POLITECNICO DI TORINO

Corso di Dottorato in Ambiente e Territorio
Georisorse e Geotecnologie

Ciclo XXV

TESI DI DOTTORATO

THE PREVENTION THROUGH DESIGN APPROACH IN THE MINING ACTIVITIES

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GIUDIZIO CONCLUSIVO SULL'ATTIVITA' SVOLTA NEL TRIENNIO 2010-2012

POLITECNICO DI TORINO
Scuola di Dottorato

dottorato in Ambiente e Territorio

COLLEGIO DEL DOTTORATO DI RICERCA IN AMBIENTE E TERRITORIO

GIUDIZIO CONCLUSIVO SULL'ATTIVITÀ NEL TRIENNIO DEL

DOTTORANDO: Alberto MARTINETTI

L'attività svolta dal candidato Alberto Martinetti per cui a suo tempo fu proposto lo sviluppo in ambito Georisorse e Geotecnologie del dottorato di ricerca in Ambiente e Territorio riguardava sostanzialmente l'ottimizzazione delle attività di coltivazione e scavo, il cui aspetto basilare (se non altro per evitare una immediata diminuzione dell'efficienza produttiva che ne deriverebbe) è rappresentato dalla gestione degli aspetti di sicurezza e igiene del lavoro.
Pertanto si è ritenuto di concentrare l'attività di dottorato da un lato nel perfezionamento, adottando un approccio in "Prevention through Design", di una tecnica "computer assisted" di supporto e analisi delle fasi di progettazione e conduzione delle unità estrattive (che peraltro ha trovato impostazione e sviluppo nell'ambito di una collaborazione tra il Dipartimento di Ingegneria per l'Ambiente, il Territorio e le Infrastrutture – DIATI, allora Dipartimento di Ingegneria dell'Ambiente del Territorio e delle Geotecnologie – DITAG del Politecnico di Torino e il Servizio di Tutela Ambientale della Provincia di Torino), e dall'altro nella ottimizzazione e gestione di tali attività in ottica di miglioramento continuo della sicurezza e dell'efficienza produttiva.
Durante questo periodo di formazione sono state svolte attività che hanno portato in particolare ad una più puntuale definizione degli aspetti di gestione delle unità estrattive attraverso il completamento del software proposto e attraverso la più peculiare conoscenza della realtà in esame grazie a ripetuti accessi in cave a giorno e in sotterraneo.
Preso atto dei risultati ottenuti durante il primo e il secondo anno di dottorato, si sono quindi seguiti due differenti temi di sviluppo al fine di rendere più efficaci gli strumenti messi a punto e nel contempo di pervenire all'obbiettivo di una sempre più capillare diffusione dei concetti di sicurezza, cercando anche di porre l'accento su aspetti sovente non particolarmente approfonditi durante la fase progettuale e di gestione quali le valutazioni di disponibilità di sistema e dei rischi economici e sociali associati a tali settori industriali. Illustrando a livello nazionale, regionale e provinciale in particolare la situazione infortunistica, le malattie lavoro-correlate di comparto e le violazioni più ricorrenti alle norme vigenti (presentando inoltre le modalità di approccio al problema MSHA / OSHA), da una parte si sono sviluppati modelli di applicazione delle tecniche di valutazione e gestione dei rischi selezionate per i diversi scenari in un comparto costituito da persone "non potenzialmente formate", e dall'altro si sono estesi i criteri di "Prevention through Design" sia a contesti estrattivi non rientranti nell'area geografica presa in considerazione per ampliare il campo degli scenari analizzati a prescindere dalle tipologie di un particolare contesto regionale (e.g. le attività in sotterraneo con le associate estese problematiche specifiche), sia a contesti di scavo anche non estrattivi (cantieristica civile a giorno ed in sotterraneo) per individuare quali spunti di approfondimento sul tema in studio se ne potevano ricavare.
Si è cercato infine di sottolineare l'assoluta importanza di una progettazione pro-attiva fin dalle prime fasi di studio in ottica di un continuo miglioramento della disponibilità del sistema (macchine, impianti e procedure formalizzate) e della valutazione e gestione dei rischi attraverso l'approccio consigliato dalla

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comunità europea con le Direttive qualità prodotto / qualità sistema / qualità ambiente – gestione in qualità della sicurezza, evidenziando anche quelle operazioni "routinarie" che richiedono costantemente di ripristinare i corretti livelli di attenzione dell'operatore e, con l'aiuto di alcune tecniche di Hazard Identification, si sono individuate le deviazioni dalle normali condizioni di lavoro e le conseguenti possibilità di gestione nei casi studio analizzati.
Il candidato, ai fini di inquadrare teoricamente il lavoro di ricerca, ha anche, durante il triennio, affrontato lo studio dei seguenti argomenti specifici:
 Disponibilità e affidabilità di sistema per una ottimizzazione dell'efficienza produttiva;
 Approccio in "Prevention through Design" alla conduzione delle attività estrattive;
 Aspetti di impostazione del sistema di ventilazione per gli ambienti sotterranei;
 Valutazione delle emergenze negli ambienti di lavoro sotterraneo con particolare attenzione alle problematiche inerenti alla formazione di incendi;
 Aspetti di Sicurezza dei lavoratori nelle attività estrattive e nei cantieri di scavo;
 Aspetti di Salute dei lavoratori nelle attività estrattive e nei cantieri di scavo.
Le ricerche svolte hanno dato origine a 2 proceeding in congressi internazionali, 2 pubblicazioni sul sito della Provincia di Torino, 2 pubblicazioni attualmente in fase di revisione su riviste scopus internazionali e 2 proceeding attualmente in fase di accettazione ad un congresso internazionale

In conclusione il Collegio, unanime, giudica **MOLTO POSITIVA** l'attività svolta dal Dottorando nel corso del suo ciclo di dottorato.

Torino, 6 dicembre 2012

ACKNOWLEDGEMENT

I would like to give my personal gratitude to Professor Patrucco, who, during these three years of PhD, has taught me a new and more rigorous “way of working”.

Moreover a special thought is for my “journey companions” Laura, Luisa and Davide, to whom I wish the very best.

Even though I am not so sure that she could understand, I would like to thank Nara for all the times she was patiently waiting for me at home.

Finally, thank you Julia for the essential English “suggestions”, and for all the rest.

FOREWORD

“Experience is simply the name we give to our mistakes”

Oscar Wilde

THE PROBLEM: why a Philosophiae Doctor on mining activities?

Writing a Philosophiae Doctor thesis is probably one of the most difficult and at the same time interesting jobs that can be faced by a student throughout his career both in terms of scientific results and in terms of “self-government”. The opportunity (and luck) to write again about Safety and Health in the mining activities after the master’s thesis is acknowledged by the author.

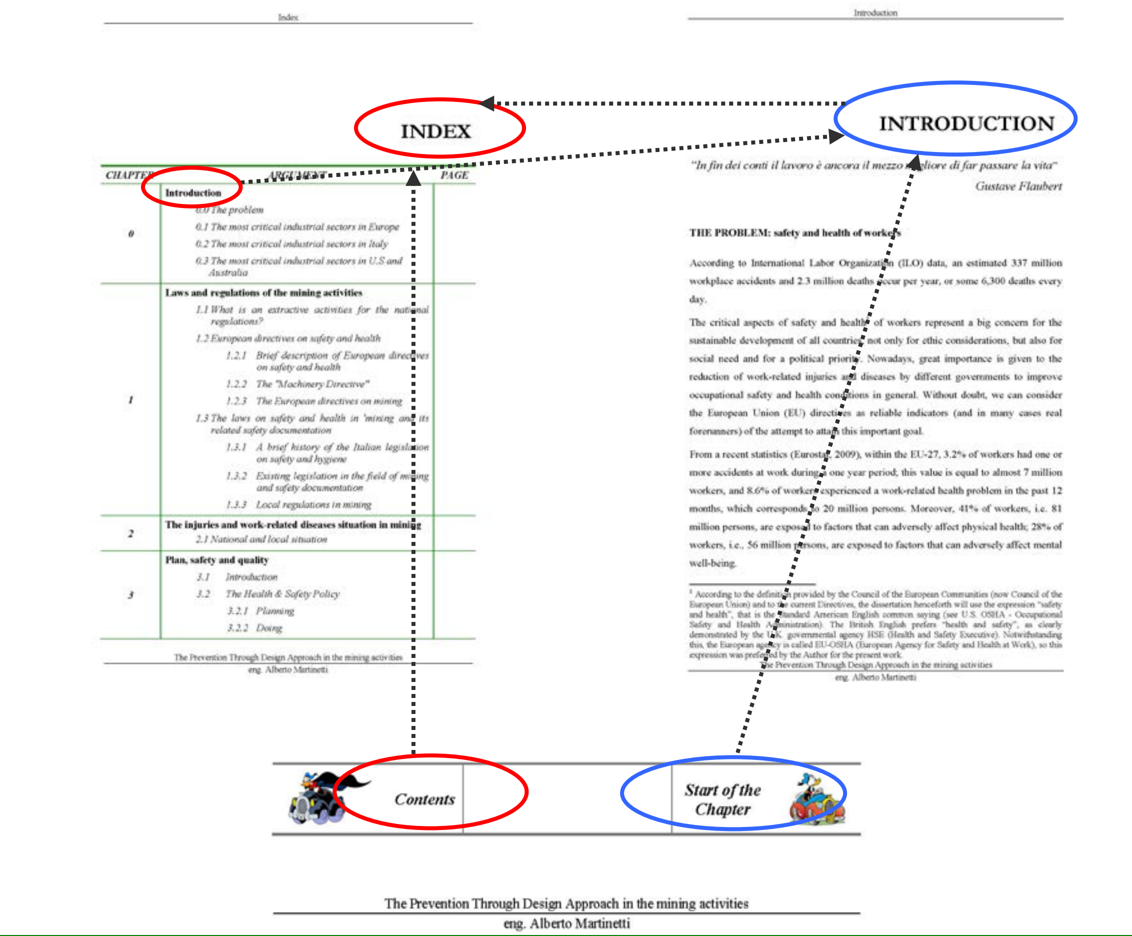
The relevance of mining activities in the industrial sectors for the supply of materials for production of goods has been known over the centuries.

However it should not be forgotten how these operations could be source of risks both for workers and for the environment. At the same time it is evident how the environmental sustainability and the working conditions are closely related not only to the regulations enforced, but also to the "best available technologies" (technical innovations available and economically adoptable) in order to minimise risks, considering Safety as a design parameter during the planning phase.

NOTE
OF THE AUTHOR

The reading of the thesis (for the digital release only) is made easier by the adoption of *bookmarks* and *hyperlinks* which allow the reader to jump through the chapters and through the annexes more quickly.

The title of every chapter (excluding the “Forward” and the “Note of the Author”) is provided of an hyperlink to return to the contents; moreover, at the end of every chapter, there are two “*hyperimages*” that lead to the top of the chapter or to the contents, as explained in the following figure.



The works carried out during the three years of PhD have led to different results written both in English and in Italian due to part of the research projects conducted for an Italian Local Mining Authority.

Nevertheless the language used for the writing of the thesis is English; an overview of the Italian documents is provided throughout the different chapters, whereas the entire documents are attached as Annexes.

CONTENTS

INTRODUCTION

"In fin dei conti il lavoro è ancora il mezzo migliore di far passare la vita"

Gustave Flaubert

0.0 THE PROBLEM

According to the International Labor Organisation (ILO) data, an estimated 337 million workplace accidents and 2.3 million deaths occur every year, or some 6,300 deaths every day.

0.1 THE MOST CRITICAL INDUSTRIAL SECTORS IN EUROPE

The critical aspects of Safety and Health[1] of workers represent a big concern for the sustainable development of all countries, not only for ethical considerations, but also for social need and for a political priority. Nowadays, great importance is given to the reduction of work-related injuries and diseases by different governments to improve occupational Safety and Health conditions in general. Without doubt, we can consider the European Union (EU) directives as reliable indicators (and in many cases real forerunners) of the attempt to attain this important goal.

From a recent statistics (Eurostat, 2009), within the EU-27, 3.2% of workers have had one or more accidents at work during a one year period; this value is equal to almost 7 million workers, and 8.6% of workers experienced a work-related health problem in the past 12 months, which corresponds to 20 million people. Moreover, 41% of workers, i.e. 81 million people, are exposed to factors that can adversely affect physical health;

[1] According to the definition provided by the Council of the European Communities (now Council of the European Union) and to the current Directives, the dissertation henceforth will use the expression "Safety and Health", that is the Standard American English common saying (see U.S. OSHA - Occupational Safety and Health Administration). The British English prefers "Health and Safety", as clearly demonstrated by the U.K. governmental agency HSE (Health and Safety Executive). Notwithstanding this, the European agency is called EU-OSHA (European Agency for Safety and Health at Work), so this expression was preferred by the Author for the present work.

28% of workers, i.e., 56 million people, are exposed to factors that can adversely affect mental well-being.

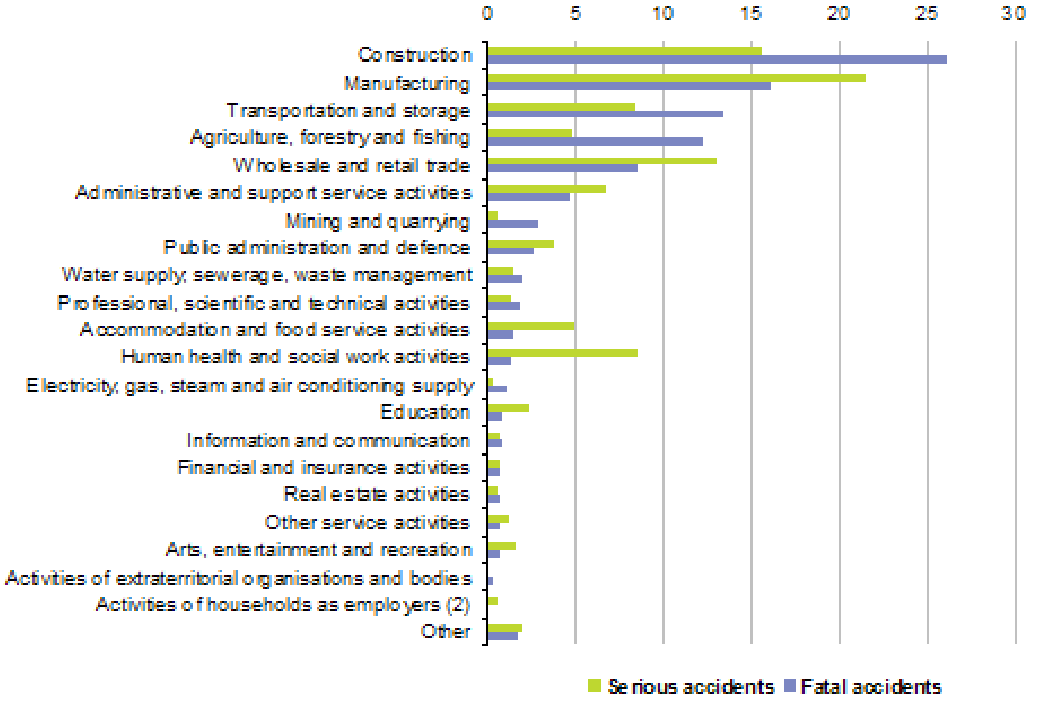
In 2009, there were just over 2.8 million serious accidents that resulted in more than three days of absence from work, and an estimated 3,106 fatal accidents in the EU-27 (excluding Greece and Northern Ireland). These figures marked a considerable reduction in relation to 2008, when there had been approximately 400,000 more serious accidents and nearly 700 more fatal accidents. Men are considerably more likely than women to have an accident or to die at work. Almost four out of every five (79.5 %) serious accidents at work and nineteen out of every twenty (94.9 %) fatal accidents at work in the EU-27 in 2009 involved men.

	Accidents at work involving more than three days of absence from work			Fatal accidents at work		
	Total	Male	Female	Total	Male	Female
EU-27 (2)	*2 800 681*	*2 226 693*	*573 627*	*3 806*	*3 610*	*196*
Belgium	54 707	45 568	9 118	65	64	:
Bulgaria (3)	*1 961*	*1 513*	*448*	*78*	*74*	*4*
Czech Republic	58 100	43 993	14 106	91	84	7
Denmark	37 725	28 832	8 697	31	31	:
Germany	698 070	572 953	125 003	454	436	18
Estonia	4 255	2 583	1 672	13	13	:
Ireland	7 751	5 628	2 092	31	30	:
Greece	:	:	:	:	:	:
Spain	441 616	344 095	97 521	354	338	16
France	474 825	368 609	106 216	492	452	40
Italy	383 274	310 639	72 635	633	617	16
Cyprus	1 960	1 561	399	7	7	:
Latvia (3)	*872*	*612*	*260*	*29*	*25*	*4*
Lithuania	1 640	1 217	423	45	40	5
Luxembourg	5 895	5 066	829	5	5	:
Hungary	15 326	11 140	4 186	91	85	6
Malta	2 413	2 178	235	6	6	:
Netherlands	106 439	80 085	26 353	54	53	6
Austria	57 715	48 329	9 386	153	144	9
Poland	62 721	48 696	14 025	334	319	15
Portugal	133 100	105 577	27 523	204	198	6
Romania (3)	*3 020*	*2 366*	*654*	*370*	*340*	*30*
Slovenia	14 361	11 636	2 725	26	26	:
Slovakia	8 112	5 896	2 216	42	38	4
Finland	34 316	27 730	6 586	28	25	:
Sweden	21 464	16 196	5 268	37	34	:
United Kingdom (4)	169 043	133 992	35 051	133	126	7
Norway (5)	31 728	25 983	5 745	42	40	:
Switzerland	64 741	54 101	10 640	63	60	:

(1) NACE Rev. 2 Section A and Sections C to N.
(2) Estimates exclude Greece and Northern Ireland; estimates include a certain level of under-reporting for Bulgaria, Latvia and Romania.
(3) Data include a certain level of under-reporting.
(4) Great Britain (hence, excluding Northern Ireland); also excludes road traffic accidents at work.
(5) 2008.
Source: Eurostat (online data code: hsw_mi01)

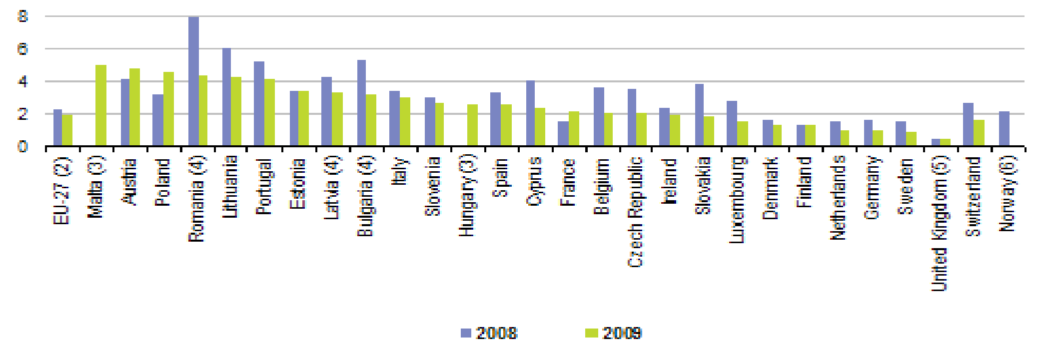
Figure 0.1: Workers reporting accidents in 2009 by different Country (Eurostat, 2009)

Among all industrial sectors, mining always appears to be one of the most critical: this particular situation led legislators to enact specific laws. It must be stated that it's not easy to improve the working conditions in a sector that historically represents one of the highest risk industries, as also confirmed by the aforementioned survey.



(1) Estimates exclude Greece and Northern Ireland; estimates include a certain level of under-reporting for Bulgaria, Latvia and Romania.
(2) Fatal accidents, not available.
Quelle: Eurostat (online data codes: hsw_n2_01 and hsw_n2_02)

Figure 0.2: Fatal and serious accidents at work by economic activity, EU-27 (% of serious and fatal accidents) (Eurostat, 2009)



(1) Greece, not available.
(2) Estimates exclude Greece and Northern Ireland; estimates include a certain level of under-reporting for Bulgaria, Latvia and Romania.
(3) 2008, not available.
(4) Data include a certain level of under-reporting.
(5) Great Britain (hence, excluding Northern Ireland); also excludes road traffic accidents at work.
(6) 2009, not available.
Source: Eurostat (online data code: hsw_n2_02)

Figure 0.3: Number of fatal accidents at work, 2008 and 2009 (incidence rates per 100.000 people employed) (Eurostat, 2009)

The highest incidence of fatal accidents at work in 2009 was recorded in Malta (5.0 deaths from accidents at work per 100,000 persons employed); Malta led a group of six EU Member States that reported incidence rates above the level of four fatal accidents per 100,000 persons employed. In contrast, at the other end of the range, Luxembourg, Denmark, Finland, the Netherlands, Germany, Sweden and the United Kingdom (whose data exclude Northern Ireland and road traffic accidents at work) recorded the lowest incidence rates, within the range of 1.5 down to 0.5 fatal accidents at work per 100 000 people employed.

Part of the gender difference in relation to accidents at work may be attributed to the fact that there were more men than women employed in the labor force – although after adjusting for this, the rates recorded for men remained consistently higher than those for women in each of the EU Member States in 2009; another reason may be the different operations and jobs in which they are employed. In Denmark, Sweden, Ireland and the Netherlands, the average incidence rate for serious accidents at work for men was no more than 1.5 times higher than that recorded for women, while in Portugal, Austria and Malta the rate for men was little over three times higher than for women.

Another reason why the incidence of accidents is considerably higher for men is linked to the economic activities where they more frequently work. Indeed, the number of accidents at work varies considerably depending upon the economic activity in question and is positively skewed in relation to male-dominated activities. Within the EU-27 in 2009, the construction, manufacturing, transportation and storage, and agriculture, forestry and fishing sectors together accounted for just over two thirds (67.8 %) of all fatal accidents at work and just over half (50.2 %) of all serious accidents. More than one in four (26.1 %) fatal accidents at work in the EU-27 in 2009 took place within the construction sector, while the manufacturing sector had the next highest share (16.1 %). Apart from transportation and storage, most service activities recorded relatively low shares of the total number of serious or fatal accidents. Nevertheless, serious (rather than fatal) accidents were relatively common within wholesale and retail trade, human health and social work activities, administrative and support service activities and accommodation and food service activities.

It is also possible to analyse the data according to the type of injury sustained during the accident. Data for the EU-27 for 2009 shows that there were two types of common injury, namely, wounds and superficial injuries (34.0 % of the total) and dislocations, sprains and strains (30.0 %). Around one in ten accidents concerned bone fractures (10.6 %), while there was a similar proportion of accidents resulting in concussion and internal injuries (10.2 %).

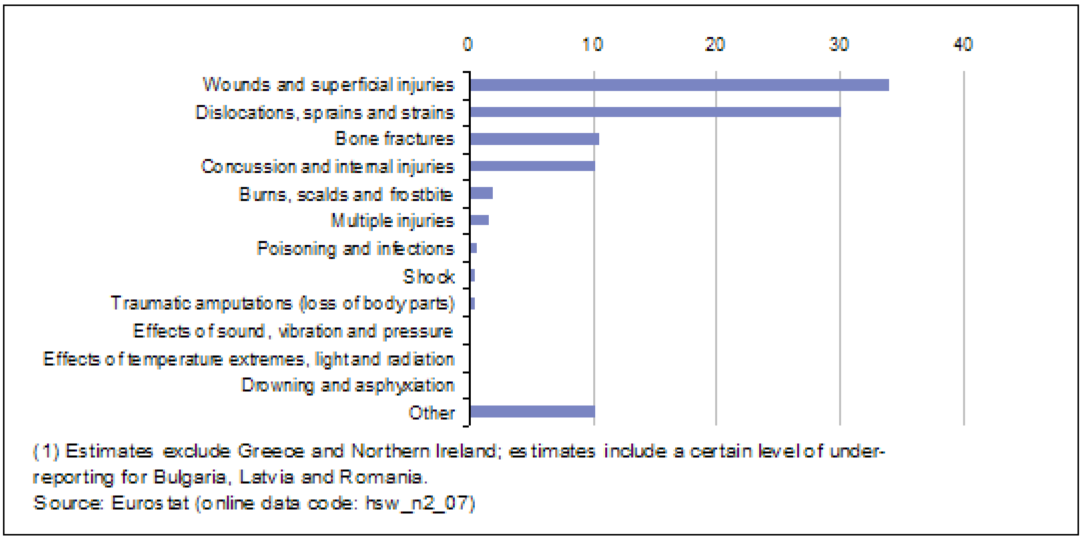


Figure 0.4: Accidents at work by type of injury (%) (Eurostat, 2009)

By comparing incidence rates of accidents at work among the different country and especially among the most important industrial sectors, the need of a specific approach (and care) when dealing with mining and quarrying appears necessary: the incident rates for this sector are at least 30% above the other values.

0.1 THE MOST CRITICAL INDUSTRIAL SECTORS IN ITALY

ALL INJURIES INCIDENCE RATES

Industrial Sectors	Incidence Rate
Metal manufacture (iron and steel industry)	61.95
Non-metal mineral manufacture (material for glass, ceramics...)	59.94
Wood manufacture	56.64
Constructions	54.37
Extractive activities (marble, sand, gravel…)	49.62
AVERAGE VALUE	32.21

Table 0.5: Incidence rates of all injuries among the most critical industrial sectors (Indemnified injuries for 1,000 workers/year) (INAIL, 2007)

SEVERE INJURIES INCIDENCE RATES	
Industrial Sectors	**Incidence Rate**
Constructions	4,46
Wood manufacture	4,14
Extractive activities (marble, sand, gravel…)	4,13
Non-metal mineral manufacture (material for glass, ceramics...)	3,03
Transports	2,69
AVERAGE VALUE	1,60

Table 0.6: Incidence rates of most severe injuries among the most critical industrial sectors (Indemnified injuries for 1,000 workers/year) (INAIL, 2007)

FATAL INJURIES INCIDENCE RATES	
Industrial Sectors	**Incidence Rate**
Extractive activities (marble, sand, gravel…)	0,37
Constructions	0,20
Transports	0,20
Non-metal mineral manufacture (material for glass, ceramics...)	0,11
Metal manufacture (iron and steel industry)	0,10
AVERAGE VALUE	0,06

Table 0.7: Incidence rates of fatal injuries among the most critical industrial sectors (Indemnified injuries for 1,000 workers/year) (INAIL, 2007)

An accident at work is an occurrence in the course of work which leads to physical or mental harm. It excludes accidents on the way to or from work, occurrences having only a medical origin, and occupational diseases.

0.2 THE MOST CRITICAL INDUSTRIAL SECTORS IN THE U.S. AND AUSTRALIA

Within the EU, the mining and quarrying sector criticality is highlighted by the Council Directives 92/91/EEC of 3rd November 1992 and 92/104/EEC of 3rd December 1992, respectively on the minimum requirements for improving the Safety and Health protection of workers in the mineral-extracting industries through drilling and on the minimum requirements for improving the Safety and Health protection of workers in

surface and underground mineral-extracting industries. However, similar standards, codes of practice and laws can be found almost in every country all over the world.
The following figures show the statistics provided by the U.S Department of Labor on the fatal occupational injuries by industrial sectors and their related incidence rates; it should be noted how the mining activities appear as one of the most hazardous sectors, even though the number of fatal work injuries is about the 25 % of the transportation injuries.

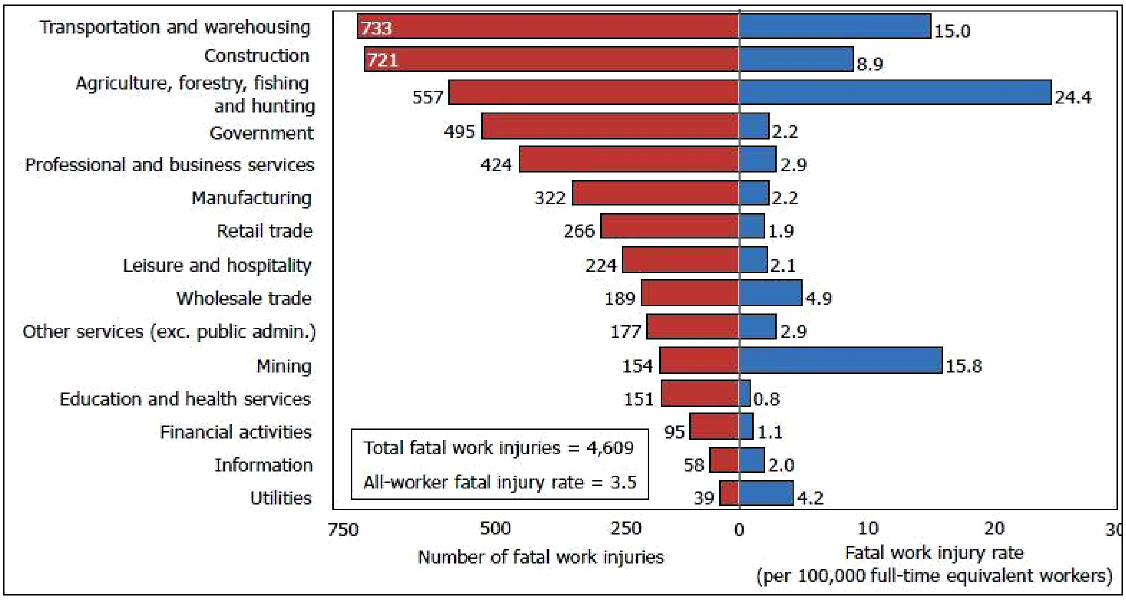


Figure 0.8: Number and rate of fatal occupational injuries, by industrial sector (U.S. Department of Labor, 2011)

Quite similar data are available in the Australian Safe Work Statistics; the mining and quarrying is, however, one of the most critical sectors.

Industry	Number	Fatality Rate
Agriculture, forestry & fishing	42	11.4
Transport, postal & warehousing	51	8.8
Construction	39	3.9
Mining	6	3.5
Rental, hiring & real estate services	5	2.7
Administrative & support services	9	2.4
Manufacturing	24	2.4
Electricity, gas, water & waste services	3	2.3
Wholesale trade	6	1.4
Arts & recreation services	2	1.0
Public administration & safety	5	0.7
Retail trade	8	0.7
Health care & social assistance	6	0.5
Other industries	9	0.2
All industries	**216**	**1.9**

Source: Work-related Traumatic Injury Fatalities, 2009–10

Figure 0.9: Number and rate of fatal occupational injuries, by industrial sector (Safe Work Australia, 2009-2010)

It should be noted, however, the different number of employees used to scale the number of injuries and to create the incidence rate according to the different number of workers applied in the different country for every industrial sectors. Moreover, what appears quite clearly, even though the data available are not entirely comparable, are the common critical industrial sectors on which the major prevention actions probably should be focused on: **the mining and quarrying activities, the transportation and warehousing, the agriculture, forestry and fishing and the construction.**

These considerations on the most hazardous occupational sectors are certainly confirmed by the International Hazard Datasheets on Occupations provided by the ILO.

Figure 0.10: International Labor Organisation Safe Work web page[2].

[2] http://www.ilo.org/safework/areasofwork/hazardous-work/lang--en/index.htm

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Council of the European Communities, 1992, Council Directive 92/104 EEC concerning the minimum requirements for improving the Safety and health protection of workers in surface and underground mineral-extracting industries (eleventh individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC).

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Start of the Chapter

CHAPTER 1: LAWS AND REGULATIONS OF THE MINING ACTIVITIES

“Con cattive leggi e buoni funzionari si può pur sempre governare. Ma con cattivi funzionari le buone leggi non servono a niente”

Otto von Bismarck

THE PROBLEM: Which laws? Which regulations?

The exploitation of mineral and raw materials represents one of the key elements of technological and technical progress. A wide part of the productive sectors, such as the energy and construction ones, bases its development on the extractive activities. In Italy, the companies involved in mining activities provide employment to over one hundred thousand workers, with more than 50 billion euros of profit.
The mining and quarrying are, therefore, an important part of the economic, cultural and artistic heritage of the country, covering a strategic role in the local and national policy.

Aggregates are in fact the main raw material in the construction industry, a sector that accounts for 6% of PIL (13% if taking into account all the related activities), with relevant occupational opportunities (about 7% of the entire national employment).

With regard to dimension stones (characterised by a high unit value per unit mass [€ / t]) it must be underlined to the importance and the great economic competitiveness of our country in the world, the undoubted cultural meaning for the preservation of historical, artistic and architectural buildings.

Moreover, the materials related to industrial utilizations are intensively used in the regional and national economic production. In Piedmont, these minerals are mainly limestone for cement plants, clays, sands and siliceous chalk.

The quarries of materials for industrial use are closely linked to processing establishments such as cement plants and facilities for plaster or the enrichment of silica sand.

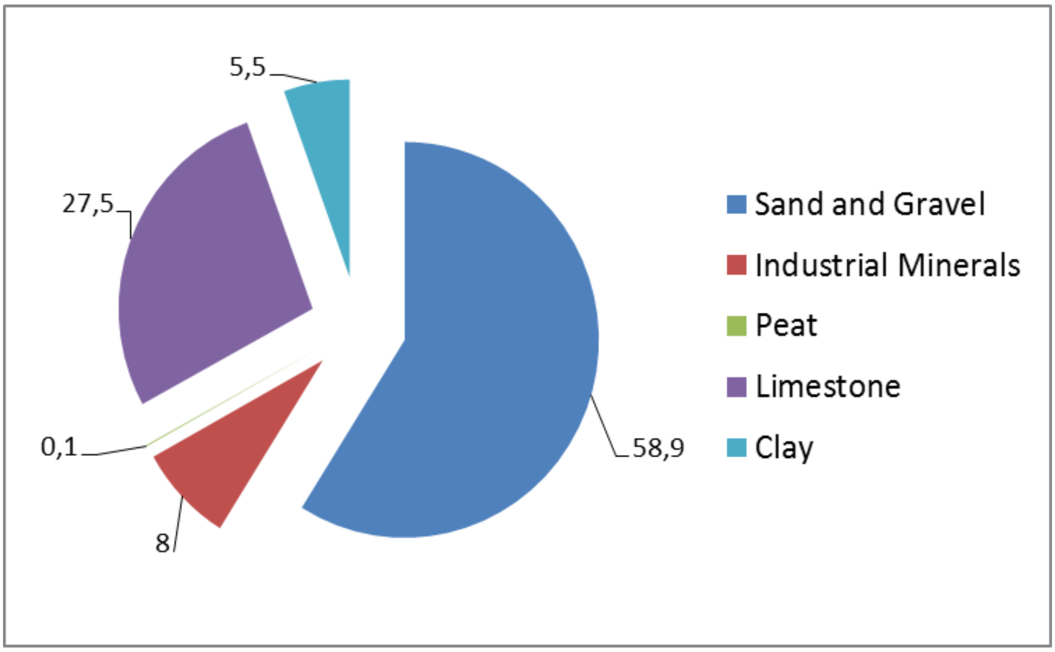

Chart 1.1: Amount of materials extracted in Italy (data mean 2006-2009)

1.1 WHAT IS AN EXTRACTIVE ACTIVITY FOR NATIONAL REGULATIONS?

A mine or a quarry is an activity designed to supply raw materials for further industrial processing or to supply materials for the construction of public infrastructures and facilities.

In Italy this classification is still ruled by the Regio Decreto 29th July 1927 n° 1443, which differentiates the mine and the quarry according to their characteristics of the ore extracted, regardless of the operating organisation (opencast or underground).

There are four categories of materials extracted in quarries and defined by the legislation:

1. peat;
2. sand and gravels (materials for construction of buildings, roads etc…)
3. colouring soils; diatom flour, clay, quartz, silica, grinding stones

4. other not included in the list of materials that are extracted in mining sites.

The materials included in the "mining list" are the following:

1. metal minerals;
2. graphite solid, liquid and gaseous fuels, bituminous and asphaltic rocks;
3. Phosphates, alkali metal salts and magnesium, alumina, mica, feldspat, kaolin and bentonite and other soils with an higher refractoriness degree than 1630 degrees Celsius;
4. Precious stones, garnet, corundum, bauxite, leucite, magnesite, fluorine, barium and strontium mineral, talc, asbestos, cement marl, lithographic stones;
5. Radioactive substances, mineral and thermal waters, gases and vapours.

Moreover, another important difference is that the property of quarries belongs to the owner of the land, whereas in the case of mines it is the State.

In addition, we can distinguish two main types of exploitation:

- opencast: every operation is lead from the surface;
- underground: the extractive activities and, if necessary, other operations take place beneath the surface through shafts tunnels, chambers etc…

Over the past 50 years the quarrying activity has become more and more significant within the national economy, due to the growing lack of “precious” materials.

Nevertheless, there are many cases of underground quarries (e.g. dimension stones and fittings, cement marl, chalk).

On the other hand, materials that the Regio Decreto assigns to the mining sites are excavated with opencast activities (e.g. metal deposits, fuel outcropping…)

Figure 1.2: Opencast marble quarry in Carrara, Italy

Figure 1.3: Salt underground mine in Sicily, Italy

The different kinds of materials that could be extracted, due to the different characteristics of the sites, can deeply affect the exploitation and the related operations.

1.2 EUROPEAN DIRECTIVES ON SAFETY AND HEALTH

1.2.1 Brief description of European directives on Safety and health

The obligations and requirements introduced in Italian laws and regulations on occupational Safety and health in the last years, are drawn by the directives issued by the European Community.

- ✓ Treaty of Rome (1957): among others, also a common commitment was introduced to improve the Safety and Health of workers at the workplaces (art.118a).
- ✓ Single European Act (1985), modifying the artt. 100 and 118 of the treaty of Rome: the Safety was recognized as a shard principle for the approximation of the laws of the member States relating to machinery.

SOCIAL DIRECTIVES	ECONOMIC DIRECTIVES
❑ Directive 89/391/EEC of 12sd June 1989, *on the introduction of measures to encourage improvements in the Safety and Health of workers at work*	❑ Directive 89/392/EEC of 14th June 1989, *on the approximation of the laws of the Member States relating to machinery* *[replaced by 98/37/EC and now by 2006/42/EC]*
❑ Directive 1999/92/EC of 16th December 1999, *on minimum requirements for improving the Safety and Health protection of workers potentially at risk from explosive atmospheres* (15th ind. Directive within the meaning of Art. 16(1) of Directive 89/391/EEC)	❑ Directive 94/9/EC of 23rd March 1994 (updated), *on the approximation of the laws of the Member States concerning equipments and protective systems intended for use in potentially explosive atmospheres*

Table 1.4: European approach to the Occupational Safety and Health.

The Directives are based on the analysis of each risk and its related safety actions which need undertaking by everyone involved in the process. The direct consequences of the European improvements can be seen both in the accomplishment of the Art. 118a of the Treaty of Rome, Dec. 21st, 1987, and in the resolution of the Council, as well as four resolutions adopted in February 1988 by the European Parliament which led the Commission to draw up a framework Directive to serve as a basis for subsequent

Specific Directives concerning the improvement of the working environment and to ensure a higher level of health of workers.

The very first directive to improve the Safety and the Health of workers was the n° 391 of 12th June 1989. In it are contained the fundamental principles of the entire system of Safety issues related to the application (Art. 1), to every subject involved (Art. 2), as well as the general guidelines that need applying in the following cases:

• general measures of prevention and protection (Art. 3);

• obligations of the employer (Art. 4);

• obligations of workers (Artt. 5, 18 and 19)

• contracts (Art. 7)

• fire prevention, evacuation and first aid (Artt. 12, 13, 14 and 15)

• health surveillance (Artt. 16 and 17)

• training and information (Artt. 21 and 22)

The European Parliament has also approved, on the basis of the Framework Directive, 11 Directives among which, eight Directives were transposed and put in forced in the Italian regulation with the Legislative Decree 19th September 1994, n° 626 (now replaced by the Legislative Decree 9th April 2008, n° 81):

89/391/EEC - Framework Directive: measures to encourage the improvements on Safety and health of workers at work;

89/654/EEC – Workplaces: minimum Safety and health requirements for the workplace;

89/655/EEC - Work Equipment: minimum Safety and health requirements for the use of work equipment;

89/656/EEC - Personal Protective Equipment: minimum requirements for the safe use of personal protective equipment at work;

90/269/EEC - Manual Handling of Loads: minimum Safety and health requirements for the manual handling of loads;

90/270/EEC - Display Screen Equipment: minimum Safety and health requirements for the activities of display screen equipment;

90/394/EEC - Carcinogens: protection of workers against risks deriving from exposure to carcinogens at work;

90/679/EEC - Biological Agents: the protection of workers against risks deriving from exposure to biological agents at work;

1.2.2 The "Machinery Directive"

With regard to 89/392/EEC Directive, the twin Directive of the 89/391/EEC Directive, the Italian enforcement consisted in the President of the Republic Decree 24th July 1996, n° 459 - Machinery Directive: regulations for the implementation of the EU Directives on the reproaching of the laws of the European Member States related to machinery.

With relevance to the machineries and equipment[3] (and to their maintenance), it should be noted that the 2006/42/EC Directive (replacement of the aforesaid 89/392/EEC and enforced in the Italian regulation by the Legislative Decree 27th January 2010, n° 17) states in its preamble that the social cost of the large number of accidents caused directly by the use of machinery *can be reduced by inherently safe design and construction of machinery and by proper installation and maintenance*.
It is also underlined that *the machinery manufactured in conformity with a harmonised standard published in the Official Journal of the European Union shall be presumed to comply with the essential Health and Safety requirements covered by such a harmonised standard.*[4].
With special reference to the workers information, formation and training, in the 89/391/EEC Directive the informing, consultation, balanced participation and training of workers and their representatives are considered, ensuring that each worker receives *adequate* (i.e. derived from a Risk Assessment special for the situation) Safety and Health training, in the form of information and instructions specific to the workstation or job, and in every occurrence of job changing or in the event of the introduction of new/modified equipment. An obvious, but sometimes neglected concept, is that also, and in particular, una-tantum operations should be object of careful preliminary Risk Assessment / Management.

[3] Even if formally defined in different ways, obviously the basic concept of a safe approach covers machines, equipment, fittings, tools, etc…

[4] From the Guide to application of the Machinery Directive 2006/42/EC *"a harmonized standard provides an indication of the state of the art at the time it was adopted. In other words, the harmonized standard indicates the level of Safety which can be expected of a given type of product at that time. A machinery manufacturer who chooses to apply other technical specifications must be able to demonstrate that his alternative solution is in conformity with the EHSRs of the Machinery Directive and provides a level of Safety that is at least equivalent to that afforded by application of the specifications of the harmonized standard – see §161 and §162: comments on General Principle 3 of Annex I".*

Moreover, the Annex I to the 2006/42/EC Directive includes specific provisions for the user's Safety in terms of information, warnings and instructions; in particular, in accordance with the machinery "Contents of instructions", the formation and training of the workers should be provided also for the adjustment and maintenance operations.

As described in the paragraph above, the Legislative Decree n°. 17/2010, born as a national enforcement of the 2006/42/EC "Machinery Directive", is also applied to the milling, crushing and feeding plants of stone materials. Here it becomes a mandatory obligation to display the instructions for use and maintenance of the various "machines" or "partly completed machinery" that form the system, in addition to various declarations of conformity.

Machinery or partly completed machinery built before 1996 and therefore not CE marked, must still comply with the general Safety requirements set out in Annex 5 of Legislative Decree 81/2008. It should also possess a declaration of conformity by the seller or renter.

The main differences with the "old" Machinery Directive" are:

1) a specific article designed to introduce changes to the alignment of Directive 95/16/EC on lifts. For example, a category of products, lifting equipment that does not move along guides which are rigid, will no longer be regulated by the Lifts Directive but by Machine Directive. Moreover machinery and lifting equipment with a speed lower than 0.15 m/s are also excluded from the Lifts Directive (e.g. platforms) and fall under the Machinery Directive;

2) the reinterpretation of the boundary with the Low Voltage Directive. The new Machinery Directive lists six categories of electrical machinery subject to the Low Voltage Directive while for all other machinery the Low Voltage Directive can be applied only to electrical hazards. The Machinery Directive regulates the obligations related to the declaration of conformity and the market;

3) changes to the field of application and to the definitions of "machine". The new definition improves the concept of a plant, which must be in compliance just like all the parts that compose it;

4) changes to the definitions of "Safety component": also in this case, the definition becomes clearer in respect to the Directive 98/37/EC;

5) the definition of "partly completed machinery" as an ensemble which is almost machinery but which, by itself, isn’t able to perform a specific application. Partly completed machinery is only intended to be incorporated into or assembled with other machinery or other partly completed machinery or equipment, thereby forming a machinery which needs to be marked CE

6) a modification of the list of the most dangerous machines and their less ambiguous identification .

1.2.3 The European directives on mining

With special regard to the mining regulations, two key directives have been issued concerning Safety and Health: the Council Directive 92/91/EEC on the "... *Safety and Health of workers in the mineral-extracting industries through drilling*" and the Directive 92/104/EEC concerning the "... *Safety and Health of workers in the mineral-extracting industries and underground*."

In the Italian regulation they have been enforced by Legislative Decree n° 624/1996.

Concerning Safety aspects, this Legislative Decree regulates both the opencast and the underground mining operation. The following paragraph will illustrate its contents.

1.3 THE LAWS ON SAFETY AND HEALTH AND THE RELATED SAFETY DOCUMENTATION

1.3.1 A brief history of the Italian legislation on the Occupational Safety and Health

The relevant aspects of occupational Safety and Health have gained attention over the years. An increasing interest to Safety at the workplace is a necessary step to ensure better living conditions and to strengthen the quality standards of the working life. Such attention is intended to be constantly improved. The “pursuit of happiness" must necessarily walk together with a gradual and progressive improvement of the working conditions. To underline the Safety aspects it was necessary to write specific rules that started to define and to establish the procedures, the organisational aspects, the technical data, the ways of using the correct equipment, tools and machinery, as well as empowering all the figures in the working environment.

The first mentioning of such aspects in the legislation was found on the Civil Code of the year 1865 where the idea of fault-based liability emerged; then with the Law 80/1898, compulsory insurance against accidents at work was introduced. Soon the concept of strict liability of the employer limited to the repair of the damage was introduced: the financial compensation for the worker who suffered the injury was implied.

With the introduction of the Constitution in 1948, it was stated that Safety and Health should be protected as a fundamental right of the individual and as a collective interest.

The first regulations of great importance regarding Safety date back to the second half the 50’s. These laws were very precise and detailed but altogether not completely exhaustive. New terms and topics were introduced, such as "duties" (differing from the current term “obligations”), penalties, operational methods to ensure Safety, technical and structural characteristics of the various equipment, the definition of measures of prevention and protection, proper use of equipment, technical data, etc…

They were mostly technical standards to provide data, measures, numbers, and did not pay particular attention to the organisation of the work in order to ensure the Safety of the workplace and to the responsibilities belonging to the different figures.

The first law of a certain importance regarding the Safety and Health in Italy was the President of the Republic Decree 547/55 "Regulations for the prevention of accidents at work", with which the “rules” for a safe working environment were established for the first time. As previously mentioned, this approach was concentrated mainly on technical aspects, such as the structural parameters, the dimensions, the various types of work and the specifications of the various equipment.

With the President of the Republic Decree 303/56 "General requirements for Occupational Health.", subsequent to the President of the Republic Decree 547/55, more emphasis was put on aspects such as health at work, introducing for the first time the basic concepts of health surveillance, of emergency care and other topics related to the illnesses while also listing some hazardous substances to the health of the worker.

In the same years other regulations were issued concerning Safety aspects related to construction, (President of the Republic Decree 164/56), and to demolition activities and underground activities (President of the Republic Decree 320/56).

After that, further local and national laws were passed, until, under the pressure of the European Union, it was necessary to harmonize all the different regulations and the legal aspects of all member states. The aforesaid directives were therefore issued by the European Parliament and then enforced by the different member states of the Community.

In Italy the European Directive on mining was enforced with the Legislative Decree n° 626/1994, which is considered the first real legislative innovation in the field of Occupational Safety. It stresses the actual obligations for each of the figures present at a workplace, giving most of the responsibility to the employer: the obligation to assess the risks in the company, to prepare, organise and implement all the measures of prevention and protection necessary for the proper management of the operations. Moreover, new occupational figures were introduced such as the R.S.P.P (Responsabile del Servizio di Prevenzione e Protezione), the R.L.S. (Rappresentante dei Lavoratori per la Sicurezza) and the workers assigned to face the emergency, the first aid, the fire.

For the first time, with this regulation, the attempt was to increase the synergies and the collaborative activities, involving all stakeholders at work. It was introduced the obligation to carry out the risk assessment in the workplace, to prepare health surveillance through the appointment of a specialized doctor and to establish the figures responsible for the control of the Safety aspects (R.S.P.P.).

Other regulations were later introduced in order to follow the evolution of the technology which allowed the use of more precise procedures to measure and to evaluate other kind of health risks, such as noise, vibration, chemical hazards, risk use of display screen equipment, manual handling of loads, etc..

Inthe 2008, the coming into force of the Legislative Decree n° 81/2008 was a huge effort to unify all the Italian regulatory framework in this area; however some sectors, such as mining, continue to have a specific regulation of their own.

Finally, it is surely necessary to mention the art. 2087 of the Civil Code, which recognises the "principle of the protection of health".

1.3.2 Existing legislation in the field of mining and Safety Documentation

With regard to the Safety aspects of work within the quarrying and mining activities, different regulations and specific rules governing these issues exist, as previously mentioned.

At the end of the fifties, the President of the Republic Decree 128/59 "Rules of mining surveillance" (currently in force with some articles repealed or amended) was adopted. The particular operations and peculiarities characteristic of mining and quarrying, needed a specific regulation. Moreover the particular environmental conditions and the use of explosives needed appropriate standards.

The Legislative Decree 624/1996 defines and indicates which are the obligations and requirements for Safety and Health in mining. In addition to it, however, reference should be made to the Legislative Decree n° 81/2008, to the new Machinery Directive (Legislative Decree no. 17/2010) and to the regional standards (Legge Regionale 69/1978 and Legge Regionale 44/2000 for Piedmont with which, in accordance with Art. 29, the activity of the Mining Authority has been transferred to the Provinces.

The Legislative Decree 624/1996 applies to mining and quarrying activities the concepts introduced by Legislative Decree n° 626/1994 (now replaced by the Legislative Decree 81/2008).

Even in the field of mining, the greatest responsibility is given to the employer (or owner of the mining concession), who has an obligation to ensure the appropriate Safety and Health of workers. As part of the mining activities appear other specific corporate figures who are charged with protecting the Safety of workers, such as the "Director of the quarry or mine" and the "supervisor".

The Legislative Decree 624/1996 states: "The employer/owner shall appoint a director in possession of the skills and competencies required for the performance of this task and under whom the responsibility falls at all times: it is up to the director to observe and enforce the laws and regulations concerning the protection of the Health and Safety of workers."

The supervisor is "person, with the necessary skills and competencies, appointed by the employer to monitor the workplace". They should be appointed in sufficient number according to the entity of the activity.

One of the primary obligations of the Employer is to develop the Risk Assessment Document, which in mining is called D.S.S. (Safety and Health Document).

The D.S.S. must be submitted to the supervisory authority before the beginning of the activity.

If making a comparison between the temporary or mobile construction and mining activities, the D.S.S. resembles, rather than the D.V.R (Risk Evaluation Document) and the P.S.C. (Safety Plan and Coordination), the P.O.S (Operational Safety Plan), as it is produced after the phase project and before the beginning of work.

The document must contain the assessment of all risks to the Health and Safety of workers in relation to the activity and the identification of measures and operating procedures, indicating in particular the solutions, for each of the following elements:

- protection from fire, explosions and health-endangering atmospheres;
- escape and rescue facilities;
- communication, warning and alarm systems;
- health surveillance;
- maintenance (in particular of the pressure vessels) of all equipment and the maintenance of the Safety;
- Safety drills;
- storage areas;
- stability and solidity;
- ventilation;
- gas outbursts, rockbursts and water inrushes
- precautions for withdrawal of workers
- the organisation of rescue services;
- Safety devices and operating precautions in drilling fluids other than mud;
- use of explosives;
- program of simultaneous activities;
- rescue organisation;
- remote controls in case of emergency;
- underground workforce accounting;
- lightning;

The DSS must also contain information on:

- activities of the information, formation and training of workers;

One of the most important *administrative* document (in Italy) in the mining activities is the notification of work: the work taking place in mining activities must be reported to the competent Authority at least eight days before the start or restart of the work.

This notification is made by the employer or an authorized representative and shall contain, for each workplace:

a) the details of the mining title or authorization of the quarry;

b) the location of the work and whether they are open or underground;

c) the name and address of the director;

d) the name, surname and address of the overseers of the works, for each turn.

In the case of a company the legal representative shall be indicated.

For all other duties and obligations of the Employer and the various corporate figures (workers, supervisors, etc.) the precepts laid down by Legislative Decree 81/2008 and contained in Title I must obviously be respected and followed .

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Italian Regulation, 2008, Decreto Legislativo 81 concerning the Safety and health at work places.

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CHAPTER 2: THE INJURIES AND WORK-RELATED DISEASES SITUATION IN MINING

"Non mi fido molto delle statistiche, perché un uomo con la testa nel forno acceso e i piedi nel congelatore statisticamente ha una temperatura media"

Charles Bukowsky

THE PROBLEM: which is the situation of the mining and quarrying sectors from the point of view of injuries and work-related disease?

2.1 NATIONAL AND LOCAL SITUATION

As can be seen from the graph below, based on data provided by INAIL, which shows the trend of accidents at work during the years from 2001 to 2007, the accident situation in Italy is slowly, but steady, improving.

It should be noted that the progressive improvement, which means a reduction of the total number of accidents, unfortunately is not always related to a real improvement of the Safety or the prevention action during the first planning phases. As a matter of fact the occupational probability during these years it is lower than some years ago and the occupational index is decreasing.
Anyway, the following figure is an overview of how accidents are distributed on the national territory during 2007.

Focused on INAIL data on injuries in Piedmont during 2010 (see table below), it is clear that the reported accidents at work record a new lowest value of 60,014 with a decrease of 3.6% over the previous year. In the same year, however, fatalities increased, rising from 56 cases of the year 2009 (the lowest value ever recorded), to 75 of the year 2010. Taking into account the trend in the medium term, compared to 85,600 reported accidents in 2000, workplace accidents in Piedmont has been reduced by almost 30% in a decade; on the contrary, at the same time, the fatal cases, despite some fluctuations in contrast, are decreased by almost 40%.

The 41% of the reported accidents occurred in the service sector, in which are concentrated about 60% of the employees of Piedmont; on the other hand the accidents in the industrial sector are gradually decreasing; in any case, 53% of the fatalities occurred in industry and constructions according to the distribution of the workers.

ith regard to the mining and quarrying, it could be useful to take a look at the following table and graph . These data too, obtained from the website of the INAIL, provide a view of the accidents situation in the mining sector, taking into account all kind of different jobs from 2007 to 2009.

Compensated accidents occurred in the related operations to the mining activities

	2007	2008	2009
Injuries	6.338	5.365	3.429
Commuting injuries	494	379	131
Fatalities	5	5	2
Commuting fatalities	0	0	0

Table 2.4:Compensated injuries in Italy from 2007 to 2009

Compensated accidents occurred in the related operations to the mining activities

Region	Injuries	%	Fatalities	%
PIEMONTE	272	7,93	0	0,00
VALLE D'AOSTA	13	0,38	0	0,00
LOMBARDIA	582	16,97	0	0,00
BOLZANO - BOZEN	130	3,79	0	0,00
TRENTO	48	1,40	0	0,00
VENETO	516	15,05	0	0,00
FRIULI VENEZIA GIULIA	153	4,46	0	0,00
LIGURIA	121	3,53	1	50,00
EMILIA ROMAGNA	487	14,20	0	0,00
TOSCANA	223	6,50	0	0,00
UMBRIA	62	1,81	0	0,00
MARCHE	90	2,62	0	0,00

LAZIO	204	5,95	0	0,00
ABRUZZO	76	2,22	0	0,00
MOLISE	10	0,29	0	0,00
CAMPANIA	74	2,16	0	0,00
PUGLIA	118	3,44	0	0,00
BASILICATA	21	0,61	0	0,00
CALABRIA	52	1,52	1	50,00
SICILIA	89	2,60	0	0,00
SARDEGNA	88	2,57	0	0,00
Italy	**3.429**	**100,00**	**2**	**100,00**

Table 2.5: Compensated injuries organised in region in the year 2009

Compensated accidents occurred only in the mining activities

	2007	**2008**	**2009**
Injuries	490	332	100
Commuting injuries	33	17	4
Fatalities	3	2	0
Commuting fatalities	0	0	0

Table 2.6: Compensated injuries in Italy from 2007 to 2009

Compensated accidents occurred only in the mining activities

Region	**Injuries**	**%**	**Fatalities**	**%**
PIEMONTE	10	10,00	0	
LOMBARDIA	18	18,00	0	
BOLZANO - BOZEN	3	3,00	0	
VENETO	9	9,00	0	
FRIULI VENEZIA GIULIA	1	1,00	0	
LIGURIA	6	6,00	0	
EMILIA ROMAGNA	5	5,00	0	
TOSCANA	18	18,00	0	
UMBRIA	3	3,00	0	
MARCHE	4	4,00	0	
LAZIO	4	4,00	0	
ABRUZZO	1	1,00	0	
CAMPANIA	2	2,00	0	

PUGLIA	7	7,00	0
BASILICATA	2	2,00	0
CALABRIA	2	2,00	0
SICILIA	3	3,00	0
SARDEGNA	2	2,00	0
Italia	**100**	**100,00**	**0**

Table 2.7: Compensated injuries in Italy from 2007 to 2009

Even if the number of invalidating and fatal injuries and health impairments is apparently low if compared with the overall national data, the following table confirms the paramount criticality of the considered industrial sector in terms of Safety and Health problems and in particular in terms of the Frequency rate values, examined by UNI 7249, “Statistics of industrial accidents”.

The frequency required by UNI is characterised by the accidents occurred in a year and by the hours worked during that year. In order to make the result more readable, this ratio is then multiplied by 1,000,000 (one million) so that the index provides the number of accidents per million hours worked.

Moreover, the extractive activities are characterised by the typical problems of both the building and constructions sites sector and the industrial sector; the resulting accident scenario to face is certainly worthy of attention and must be properly analysed in terms of frequency and severity rate and not only in absolute numbers.

It should be noted that the rates of annual frequency are often affected by unexpected events which involve the workers and could lead to incorrect results. This is especially true when the rates are related to local areas (as the Provinces are); to mitigate the impact of these unexpected events, and to provide more representative and robust results, a statistically “significant” (based on at least five years average) number of data should be taken into account.

The Table 2.8 describes the accident frequency rates and the type of injuries (computed per 1000 workers) in mining and in other industrial sectors.

Accident Frequency Rate Organised By Sector and By Gravity

INDUSTRIAL SECTOR	ACCIDENT FREQUENCY RATE				RATE
	Temporary Disability	Permanent Disability	Fatalities	Total	
Primary metal industries	46,99	2,83	0,11	49,94	184,55
Primary NON metal industries	44,00	3,28	0,12	47,41	175,2
Lumber and wood	41,55	4,21	0,09	45,85	169,44
Building	37,46	4,45	0,18	42,09	155,54
Transportation and public utilities	36,25	3,16	0,19	39,60	146,34
Rubber and plastic	36,33	1,74	0,08	38,15	140,98
Mining	**32,90**	**4,10**	**0,36**	**37,36**	**138,06**
Trasportation equipment	34,65	1,38	0,03	36,06	133,26
Manufactured metal products	30,84	1,48	0,04	32,36	119,59
Other industries	29,52	2,11	0,07	31,70	117,15
Hotels and other lodging services	29,47	1,28	0,02	30,78	113,75
Agricolture	27,73	1,72	0,05	29,50	109,02
Food	26,11	2,18	0,09	28,39	104,92
Services	25,22	1,78	0,06	27,06	100,00
Health services	25,17	0,93	0,02	26,11	96,49
Public services	22,46	1,42	0,03	23,91	88,36
Fishing	21,48	1,63	-	23,11	85,4
Electric, gas, water services	20,46	1,26	0,04	21,76	80,41
Paper	19,42	1,09	0,03	20,54	75,91
Trading	18,93	1,21	0,05	20,18	74,58
Public administration	16,90	0,97	0,01	17,88	66,08
Electronic and electric products	15,25	0,78	0,03	16,06	59,35
Property activities	14,18	0,87	0,03	15,08	55,73
Chemical products	13,74	0,71	0,03	14,48	53,51
Thread and textile	13,44	0,79	0,01	14,24	52,62
Hide	13,04	0,76	0,02	13,82	51,07

Petroleum	10,41	1,33	0,09	11,83	43,72
Educational services	8,37	0,46	..	8,83	32,63
Finance and real estate	2,35	0,22	..	2,57	9,5

(*) Compensated injuries/1.000 workers (no injuries which happen on the way to or from work taken into account)[5]

INAIL data mean (2006-2008)

Table 2.8: Accident frequency rate organised by sector and by gravity

[5] The type of injuries are characterised by the accident occurred during the way between the work place and the house of the worker.

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CHAPTER 3: PLAN, SAFETY AND QUALITY

“Il primo dovere di chi dà consigli a un uomo infermo che segue una dieta nociva alla salute è quello di cambiar sistema di vita; le altre indicazioni verranno solo se egli accetta con convinzione queste disposizioni.”

Platone

THE PROBLEM: Can the Safety and the quality improve if they have been considered during the first planning phase?

3.1 INTRODUCTION

The task of an effective Risk Analysis and Management at extractive sites, coherent to the statements of the European regulations, upon which the activity plan and management should be based, involves a pro-active approach, which should take into account all the involved parameters to achieve both quality and Safety:

- ✓ the paramount criticality of the extractive activities in terms of work related accidents (number and seriousness) and health impairments;
- ✓ the results of the recent epidemiologic surveys, in particular with reference to the possible criticality of the silica dust;
- ✓ the impressive developments in the geotechnics – geomechanic sciences, and in the mining techniques and technologies, which substantially modified the overall Safety situation.

Such a pro-active approach requires an extensive risk analysis based on careful evaluations of the possible project options and on a detailed knowledge of the site situation and scheduled operations by both the Employer and the Mining Inspectorate technicians to support the general and special Safety aspects for extractive units and the general extractive activities. For these reasons slapdash remedies and occasional inspections are clearly inadequate to effectively highlight and control the underlying Safety criticalities typical of a complex activity.

Can a Safety improvement lead to a quality improvement?

What is quality? According to the **UNI EN ISO 9004:2009** it is the ability of a product or service to satisfy the needs of a client.

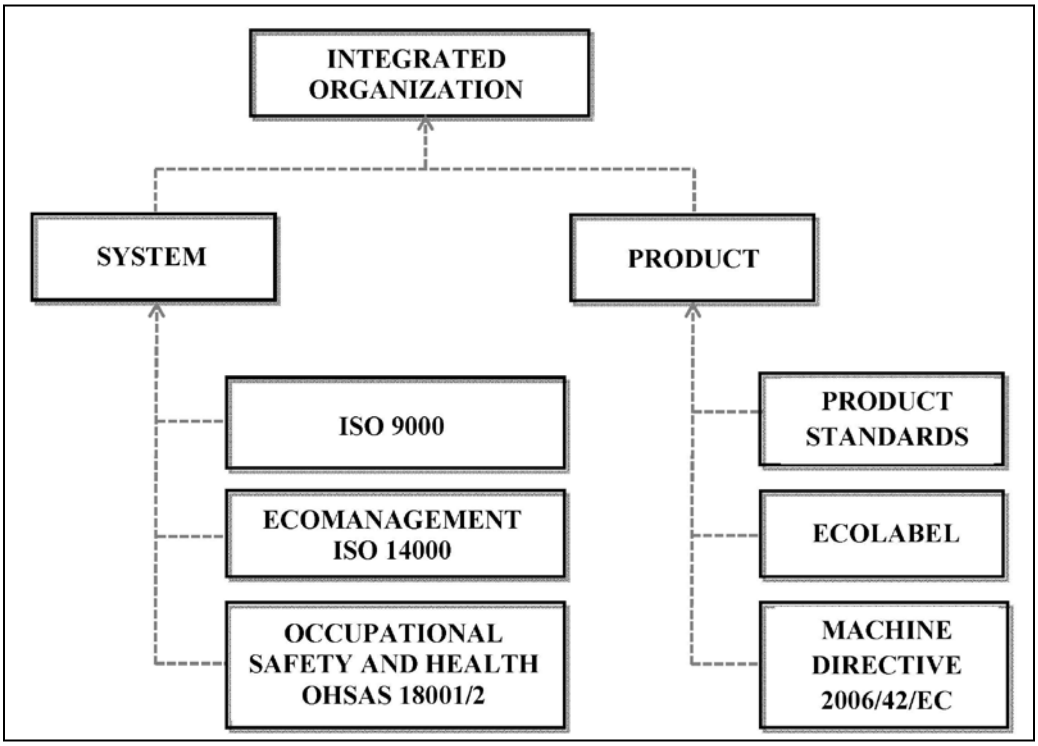

Figure 3.1: The two main aspects that should be taken into account to reach a safe and quality system

Safety and quality possess many mutual aspects which suggest how these are so closely connected. What follows is an attempt to point them out:

1 Safety and quality born from the Management. The key to ensure their effectiveness is establishing the correct responsibilities for each level of the system;

2 Safety and quality are a permanent project: the targets should not be static. They, as the company's system, are included in a constant innovation process and in a continuous improvement according to market dynamic and new reduction risk solutions;

3 Safety and quality are based on the implementation of prevention actions. For this reason it is better to forestall every unexpected event than to try to control their effects. It means that the effectiveness is measured by the achievements both in normal and emergency conditions;

4 Safety and quality should be present at all steps of the process and during the whole life cycle of the product to prevent failure events;

5 Safety and quality are measurable: the effectiveness could be achieved only if able to measure and assess the real situation and its evolutionary trend with similar evaluation techniques;

6 Safety and quality are a mutual task: they can only be achieved by including them in the structure of the system and by making them part of the way of being (nature)of each worker. Everyone has to contribute;

7 Safety and quality are achieved with correct formation and training: only with a large participation can the fundamental role of training be easily realised. Moreover, formation and training should produce attitudes and skills to ensure safe and responsible behaviour. This approach is explicitly underlined in the recent regulations concerning improvement of the worker's Safety and Health at work.

The basic approach of a check device consists in a failure detector, a comparator able to define when the essential variable is diverging from the correct value, a decision maker able to identify what action to carry out to recovery it and an actuator to bring the system back to the desired conditions. To the system we can also add a memory to store the history of the failure, in order to continuously improve the system (feedback chain).

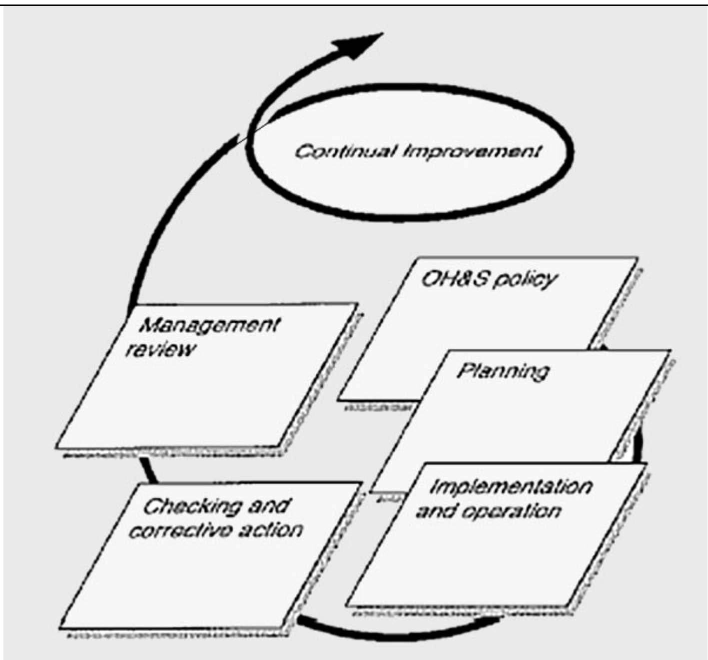

Figure 3.2: BS OHSAS 18001:2007 (Occupational health and Safety management systems – Specification) e 18002/00 (Guidelines for the implementation of OHSAS 18001)

The one described is the way of thinking of the British Standard OHSAS 1800x, as shown in picture below: the feedback chain is part of the "performance indicator" to regulate the system. The BS emphasises the importance of the involvement of every worker in the chain of feedback to check the quality and to achieve the maximum utilization of available resources.

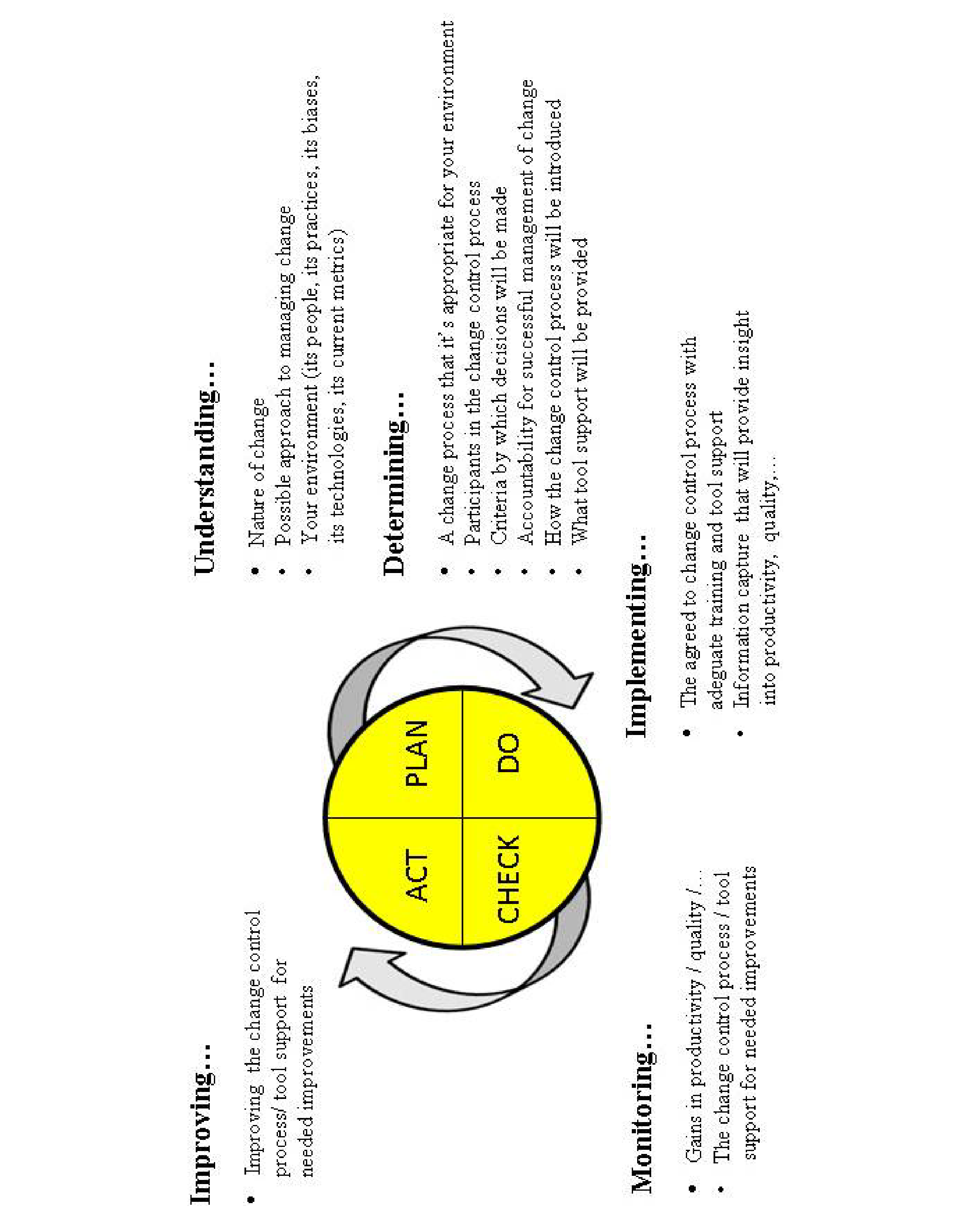

Figure 3.3: The BS OHSAS 18001:2007 Occupational Health and Safety management system.

3.2 THE OCCUPATIONAL HEALTH & SAFETY POLICY

The OH&S policy suggests that Top Management must define and periodically review the Policy for Health and Safety in the workplace, clearly pinpointing a continuous and effective improvement in work organisation and management, a legislation and other requirements subscribed by the organisation. Moreover, the OH&S policy should be dedicated to the risks that must be faced, and it should be maintained and spread to all workers to make them conscious of the personal tasks according to the Safety requirements; the OH&S should be periodically revised to ensure to be always relevant and suitable to the working condition.

3.2.1 Planning

According to this approach the Top Management has to:

- ⋆ identify the hazards;
- ⋆ evaluate and manage the risks;
- ⋆ set and review new coherent targets with the Safety policy;
- ⋆ control the risks arising from the introduction of future working evolution, such as new equipment, new working procedures, new regulations and technology developments;
- ⋆ restrict the information available to the rear, related to the knowledge of similar cases; this allows the determination of the statistical possibility that some abnormal event occurs but does not allow the identification of weaknesses in the management system adopted.
    - Limitation of responsive management: the information available, related to the knowledge of case history, allows the determination of the probability that some unscheduled events occur, but does not allow the identification of weaknesses in the adopted management system.
    - Use of the experience of a number of individuals to plan and to improve the system management with a multidisciplinary approach: different people with different skills can identify more problems.

It may be useful to draw of a list of goals using the keywords:

- To improve/increase;
- To maintain/monitor;
- To reduce/delete.

At this point the general and detailed plan can be prepared to achieve the goals, in which the following need to be specified: the workers involved, the type of intervention, the timing and results to be achieved.

After the implementation of the plan, a review should be made of the same: has the plan been implemented? It is a correct plan?

Example: three-year plan to organise the extraordinary maintenance required the replacement of several equipment or the entire system. The following actions need to be checked:

- *appropriate resources: the entire corporate structure is involved, according to their functions and responsibilities, in order to achieve the objectives of the proposed Safety;*
- *allocation of the funds;*
- *procedures for requesting new actions to be implemented:*
- *extensive check based on a technical analysis about the age of the plant, the availability of funds in order to ensure the required improvements;*
- *authorization of the Management for the implementation.*

3.2.2 Doing

The Management has to:

- identify a Management Representative to ensure that the requirements of the Safety Management System (SMS) are applied and maintained at all times and so to report information related to the performance of the SMS to the Management;
- ensure that all workers both have specific skills and are trained and aware about the risks;

- provide the right training according to the different level of responsibility and specialization;
- ensure with correct procedures the spread of information, the involvement and consultation among the workers;
- ensure the management, the identification, the traceability and control of documents and data;
- control the productive processes;
- establish the procedures and plans to face emergencies and hazardous situations;
- define the structure and the responsibility: the presence of a manager with sufficient authority in order to ensure that the management system has to be implemented to get the requirements. The quality legislation shows that the human resource is one of the most important features of a productive site;

3.2.3 Acting

- plan the actions to engage the employees to make them conscious about their roles and responsibilities; eliminate any differences between skills (goal) and competence (state of the art);
- manage all documentation to define every operation and activity encouraged (e.g. the recorded results of the measurements of pollutions in the working environments related to the TLVs). This documentation should be easy-written and should be repeatable to analyse its trend in the time.

3.2.4 Checking

- check the data to verify how the laws and the regulations can be applied to the current operations in order to plan possible corrective actions.

Unfortunately, in most cases the Safety, and its related quality, are considered only as “huge package” of procedures without a preliminary review of the risk analysis (as often is said: "we certainly cannot throw away all our plants”. It means he understood the problem...). Or even worse, the analyses are lead considering only the absolute numbers of accidents and not the accident frequency rates, therefore obviously confounding the risk with the index of attention.

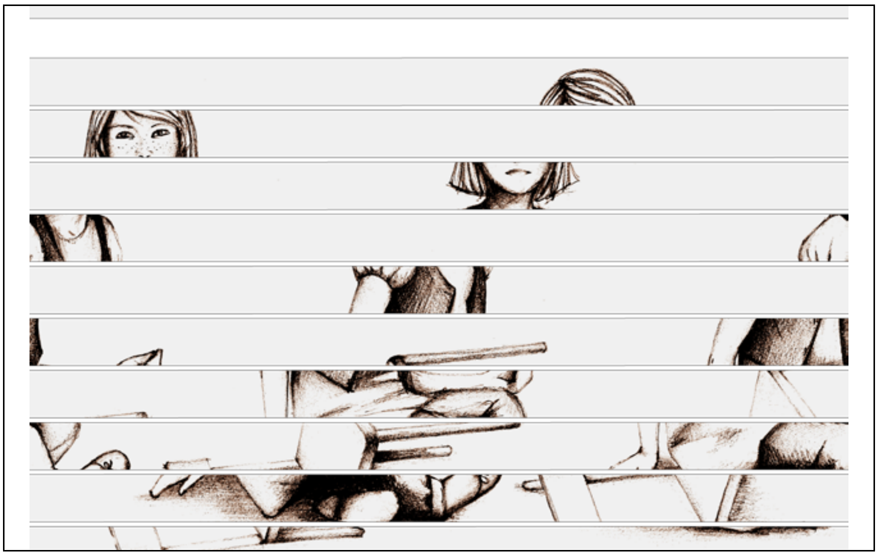

Figure 3.4: The story of the chair: in my house I have a chair with a broken leg. It was never repaired both because it was too expensive and because nobody had ever fallen down, but I wrote a procedure. "Be careful when you sit down: if someone falls, he violates the procedure and it means the fault is only his."(courtesy of M. Patrucco)

To properly fulfil the aforesaid requirements, the S&H aspects should be taken into due account at the very first step of the activity design, and during the following developments, actual operations included, preferably in a quality approach according to the OHSAS 18000/07 standards.

The special Italian regulation for extractive industries charges the Local Mining Inspectorates offices to verify both the mining plan, an official approval being required before the actual activity starts up, and the Safety and Health Document, and to carry out routine inspections on the Safety conditions at workplaces during the mining operations.

Taken into account the impressive developments in the techniques and technologies characterizing the modern extractive activities, and the results of the recent epidemiologic surveys, the task of an effective Risk Analysis, upon which the activity plan and management should be based, involves a pro-active approach. Only such an attitude makes it possible to produce positive results, since slapdash remedies and occasional inspections are clearly inadequate to effectively highlight and control the underlying Safety criticalities typical of a complex activity.

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CHAPTER 4: ASPECTS OF AVAILABILITY IN MINING

“La speranza è la più grande falsificatrice della verità.”

Baltasar Gràcian y Morales

THE PROBLEM: the management of the system availability as a key aspect for the improvement of the system quality and Safety.

“The probability that a system or equipment will, when used under specified conditions, operate satisfactorily and effectively. Also, the percentage of time or number of occurrences for which a product will operate properly when called upon.”

This is the statement able to define the concept of “**availability**” provided by J. Patton in his book “*Maintainability and Maintenance Management*”.

!!IT IS THE MOST SIGNIFICANT PARAMETER TO CHARACTERISE THE BEHAVIOUR OF AN EQUIPMENT OR OF THE ENTIRE SYSTEM IN TIME!!

U(t) = Unavailability = is defined as the probability of a system or of an equipment to be failure.

At the generic time t, the system must necessarily be in one of two states, working or failure (up and down states are not contemporary);

$$A(t) + U(t) = 1$$

The meaning of availability embodies not only the REACTION TO FAILURE of the system, but also its REPAIRABILITY.

- a system is HIGHLY available if the total time spent in the state up is much longer than the time spent in the state down.

Therefore, an available system must have good reliability (low probability of failure) and good maintainability (high probability of repair).

★ UT (Up-Time), the time in which the component or the system is actually available for operation;

★	DT (Down-Time) downtime due to technical reasons;

IT SHOULD BE REMEMBERED THAT: among the stochastic processes (such as those analysed) is defined STATE OF SYSTEM the set of parameters that characterize a variable.

4.1 WHY DOES THE AVAILABILITY AFFECT THE QUALITY AND SAFETY OF THE WHOLE SYSTEM ALSO IN MINING AND QUARRYING?

Since the Industrial Revolution, all concepts based on maintenance of technical equipment have been a challenge and a constrained necessity. Although impressive progress has been made in the field of maintaining equipment in an effective manner, maintenance of equipment is still a challenge, due to factors such as size, cost and complexity. Needless to say, today's maintenance practices are market driven, in particular for the manufacturing and process industry, for service suppliers etc…

An event may present an immediate environmental, performance, or Safety implication if the system availability is not ensured at the right time and in the right way.

Thus, there is a definite need for effective asset management and maintenance practices that will positively influence critical success factors such as **Safety, product quality, speed of innovation, price, profitability, and reliable delivery**.

Each year a lot of money is spent on equipment maintenance around the world. Over the years, many new developments have taken place in many industrial sectors to achieve better results in terms of efficiency and Safety; but the most part of these developments is based on the approach resumed with the figure below:

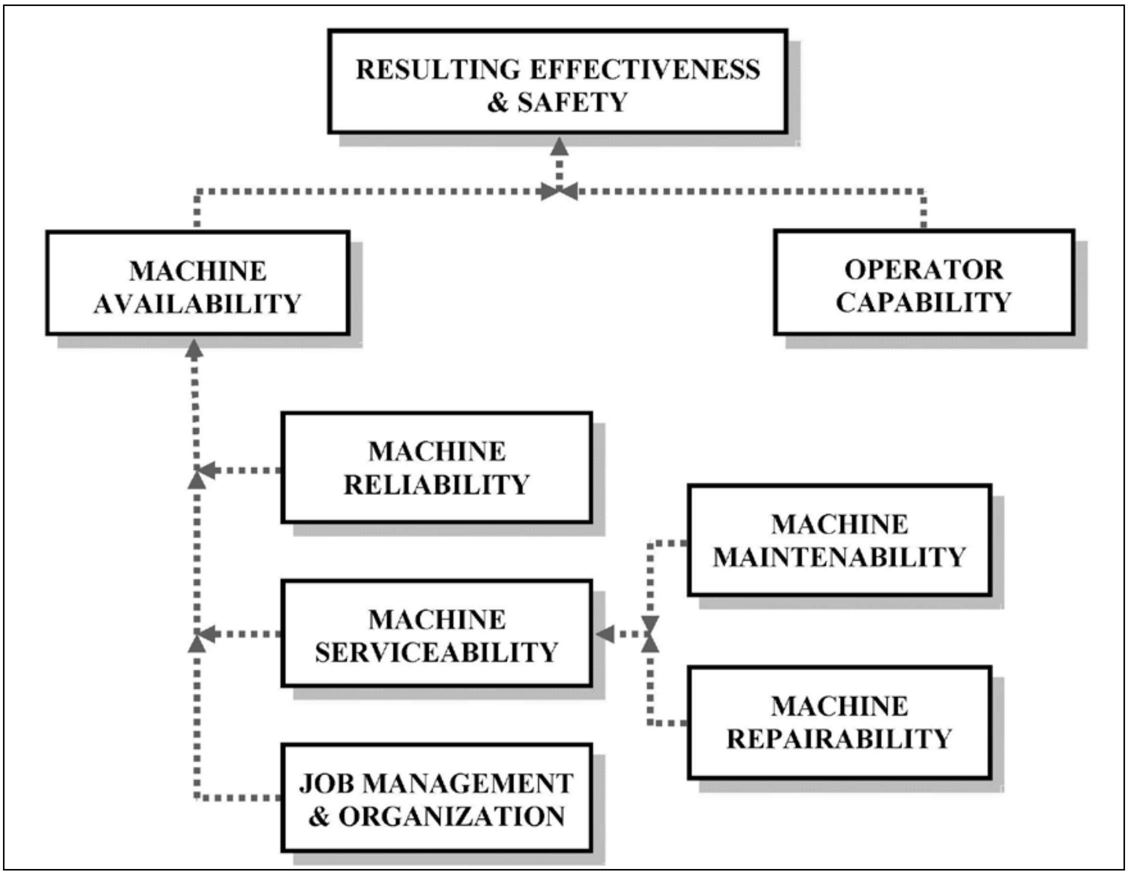

Figure 4.1: a correct approach to achieve "resulting effectiveness and Safety".

The "resulting effectiveness and Safety" could be achieved only by taking into account two different aspects: on one hand the availability of the system (related to reliability, serviceability, job management) and on the other hand the "availability" of the worker, defined as the capability.

It should be noted that the terms "maintainability" and "maintenance" mean different things to different people, and their meanings are not the same.
According to the Patton definitions, the maintainability is *"the inherent characteristic of a design or installation that determines the ease, economy, Safety, and accuracy with which maintenance actions can be performed. Also, the ability to restore a product to service or to perform preventive maintenance within required limits."*
On the contrary the maintenance is defined as "*the function of keeping items or equipment in, or restoring them to, serviceable condition. It includes servicing, test, inspection, adjustment/alignment, removal, replacement, reinstallation, troubleshooting, calibration, condition determination, repair, modification, overhaul, rebuilding, and reclamation*", or according to the European Standard EN 13306,

maintenance concerns the "*combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function*".

4.2 THE MAINTENANCE

Maintenance is a generic term for a variety of tasks in very different sectors and working environments, which includes activities such as inspection, testing, measurement, adjustment, replacement of parts, servicing, lubrication, cleaning, etc…
Maintenance operations are essential to ensure continuous productivity, to grant high quality products, and to ensure the company’s competitiveness (Figure 4.1): in general terms, to keep machines and work environment safe and reliable for all the people involved[6].
But, maintenance itself is a high-risk activity, and it has to be performed in a carefully pre-analysed safe way, with the adoption of appropriate Safety measures for the maintenance crew and other people present in the area: the available statistics (European Agency for Safety and Health at Work, 2010) indicate (Chart) that:

a) in several European countries approximately 10-15% of all fatal accidents can be related to the maintenance operations;

b) occupational diseases and work-related health impairments (asbestosis, cancer, hearing problems and musculoskeletal disorders) are prevalent among workers involved in maintenance activities.

In addition to the risks associated with any working environment, maintenance operations can be needed in all sectors, workplaces and working environment; they can require a wide range of different changing tasks, sometimes with staff from contractors; they can impose time pressure, on-call work and irregular working hours, and can involve a number of specific risks, such as working alongside a running process and in close contact with machinery, unusual work and non-routine tasks performed in exceptional conditions (confined spaces[7], access to unprotected parts, exposure to free

[6] As discussed in FACTS 27 (European Agency for Safety and Health at Work, 2002), “*accidents and occupational diseases can give rise to heavy costs to companies. For small companies particularly, occupational accidents can have a major financial impact*”. The Health and Safety Executive (HSE) lists: *production disturbance costs (cost of recruitment and work reorganisation), health and rehabilitation costs, administrative and legal costs.*

[7] It is not uncommon to record exposures e.g. to airborne particulates due to maintenances operations in the components compartments of a machine impressively higher than the ones recorded for the same machine operators, even if the machine is used in dusty areas, due to the amassed particles in the compartment.

energies and pollutants). Subcontracting, a common situation for the maintenance operations, is an important aggravating factor in terms of Safety and Health.

The *Modus Operandi* involved during the maintenance / repairing operations is affected by the typology of maintenance that is adopted.

It is generally possible to identify two different situations:

a. activities that are expected to be carried out by official maintenance personnel, routinely in the case of scheduled maintenance, or to correct unexpected failures; the machinery / equipment is tested after the intervention, and the result recorded;

b. activities on charge of the machine operator: routine lubrication, cleaning and adjustments, and elementary problems correction.

Dramatic Safety criticalities can arise if the boundary between the two situations is not clearly defined or understood, or disregarded under time-pressure conditions: information, formation and training should as a first step cover the topics of *"how to correctly do"* and *"what not to do"*[8].

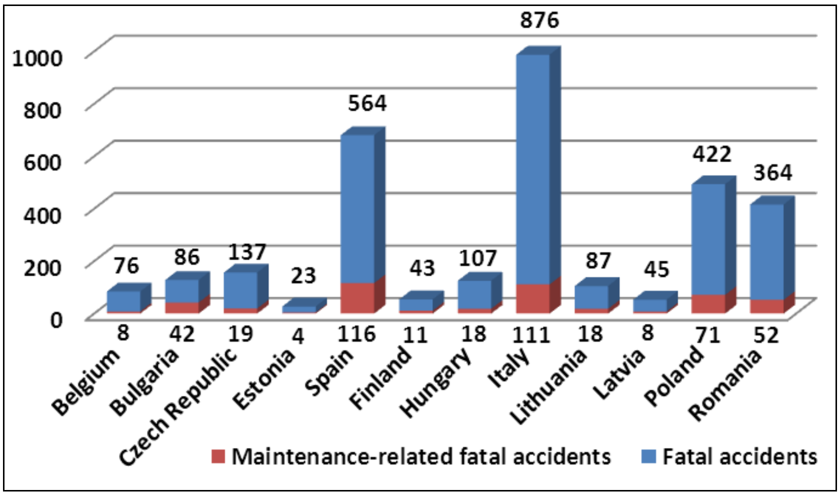

Chart 4.2: Number of fatal accidents related to maintenance operations in EU-countries (2006).

According to these, the maintenance includes both corrective and preventive activities, it assists in acquisition of resources needed, and it provides policies and plans for the use of resources in performing or accomplishing maintenance itself.

[8] Taking into account the number and severity of the accidents involving machineries for lifting, loading and haulage in Italy, the Permanent Conference of State and Regions defined the course program for a special qualification and license of the operators. The attention is focused on the correct use of the machinery / equipment, but the official program does not cover the elementary maintenance, and the failure management.

Moreover, the maintainability is a feature of a component and of the system. For this reason it is important to conduct a sufficiently careful analysis during the planning phase in order to avoid, for instance, the components for which the operation of *maintenance* are:

- **too expensive;**
- **too frequent;**
- **too difficult to carry out.**

Even though the maintainability and the maintenance have the same end-objective or goal (i.e., mission-ready equipment/item at minimum cost with the highest reasonable and available level of Safety), the environments under which they operate differ significantly. More specifically, the maintainability is an analytical function or operation as well as it is deliberate and methodical; it has to reduce the maintenance operations, the effect of complexity of the system, the skills required and the amount of supply support.

In contrast, the maintenance is a function that must be performed, under normally/adverse circumstances and stress, and its main objective is to rapidly restore the equipment to its operational readiness state using available resources.

4.3 THE AVAILABILITY IN MINING AND QUARRYING OPERATIONS

The mining and quarrying activities are characterised by specific problems, related to the logistic and systems, that are not present in other industrial sectors:

- evolution of the workplace and the consequent continuous change of scenarios to consider characterised by requirements of new allocation systems and plants in the areas with more operations (drilling face): hence the need for a dedicated Hazard Identification and Risk Management;
- energies and plants characterised by high power applied to accurate work carried on in restricted places particularly "crowded" by employers, equipment and facilities with serious problems related to both shocks and stresses for all components (cables, ventilation ducts, ...) and to nature’s phenomena (lighting, humidity , temperature, etc..);

- ★ the availability of the equipment characterised by specific emergency system with "soft down" logic, has to be taken into account during the first planning phase (the dewatering systems or ventilation systems described more carefully in the next chapters).

In addition, the planning choices for the construction sites and for the mining and quarrying activities are made more complex because:

- strongly influenced by the specific nature of the site (distance from the node of the energy distribution);
- characterised by high interdependence among the planning choices based on uncertain data.

These considerations underline the extent of the necessary confidence limits in order to deal with emergencies which are sometimes not clearly quantifiable (in terms of amount of gas formation).

Moreover, they show the great importance of a correct and well-planned availability of the system in order to ensure a "resulting effectiveness and a Safety", both during the normal conditions and emergency moments.

As a matter of fact, the availability in mobile and field equipment at mine sites is often expected to be easily maintained from the original designs with a basic maintenance job. This attitude is commonly shared across the mining industry where the maintenance operations are seen as a cost to the business and one of the first targets when trying to reduce costs from the budget.

However, due to the large number and different types of equipment this very commonly leads to the wild fluctuation of the availability of the system. Several mine sites suffer from an increasing defect list on the equipment and facilities, which is further impacted by large downtime failure events. In this way, maintenance operations fall into a breakdown focused maintenance gap when availability has not been developed.

Once the maintenance operations falls into this trap, it is difficult to provide production with the equipment they require to continue to operate at full capacity to the Safety detriment. The system is lead to suffer from inconsistent availability and MTBF[9], with large troughs from failures and peaks from focusing on that equipment recovery.

[9] Defined as the average time/distance/events a product delivers between breakdowns.

When one equipment has major failures, it becomes the focus equipment for the maintenance operations. During this time the other defects and regular servicing are completed quickly with minimal resources in order to be able to move as much man power as possible to the critical equipment. Once the focus fleet has been restored, all equipment begins to show low availability and soon another equipment will be in need of focus.

This cycle develops a culture of breakdown focus and will not be able to maintain reliable equipment that can effectively be used by production. Equipment with a low as possible variation in availability is needed.

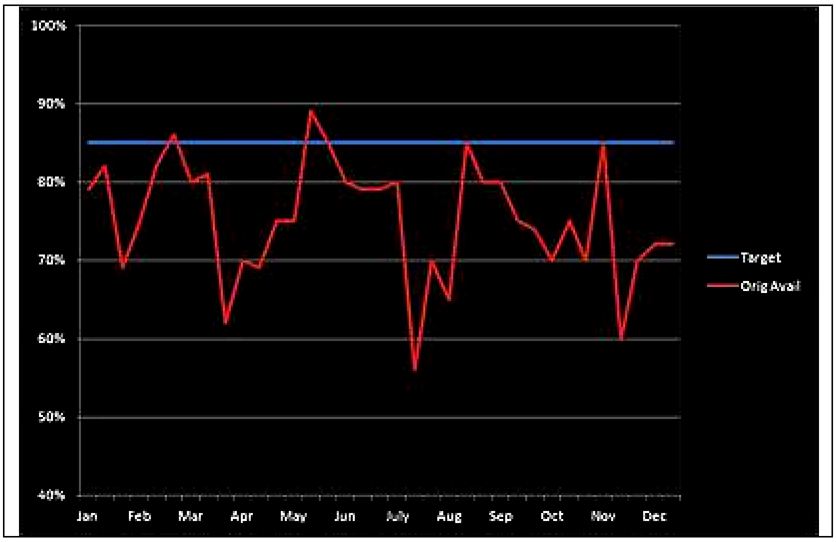

Figure 4.3: correct (blue) and wrong (red) trends of the equipment's availability.

The choice of equipment's plant (defined as a combination of equipment needed to achieve certain tasks or make certain services) has to balance productivity and costs ensuring the Safety and the Health of the workers at every moment, in order to reach the maximum efficiency.

Listed below are the possible components of a mining and quarrying site:

- equipment for delivering the different energies to the final users;
- equipment for loading, hauling and dumping;
- equipment for treating the excavated materials;
- means of communication;
- Safety equipment;
- equipment for managing the underground conditions.

It means to maximize the production at the lowest possible price, improving as much as possible the level of occupational and environmental Safety and Health.

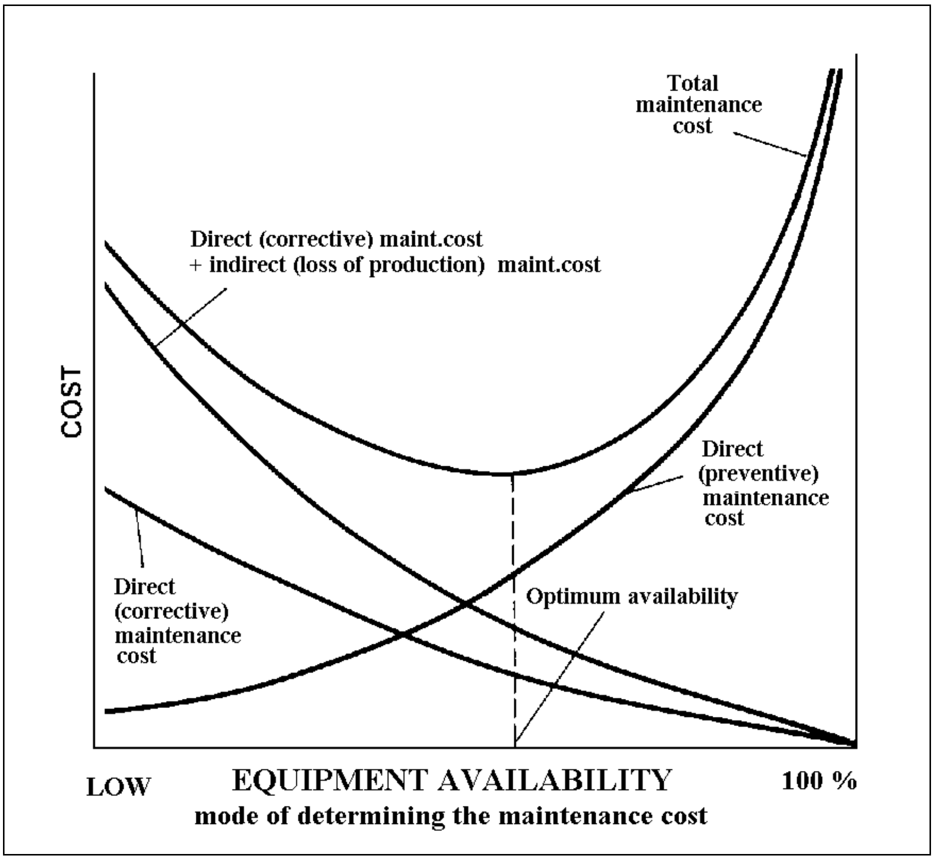

Figure 4.4: evaluation approach to define the global cost of the maintenance operations.

A precious method to reach the "break event point" between maintenance, cost and availability and to evaluate the effectiveness of the maintenance management is surely represented by the Corder's Index; the simple equation takes into account the most important parameters which affect the accuracy of the maintenance operations such as global maintenance cost, Mean Time To Repair (M.T.T.R).

Effectiveness Index of the Maintenance (Corder's Index)

$$\mathbf{E} = \frac{\mathbf{K}}{\mathbf{x} \cdot \mathbf{C} + \mathbf{y} \cdot \mathbf{L} + \mathbf{z} \cdot \mathbf{W}}$$

- C = global maintenance cost [% cost of the equipment replacement]
- L = Mean Time To Repair (M.T.T.R) [%]

- W = remaining material generated by the maintenance operations [% global production of the related process];
- x = global maintenance cost computed for every year;
- y = global cost of lost time during the maintenance operations computed for every year;
- z = global cost of the remaining materials computed for every year;
- K = constant which makes the equation value equal to 100 computed for every year;
- E = effectiveness index of maintenance; computed for every year it should be 100.

If the value increases year after year it represents **an improvement of the maintenance management**; on the contrary if the value decreases it represents **a deterioration of the maintenance management.**

4.4 HOW TO PREVENT FAILURES?

Preventing equipment failures can be achieved by following the Five Availability Principles that form the necessary foundation to achieve world class maintenance operations in any industry. The main principle is Total Asset Management which covers the management of the site culture, while the other four principles focus on how to prevent failures:

- Condition Monitoring,
- Continuous Improvement
- Root Cause Analysis
- Defect Elimination.

These principles have been chosen as they represent different moments in time, relative to equipment failure. The timeline that this develops maps the function of availability within maintenance, showing how critical this disciple is within any maintenance function.

4.4.1 Continuous Improvement

Continuous Improvement is the first principle of Reliability Engineering that can be applied to prevent failures from occurring. Continuous improvement typically involves sourcing new technologies, utilising product improvements and harnessing bright ideas from the workforce to eliminate the failure mode from ever being present. Identifying potential technologies and ideas requires good communication channels and relationship with both the workforce and suppliers. It also requires good networks to uncover new technologies from other industries and develop their potential cross application to the mining industry.

4.4.2 Condition Monitoring

The next phase, aimed at predicting when failures will or are beginning to occur, is Condition Monitoring. Typically in maintenance this is and always has been a difficult goal to fulfil, being sometimes constrained to only one type of monitoring system (traditionally oil analysis). The current diversity of condition monitoring practices available delivers a holistic view of your equipment health. Some of the better known practices are non-destructive testing, vibration testing, oil analysis, thermography and more recently, live equipment health monitoring systems. Good Condition Monitoring allows for potential failures to be predicted, controlled and prevented. They can be planned and repaired before any equipment experiences breakdowns and component failures.

4.4.3 Root Cause Analysis

After a failure has occurred the first of the availability principles is the Root Cause Analysis. Root Cause Analysis (RCA) delivers two pieces of knowledge that can be used to improve the equipment. The first piece consists in understanding and documenting the fundamental causes of failures and incidents. By doing this actions to prevent an unwanted re-occurrence can take place. The second piece that RCA delivers is the correct data relating to failures allowing for validated analysis. Without confidence in the data obtained from failures, the corrective actions cannot be put in place to prevent the re-occurrence.

4.4.4 Defect Elimination

The final phase of the failure timeline is Defect Elimination. Defect Elimination is typically a process developed around the needs of the maintenance group in order to interrogate failure data and prioritise what actions can be taken to eliminate the re-occurring failures. The most effective method for identifying the largest issues in the mining industry is to examine the downtime data. This information can be analysed with Pareto Analysis to identify which are the largest defects and then supported by information from other information sources. Having then concluded these priority actions, the group can implement a project to achieve the results needed to prevent the failures to continue to affect the performance of the equipment.

4.4.5 Asset Management

Overshadowing the failure timeline is the management of the equipment through Asset Management. In the case of availability, Asset Management is about achieving a site reliability centred culture and maintenance optimisation of the equipment in order to meet the customers' requirements. This is provided by having the right processes in place and the right personnel using these processes correctly in order to obtain the desired results. The processes must encompass the workflow of maintenance, fitting for purposes maintenance strategies in place for all equipment, and the use of optimisation software to continue to review and improve those strategies. The processes also need to be extended beyond the maintenance group and include how the equipment is operated to ensure that its reliability is achievable.

The second and most important element to Asset Management is the Availability Centred Culture within the site. Without a workforce that supports an availability culture, equipment performance will never achieve world class levels. This desired culture can only be obtained by having the workforce own and the desire to improve the equipment. With a workforce that is accountable for the quality of maintenance and desires for the equipment to perform at optimal levels, it is ensured that the processes put in place will be followed, allowing for a world class operation to be achieved.

The complete asset management is reached when both the maintenance and production teams understand their roles in creating world class reliable equipment. This can be the final and most difficult hurdle to overcome for asset management as all teams must work together to optimise the assets.

4.5 THE RESULTS OF AN INCORRECT AVAILABILITY AND MAINTENANCE POLICY

As discussed, a correct maintenance is of paramount importance for the Occupational Safety and Health, both with regards to the maintenance personnel and to the operators. In the author's opinion, the only way to prevent accidents with dramatic consequences is to carry out a careful Risk Assessment and Management, aimed to grant a safe running of the machines, equipment and plants special for these operations, and the necessary inspections, maintenance and tests, upon which to base the information, formation and training of the workers involved, no matter how occasional the interventions can be.

When these priorities are not taken into account, some deviations in the system, or in the worker's formation can lead to accidents.
With special reference to the workers information, formation and training, in the 89/391/EEC Directive the informing, consultation, balanced participation and training of workers and their representatives are considered, ensuring that each worker receives *adequate* (i.e. derived from a Risk Assessment special for the situation) Safety and Health training, in the form of information and instructions specific to the workstation or job, and in every occurrence of job changing or in the event of the introduction of new/modified equipment. An obvious, but sometimes neglected concept, is that also, and in particular, una-tantum operations should be object of careful preliminary Risk Assessment / Management.

Two fatal accidents are shown in the following pages and carried out within Prosecutor investigations; the intermediate events chain and the root causes are discussed, together with the possible prevention actions of both the direct consequences of incorrect operations, and the indirect consequences due to poor inspection and maintenance of earthmoving machines in quarrying operations.
The technique is based on a "computer assisted technique", developed at the Politecnico di Torino, which permits to thoroughly study the accident and to find the best solutions.

4.5.1 Case 1 - Loader operator struck by moving equipment during a maintenance operation

A hose of the hydraulic circuit feeding the bucket jacks started leaking; the operator tried to intervene and loosened the connection without preliminarily securing the bucket in the higher position. The bucket fell and struck the operator. No supervisor was present, no machine instructions on board and the prop provided by the manufacturer had been removed in the past. The victim worked under temporary contract.

Figures 4.5, 4.6, and 4.7: The machine involved into the event, the poor condition of the broken hose and the worn distributor parts

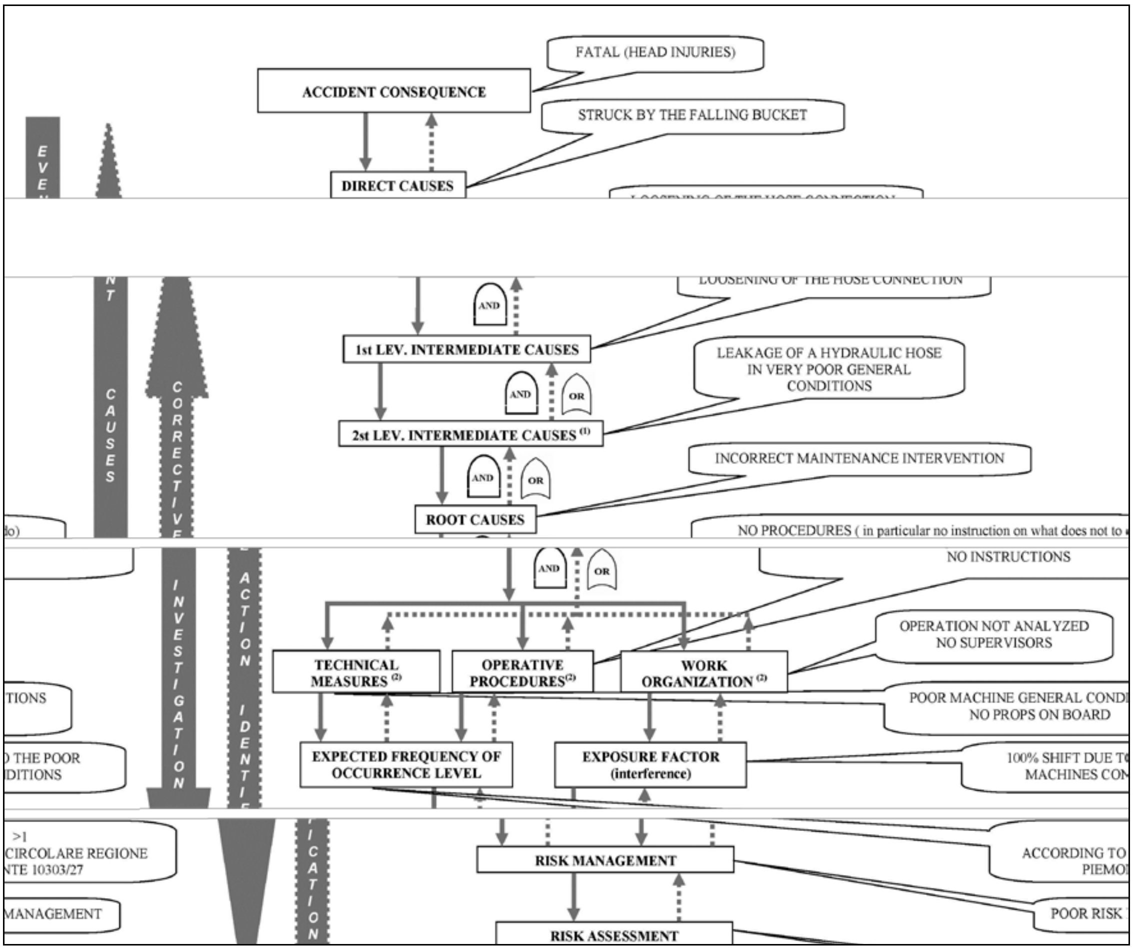

Figure 4.8: The root-causes analysis of the accident

4.5.2 Case 2 - A rear dump truck falls into a water filled pit

One of the rear right axle leaf springs had broken in the past, and the problem hadn't been detected. The accident was caused by the sudden collapse of the 2nd spring (the longest one) in the maximum load condition during the dumping phase. The balance was then compromised and the breaking action not sufficient, due to the worn treads of the tyres of the 2nd axle (the 3rd axle lost adherence due to the modified situation of the suspensions). No barricades were installed in the dumping area.

Figures 4.9 and 4.10: The recovery operations and the couple of collapsed leaf springs

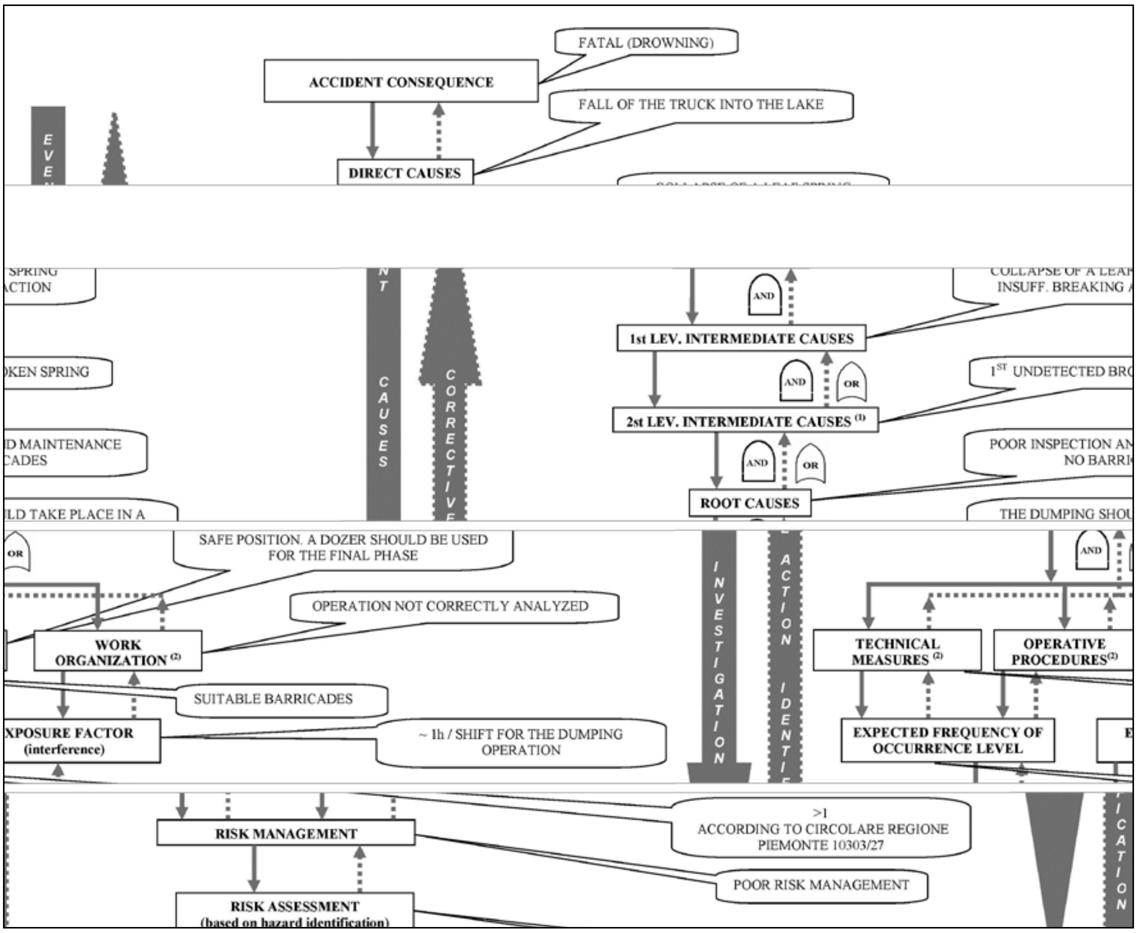

Figure 4.11: The root-causes analysis of the accident

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CHAPTER 5: ITERATIVE OPERATIONS

THE PREVENTION FOR MINERS' SAFETY

"The problem with the world is that the intelligent people are full of doubts, while the stupid ones are full of confidence."
Charles Bukowski

THE PROBLEM: how can we maintain the right level of attention during all the work shift?

In response to economic, technological, and social pressures a 24-hour organisation of the workplace is now common. This requires the workforce to accept and become adapted to many different forms of work schedule and shifts.
The decadence of the right level of attention during all the work shift is surely a non-negligible source of injuries.

5.1 THE WORK SHIFT

The organisation into work shifts is now a major feature of working life across a broad range of industries, including mining. The features of the shift systems can impact on the wellbeing, performance, and sleep of shift workers according to the shift rotas and the shift duration (for instance comparing the relative effects of 8 hour and 12 hour shifts on fatigue and job performance, Safety, sleep, and physical and psychological health). At the organisational level, factors such as the mode of system implementation, attitudes towards shift rotas, sickness absence and turnover, overtime, and moonlighting have to be deeply considered to reduce the effect of hazardous loss of concentration during the operations. Some studies suggest few differences between eight and 12 hour shifts in the way they affect people. There may even be advantages to 12 hour shifts in terms of lower stress levels, better physical and psychological wellbeing, improved durations and quality of off duty sleep as well as improvements in family relations. On the contrary, the main complicated aspects are fatigue and Safety. It is noted that a 12 hour shift does not actually mea being active for only 12 hours. There can be considerable extension of the person's time awake either side of the shift. However, the effects of longer term exposure to extended work days have been relatively uncharted in any systematic way.

5.1.1 The adverse effects of the work shift

The adverse effects of work shift are well chronicled. As briefly listed, they include biological disruption to physiological processes, including the sleep-wake cycle; the impairment of physical health and psychological wellbeing; problems with alertness, performance, and Safety, and lastly, interference with social and domestic life. The extent to which shift work affects the individual person depends largely on the job (the same operations for n-times or different operation in different scenarios), on the characteristics of the individual, on the organisational and social environments, and on features of the shift system. This potential impairment to functioning exists because daily rhythms in human physiology, hormone concentrations, biochemistry, and behaviour have become entrained to the most reliable and predictable cyclic changes in the physical and social environments. Moreover, under work shift conditions, and especially when required to work at night, the components of this system of circadian rhythms are regularly disrupted as a result of having to alter the activity-rest cycle.

It should be kept in mind that also every technological improvement or innovation introduced in the productive cycle has to be extensively evaluated in order to avoid the occurrence of new and unexpected risks; on the other hand the workers have to be correctly formed and trained to re-established the proper level of attention.

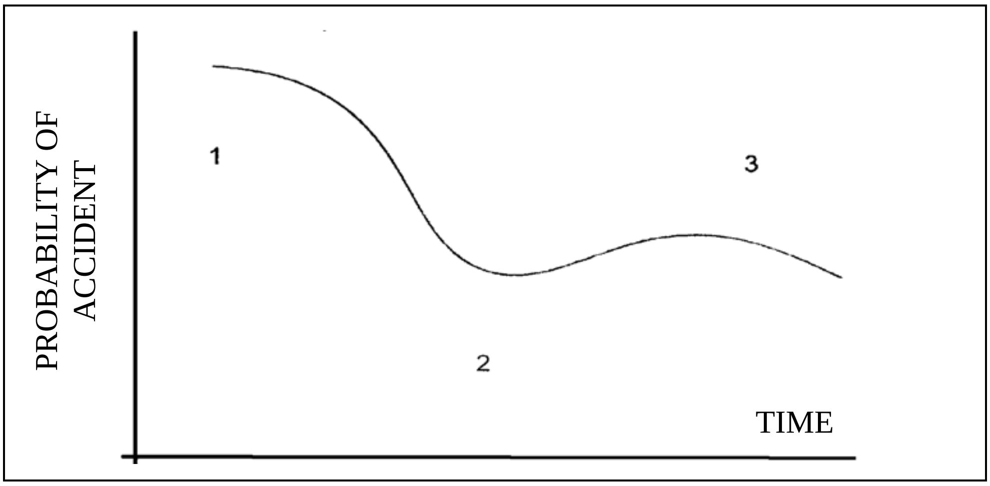


Figure 5.1: The common trend of a worker's level of attention during his working life. It should be underlined that a similar trend is quite recurrent also during the work shift.

5.1.2 The level of attention during the work shift and during the working life

In Figure 5.1 three different phases of the level of attention can be identified with the related three different probability of an accident:

1. *inexperience phase: the worker is learning the unpredictable planning problems of the operation. High probability of an accident;*
2. *running phase: the worker has just learnt and he is afraid of the accident. Low probability of an accident;*
3. *critical phase: the excess of confidence leads to lose the fear of the accident. The probability of an accident increases again.*

The introduction of formation and training help to lower the general trend (the probability of an accident) and to reduce the consequences of an occurred accident; instead, the periodical formation maintains the right level of attention of the worker, helping him to identify the hazards of the repetitive operations.

As aforesaid, these considerations can be applied not only to the entire working life, but also to the work shift; as a matter of fact three different moments can be found which are characterised by the same probabilities of an accident:

1. *starting moment: the worker is starting his job and he is not focused to his operation yet. High probability of an accident;*
2. *running phase: the worker has recovered the skills to correctly carry on his operations. Low probability of an accident;*
3. *end of the shift: the concentration of the worker is very low. Now he thinks to the end of the shift. The probability of an accident increases again.*

According to that, the injuries can be classified by different parameters (root causes, age of the worker, sex of the worker, duty, incapacity type, disease etc…) in order to point out and to find the right solutions to minimise their occurrence. Moreover also the month, the day and the hour of the accident are surely very significant; but unfortunately, these data are very difficult to discover because the national database do not permit to lead this kind of investigation.

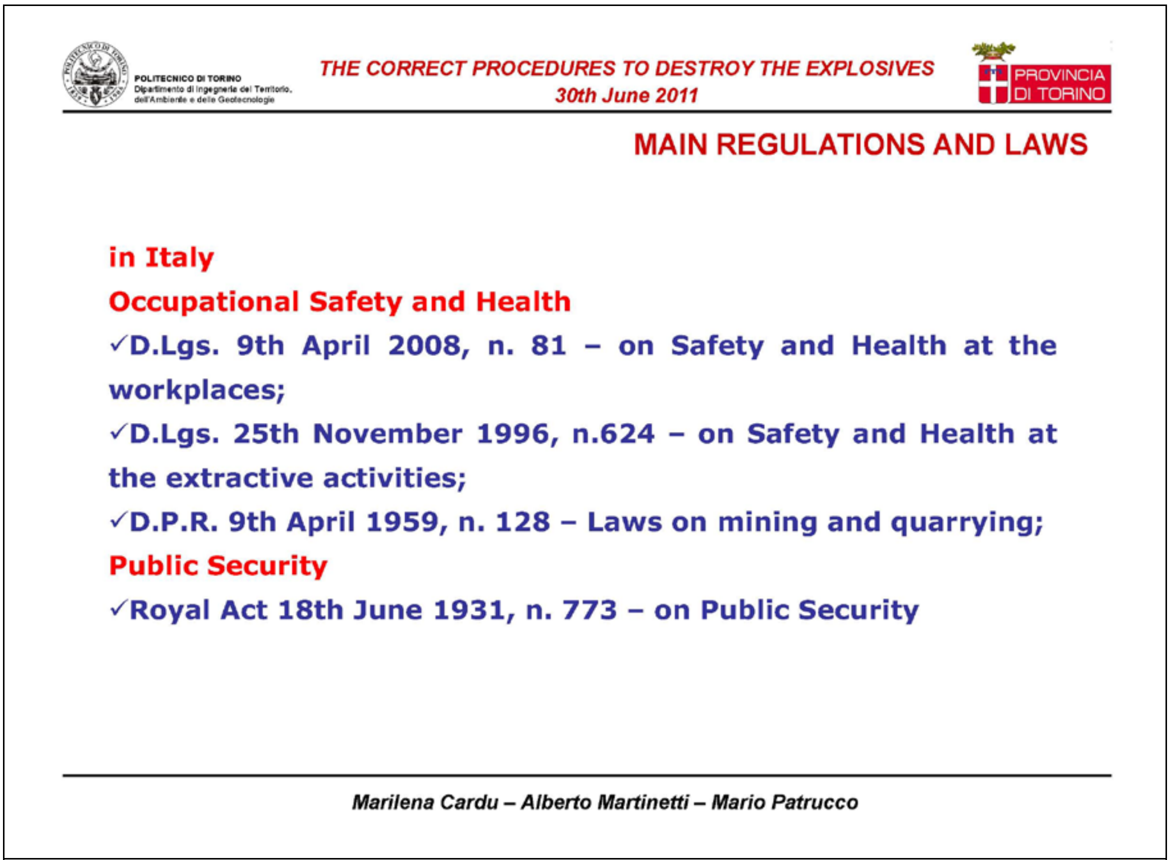
5.2 THE DESTRUCTION OF BLASTING AGENTS: AN ITERATIVE OPERATION

The Local Mining Authority of the Provincia di Torino has faced an increasing number of injuries related to accidents occurred during the repetitive operations of the destruction of the blasting agents at the end of the work shift at the extractive sites.

5.2.1 The Italian regulation on the explosives and the blasting agents

The Italian regulations for mining and quarrying (but in general for using explosives) establish that all the unused blasting agents have to be destroyed before the end of the day and any explosive storage facilities are forbidden. These rather strict laws were put into force to control weapon smuggling; unfortunately, in some cases, in order to increase public security, the Safety at work was diminished.

For these reasons, the Politecnico di Torino within a wide Research Project has organised a formation and training day on the correct procedures to destroy the explosives.



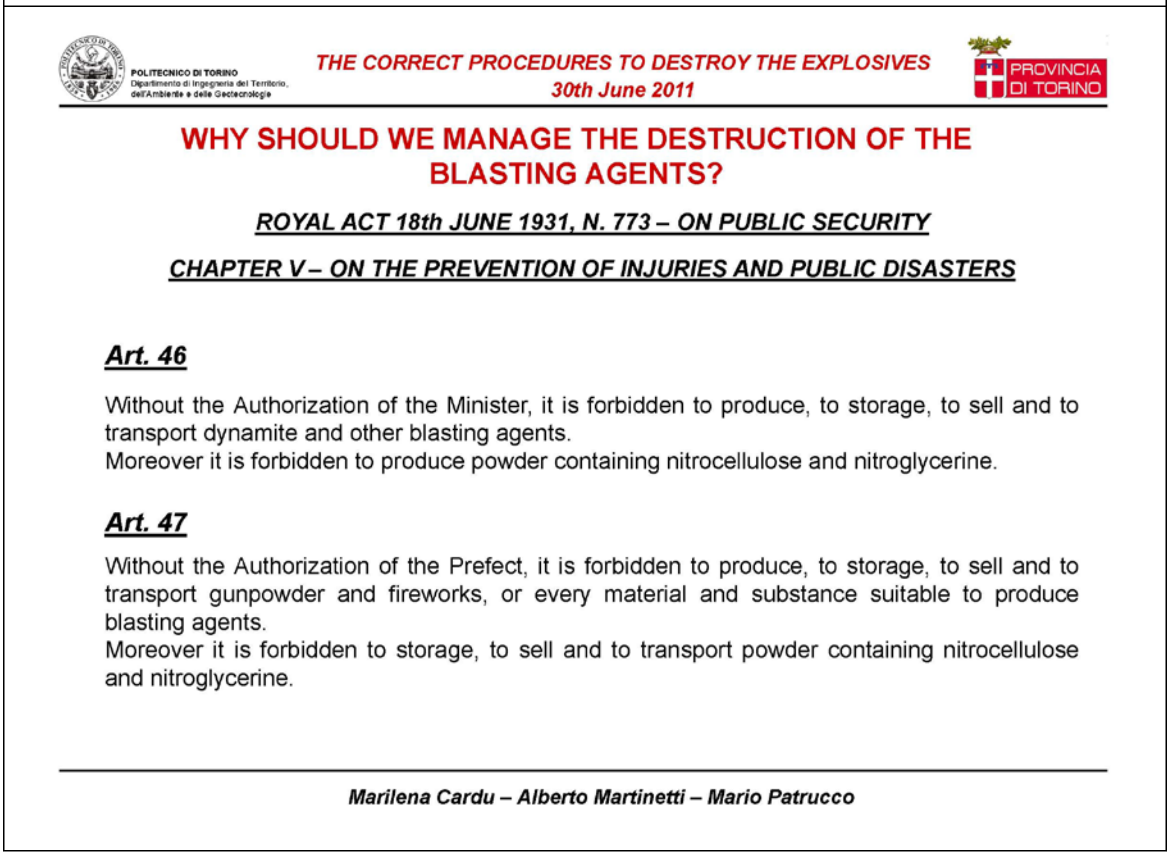


Figure 5.2 and 5.3.: The Italian regulations on the blasting agents (extracted from "The correct method to destroy the blasting agents – Training Day at the Mining Inspector Authority, 30th June 2011")