Risk assessment and safety in Stone industry

1

Risk Assessment and Safety

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1.1. Introduction

The accident-at-work rates in the Ornamental Stones sector at the beginning of the 21st century justify the necessity of improving safety conditions. For that reason, it is crucial to use new technological developments as well as the existing experience to prevent accidents. Within the dominating globalisation environment, it is important for E.U to carefully examine the issue of work accidents in the Ornamental Stones Sector. Those who do not have an adequate knowledge of the Sector's industries may think that productivity implies a safety reduction. This is totally untrue; safety and productivity must work together.

Industrial accidents are related to both *direct* and *indirect* costs. The direct costs represent hospital expenses, insurance aggravation (increase of insurance costs), cost for repairing the damaged equipment and costs due to low productivity, as a result of the equipment's damage. On the other hand, indirect costs are associated with the degraded image of the company (temporary or permanent), social and family costs, commercial contracts indemnities (most times the companies are not able to meet their deadlines), workers replacement and training of new operators/workers. In addition to that, indirect costs are also related to the consequences of the accident, as the non injured workers produce less than average either because they help in the first aid process or because they are psychologically affected by the accident. Nevertheless, there are major indirect costs that depend on the time the workers return to their activities. Usually, during the rehabilitation period, the worker's productivity is far from optimum, as there is a negative psychological effect that leads to a certain fear to operate with machinery, equipment, etc.

A change in public awareness for industrial accidents is necessary. It is important to mention that there is no such thing as absolute safety but there must always be a continuous effort to keep the activities at a satisfactory safety level. This edition describes the actual situation of health, safety and environmental factors in the Ornamental Stones sector industries and aims to find reasonable measurement actions that can help change the current state of affairs both in Quarries and Processing plants.

According to statistical reports, mines and quarries are two of the most dangerous workplaces. The average number of fatal accidents at work in the E.U countries per 100.000 employees is shown in Table 1. The statistical data provided in Table 1 are very useful for the Risk Assessment. Generally, the most important data for performing a Risk Assessment are the number of fatal accidents per year, the mine type and location, type of equipment and occupation and age of the accident's victim.

Table 1. Fatal accidents at work in E.U per 100.000 employees (Source: MIRTEC – Greece).

COUNTRY	Fatal Accidents at work in E.U per 100.000 employees
Austria	3,4
Belgium	6,0
Denmark	2,8
Finland	3,6
France	4,3
Germany	3,7
Greece	4,3
Holland	2,6
Irish	3,9
Italy	5,3
Luxembourg	-
Portugal	9,7
Spain	7,0
Sweden	2,1
U.K	1,7
Average of 15 Countries	**3,9**

1.2. Legislation

Quarrying of Ornamental Stones is generally not covered by mining laws in Europe, and there are no European directives on quarrying, mineral claims and exploration. The practices and legal framework on mining vary significantly between the Member States, including the way stone is treated compared to other commodities. Design and planning of Ornamental Stones exploitation activities, as well as production development of operating quarries, are today dependent on strict environmental regulations. The most important environmental issues for Ornamental Stones quarrying are waste handling (rock fillings and dust), direct impact (noise, dust, visual impact) and land use (competing interests). The E.U Policy regarding wastes focuses on two aspects – handling and prevention. A Directive for handling mining wastes is in progress, and Eco-labelling criteria for hard floor coverings, including stone, have recently been established. Regarding land use, the NATURA 2000 areas in particular, can cause operational problems to any quarrying activity. Rehabilitation during and after the quarrying processes has become a pre-determined requirement and obligation.

Legislation should be considered as a tool that will allow industries of the Ornamental Stones sector to define and achieve their goals through the minimisation of accidents due to the implementation of Health, Safety and Hygiene norms. All existing E.U Legislation regarding Health, Safety and Hygiene of the sector workers is presented in the following paragraphs. Although the Ornamental Stones sector has deep roots in the European history, there are important challenges related to the workers protection that must be addressed in order for the industry to be in the future as successful as it has been in the past. E.U targets to set the broad policy lines for promoting sustainable development by reconciling the need for more secure and less polluting activities of the Ornamental Stones sector, while maintaining the competitiveness of the industry.

1.2.1. European Directives

- **83/477/EC**, “Noise Protection for the Workers”
- **86/654/EC**, “Minimum Requirements of Health & Safety for the Work Place”
- **86/655/EC**, “Minimum Requirements of Health & Safety for the Work Equipment”
- **86/656/EC**, “Minimum Requirements of Health & Safety to use Personal Protective Equipment”
- **92/91/EC**, “Minimum Requirements for the Improvement of Health & Safety Conditions in Drilling”
- **92/104/EC**, “Minimum Requirements for the Improvement of Health & Safety Conditions in Open Pit & Underground Mining Operations”
- **74/325/EEC**, Council Decision (27/7/1974) on “Setting up of an Advisory Committee on Safety, Hygiene and Health Protection at Work”
- **74/326/EEC**, Council Decision (27/7/1974) on the “Extension of the responsibilities of the Mines Safety and Health Commission to all Mineral-extracting industries”.
- **89/39/EEC**, “Measures for the improvement of Safety & Health of the employers for the work place”

1.2.2. National Legislation of different European countries

GREECE

General Legislation

- **Presidential Decree 17/1996**, “Measures for the Improvement of Health and Safety Conditions in the Work Environment According to EC Directives 89/391/EC and 91/383/EC”
- **Law 1568/1985**, “Workers Health and Safety”
- **Presidential Decree 16/1996**, “Minimum Requirements for Health and Safety in the Workplaces according to EC Directive 89/654/EC”

Specific Legislation

- **Presidential Degree 70A/1988**, “Protective Measures for the Workers in Contact with Asbestos Material”
- **Presidential Degree 225/1989**, “Health and Safety in Underground Technical Works”

- **Presidential Degree 212/1976**, “Health and Safety for Workers with Front-end Loaders & Belt Conveyors”

ITALY

General Legislation

- **Decreto del Presidente della Repubblica No. 459 (24/07/1996)**, “Rule for implementing 89/392/CEE, 91/368, 93/44 and 93/68 directives, concerning the convergence of all member states legislation to the machinery use”.
  Contents: Safety rules for machines manufacture, selling and rental, according to CE mark.
- **Decreto Legislativo No. 626 (19/09/1994)**, “Implementation of 89/391/CEE, 89/654/CEE, 89/655/CEE, 89/656/CEE, 90/269/CEE, 90/270/CEE, 90/394/CEE, 90/679/CEE, 93/88/CEE, 95/63/CE, 97/42, 98/24 and 99/38 directives concerning the improvement of Health and Safety during work”.
  Contents: The principal rules for health and safety at workplaces are resumed: general dispositions; organisation of protection and prevention services in the company; workplace requirements; use of equipment; individual protective systems; information, formation and training of workers; load’s manual handling risks; use of video terminal equipment; carcinogenic substances protection system; biological substances protection system; sanitary supervision.
- **Legge No. 46 (5/3/1990)**, “Norms for safe plants”.
  Contents: General rules for planning, installation and maintenance of thermal, hydraulic and electrical equipment.
- **Decreto del Presidente della Repubblica No. 303 (19/3/1956)**, “General rules for the hygiene at work”.
  Contents: Review of the main workplaces characteristics and requirements: minimum height, volume, ventilation, lighting, temperature, air pollution preservation, acoustic and vibration noise preservation, personal protection systems, bathroom, dressing room, refectory, health service, etc.
- **Decreto del Presidente della Repubblica No. 547 (27/3/1955)**, “Norms for the prevention of accidents at work”.
  Contents: Regulation for safety at work before the reception of EC directives. This law regards general dispositions, like: working environment; workplaces; general machine protection requirements; lifting system and equipment; other machinery; electric machines and installation; dangerous products and materials; maintenance operations; personal protective system; assistance and emergency.
- **Decreto Ministeriale (10/3/1998)**, “Fire prevention general rules and emergency management at work”.
  Contents: This law deals with: fire risk assessment; maintenance and control of fire equipment; fire prevention staff; emergency fire events; preventive fire training.
- **Decreto del Presidente della Repubblica No. 128 (9/4/1959)**, “Norms for mines and quarries”.
  Contents: This is the principal law regarding Health and Safety rules applied to all quarrying activities, such as: exploitation; open sky quarry activities regulation; transfer and circulation of workers; explosive materials management; toxic gas prevention; control and measurement; inflammable dust; fire prevention; water irruption; radioactive minerals; medical controls and survey; first aid and evacuation plans and hygienic rules.

Specific Legislation

- **Decreto Legislativo No. 359 (4/08/1999)**, "Implementation of 95632/CE directive, which modifies 89/655/CE directive concerning the minimum Health and Safety requirements for equipment used at the workplaces".
  Contents: Safety rules for the correct use of equipment.
- **Decreto Legislativo No. 493 (14/08/1996)**, "Implementation of 92/58/CEE directive concerning the minimum prescriptions for safety system of signs and/or of health at workplaces".
  Contents: Rules for the health and safety sign system at work facilities.
- **Decreto Legislativo No. 277 (15/871991)**, "Implementation of directives 80/1107/CEE, 82/605/CEE, 83/477/CEE, 86/188/CEE and 88/642/CEE for the protection of workers who are exposed to risks by chemical agents, (physical and biological) during work according to art. No. 7 (Law No. 212, 30/7/1990)".
  Contents: This law is one of the first EC directives that has been implemented in Italy and is dedicated to all the risks to which the workers are exposed.
- **Decreto del Presidente della Repubblica No. 320 (20/3/1956)**, "Norms for the underground accident preventions".
  Contents: This law establishes safety rules for underground tunnelling in civil construction works.
- **Decreto Legislativo No. 475 (4/12/1992)**, "Implementation of 89/686/CEE directive of December 21, 1989 about the individual protection devices".
  Contents: Indications about the correct use and employment of individual protection devices.
- **Decreto Legislativo No. 624 (25/11/1996)**, "Implementation of 92/91/CEE directive related to the workers health and safety conditions in the mining industry for drilling and the 92/104/CEE directive related to the workers safety and health conditions at open or underground mining industries".
  Contents: This law coordinates the precedent National laws concerning quarries and mining activities. The principal arguments are: general disposal; obligatory health and safety documents; mechanical and electrical equipment; maintenance operations; specific rules for surface or underground quarrying activities and exploitation, including surface plant and processing industries, and specific rules for drilling activities.

LATVIA

General Legislation

- **EO177 (2001)**, **"**Regulations regarding minimum requirements for the Safety and Health Protection of Workers in Workplaces".
- **EO224 (2001)**,"Procedures for Industrial Accident Risk Assessment and Risk reduction measures".
- **EO275**, "Product and Services Safety Law".

PORTUGAL

General Legislation

- **D.L.441/91**, "Measures for the improvement of the Health and Safety at a workplace according to EC Directive 89/391/EEC".

- **D.L.26/94**, “ORGANISATION and work operation according to Safety, Hygiene and Health guidelines for the workplaces previous in Art. No.13-23 in the D.L. 441/91”.
- **D.L. 18/85**, “General rule to Safety and Hygiene in mines and quarries”.
- **D.L. 162/90**, “Fitting and changing to the general law for Safety and Hygiene in mines and quarries”.

Specific Legislation
- **D.L. 141/95**, “Minimum requirements for Safe and Healthy workplace signalling”.
- **D.L. 348/93**, “Minimum requirements for Safe and Healthy use of PPE according to EC89/654/EEC”.
- **D.L. 142/79**, “Regulations about factory safety and storage of explosive products”.
- **Decree 286/93**, “Definition of the values for dust concentration in the atmosphere”.
- **D.L. 72/92**, “Employers protection from risks related to noise exposure during work”.
- **D.L. 204/93**, “Establish rules towards prevention of the risks for severe accidents”.
- **Law 82/99**, “Minimum requirements for safe use of equipment at work”.

SPAIN

General Legislation
- **Law 31/1995** (DIR 89/391), “Work Risks Prevention”.
- **RD 3255/1983**, “Statute of Miner”.
- **RD 863/1985**, “General regulations of the basic standards for mining safety”.
- **RD 1215/1997** (DIR 89/655), “Minimum safety and health requirements for the use of work equipment by the workers”.
- **RD 200/1995**, “Industrial quality and security”.

Specific Legislation
- **RD 1389/1997** (DIR 92/104), “Minimum requirements for improving the safety and health protection of workers in surface and underground mineral extracting industries”.
- **RD 1316/1989**, “Protection of workers against noise”.
- **RD 150/1996**, “Health and Safety in extractive industries”.
- **RD 400/1996**, “Protection of potential explosive atmospheres”.

According to the above presented Legislation, countries like Greece, Italy, Latvia, Portugal and Spain transposed the European Norms, namely Norms 89/891/EC, 89/654/EC and 89/655/CEE, to their National legal system. The first norm (89/891/EC) is related to “Measures for the improvement of the workers health and Safety at their work place”, the second one refers to the “Minimum required equipment of Personal Protection (PPE-Personal Protective Equipment)” and the last one is related to the “Improvement of the workers’ Safety and Health at work”. The specific Legislation that each country adopted was created in order to fulfil some needs for the improvement of working conditions.

1.3. Risk Assessment criteria for quarrying and processing units

Risk Assessment is a fundamental instrument for the improvement of working conditions at industrial processing plants. Based on this kind of analysis, one is able to identify the existing working risks and which of them are considered more or less significant, in order to give priority to the minimisation of the most significant ones.

1.3.1. Risk Assessment Evaluation

Benefits

Risk Assessment is performed to enable control measures. It is absolutely necessary to have an idea of the relative importance of risks and to know as much for them as possible, in order to take decisions on controls that are both appropriate and cost effective.

Types

There are two types of Risk Assessment according to IOSH (Institution of Occupational Safety and Health): the *quantitative* Risk Assessment that produces an objective probability estimate based on known risk information applied to the considered circumstances and, the *qualitative* Risk Assessment, which is subjective and based on personal judgement supported by general data on risk. The second type of Risk Assessment is much simpler to adopt. Moreover, all legal requirements refer to this type of assessment. However, there are also some cases, where hazards associated with particular situations are so unique that a special assessment has to be done for each one of them.

Contents

According to the Approved Code of Practice, the analysis should contain a statement regarding the significant hazards identified, the applied control measures and the extent to which they control the risk (cross- reference can be made to manuals and other documents), and the population exposed to the risk.

Hazard evaluation

The identified hazards in quarries and processing plants are those associated with machinery, equipment, tools, procedures, tasks, processes and the physical aspects of the plant and premises. The hazard's evaluation is achieved by assembling information from those familiar with the hazards, such as insurance companies, professional societies, governmental departments and agencies, manufacturers, consultants, trade unions, old inspection reports both internally and externally-produced, accident reports and standards. Some hazards may not be readily identifiable and there are techniques, which can be applied to assist in this aspect, like the inductive analysis, which predicts failures such as Failure Modes and Effects Analysis (FMEA) and Job Safety Analysis (JSA). Inductive analysis assumes failure has occurred and then examines ways in which this might have happened by using logic diagrams. This is time consuming and, therefore, expensive, but is extremely thorough. Management Oversight and Risk Tree Analysis are examples of hazard evaluation which are not difficult to use.

Ranking Hazards by risk

Hazards ranking produces a priority list of hazards to be controlled on a "the-worst-comes-first" basis. It takes into account the consequences (like severity) and the probability of an occurring hazard. Estimation of the first is easier compared to the second as data may not be available for all hazards. Estimates derived from experience can be also used. Moreover, in that case it is possible to carry out ranking using a simple formula, where risk equals the severity estimate multiplied by the probability estimate. These estimates can have any value, as long as it is consistently used. The simplest set of values offers a 16-point scale. Tables 2 and 3 show the severity and the probability rating for hazards. This rating is capable of further improvement introducing time as a variable and increasing the categories number.

Table 2. Severity Rating

Severity Hazard Rating	Value
Catastrophic	1
Critical	2
Marginal	3
Negligible	4

Table 3. Probability Rating

Probability Hazard Rating	Value
Probable	1
Reasonably Probable	2
Remote	3
Extremely Remote	4

Explanations

Catastrophic: Imminent danger exists; hazard capable of causing death and illness on a wide scale.
Critical: Hazard that can result in serious illness, severe injury and property and equipment damage.
Marginal: Hazard can cause illness, injury or equipment damage, but the results would not be expected to be serious.
Negligible: Hazard will not result in serious injury or illness, reduced possibility of damage beyond minor first-aid case.
Probable: Likely to occur immediately or shortly.
Reasonably: It will probably occur in time.
Remote: May occur in time.
Extremely Remote: Unlikely to occur.

1.3.2. Risk Assessment control

Decision-making

In order to take a decision it is necessary to have all the information about all different kinds of possible hazards, as well as, all the methods that help to control the risk. There are also several factors that influence the decision-making process, like: training, equipment, replacement, plant changes and cost of the proposed solution. The benefit cost will be formally and informally considered. The above cost will include the reduced risk cost and the hazard elimination cost. It will also be necessary to estimate the duration of the "pay-back period". The decisions associated with health and safety improvements usually last for a 3 to 5 years period.

Introduction of preventive and corrective measures

The main goal of Risk Assessment control is a progressive risk reduction that necessarily requires yearly improvement. It must not be forgotten that some corrective measures are more effective than others. The safety precedence sequence shows the order of measures effectiveness as follows:

- **Hazard elimination** (for example, use of alternative design improvements, change of process);
- **Substitution** (for example, replacement of a chemical by another with less risk);
- **Use of barriers**: Isolation (removes hazard from the worker, puts hazard in a box) or segregation (removes worker from the hazard, puts worker in a box);
- **Use of procedures**: Limiting exposure time, dilution of exposure, safer working systems depending upon human response;
- **Use of warning systems**: Signs, instructions, labels, which depend upon human response;
- **Use of Personal Protective Equipment (PPE)**: Depends upon human response and can be used as a sole measure only when all other options have been exhausted - PPE is the last resort.

Monitoring

The validity of Risk Assessment must be checked regularly, especially when reports indicate that it may no longer be valid. It is important to remember that new assessments will be required when the risks themselves change as conditions change, and also when new situations and conditions are encountered for first time.

Information to other parties

Cooperation and sharing of information between employers is a need. Risk Assessment will form the basis of this cooperation; it is also possible to have a contractual or legal agreement to exchange Risk Assessment data. The given information about risk must also include Health and Safety measures and be sufficient enough to allow other employers to identify anyone who can help in an emergency situation.

Health and Safety training

All employees need safety training, not only the operators but also the managers as they all have to know what can be done for their own health and safety. Knowledge of what constitutes a safe behaviour in a variety of different situations is not inherited but must be acquired, either by trial and error or by a reputable source of expertise.

General training needs are related to new employee induction, supervision, management and reinforcement. Specialised training is required for first-aid cases, drivers, use of explosives and response to fire alarm. Health and safety training is also required by law, especially for employees engaged in certain tasks.

Personal Protective Equipment (P.P.E)

In order for a PPE scheme to be effective, three elements must be considered:

- Nature of the hazard;
- Performance data for the PPE;

- The acceptable level of exposure to the hazard.

The main factors that affect the use of PPE are the following:

- Fit;
- Period of use;
- Comfort;
- Maintenance;
- Training;
- Interference;
- Management commitment.

The most common types of PPE are related to:

- Hearing Protection;
- Respiratory Protective Equipment;
- Eye Protection;
- Protective clothing;
- Skin protection;
- Safety belts and Harnesses;
- Feet Protection;
- Helmet Protection.

General requirements for provision, use, maintenance and storage of PPE are included in the Legislation of all E.U countries.

1.4. Effects, measurement and control

1.4.1. Noise-hearing damage

Excessive noise when entering the noise-hearing system causes a protection reflex, which cuts off the flow of nerve impulses and, as a result, makes the system less sensitive to low noise levels. This is known as threshold shift. Some acute effects that can occur as a result of exposure to noise are an acute acoustic trauma, temporary threshold shift and tinnitus (ringing in the ears). On the other hand, some chronic effects of noise exposure are the permanent threshold shift; the noise induced hearing loss and deafness.

Noise control can be performed through the following ways:

- Engineering controls;
- Orientation/ Location;
- Maintenance;
- Silencers;
- Lagging;
- Damping;
- Personal Protective Equipment;
- Substitution.

1.4.2. Health Hazards

Health hazards can be divided into four broad categories:

- Physical: Air pressure, heat, dampness, noise, radiant energy, electric shock.
- Chemical: Exposure to toxic materials, such as dust, fumes and gases.
- Biological: Infection e.g. tetanus, hepatitis.
- Ergonomic: Work conditions, stress and machine interaction.

1.4.3. Questionnaire

The following Questionnaire on Risk Assessment current situation is meant to be used as an example. This type of Questionnaire allows companies to understand the importance of Risk Assessment.

QUESTIONNAIRE ON RISK ASSESSMENT CURRENT SITUATION

A. UNIT IDENTIFICATION		
		ORNAMENTAL STONES
QUARRY	☐	☐ Marble ☐ Granite ☐ Slate ☐ Other
PROCESSING PLANT	☐	☐ Marble ☐ Granite ☐ Slate ☐ Other

B. QUESTIONNAIRE		
1.	A Risk Assessment Study	☐ has been already done in your company ☐ is under evaluation in your company ☐ is planned but not started yet in your company ☐ is not known as an obligation of your company ☐ is not known as a concept
2.	Who is responsible for Health & Safety management at your company	☐ The owner ☐ The H&S Manager of your company ☐ An external service (outsourcing) ☐ Nobody ☐ Other............................
3.	In the case your company **has** a Risk Assessment Study, who has performed it?	☐ The owner ☐ The H&S Manager of your company ☐ An external service (outsourcing) ☐ Other…………………..
4.	In the case your company **has** a Risk Assessment Study	What was the cost? ....Euro
5.	In the case your company **has** a Risk Assessment Study	☐ It has helped you to solve existing problems of your company (about H&S at Work)? What kind? .... ☐ It was only an obligation imposed by the legislation?

6.	In the case your company **does not have** a Risk Assessment Study yet	☐ It is in your immediate plans (in this year) ☐ It is not in your immediate plans (in this year) If yes, who would carry out the study? ....
7.	In the case your company **does not have** a Risk Assessment Study yet	Did authorities force you by written papers or by imposing penalties to meet the legislation demands? ☐ No ☐ Yes Some comments ……………………………
8.	How many working days off you had this year because of accidents at work?	Total number: …………..
9.	When you buy new equipment do you try to perform a Risk Assessment Study?	☐ No, I just read the instructions manual ☐ Yes. I try to know all the Risks and inform the operator about them ☐ Yes. I try to know all the risks pertinent to the equipment.
10.	Do you know the existing main risks in your company and the measures to minimise or eliminate these?	☐ No. I Know some risks ☐ Yes .I try to Know all the risks ☐ Yes. I try to do a work place analysis all over the company
11.	What do you think about risk assessment study?	☐ I think it is important to know what kind of protection should be implemented to improve the employers safety ☐ No. I think it is not important because if we care about all the risks production will decrease. ☐ Other............................

1.5. Risk Assessment for Health and Safety

Statistics about work accidents

In order to enable the adoption of methodology and adequate criteria to conceive prevention measures it is necessary to estimate work accident rates. These rates are based on relevant information, such as: the number of injured workers by accident, spent working days and which body parts were more affected by the accident. This kind of information allows to check the efficiency of the adopted measures and to conceive new prevention programs, if necessary.

Percentage of injured workers per accident

In order to obtain statistical information it was necessary to gather information on the number of quarry workers. Figure 1 presents the injured workers percentage for years 1998-2000. According to Figure 1, the percentage of injured workers was 10% in 1998 (throughout a total of 931 workers), 14% in 1999 (from a total of 944 workers) and 8,5% in 2000 (from a total of 1002 workers).

Percentage of working days off

Several issues were considered in order to obtain this information, namely the number of injured workers, the working days off and the total working hours. Figure 2 presents the working days off for years 1998 to 2000. It can be concluded that the percentage of working days that were lost because of the accidents is significant (1,1% for 1998 to 1,5% for 1999 and 2000).

Figure 1. Injured workers percentage for years 1998, 1999 and 2000
(Source: CEVALOR – Portugal)

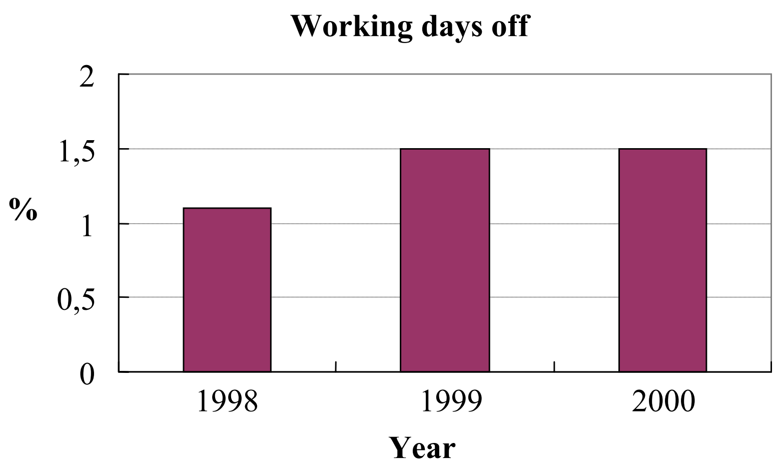


Figure 2. Percentage of working days off for years 1998, 1999 and 2000
(Source: CEVALOR – Portugal)

Percentage of injured body parts

Data were obtained through the analysis of insurance reports. The results are shown in Figure 3 as injured body parts for years 1998 to 2000. From this figure, it can be verified that the body areas that are more affected by the accidents are: hands, back, feet, eyes and legs.

Therefore, it is evident that some of the accidents could have been avoided if the workers were using Personal Protective Equipment.

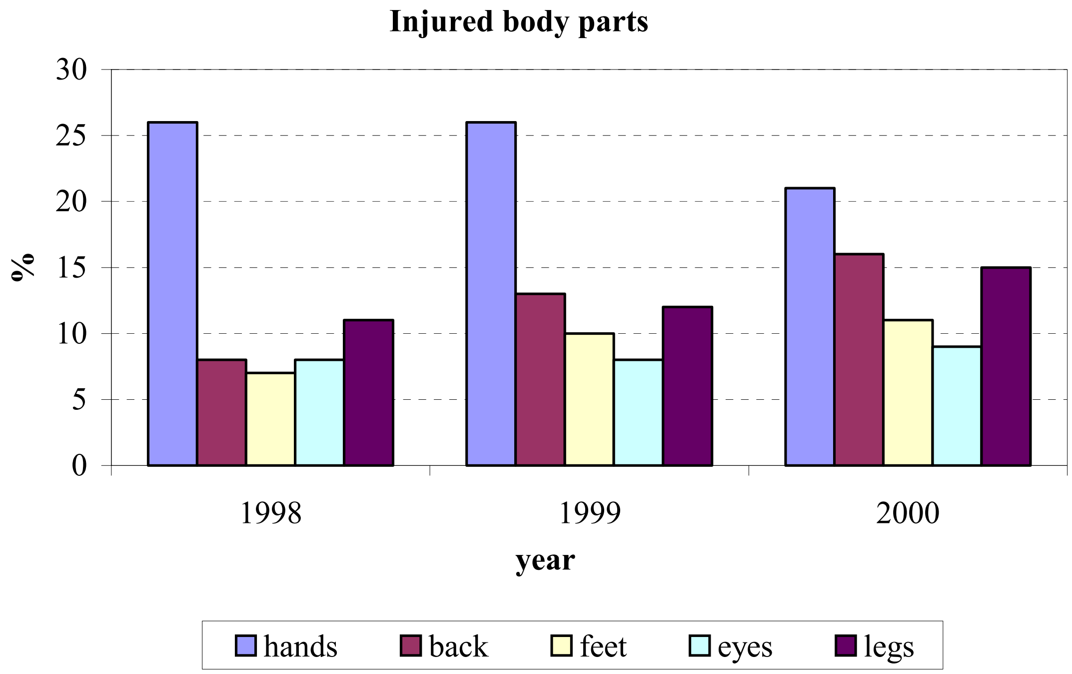


Figure 3. Percentage of injured body parts for years 1998, 1999 and 2000 (Source: CEVALOR – PORTUGAL)

1.5.1. Conclusions

After the analysis of the data for occurred accidents it is possible to affirm that minimisation measures have been successfully implemented considering that the number of injured workers has decreased. However, it can be verified that most workers are still not aware of the danger and, in consequence, they avoid the use of protection equipment. The minimisation measures would prevent accidents and, in short time, increase the production.

1.6. Risk Assessment for Health and Safety in the processing plants

Just as in the extractive units, it is very important to elaborate Risk Assessment in processing plants also, in order to identify the risks and to implement minimisation measures that can effectively protect the workers. Only if minimisation measures are implemented it is possible to avoid dangerous situations.

1.6.1. Statistics about work accidents

Percentage of injured workers

In order to obtain this information, the analysis of insurance reports as well as the number of workers in the processing plants, is required. According to Figure 4, the percentage of injured workers was 10% in 1998 (throughout a total of 991 workers), 14% in 1999 (from a total of 1040 workers) and 8% in 2000 (from a total of 1011 workers).

Figure 4. Percentage of injured workers for years 1998, 1999 and 2000
(Source: CEVALOR – Portugal)

Percentage of working days off

To obtain this information several issues were considered, namely the number of injured workers, the consequent working days off and the total hours worked. Figure 5 shows that there is an increasing number of working days off in the processing plants (0,7% for 1998 to 1,1% for 1999 and 1,3% for 2000) that consequently leads to changes in productivity.

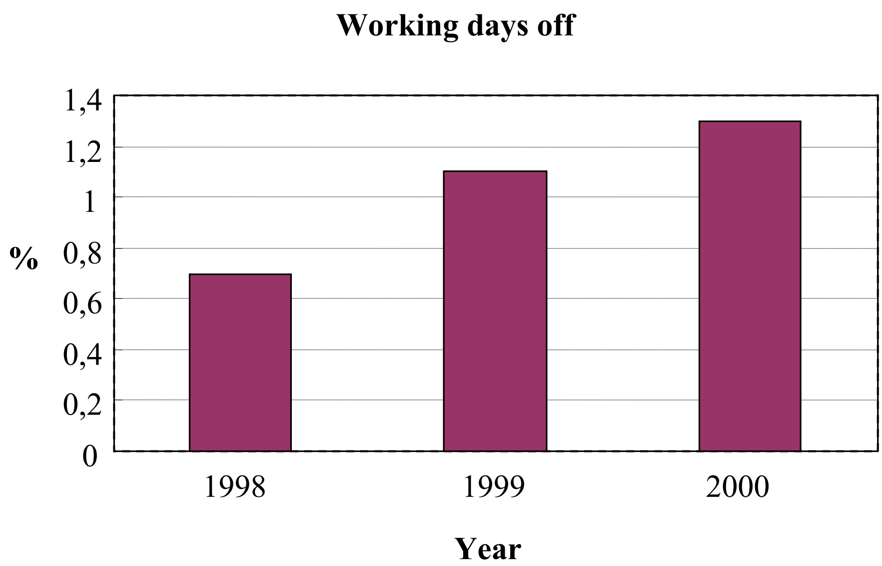


Figure 5. Working days off for years 1998, 1999 and 2000
(Source: CEVALOR – Portugal)

Percentage of injured body parts

Data regarding the injured body parts were obtained through the analysis of the insurance reports. The hands and the back are the most affected parts of human body due to work accidents. This situation is an obvious consequence of the continuous work with specific machinery and the manual movement of cargoes. It should be noted that some of these accidents could have been avoided if workers were using Personal Protective Equipment.

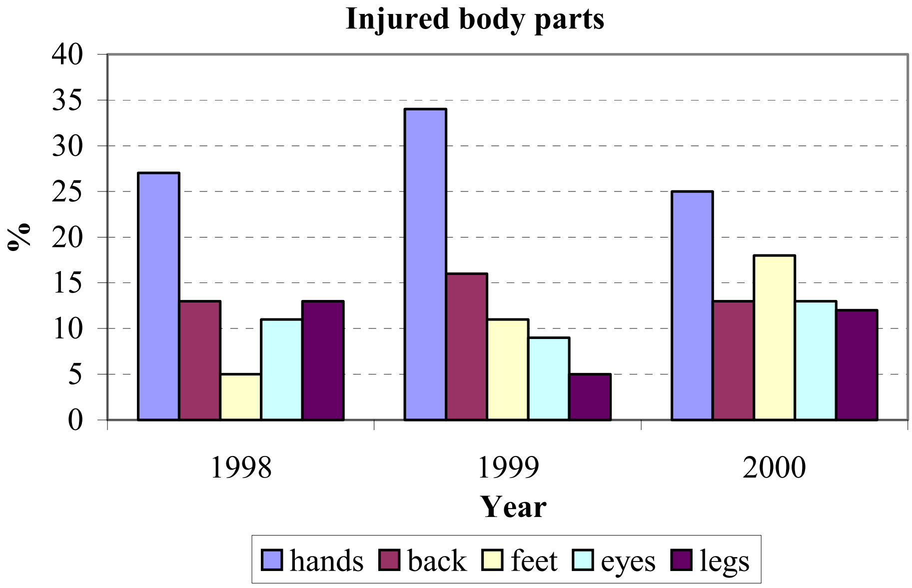


Figure 6. Injured body parts for years 1998, 1999 and 2000
(Source: CEVALOR – Portugal)

1.6.2. Conclusions

In order to achieve a high level of accident prevention in the processing plants and avoid professional diseases, it is necessary to perform a Risk Assessment analysis and verify the efficiency of the adopted measures. The main goal of Risk Assessment is to implement (and correct when necessary) a considerable number of safety measures and try to reduce the identified risks, the frequency of accidents and professional diseases like professional deafness, respiratory illness and muscle-skeletal diseases.

1.7. Specific health risks in quarrying and processing units

When taking about Health it is necessary to refer also to psychological and social Health. In the quarrying and processing sector, many activities are related to specific professional diseases like deafness (caused by the level of noise) and respiratory diseases (caused by dust) as well as other pathologies.

1.7.1. Pathologies

The most common pathologies among workers in the Ornamental Stone sector are demonstrated in Figure 7. Most of these professional diseases, like deafness and respiratory diseases may be avoided if the workers use Personal Protective Equipment, like headphones and masks. It is important to mention that if the employer implements minimisation measures, for example silent disks in the cutting machines (processing) or use of water in the extraction procedures in order to avoid dust, many of these diseases can be avoided.

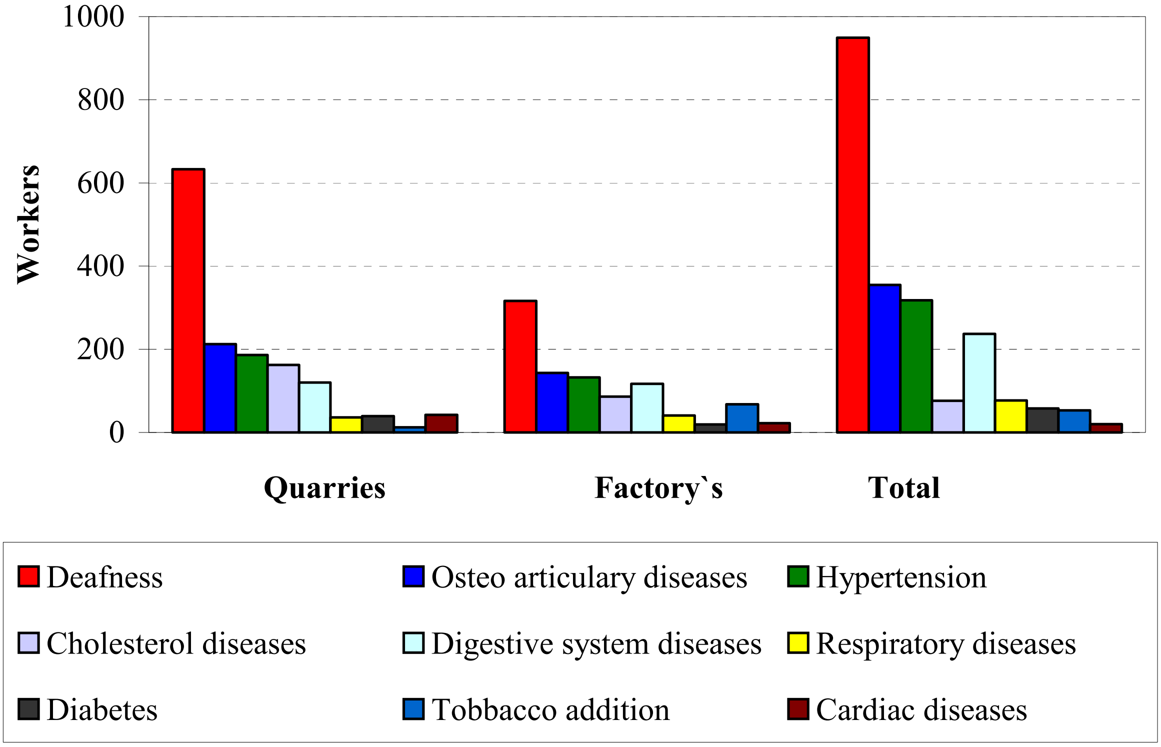


Figure 7. Pathologies distribution in the Ornamental Stones industry (Source: CEVALOR – Portugal)

1.7.2. Hearing alteration

In the Ornamental Stones sector, both in quarries and processing plants, there is a large number of workers that suffer from deafness caused by the noise of cutting and drilling equipment and because of the lack of use of Personal Protective Equipment. Figure 8 demonstrates the hearing alteration of the workers according to age. Based on the data of Figure 8, the most affected workers are those between 30 and 40 years old and the ones who are more than 60 years old. The deafness of workers older than 60 years can be attributed to noise (it is important to mention that when these workers started their professional activities there were not as many protective equipment as nowadays) but also to aging. On the other hand, hearing problems of workers in the age of 20, 30 or 40 years old come up because they are not used in wearing the available protective equipment to reduce the noise level.

The analysis of Figure 9 leads to the conclusion that the professional category most affected by noise is the ditch diggers. This is due to the extremely noisy equipment that these workers use, like the pneumatic hammer, with noise levels exceeding 80 dB. The foremen are also affected by noise considering that they are always moving from one place to another in the extraction and processing units and close to noisy machinery.

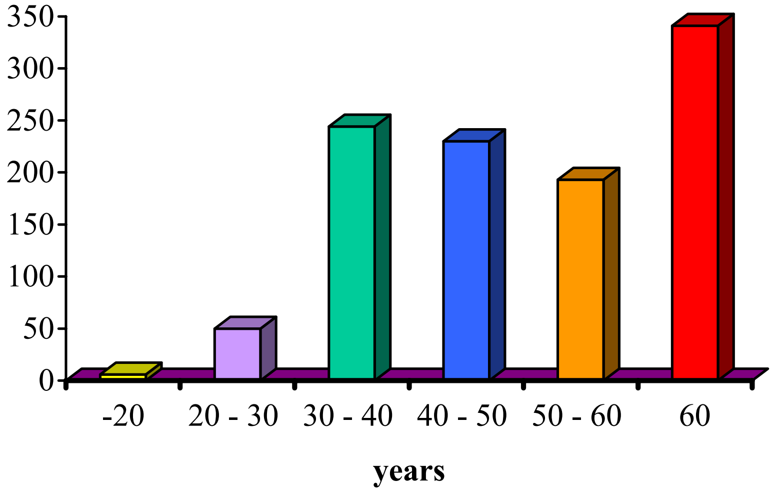


Figure 8. Hearing alteration according to age (Source: CEVALOR – Portugal)

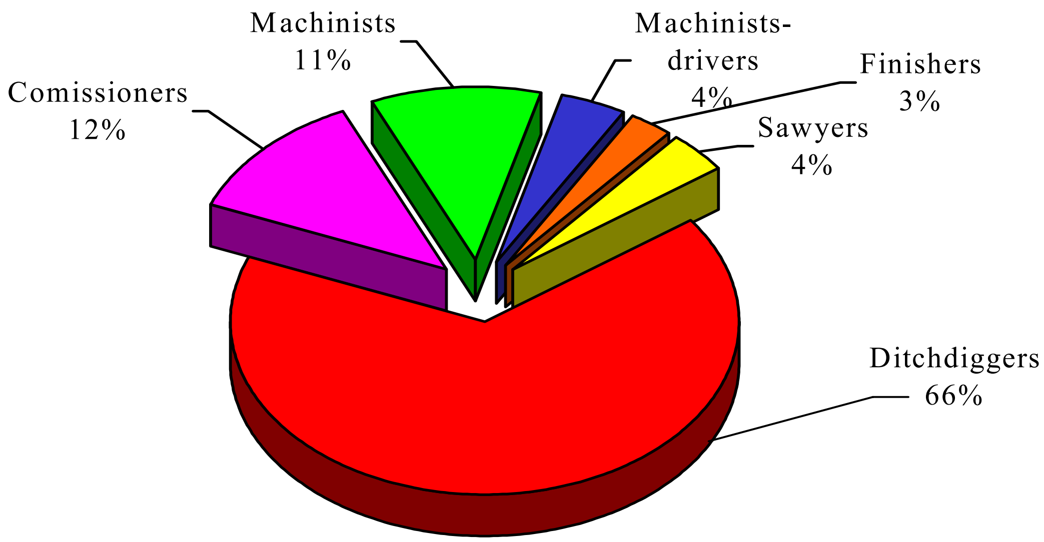


Figure 9. Categories of workers affected by noise (Source: CEVALOR – Portugal)

1.7.3. Conclusions

The pathologies distribution is almost the same both in quarries and processing plants. However, in the processing plants there are more cases of deafness, which can be perfectly understood when considering that the workers operate in confined spaces that help sound propagation. In quarries this problem is not so serious because workers operate outdoors.

When considering all the above facts it can be resumed that it is absolutely necessary to continue taking the appropriate actions in order to promote the use of the Personal Protective Equipment.

2

Risk Assessment and Safety in Quarries

GIORDANO BERTONI, SILVIA SERRANTI, MARIA LUISA MATOS

2.1. Introduction

The extraction and use of Ornamental Stones in Europe dates back to antiquity. In Europe, more than in any other part of the world, stone has been an important construction material throughout history and the primary material of which our rich cultural heritage is made.

Some of the Ornamental Stone quarries are comparable in size with large mining operations. Others are smaller, involving regular or periodic extraction of small volumes of stone. Others again, involve combined extraction of Ornamental Stones and other mineral products, such as rock aggregates or industrial minerals. Thus, the European stone quarrying industry shows great variations in size of operation, level of industrialisation and application of new technologies. Quarrying of Ornamental Stones refers mainly to two types of processing: ***Surface Quarries*** (Figure 10) and ***Underground Quarries*** (Figure 11). Both types of quarrying produce Ornamental Stone blocks (squared or shapeless, Figures. 12-13).

Surface quarrying is directly made on external soil or mountain surface (***Slope Mountain quarrying*** – Figure 14) or, on a previously cut mountain front (***Flat Level processing)*** in order to produce stone blocks (Figure 15) or bank stone blocks (Figure 16), depending on the geological and quality characteristics of the deposit.

The diagram of Figure 17 shows the typical procedure of surface quarrying.

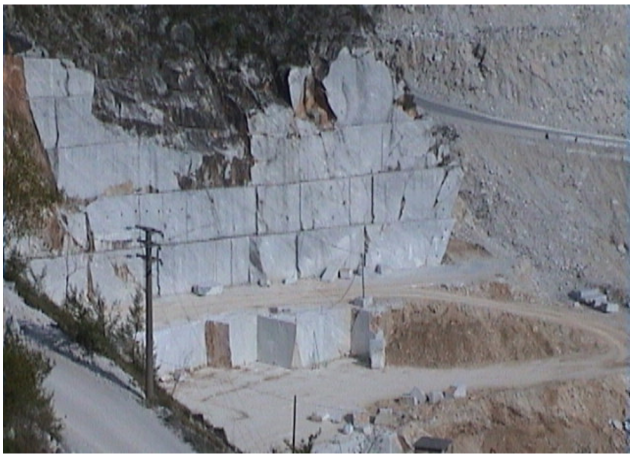


Figure 10. Surface quarry (Italy)

Figure 11. Underground quarry (Italy)

Figure 12. Squared block

Figure 13. Shapeless block

Figure 14. Slope mountain

Figure 15. Block production

Figure 16. Bank block production

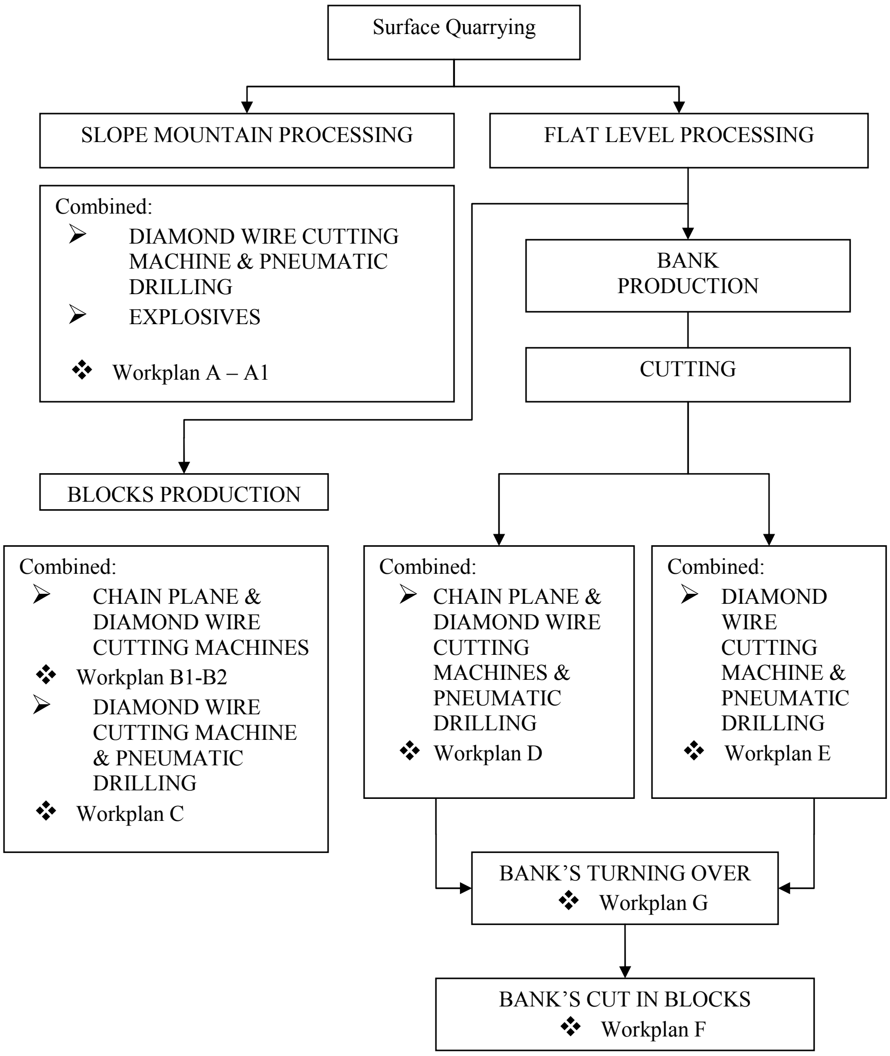


Figure 17. Typical procedure of surface quarrying

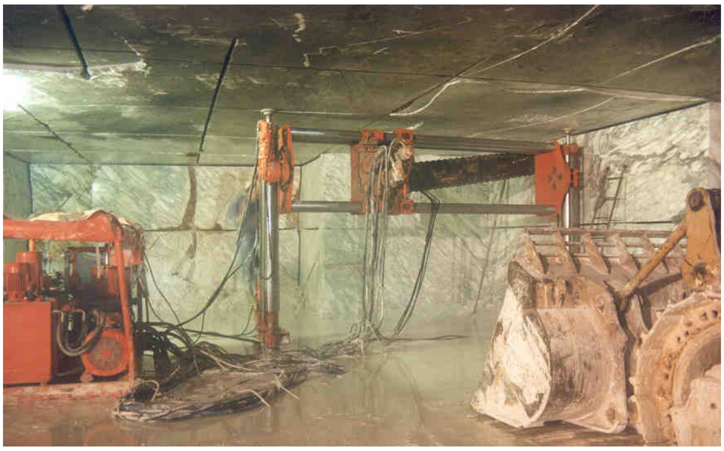


Figure 18. Gallery advancing

The two processes (surface and underground quarrying) have a significant difference the specific cutting machines used for the gallery's mining (Figure 20).

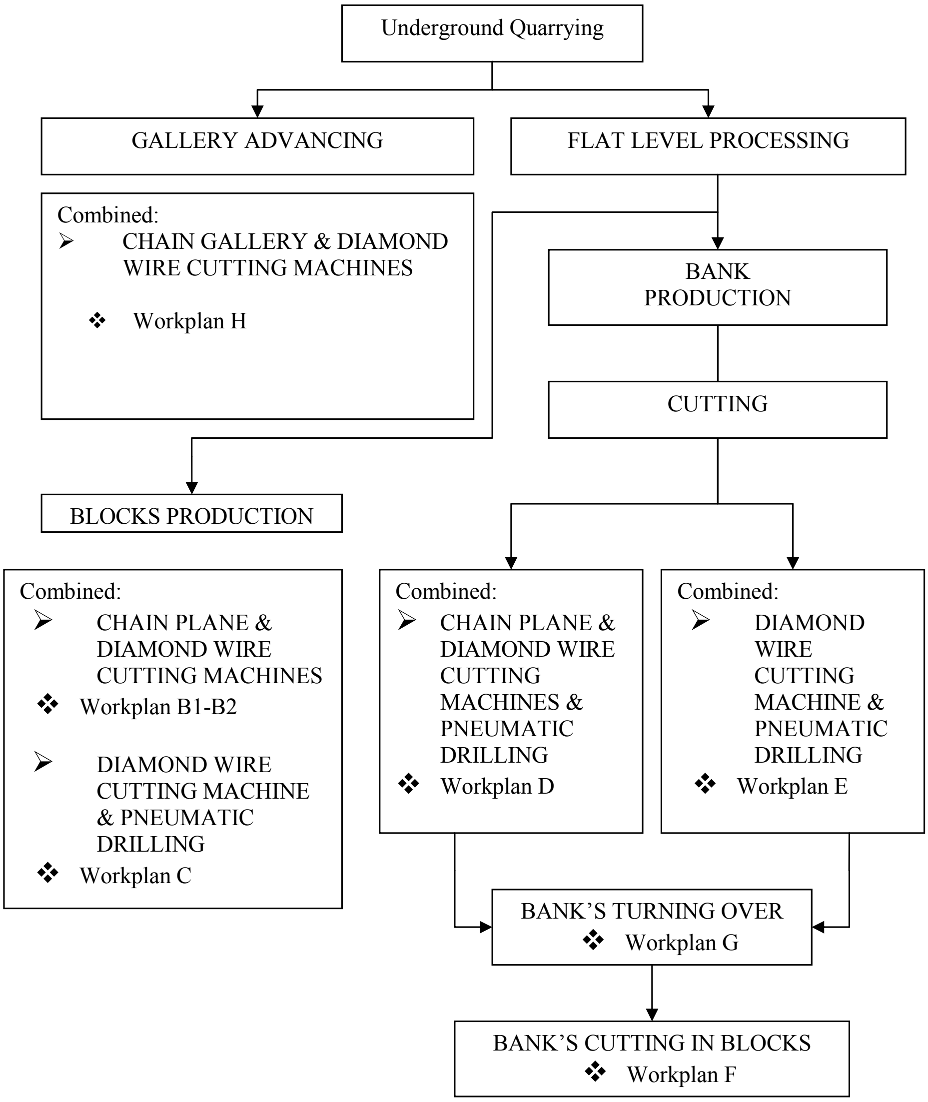


Figure 19. Typical procedure of underground quarrying

Figure 20. Gallery cutting machine

2.2. Mining operations

2.2.1. Surface Quarries - Blocks Production

Blocks production in surface mining operations can be performed with two different methods: Type B (B1 and B2) and Type C. Both methods start with cleaning of the working area by means of a power shovel (Figure 21) or excavator (Figure 22) in order to remove machines, equipment, mud, stone waste, etc.

Figure 21. Power Shovel

Figure 22. Excavator

Type B operations use two types of cutting machines either combined with drilling or not.

Method Type B1-Use of two types of cutting machines without drilling

According to type B1 method, a chain plane cutting machine (Figure 24) is positioned on a track, in order to perform vertical cuts in one direction (for example X- Figure 23, DRWG. 1). The machine is supplied with electrical power and hydraulic fluids in order to perform stone cutting.

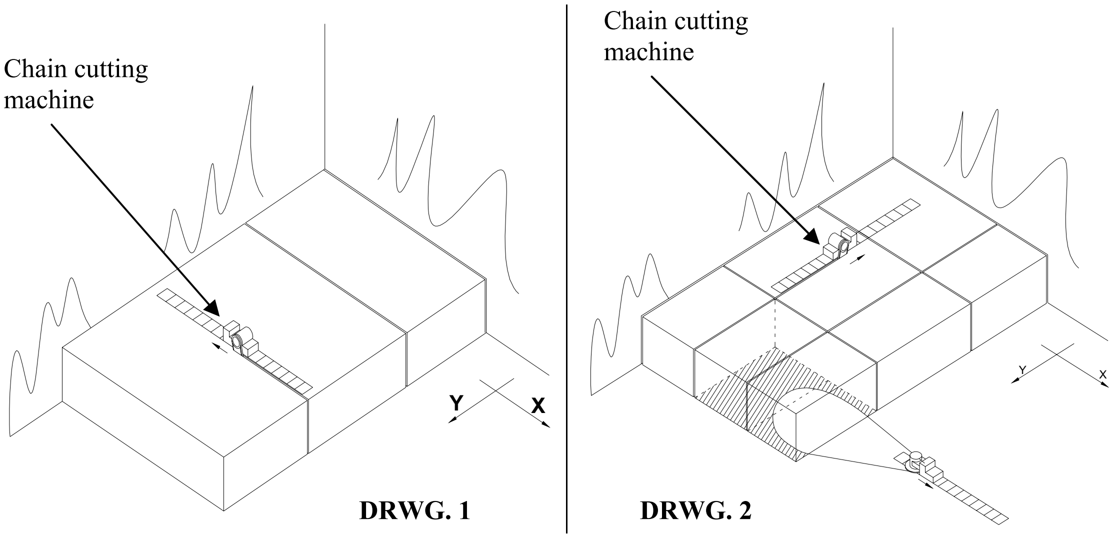


Figure 23. Method Type B1– Use of two types of cutting machines without drilling

Figure 24. Chain cutting machine

The vertical cut depth is generally about 1.5 m. At the end of the first vertical cut, the machine is moved in parallel for several times in order to accomplish a series of vertical cuts in the stone plane. The distance between two subsequent vertical cuts is normally about 1.5 – 1.8 m. When the vertical cuts in X direction are finished, the same procedure is followed in the perpendicular direction Y (Figure 23, DRWG. 2). In order to obtain commercial blocks, the distance between two subsequent cuts in Y direction is generally about 3.2 m. The result of these operations is a series of low surface, commercial blocks joined at the lower surface with the stone deposits. The block separation from the lower surface is obtained by the use of a diamond wire cutting machine (Figure 25). In technical terms this cut is called "*horizontal cut*".

Figure 25. Horizontal cut with a diamond wire cutting machine

The operation starts with cleaning of the working area, removal of machineries, equipment, mud and detritus that can obstruct the subsequent development of the process. A diamond wire machine is positioned on a track and assembled with deviation pulleys as safety protections system, in order to avoid accidents in case of diamond wire cable breaking and/or flying of parts (Figure 26).

Figure 26. Diamond wire machine with safety system

Apart from the use of a diamond wire machine, it is interesting to examine different safety systems that protect against possible accidents, like use of a safety tape (Figure 27) or rubberised or plasticised diamond wire (Figure 28).

When all stone blocks are separated, they are lifted and transported to the storage area. These operations can be carried out using power shovels, excavators, derricks, and special trucks (Figures 30-32). As a consequence, stored blocks are loaded on special lorries and transported to their final destination.

Figure 27. Diamond wire machine with a safety tape

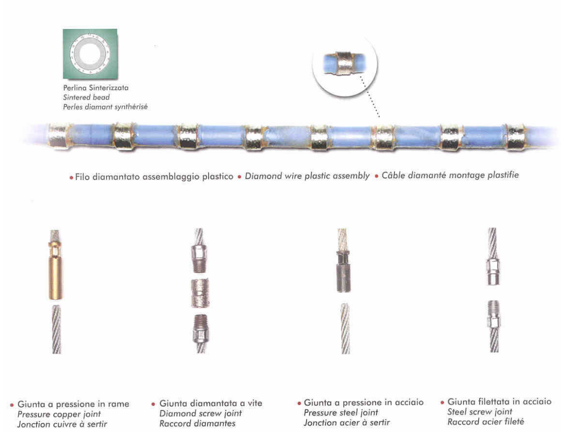


Figure 28. Rubberised or plasticised diamond wire

Figure 29. Lifting with derrick in a Portuguese quarry

Figure 30. Block handling with a power shovel

Figure 31. Block loading on truck with a power shovel

Figure 32. Blocks on truck

The sequential phases of blocks production are resumed in **Workplan B1** (Figure 33).

Workplan B1: BLOCKS PRODUCTION

Working area cleaning

↓

Chain cutting machine and equipment arrangement (Tracks, hydraulic power pack, etc)

↓

Equipment connection (electric, hydraulic, etc)

↓

Chain blade setting and cut in X direction (Figure 23, DRWG. 1)

↓

Equipment disconnection (electric and hydraulic)

↓

Working area Cleaning

↓

Chain cutting machine and equipment arrangement (Tracks, hydraulic power pack, etc)

↓

Equipment connection (electric, hydraulic, etc)

↓

Chain Blade setting and cut in Y direction (Figure 23, DRWG. 2)

↓

Equipment disconnection (electric, hydraulic, etc)

↓

Removal of machines and equipment from the bank

↓

Setting of deviation pulleys and diamond wire on machine
(manual tools, pneumatic hammer, etc)

↓

Diamond wire cutting machine / equipment arrangement (Figures 26-28)

↓

Equipment connection (electric end hydraulic)

↓

Execution of horizontal cut (Figure 23, DRWG. 2)

↓

Equipment disconnection (electric, hydraulic)

↓

Removal of diamond wire cutting machine (tracks, safe equipment, etc)

↓

Blocks Extraction

↓

Blocks lifting / transportation to storage area (Figures 29, 30)

↓

Blocks loading on lorries (Figures 31, 32)

Figure 33. Phases of block production using method type B1 (two types of cutting machines without drilling)

Method Type B2– Use of two types of cutting machines combined with drilling

According to type B2 method, an electric-hydraulic, pneumatic or electric drilling machine is installed and anchored in a vertical position corresponding to the inside corner of the block (vertical corner) in order to produce commercial size blocks. After the machine's positioning, electrical, hydraulic or pneumatic equipment are connected and a vertical hole is made beyond the lower cutting surface, (Figure 34, DRWG. 3).

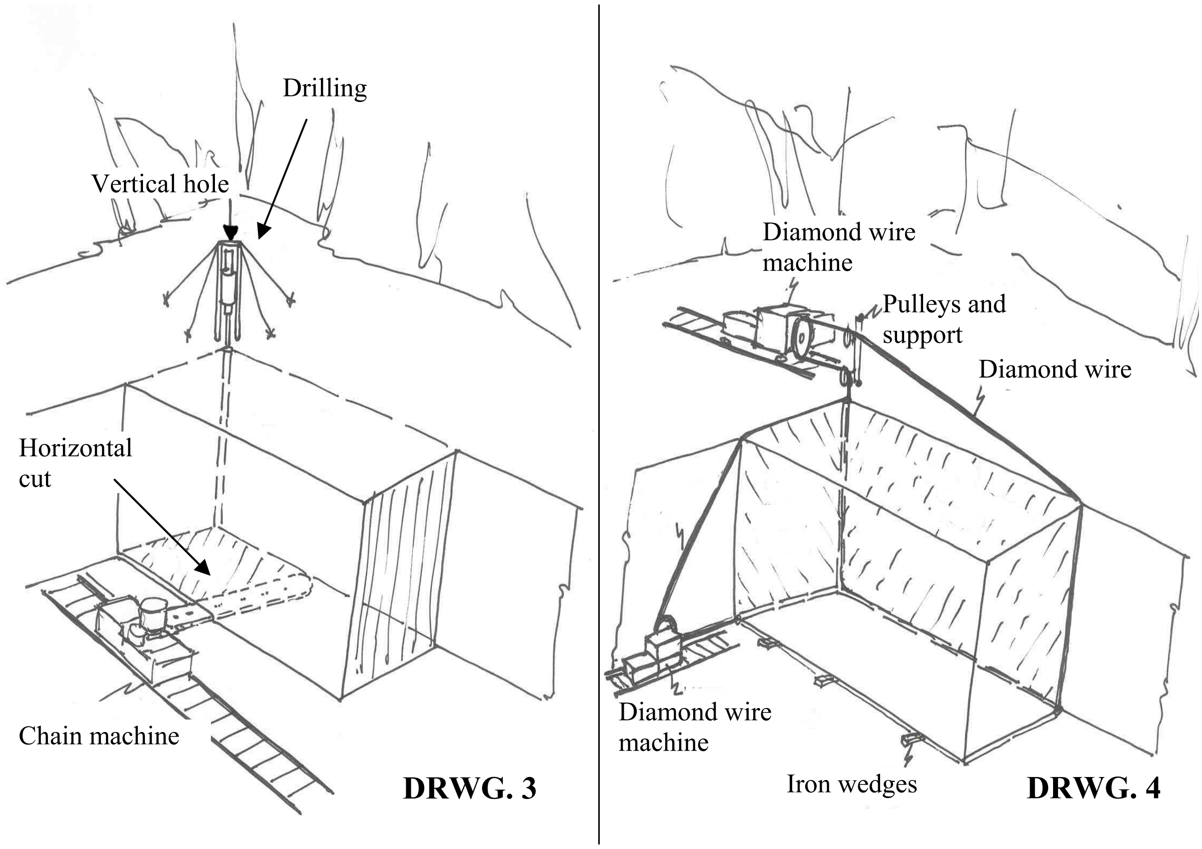


Figure 34. Method Type B2– Use of two types of cutting machines combined with drilling

Then the drilling machine is disassembled and a chain plane cutting machine is positioned on a track so as to perform a horizontal cut on the lower surface of the block. The machine is supplied with electrical power and hydraulic fluids in order to perform stone cutting. At the end of the horizontal cut, the chain plane machine is removed, to prevent any obstruction of subsequent operations. In order to prevent the block's vertical movements, several iron wedges are inserted in the horizontal cutting split. The vertical cuts are performed with the use of a diamond wire machine. At the end of the cutting operation, the block is separated from the deposit and it is ready for handling and moving. The sequential phases of blocks production are summarised in **Workplan B2** (Figure 35).

Workplan B2: BLOCKS PRODUCTION

Working area cleaning

↓

Pneumatic drilling and equipment arrangement (Figure 41)
(pneumatic, hydraulic power pack, safety system, etc)

↓

Equipment Connection (electric, hydraulic, pneumatic, etc)

↓

Vertical hole drilling

↓

Equipment disconnection

↓

Removal of machines and equipment (pneumatic, safety system, etc)

↓

Working area Cleaning

↓

Chain cutting machine and equipment arrangement (Tracks, hydraulic power pack, etc)

↓

Equipment connection (electric, hydraulic, etc)

↓

Horizontal chain cut execution (Figure 34, DRWG. 3)

↓

Equipment disconnection (electric, hydraulic, etc)

↓

Setting of deviation pulleys on the diamond wire machine

↓

Diamond wire setting on machine

↓

Diamond wire cutting machine arrangement (trucks, safety system, etc)

↓

Equipment connection (electric, hydraulic, etc)

↓

Vertical wall cut execution (Figure 34, DRWG. 4)

↓

Equipment disconnection (electric, hydraulic, etc)

↓

Machine and equipment relocation

↓

Block lifting / transportation

Figure 35. Phases of block production using method type B2 (two types of cutting machines combined with drilling)

Method Type C - Use of only one type of cutting machine combined with drilling

According to type C method, an electric-hydraulic, pneumatic or electric drilling machine (Figure 36) is installed and anchored in a vertical position corresponding to the inside corner of block (vertical corner) in order to produce blocks according to the commercial size requirements. After the machine's positioning, the electrical, hydraulic or pneumatic equipment is connected and a vertical hole is drilled beyond the lower cutting surface (Figure 37, DRWG. 5).

Figure 36. Vertical hole execution with a hammer

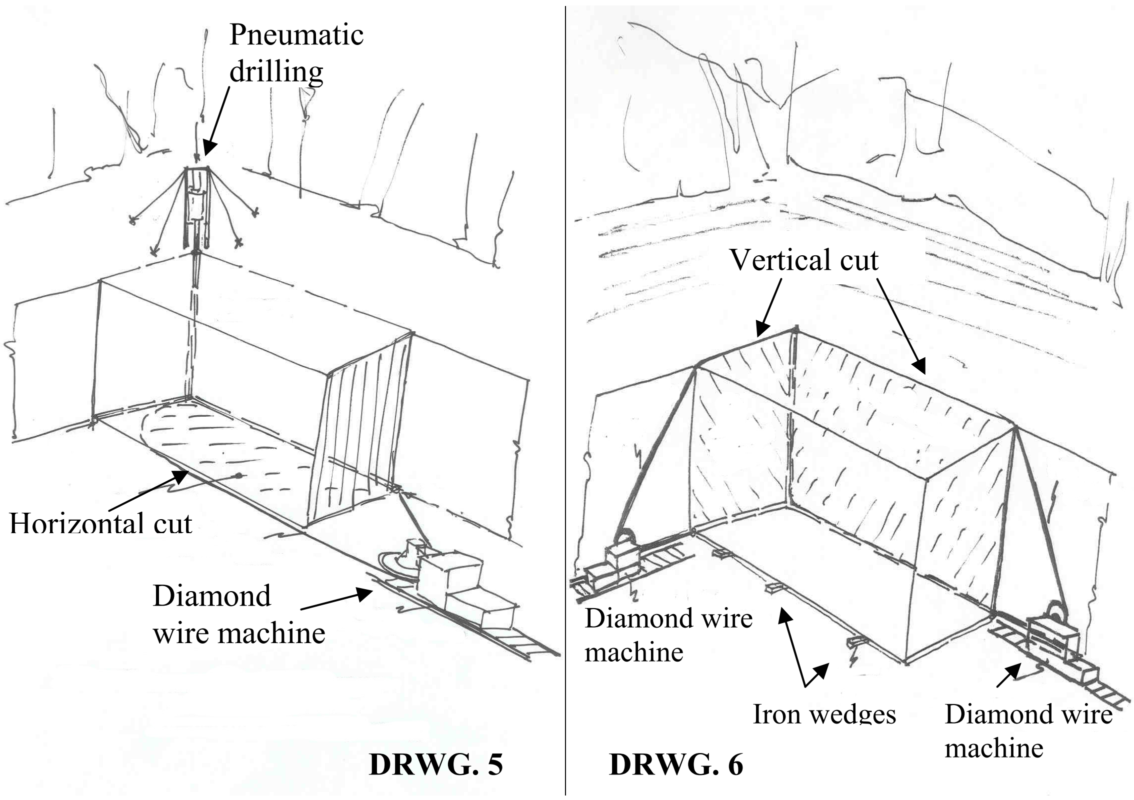


Figure 37. Method Type C **-** Use of only one type of cutting machine combined with drilling

The drilling machine is disassembled (Figures 36, 37) and two horizontal holes are made, corresponding on the lower horizontal surface, one to the inner width corner and one to the inner length corner. The operation is carried out with a pneumatic hammer (Figure 38). Both holes lead to the end of the vertical hole previously opened.

Figure 38. Pneumatic hammer

Figure 39. Diamond wire machine

Block separation is carried out exclusively with the use of a diamond wire machine (Figure 39) that first performs a horizontal cut and subsequently, the two vertical cuts (Figure 37, DRWG. 6). Cutting with a diamond wire machine and block handling and moving operations are developed in the same way as in Workplans B1-B2. The sequential phases of blocks production, with one type of machine and drilling, are presented in **Workplan C** (Figure 40)**.**

2.2.2. Surface Quarries - Bank Production

Figures 17 and 19 provide a description of the activities performed in surface and underground quarries, in order to produce blocks by cutting a very big stone portion (bank), in a unit form, from the deposit. This kind of processing is generally performed by isolating a bank with dimensions of about 1,5 m thickness, 6 m width and 6-9 m height from the deposit.

Bank Cutting

Bank cutting can be performed with two different methods: Type D and Type E. Both methods start with cleaning of the working area by means of a power shovel or an excavator in order to remove machine, equipment, mud, stone waste, etc. that can obstruct subsequent activities.

Method Type D - Use of two types of cutting machines, combined with drilling.

According to method type D, an electric-hydraulic, pneumatic or electric drilling machine (Figure 38) is installed and anchored in such a vertical position that corresponds to the inside corner of the bank (vertical corner) previously established. After the machine’s positioning, electrical, hydraulic or pneumatic equipment are connected and a vertical hole is drilled in lower depth than the lowest cutting surface.

Workplan C: BLOCKS PRODUCTION

Working area cleaning

↓

Pneumatic drilling and equipments arrangement
(pneumatic, hydraulic power pack, safety system, etc)

↓

Equipment connection (electric, hydraulic, pneumatic, etc)

↓

Vertical hole drilling (Figure 37, DRWG. 5)

↓

Equipment disconnection

↓

Removal of machines and equipment (pneumatic, safety system, etc)

↓

Pneumatic hammer arrangement (pneumatic, tools, etc)

↓

Equipment connection (pneumatic)

↓

Horizontal holes drilling

↓

Equipment disconnection (electric, hydraulic alimentation)

↓

Equipment removal

↓

Equipment Connection (electric, hydraulic, etc)

↓

Horizontal and vertical wall cut execution (Figure 37, DRWG. 6)

↓

Equipment disconnection (electric, hydraulic, etc)

↓

Machine and equipment relocation

↓

Blocks lifting / transportation to storage area

↓

Blocks loading on lorries

Figure 40. Phases of blocks production using method type C (one type of cutting machine combined with drilling)

The drilling machine is disassembled and a chain plane cutting machine is positioned on a track in order to perform horizontal cuts on the lower surface of the bank. The machine is supplied with electrical power and hydraulic fluids in order to perform the stone cut. The cut depth is generally about 1,5 m. After finishing the horizontal cut, the chain plane machine is removed, not to obstruct subsequent operations.

In order to prevent vertical movements of the bank several iron wedges are inserted in the split of the horizontal cut. To continue cutting, a diamond wire machine is positioned and subsequent vertical cuts are carried out in the same way as in **Workplan C** (Figure 41).

Figure 41. Vertical cut of bank

Figure 42. Cut bank ready for turning over

The sequential phases of bank cutting from the deposit with two types of machines and drilling are summarised in **Workplan D** (Figure 43)**.**

Method Type E - Use of one type of cutting machine, combined with drilling.

According to method type E, an electric-hydraulic, pneumatic or electric drilling machine is installed and anchored in vertical position corresponding to the inside corner of the bank (vertical corner) according to the selected dimensions. After the machine's positioning, electrical, hydraulic or pneumatic equipment are connected and a vertical hole beyond the lower cutting surface is drilled. The drilling machine is disassembled and two horizontal holes are made, one corresponding to the inner width corner and the other to the inner length corner of the horizontal lower surface. The operation is carried out with a pneumatic hammer. Both holes lead to the end of the vertical hole previously performed.

Bank extraction is carried out with the exclusive use of a diamond wire machine that first performs a horizontal cut and subsequently, two vertical cuts. In order to prevent vertical movements of the bank, several iron wedges are inserted in the horizontal cut split, before the performance of the vertical cuts. Cutting is carried out in the same way as indicated in **Workplan C** (Figure 40).
The sequential phases of bank cutting from the deposit with one type of machine and drilling are presented in **Workplan E** (Figure 44)**.** At the end of the cutting operation, the bank is separated from the deposit and it is ready for turning over, following the operations indicated in **Workplan G** (Figure 45)**.**

Workplan D: BANK CUTTING FROM DEPOSIT

Pneumatic drilling and equipment arrangement

↓

Users' Connection (electric, hydraulic, pneumatic, etc)

↓

Vertical hole execution

↓

Users' disconnection

↓

Machine and equipment removing (pneumatic, safety system, etc)

↓

Working area Cleaning

↓

Chain cutting machine and equipment arrangement
(Tracks, hydraulic power pack, etc)

↓

Users' connection (electric, hydraulic, etc)

↓

Horizontal chain cut execution

↓

Users' disconnection (electric, hydraulic, etc)

↓

Setting of deviation pulleys on diamond wire machine

↓

Diamond wire setting on machine

↓

Diamond wire cutting machine arrangement (trucks, safety system, etc)

↓

Users' Connection (electric, hydraulic, etc)

↓

Vertical wall cut execution (Figure 41)

↓

Users' disconnection (electric, hydraulic, etc)

↓

Machine and equipment relocation

↓

"Bed" preparation

↓

Safe falling devices equipping

↓

Inspection and Risks assessment related to turning over operation

↓

BANK'S TURNING OVER
To Workplan G → **Cycle A** / **Cycle B** / **Cycle C**

Figure 43. Bank cutting from deposit with method type D (two types of cutting machines combined with drilling)

Workplan E: BANK CUTTING FROM DEPOSIT

Working area cleaning

↓

Pneumatic drilling and equipment arrangement
(pneumatic, hydraulic power pack, safety system, etc)

↓

Equipment connection (electric, hydraulic, pneumatic, etc)

↓

Vertical hole drilling (Figure 37, DRWG. 5)

↓

Equipment connection

↓

Removal of machines and equipment (pneumatic, safety system, etc)

↓

Pneumatic hammer arrangement (pneumatic, tools, etc)

↓

Equipment connection (pneumatic)

↓

Horizontal holes drilling

↓

Equipment disconnection (electric, hydraulic alimentation, etc)

↓

Equipment removal

↓

Equipment Connection (electric, hydraulic, etc)

↓

Horizontal and vertical wall cut execution (Figure 37, DRWG. 5)

↓

Equipment disconnection (electric, hydraulic, etc)

↓

Machine and equipment relocation

↓

“Bed” preparation

↓

Safe falling devices equipping

↓

Inspection and Risks assessment related to turning over operation

↓

BANK’S TURNING OVER
To Workplan G → **Cycle A** / **Cycle B** / **Cycle C**

Figure 44. Bank cutting from deposit with method type E (one type of cutting machine combined with drilling

Bank Turning Over (Workplan G) - Cycle A, B, C

The operations start with cleaning of the working area by a power shovel or excavator in order to remove machine, equipment, mud, stone waste, etc. that can obstruct processing. Subsequently, the quarry's plane, in which bank will be turned, is prepared with a mixture of mud, loam and stones detritus ("Bed") so as to mitigate the bump against the horizontal plane resulting from bank turning over. The bed is prepared with the use of a power shovel or excavator.

After this procedure, the supervisor and the workers equipped with safe falling devices, check the bank and assess the risk linked with this operation. Bank turning over can be usually performed according to CYCLES A, B or C:

At the end of the operation, the bank falls down on the "bed". All machine and equipment are removed to allow the subsequent operation of marking and cutting with a diamond wire machine to obtain blocks (**Workplan F,** Figure 49). The bank, once separated from the deposit, is turned over. The operation can be performed with different methods according to the used equipment. The sequential phases are resumed in **Workplan F**.

Bank Cutting in Blocks – Workplan F

The operations start with cleaning of the working area by a power shovel or excavator in order to remove mud, stone waste, etc. that can obstruct processing. After bank's marking and, in order to assure best quality of blocks, a diamond wire machine is positioned to perform the vertical cuts. At the end, the diamond wire machine and the electric and hydraulic equipment are removed, while handling and moving operations are performed in order to transfer the blocks to the storage area or to their final destination. The sequential phases are shown in **Workplan F** (Figure 49).

Workplan G: BANK TURNING OVER

CYCLE A	Turning over with a POWER SHOVEL
F.a1	Hole drilling and rope fixing
	↓
F.a2	Pull with mechanical shovel and bank's turning over
	↓
F.a3	Rope removal
	↓
	To Workplan F – BANK CUTTING

CYCLE B — **Turning over with CUSHIONS and HYDRAULIC JACKS**

F.b1	**Hydraulic Cushions arrangement**
F.b2	**Equipment connection** (electric, hydraulic, pneumatics, etc)
F.b3	**First push with cushions**
F.b4	**Cushion removing and users' disconnection**
F.b5	**Hydraulic jacks' seat execution** (pneumatic hammer)
F.b6	**Equipment connection** (electric, hydraulic, etc)
F.b7	**Hydraulic Jack arrangement**
F.b8	**Hydraulic jacks' push and stones' insertion in the split**
F.b9	**Final push and bank's turning over**
F.b10	**Equipment disconnection**
F.b11	**Hydraulic Jack and equipment removing**

↓

To Workplan F – BANK CUTTING

CYCLE C — **Turning over with an EXCAVATOR**

F.c1	**Hydraulic Cushion/ Hydraulic jacks arrangement**
F.c2	**Users' connection** (electric, hydraulic, pneumatic, etc)
F.c3	**First push with cushions/hydraulic jacks**
F.c4	**Cushion/jacks removal and equipment disconnection (Electric, hydraulic, etc)**
F.c5	**Excavator arrangement**
F.c6	**Bank's push with excavator's arms**
F.c7	**Final push and bank turning over**

↓

To Workplan F – BANK CUTTING

Figure 45. Alternative options of bank turning over using different equipment

CYCLE A - Turning over with a power shovel

Figure 46. Bank turning over with a power shovel

- ***CYCLE B** - Turning over with Hydraulic Jacks or Cushion*

Figure 47. Bank turning over with cushion and hydraulic jack

- ***CYCLE C** - Turning over with an excavator*

Figure 48. Bank turning over with an excavator

Workplan F: BANK CUTTING IN BLOCKS

Working area Cleaning

↓

Bank Marking

↓

Diamond wire cutting machine arrangement (pneumatic hammer, manual tools, etc)

↓

Diamond wire setting on machine

↓

Equipment connection (electric, hydraulic, etc)

↓

Performance of Vertical cuts (Figures 50, 51)

↓

Equipment disconnection (electric, hydraulic, etc)

↓

Diamond wire cutting machine and equipment removal
(Tracks, chain cutting machine, hydraulic power pack, etc)

↓

Blocks lifting / transportation to storage area

↓

Blocks loading on lorries

Figure 49. Phases of bank cutting in blocks

2.2.3. Underground Quarries - Blocks and Bank Processing

The underground operations, related to blocks and bank production are performed with the same methods applied in surface quarrying. The only difference between them is that in underground quarries front advancing is more difficult and requires the use of special chain gallery cutting machines (Figure 52). As a consequence, Workplans B, C, D, E and F are similar while gallery advancing is performed according to Workplan H (Figure 53).

Figure 50. Middle bank cutting

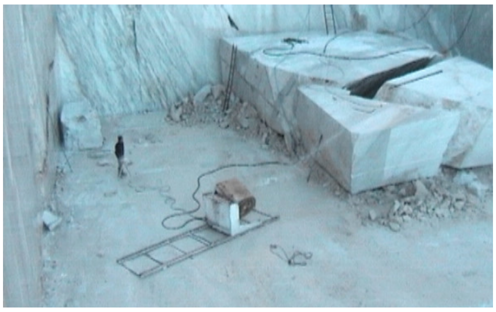


Figure 51. Very big bank cutting

Figure 52. Gallery advancing

Workplan H: UNDERGROUND QUARRIES - Gallery advancing

Working area Cleaning

↓

Chain gallery cutting machines and equipment arrangement
(Tracks, power pack, etc)

↓

Equipment connection (electric, hydraulic, etc)

↓

Horizontal and vertical chain gallery cut execution (Figures 54-56)

↓

Equipment disconnection (electric, hydraulic, etc)

↓

Hydraulic Cushions arrangement

↓

Equipment connection (electric, hydraulic, pneumatic, etc)

↓

Push with cushions and channel execution (breaking of blocks) (Figures 57)

↓

Equipment disconnection, material and detritus removal

↓

Setting of deviation pulleys for diamond wire (Figures 58-59)

↓

Diamond wire setting on machine

↓

Diamond wire cutting machine arrangement (trucks, safety system, etc)

↓

Equipment Connection (electric, hydraulic, etc)

↓

Vertical rear wall cut execution

↓

Equipment disconnection (electric, hydraulic)

↓

Machine and equipment relocation

↓

Blocks extraction (Figure 60)

↓

Blocks lifting / transportation to storage area

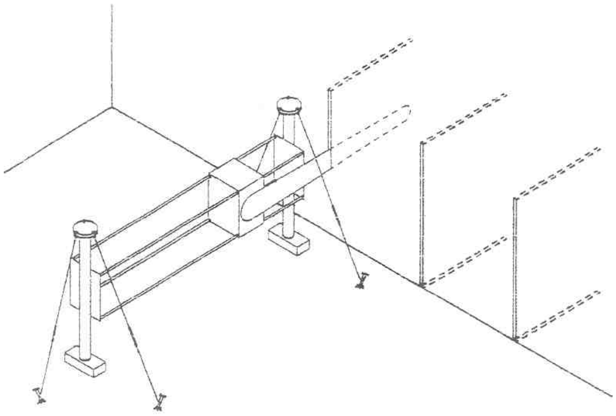
↓

Blocks loading on lorries

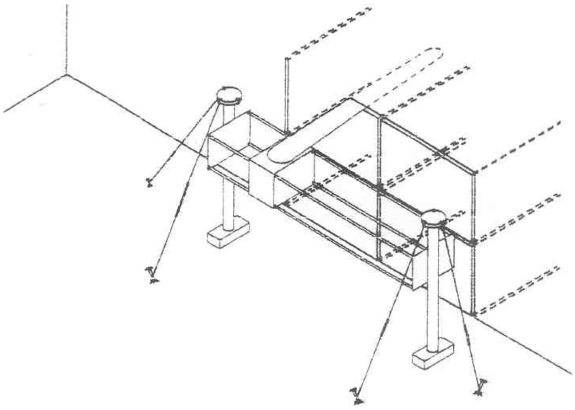
Figure 53. Phases of gallery advancing in underground quarries

2.2.4. Underground Quarries – Gallery advancing (Workplan H)

Mining operations start with cleaning of the working area by a power shovel or excavator in order to remove machine, equipment, mud, stone waste, etc. A chain gallery cutting machine and a hydraulic power pack are moved on advancing front and arranged on the correct position to make vertical and horizontal cuts. Cuts succession is illustrated in Figure 54.



DRWG. 7. Vertical cut



DRWG. 8. Horizontal cut

Figure 54. Gallery advancing

Machines and equipment are moved by power shovels. The gallery chain cutting machine is equipped, on each side, with a steel telescopic column that is locked in its position by a hydraulic pressure action at the top and at the base of the gallery in order to assure stability of the whole equipment. After the columns locking, cutting of the front wall starts with the performance of vertical cuts (Figure 55) and then horizontal cuts (Figure 56).

Figure 55. Vertical cut

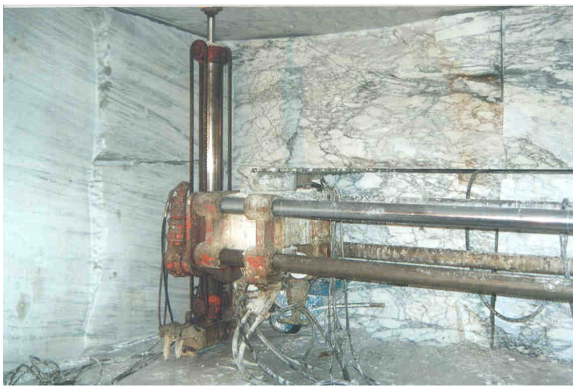


Figure 56. Horizontal cut

At the end of the cutting operations, the chain gallery machine is removed, in order not to obstruct subsequent operations. The target of this operation is to obtain blocks, joined to the deposit only at the rear vertical surface. Rear face breaking is performed using a hydraulic cushion that is inserted on a horizontal split (Figure 57).

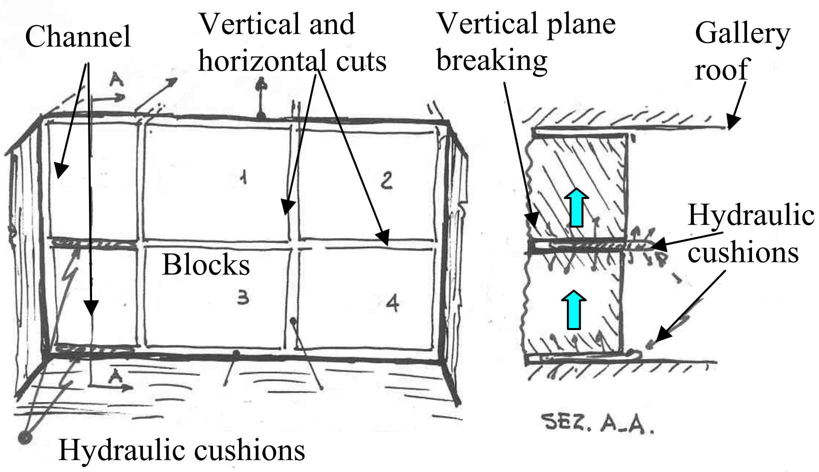


Figure 57. Channel development on gallery advancing

The removal of these two stone pieces and cleaning of the area create a lateral channel, which is used to cut the rear surface of the remaining blocks with a diamond wire machine and special equipment with several pulleys for wire diamond cable deviation to the machine (Figures 58, 59).

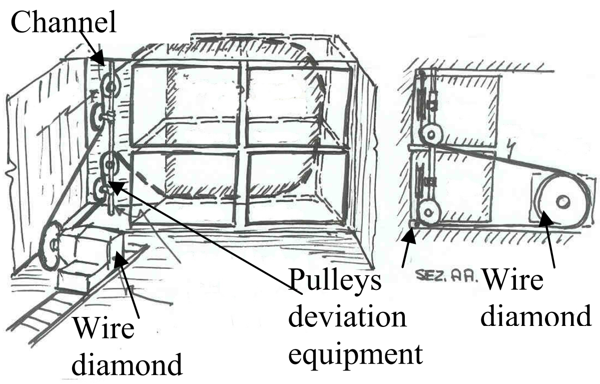


Figure 58. Pulley deviation equipment

Figure 59. Blocks rear wall vertical cut

To avoid blocks vertical motion and facilitate their extraction, several steel rolls are inserted in free split originated by cutting operations. At the end of the cutting operations, the diamond wire machine is removed, not to obstruct any subsequent operations like extraction, handling and transportation of blocks, which are performed by a power shovel (Figure 60).

Figure 60. Block extraction from wall

2.3. Risk Analysis Description

2.3.1. Risk Analysis

In this paragraph, the concept of risk is introduced and the various types of existing risks relevant to the activities of the Ornamental Stones sector are characterised. At the end, an analysis of risks is presented, for the two sub-sectors under study, namely extraction and processing, with reference to the used methodology.

Introduction to the concept of risk

The use of modern technology in the Ornamental Stones industry has brought up significant improvements in the production rates. However, these new technologies introduce other components and substances that involve new risks. The recent, rapid evolution of industrial processes has led to a constant change of the working conditions, as opposed to what used to happen about 20 years ago. Thus, there is an increasing need for an in depth study of the causes and effects of risks associated with the work place, so that more appropriate safety measures can be adopted for each case, aiming solely in minimising the risks related to accidents, professional injuries and health problems. In order for someone to understand the concept of risk, the following definitions are necessary:

> **Danger** - The intrinsic property or ability of something (for example material, equipment, work method and procedure) which can potentially cause harm.
>
> **Risk** (hazard) – The probability of the above factor to occur under conditions of use and/or exposure, focused on the magnitude of damage.
>
> **Analysis or Assessment of Risks** - The process of assessing health and safety risks of employees at a work place, under a framework of conditions leading to danger.

The risk of a particular operation can be quantified on the basis of a mathematical equation, which states that risk is equal to the probability of a danger occurrence multiplied by the cost of the damage that it causes. In this case, damage is understood as a consequence of an accident.

Risk = probability of occurrence x cost of damage

This definition is very useful; however, sometimes it can not be applied quantitatively since the values of the above mentioned parameters are not known. This happens because there are no studies for probability, and cost is often intangible, and therefore not measurable. Thus, the above formula is used in a qualitative way, weighing the probability of occurrence and the damage, depending on the importance of the risk. Risks, according to their importance, are classified into four categories:

I - Very important Risks (safety measures to be applied immediately)

II - Important Risks (safety measures to be applied in a short term basis)

III - Risks of small importance (safety measures to be taken in a long term basis)

IV - Negligible Risks (safety measures are not necessary)

Risk analysis is generally used as a first approach to the problem of safety at work and aims at examining all the factors involved in the Man-Machine-Environment system, which are capable of causing accidents or health injuries. Risk analysis has various objectives, all of which target at improving the safety conditions at work, namely:

- Prevention of professional risks;
- Providing information and raising the workers awareness;
- Organisation and development of the means for applying safety measures.

Figure 61 presents the various stages, which must be followed in the process of Risk Analysis for a specific industrial plant. During the core stage of Risk Analysis, the following aspects must be studied:

Surrounding Environment - Means of access, pavement conditions, machinery, safety, dust and fumes, temperature, lighting, noise, etc.

Activities - Identification of all working positions, sequence of tasks and methods of action, etc.

Workers - Analysis of risks from the standpoint of each individual worker.

External Factors - Atmospheric conditions, nearby industrial plants, etc.

Psychological, Social and Physical Factors - Monotony of work, working environment, organisational factors, stress factors, etc.

During Risk Analysis, safety and health criteria must be taken under consideration to allow the establishment of priorities, procedures and evaluation. These criteria must be based on:

- Legislation;
- National and International norms;
- Standards and directives included in publications;
- Recommendations from accredited entities;
- Standards of good practice;
- Company policy.

As it has been already mentioned, each accident is associated with a damage, which can be classified according to its extent and probability of occurrence. According to the “Guide for the Assessment of Risks in work place”, published by the European Commission in 1996, the damages can be classified, in terms of their magnitude, in the following way:

- Minor damages;
- Incidents that do not lead to injury;
- Minor injuries (bruises, cuts);
- Serious injuries (fractures, amputation, chronic diseases);
- Deaths;
- Repeated deaths.

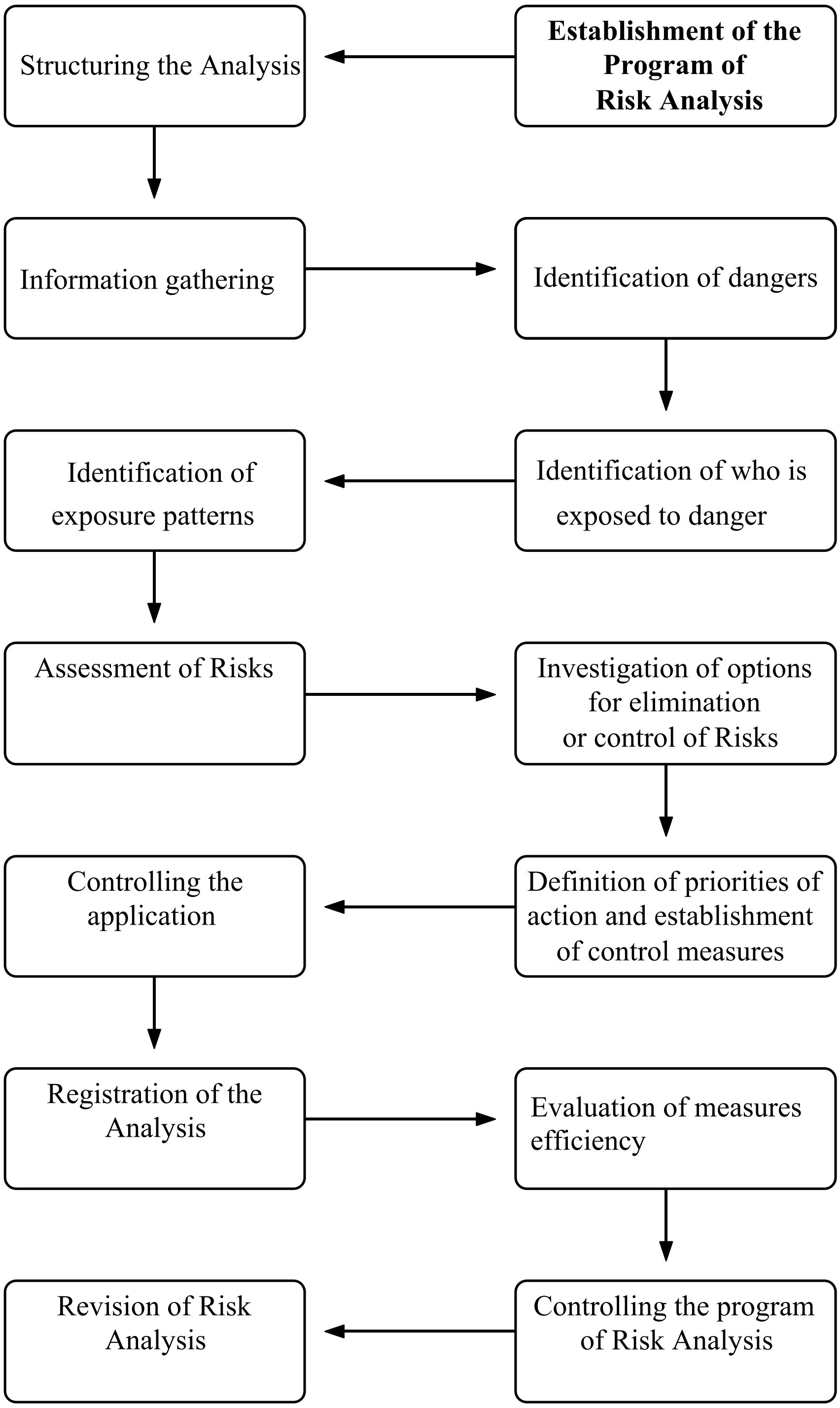


Figure 61. Flowchart of the Risk Analysis steps

In terms of the probability of occurrence and according to the same source, a risk can be classified as:

- Improbable;
- Possible (but not probable);
- Probable;
- Inevitable (in a long term basis).

The occurrence of damage, both generally and particularly in the Ornamental Stones sector, is very much related to the performance of the worker. To understand how the workers behave in terms of safety, and the factors that interfere in their performance, a scheme of the Peterson Model, also known as Motivation-Reward-Satisfaction model, is presented (Figure 62).
Lack of motivation, negligence, heroic acts and exposure to risk agents are the most important causes of work related accidents in the Ornamental Stones extraction and processing industry.

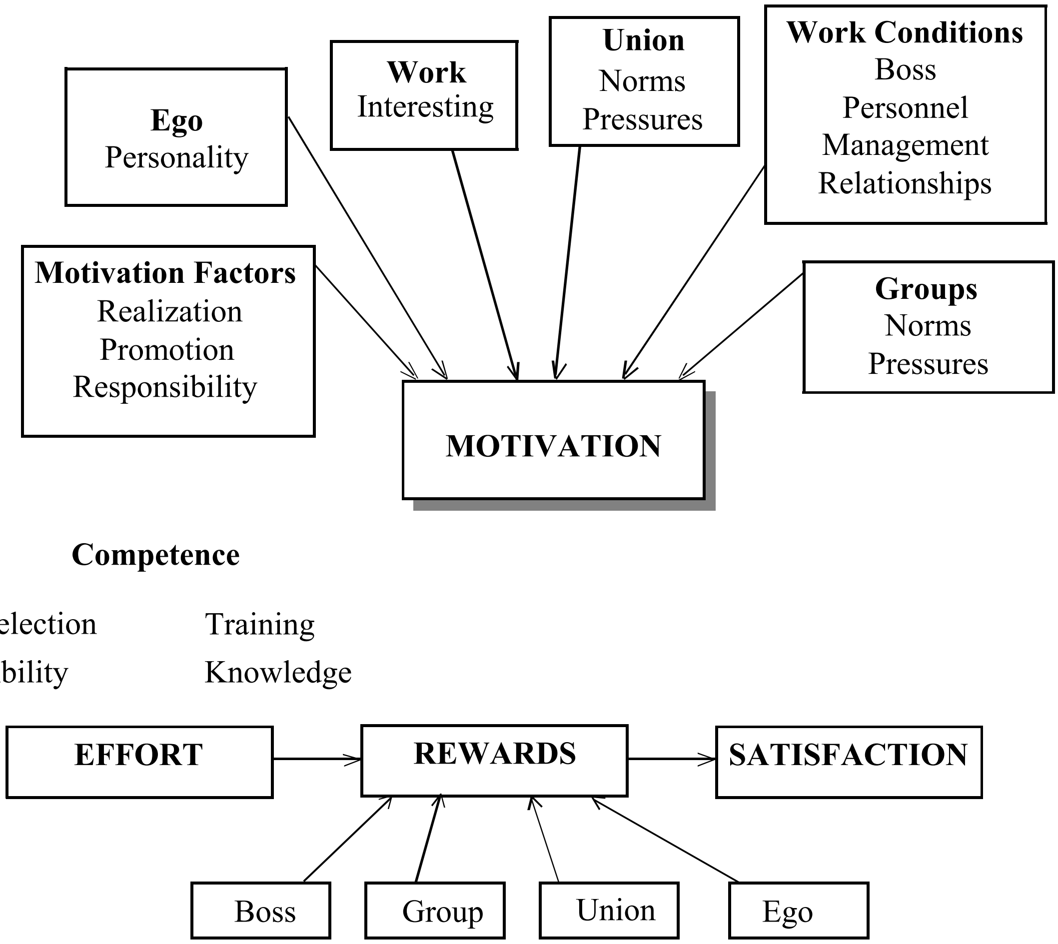


Figure 62. The Motivation-Reward-Satisfaction model

2.3.2. Associated Risks

Operations that are part of the production process during extraction and processing of Ornamental Stones are associated with the various types of risks already presented. Each category of risks is first characterised through a theoretical approach and, subsequently, the consequences of human exposure are presented. The most important risks in stone production (extraction and transformation) are the following:

- Mechanical Risks;
- Noise;
- Dust;
- Vibrations;

- Thermal risks;
- Electrical risks;
- Other risks.

The different types of risks are presented in this order, which can be considered as been organised in decreasing order of importance, taking into account the previous definition of risk that is based on the probability of occurrence and the magnitude of the resulting damages.

2.3.3. Types of Risk – General

General risks are those that can affect all quarry personnel. General hazards associated with quarrying activities are summarised in Figure 63.

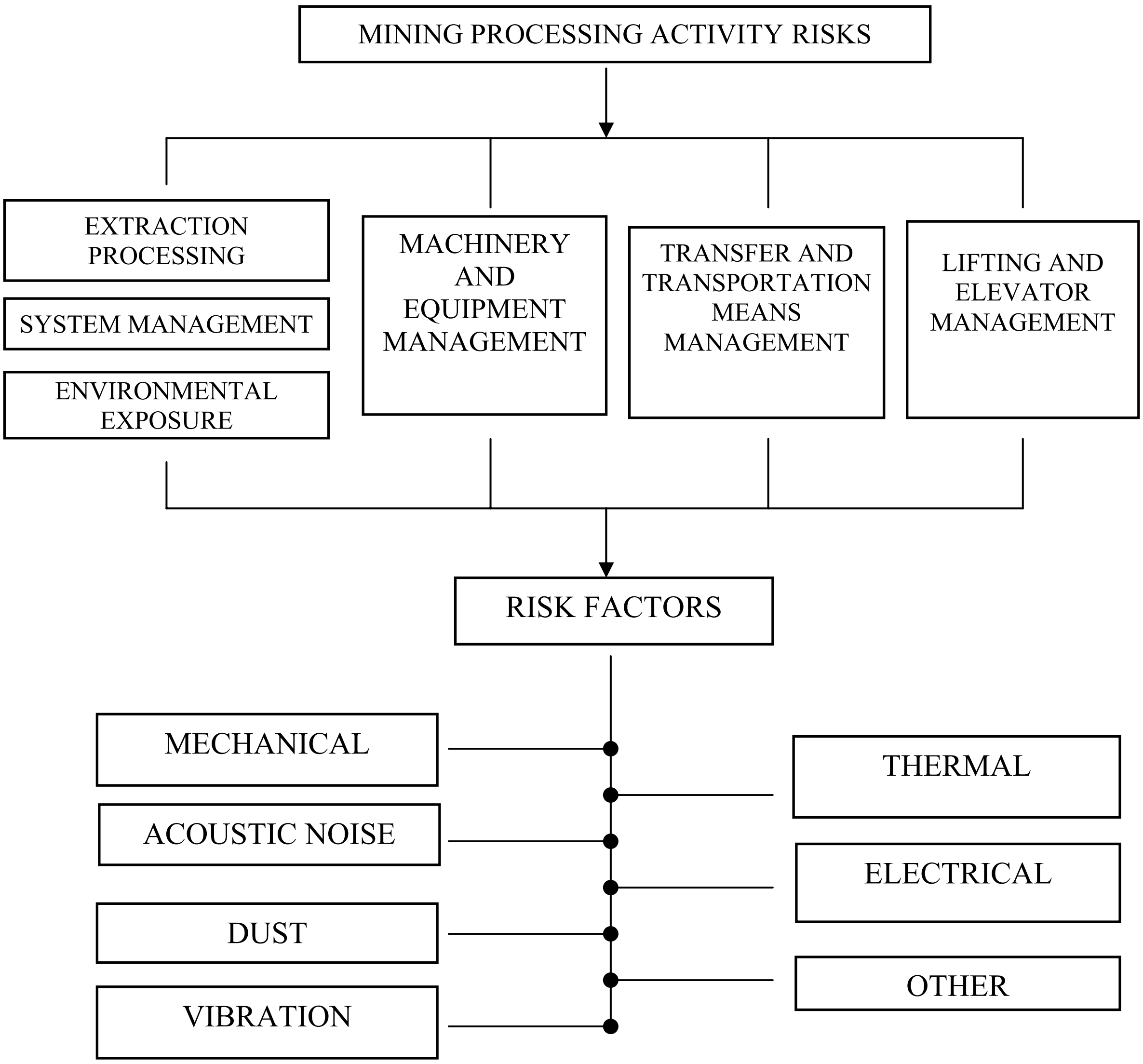


Figure 63. General hazards associated with quarrying activities.

Each type of risk can be associated with single events that can cause an industrial accident as follows, as presented in Table 4.

Table 4. Types of risk associated with single events

MECHANICAL	
Falling from high level	Prick
Sliding on level, trampling	Crushing
Equipment or loads falling	Abrasion
Landslide or collapse of slope or rocks	Clutching
Hitting, knock, impact, compression	Knocking with moving machine
Shearing	Knocking with moving load or equipment
Cutting	Flying of material or tool parts
NOISE	
Types of risk factors associated with single events	
DUST	
Inhalation of harmful substances (dust, fibres)	
VIBRATION	
Vibration from tool use	Vibration from use of transportation means
THERMAL	
Contact with high temperature parts	Exposure to excessive humidity
Exposure to heat or flames	
Exposure to sun or cold	
ELECTRICAL	
Electrocution	Burns
Electrical shock	Contraction, Fibrillation
OTHER	

Mechanical risks

Mechanical risks cause mainly accidents than professional illnesses. In fact, mechanical risks are responsible for almost all the fatal accidents that take place during the extraction process. The mechanical risks that can affect all the personnel working in a quarry can be generally summarised as follows:

- Landslides and falling of blocks from slopes;
- Falling of equipment or loads;
- Trampling;
- Falling of people;
- Entrapment and cuts;
- Impact of diamond pearls or stone fragments.

The minimisation of mechanical risks begins at the stage of quarry design, which can often eliminate hazards or at least reduce them. The quarry should be properly designed, staffed and equipped in order to operate safely. In this perspective, the quarry responsible should act in the following three basic areas:

- Planning and preparation;
- Day-to-day work,
- Review and monitoring.

Skilled personnel must properly plan each operation. In fact, an important factor affecting mechanical risks is work planning: due to high variability in the production cycle, it is essential to verify the operations duration, their sequence and, eventually, their correlations in space and time. It is crucial that all workers are informed about the mechanical risks related to the different operations. All the quarry areas as well as the equipment must be well maintained, periodically reviewed and correctly stored in appropriate places. Vehicles are one of the main causes of fatal accidents in quarries, so they must be checked periodically. In addition, the roads must be well-designed, taking into account the type and size of utilised vehicles, and well maintained, concerning for example their layout, width, slope, signs, etc.

Explosives can potentially cause the most serious and catastrophic accidents in quarries and for this reason they are the most controlled source of risks. For example, no one would allow any person to use explosives without first having been properly trained in their handling and use. Skilled personnel must be in charge of safe and secure storage, handling and use of explosives. The round of shots must be carefully planned in order to avoid misfires, early ignition and flying rock.

A relevant mechanical risk is the rejection of diamond pearls during sawing with the wire machine in case the wire breaks. Safeguards must therefore be provided for such an operation (position and distance from the workers, etc.). Areas of the quarry that present particular health or safety hazards need to be identified and marked as danger areas with the use of barriers and warning signs. Danger areas include for example (Figures 64-66):

- Sections of excavation which may collapse on people;
- Places higher than 2 m from which people can fall or places where falling from a lower height could be particularly dangerous;
- Places where people may be hit by falling objects, such as stone fragments or equipment parts.

Noise

Exposure to noise is one of the most important occupational health hazards in industry. Millions of people suffer from noise induced hearing loss (NIHL), resulting in a reduced quality of life. Hearing loss can be immediate in case of exposure to extreme sound levels, but, in general, the problem arises from exposure to noise day after day, year after year. Harmful noise levels do not always cause pain, so there is usually no immediate reaction or complaint from the worker. Unfortunately, however, when a person realises that his hearing has been severely affected, it is too late to do anything about it.

Figure 64. Example of accident in a quarry due to the lack of edge protection on roads and tips

Figure 65. Example of an accident due to no adequate design of a road or poor monitoring

Figure 66. Example of barriers and warning signs in the area of blocks squaring

In the Ornamental Stones industry there are several tools and equipment producing high noise levels. As a consequence, workers are exposed to very high noise levels during all the steps of stone extraction, such as drilling, sawing, detonation, transportation, etc. This noise exposure can induce, after long periods of time, hearing loss to the workers. Monitoring of the noise levels during stone working is the first action to be done in order to reduce noise emission. Four main factors contribute to the development of NIHL:

- overall noise level;
- frequency content;
- duration of exposure;
- susceptibility of the individual.

Noise definition

The terms “noise” and “sound” are often used interchangeably; however, noise is frequently considered as unpleasant and unwanted sound. Sound may be defined as any pressure variation that the human ear can detect. The number of pressure variations per second is called sound frequency and is measured in Hertz (Hz). The noise levels are usually expressed in decibel (dB). Decibel is not an absolute measurement unit; it is a ratio between a measured quantity and an agreed reference level. As sound is a form of energy, the potential hearing damage depends not only on its level, but also on its duration. As sound level varies during time, the level must be sampled over a well defined sampling period. In this way, it is possible to calculate a single value, known as the Equivalent Continuous Sound Level or LA_{eq}, which has the same energy content and, hence, the same potential hearing damage as the varying sound level.

The Italian legislation (D.L. 15/8/91 n. 277: Implementation of directives 80/1107/EEC, 82/605/EEC, 83/477/EEC, 86/188/EEC, 88/642/EEC on the protection of workers against the risks of exposure to chemical, physical and biological agents at works) defines the following exposure standards for noise at workplace:

- *The daily noise exposure of a worker* (LA_{eq}, d) is expressed in dB(A), measured and calculated over a period of 8 hours per day. It is expressed by the formula:

$$L_{EP}, d = L_{Aeq,Te} + 10 \log_{10} \frac{Te}{T}$$

$$L_{Aeq,Te} = 10 \log_{10} \left\{ \frac{1}{T_e} \int_0^{Te} \left[\frac{p_A(t)}{p_0} \right]^2 dt \right\}$$

Where: Te = daily duration of the noise exposure of a worker
T = 8 h = 28800 s
P_0 = 20 μPa
P_A = A weighted instantaneous sound pressure, in Pascal to which a person is exposed in the workplace; measured at the human ear height

- *The weekly noise exposure of a worker (L_{EP}, w)*, is the mean value of the daily values (L_{EP}, d) calculated during the working days of a week. It is calculated by the following formula:

$$L_{EP,w} = 10 \log_{10} \left[\frac{1}{5} \sum_{k-1}^{m} 10^{0.1} (L_{EP}, d)_k \right]$$

Where: $(L_{EP}, d)_k$ are the L_{EP}, d values for each one of the working days of a worker in a given week.

In addition, under the same law the following allowable noise levels are reported:

- The daily noise exposure of a worker (L_{EP}, d) must be less than 90 dBA;
- The instantaneous sound pressure level must be less than 140 dB (200 Pa).

Concerning the first limit, daily noise exposure of 90 dBA means that the actual energy of varying noise levels experienced by a person over the working day is equivalent to the energy from 8 hours of exposure to a constant noise level of 90 dBA. Concerning the instantaneous level, peak noise level above 140 dB from a single event can cause immediate hearing damage and must therefore be avoided.

Noise sampling strategy

The assessment of noise level exposure requires careful planning, including workers interview and noise measurements, in order to obtain information about the overall noise exposure. For a correct noise sampling strategy the following actions are recommended (Figures 67-68):

- Definition of the detailed working cycle;
- Noise measurements carried out during each unit operation;
- Computation of personal exposure levels based on the duration of exposure.

Figure 67. Monitoring of noise near a diamond wire machine

Figure 68. Monitoring of noise during drilling operation

Sources of noise in the Ornamental Stones extraction process

The main sources of noise during extraction operations are the tools and equipment normally used in the different operations carried out in a quarry. For example, the noise generated by the use of a jack-hammer during drilling, by explosion during detonation, or by a bridge-saw, single-blade saw, single wire machine and block cutter during squaring of blocks, are some types of noises encountered in the working environment.

Noise control

The best way to control noise is its reduction at source; and if this is not possible, control of noise transmission must be achieved. Machines must be designed and constructed in such a way that hazards from noise emissions are minimised. Specifications of machines noise emissions are required. It has been demonstrated that it is 10 times less expensive (unit cost per decibel reduction) to make noise-generating processes less noisy than to construct a barrier to screen the noise.

Noise levels can be lowered by the use of noise-control enclosures, absorbers, silencers and baffles. Where technical methods are insufficient, noise exposure may be reduced by the use of Personal Protective Equipment (earmuffs) and by administrative controls, such as limiting the time spent in noisy environment and scheduling the noisy operations. Essential elements of all noise control programmes are education and training of the workers, as well as regular hearing tests. When engineering and administrative noise control measures do not reduce the exposure to noise below the exposure standard, workers should be supplied with and wear personal hearing protectors. The latter should normally be regarded as an interim measure, while control of excessive noise is achieved by other means.

In the Ornamental Stones extraction process the most common way to control noise at source is the use of modern and less noisy equipment, but ear protection is always necessary due to the very high level of noise generated in most of the quarry operations.

Noise Legislative Support

- Law by decree number 162/90 (22/5/1990)
  - General regulation of Safety and Health at work on Mines and Quarries
  - Action level 85 dB
- Law by decree number 72/92 – legal decree number 9/92 (28/4/1992)
  - Action level 85 dB (A)
  - Maximum exposure level 90 dB (A)

Noise Assessment

For a detailed noise assessment all different stone production activities were classified according to Table 5.

Table 5. Classification of noise according to the different stone production activities

OPERATION	EQUIPMENT
Sawing	Single Wire Machine
	Blade-Saw
	Block-Saw
Stone Cutting	Cutting Machine
Stone Polishing	Manual Polisher
	Automatic Polisher
Stocking of Product	Stacking Truck
Finishing	Trimmer
	Uncapping Machine

Noise Measuring Equipment

Several modern, fast and precise sound analysers are available in the market to carry out noise measurements. They must be conforming to IEC and ANSI standards. An example is presented in Figure 69. The measurement must be carried out with the microphone located at the height of the human ear.

Figure 69. NE: Sound Analyzer 2260 Investigator by Brüel & Kjær that is conforming to IEC and ANSI Type 1 Standards

Dust

Airborne contaminants are an occupational problem of increasing interest as they are related to a wide number of diseases. In particular, airborne dusts are well known to be associated with several classical occupational lung diseases, such as pneumoconiosis, especially at high levels of exposure. Nowadays, there is also an increasing interest in other dust related diseases, like cancer, asthma, allergy, irritation and other illnesses that can also occur at lower levels of exposure.

Whenever people inhale airborne dust at work, they are at risk of an occupational disease. Overexposure to dust may cause temporary and permanent disabilities and deaths. Dust in the workplace may also contaminate or reduce the quality of products and negatively affect the environment.

Airborne dust produced during the Ornamental Stones extraction and processing phases is considered as one of the most risky factors for the workers health. The biggest health risk is due to the presence of free crystalline silica in the dust. Overexposure to dust composed of or containing free crystalline silica causes silicosis, which is a lung disease that is irreversible, progressive, incurable, at later stages disabling and eventually fatal.

There are four critical factors that may influence the health risk due to airborne dust. No one of these four factors can be considered independently of the others:

- Nature of the dust in question (presence of free silica, etc.)
- Size of particles
- Duration of exposure
- Airborne dust concentration in the breathing zone of the exposed person.

Dust particles definition and classification

In aerosol science, dusts are considered as solid particles ranging in size usually from 1 μm up to 100 μm that may be airborne depending on their origin, physical characteristics and environmental conditions. The size of particles refers to the *aerodynamic diameter*, defined as the diameter of a sphere of unit density with the same settling velocity in still air as the particle. In the occupational hygiene terminology, dust particles have been grouped in three size fractions based on their degree of penetration and deposition in the respiratory system (Figure 70), as follows:

- *Inhalable Particulate Mass.* It is the fraction of dust that can be inhaled into nose or mouth. This fraction includes particles having a 50% cut-point of 100 μm.
- *Thoracic Particulate Mass.* It is the fraction that can penetrate the head airways and enter the lung airways (tracheobronchial region). Dust particles have a 50% cut-point with a median aerodynamic diameter of 10 μm.
- *Respirable Particulate Mass.* It is the fraction of inhaled airborne particles that can penetrate the gas-exchange region of the lungs (alveolar region). Dust particles have a 50% cut-point of 4 μm. They include the traditional pneumoconiosis-producing dusts, such as silica.

The fractional criteria, initially proposed by Soderholm (1989), are now accepted by the American Conference of Governmental Industrial Hygienist (ACGIH), the European Community or Comité Europeen de Normalisation (CEN) and the International Standards Organisation (ISO).

Threshold Limit Values (TLVs) in industrial environment

The Threshold Limit Values provide occupational health professionals with a useful tool for assessing health risks and deciding whether a certain exposure situation is acceptable or not, and whether existing controls are adequate. TLVs are a key element in risk management and are often incorporated in legal standards. TLVs are usually expressed in one of the following forms:

- **TLV-TWA** (8-hours Time Weighted Average): time-weighted average concentration over a working day, usually of 8 hours.
- **TLV-STEL** (Short-Term Exposure Limit): the average concentration over a specified time, e.g. 15 minutes.
- **TLV-C** (Ceiling): Ceiling concentration, which is an instantaneous concentration not to be exceeded at any time.

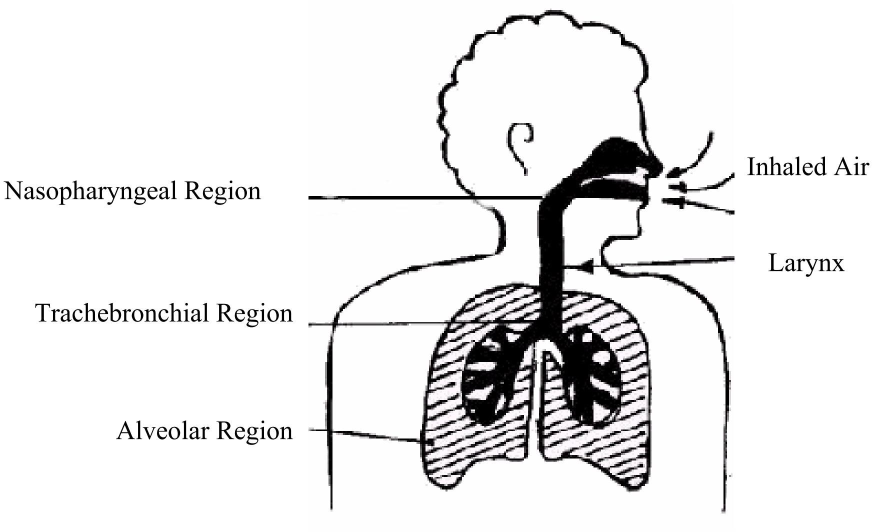


Figure 70. Schematic representation of the respiratory system

For dusts whose effects depend on a long-term average exposure, such as the pneumoconiosis-producing dusts, TLVs are given as time-weighted average concentrations, whereas for substances which are fast acting, TLVs are given as short term (STEL) or ceiling limits. Where a ceiling or STEL is not specified for an exposure standard, the STEL should not exceed three times the TWA exposure standard for more than a total of 30 minutes per eight-hours of working day and under no circumstances should the short term values exceed five times the exposure standard.

There has been an international agreement that TLVs for particles should normally be applied to one of the three size fractions previously introduced, namely inhalable, thoracic and respirable. Modern exposure limits for dusts are usually expressed in terms of the inhalable or respirable fractions. If silica is present, it is necessary to measure the respirable fraction of airborne dust. TLVs are initially based on dose-response or exposure-effect assessments. It should be kept in mind that the TLVs are not necessarily adequate in all situations. Exposures below the TLV do not mean that all workers are protected, for reasons that include concomitant exposures to other substances and individual sensitivities; it is accepted that TLVs do not usually protect the hyper-susceptible workers.

Moreover, values established for one country will not necessarily protect workers in another country, where a number of factors, including duration of working week, climate and work schedules, may differ. Also, Risk Assessment is a dynamic process and a substance once thought to be relatively harmless, may suddenly be proven to be responsible for a serious disease. In any case, TLVs cannot be used as "fine lines between safe and dangerous";

professional judgement is always required, taking account into the degree of uncertainty that exists not only in the establishment of these limits, but also in the assessment of the exposures, which actually occur in a workplace. National or local regulations and standards concerning dust exposure should be followed. However, in the absence of such legislation, internationally adopted values (e.g., by ACGIH) are often used. According to ACGIH, the reference Threshold Limit Values adopted for airborne dust in industrial environments is the following:

- TLV-TWA for inhalable fraction: 10 mg/m^3;
- TLV-TWA for respirable fraction: 3 mg/m^3;
- TLV-TWA for free silica in the respirable fraction: 0.5 mg/m^3.

Dust sampling strategy

In order to evaluate the risk, a correct dust sampling has to be carried out in the areas where stones are processed. In any work environment there are spatial and temporal variations in the concentration of airborne dust, so that exposure may differ, when workers are moving as well as with time within a day, week or even month. Sampling and analytical errors must also be considered.

A sampling strategy, taking into account all factors that may lead to any variation of the results, must be designed and followed, so that the data obtained are representative of the workers exposure and ensure a reliable exposure assessment. Some important factors that have to be considered are:

- The day, week, or month in which the sampling is performed;
- Production rate;
- Raw materials;
- Work shift;
- Task performed;
- Individual performing the task;
- Dust control measures;
- Technology used;
- Number of workers;
- Climate;
- Other nearby processes;
- Distance of worker from source;
- Errors in sampling and analytical procedures.

Obviously, any sample must be representative of the worker's exposure, which usually determines the place and time of sampling. Also, for the same type of agent and the same type of collecting medium, the recommended duration of sampling has to be of the same order. For the assessment of inhalation exposure it is necessary to characterise the air that workers are actually inhaling; therefore, the samples should be collected in the "breathing zone", which is usually defined as a hemispherical zone with a radius of approximately 30 cm in front of the head (Figure 71).

Sampling should include a representative number of workers indicative of all job categories. If compliance (or non-compliance) with a standard is too expensive and difficult, it may be better just to reduce the exposure. Risk Assessment often leads to a decrease within the acceptable exposure limits, whereas good practice should aim at controlling exposures to the lowest possible level.

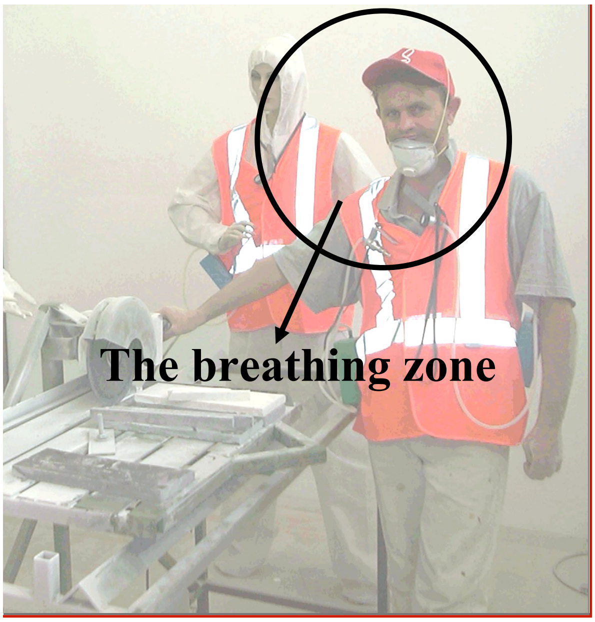


Figure 71. The breathing zone

Measuring equipment

There are two basic methods for sampling airborne dust:

- Use of direct reading instrumentation, to obtain results in (near) real time;
- Filtration sampling for subsequent laboratory analysis.

A direct reading instrument measures the concentration in a period of minutes, seconds, or even less, and displays the concentration on a dial or chart, or similar record. Most modern direct-reading dust samplers work by drawing the dusty air into an enclosed chamber and measuring the intensity of light scattered by the dust from a beam of light, such as a laser beam. This type of instruments is usually used for quick screening of environment as it provides a rough measurement.

For an exposure assessment, the best practice is to utilise personal samplers (Figure 70), which are portable sampling units carried by the workers as they move around. Sampling of airborne particles requires instruments that extract them from a measured volume of air and collect them in a manner that permits subsequent weighing and/or chemical analysis.

These instruments comprise of a sampling head, an air mover (with a power source) and a flow meter. The sampling head must be designed to collect the fraction of airborne particles where TLVs apply. The head will therefore consist of a collecting device (e.g., a filter in a filter holder) and a pre-collector, such as a cyclone for the respirable dust fraction or a specially designed entry if the inhalable dust fraction applies (Figure 73). It is essential that the air mover (a sampling pump) has a measurable and practically constant flow rate and that flow is always checked before and after sampling with a proper calibrated flow meter. The airborne dust concentrations are usually assessed by collecting dust on a pre-weighted filter. A known volume of air is passed through the filter, which is then re-weighted.

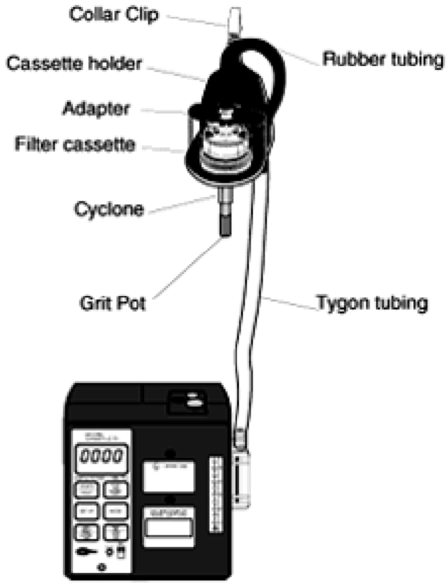
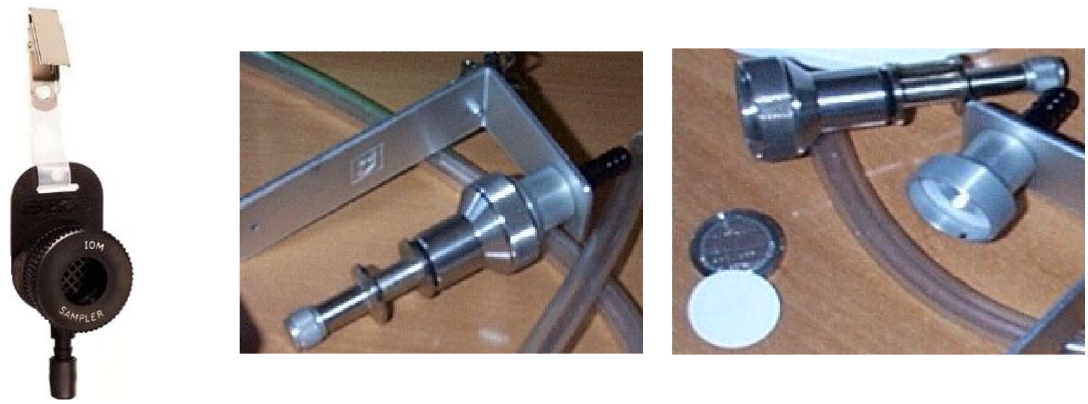


Figure 72. Scheme of a dust personal sampler

The difference in weight is the mass of dust, usually in milligrams (mg), while the volume of air is measured in cubic meters (m^3). Hence, the overall concentration of dust in air is measured in mg/m^3. The filter diameter, type and pore size vary depending on the chemical being sampled. The types of filters and applications are listed in Table 6.



a **b** **c**

Figure 73. Example of sampler heads: a - IOM sampler for inhalable fraction;
b - Two-stage Lippman's cyclone for respirable fraction;
c - Two-stage Lippman's cyclone components.

Table 6. Common filter applications

Filter Matrix	Common Application
Cellulose ester	Asbestos counting, particle sizing, metallic fumes, acid mists
Fibrous gloss	Total particulate, oil mists, coal for pitch volatiles
Paper	Total particulate, metois, pesticides
Polycarbonate	Total particulate, crystalline silica
Polyvinylchloride	Total particulate, crystalline silica, oil mists
Silver	Total particulate, coal for pitch volatiles, crystalline silica
Teflon	Special application (high temperature)

Stationary samplers can also be utilised in order to characterise the secondary airborne dust.

Source of dust in the Ornamental Stones extraction processes

In the Ornamental Stones sector workers are strongly exposed to high dust risk both during extraction and processing. When evaluating the risk related to dust, both primary and secondary dust must be taken into account. Primary dust is the dust directly generated by the process itself (i.e., rock drilling, sawing, etc.), whereas secondary dust is the dust generated by remobilisation of the deposited dust, for example on the floor, by walking or by machines use.

The friability of a stone, that is its resistance to breakage, is not related with risk. For example, very hard quartz, once submitted to strong forces that break it down to microscopic particles can be a much more serious health risk than friable marble. Moreover, the proportion of different minerals in the parent rock may be very different from their proportions in the airborne cloud, so bulk analysis is never a substitute for analysis of samples from appropriate fractions of the airborne materials.

The stone extraction process includes the following operations:

- Drilling;
- Sawing;
- Charging and detonation;
- Demolishing;
- Loading operations;
- Transportation of blocks and debris;
- Squaring of blocks;
- Unloading of debris.

Most of the above operations, such as drilling, sawing and detonation, are characterised by dust generation. Some examples of operations generating dust during the stone extraction process are reported in Figures 74-77.

Figure 74. Detonation (courtesy of G. Saviano)

Figure 75. Overturning of a bench (courtesy of G. Saviano)

Figure 76. Subdivision of a block (courtesy of G. Saviano)

Figure 77. Sawing with a wire cutter machine

The transportation and unloading of debris also generate a great amount of dust, both primary and secondary, the latter mainly due to the movement of workers and/or vehicles (Figure 78). In the extraction process, dust risk is influenced by weather conditions; for example, the presence of wind and rain can contribute to a natural dispersion of the airborne particles.

Figure 78. Dust generated during the movement of vehicles in a quarry

Control of dust sources

In the Ornamental Stones industry, the most common way of dust control is the use of wet methods, such as wetting down dusty products, wet drilling, water spraying at points of dust generation, wet cleaning of floors and work surfaces. An example of dust control in a quarry is reported in Figure 79.

After the introduction of wet drilling many studies have shown sharp decrease in the occurrence of silicosis in mines and granite quarries in the years following. A great variety of wet drills is available in the market, as well as pneumatic jackhammers with continuous flow water attachments. However, even when wet drilling is used, there may be still some dust exposure and therefore, ventilation and/or personal protection should be used as a complementary measure. Whenever wet methods are used, the evaporation of the dust-laden water may constitute a secondary dust source; this must be avoided and controlled.

An important factor of dust control is the way a worker performs a certain task, which can significantly affect exposure. For that reason, it is important to train workers in good work practices. If dust emissions cannot be eliminated or reduced to the desired level by control of their source, ways to prevent dust transmission throughout the work environment must be considered. The principle is to separate workers from the dust, either by using containers or by using general or local exhaust ventilation systems to remove the dusty air before it reaches the worker. All control possibilities should be explored before resorting to the use of Personal Protective Equipment (PPE), as this is the least acceptable means for routine control of exposure, particularly to airborne contaminants, for the following reasons:

- PPE, especially respiratory protective equipment (RPE), can be very uncomfortable, especially in hot conditions, and workers may be tempted to remove it;
- PPE only protects the worker wearing it, while the dust can present a risk to other people in the same workplace;
- Many studies have shown that PPE of all types usually provides less protection in the workplace that might be inferred by laboratory tests;
- PPE can not prevent contamination of the environment.

Figure 79. A water truck spraying the road in a quarry

2.3.4. Vibrations

The increasing use of industrial machinery has led to search of solutions that allow prevention, or at least attenuation, of the effects of inevitable vibrations. When not efficiently controlled, vibrations are a difficult phenomenon to prevent. The generation of vibrations is inherently associated with the instability and tolerances of the different parts of each machine. This may result in contact of the vibrating machine with another structure. Vibrations can also be a noise source under certain conditions.

The human body daily encounters a lot of different types of vibrations. Vibrations are present in the working environment, at home and even during transportation from one place to another. Regarding vibrations in the working environment, the workers that mainly suffer from them are those who use manual machinery, like pneumatic hammers or trimmers (Hand-arm vibration system) or those that operate seated in vehicles or machines (Whole-body vibration system). A lot of research has been done in studying the effect that exposure to vibrations has on human, especially in his working environment. The vibrations transmitted to the human body are able to, depending on their severity and time of exposure, cause temporary or permanent injuries. Criteria have been established that recommend the maximum values of exposure in both hand-arm and whole body vibration conditions.

Definitions and classification

The two basic systems for evaluating the effect of vibrations on human body (hand-arm system and whole-body system) have different characteristics resulting in quite different measurements:

- Equivalent acceleration value (a_{eq}) of the vibration;
- Direction of the vibrations;
- Vibration frequencies;
- Time of exposure to the vibration.

Legislative support

NP 1673/1980 – “Evaluation of human exposure to whole-body vibrations”. This Portuguese Standard is similar to ISO 2631.

NP 2041 – “Guidelines for the assessment of human exposure to hand-arm vibrations”. The Standard is similar to ISO 5349 and it does not define the limits for safe exposure; it only provides guidelines for measurement and assessment of hand-arm vibrations.

The exposure to hand-arm vibrations over a number of years can cause permanent physical damage usually resulting in what is commonly known as “white-finger syndrome”, or it can damage the joints and muscles of the wrist and/or elbow. In the early stages of “white-finger syndrome”, the symptoms are tingling and loss of feeling and control in the affected fingers. Damage to the wrist or elbow joints is often caused by a long-term exposure to vibrations produced by percussive tools (like rock drills).

Measuring Equipment

Mechanical vibration of a machine is caused by its moving components. Every moving component has a certain frequency associated with its movement, and as a result, the overall vibration transmitted to a human body in contact with the machine consists of different frequencies of vibration occurring simultaneously. This is an important fact to be considered while measuring human vibration because the human body is not *equally* sensitive to all frequencies of vibration.

In order to understand why human body is more sensitive to some frequencies than others, it is useful to consider the human body as a mechanical system. This system is complicated due to the fact that: (a) each body part has different sensitivity to different frequency ranges; (b) the human body is not symmetrical, and (c) no two persons respond to vibration in exactly the same way. Nevertheless, appropriate bio-mechanical models have been developed to simulate the response of human body to vibration. Figure 80 shows a simplified mechanical model of the body, where each body part is represented by a mass, spring and damper unit. The human body is a strongly damping system and therefore, when a part of it is excited at its natural frequency, it will resonate over a range of frequencies and not at one specific frequency. The human body is not symmetrical and therefore its response to vibrations is also dependent upon the direction in which the vibration is applied (Figure 81).

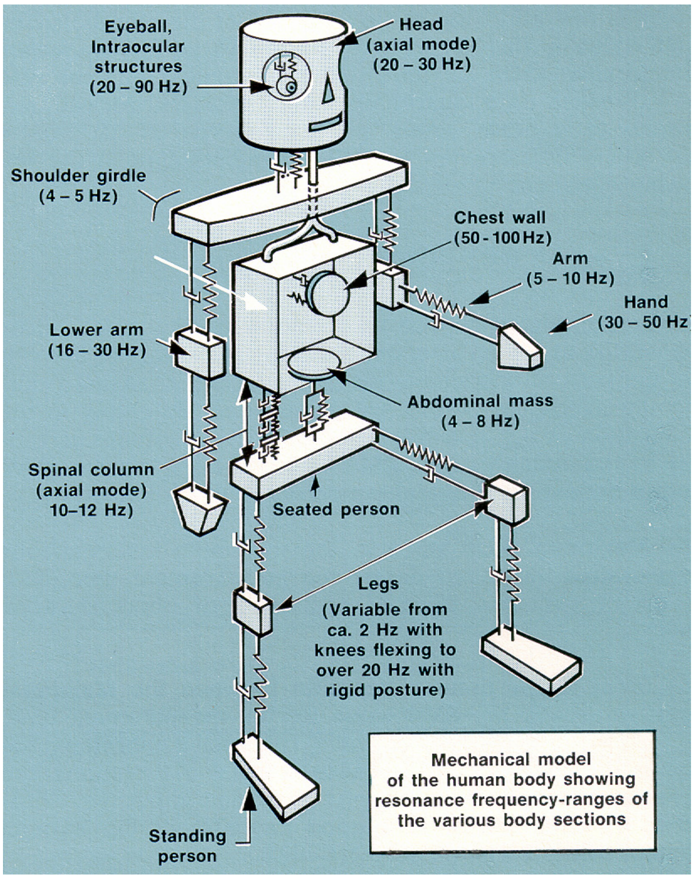


Figure 80. Mechanical model of the human body

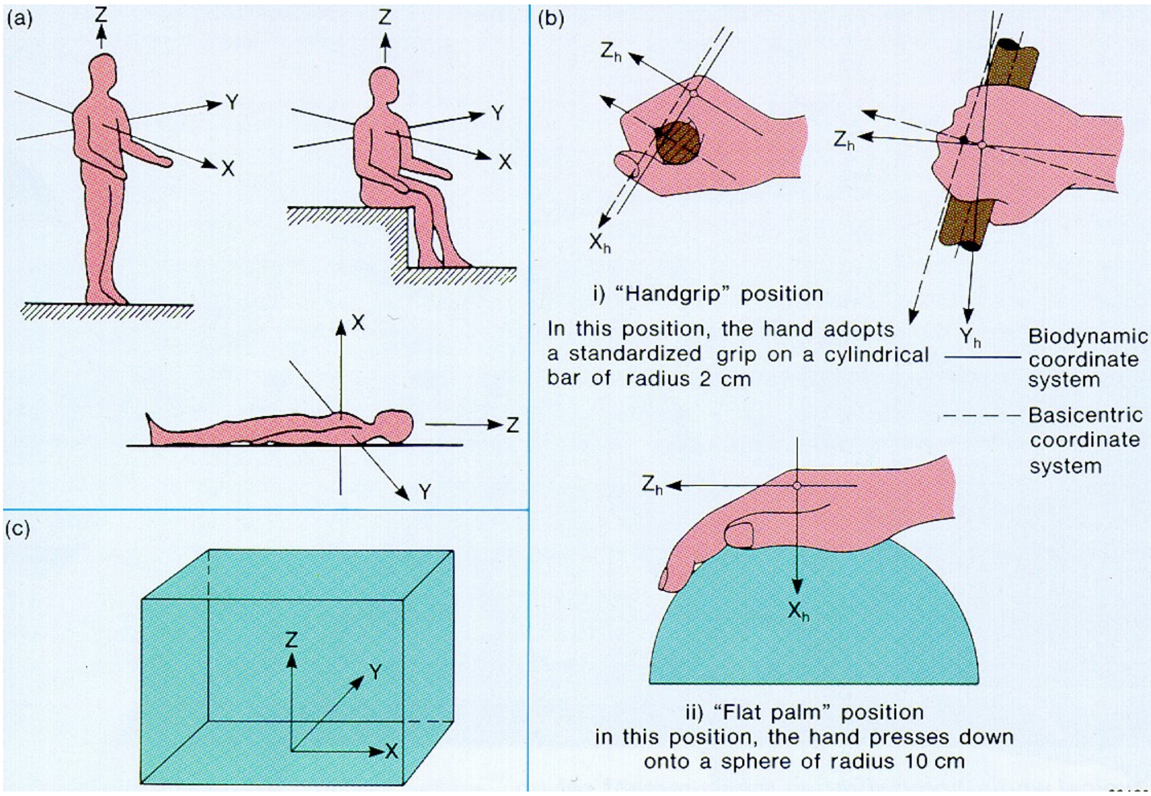


Figure 81. Measurement directions

Note: When measuring human vibration, it is extremely important that the measurement is done as close as possible to the point or area through which the vibration is transmitted to the body.

Control Systems

In the case of the whole-body vibration, vibrations can be efficiently controlled by a suspension system. While can be damped by the following systems:

- Internal damping – leads to minimised levels of vibration;
- Damping between the tool and the hand;
- Remote operation – undoubtedly the most effective, but unfortunately the most expensive, method of damping is to operate tools by remote control.
- Decrease of the daily exposure time. This is the only solution left when all the other damping methods have either failed or not been considered as feasible.

Figure 82. Whole-body transducers

Whole-Body Transducers: Vibrations enter the body at the floor/foot, seat/back or seat/buttocks interface. To measure vibrations transmitted to a vehicle driver, the driver may either sit on the transducer or strap it onto his back. To measure whole-body vibrations, which are transmitted through the floor, the transducer is placed on the floor with a small weight on top of it to ensure good contact between the transducer and the vibrating floor (Figure 82).
Hand-Arm Transducers: The transducer should be placed somewhere on the surface of contact between the palm of the hand and the vibrating object.

Use of explosives in the Ornamental Stones Industry

The Ornamental Stones industry uses explosives mainly during extraction operations that involve hard rock massifs. The use of explosives is the only practice allowing the exploitation of such hard rocks. The development of new production technologies and the diversity of the currently applied explosives allow their use in circumstances and places where, not long ago, this was forbidden. This fact was due to rock flying, ground vibrations and other pernicious effects associated with the use of explosives. In the past, even legislation itself limited the use of explosives in crystalline marbles and where explosives caused rock weakness. Black gunpowder was the only explosive used as it created a slow explosion that did not cause serious damages when used for opening free surfaces of extraction in massifs with many fractures and in regions where exploitable rock parts lay in between of non-exploitable parts.

The development of more efficient and fast drilling machines and hydraulic wedges reduced even more the use of explosives on marbles. However, the use of explosives is the most popular method for the extraction of ornamental granites and is actually spreading. The stage of opening the rock’s free surface, which allows blocks extraction, has been evolving.

Initially, ditches were opened by explosives. Then, the rock was cut with fire spurt. The current technology uses diamond wire cutting. Cutting with blowtorch is not used nay more, because it is a slow and noisy method. In addition to that, the fuel cost increases the overall cost. Where the extraction operation is mainly carried out by the use of explosives various rock cutting methods are also used to open an initial free surface. In this kind of methods, drill-holes are made to put the explosives in. The explosives load is adjusted according to the rock properties.

Figure 83. Horizontal drilling for opening of lateral cuts

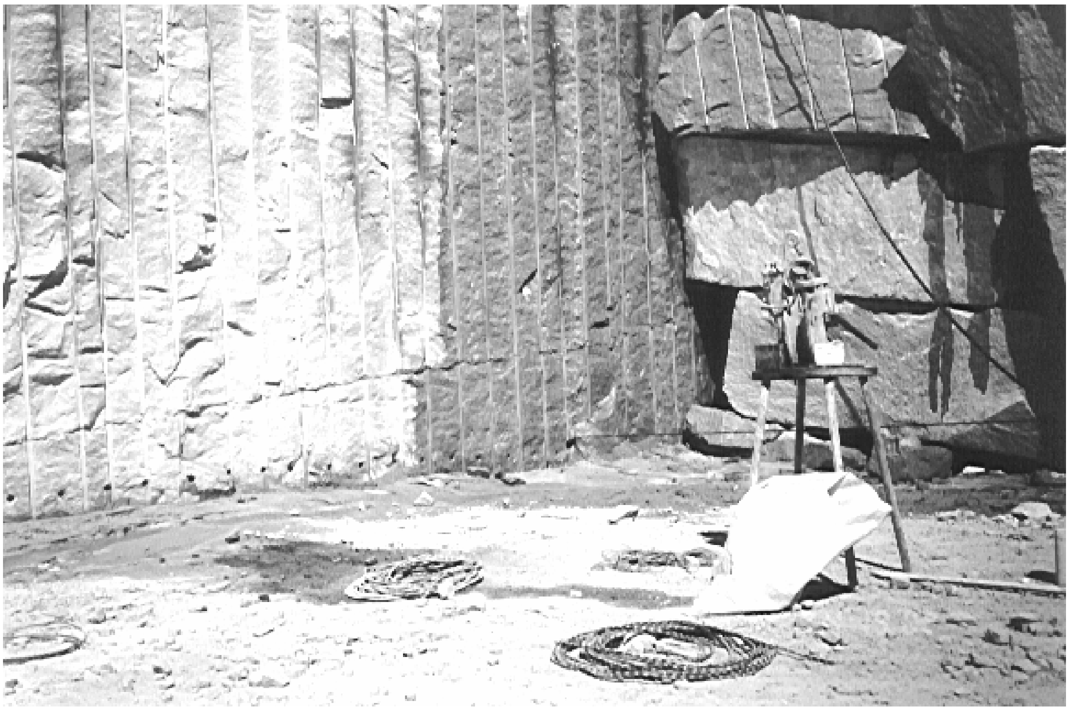


Figure 84. Block extraction (size 6x6x3 m) with explosives

The detonation cord eventually replaced the gunpowder use. The cord is light with reduced load. The use of explosives in heaps, which are much cheaper, with better properties than the traditional ones, and have speeds close to 2000 m/s, put an end to the use of old explosives. Each user tries to adjust the loads to its rock type. The distance between loads, their placement in the drilling and the weigh of each cord are adjusted to each rock type and they can vary a lot for different conditions.

Figure 85. Explosives preparation

2.3.5. Thermal risks

Heat represents one of the classical physical stresses in industrial environment. Overexposure to sun in outdoor working environment has been a problem for many years. For employees working outdoors, such as quarry workers, there are two categories of thermal risk:

- Short-term acute effect
- Long-term cumulative effect.

Concerning the short-term category, working at high temperatures results in heat stress as the heat released from the human body than the heat absorded. Unbearable heat can cause prickly heat, fainting or heat cramps (if body water and salt balance is incorrect) and, in the worst cases, heat stroke, which can be fatal. During heat stroke, the body temperature control system breaks down and the body temperature rises rapidly. The long-term risk is related with prolonged exposure to solar radiation that is responsible for various skin disorders, such as skin cancer, premature ageing and cataracts of the eyes. In the extraction process, any operation involving long periods of exposure at high temperatures is a source of risk.

Legislation does not define any precise temperature value beyond which workers should stop working. Standards for heat stress conditions in the workplace have been set by the American Conference of Governmental Industrial Hygienist (ACGIH), based on the assumption that, workers taking adequate water and salt quantities should be able to work if their core body temperature does not exceed 38°C. However, considering that it is not practical to measure the individual worker's temperature, environmental parameters are usually measured. The most commonly used method to evaluate thermal risk in hot work environments is the Wet Bulb Globe Temperature (WBGT) Index, calculated according to ISO 7243/82 and adopted by ACGIH. The WBGT Index was originally proposed as an expression of heat stress for men exercising outdoors under sun in military training. The WBGT is not a measurement of air temperature with an ordinary dry-bulb thermometer, but it is an index of various environmental parameters (such as air temperature, humidity, radiant heat and ventilation). There is a specially designed, simple and automatic equipment, designed to measure the WBGT index (Figure 86).

Figure 86. Example of a typical Electronic Direct-Reading WBGT Instrument (Metrosonics Inc.)

For outdoor use with solar load, the index is derived from the following formula:

$$WBGT = 0.7T_{nwb} + 0.2T_g + 0.1T_{db}$$

where: T_{nwb} = natural wet bulb temperature
T_g = globe temperature
T_{db} = dry bulb (air) temperature

T_{nwb} is measured by a wet bulb thermometer that is a glass thermometer with its bulb covered by a wick; it is exposed to sun and wind. T_g is measured by a globe thermometer, that consists of a hollow copper sphere painted black on the outside and containing a thermometer with its bulb at the centre of the sphere; it is exposed to sun and wind. T_{db} is measured by a dry bulb thermometer not exposed to direct sunlight.
The limit values of WBGT index for different working conditions are reported in Table 7.

Table 7. Limit values of WBGT Index according to different categories of work loads.

Work and rest period per hour	**WBGT Index (in °C) for different work loads***		
	Light	Moderate	Heavy
Continuous Work	30,0	27,6	25,0
45 min work and 15 min rest	30,6	28,0	25,9
30 min work and 30 min rest	31,4	29,4	27,9
15 min work and 45 min rest	32,1	31,1	30,0

* Examples of work loads for each category are:

- Light work: sitting or standing on control machines; light hand or arm work;
- Moderate work: walking with moderate lifting or pushing;
- Heavy work: pick and shovel work.

Table 7 refers to acclimatised people wearing light summer clothing and working under hot conditions for 5 days, 40 hours per week. For other work schedules, such as intermittent working hours in hot conditions, other figures apply and need to be calculated for each job.

The acclimatisation refers to a set of adaptive physiological and psychological adjustments that occur when a worker undertakes work in a hot environment. These progressive adjustments reduce the strain experienced from the initial exposure to heat, allowing a person to work effectively under conditions that might have been unbearable before acclimatisation. In fact, after heat exposure during several successive days, the worker performs the same job with a much lower core temperature and heart rate, higher sweat rate (reduced thermoregulatory strain) and without the distressing symptoms that may be initially experienced. Acclimatisation to heat is a remarkable example of physiological adaptation that is well demonstrated both in laboratory and field tests. Guidelines for acclimatisation to heat are reported in Table 8, for both experienced and new workers.

It must be taken into account that WBGT is not an accurate measure for the physiological responses to heat and may not be sensitive enough to protect workers. Therefore, emphasis should be put on considering the best level of preventive measures. In order to prevent heat stress, the workers must have regular rest breaks to help their body to cool off. The rest time should increase with temperature. In addition, frequent small drinks of cool water help to replace the water lost through sweat and prevent dehydration.

Table 8. Guidelines for heat acclimatisation

	Activity (% of full work assignment)	
Day	**Experienced Worker**	**New Worker**
1st	50	20
2nd	60	40
3rd	80	60
4th	100	80
5th		100

The preventive measures that should be implemented in order to protect workers are summarised as follows:

- Schedule heavy work or work in direct sunlight during cooler periods of the day or other days;
- Introduce rest breaks or assign alternative duties in a cooler place;
- Provide a cooler area for workers rest breaks;
- Provide cool water and encourage people to drink often small amounts;
- Provide shade over working areas where possible;
- Wear protective clothing (hat, lightweight opaque clothing);
- Provide and encourage regular application of sunscreens with maximum SPF protection;
- Encourage wearing of sunglasses;
- Encourage workers to inform the employer about any warning sign or symptoms of heat stress.

2.3.6. Electrical Risk

Electrical hazards are present in almost every working environment. The electric shock is the effect produced on the body, and particularly on the nervous system, when electrical current passes through it. The effect depends on the current intensity, which itself depends on the voltage and body resistance, i.e. path length and surface resistance of skin (which is much reduced when wet). The consequences of an electric shock can range from minor injury and involuntary muscle contraction to death. Other possible electrical hazards are: burns caused by current passing through the body or by direct contact with an electrically heated surface, explosion and fire caused by electrical sparks, overheating due to short circuit or overload and old wiring in the presence of flammable material.

People can suffer electrocution by coming into contact with overhead wires, carrying out maintenance work on live electrical circuits and when working with damaged electrical equipment, extension cords, plugs or sockets. All employers should take all the necessary measures to ensure that their workers are not exposed to electrical hazards. The use of Residual Current Devices (RCD) is of particular importance as they can prevent electrocutions in many cases.

In order to prevent electrical risks, a maintenance program for the electrical installations should be applied in the quarry, while the electrical equipment should be regularly tested. Equipment, including the portable electrical ones, must be selected considering the specific working environment. All the components of electrical equipment must be maintained in good condition (cables free from breaks in the insulation, cracked or broken plugs must not be used, etc.). Cables must not run across areas, where they can cause a tripping hazard or they can be damaged by traffic.

Workers should be informed about the electrical risks linked with their job: they must be competent for the tasks undertaken and they must not be placed at risk due to lack of skills or information. The most hazardous areas in the quarry should be identified. The following situations are identified as the most critical and dangerous ones:

- Working under or near overhead power lines, especially with heavy equipment or cranes. It is essential to stay clear of the overhead power lines.
- Excavating: care must be taken when underground cables are present.
- Blasting near electrical installations.

2.4. Specific Risks related to Operations and Working Places

Specific risks are those that are inherent to particular operations or working places related to quarrying activities. A list of specific risks is given below:

Risks related to front stability in:

- surface quarrying;
- surface soil quarrying with deep cavity;
- underground quarrying.

Health Risks:

- noise, vibration, dust;
- gas.

2.4.1. Risks related to front stability in surface quarrying

The instability of mountain slope is referred particularly to ***sliding or breaking of a stone portion*** due to:

- Stone fractures distribution (Figure 87)
- Interference of the cutting operation with the natural stone fractures.

One of the serious risks in quarrying is the formation of **wedge-shaped stones** that can fall down with severe consequences for the workers safety. Another type of risk related to front stability is the presence of detritus, originating from quarrying operations (Figure 88). Instability can concern:

- the whole heap due to material's sliding along the supporting plane;
- jutting parts breaking;
- movements of heap parts.

Sometimes, paths are made by a truck upon a heap (Figure 89). In this case, loaded trucks can generate soil instability with consequence:

- material sliding

- truck overturning.

Figure 87. Fractures on natural stones wall

Figure 88. Detritus on quarry's fronts

Instability can be caused also by:

- erosion caused by water (Figure 90)
- removal of material from the front base.

Another type of front instability directly related to the type of processing is related to extraction with explosives (Figure 91). The removal of a big stone block from a mountain slope can cause development of new fractures system or widening of natural fractures.

This type of processing usually generates a dangerous front that must be periodically swiped from unstable stones.

Figure 89. Paths on quarry fronts

Figure 90. Erosion caused by water on quarry fronts

Figure 91. Extraction with explosives

2.4.2. Risks related to front stability in surface soil quarrying with deep cavity

Front instability can be also caused in typical quarrying operations. Surface mining on soil can create deep cavity. Continuation of the excavation at such conditions (Figure 92) results in high vertical front with the following consequences:

- increased probability of land sliding;
- increased access difficulties for personnel and means of transportation in the working areas;
- increased difficulties on handling and moving of materials, equipment and blocks.

To assure front stability it is necessary to:

- Foresee the interruption of vertical rock wall introducing enlargement banks (Figure 93)
- Adopt appropriate computer software in combination with fracture analysis;
- Install tightened bolts (Figure 94).

Figure 92. Extraction with deep down advancing

Figure 93. Extraction with banks advancing

Figure 94. Tightened bolts installed on wall

2.4.3. Risks related to front stability in underground quarrying

In this case, instability can be generated on the wall and the vault. An important and characteristic aspect of this quarrying process, in order to assure safety in working areas is the width and the height of the exploitation chamber. In fact, strength and displacement increase during processing. During exploitation, natural cracking of the bank can also occur due to internal stresses on the rock deposit caused by the cutting operations. Among the difficulties that characterise underground quarrying, inadequate lightning conditions hinder the inspection and control of fractures distribution. In order to increase stability and assure safety in working places it is necessary to:

- install tightened bolts on walls and roof (Figure 95).
- provide adequate pillars to support the vault (Figure 96);

Figure 95. Tightened bolts installed on gallery vault

Figure 96. Pillars to support gallery vault

2.4.4. Health Risks

During quarrying operations both surface and underground, personnel is exposed to risks. Health at work places is principally affected by meteorological (weather) conditions and also dust, noise, vibration, climatic temperature, gas emission, aerosol, humidity, etc. (Figures 97-99).

Noise. Reduction of noise effects can be accomplished with the use of soundproof or less noisy machinery. Otherwise, personal protective devices should be used by the personnel.

Dust. In order to reduce the effect of dust it is advisable to conduct all operations in the presence of water or, if this is not possible, to equip machinery with a dust exhaust fan.

Vibration. This risk is associated mainly with pneumatic hammers, power shovels, excavators and truck driving. Risks can be minimised by reducing manual operation of machinery, introducing mechanised systems and using vibration absorbing seats on vehicles.

Aerosol. In underground exploitation, especially at the advancing gallery, the wire diamond machine produces a mixture of dust and water during cutting. The wire diamond, due to its velocity, sprays dust and water in microscopic particles and forms an aerosol that is spread on air and can be inhaled by the exposed personnel.

Gas. This risk is of great importance in underground quarrying. Power shovels, excavators and trucks generate exhaust gasses, which are inhaled by the personnel. Especially during advancing gallery operations, the risk is increased due to the limited room dimensions (about 6 m width, 3,2 m height and 15-20 m depth).

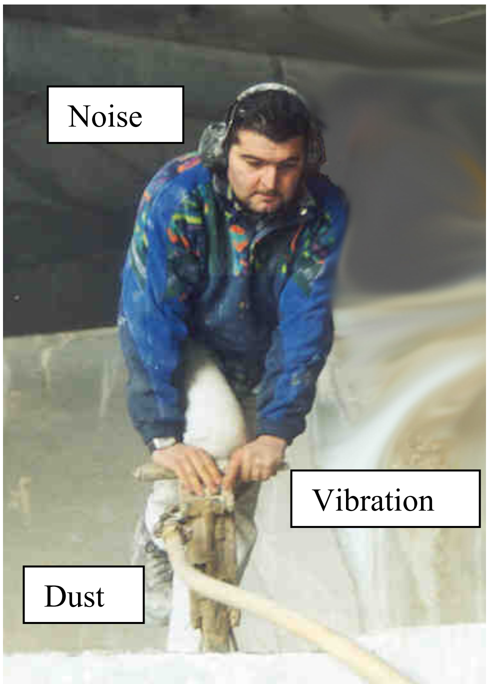


Figure 97. Quarryman during drilling

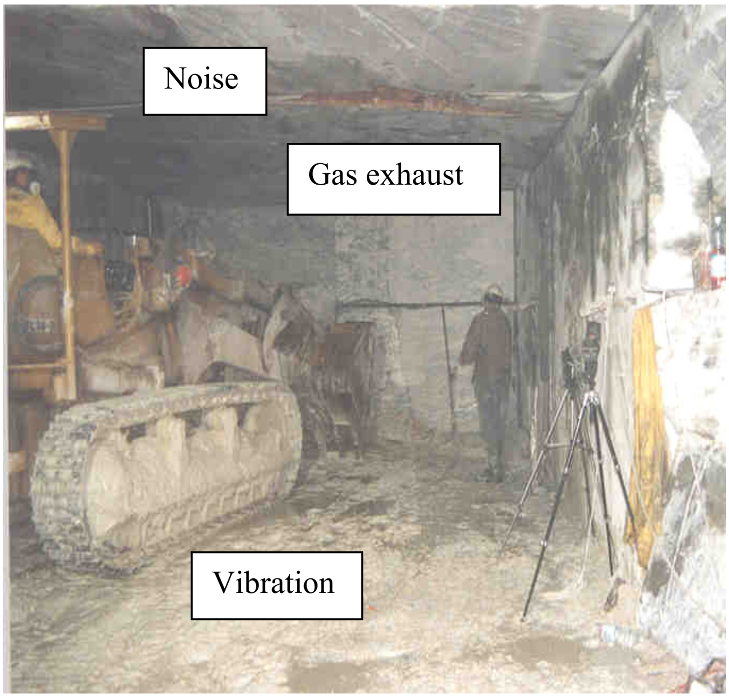


Figure 98. Quarryman in advancing gallery

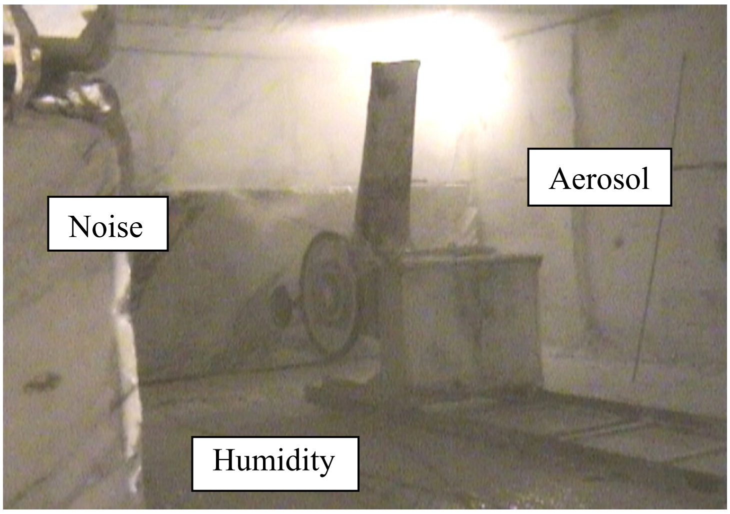


Figure 99. Diamond wire cutting machine in gallery

Reduction of this risk can be accomplished by:

- use of ventilation systems (Figure 100);
- equipping power shovels, trucks and excavators with special catalytic mufflers (Figure 101);
- employing more refined fuels;
- increasing air ventilation in galleries;
- widening the advancing room (Figure 102);

- installing suitable gas measuring instruments;
- installing suitable equipment able to assure the smooth operation of the ventilation system.

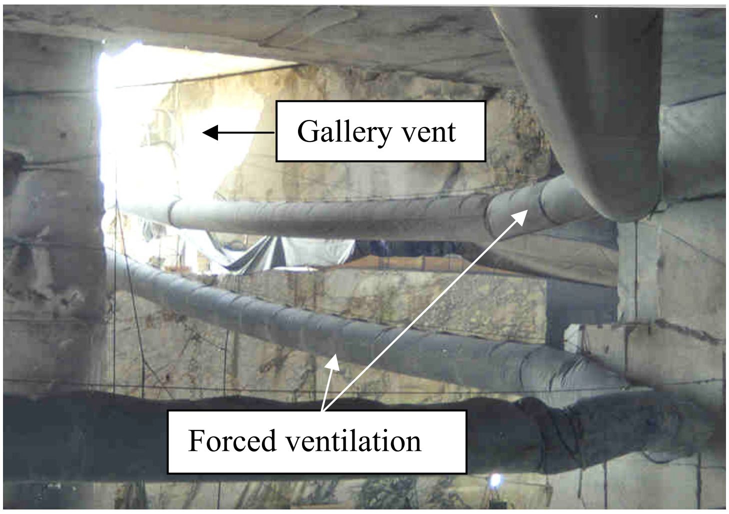


Figure 100. Ventilation system and gallery vent

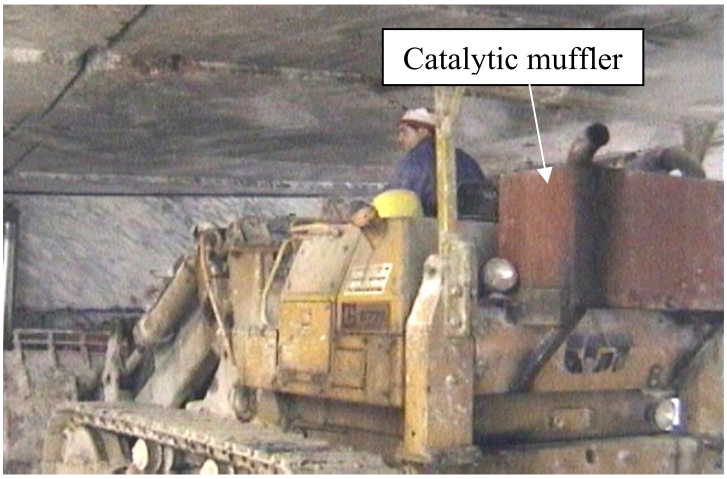


Figure 101. Exhaust gas reduction with catalytic muffler

2.5. Preventive Measures

Risk Assessment generally provides a first approach to the problem of safety at work by examining all the risk factors involved in the Man-Machine-Environment system, which are capable of causing accidents or health problems. The results of Risk Assessment are generally the following:

- Risk index (for example: slight, medium, high);
- Description of actions to be undertaken in order to remove or reduce risk;
- Time schedule for actions implementation.

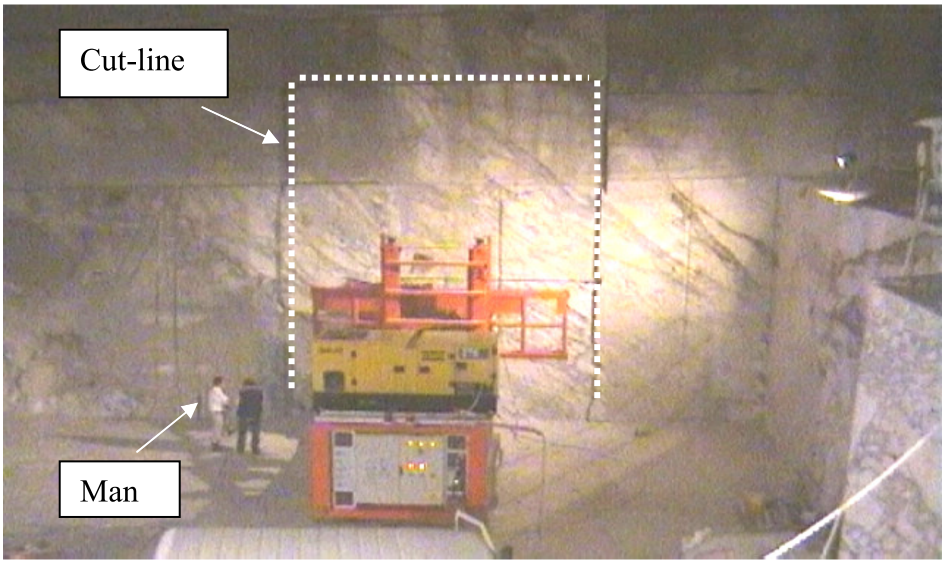


Figure 102. Widening of the advancing gallery with a special machine

Apart from Risk Assessment, appropriate safety measures, with the main purpose of minimising work accidents, professional injuries and health problems, can be adopted by carrying out preventive measures according to the following principles:

- **elimination of risk in the cases where there is an adequate knowledge of the processes based on** technical progress and, when this it is not possible, minimisation of risk;
- **reduction of risk** at its source;
- **planning risk minimisation** by creating an environment that integrates, in a coherent way, the prevention, the technical and the productive organisational conditions of business and also the influence of the factors of the work environment;
- **substitution of what is dangerous** with something else not or less dangerous;
- **respect of ergonomic concepts** in the workstations; choice of equipment; definition of work and production methods, minimisation of monotonous and repetitive tasks;
- **priority to overall protective** measures in comparison with the individual protective ones;
- **minimisation of the number of workers** that have to be exposed to risks;
- **limited use of chemical, physical and biological agents** in the workplaces;
- **sanitary control of the workers** assigned with tasks of specific risk;
- **removal of workers from places where there is a dangerous exposure to substances** hazardous for their health;
- **hygienic measures**;
- **overall and individual protective measures**;
- **emergency measures** in cases of first aid, fireproof struggle, evacuation and in case of serious and immediate danger;
- **use of health and safety signal warning**;
- **regular maintenance** of the working equipment, machines and tools with particular attention for the safety devices to conform to the manufacturers indications;

- **information and training** of the workers or of their representatives on matters that concern safety and health in the work place;
- **suitable instructions** to the workers.

2.6. General Standard Documentation

In accordance with E.U. directives, regarding measures to promote and improve health and safety of workers involved in mining industries, the employer should follow general preventive safety measures, such as:

- **Health and Safety Document (H.S.D.);**
- **Designation of Safety Overseer in work places;**
- **Designation of Safety Chief Director**.

H.S.D, in particular, must contain the Risk Assessment about the health and safety of workers in relation to their activities, measures and operational procedures for each of the following elements:

- Protection against fire and harmful atmospheres;
- Evacuation and rescue means;
- Communication, warning and alarm systems;
- Sanitary overseeing;
- Program for systematic inspection, maintenance and testing of equipment, instrumentation and mechanical, electric and electromechanical plants;
- Maintenance of safety materials;
- Use and maintenance of pressure containers;
- Use and maintenance of transportation means;
- Safety drills;
- Store areas;
- Fronts stability;
- Ventilation systems;
- Personnel evacuation;
- Organisation of rescue teams;
- Use of explosives.

The H.S.D. should also contain indications related to workers information and training of safety representative.

2.6.1. Risk Assessment methodology

Risk Assessment has the objective to oblige the employer or the managing director or the production manager to perform measures in order to assure the health and safety of the workers through actions that help to:

- **identify the danger** that exists in the work places and assess the associated risks, so as to determine the measures that have to be undertaken, in order to protect the health and safety of personnel and other workers, in respect to norms and law;

- **assess the risk,** so as to make the correct selection of equipment that are used in the work place, as well as their layout;
- **identify all personnel** exposed to danger, including the groups of persons vulnerable to special risks;
- **check if measures have adequate results**;
- **establish a priority list** in the case that further measures related to Risk Assessment are necessary;
- **show to competent authorities,** workers and their representatives, that all the factors related to working activities have been considered and they have consented to formulate a valid and motivated judgement connected to the risk and the necessary measures to safeguard health and safety in the work places;
- **guarantee that the prevention measures and the production method** are considered as necessary and effected according to the risk evaluation and that they allow an improvement of the worker's level of protection.

The methodology of Risk Assessment is presented in Figure 103.

2.6.2. Risk Assessment structure

Risk Assessment involves all operational actions that should be effected in order to evaluate the overall health and safety hazards that the workers encounter during the accomplishment of their tasks. Risk Assessment is therefore a fundamental instrument that allows the employer to characterise preventive measures and to plan realisation, improvement and control in order to verify the effectiveness and efficiency of the carried out actions. It is necessary to define the following terms, as they have been approved in an E.U level:

- **DANGER:** the intrinsic property or characteristic of a determined factor (for example material, equipment, work methods and procedures, etc.) which has the potential to cause harm;
- **RISK:** probability of the potential of the above mentioned element to be reached under conditions of use and/or exposure, with an interest in the magnitude of damage;
- **RISK ASSESSMENT:** the process of assessing the health and safety risks of employees at the work places, as a consequence of the circumstances which lead to danger at the work place.

Risk Assessment is therefore a complex procedure that necessarily requires, for each working place, a sequence of operations, such as the following:

- **identification of dangers present in processing;**
- **identification of the objectively present exposure risk;**
- **identification of the health and safety hazard**, correlated to the extension, severity and possibility of damage derived from carrying out various working tasks, such as use equipment and machinery, etc. In addition to this, the consequent identification of the priority levels of the preventive and protective measures, as these were defined from the result of risk evaluation, is carried out, targeting in a further reduction of the residual risk.

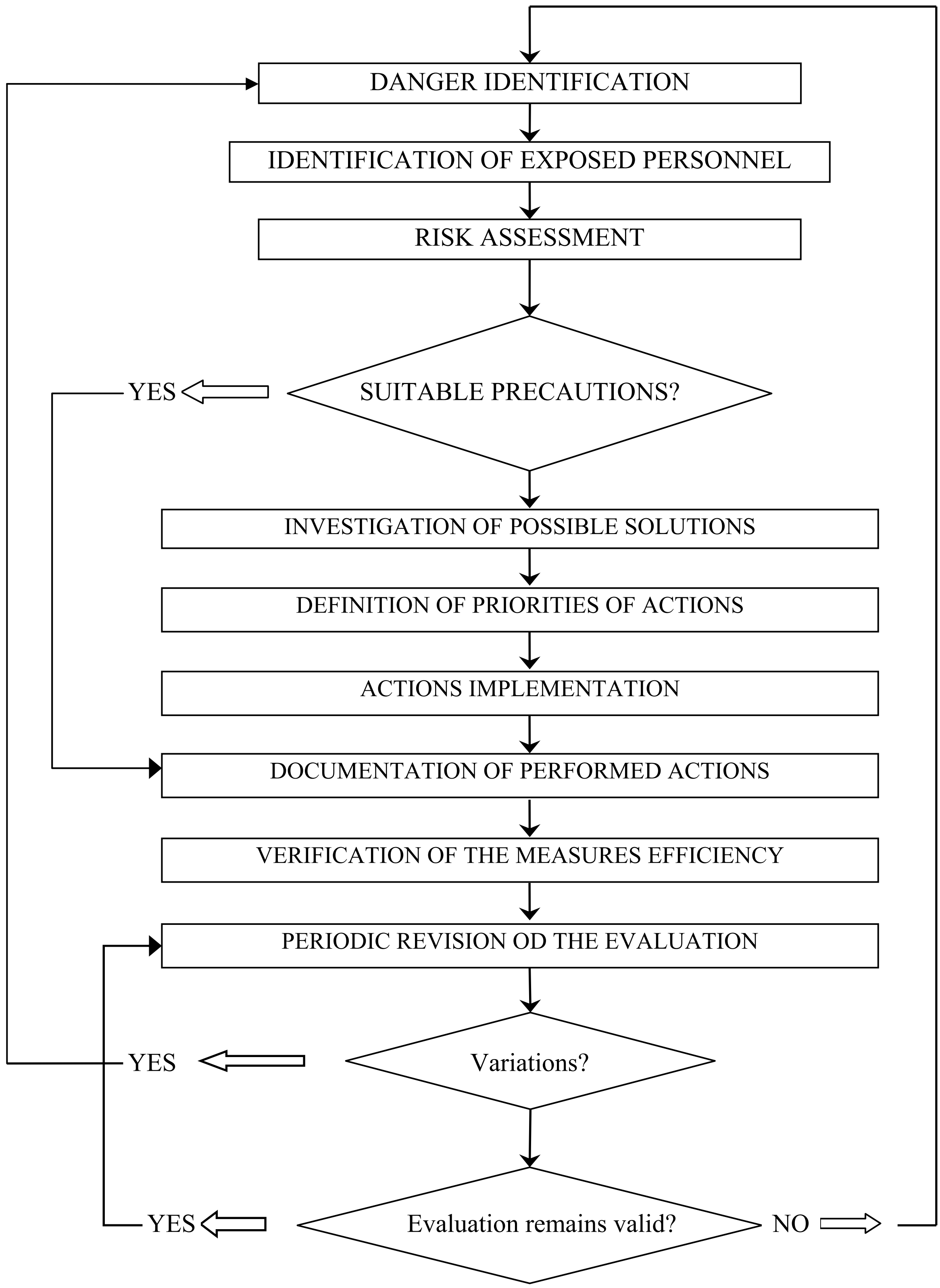


Figure 103. Risk Assessment methodology

The evaluation process leads, for every work place under consideration, to the following results:

- **Absence of risk exposure**;
- **Presence of a controlled risk exposure**, that is an exposure to danger with values that do not exceed the statutory limits or at least, in absence of exact references, do not exceed limits allowed by the norms of good technique, codes of good practice, etc;
- **Presence of an undue risk exposure** that is an exposure to danger with values that are possible to be reduced at a lower level or at least within the limit of a preceding point or even removed.

In the first case, problems related to the completion of a working activity are not considered. In the second case, the situation has to be checked at intervals. In the third case, necessary preventive and protective actions should be applied in accordance to their priority grade. It appears that the Risk Assessment process should be necessarily accomplished through operational phases, such as the following:

a) Classification and definition of potential danger

The Classification and definition of potential danger is accomplished through a thorough search of the kinds of danger associated with the different working activities. The general scheme of classification-definition of potential danger is reported in Tables 9-12.

Table 9. Industrial accidents dangerous for workers safety

Ref	CATEGORY
B1	Structural characteristics of the working environment
B2	Machinery and work equipment specifications
B3	Presence, use and characteristics of plants and equipment
B4	Presence and use of handling systems, lifting and transportation of persons.
B5	Object and material handling and storage
B6	Handling and storage of dangerous substances
B7	Handling and storage of substances with fire and/or explosion danger

Table 10. Hygienic-Environmental danger for workers health

Ref	CATEGORY
C1	Structural characteristics of the working environment and/or services.
C2	Chemical agents
C3	Physical agents
C4	Biological agents

Table 11. Indirect danger due to Organisational-Managerial aspects

Ref	CATEGORY
D1	Organisation of work
D2	Psychological factors
D3	Tasks, works, responsibility
D4	Difficult working conditions
D5	Information, training
D6	Maintenance and tests
D7	Individual protective devices
D8	Ergonomic factors

Table 12. Danger foreseen by legislation

Ref	CATEGORY
E1	Exposure to lead and his ionic compounds
E2	Exposure to asbestos
E3	Exposure to noise
E4	Use of equipment
E5	Manual handling of loads
E6	Use of equipment with video terminal
E7	Exposure to carcinogenic agents
E8	Exposure to biological agents
E9	Exposure to chemical agents

b) Survey of processing unit data

In this phase the following actions are foreseen:

- Identification of every processing unit, at least by means of a general layout, as a structure of good products and/or services, with their own technical and functional autonomy;
- Subdivision of each production unit in areas in which homogeneous activity is developed;
- Subdivision of each working area in departments;
- Description of the work cycle for each area or department, including:
  - The processing operations; transportation means, plants and used equipment; substances employed and/or produced or derived from the intermediary manufacture processes; cleaning operation and/or maintenance; treatment/disposal of wastes; possible concomitant operations.
  - The operational purpose and structural characteristics of the working environment.
  - **Number of employed** workers and/or personnel present in the working environment and relative tasks.
  - **Characteristics** of lifting equipment and/or manual handling of loads.
  - **Characteristics of storage areas** and/or of areas **with specific purposes.**
  - **Hygienic-environmental characteristics**, air quality, existing chemical, physical, biological and carcinogenic agents, whereas applicable.

c) Identification of the specific danger related to each production unit, present in the working areas that can objectively cause a potential risk of accident either of hygienic or environmental type. The latter is carried out by the compilation of various check lists, specified for each category and danger type.

d) Identification of each existing risk situation in a production unit
The identification of each risk situation in a production unit is performed by means of:

- Comparison between the level of exposure to a given risk and the corresponding limit set by the current safety and hygienic Norms related to work places or at least by codes of good practice, technical norms, etc.;
- Comparison between the statistically derived data related to safety and health in work places and notices taken from the accident's registry, documents, certifications, or other different information sources;
- Evaluation of the degree of acceptance for specific processing/working conditions and of factors that influence exposure to possible danger situations, taking into account the existing experience in the sector, through the comparison with analogous conditions in similar working sectors.

e) Classification of selected risks and identification of appropriate interventions.
In order to reduce or even eliminate each selected risk, it is necessary to effect and/or program interventions according to the **risk's class**. These interventions are classified according to priority based on the following parameters:

- **Risk's extension,** understood as the number of subjects potentially involved;
- **Severity of possible damages** imposed to workers, established on the basis of data derived from accident statistics, the sector experience, etc.;
- **Probability of the event,** connected with the frequency of the operations that cause risk exposures.

In each class of risk, the priority of the intervention is assigned considering not only the parameters arising from the analysis of the previously listed points but also from the degree of feasibility of the established intervention type.

Table 13 reports the severity of a risk and the related interventions priority level. Three risk categories are presented, associated with the relative intervention that needs to be undertaken in order to eliminate, reduce or control the exposure to risk.

General Outlines for Risk Assessment:
Risk Assessment in work places is performed by the use of several, especially prepared, check lists with the following contents:

- General data on work places;
- Quarrying areas;
- Service places;
- Fluid, solid and inflammable materials storage;
- Water conditioning plants;
- Hand Tools;
- Production plants;
- Machine card - Mechanical shovels;
- Machine card - Cutting diamond wire machine;

- Machine card - Cutting chain machine;
- Machine card - Pneumatic perforator;
- Machine card - Derricks;
- Machine card - Pneumatic compressor;
- Machine card - Air ventilation systems;
- Analysis of single production cycles.

Table 13. Relative scale of risk's severity and priority of interventions

Risk Category	Definition of risk	Type of undertaken action	Time
1	SLIGHT	**IMPROVEMENT** in order to eliminate or reduce the discomfort conditions originating from improper use of machinery, installed equipment, improper tasks sequence, monotony, repetitiveness, etc. Identification mark: **S**	LONG TERM
2	MEDIUM	**CONTROL** in order to eliminate or reduce: - accidents with slight effects; - exposure. Identification mark: **M**	MIDDLE TERM
3	HIGH	**INTERVENTION** in order to eliminate: - accidents with permanent disability effects; - exposure to irreversible effects. Identification mark: **H**	URGENT

Using a special program and answering YES or NO one can obtain a result file that contains the following answers:

- Classification of risk degree (S = Slight, M= Medium, H= High);
- Short description of the action to be undertaken;
- Allowed Time for performing interventions (L = Long term, M= Medium term, U = Urgent).

When completing an H.S.D it is advisable to also prepare the following documents and procedures to be applied during processing:

DOCUMENTS

- Document for workers' safety and health;

- Information on the workers;
- Emergency plan, first aid, evacuation;
- Personnel protections;
- Manual load handling;
- General behaviour rules for workmen in the work places;
- Program for the systematic inspection, maintenance and test of instrumentation and of mechanical, electrical and electromechanical plants;
- Program of systematic inspection and maintenance of cutting machines;
- Program of systematic inspection, use and maintenance of handling and transportation equipment and machines;
- Program of systematic inspection, use and maintenance of perforating machines;
- Program of systematic inspection, use and maintenance of compressed air containers.

PROCEDURES - SERVICE ORDER IN A QUARRY

- Organisation of first aid;
- General safety rules;
- Use of ladder and installation of parapets and barriers;
- Cleaning of work fronts;
- Norms for the use of personal protection devices;
- Instructions for the safe use of diamond wire;
- Cutting and squaring of banks with the use of diamond wire;
- Operating conditions and devices to perform banks turnover safely;
- Materials and equipment handling with the use of mechanical machines (shovels, excavators);
- Behavior norms for mechanical machines drivers (shovels, excavators);
- Norms of use for lifting apparatus;
- Cutting and squaring of blocks;
- Guidelines for explosives use.

Example of check lists for Risk Assessment

CHECK LIST **Working Place : Quarrying Area**

Marked as

Processed materials:

MARBLE	
STONE	
INERT	

CHARACTERISTICS OF THE QUARRY					
surface		underground		deep underground	

Object: FRONT AND VAULT STABILITY	Sheet 1 of 2	
100	**YES**	**NO**
Is there, in the context of an exploitation plan, an assessment of the overall quarry stability?		
101		
Is such an assessment periodically updated?		
102		
The supervisor, under extraordinary circumstances in cooperation with the work director, evaluates and inspects the fronts and rocky walls at the beginning of every shift, after each explosion and after heavy rain or thaw, affected by the work?		
103		
Is a periodical cleaning of rocky walls and/or vaults performed?		
104		
If yes, is such cleaning reported in the register of rocky wall cleanings?		
105		
The cleaning is periodically performed also by companies that are specialised in such kind of work?		
106		
The workers performing cleaning that access fronts or rocky walls with an inclination greater than 40º are equipped with safety ropes and helmets?		
107		
Is there any existing or possible-to-be area where rocks or debris may fall, affecting work or passage areas?		
108		
If there is, are any suitable protections been applied?		

	If yes, please state the kind of protection:
	barriers with wood planks
	metallic barriers
	barriers with metallic net
	barriers with metallic net and contention devices

CHECK LIST **Working Place: Quarrying Area**
Marked as

Object: FRONT AND VAULT STABILITY	Sheet 2 of 2

	YES	NO
109 Was a suitability test performed on such barriers by qualified technicians?		
110 Are barriers, if present, the object of special specifications (type, size, etc.) set by the supervision bodies?		
111 Are the upper edges of the quarry, if they are accessible and a potential danger for people safety exists, suitably protected by a fence located at least 1 m from the edge itself?		
112 If such edges are scarcely accessible or if they are located in a scarcely frequented area, are any suitable warning signs installed?		
113 The upper edge of the excavation area is being kept clear of vegetation and/or clay and debris for a width of at least 1,5 m from the edge itself?		
114 If the quarry is underground, are there any vaults or parts of vaults where the presence of fractures is evident?		
115 In this case, have any reinforcement and protection systems been installed (sprigs, bolts, nets, etc.)?		
116 If the quarry is underground, does the personnel have access to it only if equipped with an helmet?		
117 In the operations that require the use of explosives, after every explosion and before starting any other work are any operations for the removal of unstable rocks and cleaning of fronts and vaults (if underground) performed ?		
118 During excavations with machines located at the foot of the front, is the front height not higher than the maximum height that can be reached by the machines used?		
119 Is there another quarry near the considered one, belonging to the same or a different company that may leave an open encavation?		
120 In this case, can the excavation be considered as stable on its own stability or after possible disposal of materials in it?		

DATA - BASE	Working Place: QUARRYING AREA
Object	FRONT AND VAULT STABILITY

Codex	Risk assessment class		Performing Time	
100	H	High	U	Urgent
	Action : Prepare an assessment of the overall quarry stability			
101	M	Medium	M	Medium term
	Action: Update the assessment of the quarry stability			
102	M	Medium	M	Medium term
	Action: Inform the Supervisor about his obligation to inspect fronts and vaults			
103	H	High	U	Urgent
	Action: Perform periodical cleaning of rocky walls and vaults			
104	S	Slight	L	Long term
	Action: Order that such cleanings are regularly reported in the special register			
105	M	Medium	M	Medium term
	Action: Make sure that the subcontracted Companies are suitable and authorised to carry out such work, and that their personnel is properly instructed and informed about the specific risks			
106	H	High	U	Urgent
	Action: Prepare information and instructions about accessing fronts with an inclination greater than 40°			
108	H	High	U	Urgent
	Action : Assess and prepare suitable protections against falling rocks			
109	H	High	U	Urgent
	Action : Assess the suitability of the present protection barriers			
110	H	High	U	Urgent
	Action : Adapt the barriers to the special instructions and requirements			
111	H	High	U	Urgent
	Action : Install a fence around the quarry's edge			
112	M	Medium	M	Medium term
	Action : Install warning signs about the presence of the quarry's edges			
113	H	High	U	Urgent
	Action : Clean the upper excavation edge up to a minimum depth of 1.5m			
115	H	High	U	Urgent
	Action: Assess the danger and install the necessary devices to protect the vaults			
116	H	High	U	Urgent
	Action : Instruct the personnel in the compulsory use of helmets underground and in dangerous places			
117	H	High	U	Urgent
	Action : Instruct the personnel in clearing the areas where explosives are used			
118	M	Medium	M	Medium term
	Action : Limit the excavation heights to those allowed by the used machine			
120	H	High	U	Urgent
	Action : Assess the stability and toughness of the diaphragm			

An example of a summary sheet related to actions to be undertaken as a consequence of the Risk Assessment results is presented below.

Work place: QUARRYING AREA

Objective: FRONT AND VAULT STABILITY

RISK ASSESSMENT CLASSIFICATION

Risk degree = H	Time int.= U	Risk degree = M	Time int.= M	Risk degree = S	Time int.= L
/ / 116	103 /	/ / /	/ 112 /	/ / /	/ / /

ACTIONS TO BE UNDERTAKEN

103
Arrange periodical reclaiming of fronts and vaults.

112
Install warning signs about the presence of quarry's edges.

116
Instruct the personnel to use a helmet in underground working areas and in work places where there is a risk of falling rocks.

2.6.3. Identification of critical and/or more dangerous production phases

Some critical or dangerous production phases are listed below:

- Cutting of very big stone parts (bank) from the deposit;
- Bank's turnover;
- Handling and movement of materials and equipment;
- Power shovel, excavator, truck driving;
- Working operations in gallery;
- Construction of the quarry's rock paths.

2.6.4. Development of some critical and/or more dangerous production phases

Bank's turnover is one of the most dangerous working phases, because of its complexity and of the serious consequences in case of an accident. In this phase, a great number of risks can be identified; however, such risks are also present in other processing phases that are typical in quarrying activities, though in these latter cases the risks are generally less serious in relation to volumes, moved masses, equipment and employed machinery.

When performing dangerous activities like bank's turnover or bank cutting in blocks with a diamond wire, workers have to conform to the written instructions given by the person in charge of safety, the quarry director or the supervisor, before the beginning of the work.

When the bank is completely cut from the mountain and remains in its position, laying on its base, the quarry chief (or director in charge or the supervisor), after performing a cleaning and/or washing of the areas affected by the cut, carries out a preventive examination of the bank in order to identify its position and characteristics, and the pattern of grain and imperfections. The quarry chief evaluates also which area will be affected by the turning over of the bank, making sure that:

- No other work is being carried out nearby;
- The area is clear of personnel

After the examination, the quarry chief chooses a number of qualified workers for performing the turnover. The quarry chief, after conferring with the workers and deciding who will perform this task, assesses the risks involved in the turnover and selects the way, the equipment, the devices and the machines that will be used, as well as the points where the turnover equipment (metallic ropes, jacks, bearings, etc.) will be positioned. As soon as the bank has been completely sectioned, the construction of a debris bed can start. The debris bed must have width and thickness proportional to the bank that will be turned over, and must be completed before starting the turnover operation. The bed must be made up of small size materials, regular and, if possible, dry. During the preparatory work, the quarry chief makes sure that the appropriate fitting chips and the mechanic shovel are available and provides an adequate space for maneuvering.

Before starting the turnover maneuver, holes must be drilled at the points where the new parapets on the residual front will be secured. Workers must also wear their personal protection devices, helmets and suitable safety belts, provided by the supervisor, who, together with the workers, selects the appropriate fastening points for their safety. Fastening ropes must be secured in a way that does not hinder the movements of the workers during the maneuver. Before starting the maneuver, the quarry chief must check that the workers conform to the above-mentioned provisions. The holes, to which the safety belts are secured, are drilled by means of a pneumatic hammer. The quarry chief and/or the workers assigned to the operation, before starting with the first shove, must order the removal of personnel and machines from the area that might be at risk, must warn all personnel present in the surrounding areas, and must pay special attention to the assessment of risks and steps to be undertaken in case the turn over might affect other processes underneath.

Workers working at increased height, facing the danger of falling down, must be secured with a safety belt to previously identified firm points. The fitting of the bank with small chips, performed in order to keep the cut open, is made by the same workers who are assigned to the turnover maneuver and secured with safety belts during the whole process. For big chips, a mechanical shovel is used, as well as crowbar equipment, if necessary.

When the first shove is over, the workers perform a first test and check the imperfections identified during the preliminary examination of the bank. Afterwards, during the sequence of maneuvers, they perform new inspections in order to identify other imperfections or new dangerous situations that could reveal as a consequence of the maneuvers. If necessary, the workers call the quarry chief and, along with him, they perform a new check of the bank, changing if necessary, the initial work plan. When the turnover has been completed, the quarry chief, before allowing the personnel to access the area surrounding the bank, orders the removal of all materials present on the residual front and on the overturned bank that might fall.

The various phases of the bank turnover operation, together with a description of the involved risks and prevention and protection measures, are summarised in the following tables.

Phases of the bank turn over operation – Dangerous situations – Preventive measures

Bank turnover with a mechanical shovel and a metallic rope – PHASE 1

Operation 1	**Cleaning/washing of the area around the cut**
Description	Before starting the bank turn over, the area around the cut is washed in order to identify imperfections that might be present on the bank.
Machines and equipment	Pipes and hoses with high pressure water. Pneumatic hammer.

Possible Risks: identification and assessment

	Dangerous Situation
1	Falls from a higher level, when the area to be washed is higher than the surrounding area.
2	Slipping, falling at the same level, when there is a slippery and muddy soil.
3	Falls of materials from above, due to detachment of small-medium size rocks from the rocky slope.
4	Bumps, blows, crashes, compressions occurring during the movement of materials, equipment and machines used in the working area.
5	Cuts, abrasions occurring during the movement of materials, equipment and machines present in the working area.
6	Flying of objects and/or materials during the cleanings. Water droplets and small particles of mud can reach the eyes.

Prevention and protection measures and actions	Install suitable parapets along the edges of the working areas, where risk of falling exists. Inspect the fronts, where there is a risk of falling rocks, and arrange for a cleaning.
Personal Protective Equipment (P.P.E.):	Helmet, safety shoes, gloves, safety belts, noise protecting plugs or guards, eyeglasses.

Bank turnover with a mechanical shovel and a metallic rope – PHASE 2

Operation 2	**Bed Preparation**
Description	In order to avoid possible damages of the bank when hits the ground during the turning over, a bed made up of debris from the quarry is built, that softens the impact of the bank with the ground.
Machines and equipment	Mechanical shovel

Possible Risks: identification and assessment

	Dangerous Situation
1	Fall of the operator from the mechanical shovel while climbing/descending
2	Slipping, falling at the same level when there is a slippery and muddy soil.
3	Falls of materials from above, due to detachment of small-medium size rocks from the rocky slope.
4	Bumps, blows, crashes, compressions, during the movement of materials, equipment and machines used in the working area
5	Danger of collision with moving machines (mechanical shovel) and materials
6	Flying of objects and/or materials
7	Exposure to noise
8	Exposure to the exhaust gasses of the mechanical shovel, especially in the tunnels
9	Exposure to dust, especially in the tunnels

Prevention and protection measures and actions	The debris bed must have width and thickness proportional to the bank that is going to be overturned; it must be completed before starting the maneuver and must be made up of small size materials, regular and, if possible, dry. During the preparation of the working area, the quarry chief must: ▪ Make sure that the mechanical shovel has an adequate space for maneuvering. ▪ Check the fronts and remove rocks that might fall. In order to reduce the risks related to falling rocks on the operator of the mechanical shovel, the cab of the machine must be of ROPS kind or equivalent. ▪ Install muffler on the mechanical shovel. ▪ Arrange for a periodical maintenance of the shovel in order to reduce noise and exhaust gasses.
Personal Protective Equipment (P.P.E.):	Helmet, safety shoes, gloves, safety belts, noise protecting plugs or guards, eyeglasses, masks against gas and dust.

Bank turnover with a mechanical shovel and a metallic rope – PHASE 3

Operation 3	**Inspection of the bank and assessment of risks during turnover**
Description	Before starting to turn the bank over, the bank is inspected in order to identify any imperfections that might be present. According to the characteristics of the bank, an assessment of the related risks and dangers is made.
Machines and equipment	

Possible Risks: identification and assessment

	Dangerous Situation
1	Falls from an elevated area.
2	Slipping, falling at the same level when there is a slippery and muddy soil.
3	Falls of materials from above, due to detachment of small-medium size rocks from the rocky slope.
4	Bumps, blows, crashes, compressions, due to movement of materials, equipment and machines used in the working area.

Prevention and protection measures and actions	An examination of the bank must be carried out, in order to identify its position and characteristics, and the pattern of grain and imperfections. The bank chief must also evaluate which area will be affected by the bank turnover, making sure that no other work is being carried out nearby and that the area is clear of personnel; he must also choose a number of qualified workers for performing of the task. The quarry chief, after conferring with the workers that will perform the operation, assesses the risks involved in the turnover and selects the way, the equipment, the devices and the machines that will be used, as well as the points where the turnover equipment (metallic ropes, jacks, bearings, etc.) will be positioned. If the working area is higher than the surrounding area, suitable parapets must be installed. Check and clean the fronts in order to remove the danger of falling rocks.
Personal Protective Equipment (P.P.E.):	Helmet, safety shoes, gloves, safety belts, noise protecting plugs or guards.

Bank turnover with a mechanical shovel and a metallic rope – PHASE 4

Operation 4	**Fastening of devices to prevent falls**
Description	Before starting the turnover maneuver, workers must also wear their Personal Protection Devices, helmets and suitable safety belts, provided by the supervisor, who, together with the workers, selects the appropriate fastening points according to the safety system used.
Machines and equipment	Pneumatic hammer, slinging, ropes.

Possible Risks: identification and assessment

	Dangerous Situation
1	Falls from above since the working area is elevated.
2	Slipping, falling at the same level when there is a slippery and muddy soil.
3	Falls of materials from above, due to detachment of small-medium size rocks from the rocky slope.
4	Bumps, blows, crashes, compressions, due to the movement of materials, equipment and machines used in the working area.
5	Flying of objects and/or materials during the work.
6	Exposure to noise.
7	Exposure to dust.
8	Vibrations as a consequence of the use of pneumatic hammer.

Prevention and protection measures and actions	Install suitable parapets at the edges of the working area, where there is a risk of falling down. Check and clean the fronts where there is a risk of falling rocks. Safety belts must be secured in a way that do not hinder the movements of the workers during the maneuver.
Personal Protective Equipment (P.P.E.):	Helmet, safety shoes, gloves, safety belts, noise protecting plugs or guards, eyeglasses, masks against dust.

Bank turnover with a mechanical shovel and a metallic rope – PHASE 5

Operation 5	**Preparation of holes and fastening of "piro"**
Description	Workers drill a hole in which they will insert a "piro" (an ace or wooden item, to which a rope will be fastened), at the top of the bank.
Machines and equipment	Pneumatic hammer.

Possible Risks: identification and assessment

	Dangerous Situation
1	Falls from above since the working area is elevated.
2	Slipping, falling at the same level when there is a slippery and muddy soil.
3	Falls of materials from above, due to detachment of small-medium size rocks from the rocky slope.
4	Bumps, blows, crashes, compressions, due to the movement of materials, equipment and machines used in the working area.
5	Flying of materials during the work.
6	Exposure to noise.
7	Exposure to dust.
8	Vibrations as a consequence of the use of pneumatic hammer.

Prevention and protection measures and actions	Install suitable parapets at the edges of the working area where there is a risk of falling. Check and clean the fronts in order to eliminate risks of falling rocks.
Personal Protective Equipment (P.P.E.):	Helmet, safety shoes, gloves, safety belts, noise protecting plugs or guards, eyeglasses.

Bank turnover with a mechanical shovel and a metallic rope - PHASE 6

Operation: 6	**Positioning of pulling ropes - Pulling with a mechanical shovel**
Description	Turning over of the bank by means of shovel and "piro" (an ace or wooden item, to which a rope will be fastened).
Machines and equipment	Mechanical shovel, ropes, equipment.

Possible Risks: identification and assessment

	Dangerous Situation
1	Falls from elevated places
2	Slipping or falling of the operator from the mechanic shovel while climbing/descending
3	Slipping, falling at the same level when there's a slippery and muddy soil.
4	Falls of materials from above, due to detachment of small-medium size rocks from the rocky slope.
5	Bumps, blows, crashes, compressions, due to materials, equipment and machines movements in the working area.
6	Rope breaking due to flying of parts on it; collision with materials from the debris bed.
7	Danger of collision with moving mechanical shovel.
8	Flying of objects and/or materials during the work.
9	Exposure to noise.
10	Exposure to the exhaust gasses of the mechanical shovel.
11	Exposure to dust.

Prevention and protection measures and actions	Check and clean the fronts in order to eliminate the risk of falling rocks. In order to reduce the risks related to falling rocks on the operator of the mechanical shovel, the cab of the machine must be of ROPS kind or equivalent. Install muffler on the mechanical shovel. Arrange for a periodical maintenance of the shovel in order to reduce noise and exhaust gases. During the maneuver it is not allowed to access the bank to be turned over and the nearby areas.
Personal Protective Equipment (P.P.E.):	Helmet, safety shoes, gloves, safety belts, noise protecting plugs or guards, eyeglasses, masks against gas and dust.

Bank turnover with a mechanical shovel and a metallic rope – PHASE 7

Operation: 7	**Disconnection of equipment - Removal of equipment**
Description	Disconnection of pneumatic junctions, removal of ropes and equipment used during the operation.
Machines and equipment	Metallic rope, mechanical shovel, pneumatic hammer.

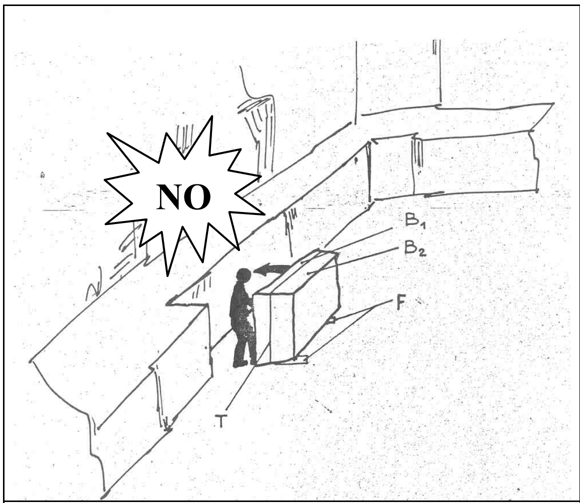
Possible Risks: identification and assessment

	Dangerous Situation
1	Falls from elevated places
2	Fall of the operator from the mechanic shovel while climbing/descending.
3	Slipping, falling at the same level when there is a slippery and muddy soil.
4	Falls of materials from above, due to detachment of small-medium size rocks from the rocky slope.
5	Bumps, blows, crashes, compressions, due to materials, equipment and machines movements in the working area.
6	Danger of collision with moving mechanical shovel.
7	Exposure to noise while the mechanical shovel is moving.
8	Exposure to the exhaust gases of the mechanical shovel.

Prevention and protection measures and actions	Equipment and machines used during the operation must be stored in a safe area, so that they would not obstruct other operations. Workers working at elevated areas, facing the danger of falling down, must be secured with a safety belt to previously identified firm points. Install suitable parapets at the edges of the working area where there is a danger of falling down. Check and clean the fronts in order to minimise the risk of falling rocks. In order to reduce the risks related to falling rocks on the operator of the mechanic shovel, the cab of the machine must be of ROPS kind or equivalent. Install muffler on the mechanical shovel. Arrange for a periodical maintenance of the shovel in order to reduce noise and exhaust gasses.
Personal Protective Equipment (P.P.E.):	Helmet, safety shoes, gloves, safety belts, noise protecting plugs or guards, masks against gas.

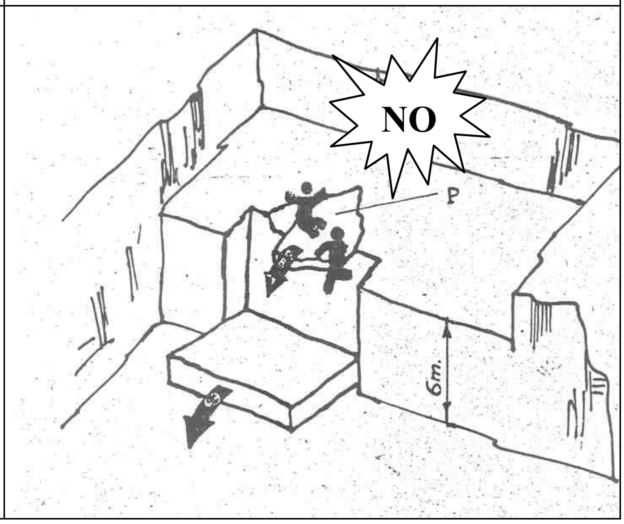
2.6.5. Information of the workers

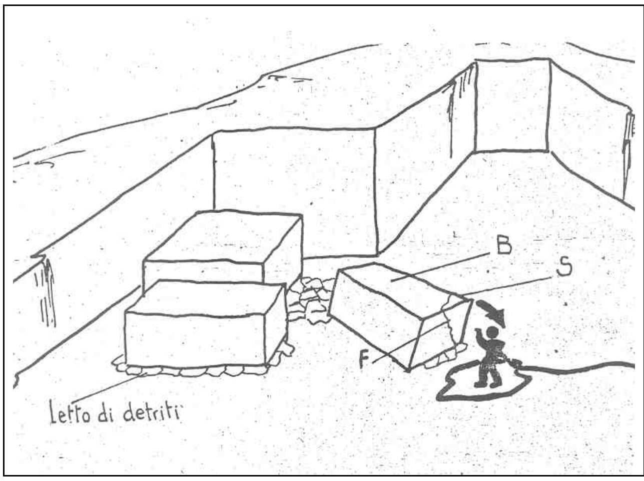
Information and training of workers as well as other aspects involved in safety management play a leading role in the correct development of prevention and protection measures in work places. The goal of achieving a “safety culture ” that will positively influence the awareness and behaviour of workers, is one of the most efficient measures in order to control the residual risks, when technical factors related to environment, equipment, products and so on, have been resolved. For this reason, it is essential that each worker is given enough and adequate information and training with particular reference to his working position and tasks undertaken. This information should be provided in a simple and immediate way, using modern tools as to resort to explanatory pictures instead of long written lists of what has to be and not to be done. Simplicity and immediacy of messages help the workers to assimilate more easily the given information and make them part of their knowledge.



DO NOT WALK INTO DANGEROUS AREAS!!!

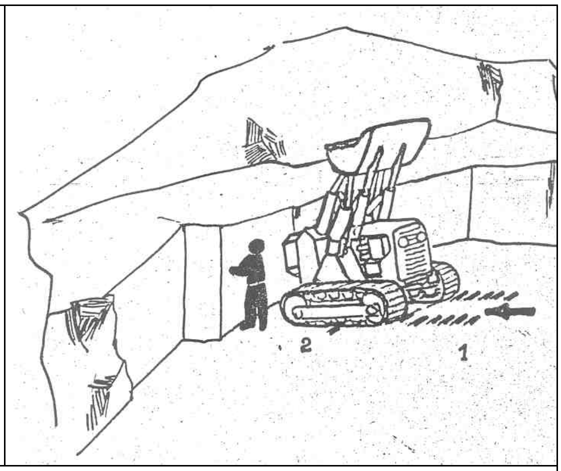
DO NOT GO TOO NEAR TO DANGEROUS PLACES!!!



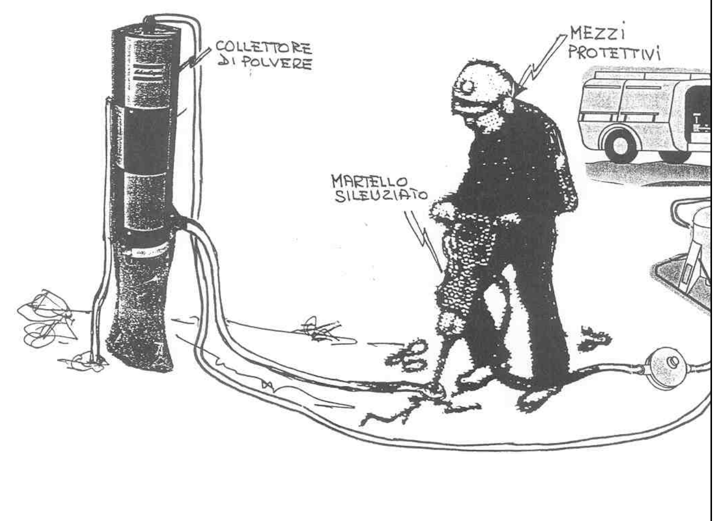


DO NOT APPROACH FRACTURED PARTS OF THE BLOCK. SOME PARTS CAN FALL DOWN!!!!

DO NOT APPROACH THE OPERATING ZONE OF A POWER SHOVEL!!!!

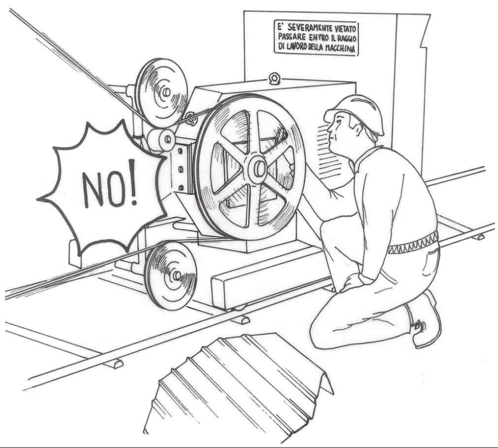


NOT IN THIS WAY!!!



USE PERSONAL PROTECTIVE DEVICES AND CORRECT EQUIPMENT!!!!

DO NOT DIRECT LIFTED LOAD WITH THE HANDS!
KEEP CLEAR!!!

DO NOT USE THE BUCKET AS A WORKING PLANE!!!	
	**DO NOT REMOVE DETRITUS FROM THE BASE OF A STONES' PILE!!!!**
DO NOT USE MACHINES WITHOUT ANY SAFETY EQUIPMENT!!!!	

3

Risk Assessment and Safety in processing plants

JOAQUIN OBIS

3.1. Introduction

The technology for Ornamental and Dimensional Stones production has been steadily undergoing significant changes over a number of years and this has helped to maintain a healthy Sector growth rate. In order to identify areas for further improvement, it is necessary to examine the current situation of the processing technologies for the different sub-sectors (namely marble, granite and slate) in the E.U.

3.2. Main and auxiliary operations in the processing plants

The Ornamental Stones manufacturing process consists of two different phases, known as *Extraction* and *Processing*. Extraction aims at obtaining the raw material, while Processing includes manufacturing of the final products. Processing is performed with several operations, starting with stone blocks storage and concluding with the final product manufacturing. Main operations of the Processing phase are sawing, cutting and polishing. These operations are illustrated in detail for every sub-sector in Figures 104-106.

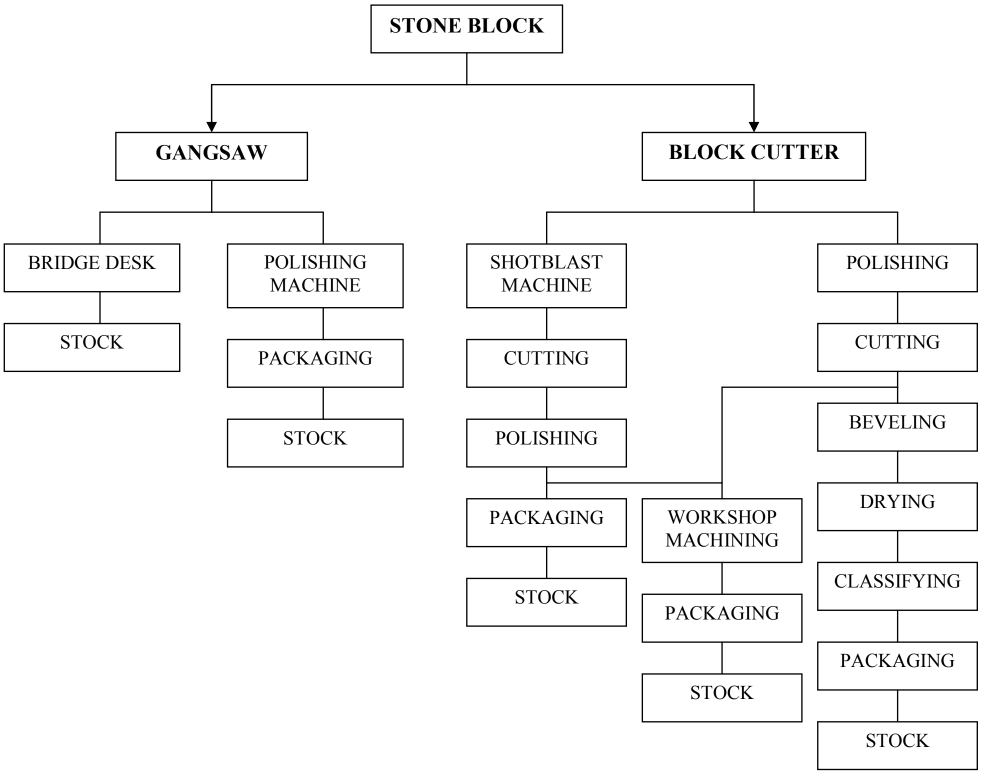


Figure 104. Marble processing flowchart

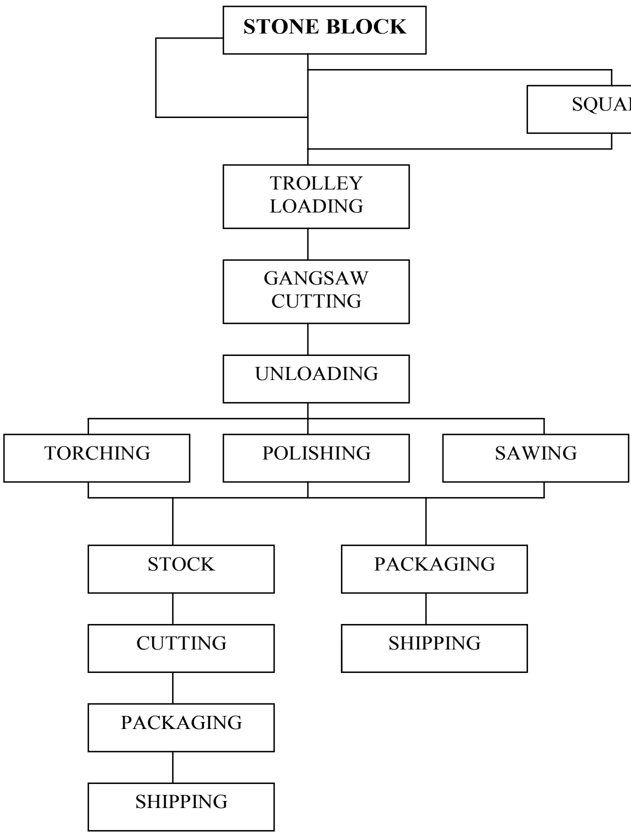


Figure 105. Granite processing flowchart

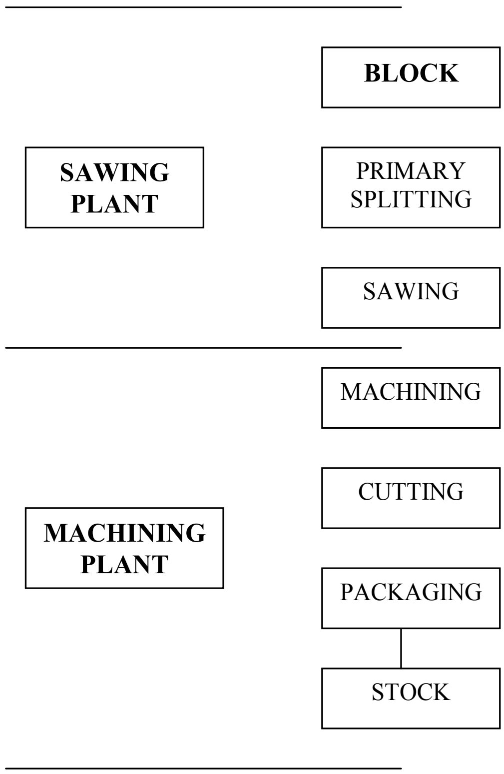


Figure 106. Slate processing flowchart

3.3. Risk Analysis description

The first stage of Risk Analysis should be a detailed information data collection about the company's organisation, existing documentation on safety, installations and equipment, working positions, etc. The chosen method for risk identification and analysis in the Ornamental Stones processing sector is based on well known risk analysis methods, as well as in European and International standards (EN, ISO). Risk Analysis consists of the following stages:

1. Preparation and information collection;
2. Risk identification;
3. Risk analysis;
4. Definition of priorities regarding action and control measures;
5. Preventive measures planning;
6. Periodical review;
7. Information of workers;
8. Process documentation.

3.3.1. Associated Risks

The first item to the Risk Analysis preparation is to know both workers and employer's responsibilities as those are defined in the 89/391 E.U Directive. On the other hand, there must be some sound criteria to identify, assess and define every working position that will be considered, its special features and the related workers. Regarding the information collection, the company under study should maintain a detailed list of Legislation, National and International standards, internal standards of good practice, available equipment, working position layout and characteristics, workers training, etc.

There are three phases on the *Risk Identification stage*:

- **Check list drafting**

This phase is not mandatory but aims to ease the risk factors identification. It is recommended to draft and use several check lists. This document consists of several questions in order to identify those risky situations related to a specific working activity. The outcome of those questions is linked to one or more risks with a known code. The check lists must be "open" documents, so they can be modified or enlarged, taking into account the specific features and characteristics of every company as well as the analyst's criteria.

- **Inspection visit and Check list implementation**

Once the check lists are prepared, the analyst will review the company's installations and equipment, the working positions, etc, and will proceed in filling those lists. As a minimum requirement, a general check list and at least one specific list should be prepared for every working position under assessment. Besides that, if a worker carries out several activities at different working positions, then he has to fill an individual list for each one of these activities.

- **Risk identification**

This is a critical phase because risk identification success relies on several factors, such as the analyst's training and experience, his knowledge about the specific activities under assessment, his objectivity, etc. The analyst will identify every risk related to the installations, equipment and working positions, using the information collected during his inspection visit and other available analysis data of the sector. All those identified risks should be displayed in a kind of risk identification card for every working position.

3.3.2. Risk Analysis

Once the risks are identified, the following stage is to analyse them by the use of a well-known risk analysis method (FINE method) described by the following equation:

$$IR = C \times P \times E$$

Where:

IR: Risk Index
C: Consequences due to a risk occurrence
P: Probability of a risk situation occurrence
E: Risk exposure or risk situation occurrence frequency

The analyst will set a value for the above factors as follows:

FACTOR	CONCEPT	VALUE
CONSEQUENCE (C)	• **CATASTROPHE**: numerous deaths or big damage	100
	• **DISASTER**: several deaths	40
	• **VERY SERIOUS**: one death	15
	• **SERIOUS**: serious injuries (amputation, chronic diseases)	7
	• **IMPORTANT**: injuries like bruises, cuts, strains, etc.	3
	• **LIGHT**: minor damages	1

FACTOR	CONCEPT	VALUE
RISK EXPOSURE (E)	• **CONTINUOUS**: during all working time	10
	• **USUAL**: at least once every day	6
	• **OCCASIONAL**: weekly	3
	• **SCARCE**: monthly	2
	• **UNCOMMON**: yearly	0,5
	• **VERY UNCOMMON**: very unlikely to happen	0,1

FACTOR	CONCEPT	VALUE
PROBABILITY (P)	• **INEVITABLE**: the risk situation is going to happen	10
	• **VERY PROBABLE**: a 50% probability	6
	• **POSSIBLE**: it can happen, but it is not probable	3
	• **IMPROBABLE**: it happened once	1
	• **IMPOSSIBLE**: one against a million probabilities	0,2
	• **VERY IMPOSSIBLE**: zero or nearly zero probability	0,1

The outcome of the above equation corresponds to the Risk Index value, which enables the classification of the risk situation and suggests subsequent actions as follows:

RISK INDEX	CLASSIFICATION	ACTION REQUIRED
More than 400	VERY HIGH RISK	Stop the process
251-400	HIGH RISK	Immediate action required
91-250	MEDIUM RISK	Adjustment is needed
41-90	TOLERABLE RISK	Attention is required
Less than 40	ACCEPTABLE RISK	No action

This Risk Index could be modified based on the analyst's criteria as well as on information about the company (like, workers training and experience), safety and control measures implemented, etc.

Definition of priorities of action and control measures

Once the risks are analysed, the next stage is to proceed to the following actions:

- Check the already existing measures to verify their suitability;
- Adopt preventive measures to lessen or remove the risk;
- Adopt preventive measures for the periodical control of working conditions and workers health.

According to the calculated Risk Index value, the next step is to define the priorities of action, the control and preventive measures and the needed means to implement them.

Preventive measures planning

Once the decisions are made, a draft plan of the preventive and control measures has to be implemented taking into account:

- Involved risks and workers;
- Measures to lessen or remove the risks;
- Priorities of action;
- Legislation to abide by;
- Workers training, information and willingness.

Periodical review

The outcome of Risk Analysis must be reviewed when:

- Legislation requires it;
- There is an accident or an incident;
- After a review, the unsuitability of an implemented measure is verified;
- New working conditions, technologies, equipment, etc. are introduced;
- The workers decide it.

In any case, there should be a Risk Analysis review after a pre-established period.

Information to Workers

89/391 E.U Framework Directive requires that the employer should inform workers about the possible Health and Safety risks at work, whether they might be affected or not. The employer should also inform workers about the implemented preventive measures for those risks.

3.3.3. Types of Risks

Mechanical Risks

Mechanical risks are related to machinery, tools and working equipment movement that, due to their mechanical energy, could result in accidents. Concerning the Ornamental Stones sector, the main factors related to mechanical risks are:

a) Equipment

- Stability loss;
- Machinery or equipment break down;

- Falling and flying of objects;
- Surfaces and sharp edges;
- Traversing rates;
- Movable elements.

b) Tools
- Falling of objects;
- Surfaces and sharp edges.

c) Materials
- Falling and flying of objects;
- Surfaces and sharp edges.

d) Traffic lanes, approaches and ramps
- Bad maintained flooring;
- High grade slope;
- Obstacles in lane;
- Slippery floor;
- Unfit lane width;
- Bad signalling.

Accidents due to mechanical risks have very serious or even deathly outcomes to human beings. Since huge and heavy load materials (blocks) are used in the Ornamental Stones processing plants, even a minor accident could have serious consequences.

Noise

Noise, represented by annoying and frequently irritant sounds, could be a source of serious risks. Beyond a specific level, noise can be uncomfortable and act as an obstacle to communications, as well as a stress increasing and neural system creeping factor that eventually can lead to deafness. Noise consists of several disordered waves with different frequencies and amplitudes generating a disturbing feeling that could be painful. During Ornamental Stones processing there are several extremely noisy machines like:

- Gangsaws;
- Block cutters;
- Cutting machines;
- Edge polishers.

Loss of hearing due to noise exposure is a function of frequency, loudness and exposure time. Mandatory regulations call for noise measuring at every working position, aiming at:

- Setting up the noise levels, which could be harmful to hearing;
- Setting up acceptable working machine noise levels;
- Data collection for diagnostics.

A dosimeter or a sonometer, in a fixed or portable form, is the equipment for conducting noise measurements.

Dust

Dust is a concentration of very small diameter particles suspended in air, affecting both the environment and the workers health. Several operations in the Ornamental Stones processing result in dust generation. Among those operations stone cutting and finishing are the most important ones. There are several parameters to measure the dust concentration and its harmful effects. Most dangerous substance is silica, fact that makes it imperative to know its total concentration and ratio. Total dust concentration is measured in mg/m^3, while the silica ratio is determined as the silica rate in the dust. Marble processing produces mainly inert dust, while granite processing results in the production of very dangerous dust concentrations.

Dust measurements are absolutely necessary in order to determine the Risk Index for the dust generated in working positions. Filtered suction pumps are the equipment used to hold up hazardous for health dust particles (size less than 5 μm). The total dust concentration is calculated as follows:

$$C = \frac{P \times 10^3}{Q \times T}$$

where:

C: Concentration (mg/m^3)

P: Dust weight collected in the filter (mg)

Q: Airflow sucked into the pump (m^3)

T: Sampling time (min)

The main outcome of dust exposure is pneumoconiosis and, in some cases, silicosis. This occupational disease is caused by the accumulation of very small silica particles in the worker lungs due to granite and other siliceous rocks processing. Airborne dust produced during stones processing is considered as one of the most risky factors for the workers health employed in this industrial sector. The biggest health risk is due to the presence of free crystalline silica in the dust. Overexposure to dust containing or composed of free crystalline silica causes silicosis, a fibrotic lung disease which is irreversible, progressive, incurable, at far-gone stages disabling and eventually fatal. Four critical factors influence the health risk due to airborne dust:

- Dust nature (presence of free silica, etc.);
- Particles size;
- Exposure duration;
- Airborne dust concentration in the breathing zone of the exposed person.

In aerosol science, dusts are considered as solid particles ranging in size usually from 1 μm up to 100 μm that maybe airborne, depending on their origin, physical characteristics and environmental conditions. In order to evaluate the risk, a correct dust sampling has to be carried out in the areas where stones are processed. A sampling strategy, accounting for all factors that may lead to any variation in the results, must be designed and applied, so that the obtained data is representative of the workers exposure and ensures a reliable assessment. There are two basic methods for sampling airborne dust:

- Use of direct reading instrumentation, to obtain results in (near) real time;
- Sampling through filtration for weighing and subsequent laboratory analysis.

For an exposure assessment, the best practice is to use personal samplers that would be carried by the workers as they move around. Dust collected with these personal samplers should not exceed the Threshold Limit Value (TLV). TLV is a key element for assessing health risks and deciding whether a certain exposure situation is acceptable or not, and whether existing controls are adequate. The TLV is often incorporated into legal standards. The TLV for dust is usually expressed in terms of time-weighted average concentration (TLV-TWA) over an 8-hours working day. Concerning the dust generated during stone processing, the operations can be divided in two main groups:

- Operations carried out in wet conditions;
- Operations carried out in dry conditions.

The first group is considered less dangerous for the workers health, as the produced dust is reduced by the use of water and the operations are usually performed by NC-machines (Figure 107a). The second group is the most dangerous for health, as the generated dust remains in the air (Figure 107b). In addition, such operations are usually carried out manually by the workers on small pieces of stone. The operations carried out manually by the workers belong to the finishing stage of the stone processing and include mainly the following: sawing, surface and edge polishing, sanding and filling.

As mentioned above, during stone processing, the most common way for dust control at its source is the use of wet methods, such as wetting down dusty products and wet cleaning of floors and work surfaces. Considering that the rate of dust generation increases with the energy associated with the process in question, a stone sawing tool will produce more dust when it operates at higher speed. A possibility to reduce dust at source could be the use of tools operating at low-speed, taking into account that it will take more time to obtain the same result. An important way of dust control is the work practice; in fact the manner in which a worker performs a task can significantly affect exposure. For that reason, it is important to train workers in good work practices.

If dust emissions cannot be eliminated or reduced to the desired level by control at their source, ways to prevent dust transmission throughout the working position should be considered. The principle idea is to separate workers from the dust, either by containment or by using general or local exhaust ventilation to remove the dusty air before it reaches the workers. In the Ornamental Stones industry, it is not always possible to isolate the source of dust from the worker, as the worker is directly involved in the operation (manual sawing, polishing, etc.). In this case, the control of dust transmission is reached by working on aspirating desks (Figure 108) or inside an aspirating cabin (Figure 109) or by using a hood directly mounted on the tool (Figure 110).

Figure 107. a) Stone sawing using wet method. **b)** Dry manual sawing of a stone slab.
(ENVICUT GRD1-1999-10351 GROWTH Project report)

Figure 108. Dust control by an aspirating desk.
(ENVICUT GRD1-1999-10351 GROWTH Project report)

Figure 109. Dust control by an aspirating cabin.
(ENVICUT GRD1-1999-10351 GROWTH Project report)

Figure 110. Dust control by a caption hood mounted on a manual tool.
(ENVICUT GRD1-1999-10351 GROWTH Project report)

All control possibilities should be explored before resorting to the use of Personal Protection Equipment (P.P.E) (Figure 111), as this is the least acceptable means for routine control of exposure, particularly to airborne contaminants. The reasons for this include the following:

- PPE, especially Respiratory Protection Equipment (RPE), can be very uncomfortable, especially in hot conditions, and workers may be tempted to remove it;
- PPE only protects the worker wearing it, while dust can present a risk to other people in the same working position;
- Many studies have shown that PPE of all types usually provides less protection in the working position compared to that determined through laboratory tests;
- PPE will not prevent environmental contamination.

Figure 111. Example of worker wearing PPE (respiratory protective equipment and ear caps) during manual stone working

Vibrations

Vibration is a swinging movement of liquid, solid or gas particles around a balance point. There are several activities in stone processing with inherent vibrations:

- Conventional machine operation (cutting machine);
- Alternate forces not balanced, due to land irregularities;
- Faulty or bad maintained machinery;
- Natural phenomena (winds).

There are several methods for measuring vibration effects on human bodies, like Root Mean Square (RMS), the Equivalent Acceleration or the Peak value method. Measurement could be made with an accelerometer. A triaxial accelerometer is made of three accelerometers to measure in three main directions and it could be set up without disturbing the user.

Thermal Risks

The effort of the human body to maintain its internal temperature is the cause of the thermal risks. A changing temperature and moisture content in a working position could not guarantee a homoeothermic balance. As a consequence, human body could begin to undergo gradual physiological disturbing changes that affect its internal temperature (37 ± 0.8ºC), which is controlled by biochemical reactions.

Ornamental Stone processing plants, due to the plentiful use of water in cutting, sawing and polishing operations, have high and steady moisture content in the working environment. In order to determine the thermal stress of a working position the following factors should be monitored:

- Air temperature;
- Air moisture content;
- Air velocity;
- Irradiated heat.

The above parameters must be controlled in a periodical way in order to prevent any change in the thermal environment. The thermal environment could be monitored by the use of the following equipment:

- Thermometer (temperature);
- Psychrometer or hygrometer (moisture);
- Anemometer (air velocity);
- Thermometer for irradiate heat measurement.

Electrical Risks

Electrical risk is defined as an exposure to electric current. The phenomenon occurs when two different parts of the human body face a potential difference. This happens when a part of the human body touches a surface or an object with a certain electric potential and another surface or object with a different electric potential. Ornamental Stone processing plants have mainly electric machinery, so there is a high probability for electrical risks. The electrical potential could be measured with several equipments, like voltmeter, a responder, etc. The most common ways to suffer an electrocution at work are:

- Direct contact (a person touches a power conductor);
- Indirect contact (a person touches an object or surface, which is accidentally under electrical power);

Numerous studies have determined the safety values for electrical potential in a dry working position, that is, values under which human body is no harmed in case of electrocution, irrespectively of the contact time. These safety values are determined to 50 V for A.C. and 120 V for D.C.

Chemical Risks

Chemical risks in the Ornamental Stones sector are a consequence of exposure to certain substances that could lead to inflammations if they come in contact with the skin or mucous membranes. This situation could create a hypersensitivity reaction and could cause serious effects in future exposures. Occupational diseases caused by chemicals are mainly due to the use of resins, glues or other irritant substances in the stone finishing phase. This kind of risks is less important in comparison with other risks in the Ornamental and Natural Stones processing.

Other Risks

Finally, there are some other risks related to Ornamental and Natural Stones processing:

- Fire;
- Disease spreading.

Fire is a risk related mainly to the use of fuel or flammable substances or even electric power, with the following results:

- Burns;
- Work equipment damages;
- Installation damages.

Working position parameters have to be taken into account when selecting appropriate fire extinguishers. It is recommended to use dry chemical fire extinguishers in those places, where electric power could be the fire source, and CO_2 extinguishers for the rest of places.

3.4. General and Specific Risks

The use of new and modern technologies in the Ornamental Stones extraction and processing phases has extensively improved production rates. On the other hand, those technologies have generated new working factors that imply new risks. Nowadays, industrial development is very fast and, as a consequence, the working conditions are continuously changing in opposition to the last decades. For that reason, it is truly essential to study and assess the causes and effects of those new risks with the aim of developing and implementing more suitable safety measures to minimise accidents and diseases at work.

3.4.1. Risks related to specific operations and working positions

A list with the working positions or equipment in the stone processing plants that generate potential risks is presented in the following paragraphs for each Ornamental Stones sub-sector (namely, marble, granite, slate, sandstone and quartz).

Marble Sub-sector

- Frame crane operator;
- Gangsaw operator;
- Gangsaw assistant;
- Table feeder operator;
- Filler;
- Polishing machine operator,
- Table granulating operator;
- Table torching operator;
- Table reinforcing operator;
- Table packaging operator;
- Bridge disk operator;
- Cutting disk assistant;

- Block cutting operator;
- Wire cutting operator;
- Water blast cutting operator;
- Pantograph operator;
- Shotblast machine operator;
- Cutter operator;
- Slab classifier;
- Packaging operator;
- Stone cutting operator;
- Lathe machine operator;
- Workshop machine operator (grinding, side polishing, etc.);
- Trolley operator;
- Mechanic;
- Electrician;

Granite Sub-sector

- Block storage operator;
- Loading operator;
- Packaging operator;
- Gangsaw operator;
- Sludge operator;
- Mechanic;
- Electrician;
- Trolley loading operator;
- Torching operator;
- Polishing operator;
- Container packaging operator;
- Cutting feeder operator;
- Cutting operator;
- Side polishing and drilling operator;
- Trolley operator;
- Group leader.

Slate, Sandstone and Quartz Sub-sector

- Power shovel driver;
- Crane operator;
- Sawing operator;
- Splitter operator;
- Cutting operator;
- Trolley loading operator;
- Machining operator;
- Packaging operator;
- Frame crane operator;
- Trolley operator;

- Mechanic;
- Electrician;
- Group leader.

3.4.2. Risks related to the sub-sectors

The card of each operator in every Sub-sector is presented in the following paragraphs. The order follows the flowcharts of each Sub-sector (Figures 104-106). Every card includes the following information: working position identification, working area, developed activities, working organisation, operators, equipment and machines, hand tools, pneumatic and electric tools, implements, substances and chemical products.

Marble Sub-sector

WORKING POSITION IDENTIFICATION	**BRIDGE CRANE OPERATOR**	
WORKING AREA	**BLOCK STORAGE**	
DEVELOPED ACTIVITIES	• Block pick up and storage • Block identification and classification • Trolley loading • Slab unloading • Maintenance	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Bridge crane • Gantry crane	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Hand tools (wrenches, hammers, drills, etc.)	
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS		

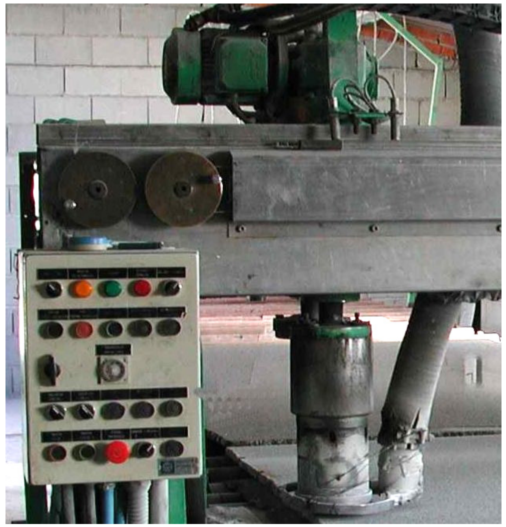
WORKING POSITION IDENTIFICATION	**GANG SAW OPERATOR**	
WORKING AREA	**SAWING PLANT**	
DEVELOPED ACTIVITIES	• Machine operation monitoring • Block cooling, control and handling of abrasive mixtures • Slab wedging • Straps change and maintenance • Gang saw maintenance • Piece unloading • Piece transportation to washing plant • Piece washing	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Bridge crane • Trolley winches	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Hand tools (wrenches, hammers, drills, etc.)	
IMPLEMENTS	• Wedge tools and chisels • Metallic bars • Wooden wedges	
SUBSTANCES AND CHEMICAL PRODUCTS	Slurry	

WORKING POSITION IDENTIFICATION	**GANG SAW ASSISTANT OPERATOR**
WORKING AREA	**SAWING PLANT**
DEVELOPED ACTIVITIES	• Slab wedging • Straps change and maintenance • Gang saw maintenance • Piece unloading • Piece transportation to washing plant • Piece washing • Slurry and flocculants monitoring • Maintenance
WORKING ORGANISATION	Continuous work in shifts
NUMBER OF OPERATORS	
EQUIPMENT AND MACHINES	• Bridge crane • Trolley winches
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Hand tools (wrenches, hammers, drills, etc.)
IMPLEMENTS	
SUBSTANCES AND CHEMICAL PRODUCTS	

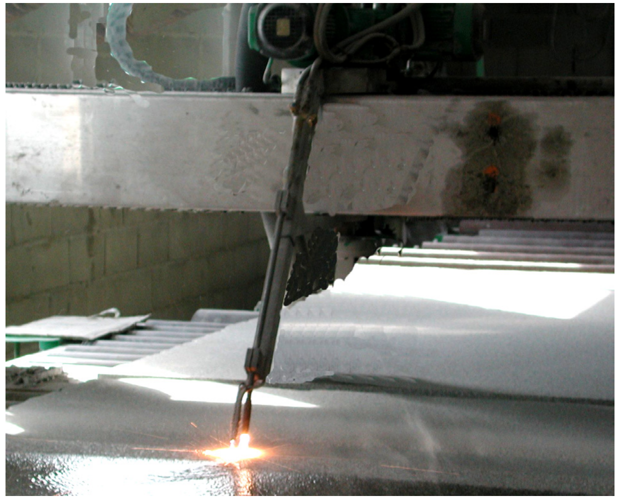
WORKING POSITION IDENTIFICATION	**SLAB FEEDER**	
WORKING AREA	**POLISHING MACHINE**	
DEVELOPED ACTIVITIES	• Polisher slab loading • Piece puttying • Maintenance	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES		
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS	• Smoothers • Chisels, hammers	
SUBSTANCES AND CHEMICAL PRODUCTS	Polyester resin	

WORKING POSITION IDENTIFICATION	**SLAB PUTTYING OPERATOR**	
WORKING AREA	**POLISHING PLANT**	
DEVELOPED ACTIVITIES	• Pieces puttying • Maintenance	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES		
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS	• Smoothers • Chisels, hammers	
SUBSTANCES AND CHEMICAL PRODUCTS	Polyester resin	

WORKING POSITION IDENTIFICATION	**SLAB POLISHING OPERATOR**	
WORKING AREA	**POLISHING PLANT**	
DEVELOPED ACTIVITIES	• Polishing operation monitoring • Machine maintenance • Piece unloading and storage	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Bridge crane • Polishing platform	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Hand tools (wrenches, hammers, drills, etc.)	
IMPLEMENTS	• Chisels and wedging tools • Metallic bars	
SUBSTANCES AND CHEMICAL PRODUCTS	Polyester resin	

WORKING POSITION IDENTIFICATION	**SLAB BUSH HAMMERING OPERATOR**	
WORKING AREA	**POLISHING PLANT**	
DEVELOPED ACTIVITIES	• Bush hammering operation • Machinery maintenance • Piece unloading	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Bridge crane • Bush hammering platform	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Hand tools (wrenches, hammers, drills, etc.)	
IMPLEMENTS	• Chisels and wedging tools • Metallic bars	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**SLAB FLAME MACHINE OPERATOR**
WORKING AREA	**POLISHING PLANT**
DEVELOPED ACTIVITIES	• Use of Chloridic acid • Flame machine feeding • Flame operation monitoring • Machinery maintenance • Piece unloading
WORKING ORGANISATION	Continuous work in shifts
NUMBER OF OPERATORS	
EQUIPMENT AND MACHINES	• Bridge crane • Flame machine
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Hand tools (wrenches, hammers, drills, etc.)
IMPLEMENTS	• Chisels and wedging tools • Metallic bars
SUBSTANCES AND CHEMICAL PRODUCTS	



WORKING POSITION IDENTIFICATION	FABRIC COVERING OPERATOR
WORKING AREA	POLISHING PLANT
DEVELOPED ACTIVITIES	• Resin and glass fiber laying for slab strengthening • Slab pressing with resin, glass fiber and plastic
WORKING ORGANISATION	Continuous work in shifts
NUMBER OF OPERATORS	
EQUIPMENT AND MACHINES	• Bridge crane • Pressing machine
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Hand tools (wrenches, hammers, drills, etc.)
IMPLEMENTS	• Chisels and wedging tools • Metallic bars • Smoothers
SUBSTANCES AND CHEMICAL PRODUCTS	• Polyester resin • Glass fiber

WORKING POSITION IDENTIFICATION	**PALLETS PACKAGING**	
WORKING AREA	**POLISHING PLANT**	
DEVELOPED ACTIVITIES	• Slab packaging • Packed slab storage • Final products truck loading	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Bridge crane • Motor wood saw • Pneumatic pistol	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Hand tools (wrenches, hammers, drills, etc.)	
IMPLEMENTS	• Chisels and wedging tools • Metallic bars • Wooden wedges	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**BLOCK SAW OPERATOR**	
WORKING AREA	**CUTTING PLANT**	
DEVELOPED ACTIVITIES	• Block saw feeding monitoring • Block saw monitoring • Flawed block selection	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Multi disk circular saw and block saw • Lift truck	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS	• Chisels and wedging tools • Metallic bars • Wooden wedges	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**BLOCK SAW ASSISTANT OPERATOR**	
WORKING AREA	**CUTTING PLANT**	
DEVELOPED ACTIVITIES	• Slab feeding to block saw • Piece unloading	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Block saw • Lift truck	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS	• Chisels and wedging tools • Metallic bars • Wooden wedges	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**BLOCK CUTTER OPERATOR**	
WORKING AREA	**CUTTING PLANT**	
DEVELOPED ACTIVITIES	• Cutter feeding monitoring • Block cutting monitoring • Flawed blocks selection • Maintenance	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Multi disk circular saw and block saw • Lift truck	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS	• Chisels and wedging tools • Metallic bars • Wooden wedges	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**CHAIN SAW OPERATOR**	
WORKING AREA	**PROCESSING PLANT**	
DEVELOPED ACTIVITIES	• Pieces loading on platform • Piece levelling and wedging • Chain saw operation and monitoring • Cut pieces unloading	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Chain Saw	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS	Wedges and wedging tools	
SUBSTANCES AND CHEMICAL PRODUCTS	Polyester resin	

WORKING POSITION IDENTIFICATION	**WATER JET CUTTING MACHINE OPERATOR**
WORKING AREA	**PROCESSING PLANT**
DEVELOPED ACTIVITIES	• Pieces loading on platform • Piece levelling and wedging • Chain saw operation and monitoring • Cut pieces unloading
WORKING ORGANISATION	Continuous work in shifts
NUMBER OF OPERATORS	
EQUIPMENT AND MACHINES	Water jet cutting machine
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	
IMPLEMENTS	Wedges and wedging tools
SUBSTANCES AND CHEMICAL PRODUCTS	Polyester resin

WORKING POSITION IDENTIFICATION	**PANTOGRAPH OPERATOR**	
WORKING AREA	**PROCESSING PLANT**	
DEVELOPED ACTIVITIES	• Pieces loading on platform • Piece levelling and wedging • Chain saw operation and monitoring • Cut pieces unloading	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Pantograph	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS	Wedges and wedging tools	
SUBSTANCES AND CHEMICAL PRODUCTS	Polyester resin	

WORKING POSITION IDENTIFICATION	**BUSH HAMMERING/SHOT BLASTING OPERATOR**
WORKING AREA	**PROCESSING PLANT**
DEVELOPED ACTIVITIES	• Blasting operation monitoring • Bush hammering operation monitoring • Machine maintenance • Pieces unloading and storage
WORKING ORGANISATION	Continuous work in shifts
NUMBER OF OPERATORS	
EQUIPMENT AND MACHINES	• Bridge crane • Bush hammering platform • Shot blasting platform
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Hand tools (wrenches, hammers, drills, etc.)
IMPLEMENTS	• Wedging tools and chisels • Metallic bars
SUBSTANCES AND CHEMICAL PRODUCTS	

WORKING POSITION IDENTIFICATION	**STRIP SLITTER OPERATOR**	
WORKING AREA	**PROCESSING PLANT**	
DEVELOPED ACTIVITIES	• Machine feeding monitoring • Pieces cutting monitoring • Flawed pieces selection	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Multi disc circular saw or block saw • Lift truck	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS	• Wedging tools and chisels • Metallic bars • Wooden wedges	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**SLAB PACKAGING OPERATOR**	
WORKING AREA	**PROCESSING PLANT**	
DEVELOPED ACTIVITIES	• Packaging machine feeding • Packed pieces storage • Truck loading with final product	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Bridge crane • Motor wood saw • Pneumatic pistol	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Hand tools (wrenches, hammers, drills, etc.)	
IMPLEMENTS	• Wedging tools and chisels • Metallic bars • Wooden wedges	
SUBSTANCES AND CHEMICAL PRODUCTS		

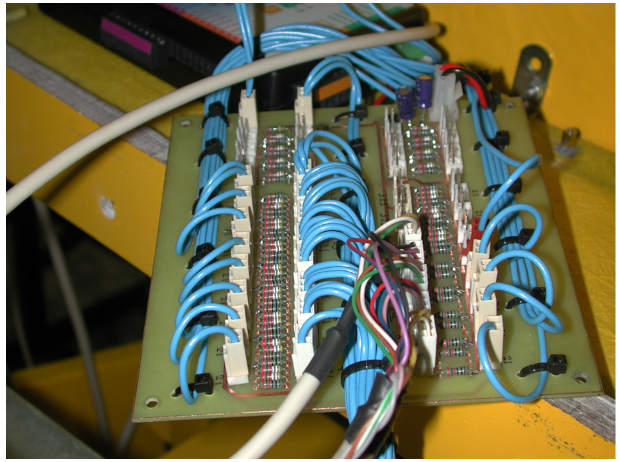
WORKING POSITION IDENTIFICATION	**TURNING OPERATOR**	
WORKING AREA	**WORKSHOP**	
DEVELOPED ACTIVITIES	• Piece turning • Tools handling (chamfering, smoothing, etc) • Workplace maintenance	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Turning machine • Chamfering machine • Milling machine • Smoothing machine, etc	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Hand tools (wrenches, hammers, drills, etc.)	
IMPLEMENTS	• Wedging tools and chisels • Metallic bars	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**MACHINE-CUT OPERATOR**	
WORKING AREA	**WORKSHOP**	
DEVELOPED ACTIVITIES	• Piece cutting • Tools handling (chamfering, smoothing, etc) • Workplace maintenance	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Cutting machine • Chamfering machine • Milling machine • Smoothing machine	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Hand tools (wrenches, hammers, drills, etc.)	
IMPLEMENTS	• Wedging tools and chisels • Metallic bars	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**WORKSHOP OPERATOR**	
WORKING AREA	**WORKSHOP**	
DEVELOPED ACTIVITIES	• Piece specific cutting • Tools handling • Maintenance	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Polisher • Chamfering machine • Milling machine • Smoothing machine, etc	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Hand tools (wrenches, hammers, drills, etc.)	
IMPLEMENTS	• Wedging tools and chisels • Metallic bars	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**LIFT TRUCK OPERATOR**	
WORKING AREA	**WORKSHOP**	
DEVELOPED ACTIVITIES	• Pallets transfer to storage • Final product truck loading	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Lift truck	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS	• Wedging tools and chisels • Metallic bars	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**MECHANIC**	
WORKING AREA	**WORKSHOP**	
DEVELOPED ACTIVITIES	• Welding operations • Bridge crane handling • Machinery maintenance	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Electric welding equipment • Flame cutting machine • Drills	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Machinery tools • Workshop tools • Fire extinguishers	
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS	• Detergents • Oils • Gas oil • Machinery cleaning and maintenance material • Oxygen and acetylene carboys • Distilled water and acid for battery • Buffer liquid • Hydraulic liquid	

WORKING POSITION IDENTIFICATION	**ELECTRICIAN**	
WORKING AREA	**WORKSHOP**	
DEVELOPED ACTIVITIES	Electric machinery and installations maintenance	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Drills and electric portable tools	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Machinery tools • Workshop tools • Fire extinguishers	
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS	• Detergents • Oils • Gas oil • Machinery Cleaning and maintenance material • Oxygen and acetylene carboys • Distilled water and acid for battery • Buffer liquid • Hydraulic liquid	

WORKING POSITION IDENTIFICATION	**WORKSHOP LEADER**	
WORKING AREA	**MONITORING**	
DEVELOPED ACTIVITIES	• Daily operations control and monitoring • Production and quality directives control • Machinery, equipment and installations management	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Operation of the plant machinery	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**TECHNICIAN**	
WORKING AREA	**MANAGEMENT**	
DEVELOPED ACTIVITIES	• Plant operations control, monitoring and planning • Production and quality directive set up • Staff management • Machinery, equipment and installations management	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Software and hardware tools	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS		

Granite Sub-sector

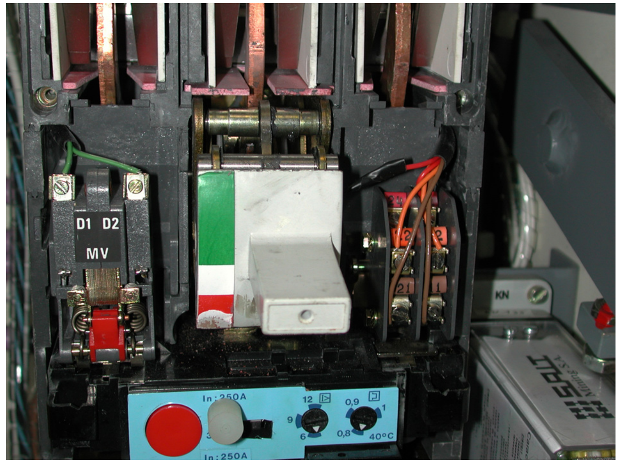
WORKING POSITION IDENTIFICATION	**BLOCK STORAGE OPERATOR**
WORKING AREA	**BLOCK STORAGE**
DEVELOPED ACTIVITIES	• Reception and storage of blocks • Identification and classification of blocks • Squared blocks in the wire cutting machine • Fluke trucks use
WORKING ORGANISATION	Continuous work in shifts
NUMBER OF OPERATORS	
EQUIPMENT AND MACHINES	• Bridge crane • Fluke trucks • Diamond studded wire cutter
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Usual hand tools
IMPLEMENTS	
SUBSTANCES AND CHEMICAL PRODUCTS	

WORKING POSITION IDENTIFICATION	**BLADES OPERATOR**	
WORKING AREA	**GANGSAW**	
DEVELOPED ACTIVITIES	• Introduce blocks in the gangsaw • Change and maintenance of blades • Maintenance of gangsaws • Transportation of pieces to the washing area • Washing of pieces	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Bridge crane	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Usual hand tools • Pressure water jets	
IMPLEMENTS	• Chisels • Metallic bars • Wooden wedges	
SUBSTANCES AND CHEMICAL PRODUCTS	Sludge with clay	

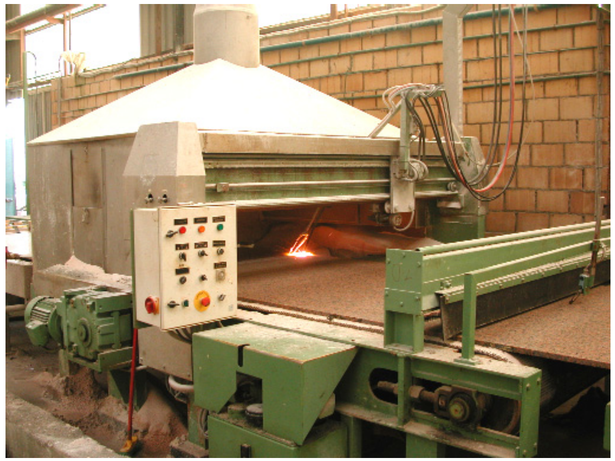
WORKING POSITION IDENTIFICATION	**GANGSAW OPERATOR**
WORKING AREA	**GANGSAW**
DEVELOPED ACTIVITIES	• Machine control • Block cooling, control and handling of abrasive mixtures • Sawed board wedging
WORKING ORGANISATION	Continuous work in shifts
NUMBER OF OPERATORS	
EQUIPMENT AND MACHINES	Gangsaw
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	
IMPLEMENTS	• Abrasive substance collecting containers • Wooden wedges
SUBSTANCES AND CHEMICAL PRODUCTS	Sludge with lime additives

WORKING POSITION IDENTIFICATION	**SLUDGE OPERATOR**
WORKING AREA	**SLUDGE**
DEVELOPED ACTIVITIES	• Control of sludge • Control of sludge filters • Loading of sludge • Sludge transport to the dump
WORKING ORGANISATION	Continuous work in shifts
NUMBER OF OPERATORS	
EQUIPMENT AND MACHINES	• Press filters • Mechanical digger • Truck
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	
IMPLEMENTS	
SUBSTANCES AND CHEMICAL PRODUCTS	Sludge with lime

WORKING POSITION IDENTIFICATION	**MECHANIC**	
WORKING AREA	**SHOP**	
DEVELOPED ACTIVITIES	• Welding • Bridge crane • Repairing and maintenance operations	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Electrical welding equipment • OXI - Cut • Drilling	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Usual hand tools • Extinguishers	
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS	• Detergents • Grass and oil • Gas oil • Material for cleaning and maintenance • Oxygen and acetylene • Distilled water and acid for batteries • Hydraulics fluid	

WORKING POSITION IDENTIFICATION	**ELECTRICIAN**	
WORKING AREA	**SHOP**	
DEVELOPED ACTIVITIES	Repairing and maintenance of electrical machines	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Portable electrical tools	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Usual hand tools • Extinguishers	
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS	• Detergents • Grasses and oil • Gas oil • Oxygen and acetylene • Distilled water and acid for batteries • Hydraulics fluid	

WORKING POSITION IDENTIFICATION	**TROLLEY'S OPERATOR**
WORKING AREA	**PROCESSING PLANT**
DEVELOPED ACTIVITIES	• Trolley unloading • Feeding of the processing line • Identify slabs
WORKING ORGANISATION	Continuous work in shifts
NUMBER OF OPERATORS	
EQUIPMENT AND MACHINES	Crane bridge
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	
IMPLEMENTS	• Chisels • Metallic bars • Wooden wedges
SUBSTANCES AND CHEMICAL PRODUCTS	

WORKING POSITION IDENTIFICATION	**FLAMING OPERATOR**	
WORKING AREA	**PROCESSING PLANT**	
DEVELOPED ACTIVITIES	• Apply acid on the slab surface • Placing of the slab in the machine • Maintenance of the flaming machine • Finished pieces pilling up	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Bridge crane • Flamed lance	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Usual hand tools	
IMPLEMENTS	• Chisels • Metallic bars	
SUBSTANCES AND CHEMICAL PRODUCTS	Hydrochloric acid	

WORKING POSITION IDENTIFICATION	**POLISHING OPERATOR**	
WORKING AREA	**PROCESSING PLANT**	
DEVELOPED ACTIVITIES	• Placing of the slab in the machine • Maintenance of the flaming machine • Finished pieces pilling up	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Usual hand tools	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Bridge crane • Polishing platform	
IMPLEMENTS	• Chisels • Metallic bars	
SUBSTANCES AND CHEMICAL PRODUCTS	Sludge with clay	

WORKING POSITION IDENTIFICATION	**CONTAINER PACKAGING OPERATOR**	
WORKING AREA	**PROCESSING PLANT**	
DEVELOPED ACTIVITIES	• Pieces packaging • Storage of finished pieces • Load of the final product for shipping	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Bridge crane • Saws for wood • Pneumatic pistols	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Usual hand tools	
IMPLEMENTS	• Chisels • Metallic bars • Wood wedges	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**CUTTING FEEDER OPERATOR**	
WORKING AREA	**CUTTING PLANT**	
DEVELOPED ACTIVITIES	Transportation of slabs to the cutting machine	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Bridge crane	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Usual hand tools	
IMPLEMENTS	• Chisels • Metallic bars	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**CUTTING SAW OPERATOR**	
WORKING AREA	**CUTTING PLANT**	
DEVELOPED ACTIVITIES	• Control cutting machine feeding • Pieces cutting supervision • Selection of defective pieces	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Multi-discs cutting saws • Forklift trucks	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**SIDE POLISHING AND DRILLING OPERATOR**	
WORKING AREA	**CUTTING PLANT**	
DEVELOPED ACTIVITIES	• Feeding of the machine with cut pieces • Maintenance of the abrasive spare parts • Drilling maintenance • Use of forklift trucks	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Side polishing machine • Drilling • Forklift trucks	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Usual hand tools	
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**PACKAGING OPERATOR**	
WORKING AREA	**CUTTING PLANT**	
DEVELOPED ACTIVITIES	• Packaging of finished pieces • Storage of pieces • Final products loading on trucks	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Bridge crane • Forklift trucks • Pneumatic pistols	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Usual hand tools	
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**FORKLIFT TRUCKS OPERATOR**
WORKING AREA	**CUTTING PLANT**
DEVELOPED ACTIVITIES	• Transportation of pallets to the storage area • Load final products on trucks
WORKING ORGANISATION	Continuous work in shifts
NUMBER OF OPERATORS	
EQUIPMENT AND MACHINES	Forklift trucks
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	
IMPLEMENTS	• Chisels • Metallic bars
SUBSTANCES AND CHEMICAL PRODUCTS	

WORKING POSITION IDENTIFICATION	**GROUP LEADER**	
WORKING AREA	**STAFF**	
DEVELOPED ACTIVITIES	• Surveillance, control and operations planning • Control of quality and production • Equipment, machines and installations management (control, maintenance, etc)	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES		
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**TECHNICIAN**	
WORKING AREA	**STAFF**	
DEVELOPED ACTIVITIES	• Surveillance, control and operations planning • Control of plant productivity and product quality • Management of the plant personnel • Management of equipment, machines and installations	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Informatics equipment	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS		

Slate Sub-sector

WORKING POSITION IDENTIFICATION	**POWER SHOVEL DRIVER**	
WORKING AREA	**SAWING PLANT**	
DEVELOPED ACTIVITIES	• Primary exfoliation of block-slates • Distribution of block-slates by the cut line • Loading and cleaning of waste • Transportation of waste to a waste dump	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Mechanical digger • Truck	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS	Mechanical digger accessories	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**CRANE OPERATOR**	
WORKING AREA	**SAWING PLANT**	
DEVELOPED ACTIVITIES	Distribution of block-slates in the sawing table	
WORKING ORGANISATION	Discontinuous work (morning and evening)	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Bridge crane	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Usual hand tools	
IMPLEMENTS	• Hook for lying slate • Metallic bars • Wood wedges	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**SAWING OPERATOR**	
WORKING AREA	**SAWING PLANT**	
DEVELOPED ACTIVITIES	• Saws control • Control and management of the sawing table • Maintenance of saws and conveyor belts	
WORKING ORGANISATION	Discontinuous work (morning and evening)	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Saws	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Usual hand tools	
IMPLEMENTS	• Chisels • Metallic bars	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**SPLITTER OPERATOR**	
WORKING AREA	**SAWING PLANT**	
DEVELOPED ACTIVITIES	Manual exfoliation of the block-slate into thin sheets	
WORKING ORGANISATION	Discontinuous work (morning and evening)	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Bridge crane	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Pneumatic hammer • Usual hand tools	
IMPLEMENTS	• Chisels • Metallic bars	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**BLOCK CART OPERATOR**
WORKING AREA	**SAWING PLANT**
DEVELOPED ACTIVITIES	Transfer of blocks from the cutting table into water containers
WORKING ORGANISATION	Discontinuous work (morning and evening)
NUMBER OF OPERATORS	
EQUIPMENT AND MACHINES	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Usual hand tools
IMPLEMENTS	• Chisels • Metallic bars
SUBSTANCES AND CHEMICAL PRODUCTS	

WORKING POSITION IDENTIFICATION	**MACHINING OPERATOR**	
WORKING AREA	**MACHINING PLANT**	
DEVELOPED ACTIVITIES	• Exfoliation of the cut blocks • Maintenance and cleaning of the workplace • Maintenance of working tools	
WORKING ORGANISATION	Discontinuous work (morning and evening)	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES		
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Usual hand tools	
IMPLEMENTS	Manual hammer	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**CUTTING OPERATOR**	
WORKING AREA	**MACHINING PLANT**	
DEVELOPED ACTIVITIES	• Cut of flags as specified • Maintenance and cleaning of the workplace • Maintenance of working tools	
WORKING ORGANISATION	Discontinuous work (morning and evening)	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Cut saws	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Usual hand tools	
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**PACKAGING OPERATOR**	
WORKING AREA	**MACHINING PLANT**	
DEVELOPED ACTIVITIES	• Classification of flags • Introduction of flags into pallets • Identification of pallets	
WORKING ORGANISATION	Discontinuous work (morning and evening)	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Bridge crane	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Usual hand tools	
IMPLEMENTS	Plastic hammer	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**BRIDGE CRANE OPERATOR**	
WORKING AREA	**MACHINING PLANT**	
DEVELOPED ACTIVITIES	Transportation of the finished pallets to the storage area	
WORKING ORGANISATION	Discontinuous work (morning and evening)	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Bridge crane	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	Usual hand tools	
IMPLEMENTS	• Chisels • Metallic bars	
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**FORKLIFT TRUCK OPERATOR**
WORKING AREA	**MACHINING PLANT**
DEVELOPED ACTIVITIES	• Transportation of finished pallets to the shipping area • Loading of trucks with the final product
WORKING ORGANISATION	Discontinuous work (morning and evening)
NUMBER OF OPERATORS	
EQUIPMENT AND MACHINES	Forklift truck
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	
IMPLEMENTS	Metallic bars
SUBSTANCES AND CHEMICAL PRODUCTS	

WORKING POSITION IDENTIFICATION	**MECHANIC**	
WORKING AREA	**WORKSHOP**	
DEVELOPED ACTIVITIES	• Welding operations • Bridge crane driving • Maintenance	
WORKING ORGANISATION	Discontinuous work (morning and evening)	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	• Electrical welding equipment • Oxi-cut equipment • Drillings	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Usual hand tools • Extinguishers	
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS	• Detergents • Grasses and oil • Gas oil • Material for equipment cleaning and maintenance • Oxygen and acetylene • Distilled water and acid for batteries • Hydraulics fluid	

WORKING POSITION IDENTIFICATION	**ELECTRICIAN**	
WORKING AREA	**WORKSHOP**	
DEVELOPED ACTIVITIES	Repair and maintenance operations of the electrical machines	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Portable electrical tools	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS	• Usual hand tools • Extinguishers	
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS	• Detergents • Grasses and oil • Gas oil • Oxygen and acetylene • Distilled water and acid for batteries • Hydraulics fluid	

WORKING POSITION IDENTIFICATION	**GROUP LEADER**	
WORKING AREA	**STAFF**	
DEVELOPED ACTIVITIES	• Surveillance, control and operations planning • Quality and production control • Equipment, machines and installations management	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES		
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS		

WORKING POSITION IDENTIFICATION	**TECHNICIAN**	
WORKING AREA	**STAFF**	
DEVELOPED ACTIVITIES	• Surveillance, control and operations planning • Quality and production control • Management of the plant personnel (distribution, etc) • Equipment, machines and installations management (control, maintenance, etc)	
WORKING ORGANISATION	Continuous work in shifts	
NUMBER OF OPERATORS		
EQUIPMENT AND MACHINES	Informatics equipment	
HAND TOOLS, PNEUMATIC AND ELECTRICAL TOOLS		
IMPLEMENTS		
SUBSTANCES AND CHEMICAL PRODUCTS		

3.5. Preventive Measures

The various working operations of the Ornamental Stones processing phase have been associated with several kinds of risks. An analytical list of the general risks, along with their subsequent effects and suggested preventive measures are presented in Table 14.

Table 14. General risks related with the Ornamental Stones processing phase, their effects and suggested preventive measures

GENERAL RISKS	EFFECTS	PREVENTIVE MEASURES
	OVER STRESS	
OVER STRESS	MUSCULAR ACHES DORSAL INJURIES CERVICAL INJURIES	▪ Load weight limitation ▪ Load handling training ▪ Lifting equipment ▪ Lifting equipment training
	MECHANICAL RISKS	
FALLING OF EQUIPMENT OR LOADS	CRUSHING OF EQUIPMENT	▪ Do not exceed the equipment capacity ▪ Distribute the load evenly ▪ Perform daily checks and periodic inspection of the extraction, loading and processing equipment ▪ Use helmets ▪ Use protective boots
TRAMPLING	▪ CRUSHING ▪ FRACTURES ▪ OTHER INJURIES	▪ Periodic and proper maintenance of machinery ▪ Properly mark the areas of machines ▪ Use reverse gear sound signals in machinery
FALLING OF PEOPLE FROM STAIRS AND CLIFFS	▪ FRACTURES ▪ OTHER INJURIES	▪ Fix ladders so that they cannot skid, topple or oscillate ▪ Position hand ladders at least 1 m higher than the highest point to be reached ▪ Use fixed stairs with lateral protections for access ▪ Use suitable cliffs ▪ Use fences with a height of more than 90 cm next to the cliffs
FALLING OF PEOPLE ON THE SAME LEVEL	▪ FRACTURES ▪ DISLOCATIONS ▪ OTHER INJURIES	▪ Keep the floor of the accessing areas level and non slippery ▪ Keep accessing areas clear of obstacles ▪ Use boots with non slipping soles
ENTRAPMENT AND CUTS	▪ AMPUTATIONS ▪ DISLOCATIONS ▪ BRUISES ▪ OTHER INJURIES	▪ Perform periodic maintenance of equipment ▪ Equipment training ▪ Use tools being in good condition ▪ Use gloves ▪ Use helmet ▪ Use protective boots

NOISE		
NOISE	▪ INJURIES TO HEARING ORGANS ▪ EFFECTS ON CENTRAL NERVOUS SYSTEM ▪ FATIGUE ▪ REDUCED PRODUCTIVITY	▪ Use more modern and less noisy equipment ▪ Reduce exposure time ▪ Use proper ear protection
GENERAL RISKS	**EFFECTS**	**PREVENTIVE MEASURES**
DUST		
DUST	▪ PNEUMOCONIOSIS AND SILICOSIS ▪ BREATHING DIFFICULTIES ▪ REDUCED PRODUCTIVITY	▪ Use dust removal or wet cutting systems ▪ Use protective masks
THERMAL RISKS		
INTEMPERATE EXPOSURE TO COLD OR HEAT	▪ PHYSICAL DISORDERS ▪ REDUCED PRODUCTIVITY ▪ DISORDERS ASSOCIATED WITH HEAT, COLD AND EXCESSIVE HUMIDITY	▪ Reduce exposure time ▪ Use proper clothing and footgear
ELECTRICAL RISKS		
ELECTRIFICATION	▪ ELECTROCUTION ▪ SHOCK ▪ VENTRICULAR FIBRILLATION ▪ BURNS	▪ Perform periodic maintenance of circuits and electrical boards ▪ Do not allow electrical wiring pass through areas where they could be stripped of their protective coating ▪ Do not place movable electric boards in areas where they can be submerged
CHEMICAL RISKS		
CONTACT WITH LUBRICANTS CONTACT WITH CORROSIVE SUBSTANCES	▪ DERMATOSIS ▪ BURNS	▪ Storage of lubricants and corrosive substances in appropriate places ▪ Use suitable clothing and gloves ▪ Use protection shields
OTHER RISKS		
FIRE OR EXPLOSION	▪ DEATH ▪ BURNS ▪ DAMAGE TO THE PLANT, EQUIPMENT AND OTHER MATERIALS	▪ Storage of fuel and lubricants in appropriate places ▪ Adequate marking of storage places with proper prohibition and danger signs ▪ Keep these substances locked
DISEASE TRANSMISSION	▪ SICK WORKERS ▪ SICK DAYS	▪ Use individual water cups for workers ▪ Provide clean and well-kept hygiene and social facilities

3.5.1. Preventive Measures pertinent to stone processing industry

Marble Sub-sector

OPERATION	WORK PLACE	SPECIFIC RISKS	PREVENTIVE MEASURES
BLOCKS TRANSPORTATION	CRANE OPERATOR	▪ Mechanical risks ▪ Falling of materials ▪ Falling of piled blocks ▪ Trampling and hits with machinery ▪ Collision with objects	▪ Do not exceed equipment capacity ▪ Load evenly distributed ▪ Periodic maintenance of machinery and equipment ▪ Use even and stable storage surfaces ▪ Marking of the maneuvering areas
BLOCKS CUTTING	CUTTING OPERATOR CUTTING OPERATOR ASSISTANT	▪ Trampling and hits with machinery ▪ Over stress ▪ Falling of operator ▪ Noise exposure	▪ Use internal working and safety procedures ▪ Use suitable protection devices ▪ Use suitable cliffs ▪ Load handling limitation ▪ Load handling training ▪ Use proper personal protection
PROCESSING PLANT	MACHINERY OPERATORS	▪ Trampling and hits with machinery ▪ Hand injuries ▪ Hits against objects ▪ Over stress ▪ Noise exposure	▪ Worker training ▪ Periodic maintenance of equipment and tools ▪ Use helmet ▪ Periodic check of lifting means ▪ Use ear protection ▪ Load handling limitation ▪ Load handling training ▪ Use lifting equipment
STORAGE	MATERIAL CLASSIFICATION OPERATORS	Physical fatigue	▪ Periodical rest and refit ▪ Alternation between classification and other activities
WORKSHOP	ELECTRICIAN MECHANIC	▪ Cutting and hits with the tools ▪ Falling of materials or tools ▪ Burns ▪ Solid or liquid flying	Use personal protection (clothing and gloves) Workers training and information Use of protection shields Periodic maintenance of equipment and tools Internal working and safety procedures

OPERATION	WORK PLACE	SPECIFIC RISKS	PREVENTIVE MEASURES
CUTTING PLANT	MACHINERY OPERATORS	▪ Cutting and entrapping by machinery ▪ Falling of materials ▪ Noises exposure ▪ Dust exposure ▪ Hand injuries ▪ Hits against objects	▪ Workers training and information ▪ Periodic maintenance of equipment, tools and machinery ▪ Use gloves ▪ Use ear protection ▪ Use helmet ▪ Use protective mask ▪ Use right tools ▪ Proper internal working procedures ▪ Proper material piling ▪ Periodic check of lifting means ▪ Use dust removal or wet cutting systems
SHIPPING PLANT	TROLLEY OPERATOR CRANE OPERATOR PACKAGING OPERATOR	▪ Hits against objects ▪ Falling of materials ▪ Hits and cutting with tools	▪ Periodic maintenance of the lifting machinery and tools ▪ Use helmet ▪ Use proper clothing and gloves ▪ Proper material piling ▪ Worker training and information ▪ Lifting equipment training

Granite Sub-sector

OPERATION	WORK PLACE	SPECIFIC RISKS	PREVENTIVE MEASURES
BLOCKS TRANSPORTATION, LOADING AND UNLOADING	BLOCKS AND LOADS STORAGE OPERATOR	▪ Mechanical risks ▪ Falling of materials ▪ Falling of piling blocks ▪ Trampling and hits with the lifting and carrying machinery ▪ Hits against objects	Do not exceed equipment capacity Load evenly distributed Use even and stable storage surfaces Periodic maintenance of machinery and equipment Marking of the maneuvering areas Use reverse gear sound signals Traffic areas with gentle slope
TRANSPORTATION	DUMPER DRIVER	▪ Mechanical risks ▪ Trampling ▪ Hits against objects ▪ Overturning	▪ Do not exceed equipment capacity ▪ Well maintained traffic areas ▪ Load evenly distributed ▪ Periodic maintenance of machinery and equipment ▪ Traffic areas with gentle slope ▪ Marking of the maneuvering areas ▪ Use reverse gear sound signals ▪ Use well maintained access ladder to machinery
CUTTING	CUTTING OPERATOR	▪ Entrapping by movable parts ▪ Falling of operator ▪ Over stress ▪ Noise exposure	▪ Internal working and safety procedures ▪ Use proper protection shields ▪ Use appropriate working platforms ▪ Load handling limitation ▪ Load handling training ▪ Use proper personal protection
PROCESSING PLANT	MACHINERY OPERATORS	▪ Entrapping and hits with the machinery ▪ Hand injuries ▪ Hits against objects ▪ Noise exposure ▪ Over stress	▪ Workers training ▪ Periodic maintenance of machinery, equipment and tools ▪ Use helmet ▪ Use ear protection ▪ Periodical checking of lifting equipment ▪ Load handling limitation ▪ Load handling training

OPERATION	WORK PLACE	SPECIFIC RISKS	PREVENTIVE MEASURES
WORKSHOP	ELECTRICIAN MECHANIC	▪ Cutting and hits with tools ▪ Falling of materials or tools ▪ Burns ▪ Solid or liquid flying	▪ Use personal protection (clothing and gloves) ▪ Workers training and information ▪ Use protection shields ▪ Periodic maintenance of equipment and tools ▪ Internal working and safety procedures
CUTTING PLANT	CUTTING OPERATOR	▪ Cutting and entrapping by machinery ▪ Falling of materials ▪ Noise exposure ▪ Hand injuries ▪ Hits against objects ▪ Dust exposure	▪ Worker training ▪ Periodic maintenance of machinery, equipment and tools ▪ Proper material piling ▪ Use proper tools ▪ Internal working and safety procedures ▪ Use gloves ▪ Use ear protection ▪ Use helmet ▪ Use protection mask ▪ Periodical checking of lifting equipment ▪ Use dust removal or wet cutting systems
SHIPPING PLANT	TROLLEY OPERATOR CRANE OPERATOR PACKAGING OPERATOR	▪ Hits against objects ▪ Falling of materials ▪ Hits and cutting with tools	▪ Periodic maintenance of lifting equipment and tools ▪ Use helmet ▪ Use proper clothing and gloves ▪ Proper material piling ▪ Worker training and information ▪ Lifting equipment training

Slate Sub-sector

OPERATION	WORK PLACE	SPECIFIC RISKS	PREVENTIVE MEASURES
BLOCKS TRANSPORTATION, LOADING AND UNLOADING	POWER SHOVEL DRIVER CRANE OPERATOR	▪ Mechanical risks ▪ Falling of materials ▪ Trampling and hits with lifting and transportation machinery ▪ Hits against objects	▪ Do not exceed equipment capacity ▪ Load evenly distributed ▪ Safety distance from load lifting ▪ Periodic maintenance of machinery and equipment ▪ Marking of the maneuvering areas ▪ Use reverse gear sound signals ▪ Use helmet ▪ Avoid sudden movements
SAWING	SAWING OPERATOR	▪ Hits and cutting by objects and tools ▪ Falling of people on the same level ▪ Entrapping ▪ Noise exposure	▪ Well maintained sawing protection devices ▪ Periodic maintenance of machinery and equipment ▪ Do not abandon working position until sawing is stopped ▪ Use appropriate tools ▪ Use gloves ▪ Internal working and safety procedures ▪ Periodic maintenance of accessing areas and working positions ▪ Use proper material piling ▪ Use ear protection
CUTTING	CUTTING OPERATOR	▪ Entrapping by movable parts ▪ Solid and liquid flying ▪ Over stress ▪ Noise exposure	▪ Internal working and safety procedures ▪ Proper protection devices ▪ Use of gloves ▪ Block handling training ▪ Working position cleaning ▪ Periodic maintenance of

			machinery, equipment and tools ▪ Use protection goggles ▪ Load handling limitation ▪ Load handling training
PACKAGING	PACKAGING OPERATOR	▪ Hand injuries ▪ Hits against objects ▪ Falling of workers on the same level ▪ Noise exposure ▪ Over stress	▪ Workers training ▪ Periodic maintenance of machinery, equipment and tools ▪ Use gloves ▪ Use helmet ▪ Use ear protection ▪ Periodic maintenance of lifting equipment ▪ Maintenance and cleaning of working position ▪ Load handling limitation ▪ Load handling training
WORKSHOP	ELECTRICIAN MECHANIC	▪ Cutting and hits with tools ▪ Falling of materials or tools ▪ Burns ▪ Solid or liquid flying	▪ Use proper personal protection (clothing and gloves) ▪ Workers training and information ▪ Use of protection shields ▪ Periodic maintenance of equipment and tools ▪ Internal working and safety procedures
SHIPPING PLANT	TROLLEY OPERATOR	▪ Hits against objects ▪ Falling of materials ▪ Hits and cutting with tools	▪ Periodic maintenance of lifting equipment and tools ▪ Use helmet ▪ Proper clothing and gloves ▪ Proper material piling ▪ Worker training and information ▪ Lifting equipment training

3.6. General Standard Documentation

The following documents are generated by the software program and refer to the working position of a gangsaw operator.

3.6.1. Risk identification for the different phases of production

RISK IDENTIFICATION

Enterprise:		Working site:	
Working position: **Gangsaw operator**		Nr of workers:	(Enterprise stamp)
Working areas:			
Date:	Review:	Realisation:	

V	C	Risk factors
		ACCIDENT RISK
X	01	Falling of people (stairs, cliffs, etc)
X	02	Falling of people on the same level
X	09	Hits, cuts, bruises by objects or tools
X	11	Entrapping
X	16	Direct electrocution
X	17	Indirect electrocution
X	18	Contact with corrosive or caustic substances
X	21	Explosion
X	22	Fire
		DISEASE RISK
X	27	Chemical pollutants. Dust. Aerosols
X	30	Noise exposure
		ERGONOMIC FACTORS
X	36	Physical and/or mental fatigue

V: Identified risk C: Risk code

3.6.2. Risk Assessment of the different phases of production

RISK ASSESSMENT

Enterprise:		Working site:	
Working position: **Gangsaw operator**		Nr of workers:	(Enterprise stamp)
Working areas:			
Date:	Review:	Realisation:	

V	C	Risk factors	Consequence	Exposure	Probability	IR	Risk level
		ACCIDENT RISK					
X	01	Falling of people (stairs, cliffs, etc)	Important	Usual	Possible	54	Tolerable
X	02	Falling of people on the same level	Important	Continuous	Impossible	6	Acceptable
X	09	Hits, cuts, bruises by objects or tools	Very serious	Usual	Possible	270	High risk
X	11	Entrapping	Serious	Occasional	Improbable	21	Acceptable
X	16	Direct electrocution	Serious	Occasional	Possible	63	Tolerable
X	17	Indirect electrocution	Serious	Usual	Possible	126	Medium risk
X	18	Contact with corrosive or caustic substances	Serious	Usual	Improbable	42	Tolerable
X	21	Explosion	Very serious	Usual	Possible	270	High risk
X	22	Fire	Very serious	Usual	Possible	270	High risk
		DISEASE RISK					
X	27	Chemical pollutants. Dust. Aerosols	Important	Usual	Possible	54	Tolerable
X	30	Noise exposure	Important	Scarce	Impossible	1,2	Acceptable
		ERGONOMIC FACTORS					
X	36	Physical and/or mental fatigue	Important	Uncommon	Impossible	0,3	Acceptable

3.6.3. Risk schedule for dangerous phases

PREVENTIVE MEASURES

Enterprise:		Working site:	
Working position: **Gangsaw operator**		Nr of workers:	(Enterprise stamp)
Working areas:			
Date:	Review:	Realization:	

Code	Identified risk	IR value	% Expected risk reduction
01	**Falling of people (stairs, cliffs, etc)**	**54**	**80**
PREVENTIVE MEASURES IMPLEMENTED			TYPE % Risk reduction
clean and well arranged conditions in cliffs			**Procedure** **80**
well arranged electrical cables and electrical equipment storage			**Procedure** **70**

Code	Identified risk	IR value	% Expected risk reduction
09	**Hits, cuts, bruises by objects or tools**	**270**	**90**
PREVENTIVE MEASURES IMPLEMENTED			TYPE % Risk reduction
Use safeguard shelters			**Protection** **90**

Code	Identified risk	IR value	% Expected risk reduction
17	**Indirect electrocution**	**126**	**80**
PREVENTIVE MEASURES IMPLEMENTED			TYPE % Risk reduction
Replacement of electrocution protection devices			**Protection** **80**

3.6.4. Preventive measures for different phases of production

PREVENTIVE MEASURES TO IMPLEMENT ASSESSMENT

Enterprise:		Working site:	
Working position: **Gangsaw operator**		Nr of workers:	(Enterprise stamp)
Working areas:			
Date:	Review:	Realisation:	

CR: **01**	Identified risk: **Falling of people (stairs, cliffs, etc)**					IR: **54**
Preventive measures	E = Preventive efficiency I = Process is interfered M = Discomfort to workers			F (%)	D (euros)	J (value)
clean and well arranged conditions in cliffs	E	8		**80**	**10**	**27**
	I	2		**2**	**1**	**YES**
	M	0				
well arranged electrical cables and electrical equipment storage	E	9		**70**	**198**	**9**
	I	0		**3**	**2**	**NO**
	M	0				

CR: **09**	Identified risk: **Hits, cuts, bruises by objects or tools**					IR: **270**
Preventive measures	E = Preventive efficiency I = Process interfered M = Discomfort to workers			F (%)	D (euros)	J (value)
Use safeguard shelters	E			**90**	**1500**	**34**
	I			**2**	**4**	**YES**
	M					

CR: **17**	Identified risk: **Indirect electrocution**					IR: **126**
Preventive measures	E = Preventive efficiency I = Process interfered M = Discomfort to workers			F (%)	D (euros)	J (value)
Replacement of electrocution protection devices	E			**80**	**1998**	**16**
	I			**2**	**4**	**YES**
	M					

F: Risk reduction factor	**Value**	**D: Cost factor**	**Value**	**J: Justification (J = IR/F x D)**	**Value**
Completely suppressed risk	**1**	More than 12000 euros	**10**	Justified (YES)	**J ≥ 10**
Risk reduction to 75 %	**2**	From 6000 to 12000 euros	**6**		
Risk reduction from 50 % to 75 %	**3**	From 600 to 6000 euros	**4**		
Risk reduction from 25 % to 50 %	**4**	From 60 to 600 euros	**2**	Non justified (NO)	**J < 10**
Light risk reductio (< 25 %)	**6**	From 12 to 60 euros	**1**		
		Less than 12 euros	**0,5**		
IR: Risk index (IR = Consequence x Exposure x Probability)					

3.6.5. Preventive measures planning

PREVENTIVE MEASURES PLANNING

Enterprise:			Working site:	
Working position: **Gangsaw operator**			Nr of workers:	
Working areas:				
Date:	Review:	Realisation:		(Enterprise stamp)

CR: **01**	Identified risk: **Falling of people (stairs, cliffs, etc)**				IR: **54**
Preventive measure:	**clean and well arranged conditions in cliffs**				
TYPE **Procedure**					
Responsible		Justification	Initial date	Final date	Measure efficiency check (signal and date)
		YES 27			
Preventive measure:	**well arranged electrical cables and electrical equipment storage**				
TYPE **Procedure**					
Responsible		Justification	Initial date	Final date	Measure efficiency check (signal and date)
		NO 9			

CR: **09**	Identified risk: **Hits, cuts, bruises by objects or tools**				IR: **270**
Preventive measure:	**Use safeguard shelters**				
TYPE **Protection**					
Responsible		Justification	Initial date	Final date	Measure efficiency check (signal and date)
		YES 34			

3.6.6. Information to the workers

INFORMATION TO WORKERS

Enterprise:			Working site:	
Working position: **Gangsaw operator**			Nr of workers:	
Working areas:				
Date:	Review:	Realisation:		
				(Enterprise stamp)

RISK		RISK CLASSIFICATION
	ACCIDENT RISK	
01	Falling of people (stairs, cliffs, etc)	**Tolerable**
02	Falling of people on the same level	**Acceptable**
09	Hits, cuts, bruises by objects or tools	**High risk**
11	Entrapping	**Acceptable**
16	Direct electrocution	**Tolerable**
17	Indirect electrocution	**Medium risk**
18	Contact with corrosive or caustic substances	**Tolerable**
21	Explosion	**High risk**
22	Fire	**High risk**
	DISEASE RISK	
27	Chemical pollutants. Dust. Aerosols	**Tolerable**
30	Noise exposure	**Acceptable**
	ERGONOMIC FACTORS	
36	Physical and/or mental fatigue	**Acceptable**

DOCUMENTATION DELIVERED TO WORKER

Mr.:	
Has received the information regarding his working position risk assessment.	Signature and date

4

Ornamental Stones Sector and the Environment

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4.1. Introduction

During the last two decades the Ornamental Stones industry has been severely criticised for causing harm to the environment and has therefore come into question. In spite of the fact that the activities of the Ornamental Stones sector, such as quarrying, have been carried out since the Stone Age, the public opinion in its majority still regards those activities with distrust and believes that their effects on the environment are harmful.

It should be underlined that the activities of the companies of the Ornamental Stones sector, such as the extractive and processing industries of marble and/or granite, are closely dependent on the particular location of minerals. In other words, the operator will face hard-to-solve technical problems or hard-to-work-under circumstances; there is no other alternative for producing those products. In the case of marble, for example, the extracting companies should develop their quarrying activities in places where marbles with commercial value exist, even if this might cause various problems (regarding the environment, the neighbouring populations, etc.).

It is well known that almost every human activity has an environmental impact. Even the simple act of writing on a sheet of paper with a pencil has en environmental impact: it generates heat. Depending on the particular circumstances, the environmental impact of a given activity can range from being of little significance to being extremely significant and the need to manage these impacts varies accordingly. Quite clearly, the Extractive Industry is likely to generate a certain number of environmental impacts. It should be emphasised, however, that most impacts remain quite localised and do not have any wide-spread effect beyond the immediate vicinity of the extraction or processing site.

It would be misleading to believe that the Extractive Industry operators have "carte blanche" to dig wherever and however they like. It would also be wrong to believe that there should be a unique and uniform Legislation that would apply in exactly the same way to all the different extraction sites in Europe. It is quite clear that the potential effects vary considerably according to the characteristics of the local environment, and that, in fact, both a flexible and an adaptable management approach is required.

The authorisation procedure is the "open sesame" to environmental Legislation and constitutes an integral part of any extractive activity. In the past, the relationship between operators and national authorities was regulated almost exclusively by mining codes. These codes, where they still exist, continue to regulate questions of property and access to underground resources. Nowadays however, the extraction of minerals not only needs to satisfy the resource need, but also has to be acceptable from an environmental point of view to a major part of the society. In addition to that, it could be argued that European Union supports the opinion that environmental protection should *"walk hand by hand"* with industry.

The procedure that relates the granting of extraction and processing phases permissions usually becomes a complex and drawn-out process during which, a project submitted by an operator goes through a quite large number of authorities, responsible for all types of environmental and other regulations. In many European countries, extraction permissions are subjected to inquiry and authorisation at two, three and sometimes four administrative levels, from local authorities up to national ministries. During this procedure (which might end up to be quite long, lasting up to 3 years) the quarry operator should often have to submit the file of the environmental effect study to a great number of authorities, e.g. Natural Resources, Land Use or Environment Division, National River Authority, Waste Regulation Authority or Air Pollution Authority, etc. The permits can also be different according to the kind of raw material and processes or even the size and height of the plant. Throughout this consultation phase, the project is analysed, clarified and amended, until it is acceptable by all the departments involved. The positive aspect of this process is that, in general, it is highly interactive, often at a very local level. This increases the chances of the project being considered on a practical rather than on a theoretical basis.

On the other hand, with regard to the increasing environmental concerns and the concomitant steep increase in regulations, the negative aspect is that the time needed to go through the whole procedure can be excessive. In the past, several efforts have been made to compile a reference guide that would refer to the most important aspects of the Extractive Industry, as well as, to the impact of the Ornamental Stone sector activities to the environment. For example, the *Centre Terre et Pierre*[1] *of Tournai in Belgium* has issued a reference guide where real life examples of many European Countries are included. The present document can be considered as a significant effort to compile and describe "*How things are*" in the Ornamental Stones sector, namely regarding the following:

[1] Centre Terre et Pierre – Tournai (Belgium) 07/09/99 – Draft 5

- Legislation in force in the various E.U member countries;
- Environmental impact of the Ornamental Stones sector activities (the Extractive Industry as well as the Processing Plants);
- Best available techniques in the market and,
- Other issues related to both the environment and the Ornamental Stone sector, such as the growing importance of the Quality Certification, many real life examples and so on.

Furthermore, it should be noted that the point of concern for the non-metallic mineral industry is usually the environmental impact of a temporary and localised character rather than one of major ecological significance. This certainly does not mean that more significant impacts do not occur, or that the effects of minor importance should not be dealt with. The commitment of the industry to sustainable environmental management is rapidly increasing as new environmental standards and instruments are developed (e.g. the ISO 14000 Series, EMAS etc).

Drawing on the experience of quarry operators over the years, it appears that people living closely to a quarry generally suffer from very specific effects, such as noise from explosions, the start-up of engines during the morning hours, lorry traffic, etc. *Open dialogue* with the local population on these matters is critically important, since it allows the operator to take corrective actions and gives the local people the certainty that their views are really being taken into account. Living together in mutual satisfaction requires mutual respect and dialogue. This important aspect has occasionally been overlooked in the past, but now it seems that the Extractive industry and its neighbours are back on the right track. The emergence of local associations and groups allows constructive dialogue and facilitates the public consultation normally required by the permit procedure, or, if not, it should be then initiated voluntarily by the operator. Extractive industry has also become more transparent. While, for obvious safety reasons, day-to-day access to quarries needs to be restricted, open days and guided tours are often organised, contributing significantly to a growing mutual confidence.

4.2. Environmental Legislation for the Ornamental Stones Sector

4.2.1. Introduction

The environmental concerns at a global level rose to a higher level in the decade of ‘70 as a consequence of the accentuated economical development that occurred after the end of the Second World War. The strong industrial growth, based mainly on the use of non renewable natural resources with inevitable and unpredictable consequences, led to several ecological disasters. Despite of the existence of natural recovery process, it was soon concluded that these kinds of actions caused by human hand should not continue, considering the Planet survival. It can be said that public opinion and the state entities, seemed to awake and started a serious approach to the problem in order to achieve different growing development models and, as a result, environment became a priority.

At a European level, the first publications related to the environment appeared in 1968 with the “*Declaration of control on the air pollution*” and with the “*European Letter of the Water*”. After the Stockholm Conference in 1972, the first world wide conference on environment, and till the Rio Conference, in 1992, a lot of things were done, as far as environment was concerned. Nowadays, the effort that has been put in order to place the environmental issues at the same level as economic issues can not be denied. This effort created new concepts, like "*Sustainable Development*", "*Eco-management*" or "*Eco-efficiency*" among others. These concepts assume a stronger role in the "communities", helping in the development of an "Environmental Consciousness" resulting from the individual interpretation of the environmental issues, as well as the different legal dispositions imposed by the society.

The Environment Community Laws began their developing process in the Stockholm Conference. As a consequence of this conference, the Declaration of Paris (written in 1972) played a major role, since it was the basis of the first European Action program as far as environment was concerned (1972-1976). The most recent Environmental Conference took place in Johannesburg in 2002. The main goal of this conference was to assure that the revolved environmental concepts can be truly applied by the involved countries, in order to accomplish the desired "Sustainable Development".

4.2.2. European Directives

The European Directives reflect the several Action Programs of the European Community that intend to be (all together) regulative norms for all Member States and must be included to their National Legislation. In that way, it is ensured that the criteria applied in all European countries are uniform and, at the same time, that Legislation addresses specific issues. However, this process should be done with respect to the characteristics of every country's Legislation; in addition, all countries represented in the European Parliament must firstly approve the above-mentioned Directives. The E.U Directives play a regulative and guiding role and are considered as fundamental as they are the origin of most of the National Environmental Legislation of the Member States.

As far as environment is concerned, there is a large number of Directives. For the purposes of this edition and according to their direct and indirect relation to the Ornamental Stones sector, the following European Community Legislation (Table 15) was considered as the most important to be presented.

Table 15. European Community Legislation in force for the Ornamental Stones Sector

Water Protection
• Council Directive 75/440/EEC, Concerning the quality required of surface water intended for the abstraction of drinking water in the Member States • Council Directive 76/464/EEC, On pollution caused by certain dangerous substances discharged into the aquatic environment of the Community • Council Directive 91/271/EEC, Concerning urban waste-water treatment • Council Directive 98/83/EC, On the quality of water intended for human consumption • Directive 2000/60/EC, on establishing a framework for Community action in the field of water policy • Decision No 2455/2001/EC, On establishing the list of priority substances in the field of water policy and amending Directive 2000/60/EC

Air quality

- Council Directive 80/779/EEC, On air quality limit values and guide values for sulphur dioxide and suspended particulates
- Council Directive 82/884/EEC, On a limit value for lead in the air
- Council Directive 85/203/EEC, On air quality standards for nitrogen dioxide
- Council Directive 89/369/EEC, On the prevention of air pollution from new municipal waste incineration plants
- Council Directive 89/429/EEC, On the reduction of air pollution from existing municipal waste-incineration plants
- Council Directive 96/62/EC, On ambient air quality assessment and management
- 1999/24/EC: Council Decision adopting a multi-annual programme of technological actions promoting the clean and efficient use of solid fuels (1998-2002)

Waste Management

- Council Directive 75/439/EEC (16 June 1975) on the disposal of waste oils.
- Council Directive 75/442/EEC (15 July 1975) on waste.
- Council Directive 86/278/EEC (12 June 1986) on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture.
- Council Resolution (7 May 1990) on waste policy.
- Council Directive 91/157/EEC (18 March 1991) on batteries and accumulators containing certain dangerous substances.
- Council Directive 91/689/EEC (12 December 1991) on hazardous waste.
- Council Regulation (EEC) No 259/93 (1 February 1993) on the supervision and control of shipments of waste within, into and out of the European Community.
- European Parliament and Council Directive 94/62/EC (20 December 1994) on packaging and packaging waste.
- Council Directive 94/67/EC, On the incineration of hazardous waste.
- 94/741/EC: Commission Decision (24 October 1994) concerning questionnaires for Member States reports on the implementation of certain Directives in the waste sector (implementation of Council Directive 91/692/EEC).
- Council Resolution (24 February 1997), On a Community strategy for waste managemen".
- Council Directive 1999/31/EC, On the landfill of waste.

Environmental Impact Assessment

- Council Directive 85/337/EEC (27 June 1985) on the assessment of the effects of certain public and private projects on the environment.
- Council Directive 97/11/EC (3 March 1997) amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment.

Other Directives
• Directive 2000/14/EC of the European Parliament and of the Council (8 May 2000) on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors.
• Directive 2002/49/EC of the European Parliament and of the Council (25 June 2002) relating to the assessment and management of environmental noise - Declaration by the Commission in the Conciliation Committee on the Directive relating to the assessment and management of environmental noise.
• Council Directive 92/43/EEC (21 May 1992) on the conservation of natural habitats and of wild fauna and flora.
• Council Directive 79/409/EEC (2 April 1979) on the conservation of wild birds.

4.2.3. National Legislation

The increase of environmental concerns and the adoption of regulation norms led to a proliferation of international laws, both general and specific. Several adjustments were made by the national politics that led to the introduction of the new legal requirements in environmental terms. The companies of the Ornamental Stones sector, unable to deny this state of affairs, had to acquire new environmental postures. This need became more urgent with the increasing pressure by the public opinion and the media in order to accomplish the new standards.

Nowadays, the Environmental concerns (regarded as a factor of competitiveness) along with the Environmental laws, determined the self-regulation effort of the companies related to the mining industry (including non-metallic minerals and Ornamental Stones sector) to be in accordance with all standards and regulations. The mining codes include chapters dedicated to environmental protection (as an example, there are the new quarries laws, both in Portugal and Spain, that establish a relationship with other legislation that became complementary, like the Evaluation of Environmental impacts or the Licensing of waste land field in the Extractive Industry).

As a consequence of the principles of "Sustainable Development", it is necessary to consider new issues, such as identification and characterisation of environmental impacts, waste management and all aspects related to environmental and landscape recovery. The remarkable "effort" to adapt to the mining legislation can not be denied, but it is still necessary to follow the specific laws in the licensing procedures. This legislation refers to previous or complementary requirements of the extractive and manufacturing industries related to environmental issues such as water management, waste management, air quality (noise and dusts), evaluation of environmental impacts and soil occupation management (ecological reserves, agricultural reserves).

The following table (Table 16) depicts European reality, pointing out the several aspects for which regulations exist. It can be then concluded that all Member States have regulations in force, as far as mining industry is concerned, regarding all different environmental aspects.

Table 16. Active Environmental Laws in the E.U countries (adapted from "Minerals planning Policy and supply practices in Europe, Main report", cited in Magno, C, 2001)

	Mining Law	Other Excavation Law	Land Use Planning Law	Nature Conservation Law	Noise	Emissions	Water	Integrated Pollution Control	Other
Austria	x		x	x	x	x	x		x
Belgium	x	x	x	x	x	x	x		
Denmark	x	x	x	x	x			x	x
England and Wales			x	x	x	x	x	x	x
Finland	x	x	x	x	x	x	x	x	x
France	x		x	x	x	x	x		x
Germany	x	x	x	x	x	x	x	x	x
Greece	x	x	x	x	x	x	x	x	x
Ireland	x	x	x	x	x	x	x		x
Italy	x	x	x	x	x	x	x	x	x
Luxembourg			x	x	x	x	x		x
Netherlands		x	x						x
N.Ireland	x								
Norway	x	x							
Portugal	x	x	x	x	x	x	x		x
Scotland			x	x	x	x	x	x	x
Spain	x		x	x	x	x	x		x
Sweden	x	x	x	x	x	x	x		x

4.2.4. Effect of the existing legislation on the SME's across Europe

The Ornamental Stones sector has continued its modernisation efforts, through the use of the best available techniques and also through the best "Eco-management" practices. These efforts have been primarily made in order to align with the environmental legislation in force. However, as in all kind of industrial sectors, the continuous development of the Ornamental Stones Sector is related to a price to pay.

It could be argued that the majority of the companies that have developed their activities in the Ornamental Stones sector, and are either extractive or processing companies or in many cases vertical integrated, are of small and medium size. The criteria by which SME's (Small and Medium - sized Enterprises) are classified are based mainly on their annual revenues and on the number of employees. However, those criteria - especially the first one - are not the same for all European Countries. A great number of surveys have concluded that SME's play an important role and constitute the backbone of national economies.

The substantial increase of specific legislation on Environment, with direct or indirect impact in the Ornamental Stones industry, led to a rather fast adaptation. The SME's that operate in this sector have faced various changes in the last two decades. Fifty years ago, it could be suggested that the SME's managers were not even well aware of the existing legislation concerning the environment; neither were they sensitive towards its protection and restoration after the completion of the extraction and processing tasks.

Nevertheless, it cannot be denied that the environmental conscience of the sector companies has gradually developed and consolidated mainly through individual initiatives (that sometimes led to disappointing results). On the other hand, the standards and requirements of environmental legislation carry some high economic costs. The adjustment to new environmental legislation implies a change in the production process that necessarily requires a large investment and a structural change in the working process. Nowadays, it is possible to say that environment should not be considered as an economic burden on the budget of SMEs; instead, it must be encountered as a future bet for the new challenges imposed by the changes in global economy.

4.3. Environmental impact of the Extractive Industries Sector (Quarries)

4.3.1. Introduction

A compromise between the extracting activity and the environmental protection is a priority of the companies management and social policies in the E.U Member States. The Extractive Industries sector, as many others, imposes an environmental impact in the surrounding areas and creates certain problems in the immediate vicinity. However, the activities of this sector have always been important for the individual countries National economies. The extraction activities of the sector have certain unchangeable characteristics, such as:

- Rigid location (considering that the mineral beds are not movable, quarries must be located where the geological resources exist and not where we would like them to be located);
- Deals with non-renewable resources;
- Each bed is unique, considering its geological and geometric characteristics;
- A large amount of money is required when a bed is explored.

The extraction of geological resources must take into account not only the economic gains but also the environmental negative impacts. As a consequence of the “non-existence” of legislation, as far as the relation between the environment and the extractive industry is concerned, several rules were created for the European countries. These laws were created to rule the extraction activities and their environmental consequences.

Portugal is an exemplary case, as its ordinance law No. 270/2001 (responsibilities of the Economic ministries regarding the environment) intends to establish a strong relationship between quarrying activities and environment. Out of all the European legislation, this edition will mention the one related to the assessment of the environmental impact, directly applied to the quarries activities. However, this assessment is always dependent on different analysis criteria. When considering all the above facts, the impact (positive or negative) is usually named as “*non significant*”, “*significant*” or “*very significant*”. For this reason, it is important to explain the criteria that are internationally accepted.
The social-economic impact is usually classified as “significant” when it implies changes in population, lifestyle, high investments and undeniable consequences in the economic activity or employment. The impact is “very significant” when the extension of the areas and population justify it. On the other hand, the negative impact on the soils is considered “significant” when it appears on a considerable area. A negative impact is also considered “significant” if any violation on the air and water quality patterns is registered. The negative

impacts in fauna and flora are considered "significant" if any important change in the ecological process appears, affecting most species directly of indirectly regarding their population and diversity.

A typical example of a significant negative impact occurs when the industrial units (quarries or processing plants) reach a natural reserve. If any rare species is endangered by that, or if a large area of the natural reserve is affected, the negative impact will be considered as "very significant". The landscape criteria are much more subjective, but they are considered to face a significant negative impact if any rare or valuable aspects related to landscape are affected.

There are some publications that classify the negative impact as "significant" when it induces in a certain area cultural or religious conflicts with the neighbouring populations and with previously established environmental or development laws. The environmental impact is also usually analysed according to the different phases of production: namely construction/implementation, full activity and end of the extraction activities.

The correct approach must respect the different diversity levels, the relative dynamics related to the different scales as well as the general impact characterisation according to: the action type, the occurrence moment, its effects in time and space, the reversible actions, the recovery level and the existence of minimisation actions. The following schematic diagram (Figure 112) explains the evaluation of environment impact for Extractive Industries.

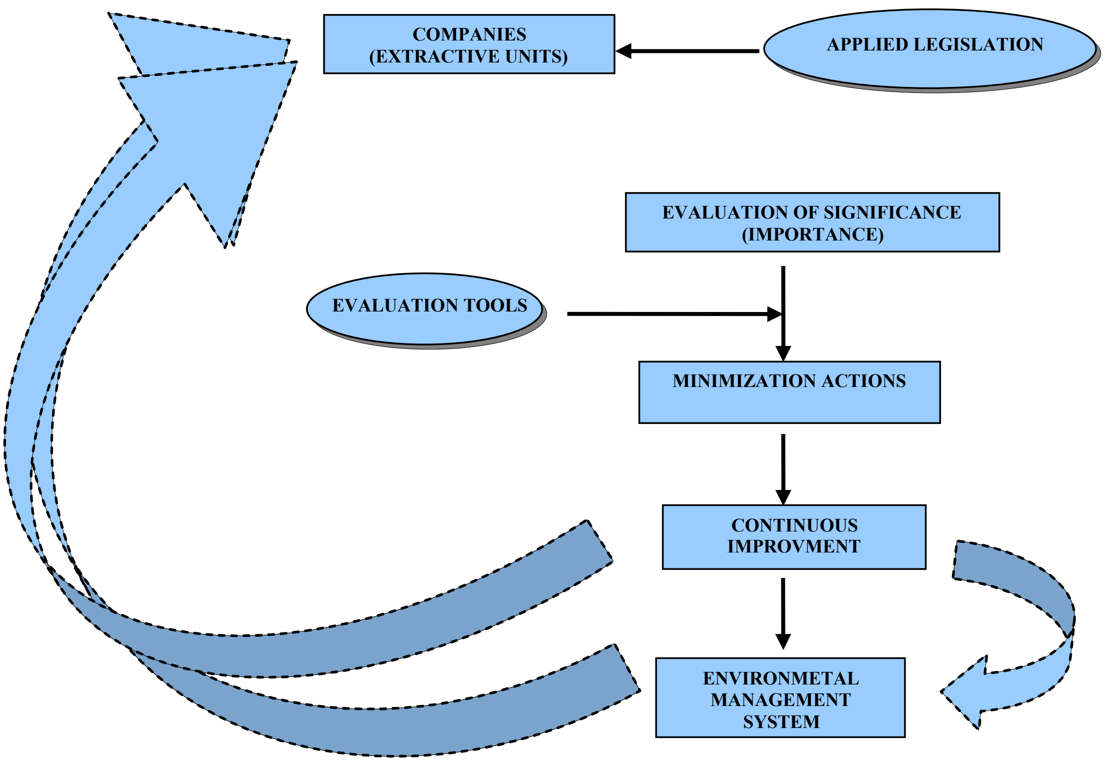

Figure 112. Environmental impact scheme for Extractive Industries.

4.3.2. Main environmental impacts as a result of Extractive industry

The extractive units are located in places where the resources are. For this reason, it is impossible to eliminate the biophysical degradation in the source. The best that can be done is to minimise the conflicts created by this activity. The main environmental categories affected by the Extractive Industry's activities are as follows:

a) Water resources
Analytically, the main types of water resources that can be affected are:

- Superficial water lines interception from the extractive unit (or any other structure related to that);
- Underground water resources;
- Water use in the productive process;
- Residual water's drain.

The existence (or not) of superficial drainage is related to the rocky substrate and the area morphology and may have consequences in the activity development. The fact that most extractive units are usually placed in ditches causes a contact with underground waters especially in the cases of carbonated rocks existence. The extractive process necessarily includes the use of water and consequently the water consumption impact is inevitable. Finally, there are two sources of water drainage, one is a result of the productive process and the other one is the result of the domestic waste water.

b) Fauna and Flora
In order to evaluate the impact of the Extractive industries on the biotic environment, it is first of all necessary to know the ecological importance of each place, its biodiversity, hemeroby, etc. As a consequence, a fauna and flora survey is needed in order to establish a comparison reference for the area under consideration (that has different climates, soils and geology). Most of the times, and considering flora as an example, when comparing data one concludes that the native flora had already been changed before the existence of the quarry.

On the other hand, the native flora detects new ways for its survival. In an industrial landscape, it is possible to find new biotops, like the waste land field (a hiding-place biotope) and the small vegetation areas that become feeding biotopes.

c) Social and Economic issues
It is very important to mention the benefits of the extraction activity on the society and National economies that arise from the direct and indirect jobs wealth, besides the innumerable activities associated to it.

d) Cultural Patrimony
The impacts of extraction activities on the cultural patrimony are not common, considering the fact that the responsible authorities do not allow any influence in the cultural patrimony. However, any patrimonial value must be considered before the opening of an extracting area.

e) Soil
The extraction activity has always a significant impact on soil. The storage of waste rock and mud, the necessary equipment and the access on the cutting area lead to considerable negative impacts.

f) Air quality
The extractive units have always some effects on the air quality basically through noise and dust emissions. The emission of air pollutants is always present due to the existence of several vehicles in an extraction unit. However, this can not be considered as very significant air pollution.

The quarry dust mainly consists of solid particles from the uncovered surfaces, such as access roads, the excavation and the waste land fields, that are always suffering the wind action. The industrial vehicles also create some dust while moving in the quarry facilities. In addition to that, it can not be neglected that cutting equipment is also responsible for dust generation.

g) Noise
There are two different kinds of noise: the industrial noise and the environmental noise. The industrial noise is directly related to the workers occupational health, while the environmental noise can be defined as the noise emission that is expanded out of the cutting area. This kind of noise becomes very significant in the cases where the extractive units are located near houses or any other kind of infrastructure. However, if the extractive unit is included in a nucleus of many other units, the noise that it creates will always be inferior to the noise created by all the nucleus units. In that case, the need of a common solution is evident and must always be based on the Regional Regulating Plans.

h) Landscape
The visual impact of the extractive units on the landscape is related to their activity characteristics, such as the constant presence of heavy machinery (mobile or not), the extracted product storage as well as the waste storage.

It is important to realise that, most of the times, the extractive unit belongs to an extractive nucleus that itself forms an industrial landscape. In that case, it can be said that the visual impact of one extractive unit is not significant considering the visual impact of the surrounding industrial landscape.

4.3.3. Environmental Negative impacts of the Extractive Ornamental Stones Sector and suggested minimisation actions

The main environmental negative impacts of the Ornamental Stones sector and a number of suggested minimisation actions are described in the following paragraphs.

a) Superficial lines interception by the extractive unit or by any structure associated to that
In this case, the units must conduct studies to find out any other available alternatives. If it becomes impossible to adopt other alternatives, it will be necessary to create ditches in order to change the water courses and preserve the quality and quantity of the existing superficial water resources. These ditches must have the right dimensions and shape in order to assure that all their creation intentions are achieved.

b) Influence on the underground water resources
This is a real problem originating from the Extractive industry activities. Minimisation actions must always be assured when water is pumped from the quarry as a continuous water flow in the equipment (as in the Ornamental Stone sector). If that water amount is significant it must be pumped out of the cutting area and inducted to ditches that re-direct it to the water course.

c) Using water in the productive process
Water recycling is an important aspect in the Extractive units internal policy, since it has a direct influence in the company's economy. There are several processes for water treatment. The most common treatment involves pumping the water out of the quarry into decantation tanks and the use of this water in other equipment at a later stage. However, there are still some companies that do not reuse the water from the productive process.

d) Water drainage
There are two different types of wastewater: one resulting from the productive process and the other that results from domestic use. The waste water from the productive process must be reused. The extra water that can not be used in the productive process must be directed into natural superficial water-lines. As far as the waste water from domestic use is concerned, there are two possibilities. One proposes its connection to the sewer system. The other one recommends the construction of an adequate septic tank.

e) Cutting the superficial soil's layer
An important aspect in cutting the superficial soils layer is the separation of soil and waste. The superficial soil's layer must be temporally stored and, at a later stage, used in the abandoned quarries. These abandoned quarries must be filled in with material from the waste land fields and covered with superficial soil to achieve a complete recovery.

f) Waste storage in waste land fields
The problem of waste disposal strongly affects the Ornamental Stones sector. In almost every extractive unit of the sector only 20,5% of the extracted material can be used for ornamental purposes, while the remaining 80,5% are wastes. For example, in order to extract 20m^3 of commercial material you need to extract almost 100 m^3 of stone. The only possible solution for this problem is the utilisation of the extracted material in other uses, such as in road construction.

g) Absence of noise emissions
Not all units need to measure their noise emissions; however, there are some cases considered as imperative that need the implementation of minimisation measures.

h) Waste management
The waste produced by the Ornamental Stones sector activities must receive proper treatment by certified companies.

i) Lack of environmental licensing
The majority of the extractive units that use public water resources are not licensed for that. In those cases, it is extremely important that the licensing entities have an exclusive control about it. The main problems, among others, are the illegal disposal of waste in water lines and the lack of septic tanks licensing.

j) Decrease of air quality
The main source of dust emissions is the existence of non-paved areas in the extractive units that are constantly submitted to the wind action aggravated by the permanent vehicles circulation. In order to solve the problem, all roads in extractive units should be paved.

4.4. Environmental impact of the Processing Plants

4.4.1. Introduction

The Ornamental Stones processing is performed in industrial units usually located near the extractive units. These industrial units have some common characteristic operations like cutting, sawing and polishing. The blocks extracted from the quarries are transformed into slabs, tiles, wall covering, window sills, tops, etc. The process of transforming the natural stone into a final product consists of a group of operations that are realised with the objective of transforming the stone block into products for several uses in the form of civil construction material.

Processing usually starts by gang sawing (sawing equipment with several blades) while, in some cases, the block has been previously subjected to a primary squaring process. At the beginning, after arriving at the factory, the blocks to be processed are placed in an area called "*park of blocks*". In this area the blocks may, or may not, be primarily processed in order to obtain a square shape and by this way pass through the following operations sequence:

Sawing: sawing of blocks in slabs of several thicknesses. This operation is performed in gang saws that produce slabs with a standard thickness.

Slabs park: the slabs resulting from the sawing operation are kept in this area, waiting to be sold or to proceed to the next processing phase.

Polishing of slabs: this operation refers to the polishing of slabs that come from sawing. The equipment used is a slab polisher with a siliceous carbide abrasive with different grain sizes.

Cut in bands: this operation is performed with bridge cutting equipment.

Dimensional stone work: this phase represents the work done for producing material of non standardised dimensions, e.g. kitchen tops, bathroom tops, windows, etc.

Line production: in the production lines, standard tiles dimensions of 30,5x30,5 cm, 40x40 cm and 60x30 cm are obtained.

The environmental impact in the processing phase of Ornamental Stones is quite different of that resulting from the extractive units due to the obvious differences (in size and type). On the other hand, it is possible to face some environmental problems in the processing units that do not exist in the extractive units. However, the current legislation does not require the evaluation of environment impacts in the processing units. The fact that most processing units are located in industrial areas assures the realisation of some environmental measures. The environmental impact of the processing units is related to air pollution, waste and water management and some minimisation measures are applied in order to prevent any risky situations.

4.4.2. Negative environmental impacts of the Ornamental Stones Processing Plants and suggested minimisation actions

The transformation of Ornamental Stones into final products has several types of negative environmental impacts and a lot of minimisation actions are suggested, as follows:

a) Dusts

Dust from the processing units originates mainly from the stones finishing phase, since all other phases are performed in a wet environment. In addition to that, dust is created also after polishing or other special finishing work. There are several minimisation actions for dust emission control, among which the following ones are the most commonly used:

- Frequent cleaning of all equipment;
- Use of dust reception system, such as aspirating cabins, water curtains and aspirating desk;
- Use of water throughout the whole productive process;
- Factory construction planning with the adoption of the best ventilation system considering all the characteristics of the production process and the dominant winds.

b) Noise

The processing units use special equipment that transforms the extracted product into a commercial one. The main sources of noise are the following:

- Crashes between stone and metallic materials;
- Equipment motors;
- Noise caused by the action of saws, polishers and discs.

Some of the minimisation actions used to prevent noise emissions are listed below:

- Preventive and regular maintenance of all equipment;
- Use of absorbent material;
- Work in closed and isolated areas;
- Stand away from the noise sources.

c) Waste residues

The Ornamental Stones processing plants produce large amounts of waste residues from the cutting, sawing and polishing phases. As a consequence, large quantities of mud are produced. Mud is the final result of the contact between water and stone dust and it is considered as the most negative environmental impact of stone processing plants. The large quantities of produced mud create some storage problems and may influence the biophysical characteristics of the surrounding area (soil occupation, water resources, landscape, etc). Besides mud, the processing plants produce some other kinds of waste residues, such as used oils scraps and urban garbage.

Depending on the different types of produced wastes there are different minimisation actions to be considered, such as:

- Drying of the produced mud through a special decantation system;
- Reuse of mud in construction works;
- Collection and storage of the used oils, as well as other waste;
- Work in collaboration with specialised recycling companies.

d) Water
Water is an indispensable resource through all the processing phases of Ornamental Stones. Cutting and sawing would be impossible without water. Water also plays an important role in the minimisation of the impacts caused by dust emission and its impact is related to the fact that wastewater discharges may affect water resources.

The most commonly used minimisation actions related to water are the decantation system and the water reuse. Water reuse represents an important action not only because it reduces the cost but also because it helps the protection of water resources, especially in areas where it does not abundantly exist.

4.5. Best available techniques (equipment and methodologies)

4.5.1. Introduction

Presently, the technical and technological evolutions associated to environmental issues are highly important to the companies' productive process. All companies are becoming aware that the minimisation actions are decreasing the environmental impacts associated to the Ornamental Stones industry, both in the Extractive and in the Processing phases. It is important to remember that new equipment, as well as better work practices, contributes to a better environment.

4.5.2. Quarries

The best available techniques for environmental protection in the different phases of a quarry are listed below.

<u>Dust control</u>

- Pneumatic hammers with a dust avoiding system;
- Pneumatic hammers using water to prevent dust;
- Perforators using water to prevent dust.

<u>Noise control</u>

- Noise reduction in its emission source;
- Pneumatic hammers with silencers;
- Isolated environment facilities;
- Use of materials that can soften vibrations;
- Standing away from the noise sources;

- Acoustic barriers;
- Using vegetation to attenuate the noise;
- Special control during explosions.

Residues/ waste control

- Improvement of the workers qualifications;
- Use of a decantation and recycling plant.

4.5.3. Processing Plants

The best available techniques for environmental protection in the different phases of a Processing plant are listed below.

Dust control

- System for dust collection;
- Use of water throughout the whole productive process;
- Desks with aspirators;
- Cabins with aspirators;
- Fans of powder aspiration;
- Water curtain.

Noise control

- Reduction of noise emissions;
- Creation of isolated facilities;
- Use of materials able to soften the impacts of a vibration;
- Standing away from the noise sources;
- Workers protection;
- Silent cutting disks.

Residues/ waste control

- Decantation recycling plant system;
- Press and drying system;
- Decantation tank;
- Water reuse.

4.6. Environmental awareness

4.6.1. Introduction

During the last decades, the Ornamental Stones sector, both in extractive and processing units, has been assimilating several concepts related to environmental issues. Each company works towards a better environmental posture and considers the inevitable relation between its activities and environment. The extremely important role played by governments through the creation of new laws and specific programs (like sectorial voluntary agreements) can not be ignored.

Some practical examples that try to illustrate the different approaches to the environmental problems in the Ornamental Stone sector are presented in the following paragraphs. These new approaches are mainly political ones and try to solve the existing problems through an environmental management system.

4.6.2. Voluntary sectorial agreements

In order to minimise or even eliminate the environmental problems, the government institutions and the companies of the Ornamental Stones sector established an agreement according to which they should respect and follow the current legislation and adopt a correct environmental practice. All companies that signed this agreement were submitted to a diagnosis and to an environmental audit that identified their strong and weak points, establishing the intervention areas. These audits pursued the following methodology:

- Description of the activity and its functional characteristics;
- Characterisation of the current environmental quality;
- Evaluation of potential positive and negative impacts;
- Global impacts evaluation;
- Synthesis of strong/weak points;
- Intervention plan.

The agreement and the consequent environmental audit were extremely well accepted by the companies managers and owners and allowed them to reach the following objectives:

- Environmental awareness;
- Creation of environmental diagnoses that allow the evaluation of a company's environmental situation;
- Implementation of corrective/preventive measures, according to the diagnosed situation;
- Technical support to the industrial managers.

After this agreement, a new environmental posture was adapted and companies began to create/maintain an environmental system that allowed appropriate environmental measures along with the companies development.

4.6.3. Environmental Certification (ISO14000, EMAS)

Companies realised that environmental protection is not only a good marketing factor but also an extremely important subject to the company's production and to society. Most companies confront their environmental problems only during their environmental certification. Considering the diversity and multiplicity of the environmental problems of the Ornamental Stones sector, several environmental management systems were created. Out of all existing systems, ISO14001:1996 (Environmental management systems) and EMAS (Eco-management and audit scheme) are the most important ones.

An environmental management system allows the correct use of natural resources (water, energy and all kinds of raw material) and this is major benefit for the companies. The environmental management systems allow also:

- Better use and control of the raw material;
- Pollution prevention and reduction of the wastes amount;
- Cleaner technologies and products creation, targeting to new markets;
- Reduction of the costs associated with energy, waste management and water use/treatment;
- Prevention of environmental accidents and elimination of the costs resulting from negative publicity and possible sanctions.

The environmental certification of a company consists of an evaluation (made by an independent and specialised entity) of the company's Environmental Management System according to existent models. The models that are internationally accepted the most are ISO14001 and EMAS. These two models contribute to the companies competitiveness in the global market.

The number of clients that demand an environmental certificate is increasing everyday and the certifying companies need to create a response in those requests. During the certification of an Environmental Management System the main problems pointed out by the certifying companies are the specific environmental training, the waste management and the lack of environmental conscience. The employees training, the technical changes, the analysis of the environmental impact and a better information system are some of the necessary changes in a company that decides to apply for an environmental certification. In addition to that, all employees need to know what the certification is; they also need a specific training that will provide them with the necessary tools to create an environmental culture inside the company. The knowledge and the rigorous quantification of risks and environmental impacts are, perhaps, the most significant changes that certification causes. The environmental risks are better known, fact that enables the evaluation, control and improvement of the environmental measures.

The improvement of the company's image is the most frequently mentioned advantage of a certification. For a company it is important, if not crucial, to be recognised by both the public opinion and by the environmental authorities as a "*green company*". This situation implies a better production system. As far as the economic/ financial gains are concerned, it is impossible to obtain them in a short term basis, considering that these structural changes influence productivity and allow better consumption and waste management. Besides that, the environmental certification proposes new technological and legislative environmental challenges to the companies.

4.6.4. Case studies

It is important to mention some practical cases related to land rehabilitation and to specific impacts management. Most of these case studies reveal environmental awareness and all of them can be found in the book entitled "The better environment practices in the Extractive Industry. A reference Guide" (2000) published by the Geological Mining Institute of Lisbon.

The case studies intend to be an example of the European current situation and are all related to environmental consciousness and to corrective actions for specific environmental problems.

A. Noise and vibration case study
Silent starting engines for machines and loaders
Milieu Quarry (Belgium) – Limestone quarry

In the region of Tournai (Belgium) there are several quarries that have managed to establish a good relationship with the neighbouring populations. Many people live near the quarry, including most of the quarry workers. One of the main problems is the noise emission. In a quarry that extracts 4 million tons/year of fragmented blocks, noise is mostly generated due to the extraction equipment such as "dumpers" and "loaders". In order to avoid this kind of noise (mainly due to the morning outburst of the motors), the quarry manager opted for a silent starter system. The smaller dumpers of 35tons were replaced by other with a cargo capacity of 85tons. These new dumpers are better equipped and have computerised systems that allow a better time and consumption management. A lot of reduction measures were applied to the loading and transport equipment and managed to considerably reduce the intermittent noise. The classic noise reduction measures, like construction of soil piles or soundproofing unload stations can also prevent some noise emissions, a fact considered positive by the community (after that, they consider these areas as "*quite areas*"). When compared to the constant noise in freeways or highways that cross the urban areas, this noise can not be considered as particularly excessive.

B. Dust control case study
Drastic dust reduction
Rübeland quarry (Germany) – Limestone quarry

The Rübeland quarry extracts limestone and was completely remodelled and reorganised targeting mainly on improving its air quality. A photograph of the quarry facilities in 1991 shows the great efforts that have been made in order to achieve this improvement. All the grinding facilities were reconstructed and turned into closed areas, the use of water was generalised and all the outdoors storage areas were removed.

All possible sources of dust emission were equipped with filter systems. In 1989, 242 tons of dust were produced while, in 1997, the residual dust discharge was only 11 tons. This quarry was recognised by the EC–ECO Audit ordinance and certified according to ISO14001 Standard.

C. Visual impact case study
A thirty-year landscape recovery
Basin of Marquee (France) – Limestone quarry

In the Boulonnais region of France there are 5 quarries that exploit a limestone bed with an annual production of 8 million tons. For geological reasons, the most important problem that these quarries face is that for each 2 tons of extracted material there is 1 ton of unrecoverable soil (sandy, loamy). Since it was impossible to store the covering soils in the quarry's bottom for a long time, an original solution was found. The quarries association elaborated an innovative recovery plan that would solve the problem in 30 years. After studying the local landscape, the architects proposed the construction of an artificial hill (similar to the natural hills, of no more than 60 m height) with slope and prolongations parallel to the rivers and quarries. This project, presented by the quarries directors with the support of local associations, was approved by the local entities and communities after a three-year discussion. Nowadays, artificial hills are something that belongs to the past and the natural roads band rivers were preserved to complete the landscape recovery while several trees were planted in those hills.

D. Water management case study

Water treatment recycling
German industry – Ornamental Stones Industry

During Ornamental Stones extraction, water is abundantly used to cool the cutting and production equipment and to remove abrasive agents and small particles produced by cutting and polishing. Even if there are no harmful additives in the water circuit, those small stone or metal particles are not allowed to be dumped in superficial or underground water courses. The German Ornamental Stones Industry particularly respects the lower limits imposed by law. For that reason, very expensive facilities were built to recycle and filter the used water. As a result, 90% of the treatment water comes from the internal recycling system.

E. Biodiversity management case study
Quarries and extractive industry (Ireland) – Limestone

Hawk population is growing in 7 different regions of Ireland. These regions have a common characteristic: the presence of quarries. From all 35 quarries – half of which are still in operation – 14 of them have nests of migratory hawks.

F. Recovery case study
Quarries recovery into urban green spaces
Cerca de Sto António in Estremoz (Portugal) – Marble quarry

After the shut down of this marble quarry it was necessary to convert it into urban green spaces because it was located in one of the main city road accesses. This project had several phases among which the most important one was the complete filling of the extraction cavity with the existent wastes, the construction of an artificial water line and an artificial lake was created filled with water from other quarries, and the creation of leisure areas with planted vegetation. By this way, the area is intended to get a higher value and receive some proper use since it was constructed as part of the surrounding environment adjusted to the population needs.

4.7. Conclusions

As a conclusion it can be said that the industrial Ornamental Stones sector is trying to set free from all the negative aspects for which it is responsible. The individual companies actions as well as the measures adopted by governments or by community exhibited some good results in the creation of an environmental awareness. Even though things are on the right track, there is still a long way to go.

The emergence of new instruments, like the new specific legislation on the rules related to the environmental certification, helps companies to achieve a positive environmental position. The companies actions are not only taking into account the environmental legislation but they also consider their company strategy and objectives.

Nowadays, all the E.U Member States have legislation in force that is directly or indirectly related to the Ornamental Stones sector, assuring rules that are able to solve the major problems. However, legislation is restrictive and inadequate for some special situations, despite of the continuous effort made by the official entities. This restricted and inadequate legislation can make companies unable to abide by the law. Considering the great amount of norms and legislation that have been created by the European Union and transposed to the National legislation system of each Member State, it becomes very difficult for each legislator to interpret them and support their practical applications.

In order to achieve the desired structural development of the Ornamental Stones sector companies, it is absolutely necessary to establish an environmental compromise between the legal obligations and the companies economic viability. The existent legislation in the European Union is quite specific, fact that allows a rigorous industrial control. However, the economic agents unofficially force the companies to first consider the economic gains and then the environmental benefits. The new rules as well as the public opinion have forced both the companies and the economic agents to create and maintain "*environmental friendly products*". In cases where the environmental rules are not followed all the industrial activity is in danger.

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Glossary

Abrasive slurry: slurry consisting of water and abrasive, used for wire sawing.

Accident statistics: Accident data collection and their subsequent analysis and mathematical processing, which allow the identification of risk prevention methods.

Accident: Occasional event, result of an unexpected situation, causing injuries or material damages.

Arenite: Consolidated sedimentary rock mainly composed of sand- size detrited fragments or mineral grains. Usually the term is used with a prefix that refers to its composition or origin, e.g. quartzarenite.

Arm polisher, hand polisher: Power driven machine for rubbing or polishing, consisting of a polisher mounted on a swivel arm. Generally, it is hand operated.

Axed finish: Rough and rugged surface achieved by using a punch or axe.

Bank of quarry: Rock portion in a quarry, having the form of a bank or step.

Basalt: Scientific definition: volcanic rock consisting essentially of plagioclase (labradorite-anorthite) and pyroxene that includes a fine grained dense fabric. Commercial definition: basalt is a mix of pure basalt, picrites, diabases, dolerites and microgabbros.

Bed: The quarry area, in which the bank will be turned over, prepared by a mixture of mud, loam and stone detritus (bed) so as to mitigate the bump of the bank at the horizontal level during the turnover. The bed is prepared by a power shovel or an excavator.

Belt polisher: Automatic machine consisting of a feed belt and a series of polishing heads with varying grit sizes.

Block cutter: Sawing machine consisting of a horizontal diamond disk and a series of vertical diamond disks, used for the production of standard-sized dimensional stone.

Block saw: Bridge saw fitted with a large diamond disk used for primary sawing.

Block: It consists of extracted quarry rocks and is the basic raw material of the Ornamental Stones industry.

Bridge saw: Saw consisting of a beam carrying the cutting head, placed at right angle to the bench.

Brill of perforation: Steel rod of variable length with a sharp bridge in one end, used in perforators.

Bush hammered finish: Finish obtained by using a bush hammer (percussion tool for surface roughening, with a square head and a few pyramidal percussion teeth or points) or a bush hammering machine (machine consisting of feed rolls and an overhanging beam supporting a pneumatic bush hammer).

Calcarenite: Limestone consisting predominantly of recycled detrital calcite grains of sand size.

Calcite: Mineral, very common in some sedimentary and metamorphic rocks; formula CaCO3; three-morphous with aragonite and vaterite.

Calcitic dolomite: Carbonate rock containing 50 to 89 % dolomite.

Calcitic marble: marble containing more than 90% calcite.

Calc-schist, carbonate mica-schist: Schist containing carbonate minerals at a lower proportion than marble.

Calc‐ silicate marble: Marble with calcium and partially magnesium silicate minerals.

Chain saw, diamond belt saw: Mechanically powered cutting device consisting of an engine section travelling on tracks and a 3 to 4 m long cutting arm, around which a diamond-tipped endless chain is driven.

Chiselling: Dressing of a stone surface with a chisel.

Cipolino marble: Calcium silicate marble with band coloured structure, consisting of layers of calcite or dolomite grains mixed with variable quantities of silicate minerals.

Claw chisel, tooth chisel: Percussion tool with a toothed edge.

Collective protection: equipment, devices and measures aiming to prevent working accidents or occupational diseases, through the protection of all workers in a working position. Typical collective protections are safety signalling, safety standards.

Corrugated, reeded: Surface finish, formed by parallel semi‐ cylindrical grooves carved in the rock.

Cushion of air: Device used in the quarries that consists of a bag with fine metallic walls or rubber. This device can be inserted in a vertical cut done in the bank and when filled with air, it causes the bank removal.

Derrick control: Electrical device that allows control the derrick from a distance.

Derrick: System for the extraction of blocks and other materials from the bottom of the quarry, formed by a fixed pile piece and a rotating mast, capable to swivel in a full circle. It is used, mainly for the extraction of the rock blocks, although it can also remove debris and transport equipment to the interior of the quarry.

Detonation: Violent combustion with propagation speed superior to that of the sound, accompanied by a shock wave and heat.

Diamond gang saw: Sawing device consisting of one or generally more metallic blades with diamond coated edges, used for cutting rough stone blocks by the abrasion produced due to the backwards and forwards movement of the blades.

Diamond pearl: Covered cylinder of electrodeposited or sintered diamond that constitutes the sharp agent of a diamond wire and is used in order to promote rock cutting.

Diamond saw finish: Smooth finish resulting from sawing a block with diamond blades.

Diamond wire: Cutting equipment formed by a steel twisted cable of 5mm thickness, on which the diamond pearls and separators are threaded.

Dimension stone work: Stone element prepared to specific dimensions for inside or outside application with a thickness of 80 mm.

Dolly pointed finish, point finish: Semi‐ rough finish achieved using a four pointed dolly point (bush hammer with four pyramidal percussion teeth or points).

Dolomite: The mineral CaMg(CO3)2, commonly with some Fe, which has replaced Mg (ankerite); carbonate rock with high percentage (90 to 100%) of dolomite.

Dolomitic limestone: Carbonate rock with a certain percentage (10 to 49%) of dolomite.

Dolomitic marble, magnesian marble: a marble containing more than 90% dolomite.

Dose: Amount of absorbed or deposited substance on the human organism for a certain amount of time.

Dosímeter (Acoustic): Portable equipment used to measure the exposure of workers to noise during the working period.

Dressing: The shaping and squaring of stone units prior to fabrication.

Dumper: Vehicle for soil transportation, self-propelled, with an inclinable box. It is also denominated as quarry truck, being used to transport the sterile for the spoil.

Dust: Particle of reduced dimensions and weight, that stays in the air and can be inhaled. Depending on its nature, it can present several risks.

Edge polisher: Machine fitted with grinding and polishing heads for edge-polishing, and sometimes for edge-chamfering and cutting drips.

Edge treatment: Grinding or other treatment made to give a continuous and regular‐ shaped profile to the edges of the stone unit.

Edge: The side which runs opposite to the panel face and borders the surface area of the panel. In particular, the side of a stone unit, whose dimensions are determined by the thickness and height of the panel.

Ergonomics: Science that studies and designs the working places in order to be comfortable for the people who occupy them. The systematic application of knowledge about the psychological, physical, and social attributes of human beings in the design and use of all things, which affect a person's working conditions: equipment and machinery, work environment and layout, the job itself, training and organisation of work.

Excavator: Machine with a shovel or "spoon" at the end of the articulate arm. It is mainly used to open ditches.

Explosives: Unstable chemical substances capable to free energy and produce fragmentation. Explosives handling and storage require special care and should be done by specialised personnel. The explosives most commonly used are: gunpowder, gelamonite and string detonating.

Extraction: Operation that aims at transporting the rock blocks from the bottom of the quarry to the surface.

Falling from one level to another: falling from one level to a lower level with deadly or serious outcome.

Falling on the same level: falling on the floor from the same level or from a slightly higher level.

Filled finish: Having natural voids in the surface of the stone filled with putty, shellac, and resins or other materials.

Finish: Final surface applied to the face of a piece of rock during fabrication.

Flamed finish: Surface texture obtained by thermal treatment of the stone using a high temperature flame.

Flaming machine: Machine consisting of feed rolls and an overhanging beam supporting a torch moving along the beam.

Gang saw, frame saw: Cutting device consisting of one or generally more metallic blades mounted on a frame, used for cutting stone rough blocks by the abrasion produced by the backwards and forwards movement of the blades, adding a slurry of water and abrasive into the cut.

Gneiss: A metamorphic rock mainly consisting of quartz, feldspar and mica, in which bands rich in granular minerals, such as feldspar and quartz, alternate with bands of planar minerals like mica. It may derive from an igneous rock (orthogneiss) or from a sedimentary rock (paragneiss).

Granite, black: A commercial term for black or dark coloured igneous rocks.

Grinding machine: Automatic machine generally consisting of a feed belt and a set of heads with varying grit sizes.

Groove: A channel of rectangular or circular cross section cut into a slab.

Ground finish, abrasive finish: Surface treatment (e.g. by means of a grinding disk bonded with silicium carbide) to produce a flat, uniform finish. Rough ground finish is obtained by a coarse grinding agent (e.g. silicium carbide of grain size F.60); medium ground finish is obtained by a medium grinding agent (e.g. silicium carbide of grain size F.120); fine ground finish is obtained by a fine grinding agent (e.g. silicium carbide of grain size F.220).

Ground finish: Surface treatment with coarse abrasive aiming to eliminate the main surface irregularities.

Guillotine, splitting machine: Machine used for the fabrication of split faced pieces of stones.

Hard way, head, tough way: Plane at a right angle to the rift and the grain, along which splitting is most difficult.

Health and safety at work planning: documentation related to the working positions, including analysis and assessment, aims and measures for implementation.

Hearing Protection: Individual protection equipment used to reduce noise effects. There are four types: inserted in the external auditory channel (lids or headphones); covering the whole pavilion headphone (auscultator); covering substantial part of the head of the whole pavilion headphone (helmet) and the active protectors.

Helmet: Personal equipment for head protection, which aims at protecting the user of any risk inside the quarry.

Honed finish: Surface finish having a dull polish or matt surface.

Hydraulic splitter: Splitting device consisting of a hydraulic pump unit operated by an electrical or combustion engine and one or more rock-splitting cylinders.

Key-way: Opening in the bench, made at a right angle to the bench, to enable further cutting operations.Limestone: A sedimentary rock consisting primarily of calcite, $CaCO3$.

Ladder: Wood or metal utensil formed by 2 longitudinal plumb lines connected by vertically fastened steps regularly spaced. They are used to access work positions that are higher or deeper from the level the worker is. Ladder use requires appropriate safety measures.

Marble: Scientific definition: Metamorphic rock containing more than 50% of carbonates (calcite or dolomite), formed by metamorphic re-crystallisation of a carbonate rock. Commercial definition: Compact and polishable natural stone, used in decoration and building, mainly consisting of minerals with hardness between 3 and 4 on the Mohs scale (such as calcite, dolomite or serpentine), e.g. marbles as per the scientific definition and cipolino marbles, as well as the following natural stones, provided that they are capable of taking a mirror polish: limestone marbles, limestones, dolomites, calcareous breccias, travertines and serpentinites.

Mask: Equipment of personal protection, adapted facially and covering the breathing zone. Mask is used with the aim to protect the workers that have to stay in polluted atmospheres or that work with dangerous substances.

Matt finish: Surface treatment (e.g. by means of a silicium carbide bonded polishing disk with grain size F.400), to produce a very flat, uniform, but not polished finish.

Modular tile, cut to size tile: A modular tile is a piece of natural stone in standard sizes, obtained by cutting or splitting at a thickness less than 12 mm. It is fixed to a structure by means of mortar or adhesives.

Monoblade gang saw, cross cut saw, crosscutter: Frame saw fitted with just one blade and used for block squaring and primary sawing.

Multi-disc circular saw: Machine for stone cutting, consisting of a bridge saw fitted with a series of circular saw blades used for dimension sawing.

Natural cleft finish, rock faced finish: Finish for metamorphic rocks, such as slate and quartzite, resulting from splitting or separating stone along the cleavage plane and showing the natural rock face.

Natural stone product: A worked piece of naturally occurring rock used in building and for monuments.

Natural Stone: A piece of naturally occurring rock.

Noise: Unpleasant sound, continuous or momentary, that, in excess, can provoke occupational deafness.

Occupational disease: Legally, it is a pathological condition as a consequence of working in those activities included in applicable legislation, due to substances or factors effects as defined for every disease. Its outcome could occur several years after exposure.

Perforator: Machine that is generally used to drill horizontal holes of about 10 cm diameter, through which the diamond wire passes.

Personal protection: protection method related to one or several risks encountered by an individual worker.

Personal protective equipment (PPE): It represents any kind of equipment and its accessories used to protect worker health and safety from working position risks.

Pneumatic Hammer: Machine used to fragment the rock, with the objective of opening holes of about 4 cm diameter, to pass the diamond wire, or to stack up explosives.

Pneumoconiosis: Lung lesion, occurring due to inhalation of mineral and other dusts.

Pointed finish: Semi- rough finish achieved by using a point chisel.

Polished finish: Surface treatment (e.g. by means of a polish disk or felt) to produce a high gloss finish.

Polishing line: Automatic machine generally consisting of a feed belt and a series of heads with varying grit sizes.

Power shovel: Used to drop the slices in the phase of the dismount, being equipped with an own lance in the phase of the removal. It is used to fill the dumpers with the sterile (equipped with bucket) or to transport the rock blocks (equipped with forks).

PPE (Personal Protection Equipment): It refers to the main, as well as any complementary or accessory equipment, used by the worker for protection from risks that he is exposed to. The equipment should be: comfortable, robust, light and adapted.

Prevention: activities to avoid or decrease occupational risks by means of measures or provisions to be implemented in the work design and development phase, as well as in the whole enterprise activities.

Professional disease: Legally, it is defined as being a pathological state that is a work consequence. The disease can be manifested several years after the exposure.

Profile cutter: Machine fitted with router bits or profile wheels for obtaining moulded edges.

Protection glasses: Protection equipment aiming to protect the operator from risks originating by particles flying, radiation, etc.

Protection mask: Personal protection equipment aiming at protecting the worker from the risk of aggressive agents inhalation.

Quarry front: The part of the quarry where rock excavation takes place.

Quarry: Extensive excavation for exploration of mineral masses (usually rocks), surface or underground.

Quartz, silica: Very common mineral of the formula $SiO2$.

Quartzarenite: Sandstone cemented by silica, which has grown around each fragment.Quartzite: Metamorphic rock consisting essentially of quartz.

Ramp: Inclined access road.

Risk prevention measures: Technical or management activities with the aim of avoiding or decreasing occupational risks and protecting worker physical and moral wholeness. Most common prevention measures are: safety signaling, personal protection equipment, collective protection equipment, information and training.

Riven cut finish: Rugged surface produced by splitting a stone.

Rough slab: Flat surface semi-finished product with unfinished edges obtained from a rough block by sawing or splitting.

Rumbling: A percussion process that produces manufactured stone masonry units with randomly irregular arises, corners and surfaces.

Safety at work: technical methodology and safety standards implementation with the aim of preventing occupational accidents, as well as related risks.

Sand blasted finish; shot blasted finish: A matt finish caused by sand or other abrasive grains expelled by a sand jet.

Sandstone: Scientific definition: a sedimentary rock composed of grains of quartz, feldspar, mica, and little fragments of older rocks. Commercial definition: a sandstone is a natural stone as per the scientific definition of sandstone and with silicates, calcite, clay minerals or iron oxides as cement.

Sawn finish: Finish resulting from the gang, block‑ cutter or diamond‑ wire sawing of rock, without further treatment.

Schist: Scientific definition: a foliated metamorphic rock composed of nearly parallel arranged mica chlorite, quartz, and other typical minerals. Commercial definition: a schist is a natural stone possessing a well developed fissility that allows an easy split, i.e. slate, some gneiss and phyllites, some limestones, quartzites, and fine grained pyroclastic rocks.

Seythe: Machine equipped with a lance responsible for rock cutting.

Shape cutter: Machine for the fabrication of specially designed stone units.

Signalling: Specifically designed signals used at working positions with the aim of warning workers and other people in a fast and effective way about situations, which could carry certain risks.

Silicosis: Pneumoconiosis caused by the inhalation of silica dusts. It is a professional disease that affects workers of granite quarries and granite processing plants, miners, casters of moulds of sand, etc.

Slab for floors: A slab for floors is a piece of natural stone obtained by cutting or splitting at a thickness > 12 mm. They are put on to a structure by means of mortar, adhesives or other adhesive materials.

Slab for stairs: A slab for stairs is a piece of natural stone obtained by cutting or splitting at a thickness > 20 mm (except risers) to form the horizontal part of a stair step (tread) or the vertical part of a stair step (riser).

Slab: Flat structural element where length to width ratio is between 1 and 8, and that of width to thickness is greater than 10. Any unit of natural stone, in which the plane dimensions exceed 150 mm and the larger plane dimensions exceed four times the thickness.

Slate: Scientific definition: fine‑ grained very low‑ to low‑ grade metamorphic rock possessing well‑ developed fissility parallel to the planes of slaty cleavage. Commercial definition: rocks which are easily split into thin sheets along a plane of cleavage resulting from a schistositi flux, caused by very low or low grade metamorphism due to tectonic compression. They are distinguished from sedimentary (stone) slates, which invariably split along a bedding or sedimentation plane.

Slope: Inclined surface of an excavation. The stabilisation angle of a slope varies, depending on the internal attrition angle of the materials, but also on the water flow. Safety measures are recommended for each case, since slopes have a high potential risk for accidents.

Sound analyzer: Equipment aiming at measuring sound pressure, in the atmosphere or at a working area. These data allow the protection of workers against deafness risks or to promote soundproofing of the working area atmosphere.

Spirometer: Equipment used for measuring the oxygen inhalation of a person for a certain period of time.

Split: The procedure of rock cutting along one preferential splitting plane with a chisel or guillotine, usually by hand.

Splitting machine: Air driven machine used for the fabrication of split faced curbing and cubic stone.

Squaring blocks: Facing and squaring stone pieces before the transformation phase. Accident report: Brief document used to inform those parties concerned about an accident.

Steel shot: Abrasive used in sawing granite blocks.

Template: Pattern, usually of thin board or wood, used as a guide for cutting a stone element.

Texture finish, dressed finish: Texture finish, the modified appearance of a piece of rock resulting from one or several mechanical or thermal surface treatments; dressed finish clearly includes tool marks.

Tooled finish; machine tooled finish: Finish resulting from mechanical surface treatment with tools.

Travertine, onyx marble: Scientific definition: a finely crystalline concretionary limestone formed by rapid precipitation of $CaCO_3$ from water. Commercial definition: the compact, banded variety of travertine, consisting of coloured and transparent layers of calcite and/or aragonite, and capable of taking a polish, is called onyx marble.

Water jet: Cutting device consisting of a nozzle projecting a pressurised thin jet of water mixed with an abrasive.

Waxed finish: Having natural voids in the stone surface of filled with cements, shellac, and resins or other materials. Polishing the surface of a stone unit with water.

Wire saw: Sawing device consisting of a twisted three-strand wire cable, running over pulleys. It cuts stone by abrasion, while slurry of water and abrasive is fed into the cut.

Work size: The size of a masonry unit specified for its manufacture, to which the actual size should conform within specified permissible deviations.

Worker information and training: activities aimed for workers with the scope of warning them regarding certain situations pertinent to health and safety at work.

Working accident: Accident as a result of a working situation, causing injuries or death.

Working health: The application of specific factors in human working in order to improve the working conditions, preserve personal and collective human health and avoid occupational diseases.