Safety and Health in the Stone Crushing Industry

A Practical Manual for Preventing Accidents, Preserving Health and Keeping a Company Profitable

N. Wagner, M. Nithiyananthan, L. Farina (eds.)

SAFETY & HEALTH IN THE STONE CRUSHING INDUSTRY

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Edited by

Norbert Wagner
University of South Florida, Tampa USA

Mannarswami Nithiyananthan
Sri Ramachandra University, Chennai India

Laura Farina
University of South Florida, Tampa USA

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Canada

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M. Nithiyananthan created the illustrations in chapter B "Improving Heavy Physical Work". All other black & white illustrations in this manual are provided by the HESPERIAN Foundation and are reprinted with their permission.

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HESPERIAN Foundation
1919 Addison Street, Suite 304
Berkeley, CA 94704 USA
Tel: (510) 845-1447, Fax: (510) 845-9141
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Email: hesperian@hesperian.org

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Foreword

This manual is based on findings of a research development project in stone crushing sites in Northern India (Bundelkhand). The International Development Research Centre (IDRC), Canada (http://www.idrc.ca), funded a community development project over several years which was aimed at improving the living conditions in the villages around stone crushing sites and the working conditions in the crushing units. Project partners were the non-governmental organization Development Alternatives, New Delhi, India (http://www.devalt.org), Dr. K. Vijaya Lakshmi (PI), and the Department of Environmental Health Engineering of Sri Ramachandra University, Chennai, India (http://www.srmc-ehe.org.in), Dr. Kalpana Balakrishnan (Co-PI).

The late Mr. M. Nithiyananthan, the Project Leader-Industrial Safety of the project from Chennai, India, produced the majority of the findings and photos, which are presented in this manual. He tragically passed away in early 2009 before this manual could be finished. We publish these findings in his memory.

The editors are grateful for the support from many contributors. Special thanks go to Ana Boischio from IDRC and the project's principal investigators Dr. K. Vijaya Lakshmi and Dr. Kalpana Balakrishnan for making this publication possible. Mr. Raghwesh Ranjan made the visits to the stone crushing units possible. Reliable and efficient as always, Mr. D. Venkatesan researched the available documents and photos that provided the basis for this publication.

The authors who contributed chapters for this manual besides the editors are: Perry Gottesfeld from Occupational Knowledge International, San Francisco USA (www.okinternational.org), who contributed the chapter on wet dust reduction technology; Dr. Ralf Steinberg, an international safety expert, Düsseldorf Germany, who kindly reviewed the manuscript and contributed to several chapters and Mr. Suvankar Bose and Mr. George S Sharma from Development Alternatives, New Delhi India who developed and explained the dry dust reduction systems.

All black and white illustrations in this manual are from publications of the Hesperian Foundation, a non-profit health organization that kindly granted permission to use some of their illustrations from two of their publications (http://www.hesperian.org). Their free publications *"A Worker's Guide to Health and Safety"* and *"A Community Guide to Environmental Health"* can be found on their website.

Many of the checklists presented at the end of this manual were developed with colleagues and friends from the Department of Environmental Health Engineering of Sri Ramachandra University, Chennai, India. They include Dr. Joerg Arnold, S. Sankar, R. Ayyappan, Dr. Ralf Steinberg and others.

The following persons were part of the research project between 2006 and 2008:

Dr. K. Vijaya Lakshmi (Principal Investigator)
Dr. Kalpana Balakrishnan (Co-Principal Investigator)
Mr. George C. Varughese (Project Advisor)
Ms. Indrani Mahapatra (Research Coordinator)
Mr. Raghwesh Ranjan (Research Coordinator/Project Leader - Social)
Dr. Reetu Sogani (Consultant – Gender)
Mr. Prawal Pratap Singh (Ex-Project Staff – Social)
Ms. Taru Mehta (Ex-Project Staff – Social)
Dr. P Jayachandran (Project Leader-Health)
Dr. M. P. Singh (Project Staff – Health)
Dr. Anandh B (Project Staff – Health)
Dr. K. Mukhopadhyay (Project Leader – Environment)
Mr. S. Sankar (Project Coordinator-Environment)
Mr. M. Nithiyananthan (Project Leader-Industrial Safety)
Mr. R. Ayyappan (Project Staff-Environment/Air)

Mr. Udit Mathur (Project Staff – Environment/Economics)
Mr. Anand Kumar (Project Leader – GIS)
Dr. Anand K Rai (Project Staff – Environment / Agro-forestry)
Mr. Suvankar Bose (Project Leader – Engineering)
Mr. George S Sharma (Project Staff – Engineering)
Mr. Pramod Kumar (Research Assistant)
Mr. S.N. Prasad (Research Assistant)
Mr. D. Venkatesan (Project Technician)
Mr. Rana Singh (Research Associate)
Mr. Dharmendra Kori (Field Assistant)
Mr. M.Saran (Research Assistant)

The International Development Research Centre (IDRC), Canada funded all activities. Without their support, the research project and this manual would not have been possible.

Norbert Wagner
Department of Environmental and Occupational Health
University of South Florida
Tampa, USA

Eulogy

Mr. M. Nithiyananthan, the nodal investigator on the safety components of this project, tragically passed away in January 2009, before he could see this wonderful publication in print.

Nithi, as he was affectionately called by his colleagues, was unusual in many ways. His main profession, that of a safety engineer at the Chennai Port Trust, was one that demanded strict enforcement often to the annoyance of his workers. He was known as a man of action during his career. After his retirement, he engaged in safety assessments with such a degree of compassion that it would be hard to capture his enthusiasm in a few paragraphs. He was very gratified that all the knowledge he had painstakingly acquired but yet could only use for enforcement at one organization could finally find a place in the academic or awareness raising domains of safety engineering. He wanted this wealth of information accrued during routine project assessments be compiled in systematic ways and made available freely so that the wheel doesn't have to be reinvented repeatedly.

The present findings in the stone quarrying sector represent one of his best such efforts. He wanted to "show and tell" how things could be improved at little cost but huge savings for health and life. He endured extreme temperatures, swaying temperaments of owners and workers, hazardous work place conditions with extra-ordinary patience just so that the unsafe conditions could be showcased and eventually done away with. He has meticulously documented the hazards and listed the accompanying solutions through a masterly photo collection.

The project staff will remember his efforts with heartfelt gratitude not only for the scientific contributions but also for serving as a role model for human compassion and dedication. We dedicate this manual in his loving memory.

Kalpana Balakrishnan
Department of Environmental Health Engineering
Sri Ramachandra University
Chennai, India

Introduction

Stone crushing is necessary in order to build roads, bridges, buildings and almost everything we need in our modern life. There are an estimated 12000 stone crushing units with about 500.000 workers in India. One can presume that several million workers are working in stone crushing all over Asia.

Stone crushing provides income for families but the working conditions of employees are often unhealthy and dangerous. Major concerns in stone crushing are accidents and injuries, hearing loss, dust-related lung diseases. All of these diseases can be prevented, the working conditions can be improved with simple means and minimal cost.

The purpose of this manual is to provide information and guidance to improve working conditions and safety in stone crushing units for owners, workers, governmental and non-governmental institutions, trade unions and interested persons. It will help stone crushing unit owners to improve their business by avoiding unnecessary cost.

The above-mentioned research and development project was funded by The International Development Research Centre (IDRC), Canada and included a thorough assessment of the situation, specifically the safety situation in stone crushing units and the working conditions. It used observations, walk-throughs, discussions with owners and workers as well as measurements of dust and noise levels to analyze the situation. Findings were documented with checklists, photos and data sheets.

Based on these findings, recommendations for immediate and low-cost solutions were formulated. Long-term, sometimes more costly interventions were added. The project team presented All solutions to the unit owners and discussed their feasibility with them.

Part A " Safety & Health in the Stone Crushing Industry" we look at solutions to prevent accidents and to keep workers and their families healthy. The last section discusses the elements of emergency preparedness for the industry.

Part B "Improving heavy physical work" describes long-term effects of heavy physical work and suggests solutions to reduce fatigue and prevent illness.

Part C "How Much Does an Accident Cost?" introduces a short and simple table to calculate, better: estimate, the real cost of an accident. It should help to keep the right perspective on the financial side of accidents and the monetary benefits of prevention.

In **Part D " Checklists and Benchmarks"**, we added checklists to make it easier to assess the working conditions. They help in analyzing a situation and in finding the appropriate measures to improve. These checklists can be used as benchmarks to document and compare the level of the safety and health performance of a company. Over time, progress and improvements can then be documented and experiences shared.

On the long run, we hope that such a "safety performance score" for crushing units helps in achieving better safety performances in the industry. We hope that in the future such a "score" will be included in tender processes as one of several selection criteria so that the order goes to the stone crushing units with the best protection for their workers..

A Safety & Health in Stone Crushing

Picture 1: typical dust cloud around the crusher and sorter

From reports and interviews with owners and workers, we know that the main causes of ***injury*** **and** ***days-lost-for-work*** in the stone crushing industry are:

- Falls from heights
- Slips and trips
- Traffic accidents inside and outside the plant
- Injury by heavy physical work and manual handling of heavy loads
- Accidents with electricity

We identified the following causes of ***long-term ill health*** **and** ***days-lost for-work*** in stone crushing:

- Dust causing chronic lung diseases such as chronic obstructive (asthmatic) bronchitis or silica-related lung scaring (silicosis)
- Noise causing noise-induced hearing loss
- Chronic diseases of the movement apparatus (joints, bones, muscles, ligaments) caused by heavy physical work and manual handling of heavy loads or hand-arm vibration by power tools

In the following chapters we will take up these topics one by one. We will discuss and describe solutions to reduce the risk of getting sick in stone crushing. We have to keep in mind the ALL of these causes can essentially be reduced and controlled. But first, we look at the management side of safety and health. The unit owner has a very important role in finding the risks, deciding where improvements are necessary and feasible as well as in managing the improvement process and the role.

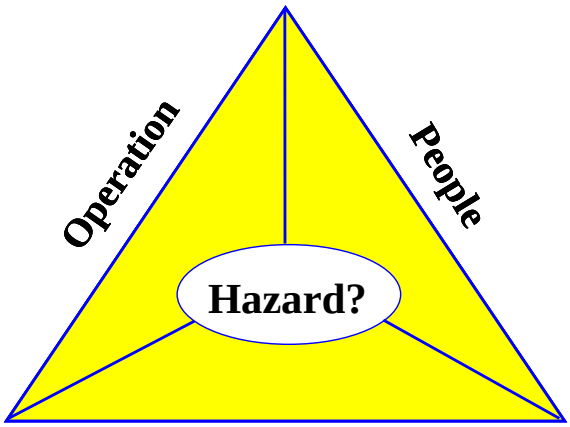
A.1 A Word for the Owners: Managing Health and Safety in Stone Crushing

Ralf Steinberg, health & safety manager, Düsseldorf Germany

Managing health and safety is little different from managing any other aspect of your business. You need to assess risks beforehand in your workplace, put sensible and cost-effective measures in place to reduce risks, and make sure they stay low. This booklet will provide you with relevant information concerning hazards and their control for operations in stone crushing.

What is a "risk assessment"?

In order to reduce health risk and prevent accidents, you first have to **assess risk**. It helps you understand the nature of hazards, how your employees could be harmed and how you can prevent that from happening. It is nothing more than a careful examination of working conditions and the way workers could be harmed. It is a practical exercise, aimed at getting practical results. At the end, it helps you to focus on the greatest risks first and set priorities for your actions. Most often, it means that simple, cheap and effective measures are feasible to ensure your most valuable asset – your workforce – is protected. The step-by-step guidance below shows you how to assess health and safety risks with minimum fuss.



Five steps of risk assessment

Step 1: Identify the hazards

Step 2: Decide who might be harmed and how

Step 3: Evaluate the risks and decide on precautions

Step 4: Record your findings and implement them

Step 5: Review your assessment and update if necessary

Don’t overcomplicate the process. You probably already know whether, for example, you have employees who move heavy loads and so could harm their backs, or where people are most likely to slip or trip. If so, check that you have taken reasonable precautions to avoid injury.

You can do the assessment yourself. We provide you with checklists at the end of this manual to help you in this process (see chapter *Checklists*). You do not have to be a health and safety expert. If you are not confident, get help from someone who is competent. In all cases, you should make sure that you involve your staff or their representatives in the process. They will have useful information about

how the work is done and how they see the possible solution to problems. It will make your assessment of the risk more thorough and effective.

When thinking about your risk assessment, remember:

- a **hazard** is anything that may cause harm, such as chemicals, electricity, working from ladders, exposure to dust etc;
- the **risk** is the chance, high or low, that somebody will be harmed by these and other hazards, together with an indication of how serious the harm could be; e.g. injury, fatality etc.

Step 1 Identify the hazards

First, you need to see what the hazards are and how people can be harmed. It is easy to overlook hazards, so here some tips to help you identify the ones that matter:

- **Walk around** your workplace and look at what could cause harm.
- **Ask your employees** or their representatives what they think. They may have noticed things that are not immediately obvious to you.
- If you are a member of a **professional association**, contact them. Many associations produce helpful guidance.
- **Check manufacturers' instructions** or data sheets for chemicals and equipment. These can be helpful finding the hazards and putting them in perspective.
- Have a look at your **accident and ill-health records** – these often help to identify hazards.
- Remember to include **long-term hazards to health (**e.g. high levels of noise or exposure to harmful substances) besides the immediate safety hazards.

Step 2 Decide who might be harmed and how

When you know which group of workers might be harmed you can identify the best way of reducing the risk. It helps to write down how they might be harmed, i.e. what type of injury or ill health might occur; for example, *'Workers who move heavy stones may suffer back injury from repeated lifting.*

Remember that some workers have particular needs, e.g. new and young workers, new or expectant mothers and people with disabilities or elderly workers. They might be at particular risk. You can also ask your staff if they can think of anyone you may have missed.

Which of these dangers would you like to eliminate first?

Step 3 Evaluate the risks and decide on precautions

Having spotted the hazard, you then have to decide what to do about it. You can work this out for yourself, but one easier way is to look for good practices in the industry. The present booklet shows such good practices and provides an overview of hazards and controls.

You can start by comparing your present working practices with examples from other industries (good practices) and see if there is more you could be doing to make your workplaces safe.

Picture 2: women collecting dust under the conveyer belts

The "Hierarchy of Controls"

When thinking about solutions, consider the principles below, if possible in order, the so-called **hierarchy of controls**:

1. try a less risky option (e.g. switch to using a less hazardous chemical);
2. prevent access to the hazard (e.g. by guards around machinery or rails);
3. organize work better to reduce exposure to the hazard (e.g. don't allow on-lookers during unloading or stop running the crusher while cleaning up to reduce dust exposure);
4. provide personal protective equipment (e.g. clothing, footwear, goggles etc); and provide welfare facilities (e.g. first aid and washing facilities for removal of contamination).

Improving health and safety often does not cost a lot. For instance, placing a mirror on a dangerous blind corner to help prevent vehicle accidents is a low-cost precaution considering the risks. Failure to take simple precautions can cost you a lot more if an accident does happen (you will find a cost calculation in chapter *How much does an Accident Cost?*). We can only encourage you to involve your workers in this discussion, so that you can be sure that what you propose will work in practice and will not introduce new hazards.

Step 4 Record your findings and implement them

Putting the results of your risk assessment into practice will make a difference when looking after people and your business. Writing down the results of your risk assessment, and sharing them with your staff, encourages you and them to follow your solutions correctly, for instance your new work practices and work orders. If you have only few employees, you do not have to write anything down. However, notes are useful so that you can review them later when something changes.

When writing down your results, you can keep it simple, for example

- *'Tripping over unused tools: container provided, staff instructed, weekly housekeeping checks conducted',* or
- *'Glare from welding: anti-UV goggles provided, workers instructed and regularly checked'.*

Nobody expects a risk assessment to be perfect, but it should be suitable and sufficient. You need to be able to show that:

a. a proper check was made;

b. you asked who might be affected;

c. you dealt with all the significant hazards;

d. the precautions are reasonable, and the remaining risk is low.

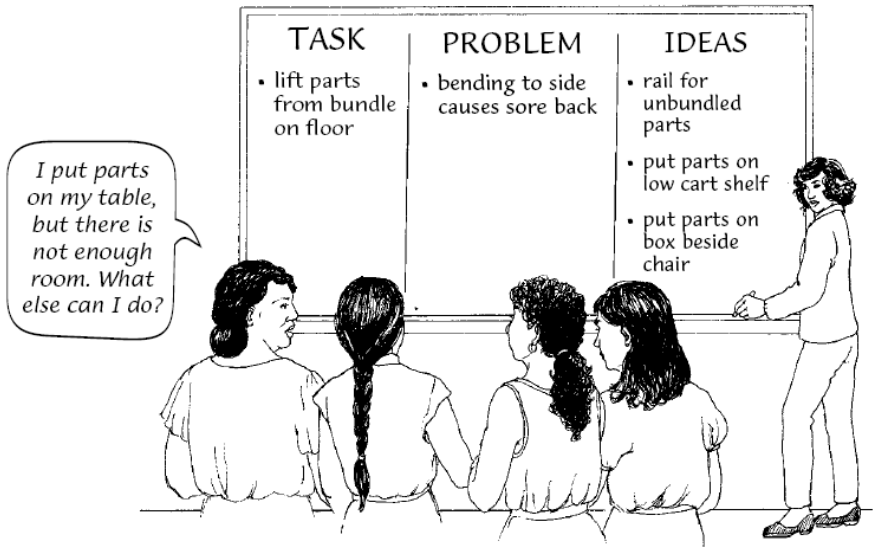
Like many businesses, you find that there are quite a lot of improvements that you can implement. Don't try to do everything at once. Make a "plan of action" to deal with the most important things first. Authorities, staff and community usually acknowledge all efforts of businesses that are trying clearly to make improvements.

A good plan of action often includes a mixture of different things such as:

- **easy improvements** that can be done quickly, perhaps as a temporary solution until more reliable controls are in place;
- **long-term solutions** to those risks that most likely cause accidents or ill health;
- a **training of employees** on remaining major risks and how they can be reduced;
- **regular checks** to make sure that the control measures stay in place; and
- **clear responsibilities** that state who will do which action, and when.

Remember, prioritize and tackle the most important things first! As you complete each action, tick it off your plan.

Finding solutions to ergonomic problems



Step 5 Review your risk assessment and update if necessary

Few workplaces stay the same. Eventually, you will bring in new equipment, change procedures or simply shift to another place. This can lead to new hazards. It makes sense, therefore, to take time to review the situation on an ongoing basis. Every year, you should review how things are, where there is room for improvements and if your former improvements are still working.

Look at your risk assessment again: *Have there been any changes? Are there improvements you still need to make? Have your workers spotted a problem? Can you learn anything from accidents or near misses?* It is best to think about this risk assessment while you are *planning* your change – that way you are ahead of any surprises. If there is a significant change during the year, do not wait. Just look at your risk assessment and, where necessary, correct it. The benefits of planning are enormous. Preventing just one accident is usually three or four times cheaper than paying for the subsequent cost of an accident.

You will find more information on hazards and risks at work at these websites:

http://www.osha.gov

http://www.hse.co.uk

http://www.cdc.gov/niosh/homepage.html

http://www.ccohs.ca/

A.2 Preventing Accidents in a Stone Crushing Unit

A.2.1 Preventing Falls from Heights

Accidents are always bad for the victim and for business. Some of the most common causes of accidents in a stone crushing unit are:

- Hands and fingers or toes being crushed by stones
- Body parts such as hands or arms being caught in machines
- Traffic accidents inside the unit
- Falling and slipping from heights

There are many occasions where stone crushing workers are at a specific risk for falls.

Location/Workplace

- Working on top of the primary crusher, for instance during boulder off loading when boulders are brought in by trailers from quarries and fed in to the receiving pit
- At the primary crusher area when stones are stuck and need to be shoved to undo the jam
- On work platforms, for instance during repair and maintenance work on the crusher itself

Picture 3: worker at the primary crusher chute

Common unsafe conditions or acts

- Too many workers are too close when dangerous work is done
- Workers need to work on the high wall of the bolder pit with no fall protection
- Workers need to access the top of the platform by climbing through supporting poles or up the stone piles
- There is no set and separated path for vehicular and persons' movement
- There is no guard around the bolder pits
- Work is performed on work platforms which are not guarded and have no railings
- Maintenance work at heights (i.e. portable conveyors) is performed without securing the working persons

Hazards and health risks

- Fall from heights or into pits with severe injuries such as fractures, head injury, or even death

Solutions to protect health

- ➔ Attach a bund wall or raised steel girder to entire length of pit to prevent falls; curb wall can be constructed from available boulders at site
- ➔ Movement on the top of the retaining wall should be avoided
- ➔ No person should be allowed to walk on the parapet of the loading pit
- ➔ Provide indicating alarms to sound when rocks are being loaded into the crusher

- ➔ Provide stable ladders that are in good condition
- ➔ Safety belts and harnesses should be provided for all those who work at heights
- ➔ Stop using the conveyor belt to climb to the top and do not use broken or make-shift ladders
- ➔ Provide steps and ladders where unconsolidated material slopes are currently used for climbing up and down. Steps can be carved to prevent the trip and fall hazard due to slippery and loose soil
- ➔ Provide ladders that are in good condition (preferably wooden) in places where there are electrical overhead lines running across and metal ladders in other places
- ➔ The ladders should be long enough to reach the top and also have an extra length of 75-90 cm for holding after reaching the top
- ➔ Provide ladders at 70-75 degree slopes
- ➔ Ladders should not be used as a platform to work

Picture 4: repairing the conveyer belts without safety harness or fall protection

A.2.2 Working Safely with Electricity

Electrical equipment makes the work and the stone crushing possible. However, electricity can be dangerous to people. They might even die from an electrical shock. Failure of electrical equipment can cause fires in a workshop, damage to machines, destroy products and seriously or fatally injure people. We need to prevent any direct contact of workers with electrical power and tension. That is the goal of preventing accidents with electrical equipment.

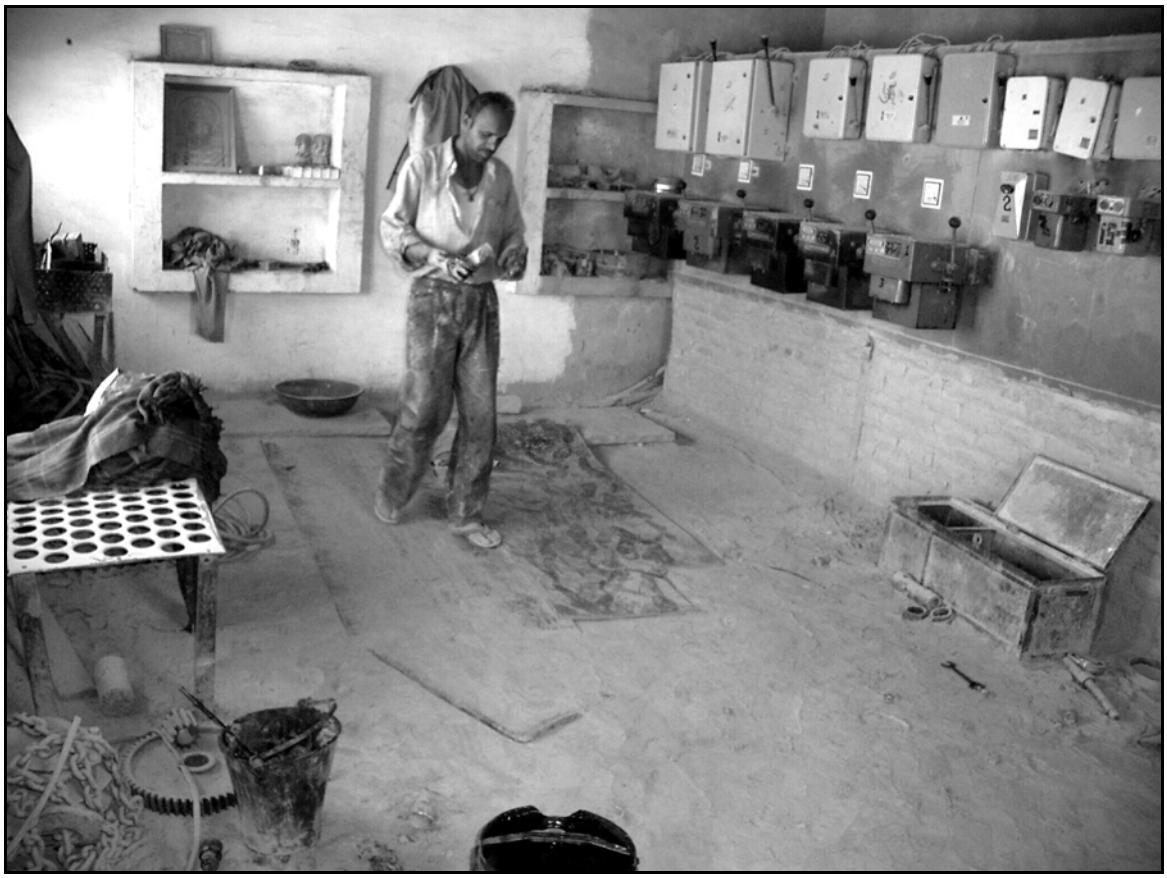
Location/Workplace

Electrical power is used in the entire stone crushing unit. Specifically critical locations are:

- The transformer yard and distribution panel room where the main incoming supply from the state's power grid is received through a transformer at the site and subsequently transformed to the bus bar panel in the panel room from where the supply to various facilities, machines, locations is taken via the various cables and circuits
- Control switches and distribution pints throughout the unit and the crusher machine

Common Unsafe Conditions/Acts

- Damaged electrical cords, for instance wires laying on the ground where trucks frequently drive over them. This leads to inadequate grounding and possible contact of workers with the power line
- Bare wires are used in sockets and plugs to draw current, as correct plugs are not provided by the company or broken connectors are not repaired



Picture 5: electrical room used for storage and rest

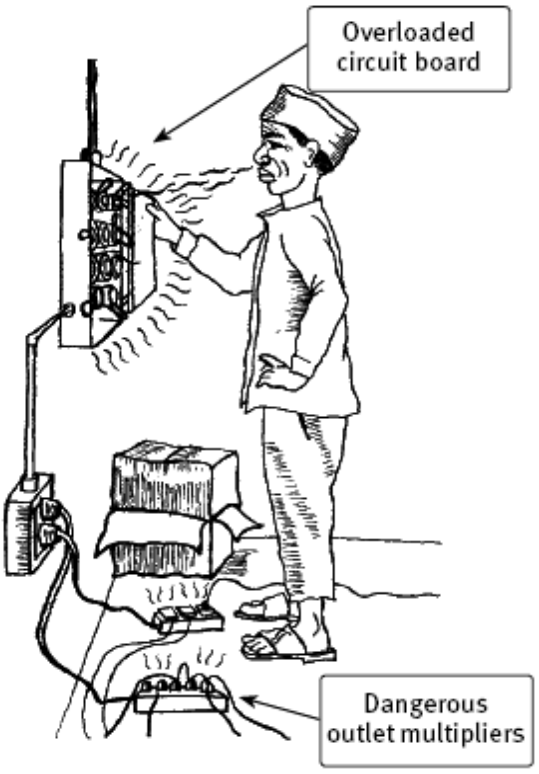
- Damaged electrical equipment, machines and tools are used so that the surface of the tool actually carries electrical power.
- Insufficient or no grounding of electrical equipment and machines lead to electrically charged machine parts
- Extension cords are used one after the other because of missing fixed installations
- Breakers and circuits are missing or overloaded for instance, the power connection to the mobile loading belt with bucket conveyor has no circuit breakers
- Sub-station, pillar boxes, junction boxes, etc. are not clearly marked as DANGEROUS. Anyone can easily access it. Often these rooms are used for storage and as social rooms by workers
- There is no regular check and maintenance of electrical installations and equipment
- Electrical rooms being used as rest areas for workers
- Fire extinguishers or insulation materials such as rubber mats are missing. If available, no one is trained to properly use fire extinguishers.

Hazards and health risks

- Electrical short circuits and fire
- Tripping of the entire power supply to the plant, which stops the entire production
- Contact of electrical power by workers which can result in serious injury, electrocution, burns or even death

Solutions to protect health

- ➔ Install Earth Leakage Circuit Breakers (ELCB) in all circuits to protect the operators from electrical hazards
- ➔ Keep the main switch box in good condition, protected from the weather in a separate room. Install an appropriately sized ELCB
- ➔ Provide good earth or ground connection for all installations
- ➔ Electrical cables should be laid into the ground in shock-proof material or taken over head. Cables should be run in extra plastic conduits
- ➔ Provide insulation materials for work on electrical equipment such as approved rubber mats in front of the distribution boards and main switches. This will help to insulate the worker and prevent a dangerous current from going through his body
- ➔ Log, and tag all installations which are under maintenance or repair, to prevent others from switching on the machines while another worker is repairing it
- ➔ All distribution points should be marked legibly in an understandable language, marking the feeding point, voltage, and identification number. This will help to Log-Out and make shutdown quicker in case of emergency
- ➔ Provide fire buckets filled with sand or portable-size fire extinguishers for use in case of fire
- ➔ Provide necessary personal protective equipment like shoes and rubber gloves for those deployed in electrical work



An overloaded electric circuit can cause a fire.

Good practices when working with electricity

- All electrical connections are in good order with ELCB attached
- All switch boards are enclosed and protected from weather and dust
- All panel boards are equipped with ELCB and all hand and power tools are run on circuits protected by ELCBs
- During electrical maintenance, a lockout/tagout system is mandatory and workers are trained to follow these instructions
- Electrical conductors such as cables are of sufficient size and load carrying capacity
- The transformer where the incoming electricity supply is received from the grid is isolated and cordoned off to prevent free access of the public and animals. A fence with or without barbed wire can enclose it. The compound is sufficiently large (around 2 meters each direction form the transformer), its surface is clear of green and dry vegetation to prevent fire

- The transformers are positioned at least 2.50 meters above ground level
- All workers are trained in the hazards and the safety measures when working with electricity
- In every shift, there is one person trained in basic life support (such as cardio-pulmonary resuscitation, CPR) in case of an accident with electricity

A.2.3 Machines and Power Tools

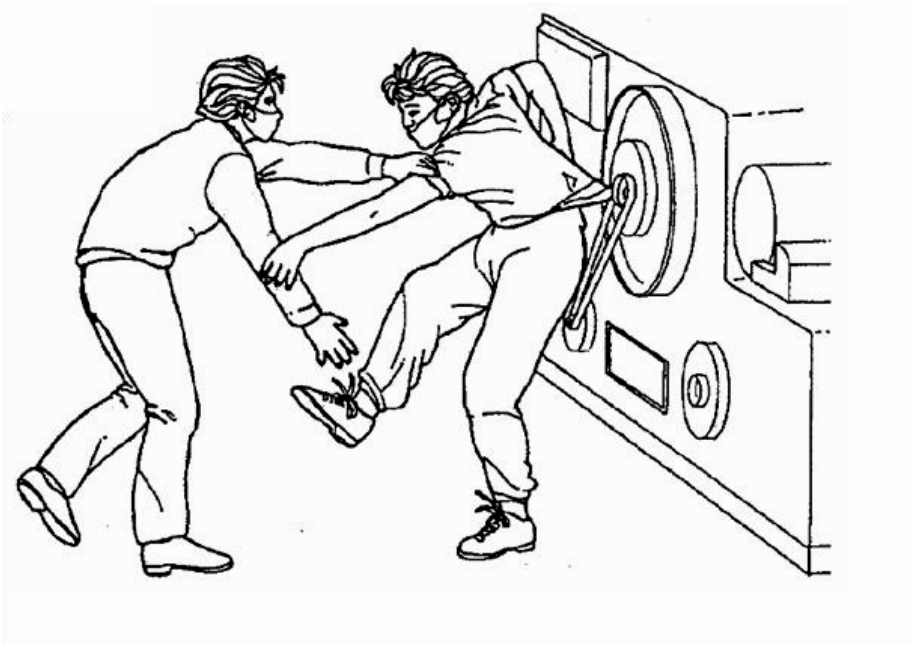
Machines can hurt people. They need to be constructed correctly to be safe for the workers who handle them or even just passing by. All too often, a worker is pulled into a machine such as a conveyor belt, a grinder or a crusher.

The major machines in a crushing unit are the primary and secondary crusher, the conveyer belt, and the sorters.

Small 'machines' such as power tools can also be dangerous if they are not properly maintained and repaired if broken.

Common unsafe conditions or acts

- No guards are installed around the crusher's moving parts, nip points, flywheels, conveyor drives, etc. to prevent clothing being pulled into the machine
- No emergency switch for the conveyor belt or the crushers is installed to stop them if a worker is pulled into them
- Workers are wearing loose clothing which can easily be caught and pulled into a machine
- Conveyors are not periodically inspected and tested
- Workers are not properly trained in safe procedures to protect themselves from making mistakes
- Movable conveyors are often in unstable positions
- No personal protective equipment (PPE) is provided to workers (see also the other chapter here in this manual), especially during maintenance and cleaning work



- Hand tools are in poor condition and not properly repaired when broken

Hazards and health risks

- Accidents and Injuries due to entangling with unguarded machine parts and being pulled into a machine, being caught between, stuck by, and dragged in to machinery
- Accidents when mobile conveyors topple over
- Equipment and conveyor damage

Picture 6: repairing the primary crusher, boulder chute on right

Solutions to protect health

- ➔ Train employees on safe work methods, avoid wearing loose clothing when working near moving machinery and conveyors
- ➔ Working near conveyors and moving machinery should be avoided as much as possible
- ➔ Install machine guards that are needed on and around all moving parts
- ➔ Repair and maintain all hand and power tools
- ➔ Only work with power tools when they are connected to a circuit, which is protected by an ELCB interrupter (see chapter on "Working Safely with Electricity")
- ➔ Use a so-called "Lock out – Tag out" system for safe locking of power sources, so that no one can accidentally switch on the machine while others are working on it
- ➔ Emergency shut-down switches should be installed for all machines in the crushing unit; train workers in their use
- ➔ Avoid unauthorized operation and entry by using a "work permit system" for contractors, which tells them what to do and how to protect themselves and the other workers

A.2.4 Using Gas Cylinders Safely

Gases are used in a stone crushing unit for repairs and maintenance work where welding or torch cutting is necessary. These gas cylinders are pressurized, which means that they contain enormous pressure. If the cylinder is cut open, for instance during an accident, they can explode; the gases in them can ignite and start a fire. It is clear that in such an event, workers and by-standers such as the unit owner can be seriously hurt or even killed. Especially dangerous are:

- cylinders of liquid propane or natural gas (LNG, LPG), even though there is little pressure in the cylinder they are highly flammable;
- cylinders with Oxygen or Acetylene, which are pressurized and also highly flammable

Preventing gas cylinders from exploding or gases in these cylinders from catching fire is therefore an important part of the safety of a crushing unit.

Picture 7: compressed welding gas cylinder (foreground) together with LPG gas tank (right side) close to a power generator on open, hand-twisted electrical cable connections (center)

Location/Workplace

– Store rooms of gas cylinders, locations of welding and cutting throughout the unit

Activities and Processes

– Storing materials, welding & cutting maintenance work

Common unsafe conditions or acts

– Gas cylinders are stored or placed all over unit

– Gas cylinders are not secured and protected from falls

– Cylinders are rolled, pushed, pulled or even thrown without care

Hazards and health risks

– Explosion

– Fire

Solutions to protect health

➔ Cylinders should be stored and used upright and secured with a chain to prevent them from tipping

➔ Cylinders should be stored in cool and dry place, in the shade. They should be placed in an upright position, never be left open, or exposed to sunlight

➔ Put full and empty cylinders in different places and mark which ones are full and which are empty

➔ Always use the protective caps on cylinders that are not-in-use. They protect the outlet from being damaged in case of a fall

➔ Simple trolleys can be used for transporting cylinders in an upright position. NEVER roll or drop cylinders

➔ All cylinders are equipped with pressure gauges

➔ Color-coding of each cylinder is used to indicate the kind of gas in the cylinder. Please ask someone for the national color coding standards, so the marking is uniform in the entire country when cylinders are bought, sold and refilled

➔ No sparks should be created when working close to the cylinders. No smoking is allowed in the vicinity of the work.

A.2.5 Keeping the Roads Safe

Accidents with vehicles are some of the most common accidents, often severe and often fatal. People are run over or crushed against other objects by moving trucks.

Often, the drivers have not received sufficient training or the company does not provide simple equipment such as mirrors.

Trucks are regularly transporting and dumping the boulders brought from the quarrying mines to the collection pit. Because of the dust in stone crushing units, the visibility is often poor and, because of the noise, shouting and warnings are often impossible to hear. Owners need to make special provisions to keep truck operations safe for the driver but mostly for the other workers.

Location/Workplace

– Hot spots for traffic accidents are: the approach road from the entrance to the top of the boulders unloading pit are, and the boulders loading point at top of primary crusher itself

Common unsafe conditions or acts

– Poor visibility for the drivers because of dust

- The conditions of trucks and roads are very poor, mirrors are often missing or not used
- Vehicles are moving freely near the work area without clear traffic lanes and parking areas inside the unit

Picture 8: unloading boulders on top of boulder pit, workers resting (background)

Hazards and health risks

- Severe traffic accident risk for all persons inside the crushing unit
- Toppling of the vehicles, damaging the vehicles as well as injuring the driver

Solutions to protect health

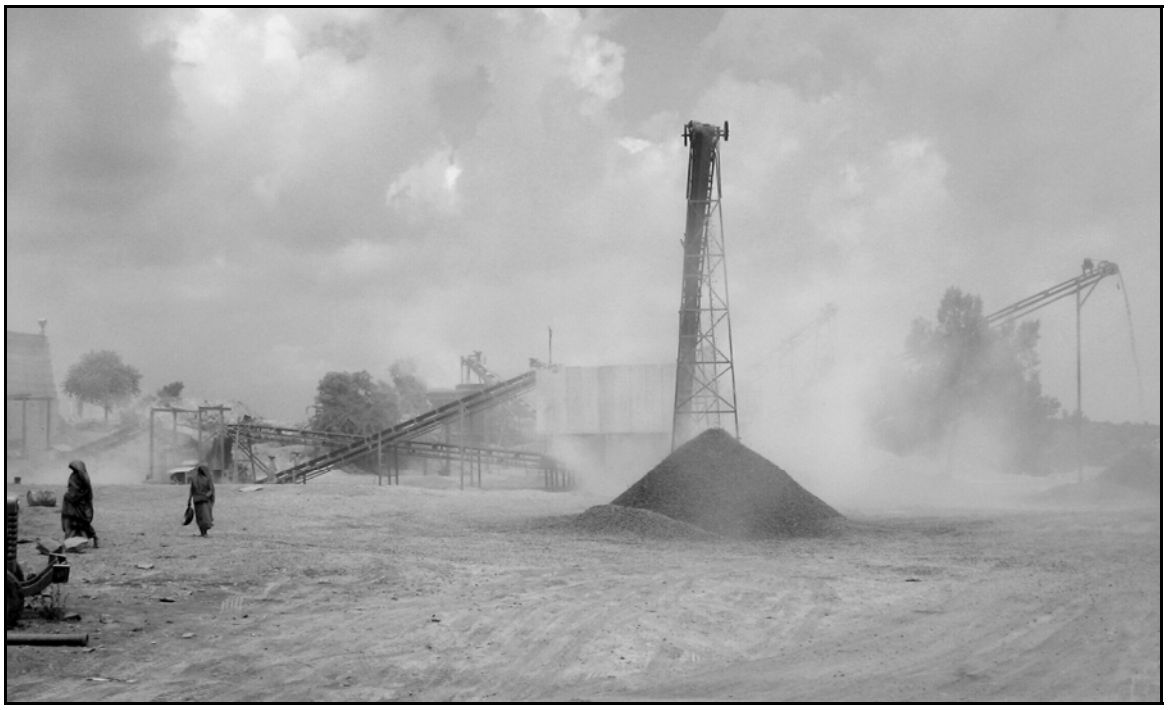
- ➔ Maintain the vehicles regularly and repair broken and missing mirrors
- ➔ Provide street lighting along the approach road
- ➔ Mark the roads inside the plant! This can be easily done by dipping the small boulders in white lime and placing them along the curb of the road to provide better visibility and guidance
- ➔ Restrict unauthorized entry of vehicles and undue parking inside the plant and restrict parking of the vehicles along the road and on the slopes
- ➔ Drivers should not move the vehicle when persons are standing on the top of the truck
- ➔ Provide warning signals and also speed limit indication for vehicles moving inside the crushing unit premises
- ➔ Wherever truck operations are carried out, particularly in uneven surfaces and slopes, wheel chokers should be provided
- ➔ Try to use gravel instead of dust for preparing roads to control dust emissions caused by vehicle movements
- ➔ The vehicles entering the crusher unit must have the proper validation of the vehicles and certificates of road worthiness
- ➔ The driver should have the valid licenses of heavy vehicle driving. They should also receive proper training in driving including some safety training for safe driving on public roads.

- ➔ All vehicles should be fitted with fog lights to drive in the dusty atmosphere at night
- ➔ Equip all vehicles with loud sound signals when backing up
- ➔ The roads shall have the allowable slope for easy ascending and descending of the vehicle

A.2.6 Securing Access to the Plant

Access to a plant in general should be prohibited for all untrained persons and all persons who do not work there. This includes specifically children, also after working hours.

However, trespassers and outsiders often have free entry to any part of the unit. This poses a security problem (e.g. things can get stolen) and a safety problem (e.g. person might get hurt because they do not know the operations). Entry of unauthorized persons therefore needs to be restricted.



Picture 9: access roads to crusher and boulder pit (background)

Solutions to secure access and protect health

- ➔ Install gates at entrance points, which can be controlled and locked after working hours
- ➔ Have a fence around the entire premise
- ➔ Vehicle movement should be controlled and documented in a log by a security guard for future reference
- ➔ Assign security personnel to the entry gate to control unauthorized entry into the unit. These security guards should then be able to assist in head counts in case of an emergency
- ➔ Security guards can also check on the condition of the drivers for their proper identification (license), credentials, and physical condition

A.3 Keeping Workers Healthy

Stone crushing produces a lot of dust. Dust consists of particles, which are dispersed in the air and remain there for a while. It is generated from mechanical actions, such as stone crushing, truck movement, etc. Although most dust particles can be seen with the naked eye, some cannot be seen without the help of a microscope. These fine dust particles can travel deep into the lungs and have the potential to cause the most damage. A "dusty lung" (pneumoconiosis in medical terms) or severe chronic lung disease (called "chronic-obstructive pulmonary disease", COPD in medical terms) is a common hazard caused by to much exposure to dust.

Several rocks such as granite and normal sand contain a substance called "silica" in varying degrees, typically about 10 or 20%. This substance causes even more severe lung disease when inhaled as fine, man-made particles ("silicosis" in medical terms). These fine particles are typically found in the stone crushing process. Scar tissue forms deep in the lungs and makes the lungs less efficient and less strong. Over time, even AFTER work in stone crushing and the dust exposure has stopped, this destruction process in the lungs continues and the worker will eventually die from the damage.

Typical signs of lung damage by dust include difficulty breathing, shortness of breath, wheezing, constant coughing, reddish or bluish color of ears and/or the lips. This difficulty in breathing is often combined with fatigue, loss of appetite, weakness.

Stone dust cannot be avoided in stone crushing. It is produced by the crushing itself, the sorting, the transport of gravel and also by vehicle movements over dusty roads. We can however reduce the amount of dust that reaches the lungs. By engineering controls, the places where dust is generated can be encapsulated so the dust is not easily carried off by the wind. Only after engineering and other controls have been used in all areas, personal protective equipment such as appropriate masks should be used. So-called Particulate Respirators Masks offer various amounts of protection depending on the type of filter and the fit provided. Using a cloth to cover the nose and mouth is NOT really protecting the worker.

There is no good short-term solution to the problem. Appropriate masks that protect workers from dust are often hard to find in developing countries. Even if they were available, the very high amount of dust would force the workers to change the masks or filters several times per day. In addition, the masks are often uncomfortable, specifically when one works in a hot climate.

The best solution is therefore to REDUCE the amount of dust that is being released into the ambient air. This can be done by:

- Enclosing the dust sources and processes
- Ventilate with a local exhaust system near the generating source
- Spraying water at the source of dust dispersion

We will discuss these solutions in the next chapters. You will find information on dust reduction systems that use

(a) water sprayers or

(b) a ventilation system

A.3.1 Reducing Dust When Water is Available

Perry Gottesfeld, Occupational Knowledge International, San Francisco USA

Water spray dust control measures are effective at reducing respirable crystalline silica dust. Studies have reported significant reductions with the use of wet methods to control silica dust in various applications including stone crushing, construction, mining, and manufacturing industries.

Reductions in respirable dust in stone crusher mills can be accomplished through engineering controls including process enclosures (or containment), dust collection (or local exhaust ventilation), and water spray systems. Water spray suppression systems may be pressurized or rely on available water pressure. Basic systems without pressurization can be effective at significantly reducing respirable silica if an adequate number of well positioned spray nozzles are used.

Silica content is known to vary greatly from area to area and may help to determine the necessary extent of controls. Quarry and mill owners can test samples of the rock to determine the silica content.

Water Spray System Design

The spray nozzle is selected to achieve the desired spray characteristics, velocity, spray pattern and angle. Below is a general discussion of these factors:

Droplet and Orifice Size: Droplet size is the most important variable for proper dust control and is determined by the orifice size and available pressure. The smallest droplets are generated with pressurized systems.

Droplet Velocity: Normally, higher droplet velocities are desirable for dust suppression control. Information on the droplet velocity, based on the available water pressure, can be obtained from the nozzle manufacturer.

Spray Pattern: Nozzles are categorized by the spray patterns they produce. The following describes the different spay nozzles used in dust control:

- **Full-cone nozzles** produce a round spray pattern and provide high velocity over a distance. These nozzles provide optimal surface area coverage for non-pressurized spray systems
- **Hollow-cone nozzles** produce a spray pattern in the form of circular ring. Droplet range is normally smaller than the other types of nozzles
- **Flat-spray nozzles** produce a rectangular or even spray pattern. They also produce relatively large droplets that are delivered at high pressure
- **Air Atomizing nozzles** require a pressurized system to produce very fine mist. They are very effective in locations where airborne dust particles are extremely small and nozzles can be located in close proximity to the dust source

Spray Angle: The spray angle determines the width of the cone-shaped spray pattern produced by the nozzle. The appropriate spray angle needed to cover a specific surface area would depend on the distance the nozzle is placed from the material.

Flow Rate: The rate at which water flows through a nozzle depends on the operating pressure and orifice size. Increased water pressure improves mist delivery and may allow for the installation of fewer nozzles to achieve the same dust reduction. It is also important not to apply too much water to the material as the finer particles can become muddy and sticky, which may cause equipment problems.

Number of Spray Nozzles: Depending on mill design and coverage area, a minimum of 8 – 11 nozzles are usually needed in small crushing units. Important nozzle placement locations include:

- 1 nozzle on the top of the crusher
- 2-3 nozzles at the delivery point of crushing material
- 2 nozzles, one on each side of the delivery of the crushed material
- 1-2 nozzle on the bottom of the vibrator screen or rotary screen
- 2-3 nozzles within the storage hopper
- 1 nozzle at the delivery point of raw materials
- 1 nozzle at the bottom of the dust hopper

Picture 10: water spray nozzle above chute. Source: Occupational Knowledge International

Placement of Nozzles: Nozzles should be placed upstream of the transfer point where dust emissions are produced and located to allow maximum time for water droplet interaction with airborne dust. Distance to crushing material depends on nozzle type, spray angle and water pressure.

Water Consumption: A typical nozzle consumes 5 to 20 liters per minute (lpm) of water (per nozzle) depending on water pressure. A correct spray systems does not use a large amount of water as the nozzles are designed to supply a mist and not a stream of water.

Water Quality: Spray systems can rely on a variety of water sources that do not have to meet drinking water quality. For non-potable water sources, careful consideration should be taken with respects to microbiological contaminants in the water, as it may pose an inhalation hazard.

Road Sprinklers: Dust previously settled on roadways and on waste materials can get back in to the air and contribute to silica exposures. Intermittent use of sprinklers on roadways can reduce the dust generated by wind or vehicles. Commercially available sprinkler equipment can be used instead of a fine mist. However, such systems typically consume considerably more water than the fine mist nozzles.

IMPORTANT NOTE: Although water spray systems are very cost-effective in significantly reducing the risk of silica dust exposure in stone crusher units, they do not eliminate the risk of silicosis or other related disease among exposed workers. Additional engineering controls and respiratory protection, may be required depending upon the crystalline silica content in the stone and the nature of the work being performed.

Reliability and Cost Considerations

The water spray systems described here require limited maintenance and are reliable if used regularly. The costs for the spray equipment (not including the installation) if water supply is already available, range from approximately $1,000 to $1,400 USD for small mills.

Contact information:

Perry Gottesfeld
Occupational Knowledge International (OK International)
220 Montgomery Street, Suite 1027
San Francisco, CA 94104 USA
Web: http://www.okinternational.org/

You can see an OK International video on *"Reducing Silica Exposures in Stone Crushing"* on YouTube (http://www.youtube.com/watch?v=6rBSL1WfNgw): Silica released from stone crushing is causing an epidemic of silicosis, cancer, other lung diseases and increases the risk of acquiring Tuberculosis (TB). This situation is particularly dire in India where the stone crushing industry employs over half a million people, many of whom are women and children. This video documents how mill owners reduced silica exposures by over 80% in one pilot study.

For additional information on the use of water spray systems, see the following publication: *Reduction of Respirable Silica Following the Introduction of Water Spray Applications in Indian Stone Crusher Mills*, Gottesfeld, P, Nicas, M, Kephart, J, Balakrishnan, K, and Rinehart, R., International Journal of Occupational and Environmental Health, Vol. 14, No. 2, 2008

A.3.2 Reducing Dust When Water is Not Available

Mr. Suvankar Bose, Mr. George S Sharma, Development Alternatives, Delhi

Why use a "dry" dust reduction system?

The water-using dust control system introduce moisture into the material flow by spraying water at dust generating locations so that fine particulates do not become air borne. This requires an arrangement to provide pressurized water to nozzles. Its installation includes a water tank, pump, filter, pressure gauges, flow meter and a network of pipeline, fitted along with regulating valves and spray nozzles. Though dust emissions can be effectively be suppressed, the water-based suppression technologies have some disadvantages:

1. Sometimes water is not available near the stone crushing sites, transporting it would require additional investments
2. Nozzles can get chocked and need regular maintenance
3. The dust coating on the crushed stone can look like low quality crushing and might fetch lower price in the market

Because of these practical limitations of water-based spray systems, a dry control system or a wet & dry -combination system are options.

Picture 11: dust capture with dry ventilation and suction system

Design and installation of a suitable engineering dust control system was one of the planned interventions in the project. During interactions with unit owners, four criteria were laid out for the team to develop a suitable dust abatement system:

- the system should not interfere with the current operating processes
- it should be energy efficient and operate within available surplus power
- it should not consume water as the region suffers from water scarcity
- investment cost should not exceed INR 400.000 or about USD 8.000

Before initiating the designing of the system, the team members studied different systems in other regions like Punjab, Rajasthan and Kerala in India. Thereafter, the system was designed, discussed with unit owners and their suggestions and inputs were integrated into the final product. The team installed two systems in participating stone crushing units:

1. A completely dry system using only ventilation and suction to capture and collect the dust particles and
2. A wet & dry combo technology that uses dry suction and wet capture of the dust

Both systems are decentralized ventilation systems with cyclones as the main component. It is designed to suck dust from the sieves, crushers and chutes. The systems include the processes of

a. Dust COLLECTION at locations where dust is generated (crushers and sieves). This includes an effective encapsulation of the dust generating machinery parts and
b. Dust SEPARATION using cyclones, bag filters or water tanks to separate the dust and reduce dust emission into the environment air

The different features of the two systems and some experiences are summarized in the table below.

Table 1: Comparison dust control systems

Feature	**Dry System**	**Wet & Dry Combo System**
Basic design element	Decentralized, dry dust extraction with suppression system using a cyclone with suction capacity of 7500 and 6000 cft/hr that finally leads to chimney fitted with bag filters to catch finer particles.	Decentralized dust extraction with suppression system with dry and wet arrangements using a cyclone with suction capacity of 7500 and 12000 cft/hr that finally leads to water tank for sedimentation of finer dust and a chimney.
Major operational difficulties	- Visible dust reduction was not accompanied by expected reductions in measured respirable dust due to incomplete encapsulation - The sources of dust could not be encapsulated completely due to owner's resistance	No operational difficulty being faced as the system. After a while, the unit owner was running it without support from the research project.
Performance in terms of dust reduction	A 30% to 40% reduction in respirable dusts was achieved when concentrations of particulate matter (PM) of less than 10, 4 and 2.5 micrometers were measured.	During the project, the installed pilot system was running satisfactorily and there was a marked difference in visible dust levels.

Features of the Dust Suppression Technology:

This systems capture the released dust, suck it through pipes to a cyclone with blower and finally leads to bag filters (dry system) or a water tank (wet & dry combo system) where finer dust particles are captured. The advantages of a completely dry system are the facts that it does not use water at all, does not alter the aspect and quality of the produced gravel and that the collected dust can easily be recovered and re-sold.

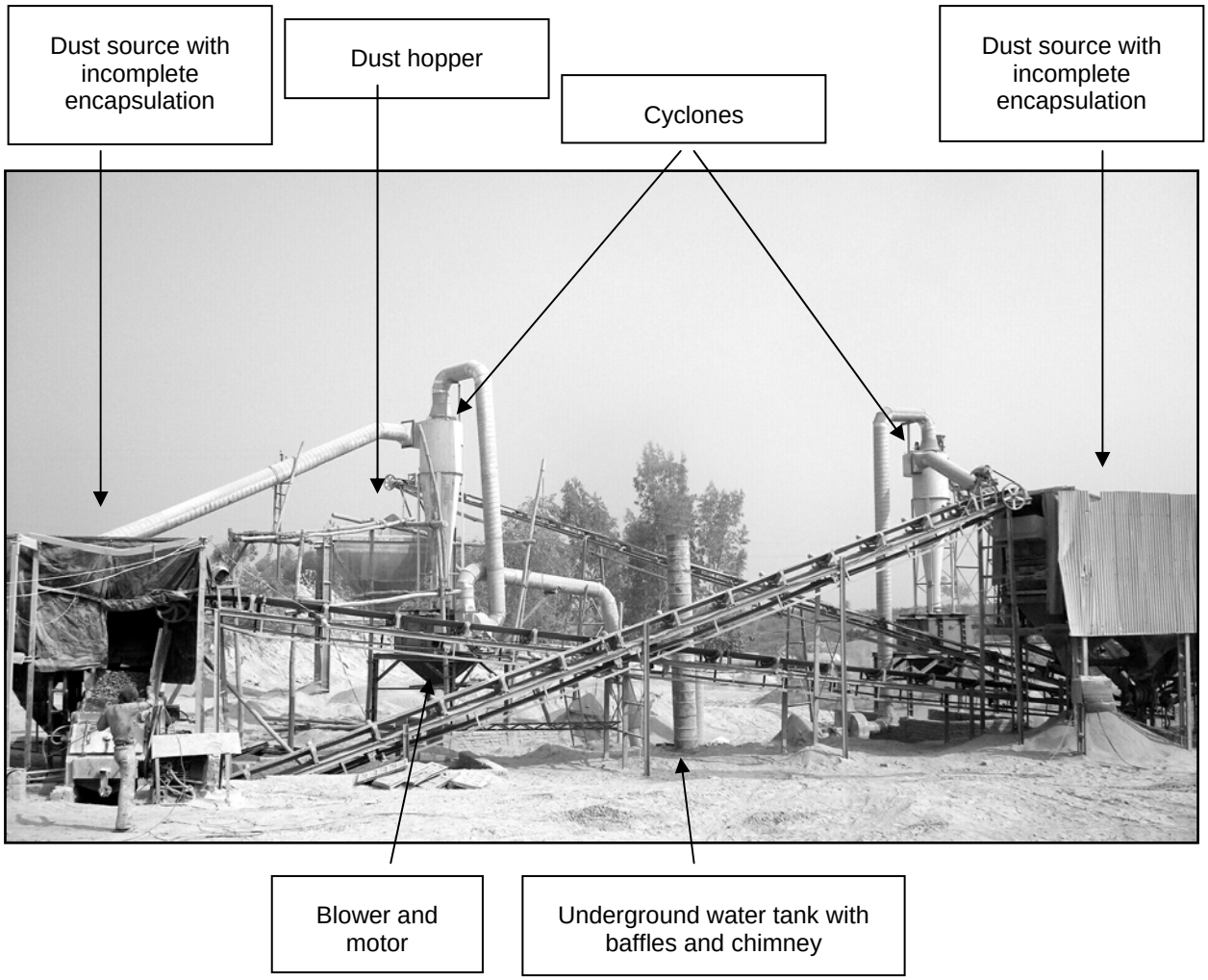
The system components include:

a. Enclosures and Ducts

A closed chamber made out of sheet metal or plastic encloses the major sources of dust such as crushers and sorters. A suction pipe connects to the enclosure and carries dusty air away to the cyclone. The complete suction hood with enclosure can easily be dismantled and refitted. It is therefore easy to maintain and to clean if needed. The ducts transport dust-filled air to the cyclones, dust hopper or water tank.

b. Cyclone separator with blower

The air filled with dust particle enters first a cyclone separator. The cyclone separator creates a vortex (a spiral flow) inside the chamber and makes use of the centrifugal force to separate the particles from the air stream. They collect in a settling chamber at the base of the cyclone The suction capacity can be adjusted by regulating the blower. This separation technology is very cost effective. In areas with no water at all, this dry cyclone separator system is an efficient and cost-effective solution to control dust emissions.



Picture 12: Overview of the wet & dry combo system with dry capture of dust-filled air at source and water-based separation of dust at end of pipe. Source: Development Alternatives

c. Dust Hopper

The coarse dust particles collected in the cyclone fall into the settling chamber and the dust hopper. Due to its size, it needs to be emptied only once a week. It therefore eliminates daily dust exposure of workers and reduces cost to the entrepreneur. The collected dust can usually be sold as a primary product to other industries such as cement or construction industry.

d. Bag filters (dry system) or Water Tank with Baffles and Chimney (wet & dry combo system)

The air coming out of the cyclone is still filled with finer dust particles. They can be captured in two ways. In a completely dry system, bag filters are used to trap the particles. The resulting dust can be sold for other purposes. In a wet & dry combo system, the air is let into a water tank where dust particles are captured in water. The finest dust particles, which are still not captured, escape from a five meter high chimney mounted onto the water tank. The tank requires about 1400 liters per week. The resulting slurry can be used for building construction .

In addition to the dust reduction system on the crushers, other measures need to accompany this effort, for instance paving and cleaning of roads to suppress secondary dust emission by traffic, planting of a "green belt" of dust-capturing trees around the plant and water harvesting for use in the plant.

The total cost of planning, consulting, purchase and installation of such systems can lie between 10.000 and 20.000 USD depending on the size of the installations and the cost of materials.

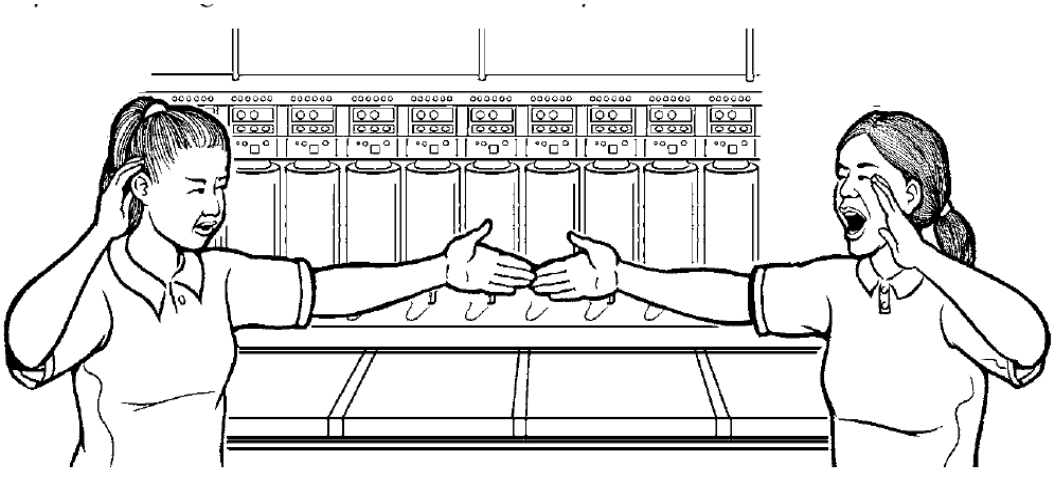
Information on wet and dry dust suppression technology, combo systems, green belt development, water harvesting or use of collected dust for construction can be obtained from:

Technology and Action for Rural Advancement (TARA)
Village Ghittorni, Mehrauli Gurgaon Road
Near NBCC Campus, New Delhi - 110030
Tel:011-26801521 / 2680 4482 / 0680 5826
Tel Fax: 011-26804484 / 26805826
E-mail: sbose@devalt.org, gssharma@devalt.org
Website: www.tara.in

A.3.3 Protecting Hearing from Noise

Exposure to loud noise can ruin a person's hearing and cause much physical and psychological stress. Without the ability to hear, it is nearly impossible to perform a job task successfully and safely. Permanent hearing loss can result from continuous noise exposure. It indicates that parts of the so-called hearing cells in the inner ear have been destroyed. They will not grow back nor can they be repaired. Hearing is lost forever.

The effects of noise on a person are not curable, but noise exposure can be controlled through many different technologies. In general, using work processes that are quieter, enclosing noisy equipment, and using sound-absorbing materials at impact sites is recommended to reduce the amount of noise being produced.



If you cannot hear someone talking 2-arms-lengths away, the noise is too loud.

Noise is mostly produced by either impact or vibration. This happens at the following **locations** in a stone crushing unit:

- The crushers themselves(Primary and Secondary) when boulders are crushed and transported along conveyors
- The boulder loading point when boulders are fed into receiving pit
- The sieves when the gravel is sorted

Noise can have the following **effects on the health** of workers and owners:

- Distortion of sounds (hearing something, but not understanding)
- Temporary or permanent hearing loss
- A continual ringing in the ears for which there is no cure ("tinnitus" in medical terms)
- Quickened pulse rate, increased blood pressure and a narrowing of the blood vessels
- Abnormal secretions of hormones, muscle tensing, nervousness, sleeplessness, fatigue

Solutions to protect health

- ➔ Conduct regular maintenance: replace all unbalanced or loose parts of machines
- ➔ Lubricate turning machine parts regularly
- ➔ Replace metal parts with quieter plastic parts if possible, for instance rollers, washers
- ➔ Machines which vibrate should be mounted on heavy, rigid bases to prevent vibration
- ➔ Consider putting heavy rubber or plastic mats on places where impact or machine parts or boulders cause noise
- ➔ Enclose especially noisy machine parts with punctured metal plates, best in several layers so the sound gets "trapped"
- ➔ Position workers away from noise sources as much as possible
- ➔ Provide hearing protection for workers, such as earplugs and earmuffs, train workers on the purpose, proper fitting, and care of hearing protectors and provide continuous monitoring of employee noise-exposure levels if possible. However, in that case collaboration with experts in occupational health is needed for advice
- ➔ Always use properly shaped and sharpened cutting tools so you need less force to cut things.

We show here a noise map of a typical stone crushing unit. The areas in the centre, in red (dark grey in the black & white print) indicate areas with more that 90 decibel of noise (measure in decibel on scale A, adapted to the capacities of the human ear, abbreviated dB (A)) where hearing protection needs to be worn. It is the area around the crushers and the sieve. The next area around it, in pink (gray) has noise levels over 85 dB(A) where hearing protection should be provided. Noise levels above 85 dB(A), and definitely above 90 db(A), are dangerous and will lead to noise-induced hearing loss after a short time. They are also a risk factor to develop high blood pressure, nervousness, and irritation, all of which can increase the risk to have heart diseases such as heart attack, or stroke.

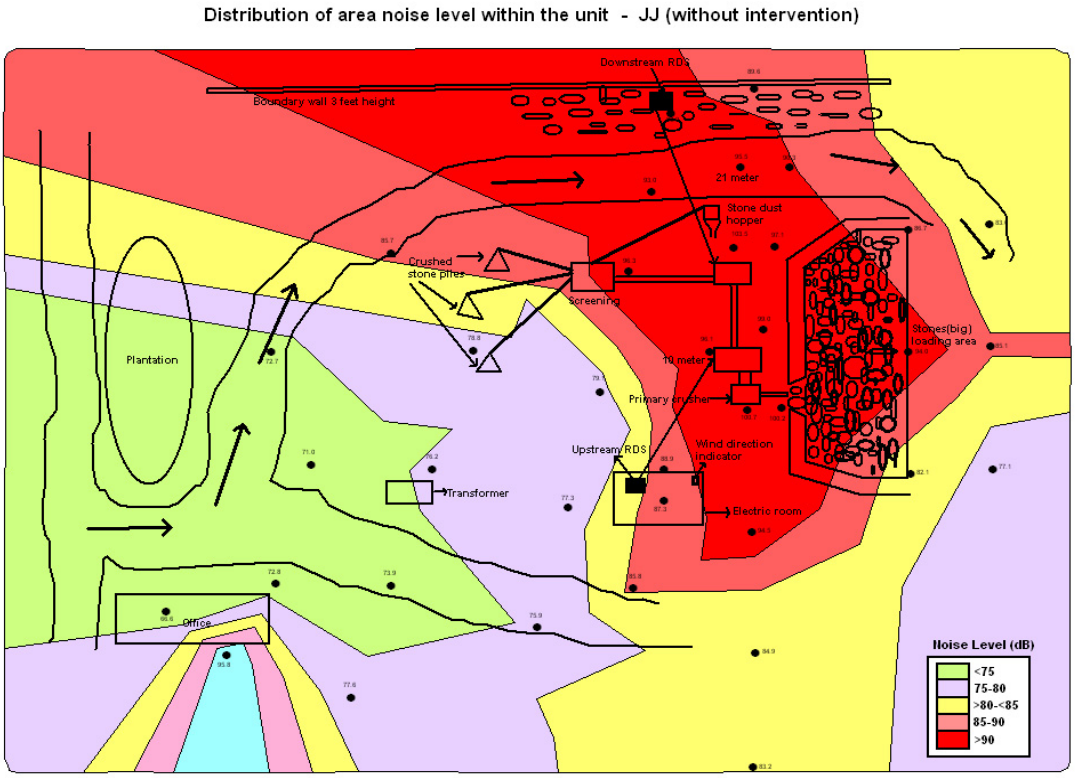


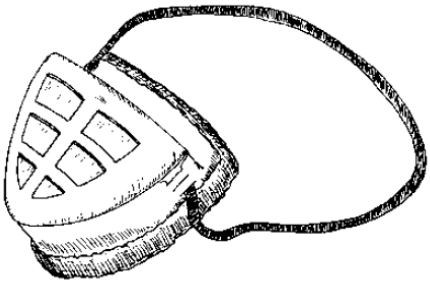
Figure 1: noise map from a typical crushing unit with boulder pit on right and machinery in center of picture (Source: SRU Chennai, India)

A.3.4 Using Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE) such as gloves, masks or goggles may sometimes be required to protect workers from an unsafe working environment. This should be used ONLY when ALL other possible means of controls, such as administrative and engineering controls, have been exhausted. This is why PPE is called a "secondary" control method, for it is a last resort option.

When we cannot enclose or isolate machines, no proper ventilation is possible, then PPE is an option to protect the health of workers and should be mandatory. It is important to realize that personal protective equipment does nothing to reduce the hazard; it merely serves as a barrier between the hazard and the worker. If the barrier fails, there is no backup and the worker is directly exposed to the hazard.

When PPE is provided, the employer must be sure that workers are wearing the equipment properly and at all times. This can be accomplished through routine inspections throughout the yard. Proper training on how to wear PPE is needed for all workers and management.



Regular use and cleaning of dust masks can prevent lung damage.

PPE might be needed throughout the stone crushing unit. It is needed to protect from:

- accidents and injuries, for instance falls or hand injuries
- noise
- dust

Solutions to protect health

- ➔ Identify which PPE is needed for which job. These job-specific PPE should then be required for all employees at that job. You might need advice from occupational health experts to select the proper PPE for different tasks.
- ➔ Ensure that PPE is used properly and regularly
- ➔ Effective PPE program should be implemented to instruct employees on the importance of using PPE and the appropriate way to don and doff PPE equipment
- ➔ Wherever possible, sun protection in the form of shade should be provided, for instance a covered shed for tally clerk
- ➔ Provide cost effective rubber-soled shoes, hard hat, gloves, and goggles to the loader
- ➔ Make a wind sock with available material at site and fix it at the top most point; this will help persons working to place themselves in such a way to avoid the dust flow
- ➔ Masks against the dust are expensive and very uncomfortable. It is much less expensive and cost-effective to reduce the dust using engineering controls and dust reduction methods (see other chapters in this manual). Nose pads or cloths are not effective. The nose mask with changeable filters is more appropriate, however it is quite expensive. Wearing it the whole day is very uncomfortable. You need to consult with occupational health experts if you want to choose an appropriate respirator mask for the employees

Different kinds of masks to protect from dust and fumes

- ➔ All those deployed in and around the crushing units and in particular those working near the vicinity of the crusher should wear the following:
  - **Hard hats** for all employees: Helmets are not expensive and could be replaced once in a year and whenever they are damaged
  - **Safety shoes:** Protect from falling objects, as well as sharp stone pieces for those working in the plant
  - **Gloves:** For those handling boulders from the truck and at the loading points
  - **Goggles:** To avoid fine stone dust entering the eyes which can create eye rashes, burning and cause chronic eye inflammation
  - **Noise Control PPE:** This is crucial for those working near crushers

Putting in ear plugs correctly

- **Ear Muffs:** For those working near the crusher and at loading points where frequent dumping of the boulders is taking place. They need to be washed regularly
- **Ear plugs:** For those working in the distal vicinity at the time of crushing activity. They need to be washed and changed regularly

A.3.5 Working Safely at Night

Lighting is important in the workplace not only for worker comfort but also for safety reasons. Good lighting is needed throughout the plant and yard but specifically at access roads, at the boulder loading point at the top of the primary crusher, and at delivery points. Truck drivers, for instance, need to see their environment, the road and other workers.

Illumination refers to the quantity of light in a certain area. A lack of illumination may make specific and general tasks both difficult and dangerous for workers

Common unsafe conditions or acts

- Poor illumination at night and uneven light distribution
- The glare from high intensity lighting is a concern; as the glare is increased by the dust and white stones as well as from reflective metal sheets often strewn around the site

Hazards and health risks

- Any kind of accident can and will occur when lighting is not sufficient: trips and falls or vehicle accidents Cost effective lamps such as sodium vapor lamp or mist/dust diffusing lights are available for stone crushing units

Solutions to protect health

- ➔ Ensure a good amount of lighting at the pit area and on the access areas. You can also conduct a survey on the continuous, frequent and occasional activity areas and provide lighting accordingly
- ➔ Focus the light on crusher operations
- ➔ Enough lighting at night time should be ensured by providing street lights and focused light to cover the entire area
- ➔ Ensure a torch light is also provided to workers at the top of the boulder pit for emergency use
- ➔ Ensure an illumination of a minimum of 150 lux around the crusher area and 200 lux projected as a spot light on the crusher itself. "Lux" is the unit in which light is measured. You might need the help of an occupational health expert or technician to determine appropriate and cost-effective light fixtures

➔ Metal sheets and other glare-generating materials should be removed from the site and stored in covered place

Picture 13: a make-shift shed to protect from direct sun light

A.3.6 Fighting off the Heat

Heat is bothersome. Heavy work in the heat is not only uncomfortable but it can also be dangerous. Heat stress is the body's response to extremes of hot temperature. In this environment, the body is not able to cool itself quickly enough. The risk of heat stress is even greater if the person exposed to the heat is also performing strenuous activity, like that performed in a rock crushing yard. Our body temperature and the consequent heat stress are not only influenced by air temperature, but also by air movement, humidity, and radiant heat. While more air movement (wind, for example) reduces the heat, higher humidity increases the body temperature. Radiant heat is what other objects give off as "heat" and which then is absorbed by the human body. Examples of this are hot surfaces of rocks or buildings.

Proper ventilation (either local or general) is important in reducing dust and other airborne contaminants in an environment. Simple fans can and should be used to provide a cooling airflow. However, in higher temperatures they also increase the risk of drying the body out as hot air is being blown onto the workers. Regular drinking of large quantities of drinking water is specifically important.

Air-conditioning systems provide cooled air. These ventilation systems need to be routinely inspected and evaluated in order to ensure they are operating properly and preventing exposure, for instance from molds growing inside such air-conditioning systems.

Unfortunately, water is often only available at the office shed and those who work hard, far away from the office, do not have easy access. If employees have to travel far distances for water, they are more likely to neglect drinking and are at risk of dehydration.

Activities and Processes

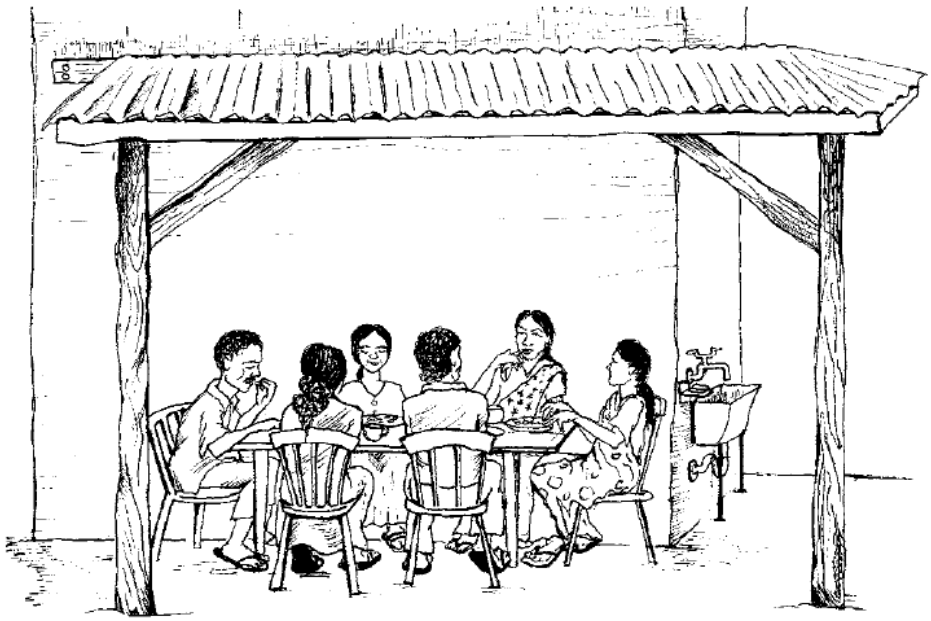
The risk of heat stress exists during all physically heavy work in a stone crushing plant, for instance during boulders pushing through the receiving pit and into the crusher, the collection of stray boulders throughout the yard surrounding the conveyors, maintenance work, cleaning work, dust and gravel collection by hand.

Hazards and health risks

- Heat stress can cause strains, muscle cramps. If no water and cooling is provided the damage can progress to dizziness, severe fatigue and exhaustion, disorders of the brain such as seizures, and unconsciousness. If no treatment and water is provided, the over-heating can cause more damage to the brain and can lead to death

Solutions to protect health

- ➔ The only possible solution against heat stress, is to provide
  - shelters and shade wherever possible
  - air flow, e.g. with fans
  - sufficient quantities of cool drinking water
- ➔ Provide temporary sheds at selected locations for the workers to rest and relax during idle hours
- ➔ Provide a fan if possible for these places
- ➔ Provide personal water bottles for those who work in a distance can carry drinking water with them or provide water pots at vital locations, maintain them clean and fill them regularly. *Example*: Each employee working at top loading points and other peripheral areas has a personal bottle to carry drinking water to their work location
- ➔ Workers should drink a full glass of water every 30 minutes if they are working in the heat. They should not wait until they feel really thirsty



Eating outdoors in the shade gives workers a chance to rest, relax, and breathe fresh air.

A.3.7 Taking care of Human Needs

Welfare amenities include basic necessities that should be provided to all people, including workers in the yard. One of these necessities is having plenty of water in close proximity to the work area. Another amenity is having toilets close by, so that workers are able to use the restroom when needed. Frequent restroom visits help prevent bladder and urinal disorders.

Common unsafe conditions or acts

- Water and bathroom breaks cannot be taken by employees at their convenience
- No latrine provided specifically for female employees
- Toilets and latrines are not properly cleaned and maintained, there is, for instance, no running water to wash hands
- No kindergarten or crèche is provided. Children are found with their employee parents in the main yard and therefore are exposed to the same level of heat and dust as the adult workers
- There is no place or room to sit and eat or have a break. Workers often have to sit in the sun during their breaks

Solutions to protect health

- ➔ Install a toilet facility, separate for men and women, in the crushing unit, locate them close to the working areas. Count on having approximately 1 toilet per 20 men or 20 women
- ➔ Clean and maintain the toilets properly to encourage use and prevent infections

- ➔ Put up clean cloths and sanitary pads in the women's toilet to help women during their monthly bleeding period. A waste basket with a lid needs to be in the women's toilet.
- ➔ Create a separate space for children away from the dust and the noise, to play and sleep while parents are working. One adult should be in charge of supervising the children
- ➔ Provide a space where workers can sit during breaks and take their food. This place should be sheltered against the sun, clean and away from the noise and dust

A.4 Being Prepared for Emergencies

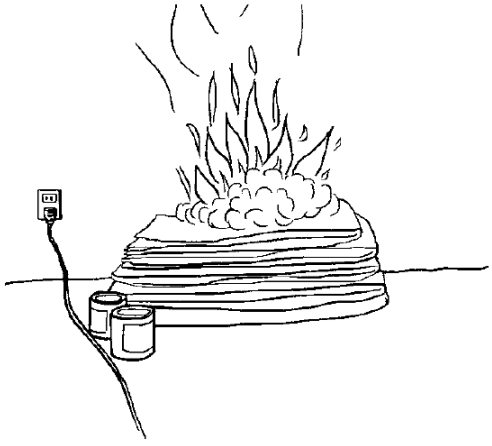
Emergencies such as accidents can happen any time, specifically in a stone crusher unit. Heavy boulders are transported and crushed, truck are coming and going any time, workers are conducting work at heights to repair and maintain the crusher and the installations, gravel heaps can slide and bury workers.

In case of such a severe accident, rapid and correct response is needed. The unit and the owners can prepare for such medical emergencies. By acting fast in case of emergency, the victim can be helped better, maybe even lives can be saved and the losses for a company can be reduced significantly.

Very often, we find the following situations in crushing units:

Common unsafe conditions or acts

- No preparations are made in case of an emergency
- No current plan enables easy and quick action in case of emergencies
- Chaos and confusion at the time of an emergency lead to more damages
- No one is trained in appropriate first aid and incorrect "help" can worsen the condition of the injured



Electrical spark causing a fire

Solutions to prepare for medical emergencies:

- ➔ Make a board with important telephone or mobile numbers of nearest:
  - Ambulance facility
  - Fire station
  - Hospitals
  - Doctors or nurses
  - Police
  - Manager and Owner contact numbers
- ➔ Have a telephone line or mobile phone facility available at all times, also during night shifts
- ➔ Draw an emergency plan through a consultant; document the plan and train the employees
- ➔ Conduct a mock drill at least once a year
- ➔ Develop a rapport with nearby industries to get help when needed
- ➔ Train selected staff in First-Aid treatment, keep a well stocked First–Aid box at the site on several locations

- ➔ Keep a system for head-count at the time of an emergency
- ➔ Train and post one responsible staff at all times to act as a responsible manager and provide him/her with training and powers to act at the time of an emergency

Picture 14: flammable material in the electric room is a fire hazard

Solutions to prepare for fire:

Fires in a stone crushing unit can happen because flammable gases are used for torch cutting or welding and because electricity is often used in an unsafe way throughout the plant. Some solutions to prepare for a fire are:

- ➔ Portable fire extinguisher should be located in:
  - Electrical Room (do not use water there!)
  - Office & Dwelling areas
  - Gas storage areas
- ➔ Keep extinguishers updated and validated regularly
- ➔ Provide training to selected workers for operating these extinguishers
- ➔ Make these extinguishers easily accessible
- ➔ Distribute the trained persons to operate the extinguishers evenly in all shifts

➔ Regularly educate employees on fire prevention and actions in case of fire

B Improving Heavy Physical Work

Many work places cause pain or discomfort when workers are working there for hours. Pain and cramps in the back, the shoulders, and the neck are often the consequences. Naturally, this can slow the work process down. By simple means, these workstations can be improved.

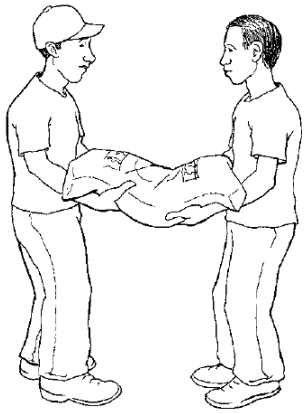
During the research project, we conducted a so-called ergonomic assessment of workplaces in stone crushing units. "Ergonomics" is a term used to describe the study of all the different demands on the body caused by work. The goal is to combat these demands in order to have a work environment that is both safe and productive.

Problematic and eventually damaging tasks are for instance tasks that require the worker to

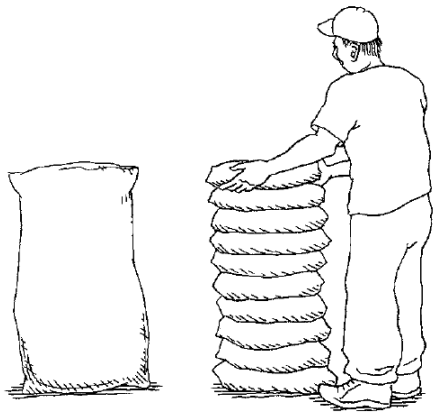
- assume an awkward posture
- repeat one movement very often and
- lift or carry heavy loads

By improving work tools and work practices, fatigue and discomfort can be reduced and ultimately injuries prevented. Having job tasks that are designed to ease worker fatigue and discomfort will actually end up saving the company money, for having healthy workers equates to having higher productivity and quality of work. An ergonomics program contains several necessary steps:

- Observe the job tasks for possible risk factors
- Identify those jobs that are of high risk
- Analyze the specific high risk jobs
- Re-design the equipment or practices used during the particular job in order to reduce risk to the worker
- Get feedback from the employees on whether the implemented changes have helped alleviate injury



Share the work by lifting the sack with another worker.



Break the sack into smaller loads.

Picture 15: collecting boulder and throwing them onto the pile; heavy work including lifting and twisting of back

Many different assessment tools can be used when evaluating a work task. Two common analyses are called Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA). These tools specifically focus on a worker's postures, movement during work and work environment. We use them here to describe how urgent improvement is needed or not. This priority listing can help unit owners to decide where to start with improving the work tasks.

As a general rule, you can say: *The lower the score the better!* This is true for both of these assessments. A high score requires action to be taken quickly to fix the problem.

For more information, please see the following sources:

McAtamney, Lynn. "Ergonomics Measurement Tools." Risk Analysis Tools. COPE. 28 Apr. 2009 <http://www.copeohs.com/ergonomics/MeasurementTools.aspx>

US NIOSH on Ergonomics: http://www.cdc.gov/niosh/topics/ergonomics/

US NIOSH Primer of ergonomic evaluation at the workplace: http://www.cdc.gov/niosh/docs/97-117

B.1 Main crusher operator

Nature of work:

Operating the main crusher, monitoring and pulling stuck boulders for a free flow, and taking care of maintenance work. This task involves lifting heavy parts and pulling boulders from the chute.

Picture 16: trying to clear and unstuck the boulder chute, an extremely dangerous work

Risk Factors:

- Musculoskeletal Disorders (MSD) due to frequent bending and pulling of heavy boulders in awkward postures
- MSD and back pain due to lifting of heavy parts in unsafe postures
- Pulmonary disorders due to constant exposure to dust
- Injury from a fall from heights
- Injuries to hand, leg or head due to falling objects from top (loading area) since no personal protective equipment (PPE) is worn
- Hands and fingers have the risk of being caught in between boulders while pulling in the chute

RULA "priority score": 7 Suggested Action: Investigate and change immediately

REBA "priority score": 10 Suggested Action: High score, action necessary soon

Solutions:

➔ Issue of proper tool for dragging the choked boulders from the chute with handle as shown below or any other suitable device

- ➔ Proper training on safe posture during work
- ➔ Issue at least rubber soled shoes, gloves, helmets, goggles and nose masks
- ➔ The platform should be sturdy and access should be made safe with a ladder or steps
- ➔ Light the chute area during night time work for better vision; yellow fog lights can be tried
- ➔ Cover the top of the standing platform to avoid falling objects coming from the loading area above
- ➔ The operator may be provided with a torch light (fog light) for seeing inside the chute during day or night

B.2 Repair and Maintenance of the Main Crusher

Nature of work:

Frequent shut down of the crusher occurs during operation and heavy parts are removed and fixed during this activity. This task is usually done as group work.

Picture 17; maintenance and cleaning of crusher

Risk Factors:

- Lifting heavy loads in unsafe postures may cause back pain
- Unsafe holding and improper lifting methods may cause the material to drop, resulting in injury to hands and legs
- Incorrect postures, unstable foot positions, and exertion in work may cause trips and falls
- Frequent and awkward work postures, over exertion, lifting above the shoulders, holding for long time etc., may cause Musculoskeletal Disorders
- Not using PPE may result in pulmonary diseases, hand, and leg injuries
- Standing unstably on the machines during work may result in falls

RULA "priority score": 7 Suggested Action: Investigate and change immediately

REBA "priority score": 11 Suggested Action: Very high score, action necessary NOW!

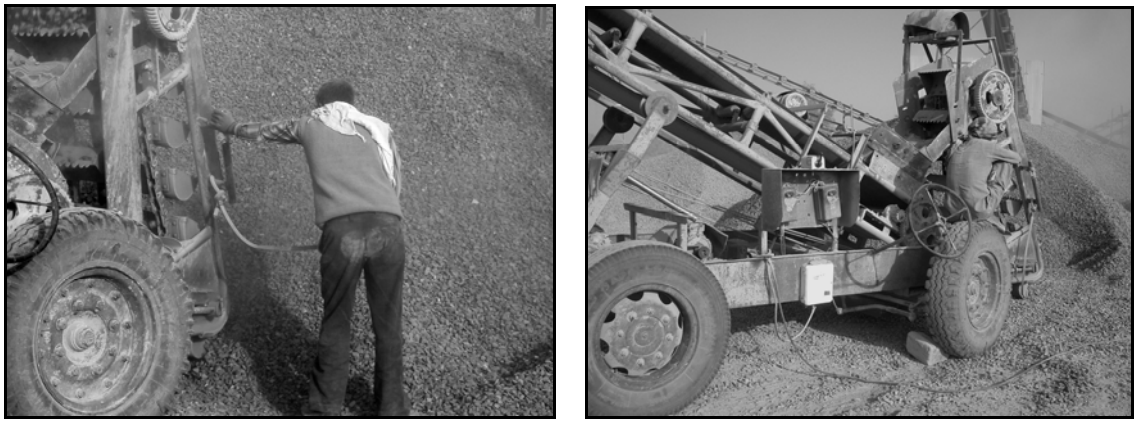
Solutions:

- ➔ Proper platform should be erected for safe and stable standing and comfortable work. Even a pre-fabricated mobile platform will suffice; or provide sturdy scaffolding materials, like wooden planks or steel sheets with supporting styles and bracings
- ➔ Train the employees with correct methods of manual handling and working in correct postures
- ➔ Issue workers PPE (at least gloves, shoes, helmets) and be sure they are using them
- ➔ Tool boxes or pouches are suggested to avoid holding tools in hands
- ➔ A torch light (fog type) to view dark portions of the machine and chute shall be provided to workers
- ➔ Housekeeping around this area should be maintained

B.3 Aligning the portable bucket conveyor for loading

Nature of work:

The mobile bucket conveyor is adjusted every time for effective pick up of material and deliver on top of the truck or lorry.



Picture 18: setting and adjusting the bucket conveyer for loading gravel

Risk Factors:

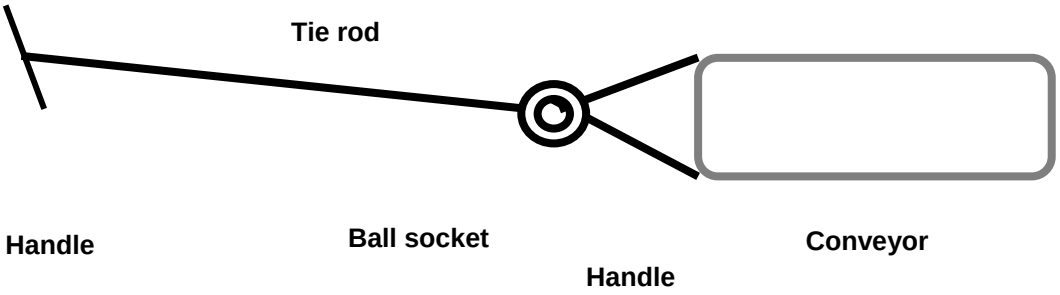
- Pushing, aligning, and holding of the conveyor will exert force on the forearm and wrist causing strain and fatigue
- Not using PPE may result in minor injuries
- Overexertion of force to push or pull the mouth of the conveyor may cause MSD or back pain
- Trips and falls are also possible since the operator is standing and working in an awkward posture is not stable
- Earlier onset of fatigue due to a combination of forces acting on the body because of incorrect methods of working

RULA "priority score": 7 Suggested Action: Investigate and change immediately

REBA "priority score": 11 Suggested Action: Very high score, action necessary NOW!

Solutions:

➔ Proper hold with ball socket fitting with a long rod for holding the conveyor as shown below may be attached for pulling or pushing the mouth of the bucket conveyor for effective pick up



➔ Provide at least gloves, shoes, goggles and nose masks. It is preferable that the operator wears flat bottom (sole) shoes

➔ Training is required to teach safe handling methods

B.4 Removing spilled stones

Nature of work:

After the trucks deliver the boulders on to the collection pit, the spilled boulders are collected and dumped back to the pit.

Picture 19: collecting spilled stones

Risk Factors:

- Injury to the hand, fingers and palm due to handling of sharp and heavy boulders with bare hands
- Musculoskeletal Disorders (MSD) due to the constant bending, lifting, and throwing of heavy boulders
- Possible setting in of back pain due to frequent bending in an unsafe way
- Quicker fatigue at work due to unsafe postures as well as the bending of knees, hands and fingers

RULA "priority score": 7 Suggested Action: Investigate and change immediately

REBA "priority score": 14 Suggested Action: Very high score, action necessary NOW!

Solutions:

- ➔ Issue and use proper leather gloves, shoes and goggles
- ➔ Immediate training is needed on safe manual material handling procedures in order to create awareness on safety and avoiding MSD, back pain, etc.
- ➔ Avoid overloading or improper loading of boulders at quarry to prevent these spillages at pit and en route
- ➔ A hand trolley may be provided to collect and dump boulders, which will reduce the strain of throwing such heavy objects

Picture 20: women leveling uneven surface on top of boulder pit by hand for truck traffic

B.5 Leveling the Boulder Collection Pit

Nature of work:

Boulders are dumped onto the collection pit by trucks and the heap of boulders are leveled over the pit in order to have uniform entry into the main crusher.

Risk Factors:

- Injury to the hand, fingers and palm due to handling of sharp and heavy boulders with bare hands
- Musculoskeletal Disorders (MSD) due to the constant bending, lifting, and throwing of heavy boulders

- Back pain due to frequent bending in unsafe positions
- Quicker fatigue at work due to unsafe postures as well as the bending of knees, hands and fingers


Picture 21: women leveling boulder pit surface

RULA "priority score": 7 Suggested Action: Investigate and change immediately

REBA "priority score": 14 Suggested Action: Very high score, action necessary NOW!

Solutions:

- ➔ Issue and use proper leather gloves, shoes and goggles
- ➔ Immediate training is needed on safe manual material handling procedures in order to create awareness on safety and avoiding MSD, back pain, etc.
- ➔ Shoes and gloves should be made mandatory for this kind of work

B.6 Cleaning work under the main crusher

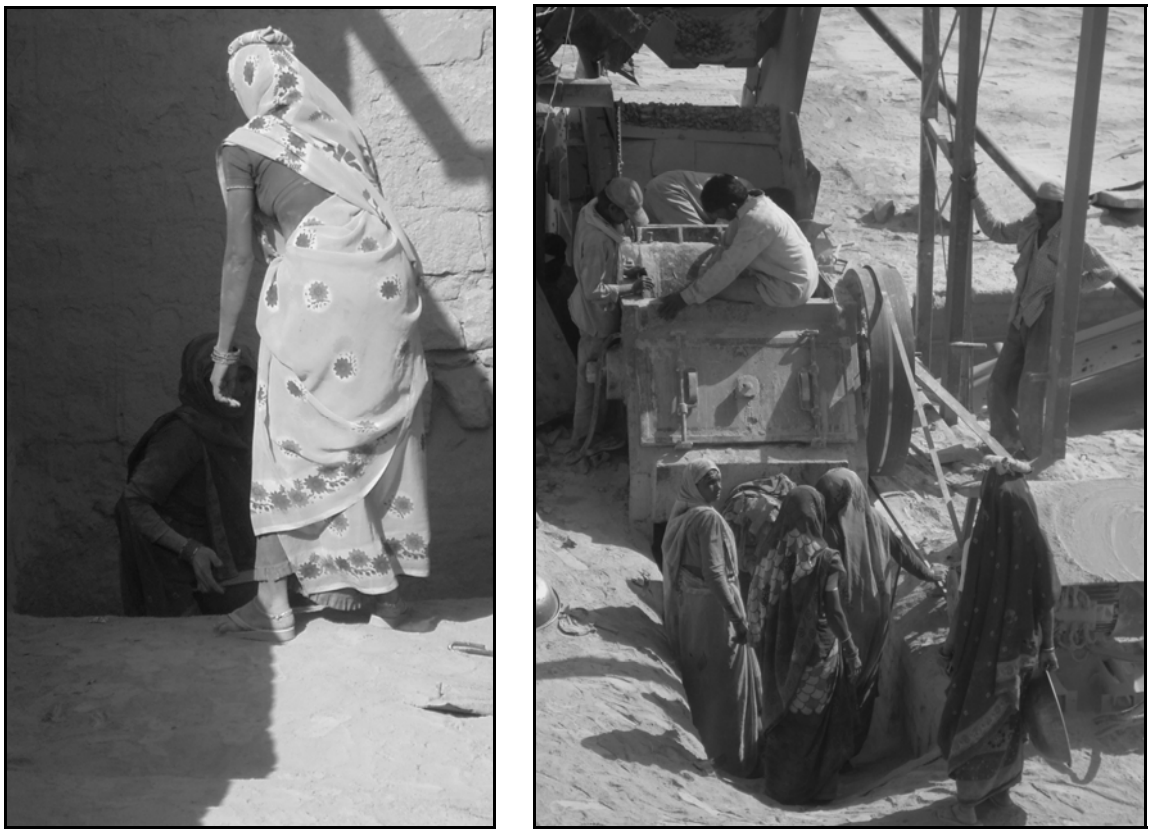
Nature of work:

The main crusher is cleaned at two stages. First, when quarry dust is collected during crushing from the pit below and the second to remove the falling and struck boulders from the pit below the main crusher. While collecting the dust from below the crusher, the workers are exposed to the highest and most hazardous concentrations of dust. Often women conduct this activity.

Risk Factors:

- Musculoskeletal Disorders (MSD) and back pain due to working in confined spaces and having little room for safe lifting
- Over exertion while lifting without proper hand protection may result in hand and leg injuries
- MSD due to the constant bending and lifting of the women workers
- Low lighting due to the location and to dust formation may cause disturbance in vision, eye disorders, pulmonary diseases, and other injuries

- Tripping and falling into the pit are possible since there is no proper ladder or barricade and vision is impaired whenever dust is released
- Not wearing Personal Protective Equipment (PPE) may cause other injuries



Picture 22: women cleaning dust and debris our from under the primary crusher

RULA "priority Score": 7 Suggested Action: Investigate and change immediately

REBA "priority Score": 11 Suggested Action: Very high score, action necessary NOW!

Solutions:

- ➔ Shut down the crusher for cleaning underneath to prevent the enormous concentration of dust
- ➔ Mandatory training on safe manual material handling practices
- ➔ Shoes, leather gloves, and nose masks are recommended for these categories of workers
- ➔ Provide a fixed ladder with hand rail for entry and exit from the pit
- ➔ A tub trolley/wheelbarrow may be provided to collect the dust and transport small stones, reducing the number of trips and the dust emissions at dust dumping sites
- ➔ Helmet may be provided to the person removing the boulders from the pit

B.7 Tally clerk work station

Nature of work:

The role of the tally clerk is to document the number of lorries dumping boulders into the pit. The clerk must remain at his post for the entire shift (usually 12 hrs) and a rest shed, as shown below, is provided for him. There is frequent movement for him in order to collect information when trucks arrive.

Picture 23: make-shift shed

Risk Factors:

- Continuous exposure to sun light may cause heat stress and other heat-related disorders
- Improper chair for rest may cause MSD and back pain
- Fatigue may set in due to exposure to heat and dust
- Other diseases related to the lungs are possible from dust inhalation

Picture 24: stone shed for worker

RULA "priority score": 2 Suggested Action: Acceptable, no action necessary

REBA "priority score": 1 Suggested Action: Low score, immediate action is not necessary

Solutions:

- ➔ Provide a stable and permanent rest cubicle for the clerk so that he can operate from a shaded place
- ➔ A covered shed of 180cm X 180cm and 2 – 4m high with chair and table and adequate lighting and vision to the operation area
- ➔ Provide a drinking water point close to the clerk's post
- ➔ Provide bright lighting at nighttime

B.8 Maintenance work activities

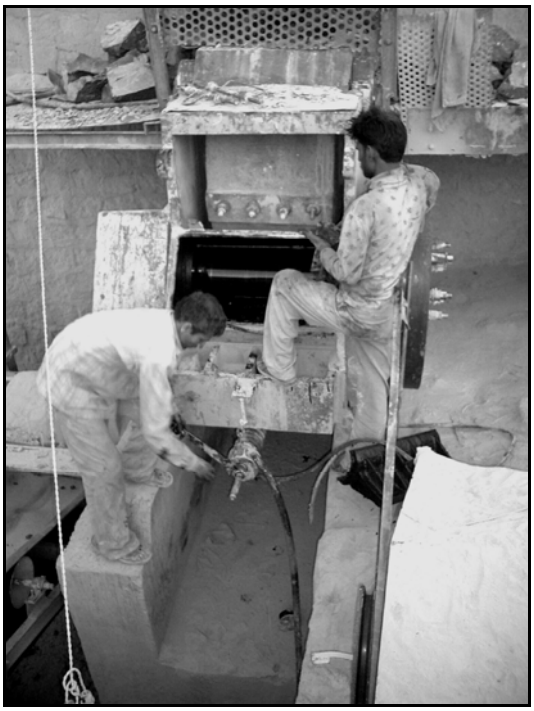
Nature of work:

Regular and shut down maintenance work is carried out on crushers, conveyors and other machineries, during which workers are employed to do work from heights, in cramped spaces, and hazardous locations.

Risk Factors:

- Working at heights without protection or harnesses may cause falls, which can result in major injuries and fatalities
- Unsafe work postures such as stretching and bending may cause MSD and back pain
- Minor injuries while handling equipment without PPE are possible
- Welding work without a face shield / welding goggles may cause eye disorders
- Wearing loose clothing while checking conveyors may cause accidents and injuries
- Fatigue and other syndromes are possible with improper work postures

Holding tools loosely at heights may cause them to slip from hands and fall, possibly hitting persons who are standing or passing below




Picture 25: maintenance and repair work on machinery

RULA "priority score": 7 Suggested Action: Investigate and change immediately

REBA "priority score": 10 Suggested Action: High score, action necessary soon

Solutions:

- ➔ Provide tool holder/tool pouch to avoid tools falling while working at heights
- ➔ Provide proper ladder or mobile scaffold platforms for work at heights
- ➔ Safety belts must be issued and worn when working at heights
- ➔ Shut down and secure the power to machinery while maintenance work is done (so-called LOG-OUT of power source) so that nobody can switch on power accidentally while others work in or close to the machinery
- ➔ Proper hand and power tools (ergonomically designed) should be used
- ➔ Training on safe manual handling and work postures should be imparted
- ➔ If required, use mechanical handling equipment when heavy machine parts are moved
- ➔ Helmet, shoes and gloves shall be provided for the maintenance staff

Picture 26: repairing the crusher

B.9 Cleaning and housekeeping work around crushers

Nature of work:

Cleaning the sites, including the removal of quarry dust and other debris and their transport to a dumping site about 200m away. Cleaning work also is involved in sieving the dust.

Risk Factors:

- Potential of musculoskeletal disorders (MSD) and back pain exist due to constant work in bent postures, poor lifting procedures, and little space for safe lifting.
- Over exertion while lifting without proper hand protection may result in hand and leg injuries
- Not wearing PPE may cause other injuries, such as pulmonary diseases (if not wearing nose mask)
- Long duration in a squatting position for collection of dust and debris may cause MSD

RULA "priority score": 5 Suggested Action: Investigate further and change soon

REBA "priority score": 7 Suggested Action: Medium score, action necessary

Picture 27: collecting fallen boulders

Picture 28: women transporting debris and gravel

Solutions:

- ➔ Provide a shovel and wheelbarrow for collection and disposal of dust, which will reduce the number of trips made as well as dust emission

or

- ➔ Issue a beach hand shovel (plastic – low cost) and a collection bucket to collect and transport without using bare hands
- ➔ Providing the necessary PPE, hand gloves and nose mask are a must
- ➔ Mandatory training in safe handling of materials manually
- ➔ Issue suitable, proper, and effective tools for collection and disposal
- ➔ Sieving releases all the dust into the air. (see below for a possible alternative)

Proposed alternate for sieving of dust to retrieve metal chips from dust

Advantage: This instrument will disable dust emissions while sieving and is very portable for easy transport. The dust and gravel are separated and stored in bulk so the need for regular removal may be avoided, which will save labor cost and time.

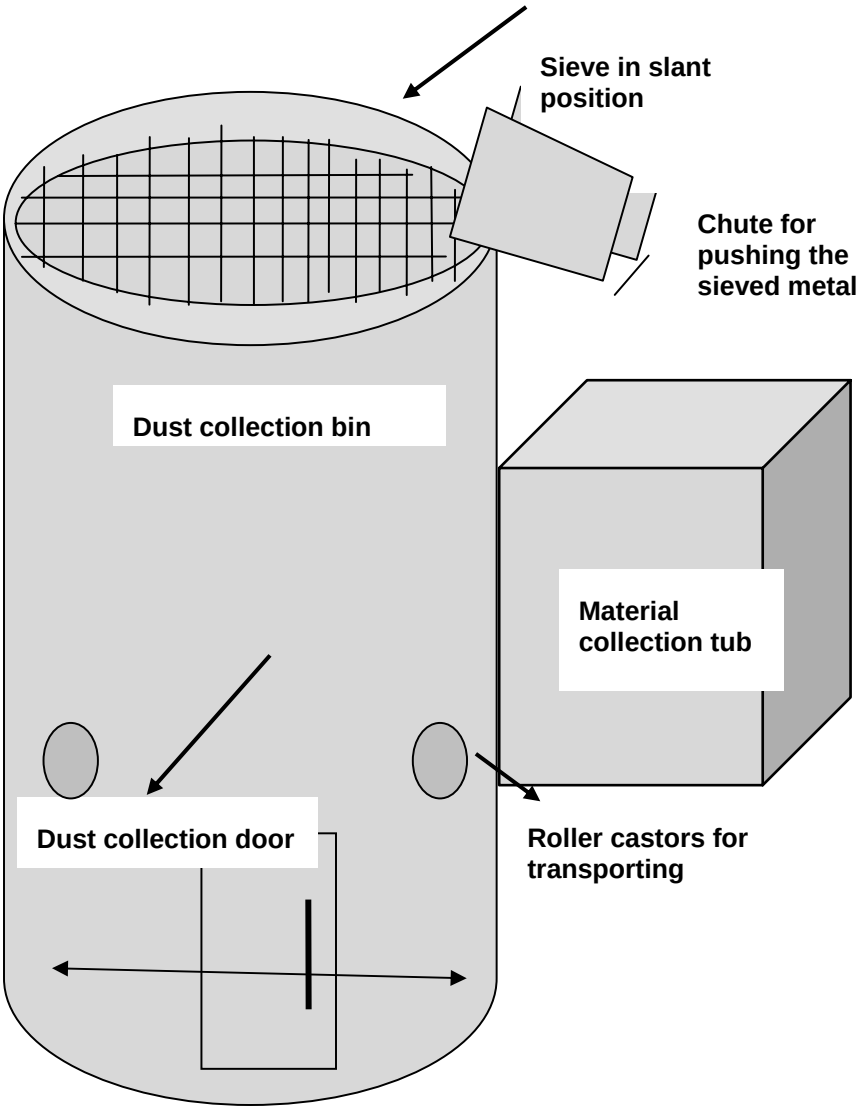


Illustration 1: sieve. Source: M. Nithiyananthan

B.10 Going to the top boulder loading

Nature of work:

Regular movement of persons to the top of the boulder collection pit, particularly the truck drivers and cleaners, and other crushing unit workers through the unleveled boulders heap.


Picture 29: waling up and down the boulder piton slippery and uneven surface (both views facing downhill)

Risk Factors:

- Trip and fall hazards present due to the unsafe manner in which workers get from the crusher area to the top of the loading pit (i.e.: climbing on boulders).
- Slips are also possible and even a slip can cause injuries and the possibility of boulders rolling over the worker
- Regular use of such access may cause MSD and back pain
- Minor hand and palm injuries, bruises, etc. are common since the palm is used as support for ascending or descending the boulder pile.

RULA "priority score": 6 Suggested Action: Investigate further and change soon

REBA "priority score": 8 Suggested Action: High score, action necessary soon

Solutions:

- ➔ Restrict improper ascending/descending practices
- ➔ Provide proper steps constructed at least 75 cm wide with the available boulders and provision of a hand rail is preferable
- ➔ Provide warning boards for restricted and safe use

B.11 Removal of Jammed Boulders in the Main Crusher

Nature of work:

Every time the boulders are struck in the chute or in the crusher, the stone is removed manually or by a pulling rod. This activity is a regular occurrence.

Risk Factors:

- High potential exists for occurrence of MSD and back pain due to working in confined spaces and spaces too small for safe lifting
- Over exertion while lifting without proper hand protection may result in hand and leg injuries
- Low lighting due to location and to dust formation may cause disturbance in vision, eye disorders, pulmonary diseases and injuries
- Trips and falls into the pit are possible since there is no proper platform or barricade to enter in \to the chute and vision is disrupted when dust is released
- Possibility of boulders rolling and hitting the operator while using the pulling rod
- Not wearing PPE may cause other injuries

RULA "priority score": 7 Suggested Action: Investigate and change immediately

REBA "priority score": 11 Suggested Action: Very high score, action necessary NOW!

Solutions:

- ➔ Mandatory training on safe manual material handling practices
- ➔ Shoes, leather gloves, and nose masks are required for these categories of workers
- ➔ Helmets may be provided to the persons removing the boulders from the chute
- ➔ Proper platform may be erected to work
- ➔ Shut down and secure the power to the crusher while this work is done (so-called LOG-OUT of power source) so that nobody can switch on power accidentally while others work in or close to the crusher chute

B.12 Truck loading by bucket conveyors

Nature of work:

Either a cleaning worker or the unit employee climbs onto the truck to level the falling material coming into the truck.

Risk Factors:

- Fall from heights is possible since the person is climbing onto truck without the use of a ladder
- Injuries are possible if the truck is moved during the leveling process, since there is no coordination between the cleaner, driver and the unit operator
- MSD and back pain could occur for the worker leveling material on the truck

Picture 30: loading truck with conveyer

RULA "priority score": 7 Suggested Action: Investigate and change immediately

REBA "priority score": 8 Suggested Action: High score, action necessary soon

Solutions:

- ➔ Use wooden chokers to prevent unwarranted movement of the truck while loading
- ➔ Issue and use proper hand tools for leveling and long hand tools to prevent the worker from having to bend excessively
- ➔ Provide and use ladders for ascending or descending from the truck
- ➔ There should be a signal from the driver to the persons on top when the truck is about to be moved
- ➔ No person should be allowed to sit on the cabin or on the body of the truck while loading is taking place
- ➔ Issue instruction (preferably printed) on the safe working procedures for the truck drivers and cleaners
- ➔ The drivers and cleaners should not be more than 25 ft away from the vehicle when loading is taking place

C How Much Does an Accident Cost?

Very often, accidents are viewed as unavoidable and negligible. No recordings are available on accidents in stone crushing units and the cost of accidents are considered minimal.

We want to show how expensive even small accidents are for a company. It is therefore a good investment of money for an owner to train workers, train first-aid personnel, install safety devices and prevent accidents and diseases in general.

Let us take a simple *example* and then calculate the direct and indirect costs of this accident. This accident happens in India and the cost is calculated in Indian Rupees:

> *A worker sustained an injury on his head by a falling piece of metal. It caused a minor head injury. He goes down, is drowsy and in terrible pain..*
>
> *All 20 workers in the plant assemble at the accident site and stay as curious bystanders till the injured is transported to the hospital. Organizing that transport takes about two hours.*

A typical cost sheet is given below for a minor injury causing accident [in Indian Rupees INR]. You can add an example from your company and country in the right column.

Table 2: Estimated Cost of an Accident

Events of Example	Example in Indian Rupees	Your example?
20 workers X 2 hours X Rs. 25/hour	1000	
Lost work days for injured worker (4 Days)	1000	
Wages of two workers who accompany the victim	500	
Time spent of the supervisor owner's	3000	
Hospital expenses	5000	
Transport & Ambulance charges	500	
Legal expenses	5000	
Medical follow up visits	2000	
Replacement of skilled worker	2000	
Providing transport to the family	500	
Welfare activities to the family	2000	
Production stoppage for 2 hours	20000	
TOTAL COST	**42500**	

As you can see, the real cost of a small accident is far more than just the cost of the days-lost-for-work and the hospital expenses. Feel free to use the table and run the numbers from an accident in your plant!

You will find more information on the cost of accidents at these sources:

* ILO-SafeWork/FIOH: '"The Economics of Health, Safety and Well-Being - Barefoot Economics"' at www.ilo.org/public/english/protection/safework/econo/barefoot.pdf

* OSHA EU Factsheet 28 "Economic appraisal of preventing work accidents at company level": http://agency.osha.eu.int/publications/factsheets/28/en/FACTSHEETSN28EN.pdf

* UK HSE: '"Business benefits of OSH"' at http://www.hse.gov.uk/businessbenefits/

* USA OSHA: '"$afetyPays:"' at: http://www.osha.gov/dcsp/smallbusiness/safetypays/index.html

* A collection of documents on cost-benefit of safety investments at http://www.osha.gov/dcsp/products/topics/businesscase/benefits.html

* A cost calculator for calculating accident cost at http://www.osha.gov/SLTC/etools/safetyhealth/mod1_costs.html and at http://www.osha.gov/dcsp/smallbusiness/safetypays/estimator_text.html

* OSHA-EU Fact sheet on 'Inventory of socioeconomic costs of work accidents'. at http://agency.osha.eu.int/publications/factsheets/

* American Society Of Safety Engineers: '"White Paper Addressing The Return On Investment For Safety, Health, And Environmental (SH&E) Management Programs"' at http://www.elcosh.org/docs/d0100/d000047/d000047.html

D Checklists and Benchmarks

The checklists can be used to

a. document a present state of safety performance of a company or stone crushing unit, the so-called safety score, and

b. to compare either different units between each other or the same unit over time. This is called *scoring* or *benchmarking*.

In this chapter you will find checklists which can be used to assess the level of safety in a plant. Faculty of the Department of Environmental Engineering, Sri Ramachandra University, Chennai, India, as mentioned in the Foreword, has developed most parts of these checklists.

You can answer the questions with careful observation only; no tools are needed. The checklists do therefore not cover all aspects of health and safety. They are definitely not perfect. However, the results should help the unit owners to see starting pints for improvements. Answers that do not comply with the preset ones ( ) indicate problem areas, which should receive further attention. Further investigation may be required to assess risks and make a decision on whether corrective measures are required.

In the following scheme, you can put in the percentage of implementation to see in which areas improvements are mostly needed. You can calculate the percentage by dividing the actual achieved score from the checklists divided by the highest possible score for that safety topic.

	Checklist	**Total points scored**	**Max points**	**[%]**
	General safety practices, hazards management and welfare facilities		38	
	Electrical Equipment, Machines and Power tools		26	
	Ergonomic Workplace Design and Manual Handling of Loads		31	
	Prevention of Fire and Explosion, Gas Cylinders and Emergency Preparedness		27	
	Accident prevention: safe working and heights, road safety		23	

To make a priority list for your actions, you can use the following criteria:

- If your percentage is **between 70 and 100%,** the safety performance is already quit good and needs to be continued and improved over time.
- If the results in certain areas are **between 40 and 70%,** then action is needed and you need to make a plan for implementing the missing elements.
- If the results are only **between 0 and 40%**, then URGENT ACTION is needed as central core elements and safety measures are lacking in your company.

D.1 Checklist: General Safety Practices, Hazards Management and Welfare Facilities

This checklist has been developed for general purposes and not specifically for stone crushing units. It provides guidance on safety and health issues and to make hazard identification easier. The questions on chemicals are here because there are not many chemicals used in a stone crushing unit. Other industries need a more detailed checklist, should they handle chemicals regularly. Answers that do not comply with the preset ones ( ) indicate problem areas, which should receive further attention.

Facility name and location: _____ Date: _____

Evaluation conducted by: _____

Work areas inspected: _____

	Area	**Yes**	**No**	**Comments / Action**
1	**General Lighting**			
1.1	Are light fittings clean and in good condition?			
1.2	Is the work area well lit?			
1.3	Is there direct/reflected glare or deep shadow?			
2	*Walkways/Floors*			
2.1	Are floor surfaces even and uncluttered?			
2.2	Are floor surfaces dry and clean?			
2.3	Are walkways clearly and adequately marked?			
2.4	Are walkways free from obstructions?			
2.5	Are there unguarded/inadequately covered floor openings (e.g. stairway floor openings, pit/trap door openings)?			
2.6	Are railings provided at open-sided floors/platforms and at stairs with more than three risers?			
2.7	Do stairs have uniform riser height and tread width?			
2.8	Are stairways in good condition with standard railings provided for every flight having four or more risers?			
2.9	Are working platforms at higher levels provided with handrails and toe boards?			
2.10	Are stand mats, platforms or similar protection provided to protect employees from wet floor in wet processes?			
3	**Ladders**			

	Area	Yes	No	Comments / Action
3.1	Are ladders free from splinters, sharp edges, decay?			
3.2	Are rungs of ladders uniformly spaced and in good condition?			
4	**Facilities and Housekeeping**			
4.1	Is safe drinking water available in the work area?			
4.2	Are adequate numbers of toilets and urinals available?			
4.3	Are toilets clean and provided with soap for hand washing?			
4.4	Is a separate, comfortable and hygienic place available for dinning and rest?			
4.5	Are covered metal waste cans used for oily and paint soaked waste? Are they emptied daily?			
4.6	Are paint spray booths, dip tanks, etc. and their exhaust ducts cleaned regularly?			
4.7	Is there planned as well as preventive maintenance practiced?			
5	**Hazardous Materials & Chemical Safety**			
5.1	Are all containers for hazardous substances clearly and permanently labeled?			
5.2	Are gases, vapours, fumes, mists or dusts released to the work environment (in harmful concentrations)?			
5.3	Are all flammable liquids kept in covered and appropriate containers when not actual in use?			
5.4	Is there a risk of gases, vapours, fumes, mists or dusts forming explosive atmospheres?			
5.5	Are “No smoking” signs posted in areas for storage and use of flammable/combustible materials?			
5.6	Are clean up kits available for removal of spilt chemicals?			
5.7	Are Material Safety Data Sheets available?			
5.8	Is a proper, adequate storage of chemicals guaranteed? (complete equipment, segregation etc.)			
5.5	Is there a storage of incompatible chemicals excluded?			
5.10	Is there a sufficient number of appropriate fire extinguisher available?			
5.11	Is the storage area under surveillance?			
6	**Safety management**			

	Area	Yes	No	Comments / Action
6.1	Are there work / safety instructions implemented and displayed?			
6.2	Are safety inspections / audits carried out			
6.3	Is there a system for accident investigations (records & statistics) implemented?			
6.4	Is there an effective system to communicate hazards throughout the company?			
6.5	Are work permits concerning hazardous operations obligatory?			

MAXIMUM POSSIBLE SCORE: 38

ACHIEVED SCORE: ……..

Notes:

D.2 Checklist: Electrical Equipment, Machines and Power tools

This checklist has been developed to provide guidance on safe work practices. It should help in a stone crushing unit to assess specific jobs and see if they pose a risk to health of the workers. Not all of these questions apply to all workplaces. To calculate the correct score you need to exclude the topics, which are not applicable. It is limited to questions that can be easily answered by observation and questioning the workers. It is therefore not all inclusive in coverage. Answers that do not comply with the preset ones (☑) indicate problem areas, which should receive further attention. Further investigation may be required to assess risks and make a decision on whether corrective measures are required.

Facility name and location: _____ Date: _____

Evaluation conducted by: _____

Work area inspected: _____

1	**Machinery and Machine Guarding**			
1.1	Are all controls and displays clearly and permanently marked to show their purpose?			
1.2	Are all machines or operations that expose workers to rotating parts, pinch points, flying chips, particles or sparks adequately guarded?			
1.3	Are mechanical power transmission belts guarded?			
1.4	Are guards affixed to machines or secured to prevent displacement?			
1.5	Are emergency stop arrangements (e.g. emergency stop buttons, grab wires) readily accessible at all machines?			
1.7	Are hand tools in good repair?			
1.8	Are portable powered hand tools provided with circuit breakers?			
1.9	Are safety devices tested regularly and frequently?			
1.10	Are all power tools in use on a circuit, which is secured by a ELCB switch?			
2	**Electrical Hazards**			
2.1	Are there broken or unsecured wires and cables?			
2.2	Are all switch boxes and distribution boxes closed with covers and in good condition?			

2.3	Are all cable trenches covered properly and cables in cable trays secured properly?			
2.4	Are all connections and electrical devices grounded?			
2.5	Are there fire extinguishers and rubber mats close to important electrical installations?			
2.6	Are there bare and raw wires inserted directly into sockets?			
2.7	Are MCB/ELCBs provided for protecting the operator from electrical hazards?			
2.8	Is the main switch box in good condition, protected from weather, and provided with an ELCB?			
2.10	Are all distribution boxes marked legibly in an understandable language marking the feeding point, voltage, and identification number?			
2.11	Are electrical conductors such as cables of sufficient size and load carrying capacity?			
2.12	Are there interlocks and a lockout-tagout system in place for electrical equipment during repair?			
2.13	Do workers who do electrical work wear the necessary PPE, like shoes and gloves and are equipped with approved rubber mats?			
2.14	During electrical maintenance, a lockout/tagout system is the mandatory and workers are trained to follow these instructions			
2.15	The transformer where the incoming electricity supply is received is isolated and fenced off; its compound is clean from vegetation to prevent fire. The transformers are positioned at least 2.50 meters above ground level.			
2.16	Electrical cables are laid into the ground in shock-proof material. Cables should be run in extra plastic conduits			

MAXIMUM POSSIBLE SCORE: 26

ACHIEVED SCORE: ……..

Notes:

D.3 Checklist: Ergonomic Workplace Design and Manual Handling of Loads

This checklist has been developed to provide guidance on hazard identification in industrial workplaces concerning safe work practices while handling loads. It should help in a stone crushing unit to assess specific jobs and see if they pose a risk to health of the workers. Not all of these questions apply to all workplaces. To calculate the correct score you need to exclude the topics, which are not applicable.

It is confined to questions that can be easily answered by observation and questioning the workers. It is therefore not all inclusive in coverage. Answers that do not comply with the preset ones (☑) indicate problem areas, which should receive further attention. Further investigation may be required to assess risks and make a decision on whether corrective measures are required.

Facility name and location: _____ Date: _____

Evaluation conducted by: _____

Work area inspected: _____

	Area	**Yes**	**No**	**Comments**
	Do the jobs involve high rates of repetitive motion?		☑	
	Do workers have to maintain the same posture over extended periods of time?		☑	
	Are the weights of loads to be lifted judged to be acceptable by the workers?	☑		
	Are materials moved over long distances?		☑	
	Do workers have to adopt awkward postures, e.g. squatting, crouching, reaching above shoulder height?		☑	
	Does material handling include			
	– reaching in extension of arms and legs?		☑	
	– twisting at the waist?		☑	
	– movements below knuckle height and above shoulder height?		☑	
	– sudden movements during handling?		☑	
	– static muscle loading?		☑	
	Is the distance between the object/load and the body as small as possible?	☑		
	Are walking surfaces			
	– level?	☑		
	– wide enough?	☑		
	– clean and dry?	☑		

	Are objects			
	– easy to grasp?	☑		
	– stable?	☑		
	– able to be held without slipping?	☑		
	– free from sharp edges and corners?	☑		
	Are there handholds or grips on these objects?	☑		
	When required, are gloves provided and do they fit properly?	☑		
	Is there enough room to perform the task?	☑		
	Are mechanical aids for handling and lifting used whenever possible?	☑		
	Are working surfaces adjustable to the best handling heights?	☑		
	Is help from other workers available for heavy or awkward lifts?	☑		
	Are loads being pushed or pulled?		☑	
	Are high rates of repetition avoided by			
	– job rotation?	☑		
	– self-pacing?	☑		
	– sufficient pauses?	☑		
	Is the worker trained in			
	– correct handling and lifting procedures?	☑		
	– recognizing signs and symptoms of potential health problems?	☑		
	Is there a maintenance program for mechanical aids, tools, and other equipment?	☑		

MAXIMUM POSSIBLE SCORE: 31

ACHIEVED SCORE: ……..

Notes:

Note: This checklist is based on the NIOSH Toolbox Tray 5-F, available at: http://www.cdc.gov/niosh/eptbtr5.html

D.4 Checklist: Fire and Explosion, Gas Cylinders and Emergency Preparedness

This checklist has been developed to provide guidance on prevention of fire and explosion, on working with gas cylinders safely and emergency preparedness practices. Not all of these questions apply to all workplaces or even to all stone crushing plants. To calculate the correct score you need to exclude the topics, which are not applicable. The checklist is limited to questions that can be easily answered by observation and by asking workers. Answers that do not comply with the preset ones (☑) indicate problem areas, which should receive further attention. Further investigation may be required to assess risks and make a decision on whether corrective measures are required.

Facility name and location: _____ Date: _____

Evaluation conducted by: _____

Work area inspected: _____

1	**Safety of Gas Cylinders**	**Yes**	**No**	**Comments**
1.1	Are cylinders in an upright position?	☑		
1.2	Are gas cylinders secured from damage from and being knocked over?		☑	
1.3	Are there cylinders left in open sun?	☑		
1.4	Do gas cylinders show obvious signs of defects, deep rusting or leakage?		☑	
1.5	Are there separate locations for empty and full cylinders?	☑		
1.6	Are valve protection caps provided and kept on gas cylinders while these are not in use?	☑		
1.7	Are portable gas cylinders mounted on an appropriate trolley for handling upright?	☑		
1.8	Are cylinders being rolled in order to move them to a different location?		☑	
1.9	Are the cylinders supplied with a pressure gauge?	☑		
1.10	Are empty gas cylinders stored separately from full ones?	☑		
1.11	Are the cylinders color-coated according to their contents?	☑		

	Fire Prevention and Emergency Preparedness			
2.1	Is a telephone line or mobile phone facility available at all times, also during night shifts?	☑		
2.2	Is there an emergency plan through a consultant; is the plan documented; are employees trained?	☑		
2.3	Is there a trained responsible person available at all time to act as responsible manager?	☑		
2.4	Are first aid kits readily available, well stocked and clean?	☑		
2.5	Are trained personnel available at all times to render first aid?	☑		
2.6	If there are emergency eyewashes or showers, are these facilities unobstructed and in good operating condition?	☑		
2.7	Are suitable fire extinguishers available and accessible for fire fighting?	☑		
2.8	Are fire extinguishers regularly serviced?	☑		
2.5	Are fire doors and shutters unobstructed and in good operating condition?	☑		
2.10	Are there sufficient fire exits to ensure prompt escape in case of emergency?	☑		
2.11	Are fire exits clearly marked and readily accessible?	☑		
2.12	Can exit doors be effortlessly opened?	☑		
2.13	Are first aid and fire equipment signs posted?	☑		
2.14	Is emergency lighting in good operating condition?	☑		
2.15	Are there fire and evacuation drills carried out at least once a year?	☑		
2.16	Is there an appropriate number of employees trained in the correct use of fire extinguisher?	☑		

MAXIMUM POSSIBLE SCORE: 27

ACHIEVED SCORE: ……..

Notes:

D.5 Checklist: Accident prevention: safe working and heights, road safety

This checklist has been developed to provide guidance on prevention of accidents. Not all of these questions apply to all workplaces or to all stone crushing plants. To calculate the correct score you need to exclude the topics, which are not applicable. The checklist is limited to questions that can be easily answered by observation and by asking workers. Answers that do not comply with the preset ones (☑) indicate problem areas, which should receive further attention. Further investigation may be required to assess risks and make a decision on whether corrective measures are required.

Facility name and location: _____ Date: _____

Evaluation conducted by: _____

Work area inspected: _____

	Climbing and working at heights	**Yes**	**No**	**Comments**
1.1	Are the ladders stable and in good condition?	☑		
1.2	Are the ladders about 1 m longer than the stepping height so they provide a handhold for the worker?	☑		
1.3	Are the ladders used at 70-75 degree angle?	☑		
1.4	Are ladders used as working platforms?		☑	
1.5	Are workers required to work at heights?		☑	
1.6	Are workers at risk of being hit by falling objects?		☑	
1.7	Do workers have to enter confined spaces?		☑	
1.8	Do the employers provide safety belts and harnesses for workers at heights?	☑		
1.9	Work is performed on work platforms which are guarded and have railings	☑		
1.10	Are there workers walking on the wall of the loading pit?		☑	
1.11	Is there a at least 80 cm high guard rail around the pit wall to prevent falls	☑		
1.12	Do workers climb on the conveyor belt to reach the top of the parapet?		☑	
1.13	Are there carved steps in the material slopes to prevent tripping and falling?	☑		
	Road safety and internal vehicle movements			
2.1	Is there adequate street lighting along the approach roads?	☑		
2.2	Is there visibility and guidance along the curbs of the roads, such as white boulders?	☑		

2.3	Are there security measures which restrict unauthorized to the plant?	☑		
2.4	Are drivers moving their vehicles during the loading process or when other workers are standing on top of the truck?		☑	
2.5	Are there warning signals and speed limit signs for vehicles moving inside the crushing unit premises?	☑		
2.6	Are wheel chokers used during truck operations on uneven or sloped surfaces?	☑		
2.7	Do the vehicles entering the crusher unit have proper validations and certificates?	☑		
2.8	Are the roads adequately sloped for easy ascending and descending of vehicles?	☑		
2.9	The vehicles are maintained regularly and broken and missing mirrors are repaired	☑		
2.10	All vehicles have loud sound signals when backing up?	☑		

MAXIMUM POSSIBLE SCORE: 23

ACHIEVED SCORE: ……..

Notes:

D.6 Checklist: Dust and noise reduction, personal protective equipment

This checklist has been developed to provide guidance on prevention of health problems. Not all of these questions apply to all workplaces or to all stone crushing plants. To calculate the correct score you need to exclude the topics, which are not applicable. The checklist is limited to questions that can be easily answered by observation and by asking workers. Answers that do not comply with the preset ones (☑) indicate problem areas, which should receive further attention. Further investigation may be required to assess risks and make a decision on whether corrective measures are required.

Facility name and location: _____ Date: _____

Evaluation conducted by: _____

Work area inspected: _____

	Personal Protective Equipment (PPE) Plan	**Yes**	**No**	**Comments**
	Was the need to wear personal protective equipment assessed and the kind of PPE decided depending on the specific job (PPE plan)?	☑		
	Is the PPE considered adequate to the risk?	☑		
	Are ALL the workers wearing hard hats and stable shoes?	☑		
	Do ALL the workers have access if needed to earplugs (or better earmuffs) as well as masks to protect against noise and dust?	☑		
	Do workers wear the required personal protective equipment properly and regularly?	☑		
	Is there an effective PPE program to instruct employees on the importance?	☑		
	Is sun protection for workers provided whenever possible?	☑		
	Noise protection	**Yes**	**No**	**Comments**
	Is the distance between the noise source and workers as large as possible to reduce noise impact on health?	☑		
	Are unbalanced and loose machine parts replaced?	☑		
	Are the machine parts regularly lubricated?	☑		
	Are metal parts replaced with quieter plastic parts if possible, for instance rollers, washers?	☑		

	Are vibrating machines mounted on heavy, rigid bases?	☑		
	Are especially noisy machines enclosed, for instance with punctured metal plates, best in several layers so the sound gets "trapped"?	☑		
	Has the possibility been considered to put heavy rubber or plastic mats on places where impact or machine parts or boulders causes noise	☑		
	Are the tools properly shaped and sharpened?	☑		
	Are the proper earplugs and earmuffs been provided for workers?	☑		
	Is there training on the purpose, proper fitting, and care of hearing protectors?	☑		
	Is there continuous monitoring of employee noise-exposure levels?	☑		
	Dust protection			
	Is there appropriate PPE provided for dust protection?	☑		
	Is there local exhaust ventilation near the dust generation source?	☑		
	Are the dusty processes enclosed whenever possible ?	☑		
	Is water used to wet down dusty processes whenever possible?	☑		

MAXIMUM POSSIBLE SCORE: 23

ACHIEVED SCORE: ……..

Notes: