

SAFE MAINTENANCE – QUARRYING SECTOR

Introduction to maintenance

Maintenance can be defined as working on something to keep it in a functioning and safe state and preserving it from failure or decline. The “something” could be a workplace, work equipment, or means of transport (e.g. a ship).

- 🔧 Preventive – or proactive – maintenance is carried out to keep something functional. This type of activity is usually planned and scheduled.
- 🔧 Corrective – or reactive – maintenance is repairing something to get it working again. This is an unscheduled, unplanned task, usually associated with greater hazards and higher risk levels.

Maintenance is not the exclusive domain of fitters and mechanics. It is the responsibility of almost all workers in every sector and is carried out in almost every working environment.

Workers’ health and safety can be affected during the maintenance process, but also by lack of maintenance or inadequate maintenance. Design of equipment and the work area also has a significant impact on the health and safety of workers performing maintenance.

Maintenance work in the quarrying industry

Quarrying¹ is one of the most dangerous industries to work in: quarry workers are twice as likely to be killed in an accident at work as construction workers, and 13 times more likely to die at work as those in manufacturing industries². The use of large earth-moving vehicles and machines, the handling of explosives and heavy loads, ever-present airborne dust, and simply working on dangerous sites are all aspects of quarrying that increase the risk of both accidents and occupational diseases. A significant proportion of fatalities in the quarrying sector are associated with maintenance work, the use of vehicles and fixed machinery, and falls from height³. Many accidents happen during maintenance work and these might affect not only maintenance staff but also other workers on site.

A worker at a stone crushing and screening plant was seriously injured while carrying out corrective maintenance on a moving conveyor belt. The worker’s right hand was trapped in the moving belt and his right arm was dragged between the return belt and tail drum. Because the worker was wearing gloves he managed to free his arm. However he had multiple bone fractures, tissue damage and friction burns to his right arm⁴.

Quarries must be properly inspected and maintained to ensure the health and safety of all workers on site. Maintenance activities at quarries range from the maintenance of machines, equipment and vehicles to the keeping of roadways on site in good order, attending to such matters as providing edge protection and securing excavations.

Quarry maintenance workers are exposed to many hazards, including frequent and heavy lifting, noise and vibration, and hazardous substances such as oil, gas, hydraulic fluid, antifreeze and welding fumes. They work in awkward positions and often have to use high-pressure hoses and vessels or work on machines that are still running.

The nature of their work means that they often have to work unsocial hours or at weekends when normal operations stop. They frequently work under severe time pressure and this, of course, increases the risk of accidents. In addition, maintenance is sometimes outsourced which means that contract workers unfamiliar with the quarry and systems of work may be on-site.

In all industries, maintenance is an area within which a significant number of accidents occur. About 32% of all occupational accidents in Germany between 1992-1995 happened while maintenance⁵ work was being carried out. In France about 44% of all fatal accidents in 2002 were related to maintenance⁶ work. The German statutory accident insurance institution for the quarrying industry reported that between 1999 and 2003, 48% of all accidents in the sector were related to maintenance and repair tasks⁷.

A quarry worker was severely injured while maintaining a stone cutter. The machine was running as he greased it, and his clothes became trapped in the shaft and were wound up with great force.⁸

Many fatalities and serious injuries at quarries happen during the cleaning and adjustment of machinery while it is still running or due to the unexpected start-up of equipment while it is being worked on. According to the German accident insurance⁹ institution 36 % of all fatal accidents among maintenance workers are caused in this way, exacerbated by such factors as machine operating errors, inadequate safety measures and poor communication.

Brief presentation of risks in the sector

The most common risks and hazards in quarries for workers involve:

Working on the faces and clearing-up operations: Risks around the faces are related to the instability of the face, loose material falling from the face, and vehicles driving over the edge of the face due to missing face protection, because of driver failure or technical problems with the vehicles.

Risks associated with **vehicle operations** include overturning, collision with other vehicles, or workers being crushed or run over by reversing vehicles, or falling while entering or leaving the very high cabs of many vehicles used in quarrying operations. Accidents may also occur as a result of technical failures such as faulty brakes and steering, or because of driver misjudgement. According to the Irish Health and Safety Authority (HSA) nearly half of all fatal accidents in quarries involve vehicles¹⁰.

Most **machinery-related accidents** occur as a result of workers becoming trapped or entangled in machinery, or falling from it during maintenance. According to the German statutory accident insurance organisation for the quarrying industry, 5% of all confirmed occupational accidents in 2008 were associated with moving conveyor belts. In the same period, stone crushers were associated with 8.6% of all confirmed accidents in the sector¹¹.

Slips, trips and falls occur in almost all workplaces and quarries are no exception. Quarry workers are also at risk of being **struck by falling objects** such as rocks.

Workers at quarries are exposed to hand-arm **vibration** and to whole body vibration. The former is generated by tools such as pneumatic drills, angle grinders and chain saws. Whole body vibration is caused by quarry vehicles and some fixed plant machinery

Risks associated with **manual handling** include the moving of heavy quarry equipment, manual shovelling of earth and mud, and lifting and carrying heavy stones.

Dust is present at all quarries because of the work processes involved, such as mining, cutting, drilling, breaking or crushing of stones. Dust containing crystalline silica can cause silicosis¹².

Quarrying is a noisy industry. Sources of **noise** include stone crushers, conveyor belts, explosions and engine noise from heavy vehicles. Persistent or sudden loud noise may lead to hearing loss.

Workers at quarries are exposed to **adverse weather conditions** such as extremes of temperature, humidity, rain and snow, and UV radiation.

There may be specific requirements relating to the storage and use of explosives if these are used on site. For example, there may be requirements for the inspection of magazines to ensure their integrity and cleanliness.

Special risks and hazards related to maintenance at quarries

Hazards related to the maintenance of quarry sites



© Steinbruch Berufsgenossenschaft

- ☑ When maintaining **faces and roadways** workers at quarries are exposed to hazards such as:
 - ☑ Falling trees and other material sliding from the tailings area onto people and machines;
 - ☑ Noise from machinery and equipment;
 - ☑ Dust, from activities such as drilling, blasting, and crushing, and from vehicle operation;
 - ☑ Falling objects, such as rocks;
 - ☑ Slips, trips and falls from height;
 - ☑ Collision of maintenance vehicles;
 - ☑ Maintenance vehicles falling over unstable and unsafe edges;
 - ☑ Uneven terrain causing unpredictable movement of vehicles;
 - ☑ Reversing vehicles.

Hazards related to the maintenance of mineral mining machines

The maintenance of and repairs to rock drills, heavy earth-moving vehicles, wheel-loaders and caterpillars, conveyor belts, stone crushers and screening plants pose a great many hazards to the workers involved in these tasks.



© Steinbruch Berufsgenossenschaft

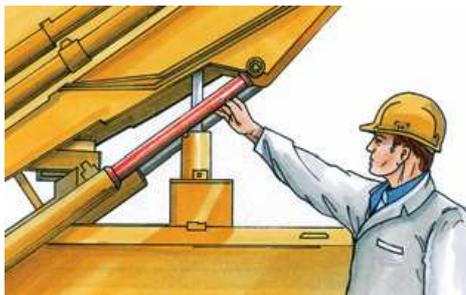
- ☑ Workers maintaining and repairing **rock drills** are at risk of:
 - ☑ Slips, trips and falls from the rock drill when entering the machine;
 - ☑ Being injured by the drill rod (see picture 3 for a drill perforation injury) or entangled in its mechanism;
 - ☑ The adverse effects of the noise and dust created by the drill.



© Steinbruch Berufsgenossenschaft

☒ Maintaining and repairing excavators, wheel loaders and caterpillars exposes workers to the following hazards:

- ☐ Falls from the vehicle;
- ☐ Being trapped or crushed as a result of unsafe lifting devices and practices;
- ☐ Inadvertent rolling and moving of vehicles.



© Steinbruch Berufsgenossenschaft

☒ Hazards associated with the maintenance and repair of stone crushers and other processing plants include:



© Steinbruch Berufsgenossenschaft

☒ Moving parts of machinery, such as the rotors of the blow bar crusher or flywheels of the crusher

- ☐ Working in awkward positions;
- ☐ Electrical hazards caused by improper insulation of electrical components;
- ☐ Dust and noise;

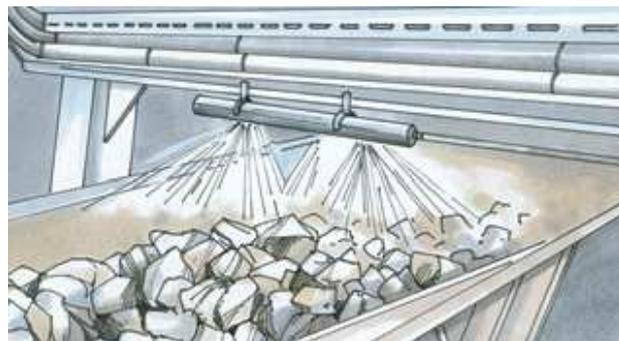
Conveyor belts pose a great hazard to workers involved in maintenance. Because too much production time would be lost by closing down the machines, maintenance often has to be carried out while the belts are still running.



© Steinbruch Berufsgenossenschaft

- ⚠ Risks associated with the maintenance and repair of conveyor belts include:
 - ⚠ Being injured by running conveyor belts or when the belt starts up unexpectedly;
 - ⚠ Falling from elevated belts;
 - ⚠ Dust and noise;

- ⚠ Maintenance and repair work of screening equipment involves high levels of exposure to noise and dust.



© Steinbruch Berufsgenossenschaft

Quarrying equipment and machines are extremely dangerous and have to be kept in good working order at all times. The maintenance and servicing of machinery such as conveyor belts or stone crushers has to be carried out by workers specifically assigned to such work, and they must have safe means of access to maintenance operation areas.

A structured approach to maintenance

The focus of this e-fact is on preventing harm to workers carrying out maintenance, but it should also be kept in mind that maintenance is essential to protect all workers from accidents and ill-health - lack of maintenance can cause serious and deadly accidents.

Examples of how maintenance can contribute to safe working conditions at quarries:

Maintenance of roads

Where possible, long-term haul roads should have asphalt or concrete paving and all road surfaces should be regularly maintained to ensure vehicles can be used safely. Roads mustn't be pot-holed or otherwise in bad condition and they should also be kept free of dust by regular wetting.

Maintenance of edge protection and safety banks

Many accidents at quarries happen as a result of inadequate, or lack of, edge protection, safety banks or barriers. Road side safety banks or barriers are essential safety features at quarries. They can effectively reduce the number of accidents involving quarry vehicles. Safety banks deteriorate due to weathering and the traffic and they should be regularly inspected and maintained.

Maintenance of vehicles - brake maintenance

Many transport accident at quarries occur due to faulty brakes. Quarry vehicles operate in extreme working environment and under difficult conditions and this should be taken into account when setting up the frequency of brake maintenance schedules. Daily checks should be carried out by the drivers and regular maintenance of the whole of braking system should be done according to manufacturer's recommendations.

Dust control – maintenance of dust extraction equipment and air filter systems

Dust poses a potential health risk to quarry workers. Dust is generated by drilling and sawing, by blasting and excavation operations as well as by haulage. There should be control measures in place to prevent dust reaching levels that could cause harm. Saws and drilling machines should have adequate dust extraction equipment and air filtration systems. Regular maintenance of the systems is essential to ensure that they are effective.

European Directive 92/104/EC, which deals with the minimum requirements for protecting the safety and health of workers in surface and underground mineral-extracting industries, also sets minimum standards for quarries. According to the directive, quarries have to be designed, constructed, equipped, commissioned, operated and maintained in such a way that quarry workers will be safe.

The risks of maintenance work can be minimised or even eliminated through good design and maintainability of the plant and machinery, the availability of the right tools for the job and by ensuring that workers have the relevant safety information for the equipment they are working on from the supplier or manufacturer¹³

Maintenance of the plant is fundamental to the safe operation of a quarry. Inspection and maintenance of the whole quarry, its plant and its electrical equipment, must be carried out regularly by competent persons. Guidelines should be set out to what should be maintained and how often. Adequate safety equipment must be in good working order and ready for use at all times.

Good maintenance management helps ensure safe maintenance work. A comprehensive approach to maintenance has five basic rules:

1. Good maintenance starts with planning. A maintenance plan for the quarry should be designed to include:
 - ◉ Roads
 - ◉ Vehicles
 - ◉ Machinery guards
 - ◉ Safety devices
 - ◉ Electrical equipment
 - ◉ Pressurised systems
 - ◉ Roadways and edge protections
 - ◉ Excavations, tips and lagoons
 - ◉ Buildings
 - ◉ Barriers around the quarry
 - ◉ Any equipment used in shot-firing operations

A risk assessment has to be carried out and its results should be included in the plan. There are various guidelines for carrying out risk assessments at quarries: the Safety and Health Commission for the Mining and other Extractive Industries¹⁴ published a set of guidelines, as did

the statutory accident insurance institution for the quarrying industry in Germany (Steinbruchs Berufsgenossenschaft)¹⁵.

To be safe, workers must understand the plant environment, the safety instructions and the hazards associated with their tasks. The maintenance plan should ensure that enough competent people are appointed to perform each task and that they are given enough time to do the job safely.

2. Work has to be performed safely. Quarries are very dangerous places and safe working procedures are absolutely vital. These include:
 - Securing the working area
 - Following safe systems of work that have been developed in the planning stage
 - Carrying out maintenance work only when a machine has been stopped and, where this is not possible, making sure that protective measures are taken.
 - Installing safety signs whenever a hazard or danger can not be avoided or reduced in some other way.
 - Ensuring that there is safe access to and exit from all work areas.

The cleaning or maintaining of running machinery and the unexpected start-up of equipment has caused many serious injuries and fatalities in quarries¹⁶. Many of these accidents could have been prevented if the machines had been stopped or protected against unexpected start-up. A checklist for safe lockout procedures has been developed by the Irish Health and Safety Authority¹⁷.

3. It has to be ensured that **appropriate tools and equipment, including PPE, are available and used**. Heavy loads, danger of rock slides, a loud and dusty environment mean that all workers at quarries need personal protective equipment such as head, foot and hand protection, respirators and hearing protection.

Maintenance workers may carry out tasks in places that are not normal workstations. As a result, they may need specific equipment and appropriate tools. Safety helmets must be worn in areas where overhead hazards exist, or while working with drilling, excavating or hazardous plant or equipment. Safety footwear with steel caps must be worn by all workers on site, and suitable gloves should be available when heavy loads such as stone blocks need to be handled.

Grinding, drilling, welding or working near crushers may cause eye injuries and eye protection must be worn. Ear protection is necessary when working with or near vehicles, quarry machines or other quarry equipment. Respiratory protection (e.g. dust mask, fume mask) is needed in areas where workers are exposed to dust or dangerous airborne fumes or particles, such as those in exhaust fumes.

Use of safety harness protection when working at height may also be necessary during quarry maintenance work¹⁸.

4. **Work as planned**. Workers involved in maintenance must be properly informed about the task in hand, the results of the risk assessment for that task, the 'chain of command' and any procedures that will be used while the task is carried out, including the procedure for reporting problems. Where maintenance at quarries is carried out by sub-contractors, this is particularly important.

The plan should then be followed and no worker should improvise or take shortcuts.

Best practice for safe maintenance work:

- Establish safe work procedures, incorporating manufacturer's recommendations, to ensure that workers are not exposed to hazards when carrying out maintenance or repair.
- Ensure that all workers are trained in established safe work procedures and that they follow them.
- Before beginning work, clear the area of trip and fall hazards.
- Provide safe access to all work areas.
- Lock and tag electrical equipment and secure mobile equipment before repair work begins.

- Use appropriate fall protection where there is a danger of falling.
- Stay focused, for your own safety and for the safety of your fellow workers¹⁹.

5. **Final check.** When a maintenance task has been completed, workers need to check whether they have left the item in a safe and functioning condition²⁰. The functional capability of the plant, machines or equipment has to be tested and all protective guards and mechanisms have to be reinstated.

The maintenance task is finished once the work is signed out and the plant, equipment or machine is unlocked.

European Legislation for safe maintenance in the quarrying sector

European directives set minimum standards to protect workers.

The most important is **Council Directive 89/391/EEC** on the introduction of measures to encourage improvements in the safety and health of workers at work ('Framework Directive'), lays down the general principles concerning Lays down the general principle concerning the prevention and protection of workers against occupational accidents and diseases. It contains the general principles of prevention and lays down employers' obligations concerning the assessment of risks, the elimination of risks and accident factors. It also contains provisions on informing, consultation and balanced participation and training of workers and their representatives.

The framework directive is supplemented by individual directives, two of which specifically cover the mineral extracting industry, imposing minimum requirements for the health and safety of workers engaged in both surface and underground mineral extraction industries. They are:

Directive 92/91/EEC concerning minimum requirements for improving the health and safety of workers in the mineral extracting industries through drilling.

Directive 92/104/EEC concerning minimum requirements for improving the health and safety of workers in surface and underground mineral extraction industries.

Part A of the Directive 92/104/EEC deals with the common minimum requirements applicable to surface and underground mineral-extracting industries and to ancillary surface installations. One paragraph is about general maintenance and the maintenance of safety equipment.

Other 'daughter' Directives relevant to safe maintenance in the quarrying sector are:

Directive 89/655/EEC concerning the minimum safety and health requirements for the use of work equipment by workers at work sets out the general framework for a series of preventive measures to be taken in the workplace. It lays down employer's obligations regarding the selection and use of work equipment, what safety devices or systems machinery should have, employers' responsibilities for maintaining equipment and ensuring conformity, and the training and information that should be made available to operators. It also puts an obligation on employers to minimise risk through risk analysis and assessment²¹.

Directive 89/656/EEC covers the minimum health and safety requirements for the use by workers of personal protective equipment in the workplace.

Directive 90/269/EEC regulates the minimum health and safety requirements for the manual handling of loads. The manual handling of stone blocks and other heavy loads is still a common practice at quarries.

Directive 92/58/EEC on the minimum requirements for the provision of safety and/or health signs at work requires employers to provide specific safety signs wherever there is a risk that cannot be otherwise avoided or controlled.

Directive 2004/37/EC lays down minimum standards for the protection of workers from risks related to exposure to carcinogens or mutagens at work.

Directive 2002/44/EC regulates the minimum health and safety requirements regarding the exposure of workers to the risks arising from vibration.

Directive 2003/10/EC deals with minimum health and safety requirements for workers exposed to the risks arising from noise. Workers maintaining machinery and equipment at quarries are likely to be exposed to physical hazards such as vibration and noise.

There are also specific directives designed to protect young workers and temporary workers:

The **Directive 94/33/EC** on the protection of young people at work prohibits the employment of children and ensures that employment of adolescents is strictly controlled. It includes associated restrictions on work by age, emphasising the vulnerability of young people and stipulating the prohibition of work which is beyond their physical or psychological capacity which is likely to entail specific risks for young people.

Directive 91/383/EEC covers measures to encourage improvements in the safety and health of workers with a fixed-duration employment relationship or a temporary employment relationship. The purpose of this Directive is to ensure that such workers have the same level of protection as any others. This is particularly relevant to quarrying where maintenance is often outsourced to temporary contractors.

Many standards such as ISO and CEN standards may also apply to safe maintenance in the quarrying sector. They give detailed technical information on the organisation of workplaces and equipment; for example, standards for machinery safety as in EN ISO 12100 Safety of machinery - Basic concepts, general principles for design.

Good practice examples

Safety passport for quarries

The SPA (Safety Pass Alliance) Quarry products, mineral processing and extractive industries' Passport Scheme has been developed for the quarrying industry in the UK. It is committed to providing a nationally recognised standard of health and safety training. The Contractors' Safety Passport scheme is a nationwide initiative to introduce a minimum health and safety standard for contractors. All contractors operating within the quarrying industry are expected to hold a Safety Passport. The programme drives good practice through the contractor supply chain, increasing safety awareness and contributing to higher standards of safety and health.

The passport is issued after a two-day training course. The first day addresses core issues providing basic health and safety education. The second day is an industry-specific session that addresses the health and safety management of quarries and focuses on lifting operations, excavations and issues associated with working in confined spaces and at height. Participants develop an awareness of health and safety issues related to mineral and extraction work and learn about the main hazards specifically associated with quarrying.²²

Safe change of wheels from Earthmovers and other Heavy duty vehicles

A great deal of time and work is required to change the wheels of large earthmovers. Wheels with a diameter of 3m which can weigh as much as two tonnes each pose a considerable risk of accident to those working with them. There was no commercially available equipment to help with this task.

A German company developed an auxiliary device to help change the wheels safely, producing a steel frame with three wheels that can be propelled by a forklift truck. The giant earthmover wheels can be supported by the frame and placed in the correct position by the forklift truck driver, eliminating the difficulties and dangers of moving them by hand. A safety guard stops the wheel falling over and a special working platform protected by a fence ensures a safe working environment for the wheel changers. This device not only helps workers change wheel quickly and safely, but also involves the minimum of effort which also reduces the risk of musculoskeletal disorders²³.



© Steinbruch Berufsgenossenschaft

Simple maintenance of the dust-removal system of rock drilling machines

Using rock drilling machines often leads to problems with dust-removal systems. The suction box of the drilling machine's de-dusting equipment is often choked by sticky materials such as loam or sand, leading to a breakdown of the system and to the uncontrolled emission of dust. Dust poses a health risk to workers at site. Disadvantages include environmental pollution, rapid clogging of air-filter suctioning systems, complete soiling of the entire machine, and the ergonomically unfavourable bent-over position that a worker must assume to clean the dust catch on the bottom of the device. Typically the suction box has to be cleaned twice a day. The cleaning procedure takes between 30 and 60 minutes and has to be performed in an awkward position. The system's filters also have to be cleaned once a week and this takes about 30 minutes and also involves working in an awkward position.

A German company has optimised the cleaning and maintenance procedure of the suction box by making a simple modification, creating a new maintenance access to it by attaching a fast-opening maintenance flap. Maintaining and cleaning the suction box is now fast and uncomplicated, taking only about 10 minutes. This improvement to the drilling machines to improving health and safety of workers²⁴ was based on their own day-to-day experience.



© Steinbruch Berufsgenossenschaft

References:

- [1] The HSE definition of a quarry includes all surface mining: i.e. opencast coal, industrial minerals, kaolin, ball clay, brick clay, barytes, gypsum, silica sands, fluorspar, china stone, slate, fullers' earth, limestone, dolomite, basalt, and aggregates (HSE, 2008).
- [2] HSE, Do you work in a quarry?, A simple guide to the Quarries Regulations 1999, 2000, <http://www.hse.gov.uk/pubns/indg303.pdf>
- [3] HSA, Irish HSA inspection blitz for quarry safety week, Press release 2008, http://www.hsa.ie/eng/News_and_Events/Press_Releases_/Press_Releases_2008/HSA_Inspection_Blitz_for_Quarry_Safety_Week.html
- [4] Workplace Safe, Workers Sustain Serious Injuries from Conveyor Accidents, safety alert no 4, 2000, http://www.justice.tas.gov.au/_data/assets/pdf_file/0010/77572/SA035_conveyor_acc.pdf
- [5] Uhlig, D., *Sicherheit und Gesundheitsschutz bei Instandhaltungsarbeiten*, BG-digital, 03/2000, p. 154-159
- [6] INRS, *Maintenance: des activités à risqué*, Fiche pratique de sécurité ED 123, 2005, <http://www.afim.asso.fr/SST/prevention/ed123.pdf>
- [7] Kretschmer, U., *Main Accident Area in the Natural Stone Industry*, Steinbruchs Berufsgenossenschaft,
- [8] St.Galler Tageblatt, *Arbeiter verunfallt im Steinbruch*, online Nachrichten vom 21.02.09
- [9] Amend, G., *Instandhalter*, BG Information 577, Maschinen und Metall-Berufsgenossenschaft, 2005, <http://www.heymanns.com/servlet/PB/show/1224742/bgi577.pdf>
- [10] HSA, *Mobile plant Safety*, Toolbox talk, Scenario 5 and 6, 2009 http://www.hsa.ie/eng/Sectors/Quarrying/Promotional_Activity
- [11] Steinbruchs Berufsgenossenschaft, M. Kretschmer, personal communication
- [12] HSE, *Occupational Health Management in the Quarry Industry*, Quarries National Joint Advisory Committee, 2004, <http://www.hse.gov.uk/aboutus/meetings/committees/gnjac/gnjac-ohg.pdf>
- [13] European Agency for Safety and Health at work (EU-OSHA), *Safe Maintenance – For Employers, Safe Work – Save money*, E-fact, 2009 (not yet published)
- [14] Safety and Health Commission for the Mining and other extractive Industries, Guidance for carrying out risk assessment at surface mining operations, <http://www.hse.gov.uk/quarries/q-risk.pdf>
- [15] Steinbruchs-Berufsgenossenschaft, statutory accident insurance for the quarrying industry, website 2009 (<http://www.stbg.de/site.aspx?url=html/fpreis/index.html>)
- [16] HSA, *Working on fixed plant/conveyors*, Toolbox talk, Scenario 2 and 6, 2009 http://www.hsa.ie/eng/Sectors/Quarrying/Promotional_Activity
- [17] HSA, *Working on Fixed Plant/Conveyors*, Tool Box Talk Scenarios 2 and 6, http://www.hsa.ie/eng/Sectors/Quarrying/Promotional_Activity/HSA_toolbox_talks.pdf (tool box accessed on 6 July 2009)
- [18] Quarry Safe, *Health and Safety Handbook*, second edition, accessed on 5 July 2009, http://www.maqohsc.sa.gov.au/_upload_docs/20090122121128.QuarrySAfe-Health-Safety-Handbook.pdf
- [19] From Mine Safety and Health Administration (MSHA), *Maintenance work – life or death experience*, United States Department of Labour, 2003, <http://www.msha.gov/alerts/maintenance2003/maintenance2003.htm>
- [20] Müller, J., Tregenza, T., The importance of maintenance work to occupational safety and health: a European campaign starting in 2010 casts its shadows, 2008 http://www.sapp1.suva.ch/sap/public/bc/its/mimes/zwaswo/99/pdf/88154_d.pdf
- [21] Adapted from: Honeywell, The European community directives, website http://www.honeywell-sensor.com.cn/prodinfo/safety_switches/catalog/v6si008e.pdf
- [22] Safety Pass Alliance, *Quarries*, webpage accessed on 2th of July 2009, <http://www.safetypassports.co.uk/html/quarries.html>
- [23] Steinbruchs Berufsgenossenschaft StBG, *Sichere Montage von Großrädern an Baumaschinen, Förderpreis Arbeit, Förderpreis 1998*, <http://www.stbg.de/site.aspx?url=fpreis/fpr98/preis01.htm>
- [24] Steinbruchs Berufsgenossenschaft StBG, *Einfachere Wartung der Entstaubungsanlage am Bohrergerät, Förderpreis Arbeit, Förderpreis 2006*, <http://www.arbeit-sicherheit-gesundheit.de/beitrag.asp?nr=101279>