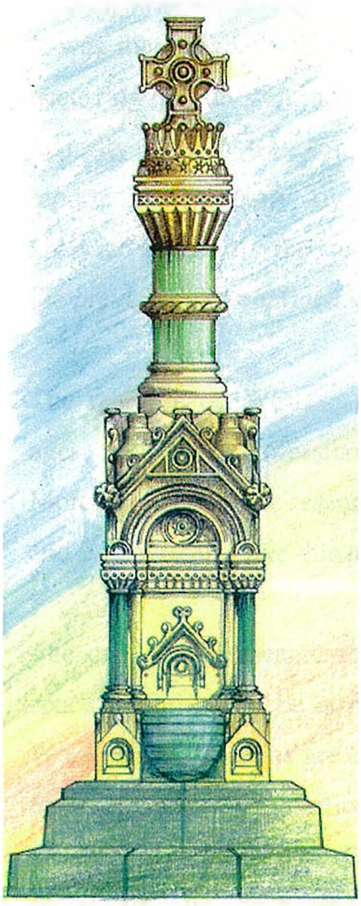

Confined space accidents are not new. This monument on Burgh Quay in Dublin commemorates an accident in which two people died and 12 were hospitalised.

The inscription reads:

"This memorial was erected in memory of Patrick Sheahan a constable in the Dublin Police Force who lost his life on the sixth day of May 1905 in a noble and self-sacrificing effort to rescue John Fleming who had in the discharge of his duties descended the main sewer close by this spot and was overcome by sewer gas.

It was also intended to commemorate the bravery of a number of citizens who also descended the sewer to assist in rescuing the beforementioned thereby risking their lives to save those of their fellowmen."

DECLARATION

I certify that this thesis does not to the best of my knowledge and belief:

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Ciaran MacCarron

ABSTRACT

The extent of work related fatal accidents has been analysed statistically by agencies throughout the world. As a result of this analysis there is a wealth of information available categorised by industry types, sub-industry, occupation, sex, age, nature of occurrence, bodily location, agency of occurrence and mechanism of injury. It is however extremely difficult to identify information pertaining to confined space fatalities such as contributory factors, mechanisms of injury and other data of an epidemiological nature.

It was the intended purpose of this research to investigate all known fatal accident statistics occurring within confined spaces throughout Western Australia and present findings. The majority of data was sourced from Coronial Reports, Death Certificates, and Investigation reports from Statutory Authorities. Fifteen case studies were chosen from selection criteria and analysed to identify the causal factors and make recommendations for change that will assist in the prevention of confined space fatalities.

The research on Western Australian work related confined space fatalities reveals common ages, industries, professions, locations and contributory factors of confined space fatalities. More importantly the research unveils reasons for the lack of information available on this topic and how we can solve this problem.

The case study research revealed that the lack of information available relating to confined space fatalities can be attributed to the method of categorisation for work related fatalities. Work related fatalities are collected and recorded according to the Australian and New Zealand Standard Industry Classification (ANZSIC). The work related fatalities are recorded under the primary work activity of the victim’s employer. It is therefore difficult to obtain statistics that are specifically identifying fatalities involving confined spaces. For example, in Australia a fatality occurring on a farm in a confined space would be recorded as an agricultural accident.

(*Refer to Australian and New Zealand Classification of Industry Guideline in Literature Review for more information*)

Common industries within Western Australia associated with confined space fatalities include construction, agriculture/fishing/forestry, electrical and manufacturing. The majority of the victim's were tradespersons and labourers including electricians, welders and plumbers.

Approximately three quarters of the fatal accidents were in Non-hazardous atmospheres including electrical (electrocution) and trench collapse (engulfment). Silo's, Vats, Ceiling spaces and trenches were common locations of confined space accidents. Majority of the causal factors revolved around failing to identify the work area as a confined space therefore procedures, training, safe systems of work other precautions were not implemented. Sadly 13 of the 15 Western Australian case studies had failed to conduct confined space training, ensure supervision and provide procedures reinforcing the need for a comprehensive confined space safety program in the workplace. It should be noted that conclusions were interpreted with caution as the sample size for the Western Australian research was very small (15) and this could influence the validity of the research.

The benefits of this study to the community and industry as a result of this research are a greater awareness of confined space hazards, design of appropriate preventative measures, which in turn will reduce both the financial and the human cost in relation to employers, employees and their loved ones.

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1.0 INTRODUCTION

1.1 Statement of the Problem

The literature of the past and present within Western Australia (WA) contains very few comprehensive studies on confined space fatalities. With little information on the aetiologies of confined space accidents there is a lack of awareness of the risks involved with this type of hazard. As result, confined space fatalities continue to occur in the workplace.

Ferry (1988) states that "identification is the starting point for a system of control" (p.24).
The purpose of this research study was to investigate all known Western Australian confined space fatalities under the jurisdiction of the Occupational Safety and Health Act (OSH) WA 1984, to identify causal factors and to make recommendations for improvements to assist in preventing recurrence.

1.2 Background of the Study

> *"Other than vehicular accidents, more multiple fatalities occur during confined space entry work than any other type of work performed in the United States today"*
> *(De Vaney, 1997, p22).*

The preceding quotation indicates the importance of research into the hazards of confined space entry.

We know little about accidents involving confined spaces. It is evident within Australia and other jurisdictions that have adopted the United Nations definition of work related fatal accidents that there is a lack of comprehensive research regarding confined space fatalities. According to information gained from accident reports by California State University Bakersfield (CSUB,1998), it is believed that over two million workers enter confined spaces each year, 39 of those workers die and approximately 5,900 are injured in confined space accidents, (p43-52). Professor Keyserling of the University of Michigan has differing figures from those mentioned above and estimates that there are between 60 and 65 confined space fatalities per annum and approximately 6,000 serious injuries resulting in lost work days (Keyserling, 2000, p6).

This apparent lack of comprehensive research is a result of various factors including; belated promulgation of OHS Legislation within Western Australia and the method of recording workplace fatalities with Western Australia.

The OHS Act WA 1984 was passed in 1984 and promulgated in 1988. Therefore the availability of records (if there were any records) such as investigation reports, death certificates and coroners reports was limited. The statistics prior to 1988 were developed in retrospect based on the information available and with little information available prior to 1988 these statistics may not be true indicators of the number of fatalities that occurred within this period. As a result of these limitations there have been no studies conducted confined space fatalities to date within Western Australia (or Australia).

Publicly available information exits primarily as a result of fatal accident investigations. National Institute for Occupational Safety and Health (NIOSH), Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA) reports are the main resources for research in the area of North America (McManus, 1999, p198). The Western Australian Department of Minerals and Resources and the Western Australian Department of Consumer and Employment Protection (WorkSafe Division and Resource Safety Division) were the primary source of information pertaining to the research.

Studies completed so far are predominantly limited to the USA although some region specific studies have been conducted in Canada and New Zealand. These studies, or lack thereof, reinforce the need for future research into the nature of confined space hazards to prevent recurrence of fatalities in confined spaces.

1.3 Significance of the Study

"In WA it is estimated that over 658,000 confined space entries are made each year" (WorkSafe, 1999,p28).

The significance of the study is to ensure the magnitude of confined space fatalities is brought to the attention of statutory authorities, industry and the general community with the aim of preventing recurrence of confined space fatalities.

Australia has not been efficient in releasing confined space accident data. Limited study into the magnitude of the problem has been conducted in Australia. The USA have conducted a great deal more study in regards to confined space fatalities than any other country in the world, however their research is not void of inconsistency. The limited amount of comprehensive information regarding confined space fatalities is therefore not confined to Western Australia alone but is a worldwide problem that industry should consider addressing.

In additional to the desperate need for comprehensive research regarding confined space fatalities is the rapid growth of industry not only within Australia but across all continents. With a growth in industry comes an increase in man hours exposed to hazards. This indicates that there is a need now more than ever for effective risk management techniques when addressing hazards in the workplace, specifically confined space hazards.

Recent legislative amendments concerning employers within Western Australia also highlight the need for confined space awareness. Employers (Body Corporate) face increased penalties of up to $500 000 and up to two years imprisonment if found negligent.

Large penalties are not restricted to Western Australia alone. In 2005 a Texas Welding company agreed to pay OSHA a fine of US$300 000 for failing to implement confined space standards which resulted in the death of two workers at the company's Ingleside facility. The financial cost is relatively minor in relation to the human cost to the victims and their respective families.

Employers need to be aware of confined space fatalities so as to ensure they exercise "due diligence" in preventing any accidents within their control. This is not solely a financial obligation but more importantly a moral obligation.

1.4 Purpose of the Study

"A recurring site of both fatal and non-fatal accidents in industry is the confined space" (McManus, 1999,p9).

OSHA estimates that there are 5,000 serious injuries and 63 fatalities annually associated with confined spaces, (Department of Energy, 1993, p11). While there may be a disparity in the exact number of fatalities due to the difficulties in searching fatal accident statistics the apparent magnitude of the problem is clearly evident.

The purpose of the study is to analyse all known work related confined space fatal accidents within Western Australia, identify the casual factors and make recommendations for prevention.

This is a historical research study as it looks at fatality reports and analyses descriptions.

The results of the Western Australian confined space research has been presented in the form of recommendations aimed at the reduction of confined space fatalities.

1.5 Summary of the Research Results

The research was conducted to investigate common aetiologies of confined space fatalities, determine causal factors and recommend prevention strategies based around these causal factors. The factors investigated within this research included age, sex, employment status, industry, profession, location of the deceased and contributory factors.

The age groups of the deceased ranged between 13 to 59 years old. Majority of the victims were male, within the 16-30 years age bracket.

Many of the victims both in the literature review and in the Western Australian research study were contractors and sub-contractors. The majority of these victims were working within the electrical, construction and agriculture industries. The Manufacturing sector also accounted for one of the fatalities.

Consistent with the electrical, construction and agriculture industries was the large proportion of tradesmen including electricians, welders, plumbers and fitters. Labourers were also a common profession amongst the victims.

Common locations of confined space fatalities within the literature review studies and the Western Australian research study were ceiling spaces, silo's, vats, and trenches. The large proportion of fatalities within a ceiling space was consistent with the large proportion of victims whom were electricians.

Causal or factors contributing to the fatality centred on the lack of training, supervision, procedures and a generally a safe system of work provided by the employer and or implemented by the employee. In the Western Australian research study the majority of the employers had not provided training or ensured the victim was competent at his role. This included the pre-employment process of viewing qualifications, licences and or competency documents as well as assessing competency during the victim's time of employment. In a couple of cases where training was provided by the employer the deceased failed to implement the advice given within the training session. This may be attributed to supervision (or lack of supervision).

It was revealed that in majority of the Western Australian cases studies supervision was inadequate. Inadequate supervision entails; no supervision present during the accidents or if present supervision was inattentive.

In many of the cases there was little evidence of a safe system of work. In the limited number of cases where a safe system of work was documented it was poorly implemented. The need for the provision of personal protective equipment (PPE) was also identified in many of the case studies. If the PPE was available it was not used by the victims.

1.6 Limitations

There were many limitations both within the literature review studies and within the Western Australian research study itself. For the readers purpose limitations in both areas will be analysed.

Literature Review Limitations

1.6.1 USA Studies

The USA study is included in the limitations as it has been used as a comparative study in the literature review and therefore affects the outcome of the research findings.

The researchers in the OSHA, MSHA and NIOSH studies constantly stress the incompleteness of accident databases when collecting data. In addition to this data was not available from all USA states. The researchers believe that the accidents selected for inclusion were only a fraction of those that actually occurred.

In addition to this the researchers gave no mention to the method of inclusion or exclusion of fatalities from the study. Without a description of the criteria and method in which the data was obtained and analysed it is difficult to assess the validity and reliability of the results! For example how would the reader know if significant findings within the studies are not a result of the differences in data retrieval and analysis by the researchers?

Many of the OSHA reports overlap in research timeframes and as a result the number of confined space fatalities may have replicated. For example all confined space fatalities reported in the OSHA Reports (1982a-1985 and 1988) were also used in the OSHA 1990 report. In addition to this many of the fatalities that were grouped into the welding and cutting, fire, explosion and toxic/asphyxiating atmospheres were also grouped in the grain handling. Grain silo's also (or engulfment of grain in the silo) also fit's the criteria of an asphyxiating atmosphere. Many of the same fatalities in the above studies are also used in the lockout & tag out fatality studies. The number of confined space fatalities was calculated individually for each report and incorporated into one general table. The number of confined space fatalities may therefore be higher than what in fact occurred.

The OSHA reports also do not consider non-hazardous confined space fatalities in their studies prior to 1982. This can be attributed to changing legislation (therefore evolving definitions of confined space). NIOSH do consider non-hazardous confined space fatalities in all their studies.

There is no universally accepted definition of confined space. The NIOSH definition for confined space contained the following elements in 1978 Study.

- Limited openings for entry and exit
- Unfavourable natural ventilation that could contain or produce dangerous air contaminants
- Not intended for continuous employee occupancy

OSHA published a series of analytical reports on confined space fatal accidents that were used as a primary means of analysis in this research study. The definition for confined workspace used in this study contained the following criterion:

- An enclosed or partially enclosed workspace
- Limited means of entry and exit
- Subject to accumulation of toxic or flammable contaminants
- May develop an oxygen deficiency
- Not intended for continuous employee occupancy

If there is currently no universal definition for what is considered a confined space there can be no universal framework for confined space fatality research. What is considered a confined space in Western Australia may not be considered a confined space in North America which in this case results in inconsistencies with research statistics making it impossible for comparison across countries, states and or jurisdiction.

Similarly there is no universal framework for industry classification. The United States of America classify industry according to the North America Standard Industry Classification whereas Australian adheres to the ANZSIC Standard Industry Classification. These standards align at the industry sub-category level but not at the highest level eg Manufacturing, Construction etc. What is considered Electrical industry in Australia would be considered under construction in the USA as there is not separate category for electrical under their classification.

This makes it difficult to compare results of studies across the continents. It is also interesting to note that according to the USA literature review majority of confined space hazards occur in the Construction industry whereas majority of confined space hazards occur in the Electrical Industry within Western Australia.

The OSHA confined space regulations would not apply to workplaces with fewer than 11 employees, federal workers, state and municipal employees in the 24 states under federal rather than state OSHA jurisdiction, self employed persons and workers in the transportation, construction and shipbuilding industries.

1.6.2 State of the Work Environment

The following limitations should be considered when making an interpretation of the data in the Western Australian State of the Work Environment report for work related fatalities within Western Australia;

This report is concerned with fatalities involving injury. In producing this data, work-related fatalities resulting from occupational diseases were included.

Fatalities are listed according to the year in which they occurred. The compensated work-related fatality data reported by WorkCover do not match the data in the report due to differences in data collection methods. For example in 2003-04 there were 25 claims lodged with WorkCover WA for compensation concerning work-related fatalities, while in the same year WorkSafe recorded 20 work-related fatalities.

The incidence rates in the State of the Work Environment report are based on total employed workforce figures, which include self-employed people

The data collected is classified according to the Australian and New Zealand Standard Industry Classification (ANZSIC) of the main work activity of the employer of the person to whom the fatal event occurred. This classification is consistent across the data collections in all States and Territories for data related to both work-related lost time injuries and diseases, however caution should be exercised when comparing this publication to publications with data from other sources which may not use the same basis for classification by industry. For example the North American Standard Industry Classification aligns with the ANZSIC standard at the sub-category level. Therefore comparison at the main industry level is difficult.

Reported data is subject to revision from year to year as coronial findings and other information may not be available at the time of producing annual reports.

1.6.3 Mining

The Western Australian mining data referred to fatality incidence rates rather than number of fatalities. The fatality incidence rate was the measure of fatality per 1000 persons working for the employer. Therefore a small sample population results in a very high fatality incidence rate giving the impression of increased fatalities when in fact this was not the case.

Exploration mining fatalities were not included in the Western Australia mining studies prior to 1998 due to changes in the Mines Safety and Inspection Act WA 1994.

1.7 Research Questions

The research questions include:

(a) Why is there a lack of information regarding confined space fatalities?

(b) What are the main industries for confined space fatalities to occur in?

(c) What are the main professions for confined space fatalities to occur in?

(d) Where do confined space fatalities occur?

(e) What are the probable causal factors for confined space fatalities?

(f) What preventative measures are required to prevent recurrence of confined space fatal accidents?

1.8 Definitions of Terms

ATTRIBUTABLE RISK refers to what is the additional risk of death experienced by exposed persons over and above that experienced by non-exposed persons (WorkSafe, 2005)

COFFERDAM is a watertight chamber attached to the side of a ship to facilitate repairs below the water line. (WorkSafe, 2005)

CONFINED SPACE is an enclosed or partially enclosed space which:

(a) Is at atmospheric pressure during occupancy;

(b) Is not intended or designed primarily as a place of work;

(c) May have restricted means for entry and exit; and

(d) May:

    (i) Have an atmosphere which contains potentially harmful levels of contaminant;

    (ii) Not have a safe oxygen level; or

    (iii) Cause engulfment.

CONFINED SPACES may include but are not limited to:

(a) Storage tanks, tank cars, process vessels, boilers in pressure vessels, silos and other tank-like compartments;

(b) Open-topped spaces such as pits or degreasers;

(c) Pipes, sewers, shafts, ducts and similar structures; and

(d) Any shipboard spaces entered through a small hatchway or access point, cargo tanks, cellular double bottom tanks, duct keels, ballast and oil tanks, and void spaces but not including dry cargo holds. (AS 2865-1995)

CONTRACTOR is person or entity who, as part of an independent business, becomes obligated to provide goods and/or services for a price (WorkSafe, 2005)

DEATH ATTRIBUTABLE AS A WORK-RELATED EXPOSURE means as a consequence of a physical trauma or poisoning. (McManus, 1999)

DEFECTIVE EQUIPMENT the equipment had a fault which was not due to normal wear and tear.(MacCarron, 2002)

ENVIRONMENT wind, rain, flooding, heat, darkness, glare, cramped conditions etc make create a hazard or increase a hazard beyond expectations (MacCarron, 2003).

EMPLOYEE is a person by whom work is done under a contract of employment; or an apprentice or industrial trainee (WorkSafe, 2005)

EMPLOYER is (a) a person by whom an employee is employed under a contract of employment; and (b) in relation to an apprentice, or industrial trainee, the person by whom the apprentice or industrial trainee is employed under an apprenticeship or industrial agreement. In other words, whether work is performed in return for money under a contract of employment.
(WorkSafe, 2005)

FATALITY INCIDENCE RATE is the numbers of fatalities per 1000 employees for a 12 month period (WorkSafe, 2005)

HAZARDOUS ATMOSPHERE includes;

- Toxic atmospheres – hydrogen sulphide, carbon monoxide, methane, inert gases, chlorinated solvent vapours and fuel vapours.
- Asphyxiating atmospheres – Oxygen deficiency, nitrogen gas displacement, fuel gas displacement and welding gases.
- Fire/Explosion – Organic solvent vapours, fuel vapours, welding gases and natural gas.

- Welding/Cutting – Organic solvent vapours, fuel vapours, welding gases and natural gas (AS2865 – 1995).

HOPPER is a funnel-shaped container in which materials, such as grain or coal, are stored in readiness for dispensation (MacCarron, 2001).

INADEQUATE WORK STANDARDS the enterprise's procedural standards and policies were not in place or were less than adequate (MacCarron, 2002)

INADEQUATE EQUIPMENT DESIGN the design of the plant or equipment was inadequate. (MacCarron, 2005)

INADEQUATE EQUIPMENT the equipment used to perform the work was not suitable for the task. This includes improvisation (MacCarron, 2005)

NON-HAZARDOUS ATMOSPHERE includes; Engulfment, entanglement, falling objects, process hazard, electrical, unstable interior (trench collapse) and falls from height. (McManus, 1999)

OCCUPATION is recorded in accordance with the 1986 edition of The Australian Standard Classification of Occupations (ASCO) produced by the Australian Bureau of Statistics (ABS, 2005)

RELATIVE RISK refers to how many times more likely are exposed persons to die than non-exposed persons (McManus, 1999)

SELF-EMPLOYED PERSON a person who works for gain or reward otherwise than under a contract of employment or apprenticeship, whether or not they employ any other person. (WorkSafe, 2005)

STOPE is an excavation in the form of steps made by the mining of ore from steeply inclined or vertical veins (Docep, 2005)

UNSAFE WORKPLACE a workplace which contains hazards which are not recognized, or are recognized or ignored (WorkSafe, 2005)

UNSAFE SYSTEM OF WORK a work procedure which is likely to cause a hazard.

WORK-RELATED FATALITY for the purpose of data collection is a fatality that occurred to an employee contractor or self-employed persons under a contract of work (documented or verbal) during working hours (including lunch breaks) whereby the death can be attributed to a cause as a consequence of the work carried out.
(WorkSafe, 2005)

1.9 Abbreviations

ANZSIC	Australian and New Zealand Standard Industry Classification
ASCO	Australia Standard Classification of Occupation
ABS	Australian Bureau of Statistics
CPR	Cardiopulmonary Resuscitation
DOCEP	Department of Consumer and Employment Protection
DMR	Department of Minerals and Resources
FACE	Fatality Assessment Control Evaluation
JSA	Job Safety Analysis
MSHA	Mines Safety Health Administration
MAPAO	Mines Accident Prevention Association of Ontario
NIOSH	National Institute of Occupational Health
NTOF	National Traumatic Occupational Fatalities
OSHA	Occupational Safety and Health Administration
OHS	Occupational Health and Safety
PPE	Personal Protective Equipment
RFDS	Royal Flying Doctor Service
SCBA	Self Contained Breathing Apparatus
SOWE	State of the Working Environment
USA	United States of America

2.0 LITERATURE REVIEW

2.1 United States Of America (USA) Studies

"The International Labour Office estimates that workers suffer 250 million accidents every year with 330,000 fatalities" (McManus, 1999, p12)

The following literature review is based upon a USA study conducted by the North West Occupational Health and Safety (a division of Safety in Design) in 1999. The study utilises previous research reports written by Occupational Safety and Health Administration (OSHA), National Institute of Occupational Safety Health and the Mines Safety and Health Administration. The reports utilised in this study are summarised below.

<u>OSHA 1982a - Selected Fatalities related to Fire & Explosion in confined spaces</u>

Associated with 50 confined space incidents selected for the study between 1974-1979 were 76 fatalities. Heat and rapid release of energy generated by the fire were major causal factors of death. Actions of the entrants and faults in equipment provided the source of ignition in many of the cases.

<u>OSHA 1982b - Selected Fatalities related to Lockout & Tagout</u>

This report grouped work related fatalities by causative agent including machines & conveyors, vehicles & equipment and electrical equipment. Confined space fatalities were not considered a factor in this report but according to *McManus* (1999), "many of the workspaces would satisfy current criteria for inclusion" (p94). Of the 83 cases selected between 1974-1980 there were 83 confined space fatalities.

<u>OSHA1983 – Selected Fatalities related to Grain Handling</u>

The report on grain handling did not consider confined space a factor during the study but many of the workspaces would satisfy current (NIOSH) confined space criteria. Of 105 fatal accidents that occurred from 1977 to 1981, 126 fatalities occurred.

OSHA 1985 – Selected Fatalities related to Toxic & Asphyxiating Atmospheres

One hundred and twenty two work related accidents relating to toxic and asphyxiating atmospheres occurred during 1974 to 1982 were selected for the study. A total of 173 fatalities resulted from the 122 selected accidents. hazardous atmosphere was the causative agent in majority of these confined space incidents. Reinforcing the tendency for confined space accidents to involve multiple fatalities. In some cases the rescuers were the only victim!

OSHA 1988 – Selected Fatalities related to Welding & Cutting

Of the 217 work related accidents selected for the study during 1974 to1985 there were 262 fatalities. In 22% of the incidents the welder was working in a workspace that would satisfy current confined space criteria. Misuse of oxygen occurred in 1% of the incidents.

OSHA 1990 - Selected Fatalities related to Shipbuilding & Repair

Of the 151 fatal accidents occurring between 1974 to 1984 were 176 fatalities. In 36% of the accidents the victim was working inside a workspace that would be considered a confined space. Misuse of oxygen occurred in 2% of the incidents.

MSHA Report 1988- Confined Space Fatalities in Mining

A compilation of accident summaries in mining was prepared by the MSHA in 1988 documenting 44 work related confined space fatalities from 38 accidents that occurred during the period of 1980 – 1986. By the end of 1993 MSHA reported that it had recorded 57 fatalities in accidents involving confined spaces. Majority of the confined space fatalities resulted from collapse of bridged and caked materials in bins, silos and hoppers. The findings in this report were used in conjunction with the OSHA reports and in the “Study of Confined Spaces within North America”(McManus, 1999, p2-456)

Table 1 – Results of OSHA & MSHA Reports (McManus, 1999)

Condition	Ac	At	%	Fc	Ft	%	F/A
Grain Handling	58	105	55	78	126	62	1.3
Lockout/Tag out	29	83	35	29	83	35	1.0
Fire/Explosion	50	50	100	76	76	100	1.5
Toxic Atmosphere	55	55	100	80	80	100	1.5
Asphyxiating Atmosphere	46	46	100	71	71	100	1.5
Other	19	21	90	19	22	86	1.0
Welding Cutting							
Interior	36	164	22	44	190	23	1.2
Exterior	58	164	35	72	190	38	1.2
Shipbuilding/repair	31	31	100	36	36	100	1.2
Mining	26	38	68	32	44	73	1.2

Ac = fatal accidents in confined spaces
Fc = fatalities in confined spaces
At = total accidents
Ft = total fatalities
F/A = Accident Fatality Ratio

According to the McManus 1999 study of selected OSHA and MSHA reports the largest number of confined space incidents occur whilst welding on top of a confined atmosphere (58) and grain handling (58). The highest percentage of confined space accidents however, occurs within toxic/asphyxiating atmospheres, fire & explosion and shipbuilding and repair. The highest ratio of fatalities also lies within these areas.

The predominant characteristic of all OSHA and MSHA studies was inadequate control of activities occurring in confined spaces. This expressed itself through failure to identify the potential hazards and failure to address them in an organised approach (McManus, 1999, p321)

The researchers of the OSHA studies repeatedly state the lack of completeness of the database used in these studies. The causal factor coding contained no reference of the parameters under the study. In addition to this data was not available from all USA states. The researchers believe that the accidents selected for inclusion were only a fraction of those that actually occurred.

Table 2 – Results from OSHA & MSHA Reports (McManus, 1999)

Condition	Hazardous Atmosphere		Confined Spaces		All Causes	
	A	**F**	**A**	**F**	**A**	**F**
Grain Handling	40	78	116	156	210	252
Lockout/Tag out	0	0	41	41	119	119
Fire/Explosion	73	112	83	127	83	127
Toxic	61	89	61	89	-	-
Asphyxiating	51	79	51	79	-	-
Other	0	0	21	21	-	-
Welding/Cutting	-	-	-	-	-	-
Interior	26	34	40	51	-	-
Exterior	64	83	64	83	-	-
Total	90	117	104	134	217	262
Shipbuilding/repair	12	16	28	33	137	160
Mining	0	0	37	46	54	63
Totals	**327**	**491**	**542**	**726**	**956**	**1175**

A=Fatal Accidents F= Fatalities occurring during these accidents

According to Table Two (McManus, 1999, p232-235) the number of confined space accident in grain handling exceeds those in other categories. The least hazardous category would be mining. The dominance of hazardous atmospheric conditions as a causal factor is clearly evident. Of the 542 fatal accidents involving confined spaces hazardous atmospheres were the causative agent in 327 (60%) of them.

Assuming the data in this study is correct; at least l64 persons die in confined space accidents annually in the USA. At least 41 of these persons are victims of hazardous atmospheric conditions and at least 49 persons die annually when welding on the exterior of structures and containers confining a hazardous atmosphere. Non-hazardous atmospheres were not considered in any of these studies as the definition of confined space did not consider non-hazardous atmospheres prior to 1994 (McManus, 1999, 257).

Using the data extracted from the OSHA reports 1982a, 1985 and 1988 McManus provided the following statistics related to the location of confined space fatalities.

Table 3 - OSHA 1982A, 1985 &1988 Reports (McManus, 1999)

	Percent Of Fatal Accidents			
Location	**TA**	**AA**	**F/E**	**W/C**
Processing plant/animal matter	4	-	-	-
Dip tank/degreaser	11	-	-	-
Storage tank/compartment/vessel	33	47	75	8
Asphalt tanks	-	-	-	4
Hydrocarbon storage tanks	-	-	-	14
Fuel tanks	-	-	-	18
Transport tanks (truck, rail)	-	-	-	7
Chemical storage/reaction vessel	-	-	-	3
205-L(55 U.S. gal) drums	-	-	-	16
Wastewater treatment	31	21	5	-
Trench	-	-	5	-
Vault	-	6	-	-
Fabrication	-	-	-	3
Other	21	24	15	27

TA= Toxic Atmosphere AA= is Asphyxiating (oxygen deficient) Atmosphere

F/E=Flammable or Explosive Atmosphere W/C= Welding and cutting

This table indicates a large proportion of confined space fatalities occurred in relatively few locations including storage tanks and waste water treatment plants.

The statistics provided in the tables are closely related with those selected for the National Institute of Occupational Safety and Health study of confined spaces. The large proportion of “other” has not been accounted for in this study!

The following table was created using the 1982a and 1985 OSHA reports. This table only included confined space fatality victims of toxic & asphyxiating atmospheres.

Table 4 – Results from OSHA 1982a & 1985 Reports (McManus, 1999)

	Percent of Fatal Accidents		
Occupation	**TA**	**AA**	**F/E**
Management/Supervisory	-	-	-
Supervisor/Foreman	11	12	12
Superintendent/Manager	3	12	0
Trades	-	-	-
Plumber	5	10	-
Painter	5	2	16
Welder	24	0	-
Maintenance	13	10	6
Operator	10	6	-
Technical	7	10	2
Labourer	36	35	32
Other	12	3	8

The table indicates that the victims of confined space fatalities are quite broad. A large portion of the victims were Labourers, Welders and Maintenance persons.

OSHA assigned an immediate cause to confined space accidents documented in the 1982a and 1985 reports. The data related to hazardous atmospheres only. 95% of the fatalities resulted from procedural deficiencies or problems with materials, equipment or facilities. See the following table.

Table 5 – Results from OSHA 1982a & 1985 Reports (McManus, 1999)

	Percent Of Fatal Accidents		
Immediate Cause	**TA**	**AA**	**F/E**
Procedural			
Failure to test prior to entry	24	25	14
Inadequate training in use of testing equipment	2	-	-
Improper test procedure	5	-	-
Failure to follow entry procedures	13	32	-
Entry against orders	7	5	5
Entry for unknown or invalid reason	5	5	-
Faulty procedure	7	5	25
Failure to follow work procedures	9	7	-
Dangerous work practices or shortcuts	5	5	-
Improper respirator selection	9	-	-
Respirator or training in use not available	5	-	-
Failure to use respirator	5	-	-
Equipment, material, or facility			
Failure of supplied air system	2	-	-
Respirator problem	2	-	-
Faulty isolation	-	5	18
Ungrounded equipment	-	11	11
Unapproved lighting equipment	-	-	16
Other	-	-	11

NIOSH Report One 1980 - 2004 - Fatality Assessment And Control Evaluation Program FACE.

The National Institute for Occupational Safety and Health (NIOSH) investigates selected workplace fatalities through the Fatal Accident Circumstances and Epidemiology (FACE) project. This surveillance project is designed to collect descriptive data on selected fatalities using an epidemiologic approach, to identify potential risk factors for work-related death, to develop recommended intervention strategies, to disseminate findings that increase employer and employee hazard awareness and to reduce the risk of fatal injuries in the workplace.

FACE is a surveillance program for the investigation and identification of fatal occupational injuries.

When the NIOSH investigation reports were matched to the death certificate there was no mention within the certificate that the incident involved a confined space therefore investigation reports were analysed on an individual basis.

From December 1983 through December 1989, 55 confined space events resulting in 88 deaths were investigated through the Fatal Accident FACE project (part of NIOSH). In these events only three of the workers who died had received any training in confined space safety. Additionally, only 27% of the employers had any type of written confined space entry procedures. Where written procedures did exist they were either not implemented, inadequate, or both. Because many employers and workers were not aware of the hazards associated with confined spaces, basic NIOSH recommendations published in 1979 that would have prevented the fatalities were not followed (Mainwaring & Conroy, 1990, p49).

It was concluded in this study that the root causal factor in the fatality was a failure to consider the workspace a confined space. Therefore atmospheric testing did not occur and procedures were not followed. Had these spaces been properly evaluated prior to entering and continuously monitored while the work was being performed and had appropriate rescue procedures been in effect, the deaths would have occurred (NIOSH, 1999, p5).

NTOF Report One – 1980-1989

In addition to this NIOSH created a report from the National Traumatic Occupational Fatalities (NTOF) database providing statistics on confined space fatalities during the period of 1980-1989. It details confined space fatality by cause, industry, reason for entry amongst other epidemiological data. In this study a total of 670 fatalities resulted from 585 confined space accidents. Asphyxiation accounted for 305 (45%) deaths, poisoning accounted for 274(41%) and drownings accounted for 91 (14%) deaths.

Table 6 Fatality by Cause of Death (NIOSH, 1998)

GROUP	NUMBER	(% of TOTAL)
Poisons (E850-858, E860-869)		274 (41%)
Drowning (E910)		91 (14%)
Asphyxiation (E911-913)		305 (45%)
(E911, 912-Obstruction of Respiratory Tract)	31	
(E913-Mechanical Suffocation	274	
TOTAL		**670 (100%)**

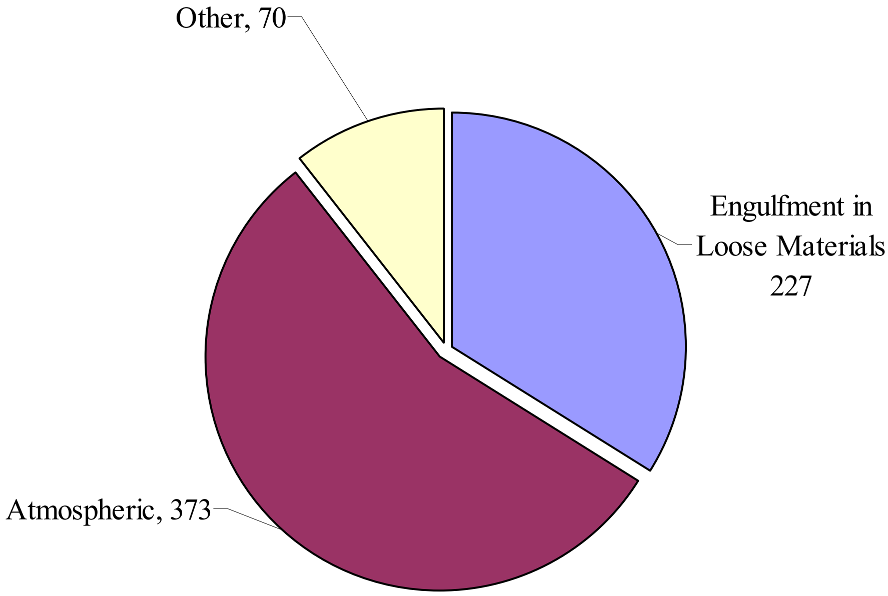
The number confined space fatalities were highest in manufacturing (152), followed by agriculture (128), construction (90), transportation/public utilities (77), and mining/oil & gas (63). It is interesting that the mining/oil & gas industry had the highest confined space fatality rate (per 100 000 persons).

Atmospheric Confined Space Fatalities

Of the 373 confined space related fatalities resulting from <u>atmospheric conditions</u>, 85 of the victims worked in the manufacturing sector, 59 in construction, 57 in the transportation & public utilities sector and 48 in the agriculture industry. Industry was not listed on 35 of the death certificates.

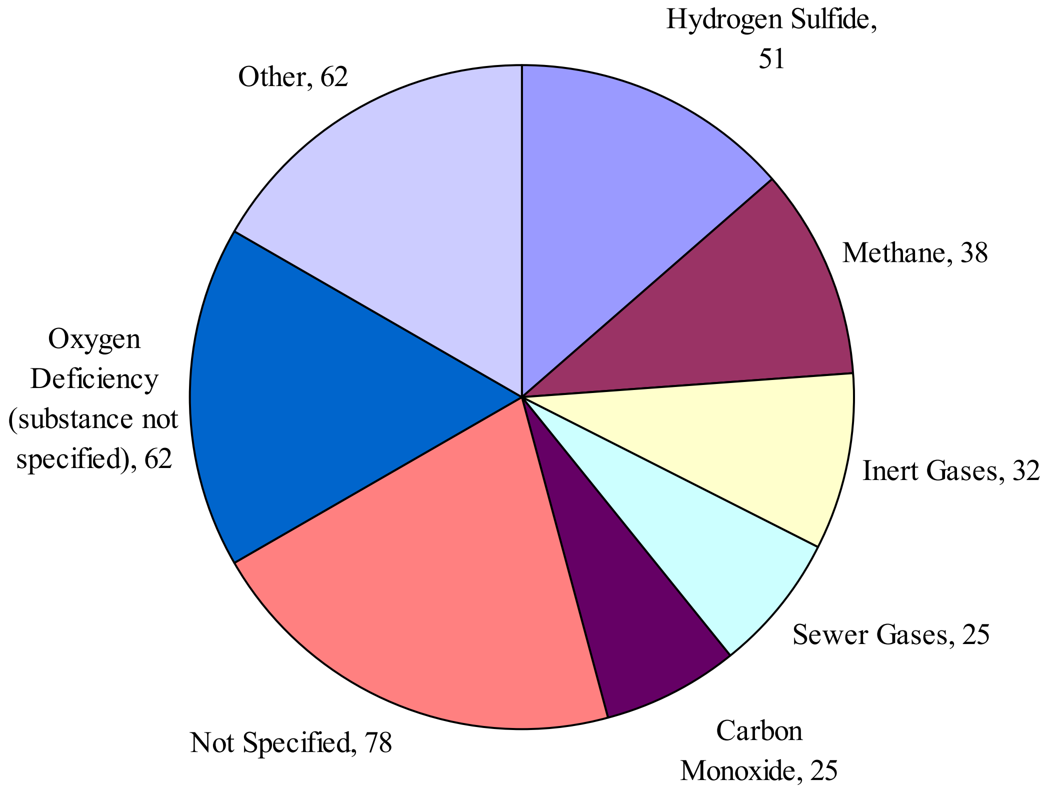
Tanks were the most common location of confined space fatalities accounting for 109 deaths, sewers responsible for 61 deaths, pits 32 (16 of these manure pits) and 27 in silo's. In 71 of the victims the location was not reported and the remaining 75 included vats, wells, bins, pipes and kilns.

Figure 1 Confined Sapce Fatalities by Atmosphere (NIOSH, 1998)



Of the confined space accidents attributed to hazardous atmospheres, hydrogen sulphide claimed 51 victims, methane 38, inert gases 32 and carbon monoxide 25. Sewer gases were also the direct cause of 25 deaths. 62 of the victims died in an oxygen deficient atmosphere but it was unspecified what other toxin was present. For 78 of the victims the death certificates did not provide enough information to determine what particular atmospheric condition caused the death.

Figure 2 **Non-Atmospheric Confinced Space Fatalities (NIOSH, 1998)**



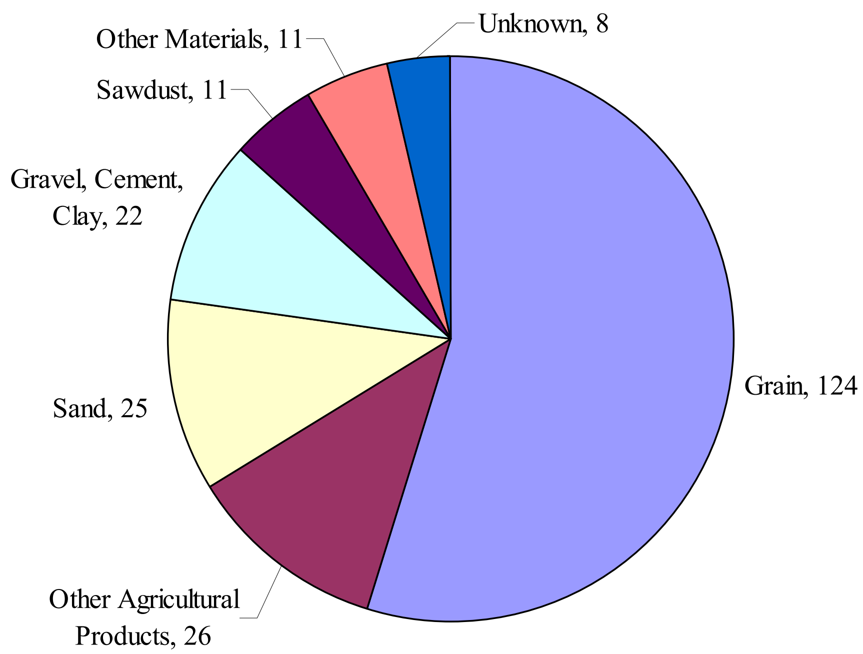
Non-Atmospheric Confined Space Fatalities

74 of the non-atmospheric confined space fatalities were in the agricultural/forestry/fishing industry. 57 of the victims worked in the manufacturing industry, 24 in wholesale trade and 24 in construction. There were less than 15 deaths in the remaining industry. 19 deaths were not determined.

Of the 227 confined space related fatalities resulting from non–atmospheric conditions (engulfment in loose materials) entrapment in grain caused 124 deaths, silage & fertiliser caused 26 deaths, sand 25 deaths and 22 deaths from engulfment in other building materials such as gravel and cement. Engulfment in sawdust also claimed 11 lives and for 8 of the victims the material was not provided on the death certificate but was assumed to have occurred in a confined space.

Silos, bins, hoppers and grain elevators were the locations of majority of the fatal engulfment's accounting for 158 deaths. 13 deaths were located in pits and 53 in other locations not stated on death certificate.

Figure 3 Non Atmospheric Confined Space Fatalities by Cause (NIOSH, 1998)



According to *McManus*, (1999) "the most glaring deficiency identified in the reports from NIOSH, OSHA and MSHA was the lack of knowledge"(p18). Workers and supervisors routinely failed to recognize the hazardous conditions that existed or could develop in these workspaces.

USA Legislation

American Standard – ANSI Z117.1 Safety Requirements for Confined Spaces does not pertain to underground mining, tunnelling, caisson work or other similar tasks that have established national consensus standards

OSHA's General Industry Regulation, §1910.146 *Permit-required confined spaces*, contains requirements for practices and procedures to protect employees in general industry from the hazards of entry into permit-required confined spaces. This regulation does *not* apply to construction.

OSHA's Construction Regulations also contain requirements dealing with confined space hazards in underground construction (Subpart S), underground electric transmission and distribution work (§1926.956), excavations (Subpart P), and welding and cutting (Subpart J). These regulations would not apply to workplaces with fewer than 11 employees, federal workers, state and municipal employees in the 24 states under federal rather than state OSHA jurisdiction, self employed persons and workers in the transportation, construction and shipbuilding industries.

(Refer to Appendix 2 for USA Confined Space Legislation)

2.2 Western Australia

2.2.1 Non-Mining

The State of the Work Environment (SOWE) series is produced by the WorkSafe Division of the Department of Consumer and Employment Protection with the assistance of WorkCover WA, to promote awareness of occupational safety and health in Western Australia. This publication in the SOWE series provides an overview of work-related fatalities that occurred between 1 July 1988 and 30 June 2005. This period coincides with the effective operation of the Occupational Safety and Health Act 1984, which gave WorkSafe legislative responsibility for all work-related fatalities, other than those on mine sites.

The data used to produce this report differs from reports on lost time injuries and diseases. The definition and identification of work-related fatalities requires case-by-case assessment of the work being performed, and the circumstances of the fatal event. The data in this report comes from a number of sources:

- Workers' compensation information from WorkCover WA;
- The Energy Safety Division of the Department of Consumer and Employment Protection (in relation to electrocutions); and
- The Resources Safety Division of the Department of Consumer and Employment Protection (in relation to fatalities in the Mining Industry)
- Fatal injuries or diseases leading to death for defence personnel and Commonwealth Government employees are not included in this data.

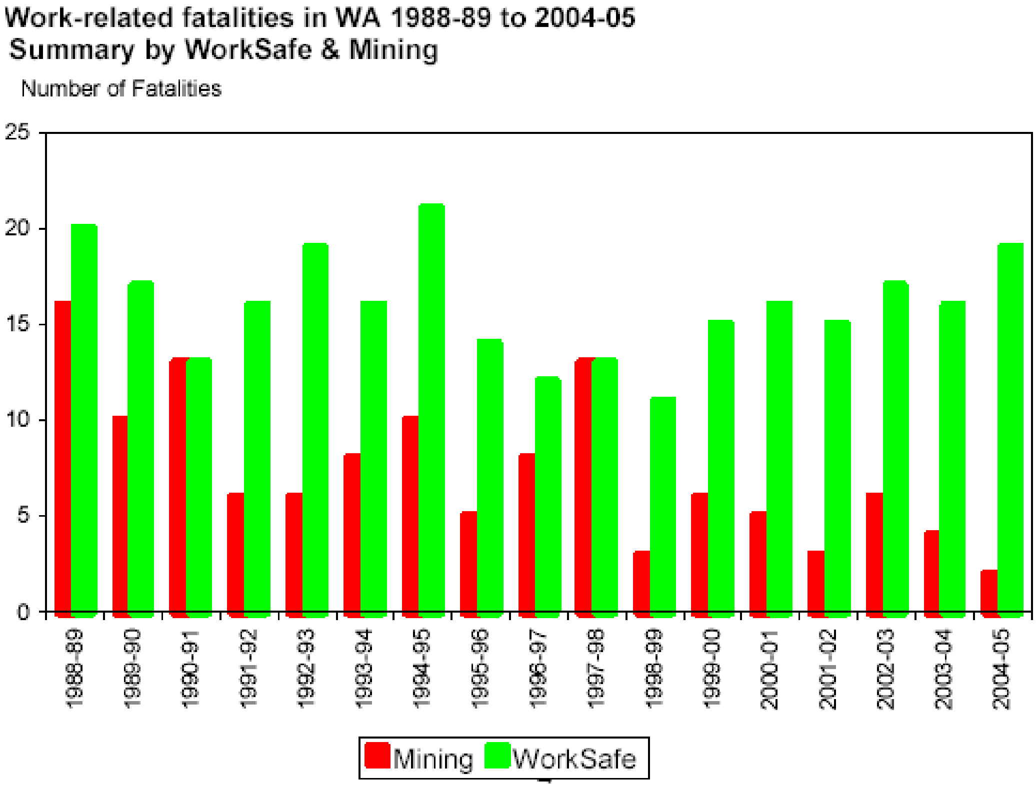
A copy of the 2004/2005 State Of The Work Environment publication released by the Department Of Consumer and Employment Protection (WorkSafe Branch) is provided below.

Work-Related Fatalities Overview

- *In Western Australia there have been 394 work-related fatalities between 1988-89 and 2004-05.*
- *In Western Australia on average a person is fatally injured in a workplace every 16 days.*
- *There has been a downward trend in fatality rates since the Occupational Safety and Health Act 1984 came into effect in 1988-89.*
- *The overwhelming majority of work-related fatalities have been male. Overall, females account for approximately 1% of the total, which is much less than the proportion of females in the workforce. In 2004-05 females made up 44% of the workforce.*
- *In the five years from 1988-89 to 1992-93, 76% of fatalities occurred in the country, however in the five years from 200-01 to 2004-05, the proportion of fatalities occurring in the country was 70%. The Agriculture, Forestry & Fishing industry has the highest proportion of country fatalities after Mining.*
- *Tradespersons and Labourers accounted for 47.6% of all non-mining work-related fatalities.*

- *The average work-related fatality incidence rate per million workers for the five-year period from 2000-01 to 2004-05 is 21.2, compared to an average fatality incidence rate for the five-year period from 1988-89 to 1992-93 of 37.5.*
- *During 2004-05 a third of fatalities were 55 years or older; however this age group accounted for about a seventh of the total workforce.*
- *During 2004-05 crushing and falls from a height were the most common causes of fatality unrelated to a vehicle.*
- *During 2004-05 just under half of the notified fatalities were caused by mobile plant and transport. Of these, slightly less than half involved road transport.*
  (WorkSafe, 2005, p3)

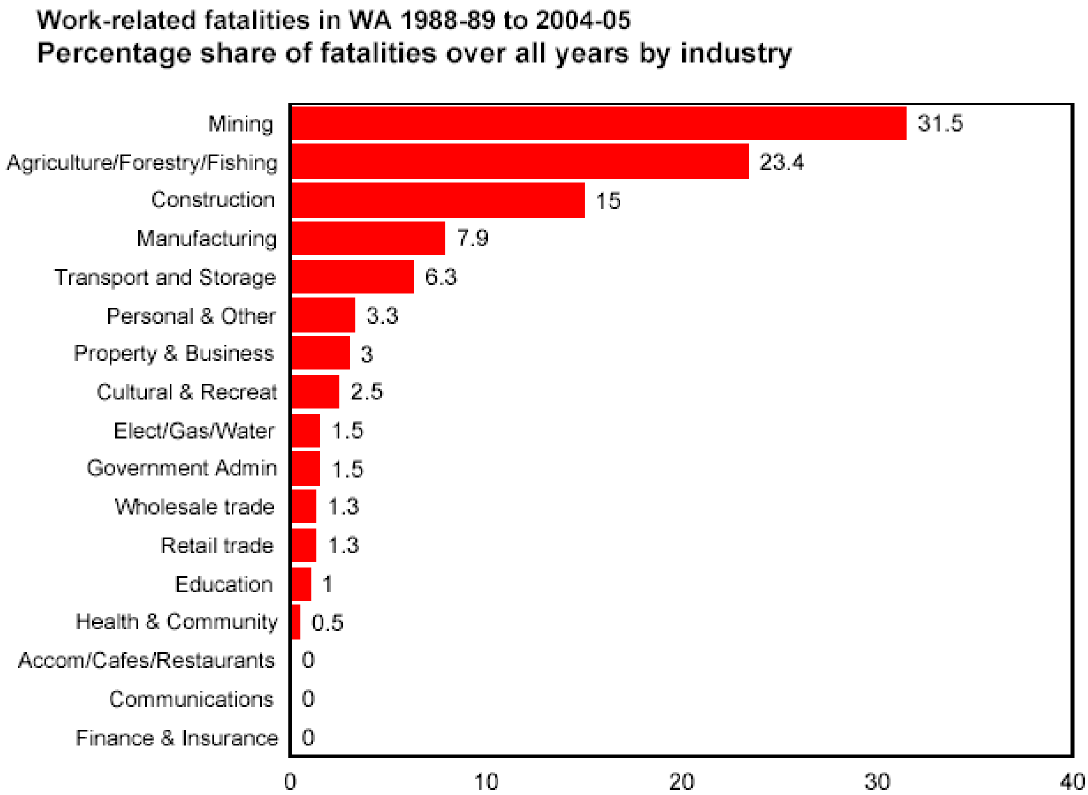
Figure 4- Work Related Fatalities by Jurisdiction (WorkSafe, 2005)



- *The fatal event that accounted for the most fatalities was in 1995 when seven crew members of two fishing vessels lost their lives during Cyclone Bobby.*
- *Mining fatalities fall within the jurisdiction of the Mines Safety and Inspection Act 1994. Non-mining fatalities fall within the jurisdiction of the Occupational Safety and Health Act 1984.*
- *The proportion of work-related fatalities that occurred in the Mining Industry between 1988-89 and 2004-05 is 31.5%.*
- *The proportion of non mining work related fatalities that occurred between 1988-89 and 2004-05 is 68.5%.*
- *In the past ten years there has been one work-related homicide, in 2001.*

  (WorkSafe, 2005, p4)

Figure 5 - Fatalities by Industry (WorkSafe, 2005)



Industry overview

- *Industry classifications are assigned according to the Australian and New Zealand Standard Industry Classification (ANZSIC) system provided by the Australian Bureau of Statistics.*

- *Work-related fatalities are classified according to the industry in which the person is working at the time of the fatal event. That industry is determined by the main industry in which their employer is involved. The result of this classification is that no matter what particular activity the person is involved in at the time of the event resulting in the fatality, the industry in which they are working is the primary criteria for classification.*

- *Overall the Mining and Agriculture, Forestry and Fishing industries accounted for over half of the work-related fatalities.*

  (WorkSafe, 2005, p5)

Agriculture, Forestry and Fishing Industry

- *The Agriculture, Forestry and Fishing Industry includes the growth of cereal crops, raising livestock, commercial horticulture, forestry, pearling and commercial fishing.*
- *The sub-industries are:*
  - *Agriculture;*
  - *Services to agriculture;*
  - *hunting and trapping;*
  - *Forestry and logging; and*
  - *Commercial fishing.*
- *92 work-related fatalities occurred in the Agriculture, Forestry and Fishing industry between 1988-89 and 2004-05, with 10 of those occurring in 2003-04.*
- *Many of these fatalities involved employees and self employed people working in the fishing industry in a range of occupations, including deckhands and seamen, fishermen, tradespersons, ship’s cook and pilots, and includes six work-related fatalities in the pearling industry.*
- *Seven work-related fatalities resulted form Cyclone Bobby in 1995. These are classified under commercial fishing.*

  (WorkSafe, 2005,p5)

Construction Industry

- *The Construction industry includes general construction and construction trade services.*
- *The number of work-related fatalities in the Construction Industry for the period 188-89 to 2004-05 was 59, which represents 15% of the total (394).*
- *Work-related fatalities in the Construction industry have involved a range of occupations, including tradespersons, labourers, machinery operators and members of the public.*
- *The five-year moving average in the Construction industry indicated that there has been a general downward trend between 1996-97 and 2001-02, followed by an increase in 2002-03 when there were seven.*
- *In the five years from 2000-01 to 2004-05 there were 18 fatalities in the Construction industry.*

  (WorkSafe, 2005, p6)

Manufacturing Industry

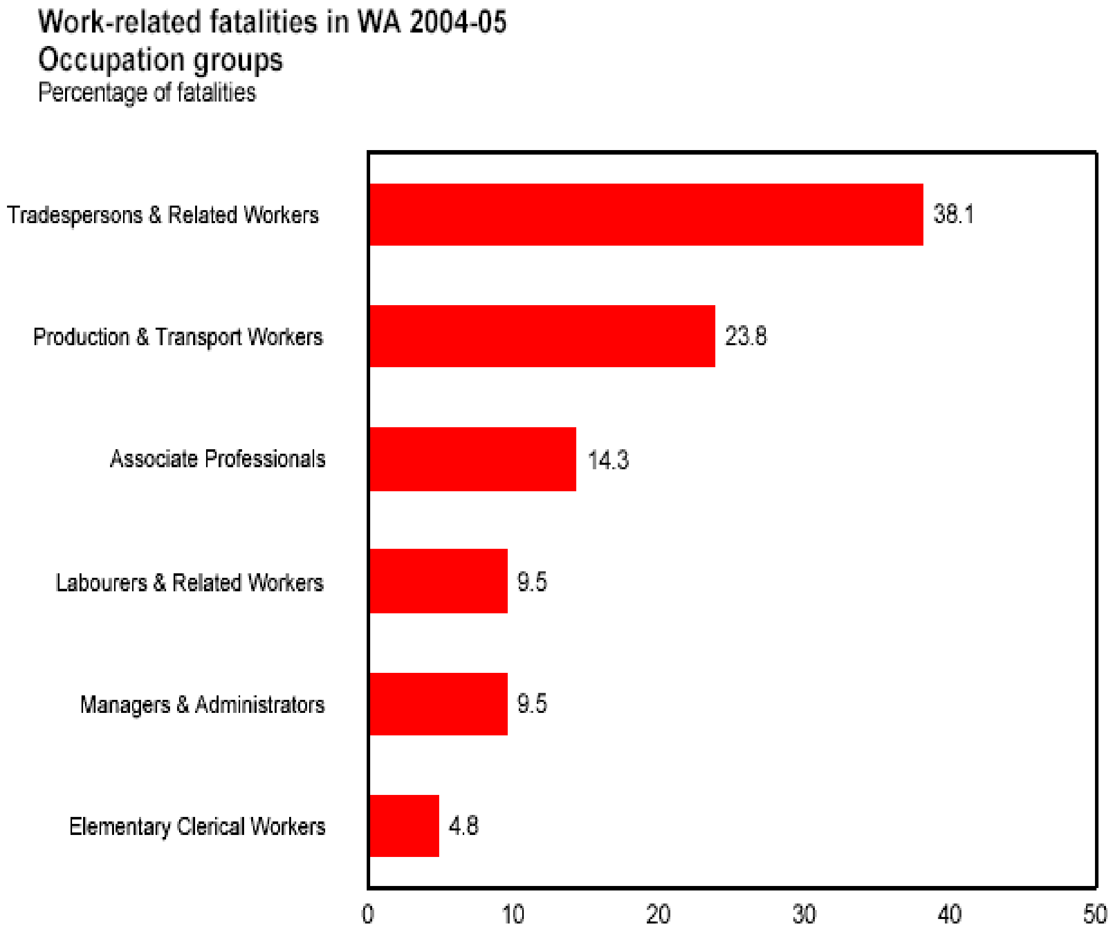
- *The manufacturing industry includes the following sub-industries:*
  - *food, beverage and tobacco manufacturing;*
  - *textiles, clothing, footwear and leather manufacturing;*
  - *wood and paper products manufacturing;*
  - *printing, publishing and recorded media manufacturing;*
  - *petroleum, coal, chemical and associated products manufacturing;*
  - *non metallic products manufacturing;*
  - *machinery and equipment manufacturing; and*
  - *Other manufacturing.*
- *The Manufacturing industry accounted for 31 fatalities between 1988-89 and 2004-05, which was 7.9% of the total (394) for that period.*
- *Due to the low numbers of work-related fatalities each year it is difficult to accurately determine a trend.*

Transport and Storage industry

- *The Transport and Storage industry covers a range of work activities including truck driving, rail, air and sea transport, warehouse storage and associated services. The sub-industries are:*
  - *Road transport;*
  - *Rail transport;*
  - *Water transport;*
  - *Air and space transport;*
  - *Other transport; and*
  - *Services to transport.*
- *The Transport and Storage industry accounted for 25 fatalities between 1988-89 and 2004-05, which was 6.3% of the total (394) for that period.*
- *The Transport and Storage industry has had at least one fatality each year since 1997-19998*

  (WorkSafe, 2005, p6)

Figure 5 - Fatalities by Occupation (WorkSafe, 2005)



- *Occupation codes are assigned according to the Australian Standard Classification of Occupations, (ASCO) provides by the Australian Bureau of Statistics.*
- *Two of the major occupational groups – Production and Transport Workers (23.8%) and Tradespersons (38.1%) accounted for about 62% of all work-related fatalities during 2004-05.*

  (WorkSafe,2005, p6)

Trends in selected priority areas

- *WorkSafe has identified a number of priority areas across industries, which have been targeted for promotion and education in order to reduce the occurrence of work-related injuries and promote safe work practices. The high-risk nature of the work in these areas means that they are likely to have a higher incidence of work-related injury and disease.*

- *These areas are:*
  - *Electricity;*
  - *Work at heights;*
  - *Slips and trips;*
  - *Manual handling (lifting)*
  - *Young people (under 20 years) and new workers;*
  - *Forklifts; and*
  - *Hazardous substances.*
- *Although improved work practices, legislation, regulation, regular inspection and better outcomes from education, training and promotion by WorkSafe and industry have been contributing factors to the overall downward trends in work-related fatalities, the trends in the selected priority areas should be viewed with some caution regarding the impact of these factors.*
- *"Tractors" are included because this has previously been a priority area and continues to be monitored.*

  (WorkSafe, 2005, p7)

Electrocution

- *Since 1988-89 there has been at least one work-related fatality due to electrocution each year.*
- *Electrocutions accounted for 39 fatalities between 1988-89 and 2004-05, which was 9.8% of the total (394) for that period.*
- *Electrocutions typically occur in the construction trades sub-industry.*

  (WorkSafe, 2005, p7)

Falls from heights

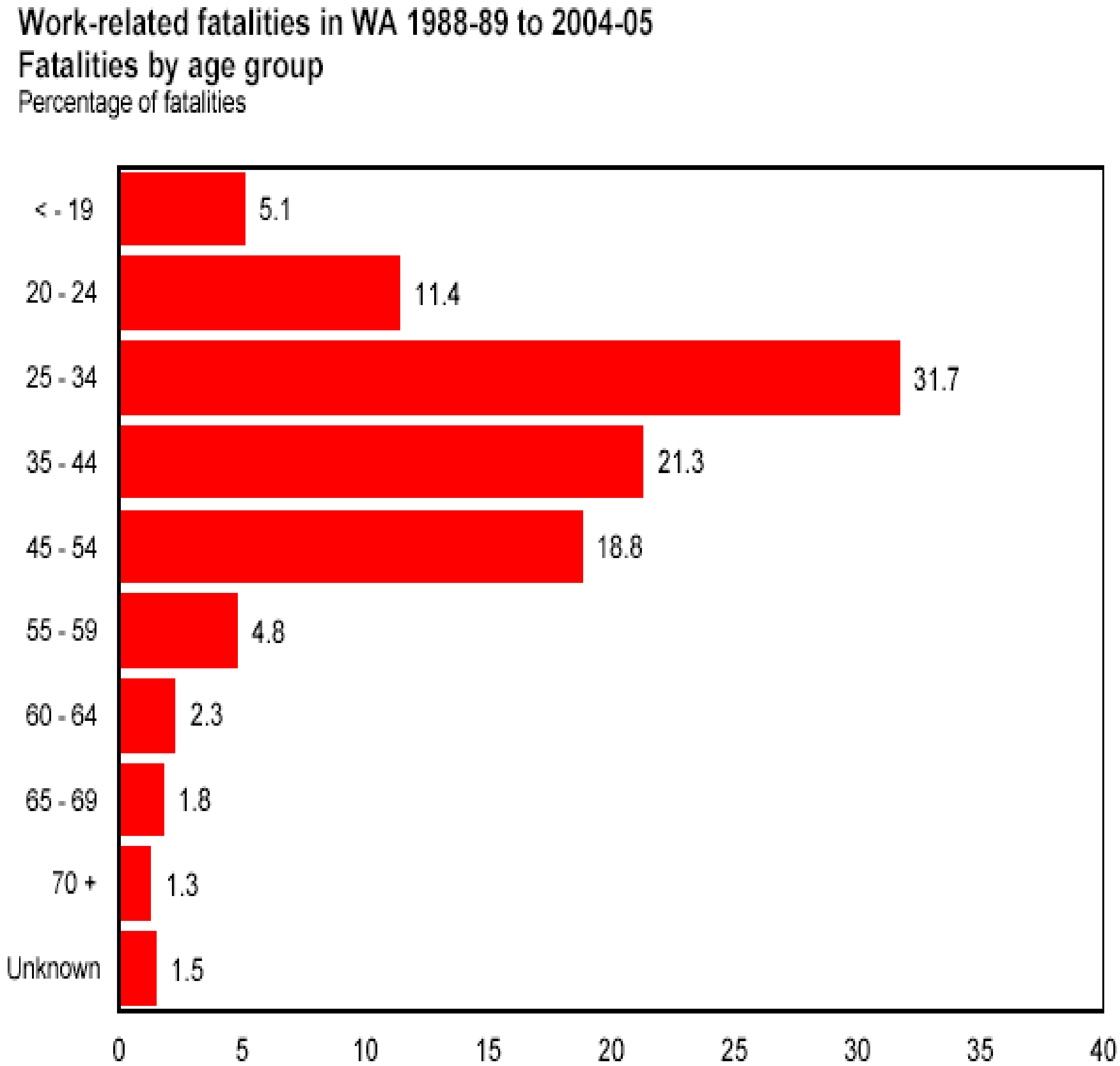
- *There were five work-related fatalities due to falls from heights in 2004-05, the highest annual figure since 1992-93.*
- *The five-year average for falls from heights has risen over the past three years.*

Fatalities by employment type (non-mining)

- *Employees accounted for 72% of non-mining work-related fatalities between 1988-89 and 2004-05.*
- *Since 1988-89 there has been an average of four work-related fatalities each year for self-employed persons.*
- *On average there are 18 work-related fatalities each year for employed persons.*
- *Since 1988-89 there have been 10 work related fatalities involving members of the public.*

(WorkSafe, 2005, p8)

Figure 6 – Fatalities by age group (WorkSafe, 2005)



- *Workers in the 25-34 age group account for about 32% of all work related fatalities and an average of seven fatalities each year.*
- *In the three years from 2002-03 and 2004-05 there have been nine work-related fatalities involving workers in the 60+ age group.*
- *In the three years from 2002-03 and 2004-05 there have been nine work-related fatalities involving workers in the under 25 age group (as well as a child member of the public)*

(WorkSafe, 2005, p8)

One might ask why the provision of information concerning fatalities that was not classified as confined space fatalities. The information concerning work related fatalities closely resembles the findings of the confined space research study and is provided as a comparison. It was also presented to emphasize the fact that although there is an abundance of statistical data for fatal accidents within the recognized categories in Western Australia the data pertaining to confined space fatalities is almost non-existent.

The Victorian Workcover Authority has identified that at least twelve (12) major confined space accidents are known to have occurred since 1988 and these accidents have resulted in five (5) fatalities. In New South Wales, a summary of confined space fatalities reported in WorkCover News from 1995 to 1997 has identified twelve (12) fatalities, with one case having multiple fatalities (MacDonald,1998, p23). There have been no other confined space fatality studies within Australia to date 2005.

The extent of the literature review (and as a result this research assignment) is constrained by the poor nature of recording both historically and at present within Australia and other countries.

One of the primary factors that have affected the nature of recording is the method of classification work related fatalities with Australia. Australia classifies work related fatalities according to the ANZSIC Guidelines. Work related fatalities are therefore classified according to the industry of the deceased. For example if a fatal accident occurred in a grain silo on a farm it would be classified and recorded as an Agricultural accident within the sub-category of farming. A portion of the ANZSIC Guideline has been provided below for additional information;

Purpose of the ANZSIC

The Australian and New Zealand Standard Industrial Classification (ANZSIC) have been jointly developed by the Australian Bureau of Statistics (ABS) and Statistics New Zealand (Statistics NZ).

An individual business entity is assigned to an industry based on its predominant activity. The term 'business entity' is used in its widest sense to include any organisation undertaking productive activities, including companies, non-profit organisations, Government departments and enterprises.

Arranging the large amount of data available about businesses into groupings that are both analytically useful and which users can understand, can be done in a number of ways. In economic statistics, this is usually achieved by either classifying the information relating to the operations of businesses (e.g. grouping all income items together); or by classifying the business units about which the data have been collected (e.g. grouping all the data about businesses operating in Tasmania).

An industrial classification is one way to organise data about business units. It provides a standard framework under which business units carrying out similar productive activities can be grouped together, with each resultant group referred to as an industry.

The ANZSIC provides a basis for the standardised collection, analysis and dissemination of economic data on an industry basis for Australia and New Zealand. Use of the ANZSIC results in improved comparability of industry statistics produced by the two countries. Prior to the development of ANZSIC 1993, separate national industrial classifications were used in Australia and New Zealand.

As well as being the standard industrial classification that underpins ABS and NZ industry statistics, the ANZSIC is widely used by government agencies, industry organisations and researchers for various administrative, regulatory, taxation and research purposes throughout Australia and New Zealand.

ANZSIC 2006 has been developed to provide a more contemporary industrial classification system. Changes in the structure and composition of the economy, changing user requirements and comparability with international standards have been taken into account. This 2006 edition of the ANZSIC replaces the 1993 edition.

Unit of Classification

Businesses can be represented in various ways for particular statistical and other purposes. Statistical agencies use the term 'unit' to refer to the representation of businesses used for particular collections of data from businesses and for the production of particular statistical outputs relating to them.

A range of business units are used for different statistical purposes e.g. Producing units are used for industry statistics and institutional units are used for financial statistics. The units and their relationships to each other are described within a unit's model. The type of business unit to be classified to industry is a critical design element for any industrial classification. Industrial classifications designed for a particular unit of classification may be less suitable, or entirely unsuitable, for application to other types of business units.

International Standards

The International Standard Industrial Classification of All Economic Activities (ISIC) was adopted by the United Nations in 1948 and is used as the international standard for guiding work on national industrial classifications.

Revisions of the ISIC were issued in 1958 (Rev. 1), 1968 (Rev. 2) and 1990 (Rev. 3) A minor update of ISIC Rev. 3 was issued in 2002 (Rev. 3.1). A further major revision of the ISIC is well advanced and is expected to be released in 2007 (Rev. 4).

Australia and New Zealand have for many years endeavoured to align their industrial classifications with the ISIC as far as possible. However, the degree of alignment able to be achieved is sometimes adversely affected by competing classification principles e.g. a different organisation or structure of Australian or New Zealand industry, or a lack of significance of some internationally recognised economic activities in the two economies. Notwithstanding this, ANZSIC 2006 is expected to achieve international comparability to a greater extent than earlier industrial classifications.

Previous National Classifications

During the late 1960s, the then Commonwealth Bureau of Census and Statistics drew together the several distinct classifications then in use in Australia to produce the first Australian Standard Industrial Classification (ASIC). The original 1969 edition of the ASIC was based at the broader levels on the ISIC, with some modifications to allow for comparability with previously used classifications. The structure and composition at the finer levels were derived from extensive investigations into the activity mix characteristics of Australian businesses.

Revised editions of the classification were released by the ABS in 1978 and 1983. The 1978 edition reflected an extensive review of the 1969 edition, involving a substantial program of empirical investigation and analytical work. Numerous changes were made, mainly affecting the definitions of individual industry classes. There was little change at the higher levels of the classification. The 1983 edition updated the 1978 edition in respect of the Transport and Storage industries.

The first New Zealand Standard Industrial Classification (NZSIC) was issued in 1970, based on ISIC Rev. 2, but adapted to the New Zealand environment. It replaced a modified form of the original 1948 edition of the ISIC, which had been used by Statistics NZ from 1948. A second edition of the NZSIC was produced in 1975, with more detail in some areas, and a third edition was produced in 1987. The second and third editions of the NZSIC were also based on ISIC Rev. 2.

Development of the ANZSIC

In 1985, the ABS commenced a major review of the ASIC. The principal objectives were to improve the alignment with ISIC; to achieve a better balance across the classification by giving more attention to the services sector, including segments relating to the culture, entertainment and other recreational industries; and to take account of the effects of technological changes and changes in the structure of industry generally since the previous edition.

The possibility of Australia and New Zealand using a common industrial classification was first raised in 1990 while the ASIC review was continuing. A succession of economic agreements between Australia and New Zealand has operated since 1922. The statistical agencies have met regularly to monitor the progress of the economic relationship and to share experiences and explore common interests. Joint working relationships have been established to harmonise statistics where practicable.

As the two statistical agencies used similar principles to create their national industrial classifications, they were able to agree on the principles and strategy for development of a single classification to meet the requirements of both countries. A particular consideration was the need to update each country's classifications to align with ISIC Rev. 3 issued in 1990.
Agreement was reached on a joint work program, which leveraged off the work already undertaken on the ASIC review. The first edition of the joint classification (ANZSIC) was released by the two agencies in 1993.

ANZSIC Standard

The ANZSIC is a hierarchical classification with four levels, namely Divisions (the broadest level), Subdivisions, Groups and Classes (the finest level). At the Divisional level, the main purpose is to provide a limited number of categories which provide a broad overall picture of the economy and are suitable for the publication of summary tables in official statistics. The Subdivision, Group and Class levels provide increasingly detailed dissections of these categories for the compilation of more specific and detailed statistics.

The hierarchical structure of the ANZSIC is illustrated below.

Table 7 ANZSIC Industry Classification Breakdown (ANZSIC, 2001)

Level	***Example***
Division	*C Manufacturing*
Subdivision	*11 Food Product Manufacturing*
Group	*111 Meat and Meat Product Manufacturing*
Class	*1111 Meat Processing*

ANZSIC Review

The review of ANZSIC 1993 commenced in January 2000. There was extensive consultation with users of the ANZSIC in Australia and New Zealand throughout the review process, with the outcomes reflected in this, the 2006 edition of the ANZSIC. There were several broad objectives set for the project.

Industrial classifications need to be periodically reviewed to ensure they remain current and relevant, reflecting the changes that have occurred in the structure and composition of industry since the previous version, as well as satisfying emerging user requirements for industry data.

The benefits of any updates and improvements to the classification need to be assessed against, and be clearly worth, the significant costs in reworking statistical collections and outputs, changing administrative database designs, and revising statistical time series to reflect the new classification.

Since ANZSIC 1993 was developed, there have been changes in the structure, composition and organisation of industrial and business activities in Australia and New Zealand. New materials, technologies and production techniques have been adopted and some of these have affected the way industry and businesses operate. New industries and activities have emerged and need to be reflected in the classification.

The requirements of users of industry statistics have also changed. In particular, consideration needs to be given to better support alternative industry views, i.e. those different from the standard concepts embodied in the classification, e.g. tourism.

ANZSIC 1993 used a mixture of supply and demand-side concepts in defining industries. This led to the classification prescribing different treatments for some very similar productive activities because of the different clients served.

The conceptual framework adopted for the development of ANZSIC 2006 uses supply-side based industry definitions and groupings. Using this approach, business units engaged in similar productive activities are grouped together. Units in an industry therefore exhibit similar production functions (a term used to describe the transformation of intermediate inputs, through the application of labour and capital, to produce outputs).

Aligning the ANZSIC with international standards "as far as possible" maximises the comparability of Australian and New Zealand industry statistics with those of the rest of the world. In the interests of international statistical comparability, ANZSIC 2006 aligns with the ISIC and the North American Industry Classification System (NAICS) at the subdivision level as far as practicable.

In the ANZSIC review, close consideration was given to the work undertaken in recent years on the ISIC and the NAICS. Australia and New Zealand have been involved in international meetings reviewing the bases of these classifications. To the extent considered appropriate to Australian and New Zealand conditions, ANZSIC 2006 therefore reflects the latest international work on industrial classifications.

The development of ANZSIC 2006 applied a number of important principles normally followed in the development of industrial classifications or for standard classifications generally. ANZSIC 2006 categories have been designed to reflect the structure of Australian and New Zealand industry, and for use in the collection, compilation and presentation of industry statistics.

In most instances, industry classes have been formed only if the activities they cover are economically significant in either Australia or New Zealand and the businesses classified to them are homogeneous in terms of industrial activity. ANZSIC categories are mutually exclusive and comprehensive in their coverage of productive economic activities.

Changes from ANZSIC 1993

ANZSIC 2006 separately identifies 19 divisions, compared with 17 in ANZSIC 1993.

A new Information Media and Telecommunications Division have been introduced. It groups units mainly engaged in the creation and storing of information products for dissemination purposes; transmitting information products using analogue and digital signals; and providing transmission and storage services for information products. This has been identified as a rapidly growing sector in the Australian and New Zealand economies since the last review. The proposed ISIC Rev. 4 and NAICS 2002 also recognise these activities in a separate Division.

The very large and diverse Property and Business Services Division in ANZSIC 1993, together with some other services, has been rearranged into three new divisions in ANZSIC 2006: Rental, Hiring and Real Estate Services; Professional, Scientific and Technical Services; and Administrative and Support Services. The three separate divisions again align with the proposed ISIC Rev. 4 and NAICS 2002.

ANZSIC 2006 identifies 86 subdivisions, compared with 53 in ANZSIC 1993. The substantial increase in the number of subdivisions was driven by improvements made to the international comparability of the classification at this level and the identification of groups of economic activities with significant differences in their production functions at higher levels of the classification. Considerable change has also occurred at the lower levels of the classification.

ANZSIC 2006

The new divisional structure for ANZSIC 2006 is as follows:

Table 8 ANZSIC Divisional Structure (ANZSIC, 2006)

Division	***Title***
A	*Agriculture, Forestry & Fishing*
B	*Mining*
C	*Manufacturing*
D	*Electricity, Gas, Water and Waste Services*
E	*Construction*
F	*Wholesale Trade*
G	*Retail Trade*
H	*Accommodation and Food Services*
I	*Transport, Postal and Warehousing*
J	*Information, Media and Telecommunications*
K	*Financial and Insurance Services*
L	*Rental, Hiring and Real Estate Services*
M	*Professional, Scientific and Technical Services*
N	*Administrative and Support Services*
O	*Public Administration and Safety*
P	*Education and Training*
Q	*Health Care and Social Assistance*
R	*Arts and Recreation Services*
S	*Other Services*

Implementation of ANZSIC 2006

Implementation of a new edition of a major classification, such as the ANZSIC, poses a number of significant issues for statistical agencies and users of the statistics. Business registers need to incorporate the new classification, statistical collections need to be redesigned and new outputs produced, and consideration needs to be given to back casting statistical series on the new basis.

These activities are costly and pose some risks to the normal operations of the statistical agencies and users of industry classification structures. Implementation of the changes needs to be well coordinated across the time series involved and the changes need to be effectively communicated to users.

Implementation of ANZSIC 2006 will therefore take considerable time. While the review was completed in December 2004, further time was needed for development of the necessary tools to support its implementation, including this publication. There will be a progressive release of statistics on the new basis from 2007 onwards. Users will be kept informed about the implementation of ANZSIC 2006 through separate information releases issued by both agencies.

Nature and Objectives of the Classification

To use statistical information about business units effectively, it is first necessary to organise that information into categories suitable for economic analysis. This can be done by using different classifications depending on the particular interests of users.

An industry classification is one way of organising data from a business unit perspective. It provides a standard framework under which units carrying out similar productive activities can be grouped together, with each resultant group being referred to as an industry. The term industry is used in its widest context, covering the full range of economic activities undertaken to produce both goods and services.

Each individual class is defined in terms of a specified range of activities. It is common for a business unit to engage in a range of activities wider than those designated as belonging to a particular class, and when this occurs we classify the unit based on its predominant activity.

Activities undertaken which belong to classes other than that to which the unit is classified, are described as its 'secondary activities'. The secondary activities of a unit play no part in assigning the class to which the unit is classified, but are useful for coverage and specialisation ratio analysis. Refer to paragraph 2.20 for the definition of coverage and specialisation ratios.

In an industrial classification, each unit has to be classified uniquely to one class so that only those units with the same predominant activities are brought together to form a class.

The ANZSIC has been designed primarily as a classification of Type of Activity Units (TAUs) in the Australian statistical system and Kind of Activity Units (KAUs) in the New Zealand statistical system, although it can also be used for classifying some other unit types. The TAU and the KAU are defined in Appendices 1 and 2 respectively.

The ANZSIC is a hierarchical classification comprising four levels, namely Divisions (the highest level of the classification), Subdivisions, Groups and Classes (the lowest level of the classification).

Principles for Recognising ANZSIC 2006 Classes

All classifications, particularly those that are international or national statistical standards, should satisfy a number of fundamental principles. These include that the classification:

- *Is comprehensive in its coverage;*
- *Has categories which are mutually exclusive;*
- *Has categories which can be readily understood by users and data providers;*
- *Is hierarchical to support its use for different statistical purposes;*
- *Should remain stable over a period of time, or be designed so that it can easily be updated; and*
- *Be based on a strong and consistently applied conceptual framework.*

The conceptual framework adopted for the development of ANZSIC 2006 uses supply-side based industry definitions and groupings. Using this approach, units engaged in similar productive activities are grouped together. Units in an industry will therefore exhibit similar production functions (a term used to describe the transformation of intermediate inputs, through the application of labour and capital, to produce outputs).

In ANZSIC 2006, this framework has been applied more rigorously and consistently than before. Industry statistics will be more consistently compiled and analytically useful as a result. Refer to paragraphs 2.16, 2.17, and 2.18 for more detail on the supply-side concept.

A basic principle in the ANZSIC is that industry classes should reflect the way activities are actually organised in the real world. This ensures that industry classes reflect realistic and recognisable segments of Australian and New Zealand industry and that the businesses classified to them have the necessary data for statistical collections.

Generally, industry classes were formed only if they were economically significant in either Australia or New Zealand. In Australia, employment had to be at least 3,500, or annual turnover at least $AUS 250 million. In New Zealand, employment had to be at least 700, or annual turnover at least $NZ 50 million. Applying this test helps ensure that the number of classes formed is justified on cost/benefit grounds and that a reasonable balance is achieved across the whole of the classification.

The criteria were modified for those industries where the standard measures of output (e.g. value added, turnover) gave a misleading picture of economic significance e.g. wholesale trade, retail trade, financial and insurance services, public administration and safety. In these cases, additional classes were not formed simply because the economic significance criterion was exceeded. Other, more relevant criteria needed to be satisfied.

Supply Side Concept

As noted above, the conceptual framework adopted for the development of ANZSIC 2006 uses supply-side based industry definitions and groupings. Using this approach, business units engaged in similar productive activities are grouped together.

Following this approach, business units in a particular class will use similar inputs and apply similar transformation processes to produce similar outputs. The study of production (e.g. industry performance, productivity and structural analysis) requires an industrial classification that follows this type of framework.

The supply-side concept can be strictly applied in developing only the lowest level of the classification (the class level). This is the level at which homogeneity of economic activity is greatest. For example, the application of this concept has led to the creation of a class for fossil fuel electricity generation and a separate class for hydro-electricity generation even though the final product, i.e. electricity, is the same.

Industry Homogeneity

As indicated above, industry classes should be comprised of businesses that undertake similar economic activities i.e. they should be as homogeneous as possible. In the development of ANZSIC 2006, the ABS and Statistics NZ have used the information that is available to assess and increase homogeneity at the class level. This has helped ensure that the classification reflects the structure and organisation of Australian and New Zealand industry.

Homogeneity can be measured by the calculation of specialisation and coverage ratios. The specialisation ratio measures the extent to which units belonging to a particular class engage in the activities designated as primary to that class. The coverage ratio measures the extent to which the activities designated to a particular class are undertaken by units belonging to that class.

It is highly desirable that the specialisation and coverage ratios exceed 70 per cent for the formation of individual classes. This minimises the extent to which the output of each class includes output of activities which belong to other classes. As a consequence, users of industry statistics should note that classes do not contain all of the units which undertake the activities belonging to that class. Units engaging in these activities on a secondary basis will be classified to a different class according to their predominant activity.

Applying and Balancing Classification Principles

The classification principles set out above for the creation of industry classes in ANZSIC 2006 often reinforce each other. For example, good industry homogeneity helps ensure the classification is on a strong conceptual basis and reflects the real world organisation of units. Economic significance helps ensure the classification reflects the real world organisation of units and that it reflects a contemporary view of Australian and New Zealand industry, or if some internationally recognised activities is not significant in the two countries. In these circumstances, judgement needs to be exercised to determine the most appropriate outcome.

On the other hand, the review and development of the classification has to balance the often competing demands of relevance, continuity and comparability. The principles applied for the definition of classes are sometimes in conflict. For example, international comparability cannot be fully achieved if there is a different structure in applying and balancing classification principals.

Formation of Broader Level Categories

As classes are grouped into higher levels of aggregation, the degree to which units exhibit similar production functions generally falls. At the higher levels of the classification, emphasis moves increasingly to the output side of the production function, so that at the top of the hierarchy, divisions are created and defined by looking more at what is produced, and less at the activities undertaken to produce that output.

This has the important consequence of causing units with very different inputs and transformation processes to be classified to the same division, due to similarities in the intent or purpose of the outputs produced. For example, hospitals and homoeopaths are both classified to the Health Care and Social Assistance Division, based on their common purpose to improve human health. This is typical of the Service Divisions.

At the division level, the main purpose is to provide a limited number of categories which provide a broad overall picture of the economy, and are suitable for summary tables in official statistical publications. Weight is also given to maintaining continuity with previous editions of the classification.

Between the highest (Division) and lowest (Class) levels of the classification, combination of groupings is driven by a number of factors including:

- *Improving the international comparability of the classification at the Sub-division level;*
- *Identifying groups of economic activities with significantly different production functions; and*
- *Promoting some of the more economically significant industries to this higher level of the classification.*

For example, subdivisions created in ANZSIC 2006 specifically to improve international comparability include:

- *Subdivision 12: Beverage and Tobacco Product Manufacturing;*
- *Subdivision 44: Accommodation;*
- *Subdivision 55: Motion Picture and Sound Recording Activities;*
- *Subdivision 58: Telecommunications Services;*
- *Subdivision 60: Library and Other Information Services; and*
- *Subdivision 70: Computer System Design and Related Services.*

Examples of subdivisions created to better identify groups of economic activities with significantly different production functions include:

- *Subdivision 26: Electricity Supply; and*
- *Subdivision 27: Gas Supply.*

Finally, examples of subdivisions created to promote some of the more economically significant industries to this higher level of the classification include:

- *Subdivision 11: Food Product Manufacturing; and*
- *Subdivision 77: Public Order, Safety and Regulatory Services.*

Methods of Classification

There are few problems classifying units engaged in only one kind of activity (i.e. a unit would be classified according to that one activity it undertakes). While it would be ideal if units could be defined such that each unit undertakes only a single activity, this is not practicable in the real world due to data availability, provider load and resource constraints.

Many units are engaged in activities which belong to two or more industry Categories, and for these 'multi-activity' units it is necessary to specify methods for classifying them to their predominant activity. This chapter describes these general methods of classification, including assessing the predominant activity of a unit.

Vertical integration is common in some multi-activity units involved in both agricultural and manufacturing activity e.g. grape growing and wine manufacturing; olive growing and olive oil product manufacturing; chicken farming and chicken meat processing; pig farming and pig meat processing. These combinations of activities are often undertaken by single business units, often on the same premises. Vertical integration also occurs in a number of other industries and circumstances.

Vertically integrated units are classified according to their predominant activity, using value added in the same way as other units. If no information is available to assess value added, or there are two or more activities of equal value, then the unit is classified to the activity which represents the last or final stage of production. This is where most of the value added is generally assumed to lie.

In some circumstances, calculation of value added for each of the activities undertaken by vertically integrated units is not possible due to the lack of market transactions to value the activities. In these cases, it may be appropriate to use one of the proxy measures discussed previously in this chapter. If it is clear that an activity is predominant, but no actual data are available, the unit should be coded to its predominant activity.

Combined Activity Classes

The ANZSIC contains a number of classes which are defined as undertaking combined activities. The most commonly recognised area where these activities occur is in agriculture, where farms are specifically set up to produce both livestock and crops, or combinations of different livestock.

The ANZSIC includes two combined activity classes within Division an Agriculture, Forestry and Fishing, namely Class 0144 Sheep-Beef Cattle Farming and Class 0145 Grain-Sheep or Grain-Beef Cattle Farming. These classes are representative of common combinations of farming activities in Australia and New Zealand.

Units engaged in these combined farming activities have fundamentally different production functions when compared with units specialising in farming one type of livestock or crop, as different types of inputs, capital and labour are required. While the ABS and Statistics NZ both use the ANZSIC to classify agriculture units, they have previously applied different coding rules to assign units to the combined farming classes. For ANZSIC 2006, the two statistical agencies use the same coding rules.

Other ANZSIC classes that include combined activities are Classes 3601 General Line Grocery Wholesaling, 4110 Supermarket and Grocery Stores and 4260 Department Stores. If these combined activity classes were not formed, the classification would fail to recognise distinct and identifiable segments of Australian and New Zealand industry.

Classifying a Unit to an Industry

There are two different methods used to classify business units to industry, In accordance with the principles outlined above:

- *Classification to categories at the broadest level of the classification in the first instance i.e. an ANZSIC division, and subsequently to categories at successively lower levels ('top-down'); or*
- *Classification directly to a category at the lowest level of the classification i.e. an ANZSIC class.*

"Top-Down Method"

Using the top-down method, units are first classified to a division, then to a Subdivision within that division, and so on until the unit is finally classified to a class. The ABS and Statistics NZ use the top-down method of classification to the ANZSIC. ISIC also recommends the use of this method because it ensures better consistency of aggregate data at the higher levels of classification.

“Direct Method”

Using the direct method, units are classified directly to the lowest level of Classification (i.e. ANZSIC class). Therefore, the unit will inherit the higher level categories to which the class belongs.

Different Outcomes

In some cases very different outcomes can result from the two methods. For example, a unit undertakes activities which are primary to three classes where:

- *40% of its income is derived from activities of wholesaling motor vehicles;*
- *35% of its income is derived from retailing motor vehicles; and*
- *25% of its income is derived from retailing motor vehicle parts.*

Using the 'top-down' method.

Step 1 Determine the Division to which the Unit Belongs

In this case the unit would be classified to Division G Retail Trade, as this is the Division where most activity occurs (i.e. 60% of the unit's income is derived from its retail activities, compared with 40% from wholesale activities).

Step 2 Determine the Subdivision to which the Unit Belongs

In this case the unit would be classified to Subdivision 39 Motor Vehicle and Motor Vehicle Parts Retailing, as both retail activities belong to this subdivision.

Step 3 Determine the Group to which the Unit Belongs

In this case the unit would be classified to Group 391 Motor Vehicle Retailing, as the income derived from retailing motor vehicles is greater than that derived from retailing motor vehicle parts.

Step 4 Determine the Class to which the Unit Belongs

In this case the unit would be classified to Class 3911 Car Retailing, as the car retailing activity is predominant.

Using the direct method, the unit would be classified according to the largest single activity undertaken. Therefore, based on the fact that the largest single income - earning activity of the unit is derived from wholesaling motor vehicles, the unit would be classified to Class 3501 Car Wholesaling. This example illustrates how different classification outcomes can result from the use of either the top-down or the direct method of classification.

As mentioned in paragraph 4.18, the top-down method of classification is the preferred method of the ABS and Statistics NZ, as well as ISIC.

2.2.2 Mining

22nd September 2006– Underground Nickel Mine (DOIR, 2006)

A 43 year old air–leg miner was found lying under a pile of rocks in an underground nickel mine in the Goldfields of Western Australia. He was an employee of a contracting company who had been assigned had been assigned to strip the sidewall of a level. It was noted by the firing crew that his tag was still on the tag board when they went to clear the area prior to firing the mid-shift blast at around noon on Friday 22 September 2006. The firing crew went to investigate why he had not removed his tag and discovered him in his workplace under a rock, he was not breathing.

Upon investigation it was evident that the deceased had received formal training from the principal mining company in the form of inductions detailing the risk of rock falls with seismic tremors from the blasting. The contracting company had not provided their own induction training. He was adequately experienced within the field of work having undertaken the task on numerous occasions during a 15 year period and it appears the contracting company believes this was means for not requiring supervision. No supervisor was present during the event. In addition to this, there were no documented procedures by the contracting company only that of the Client whom all contractors were expected to adhere to. The deceased was wearing his PPE (specifically his hard hat) at the time of the incident.

This fatality would be considered a confined space fatality outside of the Mines jurisdiction as the location of the underground mine has limited access for entry and exit and is not considered a normal place of work. (Resource Safety, 2006, p21)

15th November 2005 – Underground Nickel Mine (DOIR,2005)

A 25 year old underground electrician employed by an electrical contractor died underground at a nickel mine when he was working on a starter motor on a pump box and was electrocuted.

It was established upon investigation that the underground supervisor left the deceased in the pump chamber to work on restoring a pump to working condition. When he returned from another job a short time later, he found the electrician next to the pump, deceased, with the pump starter box open. The supervisor commenced CPR, but was not successful in reviving the electrician, who was later declared to be deceased by RFDS.

It is interesting to note that majority of these case studies involve contractors who are left unsupervised or unattended whilst performing a task. In addition to this it appears many of the mining contractors have no means of safety systems, procedures or training and rely on the Client in regards implementation. This underlines the “Contractor Safety Culture”. This also highlights the means for which the Client selects the contractors to undertake work at their premises. In this case study it was more a means of “whomever is the cheapest” with no evidence of a safe management system analysis or assessment prior to award of contract.

26th June 2000 – Underground Gold Mine (DOIR, 2001)

Three men died as a result of the failure of a sandfill bulkhead at a gold mine. At about 5.00pm on Monday 26 June 2000, a fill barricade ruptured and allowed a considerable volume of mine fill, consisting of tailings in a slurry form, to enter the 12 and 13 levels of the mine and to flow to the bottom of the decline, which is the deepest part of the mine. The stope had been filled on that day, the fill operations ceasing at around noon.

Three employees died in the accident: a jumbo operator employed by the mining contractor reported as drilling the decline face at the 13 Level in the mine; a truck driver and an electrician, also employed by contractors, both working in the area between 12 and 13 levels.

It was determined that the stope operations had been overfilled in respect to the barricading supporting it. The composition of the fill contained inadequate ratio of cement which resulted in the mix remaining sloppy and non-fixed for an extended period after the fill. As a result of this error the stope collapsed overflowing with slurry engulfing employees working below.

There were not inspections performed immediately after the fill which would have alerted all involved to the sloppiness of the infill and possibly predicted the collapse. This was stated in the procedure. There was no supervisor present at the time of the infill which could have prevented the inadequate ratio of cement to tailing and other. Upon questioning it appeared that supervision of what was considered “experienced” personnel during this task is not common practice.

Recommendations to include increased awareness of the stope fill procedures and guidelines in relation to the volume and cement ratios. Provisions for personnel to leave the work area clear until hardening has commenced.

A recommendation to release a fatal incident alert to all related industries was also stated.

The mine rescue team participated in the rescue/recovery operation, assisted by the rescue team from a neighbouring operation.
Again it is noted that both the persons who conducted the stope fill as well as the deceased are all contractors.

20th November 1997 – Underground Gold Mine (DOIR, 2001)

At approximately 20.30 on 20 November 1997, an operator contracted to a gold mine was loading ore from a previous blast at the draw point of an open stope, using a remotely controlled load-haul-dump (LHD) unit. A rock fall was heard in the area and a dust cloud was observed.

A search of the area revealed that there had been a fall of some 1000 tonnes of material inside the stope, that the LHD was buried inside the stope and that the operator was missing. The remote control unit for the LHD was found placed in a cuddy next to the draw point with its controls locked in the manual position. It was subsequently established that (for reasons presently unknown) the operator was on the LHD inside the stope.

Recovery operations were instituted immediately and other remotely controlled loaders were used to dig out and recover the buried machine. A doctor was in attendance at the scene to provide immediate treatment in case it was possible to recover the operator alive.

Rescue operations were hampered by a second rock fall, which took some time to clear using the remotely controlled equipment. When the LHD was recovered from the stope on the following night, the body of the deceased was found in the operator's cab, which had been crushed.

No findings were published but it should be noted the potential for multiple fatalities of the “would be rescuers”.

13th April 1997 – Underground Nickel Mine (DOIR, 2001)

The deceased was one of a party of four men who drove to the bottom of the decline access of an underground nickel mine in a personnel carrier to pick up the crew thought to be working there. The party drove into an access drive some distance above the decline face, where the drill-jumbo was parked up, to look for the crew. In the meantime, the crew had lit-up the fuse to initiate the blasting of a stripping round near the decline face and, using another vehicle, retreated up the decline past the point where the other party was looking for them, without either party noticing the other. The party of which the deceased was a member then travelled down the decline and parked about 20 metres from the stripping round, still in search of the face crew and unaware that the blast had been initiated.

The deceased got out of the personnel carrier (to light-up the fuse to initiate the blast) and was standing on the ground when the blast detonated. He was struck by rock projected by the blast. The three other men in his party who remained in the personnel carrier, which was badly damaged by material ejected during the blast, were injured, with one being rushed to the Regional Hospital and the other two treated on site.

On investigation the coroner revealed the following findings;

Although there was a safety induction, the induction was inadequate in two areas;

a) The volume of information made available was so great that it did not enable the inductee to gain an acceptable understanding of the material before commencing work.

b) Many of the employees are not English and adopt the language as a second language. Requirements for safety induction in their native language for these employees is needed so they could better understand the safety induction.

The coroner recommended that the written or theoretical aspects of the induction be conducted by TAFE or the Department of Minerals and Energy, Western Australia and that the written material be in the native tongue of the student or that the teaching body ensure that the student fully understands the written material supplied to him.

The income of some underground workers income was based on production and that pressure has been applied to increase production. Consideration should be given to breaking the link between production and income to avoid the temptation to take shortcuts to production.

Periodic reminders (communication) to persons working underground of the need for constant vigilance and that persons working underground be required to synchronise their watches with the mine clock should be implemented.

The Safety Manuals be updated from time to time to ensure that they correspond with current regulations. On investigation it was found the site safety manual had not been updated to reflect current practices.

12th May 1995 – Underground Gold Mine (DOIR, 2001)

A contracting long hole driller was preparing to remove the bottom ladder of a ladder way installed on the footwall of an Alimak raise when he fell 40 metres from the raise into an open stope.

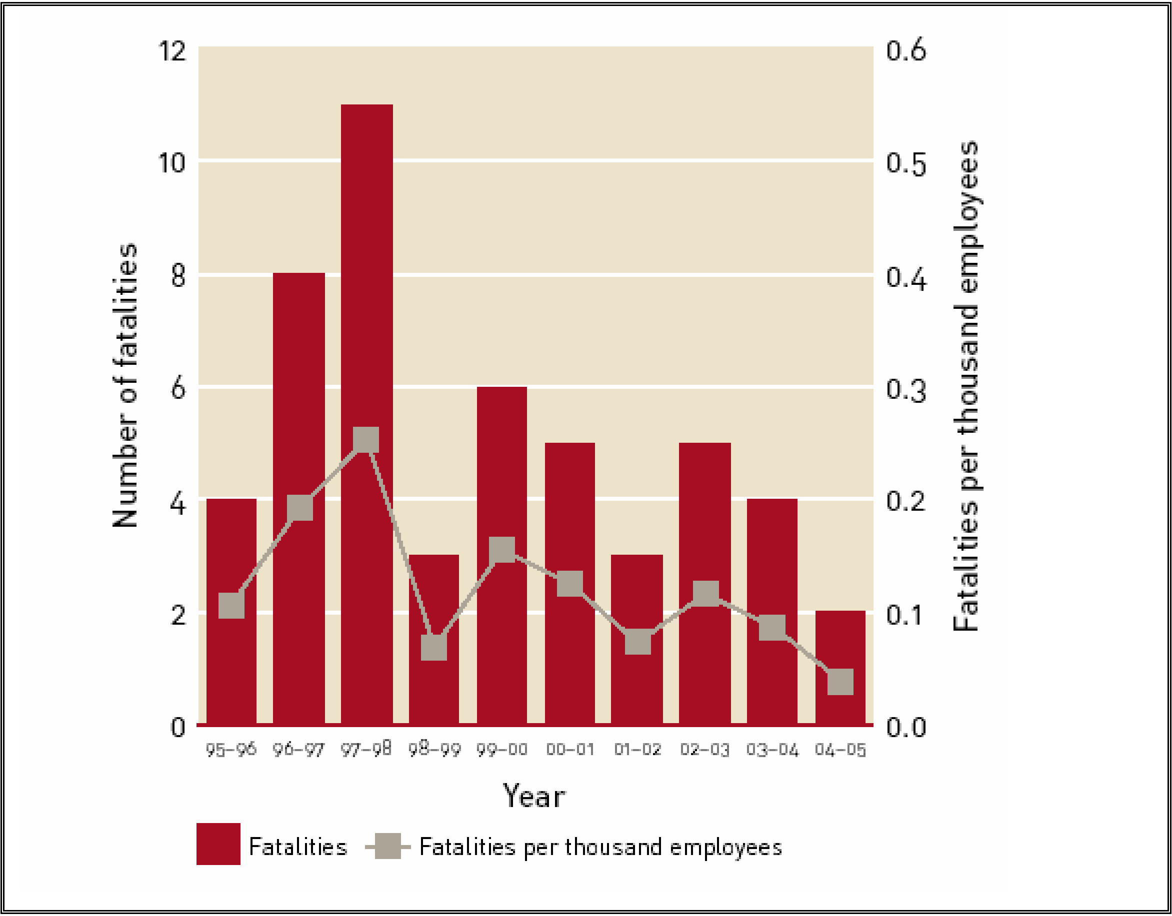
He had accessed the ladder way from the middle deck of a three deck stage suspended in the raise whilst his workmate was preparing a sling to secure the ladder prior to removal. It appears that he had unbolted the ladder when he fell into the stope void below. The deceased was not wearing fall arrest equipment at the time of death.

It was revealed during the investigation that there was a documented safe system of work including a procedure for working at heights. No training had been provided for working at heights by the contracting company or the client. It appeared that training was expected on employment with the contracting company. The deceased had completed a course for working at heights with another company two years prior to employment on the mine. The supervisor was not present within the work area at the time of the fatality.

The following statistics were obtained from the Department of Minerals and Energy Western Australia, Department of Industry and Resource Western Australia (Minerals and Petroleum Division) and the Department of Consumer and Employment Protection Western Australia (Resources Safety.)

DOCEP, (2005) reported 2 work related for the 2004/2005 financial year. The number of fatalities for the period 19951996 to 2004/2005 is as below;

Figure 6 **No. Mining Fatalities by Year (DOCEP, 2005)**



The statistics show that there was a significant increase in mining fatalities during the period of 1996/1997 to 1997/1998. This could be attributed to an increase in reporting when the Mines Safety and Inspection Act WA 1996 was implemented. The statistics within this timeframe has an almost cyclical trend or pattern with a slight downward trend.

This trend is similar to the Western Australian confined space fatalities within the mining sector

A study of mining fatalities was conducted by the Resources Safety division of DOCEP investigating the incidence rate of work related fatalities by minerals mined during the period 2000/2001 to 2004/2005.

This study revealed the highest incidence rate was in the dimension stone. It was also found that the underground fatality incidence rate is almost three times higher than the fatal incidence rate for surface operations. This is reflected in the gold, nickel and base metal sectors where most of the State's underground mining occurs. It is interesting that 100% of the confined space mining fatalities identified in the Western Australian research (above) were located within underground mines.

Table 9 - Fatal Incidence Rate by Mineral Mined (DOCEP, 2005)

Category		**Fatalities per thousand employees**
Mineral	Dimension stone	3.64
	Base metals	0.19
	Diamonds	0.17
	Nickel	0.13
	Iron ore	0.11
	Gold	0.08)
Underground		0.19
Surface		0.07

The Resource Safety Division is still concerned with the fatality incidence rate for 2004/2005. Although the overall trend continues to decline no fatal accident is acceptable (Resource Safety, 2005)

The Department of Minerals and Energy conducted a review of Fatal and lost time injuries in Western Australian mines for the 1988-1998 period. The following information was obtained out of this study;

There were thirteen fatalities during the 1997/1998 period; 2 in the surface metalliferous sector, 9 in the underground metalliferous sector and 2 on exploration sites.
Seven of these fatal accidents would have been considered a confined space under the Occupational Health and Safety Act WA, 1984.

For the five year period 1993/1994 to 1997/1998 the largest proportion of underground fatalities was due to underground rock falls (55%). This correlates with the Western Australian confined space mining fatality research where majority of the fatal accidents were within underground operations.

Figure 7 Fatal Incidence by Minerals Mined 1993/1994 – 1997/1998 (Department Minerals & Energy (DME, 1998)

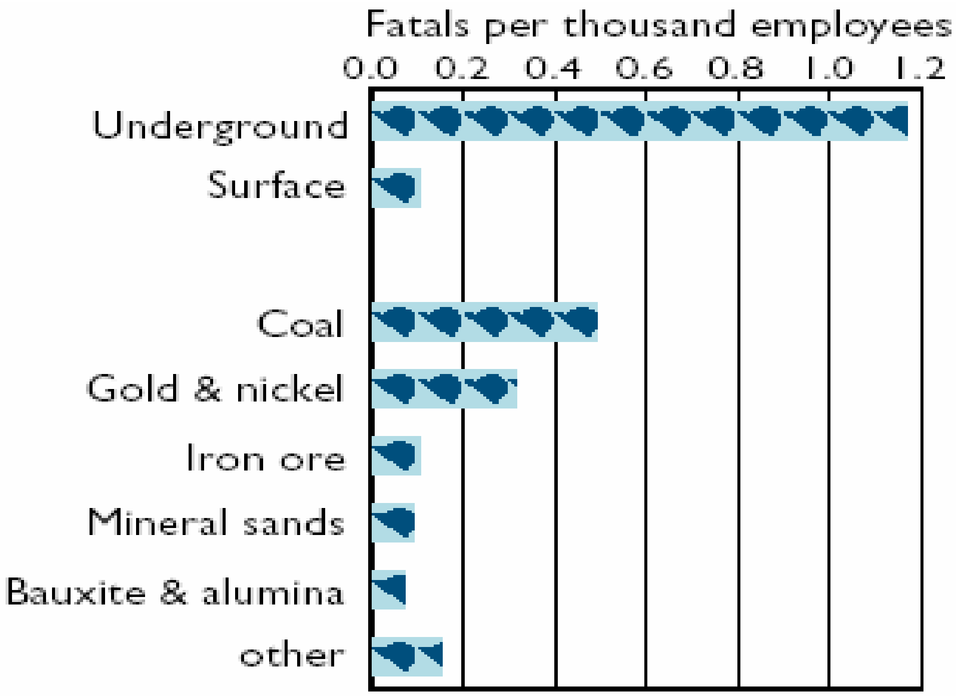
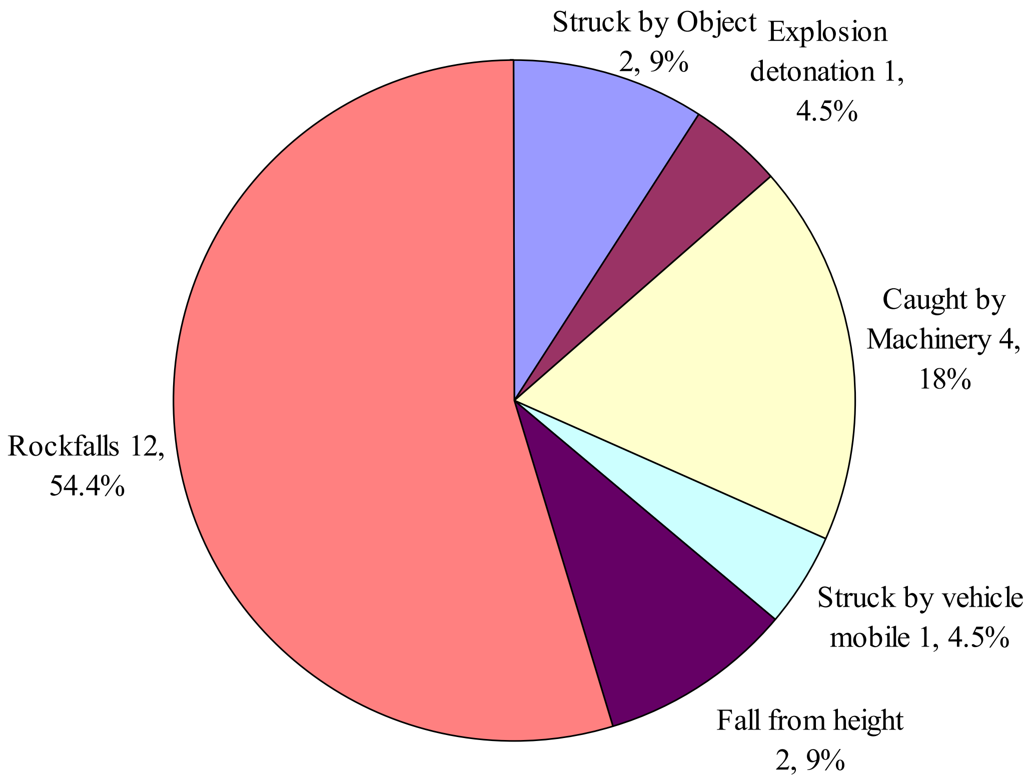
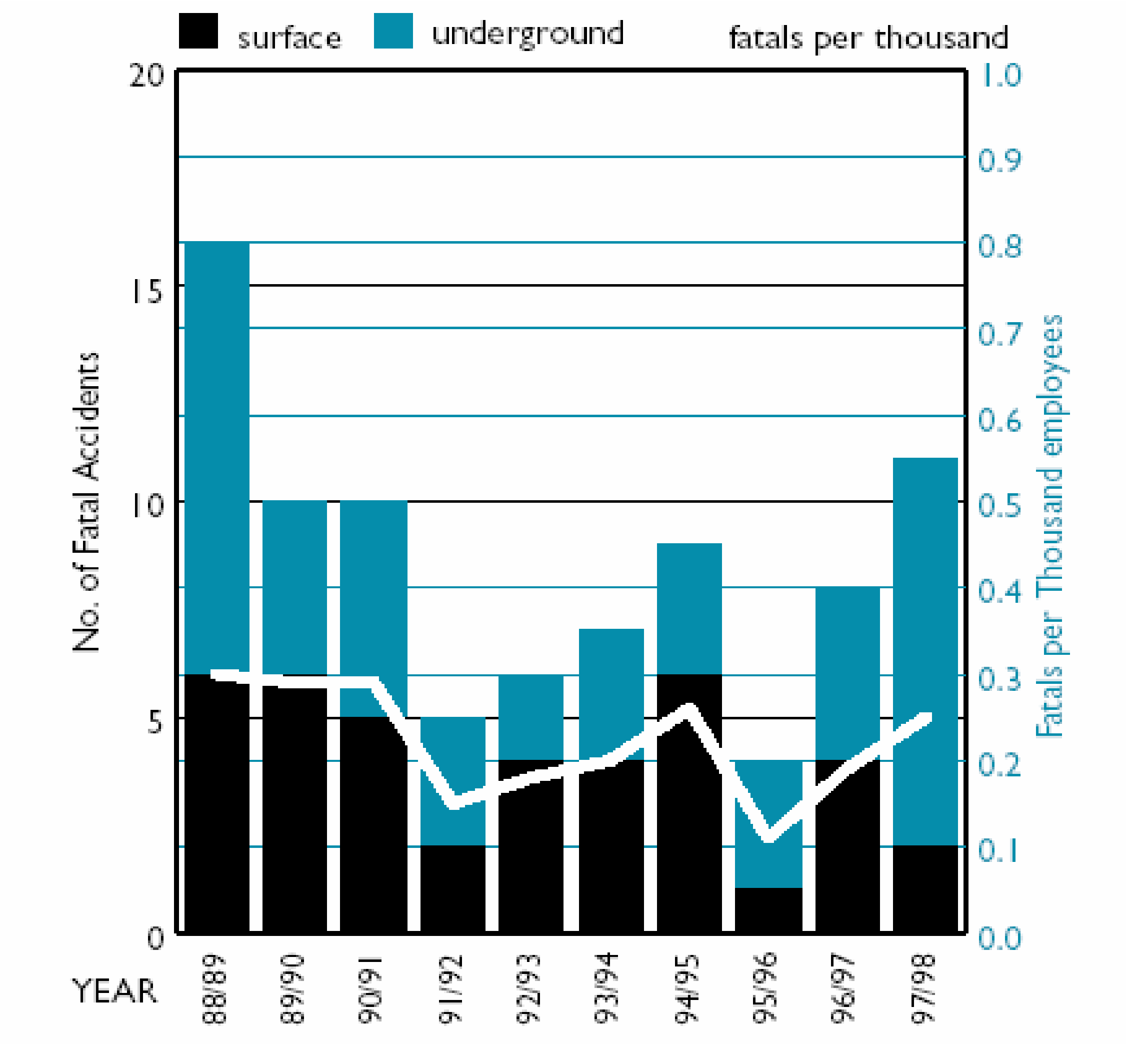


Figure 8 Underground Fatalities 1993/1994 – 1997/1998 (DME, 1998)



According to figure 8 there have been 39 recorded fatalities over the 5 year period (1993-1998) in the mining industry. Twenty two of these fatalities occurred in underground mines with 17 fatalities occurring on the surface of these mines. Twenty two of the fatal accidents recorded would have been considered a confined space fatality if they were governed (thus recorded) under the jurisdiction of the OSH Act, 1984 (WA). The underground mining sector had a fatal incidence rate over eleven times that of the surface mining sector.

Figure 9 **Fatal Incidence Rates 1988/1989 – 1997/1998 (DME, 1998)**



As a result of this research the Department of Minerals and Energy recommended a greater emphasis should continue to be placed on all aspects of ground control in underground mines, including training, excavation design and support, lighting, mechanisation of scaling operations and overhead protection for operators.

The findings of this study became the force that drove the formation of a Mines Fatality Taskforce, a body that conducted a comprehensive study into mining fatalities.

In September 1997, Western Australia's Minister for Mines "Norman Moore instructed the Chairman of the Mines Occupational Safety and Health Advisory Board (MOSHAB) to establish a body to conduct an inquiry into mining fatalities and present finding within three months.

The Mines Fatality Taskforce found that while there had been a sustained improvement in occupational safety and health performance across the industry, the incidence of fatalities in the underground mining sector remains unacceptable and indicates a failure by this sector to adequately control the risk of exposure to rock falls.

Many of the fatalities identified in the Western Australian research study would be considered a "confined space" fatality under the jurisdiction of the Occupational Health and Safety Act WA 1984 were attributed to rock falls in underground mining. It is important to note that these mining fatalities are not currently considered a "confined space" fatality within Western Australia under the Mines Safety and Inspection Act WA 1996. This is due to a minor technicality in that within the mining sector an underground mine site is considered a "normal place of work" whereas under the Occupational Health and Safety jurisdiction it would not be considered a normal place of work.

According to the Mines Fatality Taskforce recent increases in the fatality incidence have coincided with the rapid transition to contractor mine management and it appears that provisions to ensure that established occupational safety and health management systems were maintained after this change were not made.

The Taskforce found that ground issues were not adequately assessed or controlled, and that the industry has been slow to implement the risk management principles of the legislation. Increased attention by industry and the inspectorate to geotechnical issues, particularly ground support was required.

Overall work practices, the quality of supervision, the level of training and the degree to which consultation takes place were found to be inadequate, particularly in the underground sector, and although there have been attempts to improve this situation it has been hampered by a climate of high turnover.

Consistent evidence of employees not reporting hazards or being discouraged from reporting them was found amongst ground control in the underground sector.

The inquiry also found evidence of a poor “safety culture”, particularly in the underground mining sector. According to the Taskforce this can be attributed to high turnover rates, the rapid elevation of inexperienced and inadequately trained young professionals to management roles, a reduced commitment or capacity to provide adequate training and increased non-compliance with safety legislation.
In some cases there was even evidence that risk-taking behaviour, or adoption of unsafe practices is encouraged both directly and indirectly in some pars of the underground sector.

The review process for statutory positions consists of an oral and written examination along with documented evidence of experience. The certification is then valid for life with no practical demonstration of competency required. This has resulted in many incompetent line management positions. The Taskforce recommended a review of the accreditation process for all statutory mining positions and the development of a competency based training program for all underground mining employees as priority recommendations

The deficiencies identified in safety management at all levels are matters for which the enterprises where these problems exist are accountable for their correction. Therefore, all of the recommendations, other than those dealing with Departmental processed, are matters to be acted upon by the enterprises to which they relate. MOSHAB and the Taskforce recognise that if change and improvement is to be effected in a timely manner, organisations equipped to drive those changes will need to take a primary role.

2.3 Other Countries

Canada

In a Canadian study of confined space fatalities conducted by the Mines Accident Prevention Association of Ontario (MAPAO) in 1994 it was revealed that 95% of fatalities were caused by hazardous atmosphere, (50% due to oxygen deficiency), 60% died while trying to rescue others and in 64% of fatalities the work could have been conducted from outside, (Ninnes,1994, p1). It is significant to note that 60% of fatalities occurred whilst trying to rescue others.

In a review of several sources of work related injury in Alberta Canada, there was a reported 221 cases of hydrogen sulphide (H2S) poisoning from 1969 – 1973 of which 14% were fatal injuries. Majority of the fatalities occurred in confined space and were amongst Oil & Gas workers**.**

New Zealand

It is estimated that approximately 10% of all work related fatalities in New Zealand over the last three years have occurred in confined spaces including silos, tanks and bins, (ACC,1999, p58).

Australia

The industries referred to in these USA studies closely correlate to the Australian workplace fatality statistics. Although there has been no specific studies on confined space fatal accidents within Australia for the purpose of this research the following workplace fatality statistics have been provided.

Williamson, Feyer and Cairns (1992, p35-57) studied the fatal accidents in Australia for the period 1982 to 1984, as cited by Harrison, Frommer, Ruck (1989, p11-60). Of 1738 work related fatalities, 718 were excluded from the analysis due to insufficient data for classification, worker was not of the legal working age and because the fatality did not occur directly on the job. The analysis found there was a difference between the causes of the fatal accident and the type of industry. Industry was classified according to the Australian and New Zealand Industrial Classification (ANZIC) coding. The logging fatalities were due primarily to environmental factors. In the manufacturing industry the accidents were primarily due to behavioural factors. Professional and clerical workers fatally injured were mainly as a result of unsafe work practices.

(Refer to WA Work Related Fatality Statistics Appendix 4)

In a study by Fosbroke, Kisner and Myers (1997) the lifetime risk of occupational injury and death was calculated. Occupations in order of the highest risk in Australia were logging, followed by commercial fishing, hunting and trapping, taxicab driving, coal mining and water transportation.

2.4 Multiple Fatalities

More multiple fatalities occur due to accidents in confined spaces than from any other type of industrial accident (Macdonald, 1998, p39)

The incidents described below were investigated by NIOSH as part of its FACE Programme. These incidents suggest that many farm workers may be unaware of the hazards of entering manure pits. Furthermore, the incidents involved the deaths of would-be rescuers many of whom were members of the same family. According to McManus would be rescuers comprise a sizable proportion of the victims in confined space fatalities.

Case No 1 - Two Fatalities

On June 26 1998 a 31 year old male dairy farmer and his 33-year-old brother died after entering a 25-foot square 4-1/2 foot deep manure pit inside a building on their farm. A pump intake pipe in the pit had clogged and the farmer descended into the pit to clear the obstruction. While in the pit he was overcome and collapsed.

The victim's brother was standing at the entrance of the pit and apparently saw the victim collapse. He entered the pit in an attempt to rescue him. The brother was overcome and collapsed inside the pit. Four hours later, another family member discovered the two victims inside the pit and called the local fire department to rescue them. The victims were pronounced dead at the scene by the coroner. The coroners report attributed the cause of death in both cases to methane asphyxiation NIOSH (1990, p1).

Case No 2 - Five Fatalities

On July 26, 1989, five farm workers died after consecutively entering a manure pit on their farm. The pit measured 20 by 40 feet and was 10 feet deep. The victims were a 65-year-old dairy farmer; his two sons aged 37 and 28 and a 15-year-old grandson, and a nephew. The younger son initially entered the pit to replace a shear pin on an agitator shaft.

(Note: Agitation of the manure, which is required to facilitate transfer, causes a rapid release of the gasses formed during decomposition). While attempting to climb out of the pit, the initial victim was overcome and fell to the bottom. The grandson then entered the pit to attempt a rescue. He too was overcome and collapsed. The nephew, the older son and the dairy farmer then entered the pit one at a time attempting to rescue those already overcome. Each one was overcome and collapsed. A carpet installer working at the farmhouse then entered the pit to attempt a rescue. He too was overcome but was rescued by his assistant and subsequently recovered. Finally, the owner of a local farm implement business arrived on the scene with two of his workers and using a rope extricated the five victims from the pit. When the local emergency rescue squad arrived on the scene approximately 20 minutes after the incident they immediately began cardiopulmonary resuscitation. The nephew was pronounced dead at the scene. The remaining four victims were transported to the local hospital. The farmer and his younger son were pronounced dead on arrival, and the older son died an hour after reaching the emergency room.

The grandson was transferred to a major trauma centre by helicopter but he died approximately 6 hours after his removal from the pit. Reports of the medical examiner cite methane asphyxiation as the cause of these five deaths, *NIOSH* (1990, p1).

Case No 3 - Two Fatalities during construction of a sewer line

A labour foreman and another worker were assigned to start a pump one morning, which required entering a pipe, fuelling the pump and starting it. The worker went to start the pump while he foreman checked on something else in the pipe. The worker became dizzy and collapsed. The foreman attempted to carry/drag the worker but was unable, so he left the space to get help.

Seven workers entered the space in an attempt to remove the downed worker. In addition, a state inspector attempted to enter the space from another manhole opening. The state inspector eventually also passed out and was rescued by the fire fighters who arrived on the scene.

Because of misinformation about the location of the victims, their air supply on the SCBA's ran low and they used buddy-breathing techniques to give aid to the state inspector.

Both the state inspector and the worker were pronounced dead. Autopsies showed carboxyhemoglobin levels of 50%. Atmospheric measurements in the space the following day showed CO concentrations at 600 ppm (estimated as high as 2000 ppm at the time of the incident), oxygen levels of 19 to 20% and trace levels of hydrogen sulphide. Colonna (2000, p7)

Case No 4 - Three Sanitation Workers and one Policeman Die

On July 5, 1985 one police officer and two sewer workers died in an attempt to rescue a third sewer worker, who had been overcome by sewer gas at the bottom of an underground pumping station. All four persons were pronounced dead upon removal from the station. NIOSH (1994, p2)

Case No 5 - Workers Die One by One

Ontario police are investigating an accident in which three farm workers died after they climbed into an 18,000 litre liquid manure tank and were overcome by the fumes. Police believe the men were killed by inhaling deadly methane gas when they climbed into the nearly empty tank to repair a faulty part. The men were using the mobile tank to spread manure on a farm field near Drayton, Ontario 130 km west of Toronto.

One man entered the tank to make the repair but failed to return. A second man went in to rescue him and the third was then prompted to go in after the other two failed to come out.
They were pronounced dead at the scene. Their bodies were removed from the tank by fire fighters wearing air tanks.

According to McManus (1999, p97), the enigma of confined spaces is that under some conditions a particular workspace may pose no extraordinary hazard yet following a minor change the condition becomes life threatening. The hazards of confined spaces are transient and subtle and difficult to recognise. This data underscores the importance of developing and implementing comprehensive confined space entry procedures and educating workers and supervisors on following safe work procedures to reduce the number of occupational confined space related fatalities.

3.0 THEORETICAL FRAMEWORK

The research within this thesis is not based on a theory, however the basis of inclusion for the case studies into this thesis relies upon the classification and cause of the incident. Many of the investigators of the case studies utilised accident causation models to determine the cause of the fatality. A detailed description of accident causation models has therefore been provided.

3.1 Accident Causation Models

The conduction of an Accident Analysis is important in understanding and effectively managing workplace safety. It is important to note that the application of different theories and models may affect the methodologies utilized when undertaking accident investigations, and indeed the focus of the investigations on different aspects of the workplace environment and organization.

3.1.1 Domino Theory

Some of the earliest theories relate to sequential models such as Heinrich's Domino Theory, which proposed five factors within the accident sequence. The preventable accident occurs as a result of the culmination of events, occurring in a specific order, one after the other, with each event being dependent on the event preceding it. The five accident factors are as follows:

Ancestry and social environment → Fault of person → Unsafe Act/Mechanical or physical hazard → Accident → Injury

The premise is that the series of events can be interrupted by the removal of the central factor (the unsafe act/hazardous condition), which makes the preceding factors ineffective and results in the accident not occurring (Heinrich, 1980, p45).

To demonstrate, take the case of a worker utilising an unguarded electric saw when he sustains a laceration to his hand. The accident analysis process and preventative measures arising from this may be as follows:

Unsafe Act – Utilising an unguarded saw
Unsafe Condition – An unguarded saw
Preventative measure – Replacing the unguarded saw with a guarded one

Utilising an approach such as this may result in a corrective measure being identified, however, it does little to address any contributing or underlying factors associated with the accident; neither does it identify alternate possible root causes of the accident. As a consequence, it addresses only the 'symptom' of the incident and therefore applies only to the specific circumstance of a worker utilising an unguarded saw and incurring a laceration injury, at that particular point in time.

3.1.2 Multiple Causation Model

The "Domino Theory" was based on the idea of a single sequence of events. In time, however, people realised that there can be many contributing factors, causes and sub causes which combine to cause an accident. This thinking led to the development of the multiple causation models. Petersen compared the multiple causation models and the domino model of thinking with the following example:
If we apply this model to the above example regarding the saw, we are alerted to further considerations associated with the accident analysis procedure, such as:

Motivation – The worker was in a lethargic state and not concentrating on the task. He believed the task was unproductive/unmeaningful, thus affecting concentration levels

Capacity – The worker had only been on the job for one week and had only used this particular saw once, thus had not developed a high degree of skill.

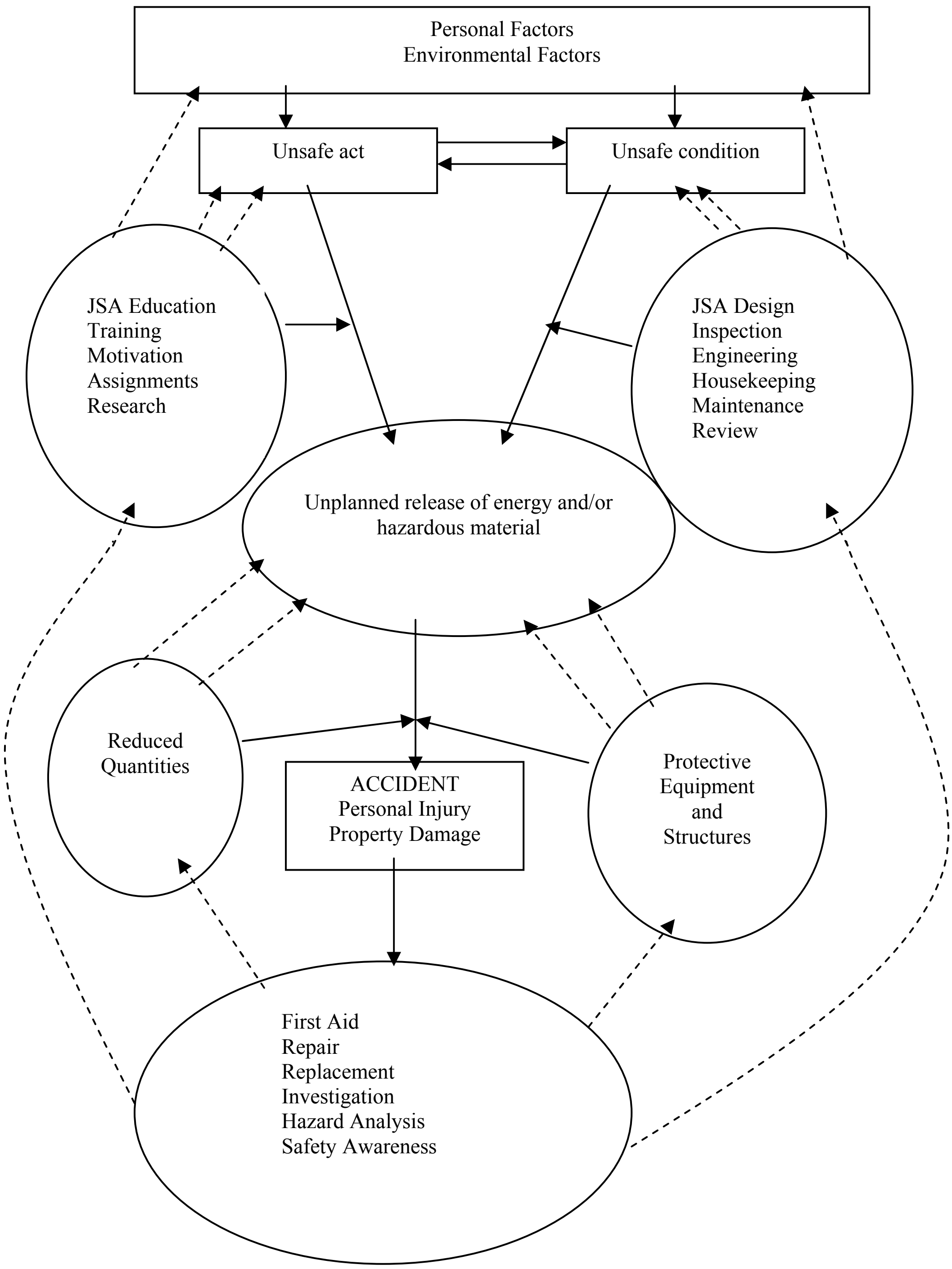
Workstation Design – The worker was of short stature requiring him to reach awkwardly in order to reach the saw.

Conscious decision to ERR– The worker was aware he should not utilise an unguarded machine, however, it was 15 minutes before lunch break and his co-worker was waiting on the wood length in order to complete an assembly line operation. The worker wanted to please his co-worker and believed the probability of sustaining an injury through utilising the saw was very low; he thus made the conscious decision to utilise it.

As can be seen from this example, by applying a different accident causation model, we have been able to identify further factors associated with the occurrence of the laceration. Accident analysis utilising this model as a basis may then identify further corrective measures, such as:

- Addressing the reasons for poor concentration and the perception the worker has about the importance of the task they are undertaking.
- Ensuring the workers capacity fits the tasks they are performing - as it is apparent the new employee was unskilled in utilising the saw. The workplace would need to assess training procedures, supervision of new staff and operating procedures (i.e. was there a procedure in place stating when a worker is deemed skilled to utilise this machine?)
- Undertaking engineering controls to ensure the work bench is designed in such a way to enable the worker to comfortably access the saw and to ensure the saw is guarded.
- Addressing issues related to peer pressure from co-workers. In this instance the peer pressure to complete the task before the lunch break commenced, may also be a factor associated with general workplace culture, policies and inappropriate production pressures placed on workers (Systems Failure). (Peterson, 1974)

Figure 10 Multiple Causation Model (Heinrich, 1998)



3.1.3 Firenze Model

This systems model depicts the integrated relationship between man, machine and environment. Each individual performs their job within the man-machine network system, and as a function of this network.

When the system is running smoothly and as planned, it achieves a desirable end (task completion/resource production). As each factor within the system is interdependent; a failure, mismatch, or interference occurring anywhere within the system, may impede achieving the desirable end and lead to accidents. The machine aspect pertains to a variety of factors associated with the equipment, tools and machines the individual utilises. The environment is the location where the process occurs. The model pertains there must be an appropriate match between human and machine elements, within any given environment, for the system to operate effectively. The model outlines that man will use acquired information (eg knowledge, skill, training) to make decisions, and will take certain risks, in order to reach the desired outcome. The man's ability to perform his task will be affected by poorly functioning equipment or inadequate environmental conditions. It must also be noted that certain stressors, whether they be of physical, psychological or physiological origin, will also affect the effective decision making process (Firenze, 1971) cited in (Heinrich, 1980).

In April 1999, Work Safe WA accident investigation inspectors issued a safety and health alert regarding the mixing of chemicals. An employee working in a chemical processing environment sustained facial burns while mixing a flammable chemical, in a plastic vessel, utilising an electric drill which was fitted with a stirrer attachment. Vapours arising from the mixing of the hazardous chemical came into contact with electrical arcing, which was generated by the commutator of the drill's electric motor, in turn causing fire production. Upon reviewing the Material Safety Data Sheet (MSDS) of the chemical being mixed, investigators found the chemical contained highly volatile substances, had a 'flashpoint' of 35°C, and was a flammable liquid which should have been isolated from heat, sparks and flame (WorkSafe WA, 1999).

Utilising the Firenze systems model as a basis for accident analysis, we can immediately see a mismatch between all three base elements of man, machine, and environment. Environment elements such as the hazardous chemicals and vapours posed significant risk to the employee. The employer had not identified the risks involved with mixing these flammable chemicals, nor had they reviewed the MSDS of the chemical product. The employee utilised an inadequate (and highly hazardous) piece of equipment, which then resulted in an ignition source coming into contact with flammable vapours. In this scenario, we can determine a number of factors associated with accident causation:

Man - The employee had not received adequate training or information on the chemical substances she was handling and there were no operating procedures in place to guide the safe mixing of these chemicals. The employee therefore had a severe lack of knowledge, skill, and information regarding the process she conducted; resulting in bad decisions being made, which resulted in exposure to significant risks and the occurrence of a burn injury.

Machine – The equipment utilised was clearly not designed for the process undertaken and thus created an ignition source fro flammable chemicals.

Environment – Environmental elements were hazardous, poorly understood and poorly controlled.

It is clear that preventative measures may include, but are not limited to, the following:

- Given the handling of hazardous chemicals, a thorough hazard identification and risk assessment would be required, including a review of the MSDS. Further to this effective control measures may then be developed, which ideally would involve eliminating the risk all together, as per the industry known hierarchy of controls.

- Ensuring the employee has adequate training and knowledge to be aware of the task requirements, potential health risks associated with hazardous substances, and the nature of harmful consequences that arise from certain decisions. Adequate training, supervision and the provision of safe operating procedures are crucial in providing this and in removing the uncertainty surrounding human decision making.

- Ensuring the appropriate equipment is utilised for the task being performed and the safe operating procedures are known. This includes not only the machine being utilised but only Personal Protective Equipment required as well.

In reviewing the Domino, Petersen and Firenze models, it is apparent that there are two important elements associated with accident occurrence which must be recognised; these being the inherent multiple causation present in all accidents and the important role of managerial processes within the accident causation sequence.
Purist human error theorists may argue that human error or the unsafe behaviour of humans causes accidents. However, to get to the root cause of an accident, it would be necessary to ask why the human error occurred. In doing this we identify multiple causation factors, and in considering multiple aspects of a causal chain, we invariably implicate management at the end of that chain. This implication may be attributable to either action or inaction by management (Hopkins, 2006).

3.1.4 MORT Analysis Tree

The Management Oversight and Risk Tree (MORT) Analysis was originally developed by Johnson in 1980 for the Nuclear Regulatory Commission in America and according to Skegg (1992) *"described in detail a fault tree derived diagram, the management actions that can be applied to prevent propagation of the failure towards the top event, or to investigate an event to determine the causative process"(p84)*

Kuhlman (1977) described MORT "*as a safety system that would be compatible with complex, goal oriented management systems"(p21).* Johnson (1975) states *"MORT focuses on a rational assessment management control system"(p11).*
Diagrams or charts are the heart of MORT. The logic tree illustrates a long series of interrelated questions. MORT, while similar to fault tree analysis. Is more generalised and has several innovative characteristics. Once completed it provides high visibility to the mishap analysis process. It allows the investigator to review findings, present them meaningfully to other, alter the analysis as facts warrant, and record the investigative steps and results for future reference (Ferry, 1988)

MORT is based on the concept that all accidental losses arise from two sources

1. Specific job oversight and omission
2. The management systems factors that control the job

A third source "assumed risks" once properly evaluated is not considered accidental, since we evaluated the risks and decided to accept their potential for mishap. The reason for not acting on known risks may be from *"there is no known preventable action"* (such as for an earthquake) to *"preventative cost is prohibitive for the value returned" (*spending millions to prevent mishap with minor damage or injury potential) (Ferry, 1988).

The program was developed to accomplish the following objectives.

- Prevent safety-related oversights, errors and omissions.
- Express risks in a quantitative form (to maximum possible degree) and refer these risks to proper management levels for appropriate actions.
- Make effective allocation of resources through the safety program to individual hazard control effort.

It was the first engineering and safety tool used to merge safety management and safety engineering. MORT was an excellent attempt at a systematic approach for analysing the adequacy of programs, procedures, controls, polices and management systems. MORT is still a viable technique for accident investigation, but the number of trained individuals and MORT proponents is rapidly decreasing. (Oakley, 2003, p. 108).

Accident investigators who use MORT work though the tree by asking questions listed in the MORT user's Manual. Each question is given a response that is marked in colour on the MORT chart. The possible responses to the questions are:

Table 9 MORT Accident Causation Chart (Oakley, 2003)

Number	Description	Colour
1	**Less than adequate (LTS)**	**Red**
2	**Adequate**	**Green**
3	**Need more information**	**Blue**
4	**Not applicable**	**Black**

A complete tree contains ninety-eight generic events (problems) and more than fifteen hundred basic events. Using MORT can be extremely confusing as it is easy to get lost in the chart. MORT is also not suited for smaller accidents. However, the biggest problem with the technique is that it assumes there is an ideal system. (Oakley, 2003, p.108).

When using MORT an investigator works through the tree and asks questions listed in the MORT User's Manual. Each question is given a response that is marked according to the fact of the accident applying the appropriate colour coding. As the tree is developed the investigator continues to explore paths indicated by red responses (less than adequate) to understand why the system failed. (Oakley, 2003, p108).

As it suggests MORT is biased towards management failures rather than focusing on energy releases, central failures or device failures. In fairness to the system, it does incorporate these items, it is only the focus of attention that is different. As a technique in the field it should be considered as a proprietary version of the Fault Tree Analysis.

A strong advantage of MORT is it permits the simultaneous analysis of multiple causes through the tree. It also provides specifically for the areas of decision and the assumption of acceptable risk.

A disadvantage of MORT is that it is unsuitable for majority of accident investigations because it is geared towards significant accidents or events such as a gas explosion on the North West Shelf.

The MORT system is widely used by WorkSafe Western Australia as part of a computer programme and is available to all officers of the Department.

3.1.5 Fault Tree Analysis

"In 1959 the Air Force became concerned with the potentially catastrophic events which could occur with the minuteman missile which was then being developed by Boeing. The Air Force contracted with Bell Laboratories to develop a method of analysis by which the probabilities of events with which they were concerned could be computed. The Air Force wanted to know the possibilities and probabilities that missile could be launched or a warhead activated inadvertently and the chance of these being done internationally by an unauthorised person in an act of sabotage.

*Two years later Bell laboratories competed the project. The new method, fault tree analysis, involved Booleam logic in ways similar to those increasingly being used in electronic industries. Safety engineers of the Boeing company adopted the proposal method so that it could be computerised to permit calculating the probabilities of the problems which the analyst was concerned. Although it is still used to determine the probabilities of mishaps in complex systems or operations, fault tree analysis is being used far more frequently to analyse logically the possibilities of the potential hazards"(*Hammer, 1985)

FTA is a systematic method for determining and displaying the cause of a major unwanted event (Gideon and Gressel, 1991).

FTA is a method that starts with the effect and seeks the causes. As such, it is backward looking or top-down approach. FTA is a graphical means of presenting all the sequences and combinations of events and failures that can lead to specified outcome.

Fault trees are time consuming and require a thorough understanding of a system and it's behaviour in all operating modes. FTA can be used at almost any stage or project development and can analyse a particular facility or evaluate alternative designs or procedures.

FTA are suitable for large complex systems and is favoured by engineers and designers because it can handle multiple failures including situations that require more than engineering judgement alone (Ozog, 1987).

Some advantages of the Fault tree analysis are:

1. It is an aid for identifying risks in complex systems
2. It makes it possible to focus on one fault at a time without losing an overall perspective
3. It provides an overview on how faults can lead to serious consequences
4. For those with a certain familiarity with the analysis, it is possible to understand the results relatively quickly
5. It provides an opportunity to make probabilistic estimates

Some of it's disadvantages are:

1. It is a relatively detailed and , in general time consuming method
2. It requires expertise and training to conduct
3. It can provide an illusion of high accuracy. It's results appear advanced and , when probabilistic analyses are conducted, these can be presented in the form of a single value. As with most methods there are manly possible sources of error.
4. It cannot be applied mechanically and does not guarantee that all faults are detected. In general different analysts will produce a variety of different trees. A tree can have different forms and still have the same content.
5. It's implementation generally requires detailed documentary detail to be available.
6. It has a single event focus

Fault Tree Analysis is the best technique for practicing safety officers according to Skegg (1992) he states *"it can be as brief or as detailed as time and circumstance allows. It readily shows pathways leading to other top events, and it is easily understood by other* (p11).

Alcoa Australia utilised FTA when investigating incidents or mishaps in conjunction with other occupational safety and health strategies.

4.0 METHODOLOGY

4.1 Design

All work related confined space fatalities within Western Australia occurring from the period of 1980-2004 were researched and analysed.

Comparisons of work injury data from different sources representing the same population can provide useful data for validity and reliability assessments (*Stout, Frommer and Harrison* ,1990, p45).

The primary method of data collection was from fatality investigation reports and death certificates obtained from Western Australian Department of Consumer and Employment Protection (WorkSafe Division) and the Department of Minerals & Resources. Reports written by Coroners, death certificates and fatal accident investigations were analysed. These sources of information were all a matter of public record therefore permission was not required to utilise the documents.

Each fatality report was evaluated in an individual basis and included or excluded from the research analysis according to the following criteria:

1) Must be defined as work related according to Australian Standard (WorkSafe);
2) Must satisfy requirements of what is considered a confined space (AS 2865-1995);
3) Must have occurred in the period 0f 1980-2004; and
4) Must be within the jurisdiction of OHS (OHS)Act WA 1984 (during the period of the study)

A pro forma was developed to collect necessary details including:

- Date of fatal accident
- Age
- Sex
- Industry
- Profession/Occupations
- Location
- Contributory Factors if provided
- Recommendations if provided

(Refer to appendix 9.2 Fatal Accident Data WA)

Occupation codes were assigned according to the Australian Standard Classification of Occupations, (ASCO) provided by the Australian Bureau of Statistics. Industries are coded according to the ANZSIC Guideline.
(Refer to State of the Work Environment 2004/2005).

The relatively low frequency of fatalities limits the potential for the use of population sampling (Stout, Frommer and Harrison,1999, p45).

All fatalities occurring within Western Australia between the periods of 1980-2004 that satisfy the requirements stated above became the sample population within this experiment. It is important to note that whilst the USA studies included underground mining fatalities as a confined space fatality in their studies, they fall within the jurisdiction of the Mines Safety and Inspection Act 1994 and are not classified as confined space fatalities within Western Australia. This is due to a minor technicality in that within the mining industry, a mine (whether it be underground or open cut), is considered a “normal” place of work and therefore not a confined space!. Within the OHS Act WA1984 it would not be considered a “normal” place of work and therefore deemed a confined space. For the purpose of this research mining industry fatalities that would be considered a confined space under OSH Act WA, 1984 has been included in the appendices for review.

The study involved the use of quantitative research in terms of quantitative historical fatality records will be used. The data was analysed using the descriptive statistics of numbers and percentages i.e. 30% of the fatal accidents.

Qualitative research was undertaken to determine the probable causes of a fatality.

Results of the Western Australian research data were then tabulated and or graphed and presented in the Results & Discussion section of this study.

4.2 Reliability and Validity

Reliability in relation to this research was measured by the consistency in the way the data was collected to decrease the chance of significant research findings being attributed to the differences in the methods researchers use to study confined space fatality information.

Many of the reliability concepts do not apply to this research due the historical nature of the research design. This includes content, criterion and construct reliability. It is the researcher who has established the criteria for the accident and the cause of the fatality. For example, a welder in a confined space whom was electrocuted would equate to occupation welder, cause of death electrocution.

In a study by Baker, Samkoff, Fisher, (1982) into work related fatalities; they found no single data source provided information on all cases. Therefore, it was necessary to gather records from a variety of sources to increase internal reliability. The available sources of information within this research were limited and much of the data in the literature review and the Western Australian research study was incomplete.

The reliability of data on death certificates and the method which the data is collected and coded has been questioned (Nairn, Fett, Cobbin,1985). In particular, the reliability of doctors and coroners deciding causes of death. This has implications for the internal quality control procedures related to collection and coding. Australian Bureau of Statistics (1985). Death certificates were used in this research to ascertain causal factors.

The inclusion of work related confined space fatal accidents as part of the research study was determined by the researched using set criteria (mentioned above). This provides consistency amongst case studies which increased inter-rater reliability.

The investigative techniques conducted initially after the fatality may possibly differ from country, to jurisdiction, to individual investigators. For example an investigator in the USA may utilise a differing accident causation model or investigation technique to that of a Western Australian investigator and as a result determine alternative causal factors (See Accident Causation Models, Literature Review).

Researchers may also be subject to bias due to life experience (amongst other factors) Therefore no one individual investigating a fatality can approach the investigation the very same way the other approaches it. Assuming this is the case how could the outcomes or causal factors be identical? Very few investigation reports utilised in the Western Australian case study provided immediate/underlying causes reinforcing this idea.

The research design also makes it impossible to conduct face-to-face interviews or questionnaires for verification of the information found in the historical records and investigations. This lack of verification decreases the internal reliability of the research.

Instrumentation may also have an effect on the reliability of the research in that the measures that affect our ability to assess e.g. fatigue, experience may influence the outcome. With only one person establishing the criteria and causes of fatalities the instrumentation can greatly affect the results of the research.

The testing (or in this case the researching of confined space fatality information) may also influence the internal reliability of the data. This may occur when the researcher's attitude or opinions change as a result of increasing their knowledge of confined space fatalities which in turn changes the attitudes towards the topic being studied. Again, with only one researcher in this study this may have an unprecedented effect on the outcome.

Experimental bias can also become an obstacle in that expectations of an outcome may inadvertently cause the experimenter to view data in a different way. Even though the research is of a non experimental design nature there is still a sample population (non random) and a researcher that is subject to bias.

The use of existing fatality investigation records will provide face validity.

4.3 Limitations

Western Australian OHS Act passed in 1984 but was not promulgated until 1988. The fatality investigation reports prior to this were incomplete and include very little information (if any). As a result of this many of the causal factors have been determined by the researcher in retrospect by analysing the investigators comments within the investigation report.

There are no specific criteria (investigation techniques) for conducting a fatality investigation within WorkSafe Western Australia. Investigators therefore draw on their own experience when conducting the investigations. As no individual investigator has the same life (or work) experience of another the approach to which they investigate would differ, which results in different causal factors. The following application to accident causation models demonstrates the effect it may have on the outcome of the investigation.

The Domino Accident Causation Model in, March 2001(fishing vessel) fatality;

"*A welder was working onboard fishing vessel welding transducer housings in the forward lower cofferdam. He had changed a welding rod when he was electrocuted*"

According to the Domino Causation model the following causal factors would be determined;

- Unsafe Act– Isolation device not used
- Unsafe Condition – exposed welding electrode
- Preventative measure – Use isolation device

If the domino theory was utilised in the Winery Fatality 19th March 1998 the causal factors and preventative techniques would be as follows;

- Unsafe Act – Climbing into the wine vat
- Unsafe Condition – Hazardous (CO_2) atmosphere (oxygen deficient atmosphere)
- Preventative Measures – Do not enter vat or use respiratory equipment (SCBA) if required to enter atmosphere.

This technique does little to address any contributory factors associated with the fatal accidents. It is very much like the bandaid approach rather than a holistic behavioural approach to accident prevention.

Alternatively, if the multiple causation model was applied to the fishing vessel fatality additional underlying causal factors would allude to;

- Inadequate supervision - The supervisor/watch was not fulfilling his task as spotter during the incident.
- Lack of adherence to procedures – For example confined space permit was not filled out completely identifying the need for the isolation switch, no isolation switch was used in the cofferdam and the deceased was changing the electrode whilst the current is supplied to the electrode holder.
- Lack of fluids in excessive heat – the welder had not taken a fluid break for over three hours which combined with the heat may have affected his mental state.

- Inadequate engineering – No voltage reduction devices installed, no means for cutting off power to welding circuit installed

If the multiple causation model is applied to the winery fatality the following additional causal factors would be taken into consideration;

- Lack of direction of supervision – the supervisor in this instance informed the trainee that he was too small to fit in the vat rather than alert him to the dangers of CO_2! He was not watching at the time of the fatality
- PPE – No use of SCBA or oxygen masks were used when entering the vat. In addition to this there was no emergency oxygen equipment available in site.
- No documented safe systems of work eg. procedures on confined space entry
- No training of new employees

It may have also encouraged additional questions on commitment of senior management, if there was any pressure to "get the job done quickly" rather than safely and or the "safety culture" within the company.

If the investigators with WorkSafe had used the multiple causation model in this case additional causal factors would perhaps have been identified

It was also difficult for the researcher to make a fair comparison between the USA research studies conducted and the Western Australia confined space research study. The differences pertaining to industry classification, jurisdictions (legislation) and timeframes of each study affected the validity of the outcomes in each case.

For example when comparing common industries in which confined spaces occur it would appear the only difference between the Western Australia data is the inclusion of the electrical, gas and water industry. Although this may appear to be a significant finding it in fact is not. In the ANZSIC guideline electricians would be classified under the Electrical/Gas /Water industry whereas in the North America industry classification Electricians would be classified under Construction. It is no surprise that majority of confined space fatalities occurred within the Construction industry.

In addition to this inconsistency within the USA mining is included under the same jurisdiction as non-mining enterprises. Therefore mining statistics are analysed within the USA studies whereas the Western Australian has excluded them as they are not considered confined space fatalities under the WA Mining jurisdiction.

The array of legislation, all with subtle differences affects the framework with which to classify a fatality as occurring in a confined space. For example fatalities occurring in a trench would be classified as a confined space fatality in the USA but in WA the trench has to be at least 4 metre deep for it to be classified as a confined space.

Research timeframes also has a bearing on the results of this study when making comparisons with studies in other countries. For example, the USA literature review studies measure confined space fatalities from the period 1979 to 1985, 1989-1998 etc. The Western Australia studies provide a single study period of 1980 – 2004. Results may therefore differ due to replication of statistics due to overlapping timeframes in the USA case studies making it impossible to make a valid correlation.

The limited sample size (15) of the Western Australian research makes it difficult to analyse trends and present findings of true significance. The findings may also lead to misinterpretation of results if using percentages rather than numbers. For example eight fatalities occurring in the agricultural industry would account for over 50% of the fatalities indicating a trend in the agricultural industry. Although it would have been useful for the researcher to analyse a larger sample population it is a positive sign that the sample population that is the number of work related confined space fatalities is relatively small.

4.4 Ethical Considerations

Information concerning fatal accidents becomes public information at the tabling of a coronial inquiry, civil and criminal litigation. Nonetheless the identification of a deceased individual may still result in family member’s distress. The study does not identify the names of individuals or organisations and will focus on the findings.

5.0 RESULTS & DISCUSSION

The sample population case studies for the this research are provided below;

Confined Space Fatalities - Western Australia Case Study

6th October 1982 - Construction Site

A 38 year old male labourer receives fatal head injuries while working in a trench. A portion of the wall of the 6.5 metre deep excavation collapsed, thrusting him against the formwork.

The deceased worked for a company contracted to construct footings and formwork. In the events leading up to the fatality the deceased arrived at work and was informed by his supervisor that he was to finish digging the trench he had started one week earlier. The supervisor claimed he had sighted the trench a couple of days earlier and it was correctly battered with no need for shoring. The deceased continued to dig the trench with no supervision. At approximately 4.30pm the supervisor attended the site to check if the trench was finished and found the deceased pinned against the formwork by a mixture of sand and rock. The deceased was pronounced dead when the ambulance attended the scene

The deceased was considered an experienced labourer having dug trenches on major construction sites for over 15 years. According to the Construction Superintendent he did not believe he required full-time supervision. On investigation the labourer had not adhered to excavation standards and the trench was too deep for the minimal battering evident. Battering was evident from a depth of 4 (is required at the 2m according to Australian Standards). No shoring had been included. In addition to this there were no procedures for excavations on-site including no excavations, permits or the need for shoring. An induction had been provided to all employees of the contracting company but it contained minimal information regarding risks of trench cave-ins. No additional training had been developed or implemented on-site.

Training and competency seemed to be assessed in the pre-employment stages with no additional courses provided from the contracting company. It is important to note that excavations regardless of the depth were not viewed as confined spaces at this point in time and only recently were considered as confined spaces. If it was considered a confined space in 1982 a safe system of entering including correct use of equipment (eg shoring) would have been considered as well as a review of safe work procedures (eg excavations).

The supervisor was busy providing inductions to new personnel at the time of the incident and it became clear that a lack of resources available was the reason for this.

Recommendations made at the conclusion of the investigation involved;

The need for additional resources especially line management! If the supervisor had not been busy attending to other areas outside of his responsibility it is *assumed* he would have been present during the excavation and ensured effective battering and or shoring was conducted.

A safe system of work for excavations should be developed including procedures job safety analyses (risk assessment prior to task), excavations and shoring.
It was also recommended for a fatal incident alert be developed and distributed to similar industries including construction, plumbing and electrical warning of the risks associated with excavations (WorkSafe, WA, 2006)

23rd November 1982 – Wheat Silo

A 19 year old farmer was preparing to weld sheet steel plates inside a portable wheat silo. He came in contact with the exposed end of the welding electrode while he was in contact with the earthed metal surface of the wheat bin.

Upon investigation it was established that there were no safe systems of work documented, implemented or trained. The deceased had no formal qualifications or training in welding (besides that of his father, the owner of the farm) and it was stated that he had performed the very same task numerous times prior to this day with no error.
The deceased father was approximately 1kilometre away from the wheat bin working in the field. His father was aware his son was welding the silo that day but did not realise what had happened until 3 hours later at 6.30pm when he did not come home for dinner. The deceased was pronounced dead upon arrival of the ambulance. (WorkSafe, WA, 2006)

23rd January 1984 - Ceiling Space

A 16 year old apprentice electrician was electrocuted in the ceiling space of a metropolitan hotel. The deceased and his supervisor were informed by his supervisor of the call out from a hotel. The supervisor and his apprentice presented to hotel management the morning of the 23rd at approximately 9.30am. Centre Management Maintenance Manager had informed the supervisor that numerous lights were out of order even though the globes had been renewed. The Supervisor ran through the task with his apprentice asking if he was confident in doing it. According to the supervisor the apprentice stated he was.

Apparently the apprentice had performed this task on numerous occasions prior to this date. The apprentice went to isolate the particular circuit he was working before he entered the ceiling space. Upon investigation it was determined that the apprentice isolated the wrong circuit and was exposed to live wires of an old light fitting where the insulation sheath had degenerated. This was consistent with the burn marks on the light fitting and the deceased's right forearm. The Supervisor returned 1 hour later and called for the apprentice with no response. He entered the ceiling space to find the deceased on his stomach. The supervisor attempted to resuscitate the victim to no avail.

The inadequate supervision was highlighted in the investigation report giving special mention to the age and experience of the apprentice. Work related fatalities within Western Australia are common in apprentices. The deceased had been taken on as an apprentice 9 months earlier by a family friend who had his own electrical business. As with many small businesses there were no documented safe systems of work including isolation and or confined space procedures. Training was provided informally in a ask questions and observe type approach and it was verbally agreed that the apprentice would accompany the supervisor to all jobs. According to the manager it was assumed by all employees (all 4 of them) that apprentices were supervised at all times (there was no documented evidence of this). A special mention was given to the culture or the common practice of working on a live circuit within the electrical industry.

Recommendations provided in the report included developing and implementing a safe system of work that includes;

- Regular training for all personnel detailing the hazards of electrical work
- Competency assessments of all personnel
- Apprentices (least experienced personnel) are to be accompanied by an experienced supervisor at all times.

It was also recommended that a fatal incident report be documented and released to all employees detailing the incident, causes and recommendations.
(WorkSafe, WA, 2006)

24th April 1985 – Residential House

A 23 year old electrician was electrocuted in the ceiling space of a private residence.
The 23 year old electrician was an employee of a company that was contracted to install a reverse cycle air conditioner in the dining room of a residential house.

The deceased presented to the owner at approximately 9.30 am whom showed him the reverse cycle air conditioner she purchased and left to go shopping for a couple of hours whilst the deceased installed the air conditioner. The events from this point onwards were unknown but upon investigation it was found that he was working on a live circuit when he entered the ceiling space and somehow made contact with the exposed wire of a light fitting. No residual current devices had been fitted as the house was older than 1985 (RCD's were included in the legislation as of 1985).The burn marks on his left index finger and forearm were consistent with this analogy.

The owner returned two hours later and called up to the deceased to see if he would like some lunch. After no answer she climbed the ladder into the ceiling space to see if he was there. After no answer she became worried and ran to get her next door neighbour whom entered the ceiling space and found the deceased. The neighbour rolled the deceased and attempted to resuscitate but he was already dead. It is important to note the potential for a second electrocution as the circuit was still live.

Upon investigation many inadequacies were given mention relating to lack of supervision and training provided by the principal contractor whom failed to fulfil their duty of care responsibilities.
(WorkSafe, WA, 2006)

13th November 1986 – Shipyard

A 53 year old furniture upholsterer was applying a fabric protector containing 1, 1, 1, trichloroethane in the forward cabin of a motor launch when he was overcome by fumes (WorkSafe, WA, 2006)

5th January 1988 – Shopping Centre Ceiling Space

A 20 year old apprentice electrician was electrocuted in the ceiling space of a shopping centre. The apprentice was working alone on an electrically operated roller door when he made contact with an exposed wire making the circuit. In the events leading up to the incident it was determined that the apprentice and his supervisor attended the scene without notifying centre management of the commencement of work. After 90 minutes of working on the roller door to establish the cause of the problem the supervisor notified the apprentice that he was going to get a drink from the supermarket inside. When he returned 15 mins later the deceased was found in the ceiling on his back. The supervisor commenced CPR but the victim was pronounced dead by attending ambulance officers soon thereafter. Upon investigation the direct cause was found to be contact with exposed wires leading to ceiling space (the insulated sheath had degenerated over time exposing the wires). The circuit was live at the time of work.

Again mention was given to the common practice of working on live circuits within the electrical field. It is difficult in public areas such as shopping centres, hotels and commercial buildings to switch off the circuit as this would disturb work practices of employees, shoppers from carrying on with their day to day business which in turn costs the owners money. (WorkSafe WA, 2006)

22nd January 1990 – Abattoir

A 53 year old abattoir process worker was cleaning out the inside of the offal vat when the strainer which was being lifted out of the vat fell of the crane hook striking the deceased. The process within abattoirs is as follows;

The animals are killed on the top floor and transferred by conveyor to the second level where the carcass is separated from the viscera (offal including intestines, hearts, liver, kidneys etc). The carcass is sent to another section for curing, trimming, processing and packaging. The offal is separated into vats (the intestines in one vat and the heart, liver kidneys in another). The vats are used for curing (cleaning) and after a period of time the offal is emptied and transferred to another level for inspection, trimming and further processing. The offal is then transferred to a separate vat where salt is added to preserve the meat that will eventually be sold for sausages (intestines) and other. After this process they are processed, cleaned, packaged and labelled for selling.

The victim entered the vat by the access ladder whilst the strainer was being lifted out of the vat. As the 1 tonne strainer was being lifted outside the vat the chain holding the strainer disconnected from the hook. The strainer fell into the fat striking the victim on the head. The victim died instantly from head injuries.

On investigation of causal factors it was determined that the crane operator did not secure the safety lock on the hook which allowed the chain to disconnect from the chain. There was no spotter (dogman) in this scenario that could have identified the problem before it occurred. The chain used on the crane was correct strength for the load. There were no procedures, training or safe systems of work for all involved. Specifically there were no procedures detailing safety measures during crane operation, cleaning of the vats and or confined spaces. The crane operator was contracted to the abattoir and was a licensed crane operator of 10 years. No supervision was present during this operation.

Recommendations made on the conclusion of the investigation were as follows;

- Development and implementation of procedures involving cranes/rigging operation. This procedure should detail safe working load, rigging standards and the prohibition of employees working directly under overhead cranes.
- Training shall be developed and regularly implemented in respect to the hazards involved within the abattoir.
- A fatal incident alert be distributed to fellow employees, abattoirs and related industries regarding overhead cranes.

It is interesting to note that no mention was given to confined space procedures and that majority of the recommendations focused on working in the vicinity of overhead cranes. Although these recommendations were applicable a confined space program that encouraged the deceased to identify the hazards prior to entering would presumably have prevented him from participating in dangerous work practices (WorkSafe WA, 2006)

3rd January 1993 - Fishing Vessel (Trawler)

A 19-year-old Apprentice Refrigeration Mechanic was cleaning out a refrigeration system on a fishing vessel. The method of cleansing or "flushing" the system was to fill the refrigeration components (i.e. evaporators, cooling coils, associated pipe work) with solvent and to circulate the solvent, via a pump, within these components. To complete this successfully a number of restrictions had to be removed to allow the solvent to circulate freely.

Leaks developed within the system, located in the freezer hold area, at the sites where these restrictions had been removed. An extensive leak also developed on an associated by-pass line connected to the removal of the restrictions. Apparently in an endeavour to rectify the problem, the deceased the area and was overcome by the toxic component of the solvent. Occurred in the Thermo-static expansion valves where a by-pass line had been disconnected.

As a consequence approximately 50 litres of the solvent leaked out. The solvent concentrations were high enough to cause the apprentice to lose consciousness: he died of neurotoxic effects.

The vessel had undergone modifications in 1986 involving the conversion from refrigerant gas Ammonia to Freon R502. The vessel was originally used as a prawn trawler and tendered a contract to a company (referred to as the contractor company in this case) to make some modifications so that it could be converted for scallop fishing operations. Whilst the vessel was dry docked undergoing these changes the contracting company requested that the refrigeration system be cleansed to remove any scale, solids or impurities which are not removed through the normal filtration system. The objective to improve efficiency of the refrigeration system and reduce maintenance costs.

The company of the deceased was contracted by the principal contractor to fulfil this task. Evidence indicates that the deceased went to work on 1st January 1993. It appeared that the procedure to pump the solvent into the refrigeration system was commenced at this time. It seems appropriate that the deceased would therefore have removed the mechanical restrictions allowing the solvent to circulate freely. It is most likely that the deceased would have filled the refrigeration system with solvent and commenced circulation of the solvent through the system. The time of commencement, durations and termination of operation cannot be determined.

The deceased returned to the shipyards at around 8.30 am on the 2nd January 1993 apparently to evaluate and progress the cleaning operation. The length of time that the process takes is determined by the quantity and difficulty of removing the impurities within the system.

If the process was at the stage where most impurities had been filtered from the system it may have been his intention to remove the solvent from the refrigeration system.

The deceased, either by observation or when turning on the pump, would have realised that the solvent was not circulating because of air in the system. It is most likely that he would have assessed all the connection points and the plastic hoses in the engine room.

Finding no solvent leaks he would have assumed that there was a leak in the refrigeration hold and entered with tools and a hand held torch (found at the scene) to rectify the problem.

In the process of assessing or attending to the leak the deceased was overcome by toxic fumes. He was found facing the ceiling of the hold.

It was determined that the contributing factors were as follows;

1. When removing the TX valve from the power element a by-pass line on the freezer was disconnected and rejoined. It was not tightened and was loose when the solvent was circulating which eventuated in the leak.

2. Inadequate warning on the solvent product sheet. The product sheet supplied with the solvent did not convey the hazardous nature of the product. When viewing the MSDS sheet for this product after the event it was apparent the associated neurotoxic hazards.

3. No use of personal protective equipment (Self contained breathing apparatus)

4. No ventilation or extraction system operating in the refrigeration hold during the operation

5. No written safe system of work eg confined space procedures

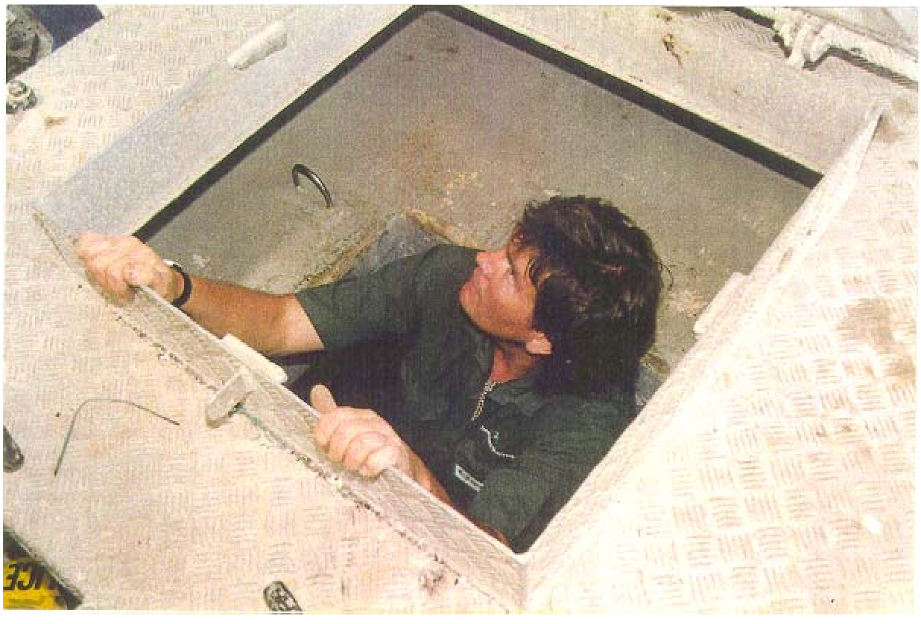
6. No supervision (nobody was on-site as it was on a public holiday after hours)

7. No formal training programmes in place for apprentices. Knowledge and advice was sought on a "ask questions" or "observe" basis.

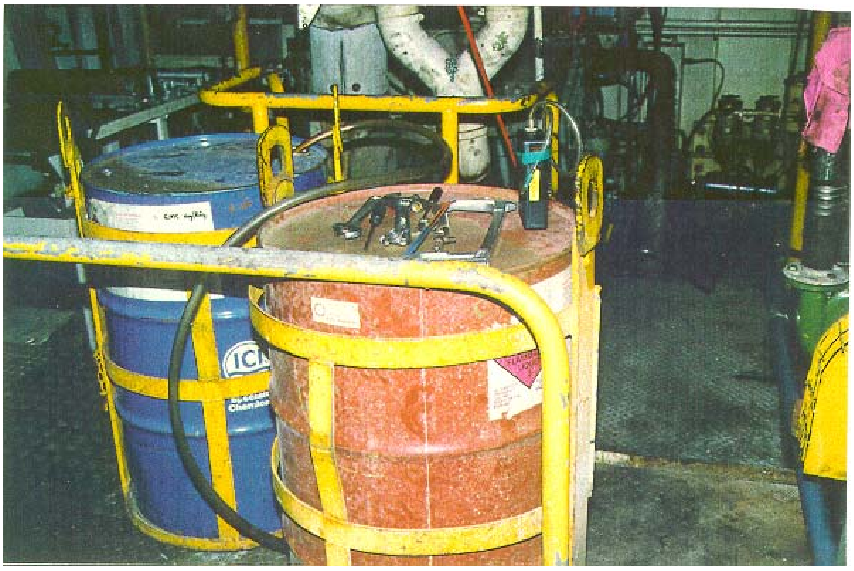
It is important to note that the responsibility for "on the job" training was that of the Services Managers responsibility whom was the father of the deceased (WorkSafe WA, 2006)

Note: Not mentioned in official report – The deceased was found by his father when he went to the workplace to see why his son had not returned home from work to attend a family function.

Position of the Ship at time of fatality



Access to refrigeration hold



Solvent drums located in engine room

Electric pump used to pump solvent

11th December 1995 - Ceiling Space

A 56 year old self employed electrician, working with his son who is also an electrician, was contracted to install the electrical supply and commission the evaporative air conditioning unit which had been installed on the roof of the premises. The deceased was specifically required to install electrical cables from the electrical meter box (switchboard) located on the front porch, through the roof space to the air conditioning unit and the control switch.

The deceased proceeded to drill holes in the wall plate (a timber joist supporting rafters) and in the wall at the switch location. The holes were drilled to accommodate the installation of electrical cabling for the air conditioning system. The household power was still turned on when the deceased then climbed into the ceiling space and crawled to position directly above the meter box. The space was very constricted due to the slanting roof and the deceased was required to lie on his stomach in order to reach the meter box. His son was feeding the plastic cables used to draw the cables through the wall cavity from the meter box to the ceiling space when he heard his father shout “shock” and mumble something.

The son called out to his father with no response. He then turned the main switch off and went up into the roof space to assist his father. The owner of the house heard the yelling and went to investigate. The owner went up into the roof space with the son of the deceased, rolled him on his back and performed cardiopulmonary resuscitation to no avail. Upon investigation a connection for a light was found near the deceased whereby the rubber insulation had become brittle and began to break away. It is unknown if the damage to the insulation occurred prior to the deceased undertaking work if it was damaged in the process of the rescue. At the time of the accident the electrical supply throughout the roof space was still connected (live). While he was in the roof space of the house he came into contact with an electrical connection for a light fitting and as a result he received an electric shock. It is unfortunately common practice throughout the industry for electrical workers to work in roof spaces while the electrical supply is still connected. This exposes these workers to electric shock if they come into contact with damaged wire insulation or connection points.

It was also discovered that the deceased was an A grade licensed electrical worker however; he was not licensed to conduct his own business as an electrical contractor. According to his son he had filled out the application form and was to file it on the following Monday. As of July 1st 1995, new arrangements apply to all applicants for an electrical contractor's license. This arrangement required the applicant to demonstrate competencies related to electrical safety and the business of electrical contracting. This is in addition to the applicants of an A Grade Electrical Workers License.

It was established that the deceased had a contract with the Contracting Company to install the electrical supply and the commissioning of the air conditioning systems. There was no formal contract only verbal. The investigation revealed it was not uncommon for the Contracting Company to issue verbal contracts. A more formal approach to the contractual agreement would allow the Contracting Company to ensure contractors have the following;

1. Necessary licenses and qualifications to conduct an electrical contracting business
2. Sufficient information for the contractors to perform their work in a safe manner
3. Contractors are made aware of any particular hazard associated with the work

It can be assumed that the deceased that would have been aware of the hazards associated with this type of work as he was licensed electrical worker and had performed his work on numerous occasions. This does not however, alleviate the Principle contractor's responsibility to provide contractors with sufficient information and instruction to undertake a safe system of work in order to perform work safely.

A statement from this particular investigation report that the researcher felt very important was as follows;

"Although there is ample evidence to support the conclusions above, they seem merely symptoms of an underlying problem within the industry. Contractors accept unreasonable risks and see there risks as part of the job"
This statement is true in many of the case studies in that majority are contractors, are not supervised with documented or implemented safe system of work. As a result many contracting tradesmen are victims of work related serious injuries (and in some cases fatal injuries). This is otherwise described within the workplace as "Contractor Mentality" or "Contractor Culture"

This mentality is not only a product of the contractors themselves but a product of numerous employers who utilise contractors with the expectation that experience persons need no supervision. It is ironic that many employers utilise contractors in order to minimise "financial risk" and expenses when in fact they may be increasing the risk by participating in such "business practices".

At the conclusion of the investigation report it was recommended that the Office of Energy and WorkSafe WA develop and implement an awareness campaign incorporating safe work procedures for the electrical contracting industry.

The Principal Contractors were to review their contractual agreements including the contract to be in writing, clearly setting out responsibilities of the contractor and their Company and the provision for a safe system of work. It was also recommended that an incident summary be prepared and distributed to the following industries; plumbing, air conditioning, electrical and insulation installers, outlining the facts surrounding this fatality (WorkSafe WA, 2006).

16th December 1996 – Silo

Two children aged 7 and 13 from a farming family in the wheat belt region of Western Australia accompanied their father to work in a field that was undergoing harvesting. When the father left hours later to obtain some fuel and oil and to make a quick phone call, the children were playing in a grain silo, and were instructed by their father to level the wheat with their hands as it flowed in by the auger from the dryer. When the 13 year old girl asked her father what to do if the silo got too full, she was assured that he would be back before that could happen. He also instructed the contractor working with him to keep an eye on the children however did not tell him what to do if the silo did overflow.

While the father was away, the silo began to overflow so the contractor climbed up the silo to help the children level the grain. When it was apparent that they could not prevent the grain from falling over the side, the contractor climbed down to start the auger that would extract the grain from the silo. The contractor told the children to watch out because he was about to start the motor. The contractor then started the motor which runs the auger, then walked back to the dryer to watch the grain and the burner flame. He heard the boy screaming but ignored it, because he knew that the boy tended to scream a lot.

After about five minutes the contractor noticed that the children weren't making any noises, so he went back to the silo just in case they had fallen off the top. He couldn't see the children so he climbed up the silo ladder, when he reached the top he saw the boys hand protruding above the grain. The contractor worked for five minutes trying to free the boy from the grain, when the father arrived. They both worked together to free the boy and then locate the girl. The seven year old boy was given mouth to mouth resuscitation and survived, the boys sister was suffocated by the grain.

The Coroner recommended that children should not be taken to workplaces where the hazards are high risk. WorkSafe Western Australia issues a media release prior to school holidays warning parents of the risks to children at workplaces not supervised. A Code of Practice titled "Safety and Health of Children and Young People in Workplaces was released in 1999 (WorkSafe WA, 2006)

> Note: The girl's foot was dragged into the auger, and only after dismantling the silo, was the deceased able to be excavated.

Bottom of silo

Portable wheat silo (note access ladder)

19th March 1998 – Winery

The system of work in a winery for white grape pressing consists of crushing the white grapes into a tank with a drainer at the bottom of the tank. While the process is being undertaken carbon dioxide gas was added to the tank via a plastic tube through the top of the tank to act as an anti oxidant, Carbon Dioxide is an inert gas used to displace oxygen thereby excluding air and assists in the control of the temperature. The juice was drained off to another tank. Remaining skins were then removed from the base of the tank through a door and into a press for further juice extraction.

A young man was working with another work colleague crushing white grapes into a 4500 litre vat. The deceased asked his work colleague if he should go through the top of the tank. The work colleague was removing the grape skins at the opening at the bottom of the vat and replied "no that he would not fit as the opening is too small". Unbeknown to the work colleague the deceased entered through the top aperture measuring 380mm, once inside the effects of oxygen starvation did occur, these effects are, headache, difficulty in breathing, ringing in the ears, loss of muscle control and a feeling of euphoria. Because the person is in a euphoric state, they have no appreciation of the danger before death occurs.

Death did occur and a rescue was initiated. The bottom door was blocked with compressed matter, a chef from the winery restaurant climbed through the top aperture because he was the smallest in stature. The chef was given a plastic hose without attachments for respiration, which had been attached to an oxygen bottle.

Note how there was the potential for a second fatality. This was alleviated by other rescuers making a hole in the compressed matter which enabled the carbon dioxide gas, which is heavier than air, to drain out. *MacCarron* (1998)

On investigation it was found that there had been no training provided to any of the employees on confined spaces (or other). Training at this particular winery is by employment of experienced personnel in a "watch and learn as you go" style. There were no documented procedures or systems of work whatsoever including procedures that helps to explain who undertakes what task eg who gas' the tanks, who turns off the gas or how everyone involved in the process will know that each task has been done.

Two employees who were working with the deceased both stated that they had not gassed the tanks (with CO_2 as it was assumed the deceased was responsible for this particular task. On investigation the gas hose was found inside the tank still pumping CO_2 at an approximate rate of 10 litres per minute. There was the possibility of the gas escaping out of the tank once full and lying at lower levels of the winery. This was potentially dangerous as there were no exhausts systems in place. The process of gassing tanks in the winery is communicated to new employees verbally or by watching the process, a procedure that is considered totally inadequate and very unsafe. Although Supervision was evident it was in this case inadequate.

Recommendations were issued to the winery that include;

- Developing and implementing procedures and systems of work to include training and provision of satisfactory equipment for oxygen measurement and personnel rescue.
- A significant incident summary of this accident be prepared and distributed to all areas of industry that work in confined space, with the intent to prevent a similar recurrence.
- The WorkSafe WA inspectorate to ensure compliance with the regulations targeting the winemaking industry
- The wine industry to develop and implement a code of practice to ensure that there is a greater awareness and following training, a greater understanding of hazards, risks and the management of these hazards and risks
- Australian Standard 2865- 1995 “Safe Working in a Confined Space” must be complied with (WorkSafe WA, 2006)

380mm Access to Tank

Tank view from above

Bottom access to tank – crushed grapes in tray, demonstrating that work can be done without access from the top hatch

18th May 1998 – Power Generation Plant

A 49 year old Engineer was inspecting expansion joint modifications in the area of the twin counter follow regenerative air heater on the 27m level when he stepped over a guardrail and fell approximately 10 metres onto an air hood. Two colleagues were working in the same area as the deceased welding modifications made to the outlet duct. One of the workers was acting as the spotter in the event of something going wrong in the confined space area in which the welder was working. It was only when two workers had completed their tasks and was ready to leave the area that they discovered the victim was missing. A brief search revealed he was lying on the air hood at the 17m level. A rescue was initiated but the injuries proved fatal.

In the events leading up to the accident the victim signed off a confined space entry permit. He then travelled to the 31 metre level asking one of the workers welding in the area if he could see the weld. He then walked away and it appears that he entered the 27 level, climbing over a guardrail to the open edge of the air hood before coming into contact with a probe. It is possible that he walked into the probe which knocked him from him off balance (judging by bruising on shoulder). This caused him to fall over the open edge striking a beam on the way down and landing face down at the top of the air hood. The steep angle of the air hood caused the victim to slide all the way down to the outer limit of the hood.

On investigation it was determined that the system of work was well documented and each employee was made well aware of the process. The company had erected a guard rail to prevent persons falling at the open edge. Additionally they provided adequate personal protective equipment, inductions, utilised safety representatives, provided safety manuals and employed full time safety personnel. Whilst it was stated that the deceased was known for his strict adherence to site safety rules they were not followed in this case. The deceased had obtained a confined space permit and was wearing his PPE but had purposely climbed over the guard rail and did not use fall arrest equipment that was readily available on the site. Without this fall arrest equipment the deceased should not have proceeded past the permanent rail (WorkSafe WA, 2006)

(Note: The reason the engineer climbed over the guardrail was to inspect an area that was likely to be unavailable once the heater started for anywhere up to five years)

Scrape marks made where the victim slipped

Confined Space Access

Case Study 13 – Fishing Vessel 3rd March 2001

A welder was working onboard fishing vessel welding transducer housings in the forward lower cofferdam. He had changed a welding rod when he was electrocuted
Rescue efforts were to no avail and officers were alerted that the welder had died.
On investigation it was determined that whilst the deceased was replacing the welding electrode in the hand piece, the wet glove (from sweat) on his left hand came into contact with the iron core of the welding electrode where the insulating flux coating was missing and he received an electric shock of approximately 72 volts ac. The current flow would have then possibly passed from his left hand to his neck region (or other parts of his body in contact with the metallic vessel via the saturated clothing (from sweat).

It appears that the victim may have collapsed and his chest came into contact with the steel pipe he was installing. This would have then offered another return path for the flow of electric current from his chest and neck area. When obtaining a confined space permit an assessment was made by the lead fitter that emergency isolation equipment was not necessary as it was jut another dry, clean space. The confined space permit should not have been issued or signed off by the permit controller. It was also uncovered that the deceased had been working in the confined space for a period of 3 hours with no fluids during that time. The heat contributed to his mental alertness and the saturated clothing that acted as a path for the circuit.

The deceased had been inducted and trained in confined spaces 3 months earlier. The lead fitter had identified the confined space, conducted a gas test and obtained a permit. All personnel had adequate personal protective equipment including welding helmet, coveralls and safety boots as well as acceptable lighting and ventilation, however no consideration was given to the use of insulating mats to insulate the welder from the surrounding metal surface. There was a procedure for working in heat or humid conditions stressing the importance of fluid intake and regular breaks. This was not adhered to in the case of the deceased.

Although the company had a well documented system it appears it was not being followed at all times.

Where there appears to be a deficiency is the decision to forego emergency isolation equipment when filling out the confined space permit. Although there was a spotter, supervision (including the lead fitter) was inadequate.

It was recommended that where welding is required to be undertaken in a confined space, the risk of electric shock is greatly increased due to the all round presence of metalwork, Health and Safety in Welding Technical Note 7 now a Code of Practice must be considered.
In confined spaces the following precautions should be taken;

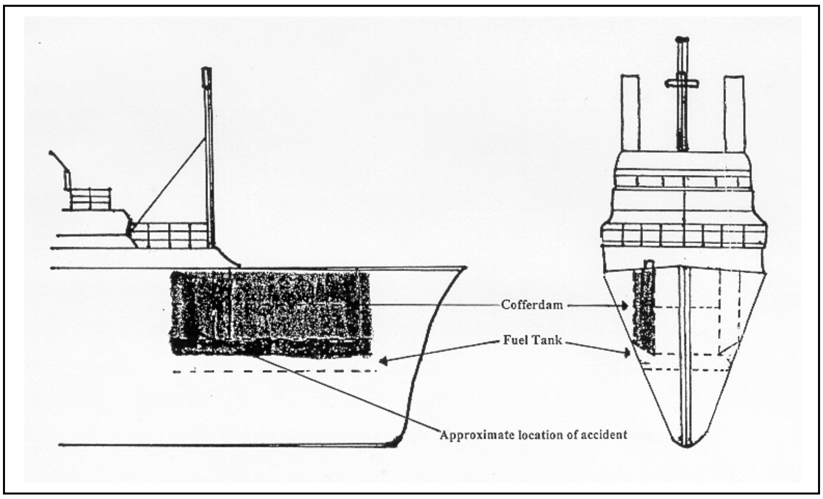
- Power sources should be left outside the confined space and should preferably be dc
- Means for cutting off power to the welding unit should be installed and readily accessible to the spotter
- The welder must be constantly observed by an assistant positioned outside the confined space
- The electrode holder should be isolated from the current supply before a used electrode is removed and before a new electrode is inserted
- The welder must avoid physical contact with surrounding metalwork whilst welding, dry insulating material may be used
- Voltage Reduction Devices (VRD's) are highly recommended for all welding situations, as a supplement to other safety measures.

Greater emphasis is to be placed on the adverse effects of heat stress, training of supervisors and employees in hazards associated with confined space and heat stress.

Strategies should also be developed in hot and humid conditions to decrease temperature, reduce humidity, increase air velocity, reduce workload, provision of suitable clothing, provision of shields against radiant heat, acclimatisation of workers, provision of adequate fluid replacement to prevent dehydration and a protocol to ensure workers do not spend more than a stated time in hostile environment
(WorkSafe WA, 2006)

A confined space may be defined as that, by design, has limited openings for entry and exit, and unfavourable natural ventilation that could contain or produce dangerous air contaminants, and is not intended for continuous employee occupancy. Confined spaces include, but are not limited to, storage tanks, compartments of ships, process vessels, pits, silos, vats, degreasers, reaction vessels, boilers, ventilation and exhaust ducts, sewers, tunnels, underground utility vaults and pipelines *NIOSH*, (1994).

Approximate locaton of accident



Entrance hatch to cofferdam

Cofferdam deck manhole – close up

Cofferdam deck - aerial

Ceiling Space – 12th November 2002

A 27 year electrical fitter was working the ceiling space of a shopping centre tracing a fault to an external floodlight when he was electrocuted. A period of three hours had passed before he was discovered in the area where no permit had been granted for him to work in on the day of the 12th November. On investigation it appeared that clear lines of communication between contractors, tenants and the centre management group failed and centre management was unaware of the deceased's work plans on the day of the fatality. It was also discovered that accessing the ceiling without obtaining approval was normal practice at this particular shopping centre. There were no safe systems of work developed, communicated and implemented by the contracting company nor was any supervision provided by the electrical contracting company or the shopping centre management. It was specifically mentioned that there was no system whereby contractors were to report commencement and completion of maintenance and repairs to centre management.

Recommendation were made to all company's involved in the fatality to as quoted "release a safety alert and or media release to the community that ceiling spaces do have hazards and persons entering such spaces need to be aware of maintaining some form of communication with others and vice versa" WorkSafe, 2002.
It was also recommended that a system of reporting commencement and completion of work within the shopping complex to centre management (WorkSafe, 2002)

It should be noted that although this accident occurred within the last 5 years the investigation report was a total of 2 pages with little information on events leading up to the fatality and immediate and underlying causal factors (WorkSafe WA, 2006)

Another reason for the 2 page report is the lack of suitably trained investigators since the disbandment of the Fatalities and Special Investigations branch in 2000.

20th January 2004 – Residential Ceiling Space

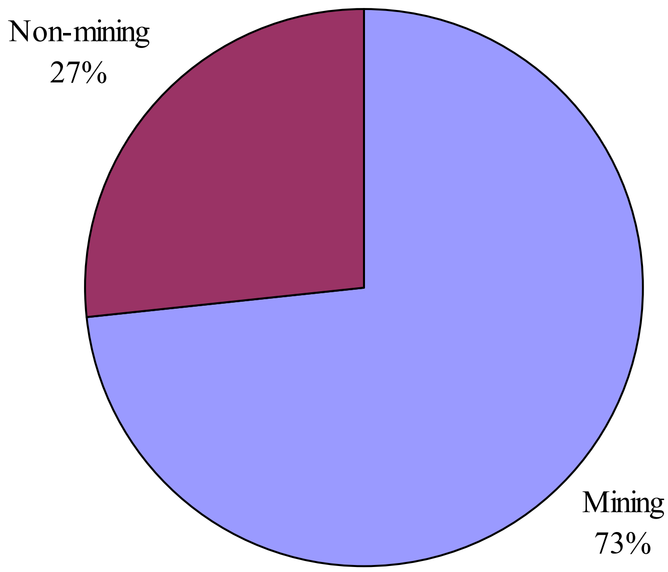
A 48 year old self employed electrician attended a private residence to repair a fault in an air-conditioner on the morning of the 20th. The owner of the household had used this contractor on numerous occasions for installation of lighting. As a result she left immediately after meeting with the deceased to run some errands. The victim entered the ceiling space to determine the cause of the fault when he made contact with an exposed wire from the air conditioner creating a circuit. The owner's husband returned from work approximately 4 hours later and thought the electrician was still working on the air-conditioner.

It was only when the wife returned home 30 mins later that they became worried at the lack of noise from the ceiling. After calling out to the contractor the husband entered the ceiling space crawling to the area directly above the air conditioner. The husband attempted CPR to no avail. The power to the household was live which could have resulted in another fatality if the husband had made contact with the exposed wire when resuscitating the deceased. It was noted that a very similar fatality occurred in 1995 (WorkSafe WA, 2006)

As the electrician was self employed there was no documented evidence of safe work practices nor was there any form of supervision. The victim was a qualified electrician with an "A" Class Electrical Contractors license permitting him to perform contract work. The deceased had performed tasks similar to this for a period of 20 or more years.

The following results and discussion were obtained by conducting a study of all Western Australian confined space fatalities that occurred during the period of 1980 to 2004. Confined space fatality incidence rates should be interpreted with caution, due to the small population sample.

Figure 11 Confined Space Fatality by Jurisdiction



The OSHA, MSHA and NIOSH reports include confined space fatalities within the mining sector. Confined space fatalities taking place within the mining industry have not been included in the Western Australian case study analysis as they are governed by a separate jurisdiction.

The researcher has included the ratio of mining to non-mining confined space fatalities within Western Australia to highlight the extent of confined space fatalities within the mining industry. It is very clear in the graph above that there is a high incidence of confined space fatalities within the mining sector.

There were a total of 41(73%) confined space fatalities within the mining sector. These were all underground mining fatalities with over 50% related to the victims being struck by objects (predominantly rock or iron ore). 48% of the mining victims were tradespersons predominantly operators and electricians. Because they are governed under the Mines Safety and Inspection Act WA 1996 they are not classified as confined space fatalities. This is based on a minor technicality in that within the mining sector the mining an underground mine (with limited access and egress, and ventilation) is considered a normal place of work. The exclusion of confined space mining fatalities disguises the magnitude of the problem.

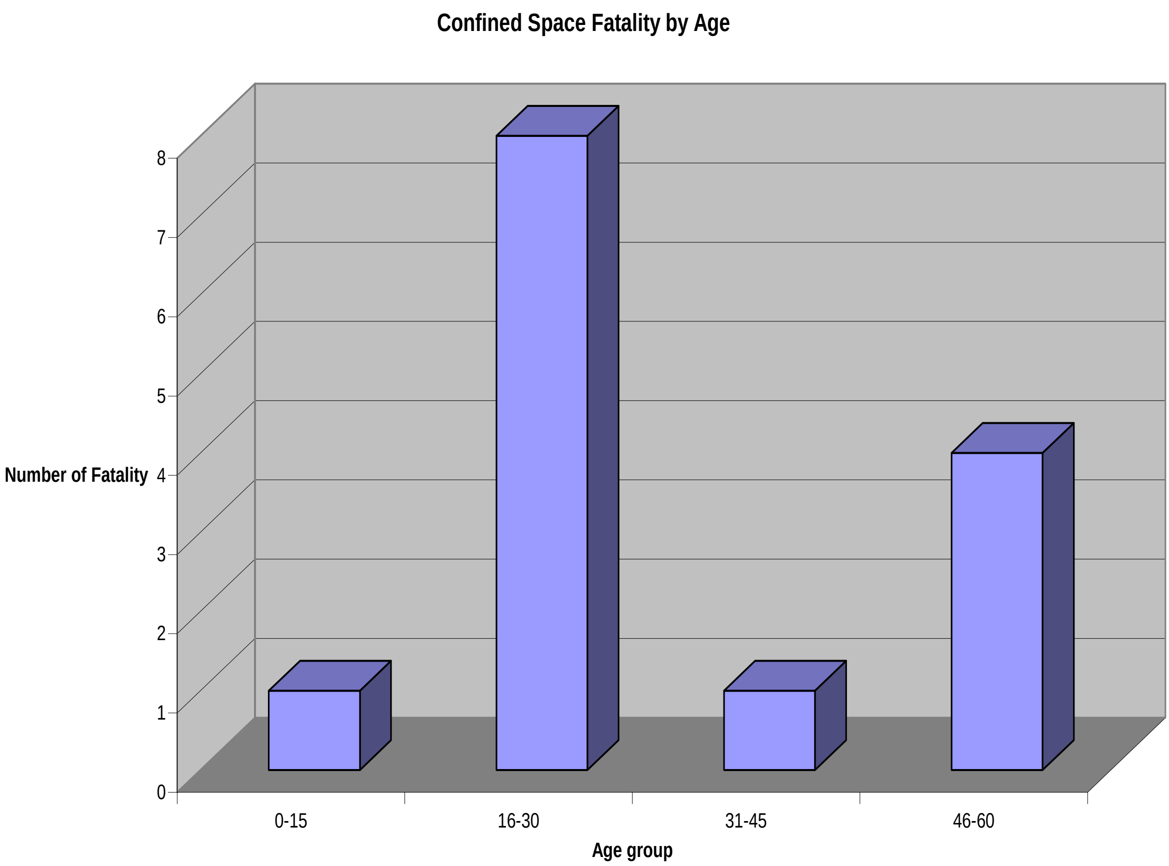
15 (26%) out of the 56 confined space fatalities that occurred within the period of 1980-2004 were related to non mining industries.

These results differ from those of the McManus' (1999) study. According to McManus there were *"more confined space fatalities within the mining sector"* (McManus,1999, p284) It should be noted that the OSHA reports utilized by McManus excluded non-hazardous confined space fatalities (even within the mining industry). Majority of the WA mining fatalities that occurred in what would be considered a confined space were of a non-hazardous nature.

Confined Space Fatality by Year (1980-2004)

A large portion of the confined space fatalities occurred in 1982 and 1998. There was a decline after 1982 with a fairly steady number of fatalities until 1998. It is difficult to determine a true pattern with the limited number of fatalities investigated. It should be noted that there seems to be consistency amongst the figures which indicates little improvement.

Figure 12 Confined Space Fatality by Age



A significant finding within the study was the proportion of victim's ages between 16 to 30 years old. A large proportion of this victims were apprentices, trainees that had been provided with little training, supervision or guidance from their employers.

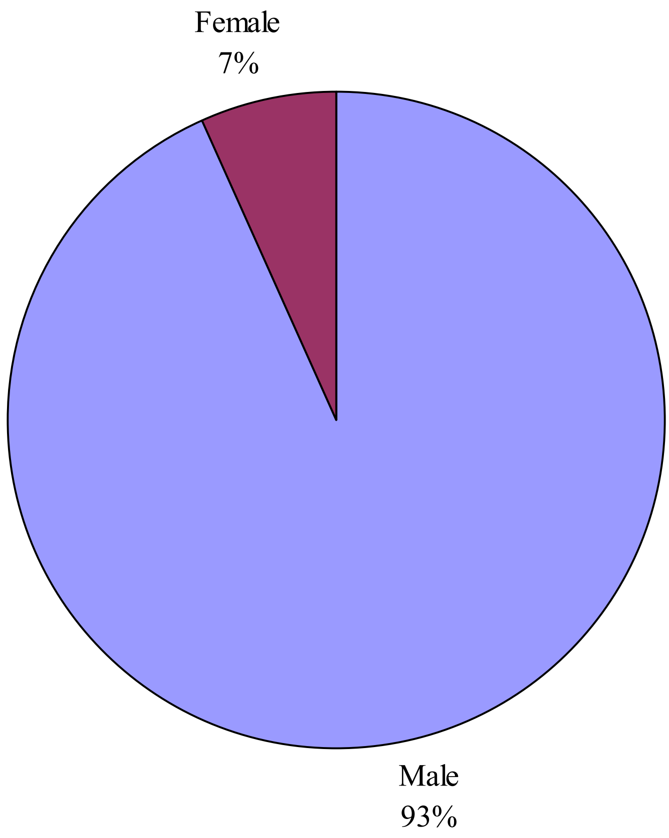
For example; on 23rd January an apprentice electrician was electrocuted when attending to faulty lighting in hotel. His supervisor had left him to perform the task and attended another job. When the supervisor returned he discovered the deceased. On the 24th April 1995 a 23 year old electrician whom had recently finished his apprenticeship was again electrocuted in a ceiling space of a residential house when installing an air conditioner. On the 5th January 1988 an apprentice electrician was electrocuted in a ceiling space of a shopping centre when coming into contact with the exposed wires on a faulty electrical roller door.

There seems to be a trend in these cases involving apprentice electricians. In all cases there was no training, supervision, procedures and very little instruction on behalf of the supervisors. On the 3rd January 1993 a 19 year old apprentice refrigeration mechanic died when purging a refrigeration system. The hose developed a leak and the victim was overcome with fumes. On the 19th of March 1998 a trainee winemaker entered a fermented wine vat to clean out the skins and asphyxiated with the lack of oxygen (increased CO2). Little information, instruction, training or supervision was provided in these cases.

The increased prevalence of young inexperienced fatalities is correlated with the decrease in guidance, training, supervision and generally a documented safe system of work.

In addition to this, the findings resemble the Western Australian work related fatality statistics whereby 33% of victims were aged between 25 and 34 years of age.

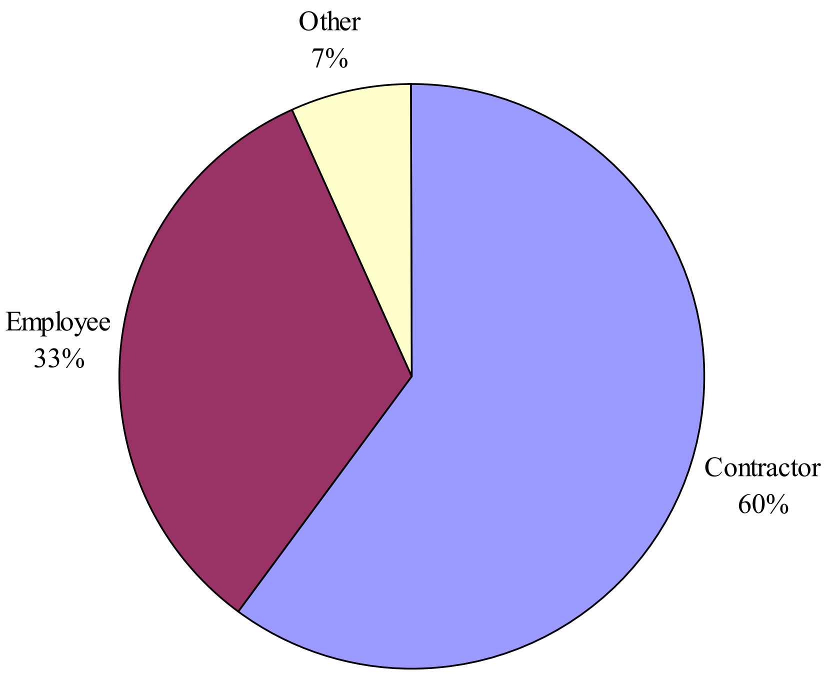
Figure 13 Confined Space Fatality by Gender



Consistent with male dominated industries and occupations (trades and labour) identified in the Western Australian research study is the very high proportion of male victims. Ninety Three percent (14) of the victims were male with only one individual remaining who was the daughter of a farmer and not classified as an employee within this study.

Further study needs to be conducted. The study could perhaps investigate the psychosocial aspects of gender on fatalities in the workplace. For example it may be the case that males are more inclined to take risks due to social pressure (influence) which could result in a higher incidence of male work related fatality rates.

Figure 14 Confined Space Fatality by Employment Status



According to the study 60% (9) of the confined space fatality victims were contractors, 33 % (5) were employees and 1 fatality involved the daughter of a farmer. Many of fatalities involving contractors were a result of poor management and implementation of safety systems to all personnel (including contractors) on behalf of the principal employer.

As a result of this safe systems of work that include reporting authorities, and supervisory and employee responsibilities were not documented or implemented. An example of this was in the case involving a 27 year electrical fitter who was working in the ceiling space of a shopping centre tracing a fault to an external floodlight when he was electrocuted. On investigation it appeared that clear lines of communication between contractors, tenants and the centre management group failed and centre management was unaware of the deceased's work plans on the day of the fatality. In addition to this the absence of contractors "checking in and out" was normal practice.

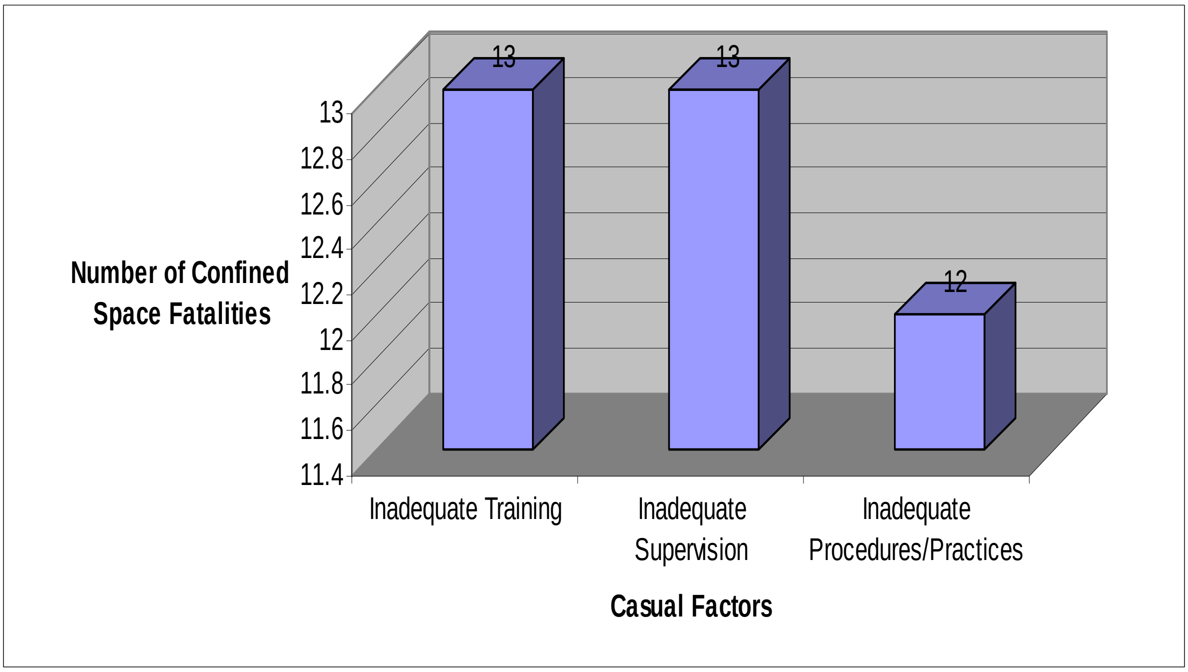
No safe systems of work were developed, communicated and implemented by the contracting company nor was any supervision provided by the electrical contracting company or the shopping centre management.

A similar fatality that underpins the “contracting culture” is the fatal accident involving an apprentice refrigeration mechanic. A 19-year-old Apprentice Refrigeration Mechanic was cleaning out a refrigeration system on a fishing vessel when leaks developed in the system. The apprentice went to investigate the leak in the refrigeration hold when he was overcome with toxic solvent fumes and died.

The deceased was employed under the contracting company to clean out the refrigeration system. What is interesting in this study is that the apprentice was working on a public holiday in order to finish the task in the timeframe requested by the client. Not only was he working under the pressure of a timeframe but he was working unsupervised, alone out of hours. There were no safe systems of work documented or implemented on behalf of the client or the contracting company nor was any training provided by all involved.

These factors reinforce the mentality of contractors in accepting unreasonable risks and seeing it as part of their job. This mentality may be a product of the client companies involved who perhaps in the quest for financial gain have overlooked safety precautions.

Figure 15 Confined Space Fatality by Contributory Factors



Of the 15 case studies two of them gave no mention to causal factors. These case studies occurred on the 5th January 1988 in a ceiling space and 13th November 1986 in a motor cabin of a ship. The two case studies were therefore excluded from this research analysis.

It was alarming that 92% (12) of fatalities were attributed to inadequate supervision. Inadequate training was calculated under three categories:

1. Was the training provided?
2. Was the training attended?
3. Was the training adhered to?

Two of the victims were provided training and attended this training but failed to adhere to the principles on the day of the fatality. One of the victims was an Engineer working in a Power Generation Plant. He was in the process of inspecting the welds at the opening of an air heater when it appears he slipped falling 15metres. The victim sustained fatal heads injuries dying on impact. Upon investigation it became clear that the company had taken every means possible to prevent injuries to their employees.

This included a thorough and comprehensive safety management system of procedures, practices, training and supervision. The deceased had attended all training required (in this case a safety induction) which highlighted the dangers of working at heights and subsequent safety measures to be taken. The deceased did not follow advice provided when he stepped over a guard rail to gain access to the air heater without a fall arrest harness attached.

In another case the deceased was welding in the cofferdam of a fishing vessel when he came into contact with the exposed electrode. The company in question had documented safe work practices including supervision, training and instruction. Furthermore the deceased had attended the induction three weeks earlier that detailed the dangers of welding and cutting and the process of the permit to work system. System failure was evident in the following;

1. The lead fitter did not fully complete his confined space and hot work permit by getting it signed off
2. The lead fitter made the decision that an isolation device (deadman) was not needed even though it was stated on the permit that a device was required
3. The welder failed to take regular fluid breaks above deck as per the Heat Stress procedure
4. The welder was changing the weld electrode with the current supply still on.

The Failure to follow safe work systems of work provided by the employer is part of their duty of care and in failing to adhere to the practices referred to above they failed to fulfill their duty of care.

Another disturbing finding is the 92% (12) of fatal accidents attributed to inadequate supervision. The criteria for inadequate supervision were;

1. Was a supervisor present?
2. Did the supervisor provide guidance and instruction
3. Was this instruction followed?

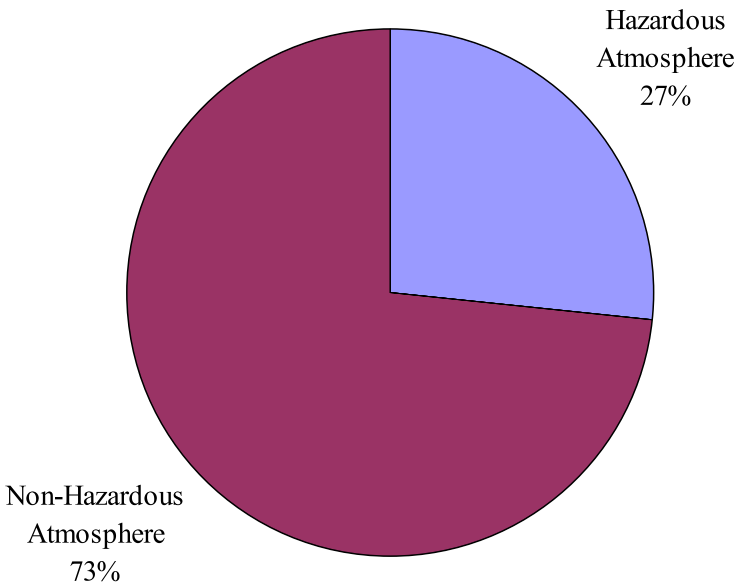
In 92% (12) of the fatal accidents supervisors were not present. A mere 15% (2) received instructions from their supervisor.

Only 15% of the companies involved in the fatality had adequate procedures in place. The adequacy of procedures was measured on the following criteria;

1. Were procedures developed/documented?
2. Was training/instruction provided on these procedures?
3. Were the procedures or safe work practices adhered to?

Fifteen percent of the companies of the deceased had documented safe work practices that had been trained and effectively communicated. In both cases the victims did not adhere to the procedures which contributed to the fatality. These cases are referred to above.

Figure 16 Confined Space Fatality by Atmosphere



Confined space fatalities were separated initially into hazardous atmosphere and non hazardous atmospheres. 73% (11) of the confined space fatalities occurred in a Non-Hazardous Atmosphere with the remaining 27% (4) of fatalities taking place in Hazardous Atmospheres.

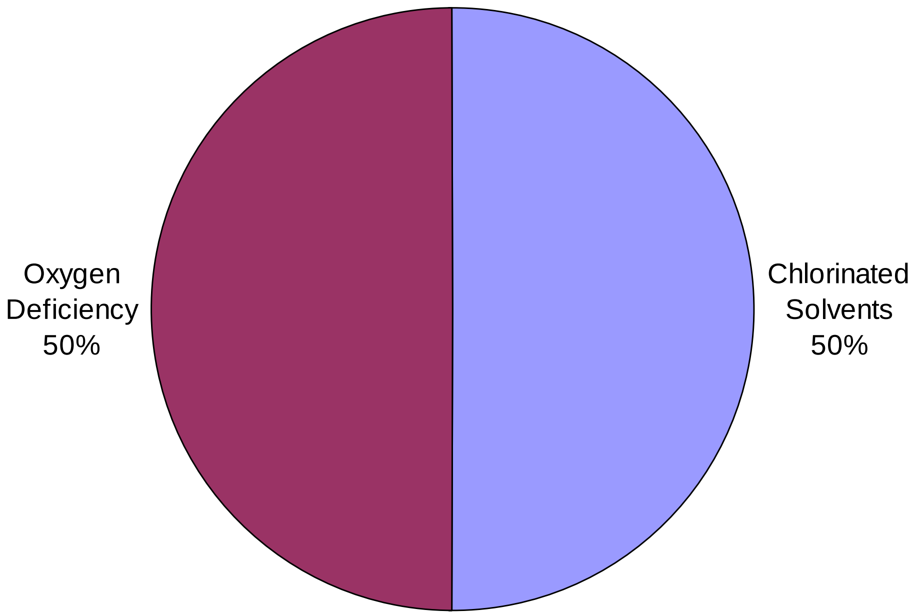
Hazardous atmospheres include;

- Toxic atmospheres – hydrogen sulphide, carbon monoxide, methane, inert gases, chlorinated solvent vapours and fuel vapours.
- Asphyxiating atmospheres – Oxygen deficiency, nitrogen gas displacement, fuel gas displacement and welding gases.
- Fire/Explosion – Organic solvent vapours, fuel vapours, welding gases and natural gas.
- Welding/Cutting – Organic solvent vapours, fuel vapours, welding gases and natural gas.

Non Hazardous atmospheres include;

- Engulfment, entanglement, falling objects, process hazard, electrical, unstable interior (trench collapse) and falls from height.

Figure 17 Confined Space Fatality – Hazardous Atmosphere



73% of fatalities occurred in Non-Hazardous Atmospheres. Over three quarters (8) of the fatalities occurring in non-hazardous atmospheres involved electrocution.

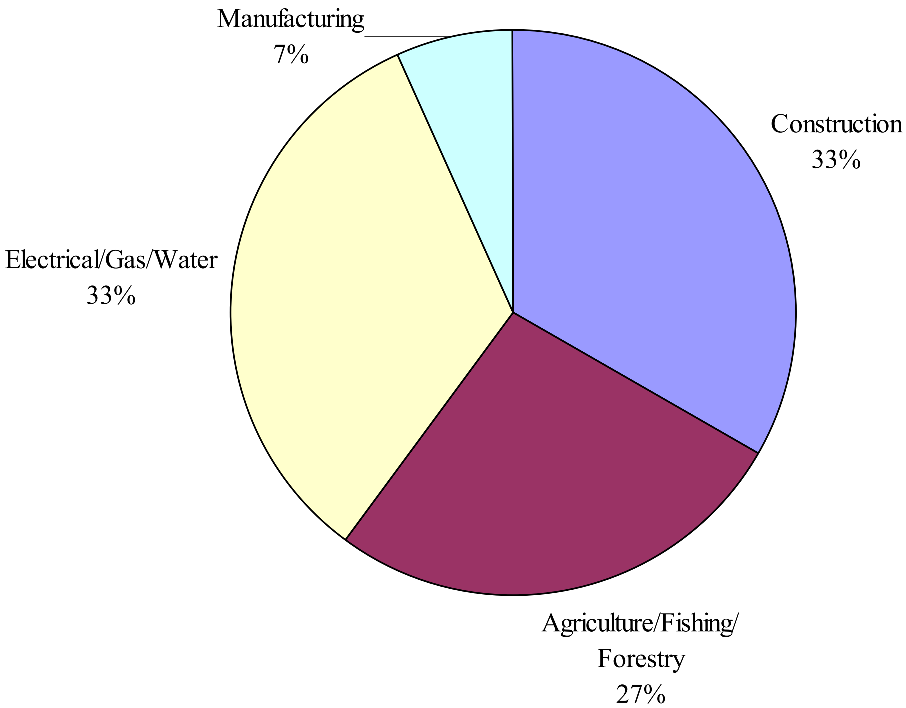
Of the 27% of fatalities taking place in a Hazardous Atmosphere (2) involved the victim being overcome by chlorinated solvent vapours and (2) were attributed to oxygen deficient atmospheres.

The USA studies differ somewhat in this area as majority of the confined space fatal accident occurred in non-hazardous atmospheres unlike that of the NIOSH study where 55% (373) of the incidents occurred in hazardous atmospheres. The OSHA study did not include non-hazardous atmospheres.

The NIOSH study does give mention to oxygen deficiency as a main causal factor of hazardous atmospheric fatalities but there are a great deal more factors referred to in this study. In addition to this the NIOSH data does not give reference to solvents as a main cause. The limited sample population within the Western Australian research may be responsible for the lack of information regarding hazardous atmospheres.

The NIOSH data concerning non-hazardous atmospheres was very different to the Western Australian findings. It was extremely difficult to make comparison in this case due to the difference in classification of hazardous/non-hazardous conditions.

Figure 18 Confined Space by Industry



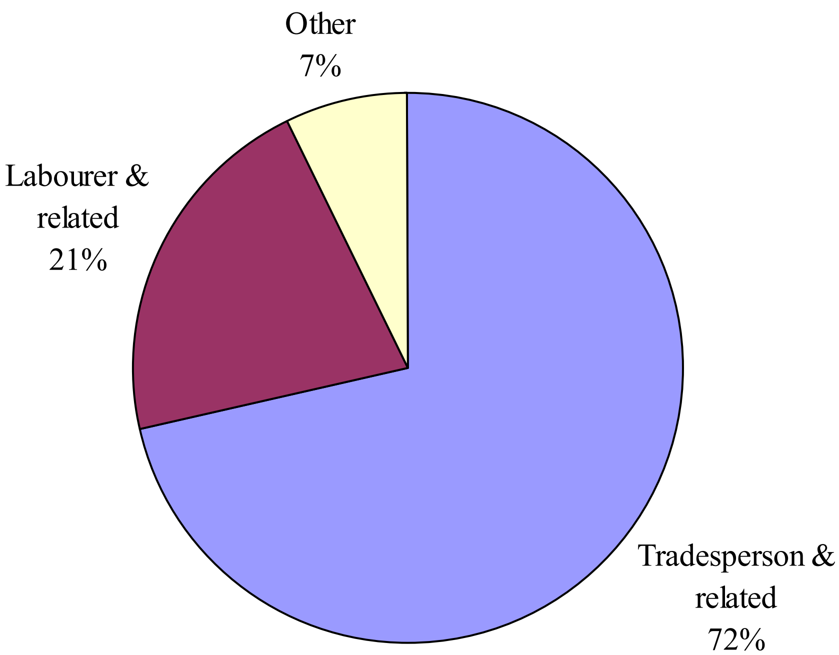
Of the 26% (15) of non mining confined space fatalities identified for the Western Australian research 33% (5) were from the electrical industry, 33% (5) were from the construction industry and 26% (4) within the agricultural industry. One of the fatalities was classified as manufacturing.

It is difficult to make a comparison between the USA studies and the Western Australian studies as the standards for industry classification are different. Western Australia uses the ANZSIC

classification guidelines (used in this study) whereas the USA uses the North America (USA, Canada and Mexico) Industry Classification. (Although very similar to that of the ANZSIC standard there is no classification that pertains specifically to Electrical/Gas/Water. The Western Australian case studies would be classified under construction if using this guideline (Refer to ANZSIC Standard in literature review).

The Western Australian research findings are similar to the NIOSH data in that the main industries for confined space fatalities are Manufacturing, Agriculture & Construction. Western Australian data also includes the Electrical, Gas & Water industries.

Figure 19 Confined Space Fatality by Profession



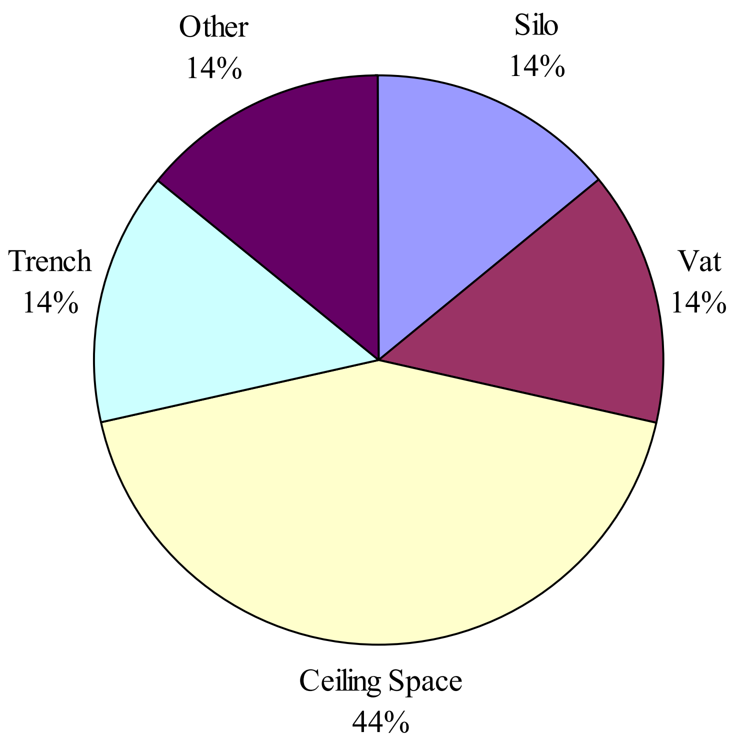
Occupation codes are assigned according to the Australian Standard Classification of Occupations, (ASCO) provided by the Australian Bureau of Statistics.

66% (10) of the victims were tradespersons, primarily Electricians (33%, 5), Plumbers (13%, 2), Fitter, Welder, Refrigeration Mechanic, and Furniture Upholsterer (6%, 1). Twenty percent (3) of the victims were laborers' and one of the victims was the daughter of a farmer. The high proportion of tradesmen and laborers' are consistent with the male dominated professions identified within the Western Australian research.

The data obtained from the OSHA 1982 and 1985 reports also associate trades and labour as common professions for confined space fatalities. Majority of the victims were involved in labour in the OSHA studies whereas majority of the victims of the Western Australian research were involved in trades.

The NIOSH studies did not include the occupation of the victims in their 1998 study.

Figure 20 Confined Space Fatality by Location



Consistent with the high proportion of Electricians involved with confined space fatality is the large proportion 40% (6) of confined spaces occurring in a ceiling space. Thirteen percent of the fatalities were located in silos, vats, and trenches. A shipyard and a motor launch cabin accounted for the two locations classified as “other”. It is interesting that ceiling spaces were not considered a “confined space” until 2001 where a review of the standard resulted in inclusion. If this review was not conducted almost 50% of the confined space fatalities would be excluded disguising the extent of the hazard. It is also interesting that Western Australia is the only state within the country that does not have a representative on the Australian Standards review panel. The purpose of the representative’s is to provide advice to Standards Australia on required on behalf of the state.

The data analysed in the NIOSH study is similar to the Western Australian results. The most common locations in this study were sewers, pits, silos, vats, wells, bins, pipes and kilns. It is interesting that the NIOSH study did not include ceiling space as a common location even though non-hazardous environments were considered.

The main locations were associated with processing plants, tanks & vessels, wastewater treatment and trenches.

The OSHA studies did not include non-hazardous atmospheres in their study and it is therefore difficult to make a valid comparison.

6.0 RECOMMENDATIONS

In view of the research it appears that confined space fatalities within Western Australia are on the downward trend however, the dangers of a confined space cannot be underestimated given that the average emergency response time in a confined space is 7 minutes. Yet in an oxygen deficient atmosphere more than four minutes changes rescue into body recovery.

Confined work spaces and structures that confine hazardous atmospheres are deceptively innocuous. The hazardous condition is unlikely to provide warning to the senses. Persons entered these spaces apparently without concern for potential dangers. A minor error or oversight in preparation of the space, selection or maintenance of equipment, or work activity can produce catastrophic consequences. These consequences appear to be considerably more severe than what occurs in accident situations involving normal work places.

It should be noted that an investigation unit of WorkSafe Fatalities and Special Investigation Branch, which was responsible for the effective investigation into work related fatalities disbanded in the year 2000. The unit function was to increase awareness of work related fatalities (amongst others) and has not since been reformed. If the unit was reformed it is anticipated that there would be an improvement not only with the methods of investigation but of the research and preventative strategies of all work related fatalities.

The following recommendations focus on the top level preventative strategies down to the lower level strategies involving the principles of information, instruction, supervision and training.

6.1 Legislation/Standards/Guidelines

Both the ANZSIC and North American classification of industry guideline do not provide a category for confined space fatal accidents within the standard which makes it impossible to identify confined space fatalities. The only way to identify these fatalities is to research individual fatal accident investigation which becomes very time consuming and future studies to increase awareness. If the guideline included a category for confined space fatal accidents amongst other hazardous conditions (e.g. working at heights) data would be extracted with ease. The category can be a third tier sub category under the sub industry, for example a confined space accident in a grain silo on a farm would be classified as:

AGRICULTURE/FORESTRY/FISHING

⇓

AGRICULTURE (sub category)

⇓

CONFINED SPACE (hazard category)

The work related fatality databases around the world would then follow suit and the flow of information regarding these fatalities will begin. The quality of the information would of course need to be of a high standard which was not the case within the studies mentioned throughout this research study. A sub-category is the first step of a series of steps that need to be taken in order to increase awareness of confined space fatal accidents in aim of preventing recurrence. Another example would be the 16 year old apprentice Electrician whom was electrocuted in the ceiling space of a metropolitan hotel when attending to some faulty wiring. This case would be classified as ;

ELECTRICAL, GAS, WATER

⇓

ELECTRICAL (sub category)

⇓

CONFINED SPACE (hazard category)

The strategy required to prevent confined space fatalities from recurring is the need for a unified standard applicable to all industries and jurisdictions throughout the world.

As previously mentioned there are no specific USA standards that apply to all jurisdictions. Currently confined space regulations are specific to the jurisdiction, industry and task being performed. For example the Confined Space regulation for general industry (1910.146) does not apply to agriculture (1928), construction (1926) or to shipyard employment (1915).

The lack of uniformity in legislation and regulations can not only confuse the average worker/employer making it difficult for adherence, but more importantly creates limitations for study comparisons throughout the world. The definitions of confined space in the USA legislation differ from that of the Australian legislation. Confined space mining fatalities are under the same jurisdiction as non-mining and are therefore reported together. For example in the OSHA NIOSH studies underground mining fatalities were selected for the study (increasing the sample size of the study). If underground mining fatalities were included in the Western Australian study the population size would increase from 15 to 56! Statistics in the USA are therefore higher than that of Western Australia whom does not include mining fatalities within the same jurisdiction. The statistics are therefore not comparing "apples with apples" and can mislead the reader.

Differing legislation also results in differing terminology for adherence. For example, NIOSH conducted the first confined space fatality analysis in 1978 when the definition of a confined space (in the USA) was
Defined as:

- Limited openings for entry and exit by design
- Unfavourable natural ventilation that could contain or produce dangerous air contaminants
- Not intended for continuous employer occupancy

The definition of confined space during the OSHA Reports (1982-1990) was

- An enclosed or partially enclosed workspace
- Limited means of entry and exit
- Subject to accumulation of toxic and flammable contaminants
- May develop an oxygen deficiency
- Not intended for continuous employee occupancy

These definitions limit the focus of concern exclusively to atmospheric hazards restricting this research assignment and more importantly disguising the true extent of this hazard in the workplace.

It is to be noted that Standards Australia have recently conducted a review of the AS/NZS 2865, Confined Spaces, 2001 with the intention to change;

- Terminology for consistency
- Hazards created by different work groups in a confined space
- Application to a variety of industries
- Definition of airborne contaminants
- Testing for “LEL” in combustible atmospheres
- Training and competencies in conjunction with National Training standards
- Intrinsically safe equipment in flammable atmospheres

The existing standard is extremely difficult and complex for the average worker to follow because it was written by engineers, bureaucrats and the legal profession. It is expected that the revised comprehensive standard will be released in January 2007.

Highly prescriptive standards emphasize defining rules and look for infractions rather than creating workable solutions to improve. Such a black-or-white approach suggests that people need not make independent or interdependent decisions. It also causes employees to think, "Just know and follow the rules, and I'll be safe." This creates a dependent, mindless perspective about incident prevention and can be detrimental to an individual's safety and health (Geller, 2001).

Swedish work environment law requires employers to take responsibility for safety, but does not attempt to regulate every detail. And, although Sweden has many labor unions, the safety culture is more collaborative and cooperative than that in the U.S.A.

Sweden has a population near 9 million, with many people working in heavy industry and mining; yet, less than 100 occupational fatalities occurred in all of Sweden in 1998 (Swedish Occupational Safety and Health Administration 1998). In Virginia, which has a population of about 6.5 million, 176 occupational fatalities were reported in 1998 (Bureau of Labour Statistics). Although this clearly is not a unilateral comparison, it suggests that one approach is more effective (Geller, 2001).

For example, under the Canadian Occupational Health and Safety Act (Ontario), the government attempts to assist and consult before it enforces; enforcement and citations are used only when all else fails. In most cases, Canadian authorities seek out root causes of existing hazards rather than emphasize surface violations (Geller, 2001)

Statutory authorities need to attain more expertise in the person-based and behaviour-based aspects of safety. The goal is not to establish more regulations, but rather to help employers address the individual and social dynamics of safety. The emphasis for the past 29 years has been on improving the working environment. It is now time to take a more-balanced approach that also considers the human dimensions of safety improvement
(Geller; Krause, McSween, Sulzer, 2001).

In many of the investigation reports utilised in this study, there was no uniform accident investigation (accident causation) model or standard used. The results of the investigation may then be subject to bias and decreased validity. If governing authorities could develop a standard investigation method for all investigators to implement, the results of the investigation may be more insightful and provide opportunities for further study thus improvement.

6.2 Organisational

Organisations need to implement a program to improve safety culture, as reflected by behaviour, which focuses on management commitment and personal aspects of safety awareness at all levels of the workforce.

Only when strong safety culture exists within organisations, that is where the commitment of senior management is clearly evident to all levels of management and the workforce, will safety and health performance follow a continuous improvement pattern.

To help in facilitating a positive safety culture, organisation's need to address safety in all professions so as every individual regardless of their occupation takes accountability for their own safety.

In "*Safety Management: A Human Approach",* Pedersen explains that the "Safety Era" focused on inspections and government controls and de-emphasized human approaches (p41). Safety professionals have two distinct duties, complying with the legislation and controlling losses. The use of these external incentives to drive the safety process merely suppresses internal motivation to improve (Pederson, 2001). The more control exerted from the outside, the less control and ownership develops from the inside. Many companies engage in safety activities only because the government requires it. Ownership, commitment and proactive behaviour are less likely to develop when people are working to meet goals or deadlines set by someone else than when striving to achieve goals set by their own team (Pederson, 2001).

A safe system of work including documented safe work procedures and regular training on this system was provided. The area of weakness in these examples was the decision by someone involved to not adhere to these methods. There was no evidence of commitment to their safety. This was demonstrated in the case study involving the engineer whom fell 10 metres down an air heater and died when conducting an inspection. This fatality was one of the rare examples where a safe system of work was already in place including documented confined space, working at height procedures and a regular training was provided. In this case the victim had received training and was aware of the safe systems of working in confined spaces (or more specifically working at heights) but made the decision (it is assumed this decision was not deliberate) not to adhere to the procedures eg by not utilising fall arrest and as a result was fatally injured. There were numerous safety professionals on-site which may have also led to the deceased becoming victim to the "that is what the safety department is for" attitude whereby the expectation is on the site safety professionals to prevent fatal accidents. This promotes a lack of accountability which eventually led to poor working practices and increased incidents (in this case a fatal incident).

Another incident involved a welder whom was electrocuted in the cofferdam of a vessel when he came into contact with an exposed electrode. The system for confined space and hot work permit was documented and trained to all personnel on board the vessel. The deceased was an experienced and licensed welder whom had performed the task numerous times before. The immediate cause of death was electrocution when he made the circuit between the electrode and the metal wall/floor off the cofferdam. No isolation device was used at the time. The lead fitter who had applied for the hot work and confined space permit had made the decision that there was no need for the isolation device. The lead fitter was aware of the procedures but chose to ignore them even stating

"I did not think there was a need for the deadman (isolation) because it was a clean, dry space just like all the others we had worked on before"

This reinforces the lack of accountability for his own safety and the safety of others in the workplace and the lack of proactive behaviour exercised by the fitter. This could have been prevented if the isolation device was used.

6.3 Systems

6.3.1 Training

Within the confined space safety program (or any safety program for that matter) suitable focus should be on training of the contractor. It is evident within the sample case studies, and the literature review on both mining and non-mining fatalities that training of both employees and contractors is a main contributory factor that needs addressing. According to the Western Australian research 92% (12) of the fatalities attributed to inadequate training which includes such factors as; no training provided, training not attended and or training not adhered to. Many of the cases involving inadequate training were associated with contractors.

Employers must provide long term, industry standard training for all employees and contractors in order to maintain safe working culture within a workforce with high turnover rates.

6.3.2 Supervision

According to the Western Australian research 92% (12) of the fatalities were attributed to inadequate supervision. In this case inadequate supervision was based on the following factors; was the supervisor present, did the supervisor provide adequate instruction and was the instruction followed.

6.3.3 Safe Work Practices

"Providing safe systems for entry and work in confined spaces is the only way to reduce the human cost of these tragedies", (McManus, 1999, pg 101)

According to the Western Australian research only 15% (2) of the companies employing the victims had adequate safe systems of work (namely procedures). Adequate procedures were based on the following criteria; were procedures developed/documented? Was training/instruction provided on these procedures? And were the procedures or safe work practices adhered to?

Of the two cases (15%) that showed evidence of adequate management systems, both victims failed to adhere to the safe work procedures.

In addition to this it appears that whilst some supervisors were aware of unsafe practices they allow them to continue in the absence of an incident because production targets are achieved. For example, in the case study involving an apprentice refrigeration mechanic work outside of hours (public holidays) was not promoted due to the safety and security risks involved. Nevertheless the supervisor of the apprentice knew full well that the deceased was working alone on his public holiday in order to finish the task in the designated timeframe set out by the client. In addition to this security keys to the vessel were only given to the selected security guards and supervisor who may require out of hour's inspections yet the supervisor handed over the keys to his apprentice so that he could access the vessel to finish the purging of the refrigeration system. In this case the supervisor knowingly bypassed verbal safety and security procedures in order to finish the job.

The OSHA studies 1082a, 1985, referred to in the literature review examined immediate causal factors of confined space fatal accidents, specifically the procedural aspects of accidents involving confined spaces. It was concluded that 95% of immediate causes was due procedural inadequacy. In 95% of cases no there was no atmospheric testing or conducted and no ventilation checks. This reinforces the need for a confined space awareness program

A comprehensive confined space entry program should be developed and implemented for all industries and or employees that may be exposed to confined spaces. Safe work practices are one element of the safety system or program and will not operate without management commitment and adequate ongoing supervision. Industry must embrace the systematic approach to safety and health to ensure their efforts are not wasted in repeatedly developing standards and practices in isolation.

The following elements are recommended and applied to the case study involving a trainee winemaker who died after entering a fermenting wine vat and was overcome by CO_2:

6.3.4 Identification of all confined spaces at the site, facility or operation

If the company involved had identified the wine vats as a confined space, identifying the hazards (increased CO_2) and conveyed this to all involved the trainee may have taken precaution such as use of respirators or not have entered the vat in the first place

6.3.5 Posting of warning signage at the entrance of all confined spaces

If warning signs were posted at the entrance of the vat inexperienced, the trainee may have been alerted to the hazard rather than having to ask his supervisor (who in this case did not provide adequate information on the hazards upon questioning from the trainee). Signage would also have assisted in providing the information that should have in this case been provided in the form of a "new employee" induction.

6.3.6 Evaluation of hazards associated with each type of confined space

The provision of information is paramount to the individual's ability to make informed and decisions regarding working safely. If the trainee had been aware of the hazards involved, the chance of him making the safe decision to not enter the vat (or use respiratory equipment) would have been high.

6.3.7 A job safety analysis (JSA)

A job safety analysis for each task to be performed in the confined space. If the process of conducting a JSA was had been implemented the trainee, it may have encouraged communication with the supervisor allowing him to explain the hazards involved.

6.3.8 Confined space entry procedures

- Initial plan for entry
- Assigned standby persons
- Communication between workers inside and standby
- Rescue procedures
- Specified work procedures within the confined space

If a confined space procedure that included all of the above was available and implemented it is anticipated that the death would not have occurred. For example if the trainee made the decision to enter he would be alerted to the possible need for respiratory equipment, the supervisor would be on standby regularly communicating with his trainee and be alerted immediately if something was wrong. The supervisor would also be equipped with the appropriate equipment in case of emergency rescue. In the particular scenario there was no supervision, means of standby, no communication and or rescue equipment. The inclusion of all or any of these steps would have prevented the fatality.

6.3.9 Evaluation to determine if entry is necessary

If gas testing was performed prior to entry the high levels of CO_2 would have been identified and the vat purged with oxygen, respiratory equipment utilised or even better, alternative methods of removing the skins that do not require entry would be considered.

6.3.10 Issuance of a confined space entry permit

Authorisation and approval in writing that specifies location, type of work to be conducted and certifies that the workspace has been evaluated and tested by a qualified person and that all necessary protective measures have been taken to ensure the safety of the worker.
If the trainee and his supervisor had filled out a permit that required authorisation or approval from the manager it is anticipated that they would not approve of entry or in the case of approval, the trainee would be alerted to the hazards and precautions. This would also improve communication with management which was lacking in this instance.

6.3.11 Testing and monitoring the air quality in the confined space

- Confined space preparation
- Isolation/lockout/tag out
- Purging and ventilation
- Cleaning processes
- Requirements for special equipment and tools

If the vat was tested and elevated levels of CO2 were identified it is anticipated the deceased would have found alternative methods to entering or worked at purging the tank with oxygen increasing removal of CO2 out of the bottom of tanks prior to entry.

6.3.12 Safety equipment and protective clothing

- Head protection
- Hearing protection
- Hand protection
- Foot protection
- Body protection
- Respiratory protection
- Safety belts
- Lifeline, harness
- Mechanical lifting device

If the deceased made the decision to enter the vat wearing respiratory equipment (SCBA) and a life harness for emergency rescue death may have been prevented.

6.3.13 Training of workers and supervisors in the selection and use of;

- Safe entry procedures
- Respiratory protection
- Lifelines and retrieval systems
- Protective clothing

6.3.14 Training of employees in confined space procedures

The provision of training is perhaps the most important preventative technique in the case of the trainee. If training in the form of a new employee induction or accredited confined space training was provided the employee would have an increased awareness of the hazards and make decisions around his safety.

6.3.15 Conducting safety meeting to discuss confined space safety

This would again increase the knowledge and awareness of the trainee (and the supervisor) so that he adopted safe work practices.

6.3.16 Availability and use of proper ventilation equipment

It is anticipated that the trainee would have made the decision not to enter the vat after a review of the hazards but in the event that he did decide to enter the vat, the availability and use of PPE (specifically a life-line harness and SCBA) would have prevented him from being overcome with CO2.

6.3.17 Monitoring the air quality while workers are in the space

The Supervisor could have monitored the air quality whilst his trainee was in the tank which would not only increase communication and training but also alert him to potentially hazardous atmosphere before the deceased was overcome(NIOSH Guidelines, 1998, p1-30)

6.3.18 Auditing of Confined Space Safety Program

According to McDonald, (1998) "*the confined space program should treated as a safety management system and that includes follow up*" (p35). Part of this monitoring is diligence auditing. Authorities have implemented legislation which imposes responsibilities before entry and during the confined space operation but have failed to include diligence auditing of confined space management. The Australian Standard for Safe Working In A Confined Space (AS2864: 1995) provides a method to manage the risks from the dangers of confined space operations but fails to provide it as a management system and identify the need for follow up (in the form of diligence audits), (McDonald , 1998, p35).

According to McDonald,(1998) the Piper Alpha oil platform disaster in1988 brought to light the effects of an organisation that has a poor quality of safety auditing and the likely occurrence of a fatality (or multiple) through the failure to audit the organisations safety management system. Without auditing how can management know if they have got their risk management right? How could they demonstrate to a court that they have been diligent? In light of recent amendments to OHS Legislation imposing increased fines and including imprisonment of directors if found negligent or to not have demonstrated due diligence the need for diligence auditing of known fatal hazards should be implemented.

The confined space entry program should be audited for effectiveness and changes made where necessary.

If a program of confined space audits was implemented at the winery, inadequacies and lack of adherence would be brought to the attention of management. In this case management seem to have no idea of the day to day operations of winery and did not effectively fulfil her duty of care responsibilities by ensuring all hazards are controlled to as low as reasonably practicable.

In addition to the recommendations above it is recommended that awareness programs and campaigns be developed and implemented by WorkSafe. This program should focus on the following as a result of the research;

- Common industries Electrical, Agriculture, Construction and Manufacturing
- Common age groups – aim program at young workers between the ages of 16-30
- Employment Status – Emphasize role of contractors in fatalities
- Professions and Locations – Focus on trades and labour
- Locations – Give reference to common locations maybe providing pictures of common locations
- Causal Factors – The need for information, instruction, training and supervision to prevent recurrence

6.4 Recommendations for Further Research

Due to the lack of comprehensive information regarding confined space fatalities there is room for a great deal more research. This research study has identified various areas of study that could be further investigated to prevent workplace fatalities. These areas include;

1. Causal factors of confined space fatalities (in particular psychosocial aspects of confined space fatalities)
2. Confined space fatality preventative techniques – are they followed and are they effective?
3. Alternative methods of recording work related fatalities (Changing the framework with which to record work related fatalities)
4. Work related fatality investigation techniques (a unified approach to investigation causation models investigation techniques)
5. The re-introduction of the work related fatality investigation unit in Australia.

All areas identified within this study could be further researched.

7.0 CONCLUSION

It is evident from the literature review and Western Australian research that confined spaces are a prominent feature in work related fatalities throughout the world.

In almost all of the studies detailed in the literature review confined space accidents involve multiple fatalities with many of these being “would be rescuers”. There were no multiple fatalities in the Western Australian research but it should be noted with caution that the sample population was limited to 15 fatal accidents and statistics are therefore not a reliable indicator of the general working population in Western Australia.

According to the research the main industries within Western Australia involved in confined space fatalities are Manufacturing, Agriculture/Forestry/Fishing, Construction and Electrical (classified as Construction within the North America region).

Professions involved in confined space fatalities are predominantly tradespersons, mainly electricians, welders and plumbers. The labour profession also accounts for many of the victims including operators and maintenance personnel.

Common locations of confined space accidents include silos, vats, trenches, sewers, pits, kilns, pipes and wells. Ceiling space accounted for many of the Western Australian fatalities involving electrocution.

It is recommended that WorkSafe conduct a campaign detailing common age, industry, profession, location and causal factors involved in confined space fatalities within Western Australia. In addition to this campaign, the need for improved safe systems that provide adequate information, instruction, training and supervision in regards to confined spaces was highlighted and is should be a priority for all employers, employees and statutory authorities.

Higher level recommendations that involve the unification of confined space legislation classification were made to improve the understanding of general industry and assist in the comparison of confined space fatality data. If we can compare “apples with apples” it is anticipated that studies throughout the world will identify significant, reliable and valid findings and recommendations that will assist in preventing recurrence.

According to WorkSafe, (2005, p1), identification is the starting point for a system of control.

If the problems associated with confined spaces, bearing in mind potentially any space in which people work or become confined in, could be identified by research it is anticipated that fewer accidents and fatalities would occur.

Perhaps the most poignant finding from this study is the lack of comprehensive research on confined space fatalities across the continents. Limitations such as incomplete fatality databases, death certificates and investigation reports have made it extremely difficult to conduct valid and reliable studies into the nature of these hazards and as a result disguise the magnitude of the problem. This study is similar to those already conducted, in that it is subject to bias, as a result of the lack of information available.

The study was however, conducted to raise awareness of confined space fatalities, the lack of data available on this topic and provide recommendations that will help to resolve this problem in the future. Maybe then the cycle of confined space fatalities can be prevented.

The researcher is a member of Standards Australia Committee AS2865 – 1995 Safe Work in Confined Spaces. There is no representation from the Western Australian Government including WorkSafe Western Australia associated with this Committee.

It would be prudent for a member of the Western Australian Government to participate in this Committee.

This research has studied deaths in confined space but nowhere within the literature has the personal cost to families and relatives been identified. The researcher was involved in four investigations identified in this paper and witnessed the major cost to the families that no amount of compensation or sympathy can alleviate. It is the purpose of this research to enable identification of confined space work areas thus endeavouring to eliminate further deaths.

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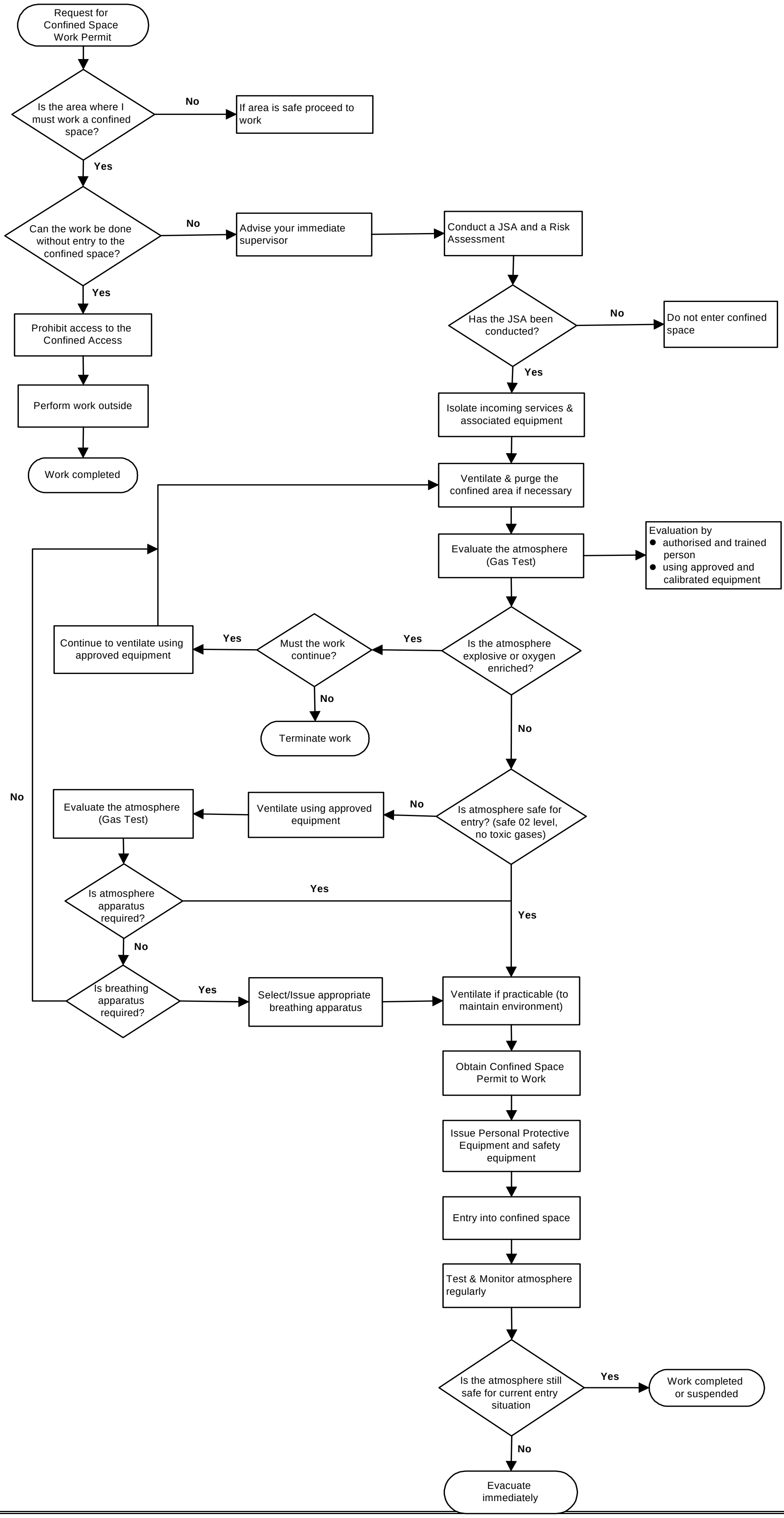
9.0 APPENDICES

9.1 Confined Space Procedures

PROCEDURE FOR CONFINED SPACE SAFETY *(Developed by the Candidate)*

CONTENTS

PROCEDURE FOR CONFINED SPACE SAFETY



The following procedures were developed by the researcher in the course of employment and for the purpose of this study.

9.1.1 Purpose

To ensure personnel working in a confined space are aware of the associated hazards, are given the correct training and have the appropriate equipment to carry out the job safely.

9.1.2 References

MacCarron		Safety Procedures
AS1657	-	Fixed Platforms, Walkways, Stairways and Ladders-Design, Construction and Installation
AS1715	-	Selection, Use and Maintenance of Respiratory Protective Devices
AS1716	-	Respiratory Protective Devices
AS2430	-	Classification Person Certificate
AS2865	-	Safe Working in a Confined Space
Client Procedures		If any

9.1.3 Responsibilities

All persons directly responsible for, or involved in, work in confined spaces are to be aware of the hazards and ensure that suitable controls are applied to manage these risks.

9.1.4 Definitions

Confined Space – A space of any volume which:

- Is not intended as a regular workplace.
- Has restricted means for entry and exit.
- May have inadequate ventilation and/or an atmosphere which is either contaminated at any time by dust, fumes, mists, vapour, gas, or other harmful substance.
- The atmosphere is liable to be oxygen deficient.
- Is at atmospheric pressure during occupancy.

Contaminant – any dust, fume, mist, vapour, gas or other substance, the presence of which may be harmful.

Explosive (flammable) Range **–** the range of flammable vapour or gas-air mixture between the lower explosive limit (LEL) and the upper explosive limit (UEL).

Hot Work – welding, thermal or oxygen cutting, heating or other fire producing or spark producing operations.

Entry – for the purpose of these procedures, a person whose upper body and/or head is within a confined space is considered to have entered the confined space.

Threshold Limit Values (TLV's) – The airborne concentrations of contaminants which represent conditions under which it is believed that workers may be exposed to without adverse effect. For the purpose of these procedures TLV's published by Worksafe Australia will be applied.

Confined Space – Permit to Work - a signed statement by the Permit Holder, Authorised Person and the person in charge, that a job may be carried out under stated precautions.

Authorised Person – a person trained in the Confined Space - Permit to Work Procedure nominated as Authorised by the Project Manager to issue the permit.

Permit Holder – the person who carries out the job or his immediate Supervisor at the work site.

Hygienist – A person authorised and trained to undertake atmosphere and/or gas testing.

9.1.5 Procedure

Introduction

Confined spaces may include but not be limited to:

- Storage tanks, tank cars, process vessels, boilers, pressure vessels, silos and other tank like compartments;
- Open top spaces such as pits or degreasers;
- Popes, sewers, shafts, ducts, and similar structures; and
- Any shipboard spaces entered through a small hatchway or access point, cargo tanks, cellular double bottom tanks, duct keels, ballast and oil tanks, and void spaces, but not including dry cargo holds.

When entry has to be made to a tank, vessel, hopper, excavation or an area where there is a constricted opening, consideration must be given to the safety of persons working in such a location. Not only for adequate atmosphere and ventilation but other aspects such as fire risk, ease of access, egress and emergency access must be catered for.

Training

Training in the critical aspects of confined space work must be completed prior to the commencement of any confined space work.

Training in confined space work is a specialist function and requires a trainer with proven expertise and experience. The suitability of training courses should be verified with the Safety Manager.

All training programs will include at least the following;

- The requirements of State OH & S legislation and AS2865 "Safe Working in a Confined Space"
- Breathing equipment including types and practical use
- Atmospheric monitoring
- Ventilation
- Isolation/Lock-out methods
- First-aid including CPR
- The use of rescue equipment (entry/exit devices)
- Hazard recognition
- Fire prevention

At the completion of training employees must prove to be proficient at confined space entry and rescue techniques utilising all required equipment. Such proof will take the form of written and practical assessment by the confined space trainer.

Modified training requirements are applicable to Category 4 confined space work (see Category 4 below).

Risk Assessment

Once the confined space and the intended work has been identified the Construction Manager or delegate together with the Authorised Person and the Supervisor will carry out a Risk Assessment. The completed risk assessment will be used to categorise the confined space.

Confined Space Categories

The varied nature of work carried out will present confined spaces with varying levels of risk. For the purpose of these procedures confined spaces have been categorised.

The designated category for each confined space shall be confirmed prior to entry, by the Authorised Person.

Confined spaces may not necessarily remain in a set category. Confined space may change with improved conditions confirmed during initial testing i.e. a Category 1 may be reclassified Category 2. Similarly conditions within a confined space may deteriorate requiring reclassification from category 2 to category 1.

The nature of the work being carried out in the confined space could also increase the risk factor which would alter the confined space while it is occupied.

The confined space categories are as follows:

Category One

i. Category One spaces are of high potential risk from a variety of contaminants which are not easily identifiable or controllable. The following conditions may exist:

- Extreme levels of known contaminants
- Suspected, unidentified contaminants
- Inability to ventilate
- Inability to guarantee total isolation
- Dangerous or difficult access and/or egress

ii. Self contained breathing apparatus must be worn by personnel entering a category one space. In addition, a self rescue breathing apparatus shall be carried at all times. Standby personnel will have immediate access to self contained breathing apparatus for rescue purposes at all time.

iii. Specialist atmospheric testing may be required in this category. Modifications to the breathing apparatus requirements may only be made following specialist advice gained after initial atmospheric testing.

Category Two

i. Category Two confined spaces are of high potential risk from known contamination. They are not frequently accessed however conditions are controllable prior to entry. The following conditions may exist:

- Known gases
- Controllable sources of contamination
- Controllable or predictable inflows
- Poor ventilation
- Restricted access or egress
-

ii. Safety harnesses will be worn at all times for safe entry into a category 2 space. In addition, self rescue breathing apparatus will be carried at all times. Stand-by personnel will have immediate access to self contained breathing apparatus for rescue purposes.

Category Three

Category Three confined spaces are normally isolated from the source of potential risk. These confined spaces are accessed regularly and entry is under controlled conditions. The following conditions may exist;

- Isolated contaminants
- Controlled release of contaminants
- Sound means of access and egress, usually to AS1657 "Fixed Platforms, Walkways Stairways and Ladders – Design, Construction and Installation".
- Adequate lighting

  Continuous monitoring will occur whilst within a Category 3 confined space. Safety Harnesses will also be worn.

Category Four

Category Four spaces are of very low potential atmospheric risk. Entry and work within the confined space shall be carried out in accordance with Australian Standards or Safety Procedures. The confined spaces are usually;

- Open access
- Well ventilated
- Foreseeable and controlled low risk contaminants
- Good lighting

Training requirements for this category may be modified to meet the Australian Standard or Safety Procedure applicable to the work being undertaken (e.g. excavations), however it remains the responsibility of the Project Manager to ensure that the confined space atmosphere is not liable to be contaminated or become oxygen deficient at any time.

Responsibilities

Project Manager

The Project Manager is directly responsible for:

- Controlling the confined space during construction work or
- The operation and or maintenance of the plant, equipment or assets associated with the confined space

The Project Manager must ensure that:

- All personnel required to enter or work as part of a confined space team are trained in accordance with these procedures
- All necessary equipment required by these procedures is available for the confined space work
- All necessary information and specialist advice has been made available to the confined space work team
- All personnel are medically fit to perform confined space work

Authorised Person

The Authorised Person is a trained employee approved by the Project Manager to authorise Confined Space - Permits to Work. The Authorised Person issues the Confined Space - Permit to Work to the Permit Holder.

The Authorised Person is to ensure that:

- These procedures are strictly adhered to prior to entry and during occupancy
- All personnel within the work team are trained
- All personnel within the work team are not suffering from any temporary disability

Hygienist

The Hygienist is a person authorised in writing by the Project Manager to perform specific tasks in relation to confined space work . The specific tasks may include:

- Atmospheric testing
- Gas testing
- Confirmation of chemical agents
- Confirmation of site specific precautions
- Confirmation of personal protective equipment

The Hygienist must report results direct to the Authorised Person, have them recorded on the Confined Space – Permit to Work and sign off.

The hygienist who is required to carry out atmospheric testing may form part of the team entering the confined space, carry a monitor and continually monitor the atmosphere whilst personnel are within the confined space.

Permit Holder

The Permit Holder is the employee trained and responsible for the job within the confined space. Before the job can start all members of the work team must sign on to the permit and the permit shall be explained in detail. The permit shall remain at the job site.

Once the job is complete, all member of the work team must sign off the permit and the Permit Holder shall forward it to the Manager or delegate for filing.

Confined Space – Permit to Work permits are only valid for 12 hours. A new permit is required if the job goes over to the next shift.

The Stand-By Person

The stand-by person (who may also be the Authorised Person) is required for all Category 1&2 confined spaces and Category 3 where assessed as necessary. The stand-by person plays a critical role in the case of an emergency:

- Remain immediately outside the entrance to the confined space
- Maintain visual, audible or tactile communication with the work team inside the structure
- Have a means of communication to contact emergency back-up or services
- Be competent at confined rescue
- Possess a current senior first-aid certificate

Sub-Contractors

Sub-contractors required to enter confined spaces under the control of the company must supply a copy of their confined space procedures to the Project Manager.

The Project Manager must ensure that the sub-contractors procedures meet the requirements of AS2865 “Safe Working in a Confined Space” as a minimum. The Safety Manager should be contacted if any doubt exists as to the quality of the supplied procedures.

Where personnel are required to enter confined spaces in conjunction with a sub-contractor the Confined Space procedures will be adopted.

Medical Suitability

Confined Space work places demands on the body in excess of normal construction or maintenance work especially in relation to an emergency or rescue situation.

No person shall be allowed to participate in a Category 1,2 or 3 entry without being medically assessed by a medical practitioner. Medical assessment will take the form of a pre-employment medical in accordance with Pre-employment Medical procedures. Medical assessments will remain current for a maximum of two years.

It will remain the responsibility of the Project Manager to ensure that medical assessments are current for all members of a confined space work team. The Permit Holder must ensure that all members of his work team are not suffering from a temporary functional or respiratory disability prior to entry and prohibit further involvement where appropriate.

Condition for Entry

Preliminary Review

Consideration should always be given to performing the work from outside the confined space. If this is possible then precautions must be taken to prohibit entry into the confined space.

If entry into the confined space is required, the Permit Holder shall undertake the following review:

- Conduct a Job Safety Analysis with work team
- Identify the confined space category
- Evaluate all proposed operations and work procedures, particularly those that may cause a change in the conditions in the confined space
- Consider the soundness and security of the overall structure and the need for lighting
- Where appropriate, consider the steps to be taken to bring the structure to atmospheric pressure
- Consider the atmospheric testing to be undertaken and the parameters to be assessed before the Confined Space Work Permit form is issued
- Consider all hazards which may be encountered including regular workplace hazards

- Confirm the status of training of those persons intending to enter or perform stand-by duties

- Confirm health status of those persons intending to enter or perform stand-by duties

- Ensure adequate instruction is given to those persons in any unusual or non-typical work procedure required, including the use of any personal protective or mechanical equipment to be used

- Ensure the adequacy of appropriate personal protective equipment, protective clothing and rescue equipment for all persons likely to enter the confined space for work or rescue reasons

- Ensure the confined space is barricaded and sign-posted to prohibit un-authorised entry

- Consider other additional protective measures such as:

- Consider the arrangements for rescue which will take into account:

- The shape and size of the confined space.

- The nature of the task to be performed.

- Obstacles within the space and the size and position of the means of entry to and exit from the space.

- The number of persons entering the confined space.

- The number of persons required outside the space to maintain equipment essential for the confined space task, to ensure adequate communication and/or observation of persons within the confined space and to properly initiate rescue procedures if required.

Isolation

Isolation of services and potential inflows that may impact on a confined space during occupancy is required where the inadvertent introduction of the material or movement or activation of machinery would create a hazard.

Authority must be obtained from the Project Manager prior to isolating any system or interfering with any plant or equipment.

Isolation or water, sewage, moving machinery, electrical power, or any energy source is required where these items may create a hazard during the confined space work.

Positive steps shall be taken by the Permit Holder to ensure:

- Prevention of accidental introduction of any materials such as water, sewage or contaminants.
- De-energisation and lock-out, or de-energisation and tag-out and where possible both, of machinery and equipment with moving parts.
- Isolation of all energy sources which may be external to, but still capable of, affecting the confined space (e.g. heating or refrigeration mediums).

Re-activation of any isolated equipment shall only occur following confirmation by the Permit Holder that all persons have left the confined space and that work is complete.

Safety of the Atmosphere

No person shall enter a confined space until it is free from any explosion hazard and either:

- The person is equipped with self contained breathing apparatus and appropriate personal protective clothing (obligatory requirement Category 1).
- Precautions have been taken to establish and maintain a safe atmosphere within the confined space during occupancy.

In order to enter a confined space without self contained breathing apparatus (Category 2) the following precautions shall be observed.

Initial Cleaning and Purging

Where practicable all solids and liquids, which are liable to present a hazard to persons inside the confined space, shall be removed from the confined space prior to the entry of personnel.

Where necessary the confined space shall be cleared of contaminants by use of a suitable purging agent.

Care should be taken to ensure cleaning agents do not create additional hazards.

When flammable contaminants are to be purged, purging and ventilation equipment designed for use in hazardous places (AS2430 "*Classification of Hazardous Areas*") shall be employed and precautions taken to eliminate sources of ignition.

All contaminants should be exhausted so that they do not create a further hazard external to the confined space.

Evaluation of the Atmosphere

Entry to Category 1, 2 and 3 confined space shall not be permitted until its atmosphere has been evaluated to determine whether there is any hazard from:

- Oxygen deficiency in air being less than 19% and not greater than 23%
- Contaminants in the atmosphere being below the relevant TLV. (Work-Safe Australia-Workplace Exposure Standard)
- Extremes of temperature
- Any flammable or combustible contaminant above 5% of its LEL.

The evaluation of the atmosphere and a survey of other hazards shall be performed from outside the confined space, before any entry occurs.

The results of all testing will be recorded on the Confined Space – Permit to Work form.

Evaluation of remote areas within the confined space may be carried out once the area adjacent to the entry point has proved safe. Evaluation of remote areas may need to be undertaken by personnel wearing Self Contained Breathing Apparatus (SCBA).

No person, wearing SCBA or not shall enter any confined space where combustible gases exceed 5% of the LEL until the source of the gas has been identified and the hazardous situation rectified.

Where any doubt exists as to the nature of any gas specialist advice must be obtained before entry is permitted.

Monitoring must be carried out by a hygienist continually when Category 1&2 confined spaces are occupied.

Ventilation

Where persons entering a confined space are not wearing SCBA the confined space must be ventilated by natural, forced or mechanical means in order to establish and maintain a safe environment. This ventilation shall be continued whilst the space is occupied.

Where the maintenance of a safe working environment is dependent on mechanical ventilation equipment e.g. a fan or blower, the equipment shall:

- Be continuously monitored while the confined space is occupied.
- Have the controls (including any remote power supply) clearly identified and tagged / locked to guard against unauthorised and/or accidental interference.

Communication

A communication system must be established by the Permit Holder prior to commencing confined space work.

Communications for Category 1&2 confined spaces shall be established so that there is always visual, audible or tactile between those personnel within the confined space and the stand-by person. Communication can be established by one of the following means:

- Unobstructed vision or conversation
- Clearly defined noise signals
- Whistles
- Torch signal
- Safety ropes
- Approved call back device

Prior to entry the Permit Holder must confirm ability to contact emergency services.

Communications for Category 3&4 confined spaces shall preferably include one of the above-mention means but may be limited to the Permit Holder notifying a central contact point of the:

- Intended location
- Proposed route
- Completion time

The Permit Holder will advise the contact of completion.

Personal Protective Equipment

Respiratory Protection

In all Category 1 confined space work self contained breathing apparatus will be required at all times. This requirement may only be modified following specialist atmosphere monitoring and written advice confirming the modified procedure.

In all situations where the results of initial evaluation and re-evaluation after further ventilation indicate that a safe atmosphere can not be established or maintained self contained breathing apparatus will be required.

In Category 1&2 all persons will carry an approved self rescue respiratory device.

Under no circumstances is entry permitted where testing indicates the potential for an explosive atmosphere.

Respiratory protective devices must be considered by the Permit Holder for Category 2,3&4 confined spaces. Selection and use shall be in accordance with AS1715 "*Selection, Use and Maintenance of Respiratory Protective Devices*" and shall take into account hazards likely to be encountered.

All respiratory protective devices must comply with the requirements of AS1716 "Respiratory Protective Devices".

Safety Equipment

Safety equipment must be selected by the Permit Holder and provide protection for all assessed risks. Safety equipment applicable to confined space work is listed below. The Permit Holder should consider each item in the following list:

- Safety harnesses
- Descent control devices
- Fall arresters
- Rapid rescue system (includes safety lines)
- Gas detectors-electronic sensor type, i.e. Exotox/Gastech
- Self contained breathing apparatus – Air supplied
- Self rescue
- Filter type
- Safety helmets
- Safety boots
- Eye protection

- Hearing protection
- Hand protection
- Safety torch
- Communication devices
- Fire Extinguishers

A rapid rescue system incorporating life lines and fall arresters are mandatory where there is a hazard of falling during ascent or descent and where rescue by a vertical or horizontal route is practicable.

Self-contained breathing apparatus is required to be available to standby personnel in all Category 1&2 confined spaces. SCBA bottles must have a minimum of 30 minutes average breathing time available and must not be less than 80% air capacity prior to use.

Authority To Enter

Entry into a confined space shall not take place without prior approval from the Authorised Person.

Approval shall take the form of a completed and signed Confined Space Work Permit form.

A Confined Space Work Permit form is required for work requiring entry into a Category 1, 2 & 3 confined space.

The Confined Space Work Permit form shall be re-validated whenever it becomes evident that the duration of the work will involve one of the following:

- Change in personnel
- A break in work continuity
- A change in risk

A copy of the completed Confined Space Work Permit form shall be forwarded to the Construction Manager and maintained with project records.

Where any aspects of the Confined Space Work Permit form are not applicable the Authorised Person will write the words 'NOT APPLICABLE' followed by his signature.

Evacuation and Rescue Procedures

Types of Evacuation and Rescue

The type of evacuation or rescue will be dependent on the situation that has developed. Evacuation or rescue may be required in the following scenarios:

- Self-evacuation in the case of a slight injury or suspected hazard
- Assisted evacuation in the case of an injured or collapsed person
- Emergency rescue in the case of atmospheric contamination

The success of any rescue will be dependent on the competency of rescue/stand-by personnel. The following rescue/evacuation procedures must be understood and rehearsed prior to any confined space work.

Note: The sounding of an atmosphere monitoring alarm requires immediate evacuation of all personnel without hesitation or continuance of work.

Self Evacuation Procedure

Self evacuation may become necessary due to a slight injury to a member of the confined space team. Alternatively a monitoring alarm may indicate that a contaminant is present in the atmosphere.

Immediately alert all confined space team members and/or the stand-by person(s) of the hazard/reason for evacuation, the nature of any injury and the route of evacuation.

Evacuate via the quickest, safest exit and means.

Apply necessary first aid where required as soon as it is safe to do so.

The stand by person will contact emergency services on notification of evacuation where warranted.

The Permit Holder will account for all personnel as soon as the confined space is evacuated and complete an Incident/Injury Report.

Assisted Evacuation – Injured or Collapsed Person

Immediate and astute decisions are required in this situation to ensure that the reason for injury or collapse is not a result of unidentified contamination. Unidentified gases may be the cause of falls or collapse. If the reason for collapse is unknown a hazardous environment must be assumed and emergency rescue procedures followed.

Immediately alert others in the confined space and the stand-by persons of the hazard and reason for evacuation. The stand-by person will immediately contact emergency services if warranted before instigating standard rescue technique.

The confined space team must exit via the quickest safest route. Where atmosphere contamination is suspected self-rescue breathing apparatus will be donned and the injured person will be assisted outside of the confined space utilising standard rescue techniques.

Necessary first-aid should only be applied within the confined space if the atmosphere is being monitored and can be determined as safe.

In an emergency the spontaneous reaction to immediately enter and attempt a rescue may lead to multiple fatalities – not only of those persons needing to be rescued but also of those attempting the rescue.

Upon exit all persons are to be accounted for by the Permit Holder.

Re-entry to the confined space for the collection of tools and equipment will only be permitted after the atmosphere has been tested and the confined space made safe.

The Permit Holder will submit a completed incident/injury investigation report to the Project Manager.

Emergency Rescue – Hazardous Environment

Immediately alert others in the work team and the stand-by person of the emergency and the need for rescue. Where the standby person is unaware of the condition of the work team OR the cause of injury OR there is a loss of communication, a hazardous environment must be assumed and hazardous environment rescue procedures adopted.

The standby person will immediately contact emergency services.

Always carry out emergency rescue via the quickest and safest route. If possible and safe to do so, identify and isolate the hazard.

Only if entry to the confined space can be made safe by:

- The use of SCBA
- Isolation of the hazard
- Standby personnel are available

And all rescue equipment is available including ventilation if required shall any person enter a confined space. This emergency response applies even in an emergency situation to provide urgent resuscitation, first-aid or rescue.

In an initial response when emergency rescue is required, standard rescue techniques shall be applied by trained personnel.

Where possible a person should await emergency services and provide direction as required.

In an emergency the spontaneous reaction to immediately enter and attempt a rescue may lead to multiple fatalities – not only of those persons needing to be rescued but also of those attempting the rescue.

Upon exit all persons are to be accounted for by the Permit Holder.

Re-entry to the confined space for the collection of tools and equipment will only be permitted after the atmosphere has been tested and the confined space made safe.

The Permit Holder will submit a completed Incident/Injury Report to the Project Manager.

Confined Space Safety Rules

- Prior to entering or commencing any work in a confined space an approved Permit must be in place.

- Always ensure the appropriate atmospheric testing and monitoring is conducted and appears on the Permit prior to entering a confined space.

- Adequate ventilation should be provided prior to entry or commencing any work.

- Never enter a confined space if a trained watch-person is not present at the entrance to oversee the work being conducted.

- All welding and cutting gear shall be checked for damage or leaks before being taken inside a confined space or tank.

- All personnel working in or associated with work activities in a confined space must have received appropriate training.

- Practical provision for emergency rescue of person from a confined space including communication arrangements for advising emergency must be made.

- Other employees working in the area shall be advised of any confined space work and suspend any activities that may create a risk.

- Adequate and suitable lighting must be provided to illuminate all aspects of the work area and access and egress points. Where a watch-person is required, they are to keep the personnel under observation whenever possible. Under circumstances where visual contact cannot be maintained, reliable and approved radio communications must be in place.

CONTENTS

1.0 STANDARD REQUIREMENTS

Safe systems of work are required for all work that is performed within confined spaces. The purposes of safe systems of work are to ensure:

The hazards associated with the confined space and the intended work are identified,

That an assessment of all risks are made and controlled in the appropriate manner,

That all personnel involved with the confined space activities have been appropriately trained and made aware of their responsibilities.

Note: This safe work standard was developed to comply with the requirements of the Australian Standard AS 2865 – 1995 Safe Working in a Confined Space. AS 2865 should be used as the primary source reference document relating to confined space entry.

Note: ***Client Representative*** *– Where the workplace is operating under a contract on the property of the client, and the agreed procedure precedence adopts the client confined space procedure, the references to the client representative(s) identifies the responsible person(s) for managing the client confined space procedure.*

1.1 Procedure Precedence

This safe work standard sets out the minimum requirements that shall be met prior to entry into a confined space. Where the client's confined space procedure exceeds the standard of this procedure then that procedure shall take precedence.

Note: ***Company Representative*** *– In the case where the workplace is operating on Company property, and by default, the Company confined space safe work standard is adopted, all references to the client representative should be interpreted as Company representative(s) responsible for managing the confined space safe work standard.*

1.2 Risk Assessment Process

1.2.1 Hazard Identification

Prior to the commencement of any work inside a confined space all the hazards associated with both the confined space and the work to be performed shall be identified.

The client representative responsible for the management of confined space work may perform the process of hazard identification. Please refer to the standard checklist "Confined Space Hazard Identification."

1.2.2 Risk Assessment

Before entry is permitted within the confined space a risk assessment shall be conducted by a person(s) who are trained and competent in conducting risk assessments. The risk assessment shall determine the level of risk associated with the work that is being undertaken within the confined space taking into account the hazards identified. The assessment shall be in writing and may be conducted by the client representative responsible for confined space entry at the site. "Confined Space Risk Assessment Sheet" details the factors that shall be taken into account when performing a confined space risk assessment.

1.2.2.1 Common Task Risk Assessments

In some circumstances, similar work may be performed in confined spaces that pose identical or similar risks. For example, inspection and cleaning of tanks that have all contained the same product and are of a similar dimension.

In these cases, a common task risk assessment may be used for the purposes of meeting the requirements of this section. Any common task risk assessment shall identify any differences between the confined spaces and any variation to the work method that is being performed.

Common task risk assessments may also be used when the same or similar work is being performed within a confined space on a regular basis. When using a common task risk assessment in this manner the following factors shall be taken into account:

- Any modifications that have been made to the confined space or its associated plant and equipment
- Any change in the operating conditions or product contained within that confined space
- Any change in the atmosphere or working environment within or in the vicinity of the confined space
- Any change in the work method
- The risk assessment is to be conducted by a competent person(s) and is to be reviewed following the opening and subsequent inspection of the confined space to ascertain whether all hazards and risks have been identified and assessed.

1.2.3 Risk Control

Where the risk assessment identifies a risk to the safety and health of personnel working within the confined space, control measures shall be implemented that will eliminate or minimise the risks associated with the work that is being performed.
Control of risk shall be in accordance with the hierarchy of control process and the controls implemented shall follow the order listed below:

- Elimination
- Substitution
- Engineering controls
- Administrative controls
- Use of personal protective equipment

Safety Management Procedure Hazard and Risk Management provides guidance on how the hierarchy of controls is to be implemented.

The process of risk control shall be used for all the identified hazards associated with the work within the confined space. It may be necessary to use a combination of the control measures to eliminate or reduce the hazards.

The most important factor is that the highest order hierarchy of control measure shall be used wherever practicable.

1.3 Isolation of Confined Spaces

1.3.1 Need for Isolation

No person shall enter a confined space until all materials that could enter the confined space have been positively isolated. Such materials would include; steam, liquids, gases, electricity, and sources of radiation.

The above mentioned services may enter the confined space in a variety of means and could include; piping, ducts, vents, drains, conveyors, electrical conduit, fixed fire protection systems, and radiation level indicators.

1.3.2 Methods of Isolation from Contaminants

The minimum requirement for the isolation of confined spaces, against the introduction of contaminants into that space can be by one of the following alternatives:

Removal of a valve, spool piece, or expansion joint as close as practicable to its entry point into the confined space. The open end of the piece removed that leads into the confined space shall be blanked or capped. The blank or cap shall be identified by some means (normally by way of a tag) and the identification shall indicate the purpose of that blank or cap

Insertion of a full pressure blank in the piping between flanges, as close as practicable to the entry point to the confined space. The blank shall be identified to indicate its purpose.

Where neither of the above methods are practicable, confined spaces may be isolated by the closing and tagging or locking out of at least two valves in the pipe leading to the confined space. Positive proof of this form of isolation shall be sighted prior to the entry of any person into the confined space. Wherever possible this form of proof shall be by the opening of a drain

valve between the two closed valves. The drain valve shall be tagged to indicate it as being open.

In the case of these alternatives not being available the Contract Manager or his nominee shall decide whether the isolations performed for entry are of a sufficient calibre to prevent the ingress of contaminants into the confined space and protect the personnel that are working within the confined space.

1.3.3 Methods of Isolation from other Energy Sources

Prior to entry within the confined space, all other sources of energy shall be positively isolated. Such forms of energy may include:

- Mechanical or moving energy from fans, agitators, hammers
- Electrical energy from capacitors
- Hydraulic or pneumatic energy sources
- Thermal energy from radiation sources or heating elements
- Isolation from these energy sources shall be achieved by the following means:
- Tag out or lock out of the opened circuit breaker supplying the equipment or the opened isolating switch supplying the equipment,
- Where the power source cannot be isolated or controlled effectively, a belt or mechanical linkage to the equipment to be isolated shall be broken and tagged,
- Where neither of the above methods are practicable, moveable components shall be locked, and switches, clutches and other controls shall be tagged.

All tags used for isolating equipment shall indicate the purpose of the tag and that the tag shall not be removed or the equipment operated until all personnel have left the confined space.
In the case of any of these alternatives not being available the Contract Manager shall decide whether the isolations performed for entry into the confined space are of a sufficient calibre to prevent the ingress of contaminants into the confined space and protect the personnel that are working within the confined space.

1.3.3.1 Isolation of Internal Moving Parts

Where equipment inside the confined space requires isolation, the first person entering the space shall perform the isolation, attaching tags and / or locking devices as required on the permit.

1.3.4 Verification of Isolations

Prior to entry of a confined space the permit recipient, or person responsible for the work to be performed, shall verify that all isolations have been made, including all blanks have been inserted, spool pieces or valves removed, and that all isolation points have been identified in some manner such as tagging or use of a blank list.

1.4 Confined Space Atmosphere

1.4.1 Minimum Standards for Confined Space Atmosphere

No person shall enter a confined space until, where practicable it:

- Contains a safe level of oxygen,
- All atmospheric contaminants have been removed,
- The concentration of flammable gases is below 5% LEL, and
- Is free of extremes of temperature.

1.4.2 Initial Gas Testing Requirements

Prior to entry into a confined space, a person who is trained and competent in the use of atmospheric monitoring equipment shall test its atmosphere. The risk assessment performed shall determine what contaminants are to be tested for.

When determining the gaseous contents of the confined space, consideration must be given to ensure that a representative sample of the confined space is taken. Particular attention should be paid to remote areas of the confined space where contaminants may collect. If the confined space has to be entered for the purposes of gas testing, the gas tester shall wear supplied air respiratory protective equipment with a sentry or stand-by person in place.

If the levels of contaminants are higher than acceptable then additional ventilation or purging of the confined space shall be performed and a new test conducted.
Results of the gas monitoring shall be made readily available to all personnel and if necessary, the results shall be explained to them. A written copy of the testing results shall be placed with the confined space entry permit.

All gas testing shall be performed with the ventilation systems turned off.
Refer 1.17 lists the minimum and maximum levels of oxygen and contaminants that can be present within a confined space when personnel are required to enter it.

1.4.3 Re-testing Requirements

Confined spaces shall be re-tested prior to entry, the risk assessment shall determine the frequency of re-testing and the contaminants to be tested for, however the following minimum requirements shall apply.

- At the start of each shift
- An emergency situation that has occurred internal or external to the confined space that may have introduced contaminants into the atmosphere.
- At any time requested, not less than every hour

1.4.4 Continuous Gas Monitoring

In some circumstances it may be necessary for continuous gas monitoring to occur whilst persons are performing certain activities within the confined space. These activities may include:

- Welding, cutting and other heat generating activities
- Use of hazardous materials
- Where the possibility of flammable materials exists within or around the confined space,
- Where it has been identified in the hazard identification process that a risk of contaminated atmosphere exists
- Where substances such as scale or paint may release toxic vapours
- Where substances absorbed into the surface of the confined space may be released over a period of time
- Contaminants remain in the confined space, i.e. slurry in the bottom
- Where specified by the permit issuer or permit recipient.

1.4.5 Use of Supplied Air

In some circumstances, air supplied respiratory apparatus will be used by personnel working inside the confined space, such as when nuisance dust is being generated. All air supplied to respiratory protective apparatus shall be from medical air cylinders (grey cylinder with black and white top), or compressors specifically designed for this purpose.

Whenever air cylinders are used, an additional sentry shall be posted to monitor the level of the air within the cylinders and ensure an adequate supply is maintained. Where compressors are used a back up air supply shall be provided in the event of a mechanical failure of this compressor unit. The system shall be designed to ensure a constant airflow is maintained at all times. An additional sentry shall be provided to monitor the system at all times whilst in use.

1.4.6 Atmospheres that will not Support Life

Where entry is required into a confined space that contains toxic materials at levels that are immediately harmful to health, or have oxygen levels that will not sustain life, approval for entry shall be given by the Contract Manager or his nominee. It shall be established that there is no alternative to perform the work and that entry into the confined space cannot be avoided. Entry under these circumstances must only be performed by specialist personnel specifically trained in the use of breathing apparatus purposely designed for this operation.
Documentation required to give approval shall include:

- Rescue plan
- Written work method
- Training records of personnel including the use of Breathing Apparatus
- Evidence that all other alternatives have been considered and none have been found to be practicable

1.5 Cleaning of Confined Spaces

1.5.1 Requirements for Cleaning

Wherever practicable a confined space shall be cleaned prior to personnel entering it, and cleaning operations shall occur from outside the confined space wherever possible. The purpose of cleaning the confined space is to remove any contaminants that may be present that pose a hazard to the safety or health of personnel working within the confined space.
Cleaning shall encompass where practicable the removal of:

- All sludges, scales and other deposits
- Liquids, (consideration shall be given to where liquids may be trapped within the confined space)
- Solids that may be stored or used within the confined space (such as steel grinding balls).

Chemicals used for cleaning shall be assessed for volatility and appropriate safety precautions taken. Any chemical used for cleaning shall not add to the hazards of the confined space.

1.5.2 Purging

In some cases a confined space may be purged to remove the hazardous contaminants within them. For example removing flammable atmospheres using nitrogen or carbon dioxide. When situations such as this occur it is important that all hazardous materials purged are exhausted to atmosphere or collected and contained in a safe manner and away from personnel.

Following purging with materials such as nitrogen, it is imperative that these are removed and thorough testing of the confined space occurs to verify that no traces of them remain.

Particular attention shall be paid to dead legs, areas of the confined space that have inadequate flow through ventilation, and "stubs" where pockets of the material may remain relatively undisturbed either during the purging or venting process.

1.6 Ventilation of Confined Spaces

1.6.1 Ventilation Requirements

Ventilation of confined spaces is the most effective means of controlling and eliminating atmospheric hazards. Therefore, all confined spaces require ventilation in some form. Ventilation can be achieved through natural or mechanical means.

Confined spaces are so variable in design that there are not set rules for ventilation. 1.18 Ventilation considerations for Confined Spaces provides information on the factors that need to be taken into account when planning the ventilation of confined spaces.

1.6.2 Mechanical Ventilation

Mechanical ventilation shall be used where natural draft is insufficient to provide a fresh supply of air to the confined space and remove contaminants from the atmosphere.

For general ventilation of a confined space, fresh air shall be supplied by means of a forced draft fan, or air blower. Plant air shall not be used to supply ventilation air to a confined space unless the breathing quality of this air can be guaranteed. Ducting may be used to bring the fresh air closer to the work face.

Where a task generates atmospheric contaminants such as welding or cutting, local exhaust ventilation shall be used to remove these contaminants.
Any air hoses, leads or other devices used to supply ventilation air shall be tagged to indicate that these devices are not to be operated or removed.

1.7 Lighting

1.7.1 Requirements for lighting

In nearly all instances, lighting will be required to illuminate the confined space. Where the risk assessment confirms that 240 volt powered equipment is permitted into the confined space, the lighting equipment chosen shall be a robust type and positioned where lenses will be protected from being struck by objects or liquids. A preference for using low voltage (32 volt) lighting shall be considered. All sources of 240-volt power (and the transformers for 32-volt lighting) shall be connected to an RCD (residual current device) electrically protected circuit.

Where the risk assessment confirms that the working area may contain flammable gases, the confined space lighting shall be extra low voltage (i.e. 32 volt) intrinsically safe and rated for the area or zone.

1.8 Entry into Confined Spaces

1.8.1 Need for Confined Space Entry Permit

No person shall enter a confined space unless there is a valid entry permit pertaining to that confined space issued. In most situations the client representative shall be responsible for preparation of the entry permit to allow work to occur within the confined space. The permit shall be issued to the person who is responsible for the work that is being performed, known as the permit recipient or permit acceptor.

There must be a formal handover between the client representative or permit issuer and United KG that details the work to be performed within the confined space. This handover shall set out the conditions of entry that will allow work to occur in a manner that does not expose personnel to risk of injury or harm to health. "Confined Space Entry Permit."
Included with the entry permit shall be all documentation pertaining to the confined space entry; such as hazard identification, risk assessment, gas test results.

1.8.1.1 Use of Personal Danger Tags

All persons entering a confined space shall complete a personal danger tag and hang it on the permit entry board, which shall be located at the confined space entry point.

Upon exiting and leaving the confined space, personnel shall remove their personal danger tag from the board.

If persons go home and fail to remove their personal danger tag, they will be called back to work (at their own expense) to remove their tag.

1.8.2 Barricading of Confined Space Entrances

All openings to the confined space shall have some form of barrier and a "Confined Space No Entry" sign placed across the entrance which indicates that personnel must not enter the confined space. Only those openings that are used for the purpose of entry and exit shall have the barrier removed and only at times when work is being performed within the confined space. All entry points shall display a sign stating "Confined Space, Authorised Entry Only"

1.8.3 Daily Inspections

At the start of each working day the confined space shall be inspected prior to any person entering it. The person responsible for the work being performed in the confined space shall check to ensure:

- All isolations are in place
- Gas tests have been performed
- Personnel on the job are aware of the hazards and the precautions that need to be taken
- That conditions have not changed within the confined space or in the vicinity around the confined space, and
- That all conditions of the entry permit and risk assessment are still applicable

When the responsible person is satisfied that all these conditions have been met, the confined space entry board shall be placed and the entrance to the confined space and work can commence.

1.9 Sentries / Stand-by Persons

1.9.1 Use of Sentries

Entry into a confined space may require the use of a stand-by person. The risk assessment process shall determine the number of sentries required and where they are to be stationed. The sentry(s) shall remain at the entry at all times when persons are occupying the confined space, and be in contact with emergency services by radio or telecommunication in the case of an emergency.

The employer shall ensure that where the risk assessment indicates a risk to health and safety, no person enters a confined space unless stand-by person(s) are present outside the confined space.

Provision of Stand-by person – the employer should provide stand-by person(s) whenever the risk assessment indicates that –

- There may not be a safe oxygen level
- Atmospheric contaminants are present or may be present in concentrations above the exposure standards
- There may be a risk of fire or explosion
- There may be a risk of entrapment or engulfment
- The work to be performed may generate risk to health or safety
- Equipment or conditions outside the confined space require control or monitoring to ensure the health and safety of persons in the confined space (for example, ventilation, respirator air supply, vehicles and weather); or
- There may be other risks to the health or safety of persons entering the confined space.

Communication – employers should ensure that communication, and where practicable, observation between those in the confined space and the stand-by person(s) are capable of being constantly maintained. Communication can be achieved, dependent on the conditions existing in the confined space, in a number of ways, including voice, radio, hand signals and other appropriate means. For example, where visual or oral communication is not possible, then a system of rope signals could be devised. Microwave, long wave or low frequency radio equipment can be used in some confined spaces where normal radio is unsuitable.

Alternating entry and stand-by persons – where it is expected that the person entering the confined space and the stand-by person may change places, the employer may authorise either to (stand by) while the other person is inside the confined space.

The duties of a sentry are included in 1.19 Sentry Duties and Sentry Duty Checklist. Sentries require formal instruction with regards to their duties, prior to them being permitted to undertake the duties of their role.

1.9.2 Multiple Entry Points

Multiple entry points should be avoided wherever possible, as it is difficult to control entry and exit of personnel. However in some circumstances the risk assessment may determine that there is no other practicable alternative than the use of multiple entry points, in addition it may not be practicable to have a sentry stationed at each of these points. A single Entry Control Board may be used to record the entry / exit of all personnel working within the confined space.

The Entry Control Board shall be placed in a location where all personnel coming to and from the confined space can readily access the board. The risk assessment shall determine the need for a single Entry Control Board.

Number of stand-by persons – the minimum number of stand-by persons required should be recorded on the entry permit.

1.10 Safety Equipment

1.10.1 Personal Protective Equipment Requirements

All personnel who work inside a confined space shall wear the following PPE as a minimum:

- Long trousers and a shirt with sleeves
- Safety glasses with side shields
- Safety footwear
- Hand protection
- Safety helmet (requirement based on risk assessment / workplace requirements).

These are the minimum requirements, at times it may be necessary to upgrade the level of personal protection, for example respirators to protect from dusts, fumes or gases; monogoggles; welding helmets etc. It is the responsibility of the permit recipient to determine the appropriate level of protection required for personnel working within the confined space.

1.10.1.1 Respiratory Protection

In circumstances where the nature of the work to be performed in the confined space will introduce new contaminants, such as welding, grinding, use of epoxy resins, solvents, liberation of contaminants from wall, etc. additional precautions may be required in regards to PPE.

The use of filter type respirators for protection against gases, fumes or vapours may only occur within a confined space when the oxygen content ranges between 19.5% to 23.5% for the duration of the work. Continuous air monitoring and ventilation shall occur in these circumstances. The risk assessment shall determine the need for any escape breathing apparatus sets and ensure that the filters used will protect against all contaminants within the confined space.

Should it be required that air supplied breathing apparatus must be worn within the confined space the following conditions shall apply:

- A spare set of air supplied breathing apparatus and rescue equipment shall be available near to the entrance of the confined space
- all personnel required to wear air supplied equipment shall be fully trained, medically assessed and authorised to use the equipment,
- Only positive pressure air supplied breathing apparatus shall be used.

1.10.2 Other Safety Equipment

In addition to PPE, other types of safety equipment that may be required for confined space work can include:

- Fire extinguishers- dry powder or water only
- Continuous gas monitors
- Portable Radio
- 32V temporary lighting conforming to AS2381
- Welding circuit safety switch conforming to AS1674.2
- Continuous gas monitoring equipment

1.11 Closing a Confined Space

1.11.1 Actions required when closing a Confined Space

After all work has been completed within the confined space, all equipment and materials shall be removed and accounted for. Failure to remove equipment and material can cause serious damage to the internals of the confined space and / or disrupt the process.

The confined space shall be examined by the permit issuer and / or recipient to ensure that all personnel, equipment and materials have been removed. When this inspection has been completed, all external openings shall be bolted and the permit signed off.
Pipe blinds, can now be removed, spool pieces, valves and pipeline can be re-fitted. Vent and drain lines that had been tagged as open can be closed.

(i) 1.12 Training

1.12.1 Minimum Requirements

All personnel involved in confined space entry work, including sentries, persons performing hazard identification and risk assessment, persons who work within confined spaces, permit recipients and supervisory personnel shall be trained and deemed as competent to be involved with confined space work.

The client representative may supply training as long as the above requirements are met, and the training tailored to meet the specific requirements of the confined space.

Training Needs	**Responsible Person**	**Sentry**	**Confined Space Worker**
Communication Systems	**X**	**X**	
Entry Permits and permits to work	**X**	**X**	**X**
Entry/Exit Procedures	**X**	**X**	**X**
Gas Testing	**X**	**X**	
Hazard Identification and Risk Assessment	**X**		
Hazards of Working inside Confined Spaces	**X**	**X**	**X**
Isolation Requirements	**X**	**X**	**X**
Job Safety Analysis	**X**	**X**	**X**
Legislative Requirements	**X**		
Requirements of this Procedure	**X**	**X**	**X**
Rescue and Emergency Procedures	**X**	**X**	**X**
Risk Control Measures	**X**		
Supplied Air Breathing Apparatus	All persons when defined in Risk Assessment		
Use of Fire Fighting Equipment	**X**	**X**	**X**
Use of PPE		**X**	**X**
Wearing of Safety Harnesses		**X**	**X**

1.12.2 Training Standards

All training conducted shall meet the requirements of the Safety Procedure Training and Development. All persons trained shall be able to demonstrate that they meet the minimum competency standards of the training prior to becoming involved with the confined space work.
Training shall be conducted by persons knowledgeable in all relevant aspects of confined space entry, hazard recognition, use of safety equipment and methods of rescue, and approved by the Group Manager Safety Health and Environment.

1.12.3 Re-fresher training

All personnel involved with confined space entry work shall receive re-fresher training at a minimum of every two years.

1.12.4 Health Assessments

All personnel who are required to work within a confined space shall be assessed for their ability to enter and perform the tasks envisaged within the confined space. Refer to Safety Procedure Health Assessments.

Assessments shall include the ability to wear respiratory protection (excluding self-contained Breathing Apparatus and Supplied Air Respirators), the ability to climb ladders and whether the person suffers from claustrophobia.

1.13 Emergency and Rescue Procedures

1.13.1 Minimum Requirements

The person(s) responsible for the confined space work shall ensure that prior to any entry into a confined space:

- That there is equipment readily available to remove personnel from inside the confined space should an emergency arise.
- There are suitably trained personnel who can affect a rescue from a confined space who are readily available
- There are first aid facilitates available that can provide emergency treatment to personnel should the need arise, and that there are appropriately trained persons who can administer the first aid.

1.13.1.1 Use of Safety Lines & Harnesses

All personnel who work within a confined space shall wear a safety harness where it is determined by the risk assessment that it is deemed necessary. The purpose of the safety harness is to allow for quick and easy removal of the person should they collapse within the confined space. The wearing of a safety harness is mandatory where a person would have to be lifted out in a vertical position. However at times, it is not always practicable for persons working within the confined space to be attached to a safety line, as the line may interfere with the work process or become caught on obstructions.

1.13.2 Emergency Procedures

1.13.2.1 Within the confined space

In case of an emergency the sentry shall:

- Where possible evacuate all personnel from the confined space, using entry / exit log
- Alert emergency response personnel of the emergency occurring and the nature of the emergency through use of a portable radio.
- Isolate or have isolated all power sources and other supplies to the confined space, except for breathing air services
- Ensure that no one except for trained emergency response personnel enter the confined space,
- Person responsible for the work in the confined space shall take charge of the situation.

Under no circumstances shall the sentry attempt to enter the confined space to assist in the rescue of persons within the confined space.

1.13.2.2 External to the confined space

On sites where emergency alarms are installed the sentry on hearing the emergency alarm shall:

- Evacuate all personnel from the confined space,
- Isolate or have isolated all power sources and other supplies to the confined space, except for breathing air services
- Ensures that no one re-enters the confined space until the all clear has been given by the responsible person
- Ensures that all personnel follow the site emergency procedure
- Arrange for rescue if necessary (see above)
- Arranges for atmospheric monitoring to be conducted where appropriate.

1.14 Rescue from a Confined Space

1.14.1 Rescue Plan

A written rescue plan shall be developed where it has been identified in the risk assessment that the:

- Atmospheric conditions present a risk of harm to health or injury to personnel inside, or they will not support life,
- Internal obstructions / conditions make it difficult to rescue personnel (vertical entry or difficulty of access).

The rescue plan shall include:

- Worst case scenario - what the plan is addressing
- Equipment and personnel required to conduct the rescue

- Steps to be followed during the rescue.

The rescue plan is to be discussed with all personnel working within the confined space, the sentry, the person responsible for the work that is being undertaken and the rescue personnel prior to entry into the confined space.

1.15 Hot Work and Welding in a Confined Space

1.15.1 Welding precautions to be taken

Special consideration needs to be given to any form of hot work within a confined space. Hot work can be defined as welding, thermal or oxygen cutting or heating, and other related heat-producing or spark-producing operations.

Any type of hot work operation can deplete the oxygen content from the confined space and add toxic fumes into it. Welding within a confined space can considerably increase the risk of electric shock to the persons working inside.

The following precautions shall be implemented prior to the commencement of hot work in any confined space:

- The atmosphere shall be tested to ensure that hot work can take place safely.
- Monitoring of the atmosphere shall occur at all times.
- All combustible materials not required for the job shall be removed outside the confined space to a safe distance.
- A suitable flame-retardant covering shall protect combustible materials that cannot be removed.
- Portable hand held fire extinguishers shall be in place in the area - water or dry chemical powder only.
- If welding operations are suspended during rest breaks or overnight the power source to the equipment shall be switched off and if practicable removed from the confined space.
- If gas cutting or welding is suspended during meal breaks or overnight the torch and gas hoses shall be removed from the confined space and depressurised.

- Where it is determined that welding operations pose a risk of electric shock to the welder, a welding circuit safety switch or suitable alternative device shall be placed on all welding electrode leads and be so located that the standby person or welders assistant can keep the welder under constant observation and immediately isolate the electric circuit in the event of an emergency.
- The sentry or standby person must be trained in CPR.
- Welder shall work on insulated material (Note: a scaffold may be tied into the confined space structure and therefore cannot be considered insulated)
- Precautions shall be taken when welders working in close proximity from separate power sources to ensure that they do not come in contact with each other, i.e. erection of barriers.
- Exhaust ventilation shall be used to extract fumes out of the confined space.
- The Responsible Person or Standby Person shall check the area for fire 30 minutes after work has been completed.
- All gas cylinders are to remain outside the confined space.

1.15.2 Electrical Work Precautions

Using electrical tools and equipment within confined spaces poses two distinct risks:

- The possibility receiving an electric shock from the equipment
- The possibility of a spark igniting flammable gases contained within the confined space or which have entered the confined space from the external environment.

The following precautions shall be adopted to minimise these risks:

- Removal of all flammable gases from within the confined space.
- Setting up an exclusion to prevent the ingress of flammable gases into the work area.
- Performing the work external to the confined space in a non-hazardous environment.
- Using air-powered tools as an alternative.
- Using low-voltage equipment where possible.
- Having all electrical tools and equipment connected to residual current devices, as close as possible to the confined space.

- All electrical equipment shall conform to AS 3100 and be double insulated where available.
- All leads shall be heavy duty and shall be located, suspended or guarded to minimise against damage.

1.16 Safe Work Instructions

1.16.1 Need for Safe Work Instructions

From time to time it is recognised that the exact requirements of this procedure and the relevant state legislation's may not be able to be met. In these circumstances safe work instructions shall be developed for each task where this applies. The Safe Work Instructions shall detail the reasons why the requirements can not be met and specially state the task steps and controls that need to be implemented to all the work to occur without putting the safety and health of personnel at risk of injury or damage to health.

The Contract Manager and the Group Manager Safety, Health and Environment shall review these safe work instructions and authorise their use prior to the commencement of the work. It shall be made clear to all personnel working on that particular job that these instructions are a deviation from the standard procedure and that special precautions have been taken to ensure that personnel are not placed at undue risk

1.17 Atmospheric Requirements of Confined Spaces

The list below is the recommended minimum and maximum exposure limits for atmospheric quality and contaminants within confined spaces. Client organisations may specify additional quality requirements, where this is the case the client's standards should be used.

Gas Tested for	**Minimum Concentration**	**Maximum Concentration**	**Test Method**
Oxygen	N/A	23.5%	
Carbon Dioxide	N/A	0.05%	
Carbon Monoxide	N/A	24ppm	
Hydrogen Sulphide	N/A	2ppm	
Ammonia	N/A	5ppm	
Sulphur Dioxide	N/A	5ppm	
Chlorine	N/A	1ppm	
Ozone	N/A	0.1pp	
Lower Explosive Limit (LEL)	N/A	5%	

1.18 Ventilation Considerations for Confined Spaces

The following elements shall be taken into consideration when determining the ventilation requirements for confined space work.

- The work to be conducted, will it introduce additional atmospheric contaminants (welding, cleaning, abrasive blasting, painting)
- Internal obstructions that will affect the air flow, such as baffles, piping and dead legs
- Contaminants contained within the confined space. Have they been completely removed?
- Existing openings – can be used to assist in the ventilation by creating additional openings for air to circulate
- Contamination from external sources such as exhausts, vents, combustion engines. Air intakes must be located away from these contamination sources

- Natural drafts – should be used to assist in ventilation, set up air flows to take advantage of these
- Vented contaminants should be exhausted downwind from the confined space and from people working in the area
- Ventilation must take into account the internal temperature of the confined space. Consideration shall be given to the work that is to be performed within the confined space and whether this will add to the internal temperature.
- Where work is to be conducted in an area containing flammable gases, ventilation ducts must be earthed to prevent the accumulation of static electricity.

1.19 Duties of Sentries

As a minimum requirement all persons performing sentry duties shall:

- Have an awareness of the nature of the work that is being performed, read and understand the conditions of entry.
- Have a means to communicate with the persons working inside the confined space. Ideally line of sight is the best means, but use of radios, rope signals are a suitable alternative,
- Have the ability to raise an alarm immediately or almost immediately should an emergency occur within the confined space. The sentry must remain at the entry point (if it is necessary for a sentry to leave the area of the entry point to raise the alarm, then another method must be established to raise the alarm allowing the sentry to remain in position, i.e. use of radios to raise the alarm).
- Ensure that all personnel who enter the confined space read and understand the conditions for entry,
- Ensure that all personnel who enter the confined space sign onto the entry permit and hang a personal danger tag on the permit entry board,
- Ensure that all relevant documentation pertaining to the confined space entry, including gas testing results, hazard identification, risk assessment and any other paper work are located with the confined space entry permit,
- Receive training in the responsibilities of being a sentry, and deemed to be competent to perform the duties of a sentry

- Ensure that either barriers or signs are placed across every opening to the confined space when no work is being performed inside.
- Ensure that ventilation to the confined space remains in operation, should the ventilation fail withdraw personnel from the confined space.
- Withdraw personnel from the confined space should an emergency occur either internal or external to the confined space,
- Keep the entrance to the confined space clear and free of obstruction as far as practicable and ensure that the confined space and the area around it is left in a clean and tidy condition at the end of each day,
- Complete the Sentry Daily Checklist prior to allowing any person to enter the confined space,
- Suspend work and withdraw personnel from the confined space if they fail to conform to the requirements of the entry permit and this safe work standard.

2.0 DEFINITIONS

Atmospheric Contaminant

Any dust, fume, vapour, mist or gas, the presence of which can be harmful to the health of a person either short or long term.

Competent Person

Means a person who through a combination of training, education and experience has acquired knowledge and skills enabling that person to perform correctly a specified task.

Confined Space

Any area of work that is not intended as a regular workplace, has restricted means of entry and exit, has inadequate ventilation and / or an atmosphere that contains toxic materials, is deficient in oxygen or causes engulfment.

These include, but are not limited to:

- Any tank, vessel or boiler, etc.
- Open topped spaces greater than 1.2m
- Any pipe, sewer, duct or shaft
- Any plant in which the head of a person must penetrate to inspect or work in a space that has the potential for an oxygen deficient or toxic atmosphere.

Gas Tester

A competent person authorised to perform gas tests.

Local Exhaust Ventilation

A ventilating system used to extract airborne contaminants form an area at the point of generation of the contaminants.

Lower Explosive Limit (LEL)

The smallest quantity of flammable gas or vapour which when mixed with air will burn if ignited.

May

Is used where alternatives are acceptable

Hot work

Welding, thermal, or oxygen cutting or heating, and other related heat-producing or spark-producing operations. For example:

- Welding or flame cutting equipment;
- Grinder, electric drill or other non-flameproof electrical equipment;
- Hot tapping equipment;
- Spark ignition engines or non-approved compression ignition engines;
- Match, naked light, cigarette lighter, flame or spark;
- Hand tools that may create a spark;
- Non-flammable electric cables, cords, switches, lights, connections or fittings;
- Any other thing that is likely to produce a source of ignition or be an ignition source.

Permit Acceptor / Recipient

A competent person responsible for ensuring that work is conducted in a safe manner (in accordance with permit conditions) and, once work is completed, that plant and equipment is returned in a safe condition for operation.

Permit Issuer

A competent person responsible for ensuring that equipment is prepared for work and all hazards have been assessed and controlled through isolations and / or by prescribing precautions to be followed.

Sentry / Stand-by Person

A competent person who is assigned to remain outside and in close proximity to a confined space and perform duties as specified in Section x of this standard.

Shall

These terms are used where is provision is mandatory.

Should

Is used where a provision is preferred.

Entry

For the purposes of this safe work standard, a person is said to have entered a confined space if their upper body protrudes into the confined. In some cases, the risk assessment and permit condition may include that any body part (head, arm or leg) protruding into the opening of confined space shall be considered as entering the confined space.

3.0 REFERENCES

AS 1674.1 - 1990 Safety in welding and allied processes – Fire Precautions

AS 1674.2 – 1990 Safety in welding and allied processes – Electrical (welding safety)

AS 2380 – 1989 Electrical equipment for explosive atmosphere – Explosion-Protection techniques

AS 2381 – 1985 Electrical equipment for explosive atmosphere – Selection, installation and maintenance

AS 2430.1 – 1987 Classification of Hazardous Areas

AS 2865 – 1995 Safe Working in a Confined Space

AS 3100 – 1997 Approval and test specification – General requirements for electrical equipment

9.2 Western Australian Fatal Accident Data

DATE	AGE SEX	CONTRACT EMPLOYEE	INDUSTRY	PROFESSION	LOCATION	MECHANISM OF INJURY	CONTRIBUTING FACTORS
28/08/80			Mining	Tradesperson		Struck by object (rock)	
22/09/80			Mining	Supervisor		Trench collapse	
04/05/81			Mining			Struck by (rock fall)	
25/06/81			Mining	Tradesperson & Assoc		Struck by (rock fall)	
22/07/81			Mining	Tradesperson & Assoc			
11/09/81			Mining	Tradesperson & Assoc		Engulfment (iron ore)	
24/02/82				Shop Owner		Fatal Laceration	
24/05/82			Mining	Tradesperson & Assoc		Struck by (rock fall)	
15/09/82			Mining	Tradesperson & Assoc - Operator		Struck by (rock fall)	
6/10/82	Male 38	Employee	Construction	Labourer	Trench	Engulfment (NHA)	Failure to recognise area as a confined space No training No supervision
23/11/82	Male 19	Employee	Agriculture	Labourer- Farmer	Silo	Electrocution (NHA)	No training No supervision No system of work
14/12/82			Mining			Struck by (rock fall)	
24/12/83			Mining	Tradesperson & Assoc - Operator		Engulfment	

DATE	AGE SEX	CONTRACT EMPLOYEE	INDUSTRY	PROFESSION	LOCATION	MECHANISM OF INJURY	CONTRIBUTING FACTORS
22/06/83			Mining			Struck by (rock fall)	
25/08/83			Mining			Falls from height	
1/09/84			Mining	Tradesperson & Assoc		Struck by (rock fall)	
23/01/84	Male 16	Contractor	Electrical	Tradesperson & Assoc - Electrician	Ceiling Space	Electrocution (NHA)	No training No supervision No safe system of work
22/02/84			Mining	Tradesperson & Assoc		Struck by (rock fall)	
03/08/84			Mining	Tradesperson & Assoc		Struck by (concrete slab)	
01/11/84			Mining	Supervisor		Struck by (rock fall)	
23/04/85	Male 23	Contractor	Electrical	Tradesperson & Assoc - Electrician	Ceiling Space	Electrocution (NHA)	Failure to identify as confined space No Supervision No Training No system of work, procedures
02/07/85			Mining			Struck by (rock fall)	
23/10/85			Mining	Tradesperson & Assoc		Engulfment	
07/11/85			Mining	Supervisor		Asphyxiation?	
11/12/85			Mining			Asphyxiation/H2S	
19/02/86			Mining			Struck by (rock fall)	
21/03/86			Mining	Tradesperson & Assoc - Operator		Engulfment (iron ore)	

DATE	AGE SEX	CONTRACT EMPLOYEE	INDUSTRY	PROFESSION	LOCATION	MECHANISM OF INJURY	CONTRIBUTING FACTORS
13/11/86	Male 53		Construction	Tradesperson & Assoc - Furniture Upholsterer	Motor Launch Cabin	Toxic Atmosphere (chlorinated solvents) (HA)	No Supervision No Training No system of work
15/10/87			Mining			Falls from height	
05/01/88	Male 20		Electrical	Tradesperson & Assoc - Electrician	Ceiling Space	Electrocution (NHA)	No Supervision No Training No system of work
15/05/88			Mining			Engulfment (soil in hopper)	
23/05/88			Mining			Falls from height	
06/09/88			Mining	Tradesperson & Assoc - Operator		Struck by (rock fall)	
16/09/88			Mining	Labourer - Operator		Caught between (wall/operator)	
14/04/89			Mining			Struck by (roof)	
30/05/89			Mining	Tradesperson & Assoc - Electrician		Asphyxiation (unventilated)	
14/06/89			Mining	4 x Labourers / 2 x Supervisors		Drowning	
13/07/89			Mining	Labourer		Engulfment	
21/12/89			Mining	Labourer		Struck by (iron ore)	
28/12/89			Mining			Asphyxiation (carbon	

DATE	AGE SEX	CONTRACT EMPLOYEE	INDUSTRY	PROFESSION	LOCATION	MECHANISM OF INJURY	CONTRIBUTING FACTORS
						monoxide)	
22/01/90	Male 53	Employee	Agricultural - Abattoir	Labourer	Vat	Struck by (vat strainer) Non-Hazardous Atmosphere(NHA)	Failure to identify areas as confined space No training No Supervision No safe system of work
07/02/90			Mining	Director& Tradesperson & Assoc		Struck by (concrete slab)	
10/02/90			Mining	Tradesperson & Assoc		Falls from height	
20/11/90			Mining			Struck by (rock fall)	
14/05/91			Mining			Engulfment (iron ore)	
21/05/91			Mining			Engulfment (iron ore)	
02/08/91			Mining	Tradesperson & Assoc - Operator		Struck by (rock fall)	
24/08/91			Mining	Tradesperson & Assoc - Operator		Struck by (rock fall)	
21/01/93	Male 19	Contractor	Fishing/ Agriculture/ Forestry	Tradesperson & Assoc - Refrigeration Mechanic		Toxic Atmosphere (chlorinated solvent) (Hazardous Atmosphere HA)	
08/12/95	Male 56	Contractor	Electrical	Tradesperson & Assoc - Electrician	Ceiling Space	Electrocution (NHA)	Failure to identify area as confined space

DATE	AGE SEX	CONTRACT EMPLOYEE	INDUSTRY	PROFESSION	LOCATION	MECHANISM OF INJURY	CONTRIBUTING FACTORS
							No training No supervision No system of work
16/12/96	Female 13	Other	Agriculture	Daughter of Farmer	Silo	Asphyxiating Atmosphere (O_2 deficiency) (HA)	
19/03/98	Male 27	Employee	Manufacturing	Trainee Wine Maker	Vat	Asphyxiating Atmosphere (O_2 deficiency) (HA)	Failure to identify area as confined space No training Inadequate Supervision No system of work
15/05/98	Male 49	Employee	Construction	Professional - Engineer	Air Heater	Falls from height(NHA)	Failure to follow safe systems of work (fall arrest procedure not followed)
03/03/01	Male 29	Employee	Construction	Tradesperson & Assoc - Welder	Shipyard	Electrocution (boat fuel tank) (NHA)	Failure to follow safe systems of work eg confined space procedure permit and heat stress procedure.
12/11/02	Male 27	Contractor	Electrical	Tradesperson & Assoc - Fitter	Ceiling Space	Electrocution (NHA)	Failure to identify area as confined space

DATE	AGE SEX	CONTRACT EMPLOYEE	INDUSTRY	PROFESSION	LOCATION	MECHANISM OF INJURY	CONTRIBUTING FACTORS
							No training No supervision No safe systems of work
20/01/04	Male 48	Contractor	Construction	Tradesperson & Assoc - Electrician	Ceiling Space	Electrocution (NHA)	Failure to identify area as confined space No training No supervision No safe systems of work

9.3 Traumatic Work Related Fatality Statistics

TRAUMATIC WORK RELATED FATALITY STATISTICS																					
		88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	**Total**
Industry (ANZSIC)																					
01to04	Ag/For/Fish	8	5	4	9	4	5	12	4	1	5	4	5	6	5	4	10	1	2	2	**96**
11to16	Mining	16	10	13	6	6	8	10	5	8	13	3	6	5	3	6	4	2	5	0	**129**
21to26,29	Manufacturing	2	2	2	2	0	1	1	0	1	1	1	3	1	2	1	0	2	2	1	**25**
27, 28	Manufacturing Metal	1	0	1	0	2	0	0	0	3	0	1	0	0	0	0	0	1	0	0	**9**
36,37	Elect/Gas/Water	1	1	0	1	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	**7**
41to42	Construction	4	2	2	1	6	5	6	5	4	2	2	2	3	2	7	4	2	1	1	**61**
45to47	W/sale Trade	1	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	**5**
51to53	Retail trade	0	0	0	0	1	1	0	0	0	1	0	0	0	1	1	0	0	0	0	**5**
57	Accom, cafes, resta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
61to67	Transp/Store	0	2	2	2	1	0	0	2	0	2	2	2	1	3	1	2	4	0	1	**27**
71	Communications	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
73to75	Finance & Insurance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
77to78	Property & Business	0	3	0	0	1	0	1	2	1	0	0	0	0	1	0	0	3	0	0	**12**
81to82	Government Admin	2	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	**7**
84	Education	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	**4**
86to87	Health & Community	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	**2**
91to96	Cultural & Recreat	1	0	0	0	0	1	0	0	0	1	0	0	4	0	1	0	2	0	0	**10**
95to97	Personal & Other	0	1	1	0	3	0	0	1	1	0	0	1	0	1	1	0	3	0	0	**13**
	TOTAL	**36**	**27**	**26**	**22**	**25**	**24**	**31**	**19**	**20**	**26**	**14**	**21**	**21**	**18**	**23**	**20**	**22**	**12**	**5**	**412**
Type																					
Fall of person		3	1	0	2	5	2	1	2	1	4	1	3	0	3	1	2	5	2	0	**38**
Falling object		7	10	8	3	5	4	8	6	6	6	3	1	2	0	5	2	1	1	0	**78**
Struck by		5	4	4	4	7	5	0	4	8	6	3	3	2	0	8	5	8	3	1	**80**
Caught between		2	4	4	2	2	5	9	1	0	5	4	8	4	8	3	4	6	2	0	**73**
Electrocution		6	1	1	3	3	1	3	3	2	1	2	3	3	1	2	3	1	3	1	**43**

Asphyxia		12	2	0	5	2	4	8	2	2	4	0	0	2	2	3	3	0	0	2	**53**
Explosion		0	0	1	0	0	0	0	0	1	0	1	3	0	1	0	1	1	1	0	**10**
Other/unknown		1	5	8	3	1	3	2	1	0	0	0	0	8	3	1	0	0	0	1	**37**
																					0
	TOTAL	**36**	**27**	**26**	**22**	**25**	**24**	**31**	**19**	**20**	**26**	**14**	**21**	**21**	**18**	**23**	**20**	**22**	**12**	**5**	**412**
Age Group																					
< - 19		5	0	0	1	2	0	1	0	3	2	0	1	0	1	2	1	1	0	0	**20**
20 - 24		7	1	3	6	3	4	4	2	2	0	4	2	1	0	2	1	3	0	1	**46**
25 - 34		10	14	6	10	10	4	11	8	3	9	3	5	5	7	6	7	7	4	0	**129**
35 - 44		9	7	6	3	4	9	6	2	7	5	4	7	6	4	1	2	2	3	2	**89**
45 - 54		4	5	5	2	5	4	7	6	2	6	2	6	6	3	7	3	2	1	0	**76**
55 - 59		1	0	3	0	1	0	1	1	1	0	1	0	1	2	2	2	3	0	1	**20**
60 - 64		0	0	1	0	0	1	0	0	1	2	0	0	0	1	1	0	2	2	1	**12**
65 - 69		0	0	0	0	0	0	0	0	1	2	0	0	1	0	0	2	1	1	0	**8**
70 +		0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	**5**
Unknown		0	0	1	0	0	1	1	0	0	0	0	0	1	0	1	1	0	1	0	**7**
																					0
	TOTAL	**36**	**27**	**26**	**22**	**25**	**24**	**31**	**19**	**20**	**26**	**14**	**21**	**21**	**18**	**23**	**20**	**22**	**12**	**5**	**412**
Priority Area																					
Electrocution		6	1	1	3	3	1	3	3	2	1	2	3	3	1	2	3	1	3	1	**43**
Fall from Height		3	1	0	2	5	2	1	2	1	3	1	3	0	2	1	2	5	2	0	**36**
Tractor		1	3	2	1	2	4	1	0	1	1	0	0	0	0	1	1	0	0	0	**18**
Forklift		0	1	2	2	1	0	0	2	0	2	0	1	0	0	0	0	1	0	0	**12**
Demolition		1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	**4**
Non Priority areas		25	21	21	14	14	17	26	11	15	19	11	14	18	15	19	13	15	7	4	**299**
	TOTAL	**36**	**27**	**26**	**22**	**25**	**24**	**31**	**19**	**20**	**26**	**14**	**21**	**21**	**18**	**23**	**20**	**22**	**12**	**5**	**412**
Locality where death occurred (Metropolitan area as defined by DOLA)																					

Country		27	22	21	19	14	19	26	12	14	23	11	17	18	11	16	16	12	8	3	**309**
Metropolitan		9	5	5	3	11	5	5	7	6	3	3	4	3	7	7	4	10	4	2	**103**
	TOTAL	**36**	**27**	**26**	**22**	**25**	**24**	**31**	**19**	**20**	**26**	**14**	**21**	**21**	**18**	**23**	**20**	**22**	**12**	**5**	**412**
	Note: All deaths in Group 11 to 16 (Mining) were in the country																				
								Data collection at 21 September 2006													