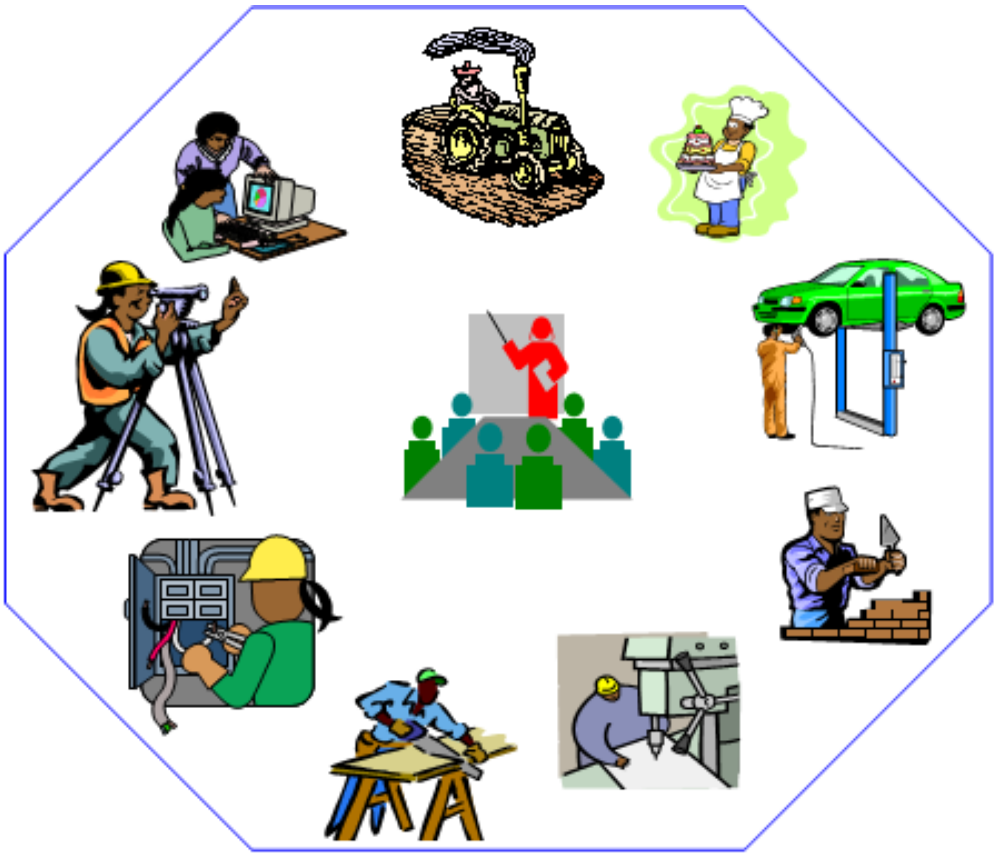
Lapidary Level-1

Based on Jan 2014, Version 1 OS and April, 2021, V1 Curriculum



Module title: **Operating and maintaining manufacturing machineries and equipment**

LG Code: **MIN LAP1M02 LO(1-6)LG(3-8)**

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LG #03	LO #1- Check job requirements

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics :

- Identifying Workplace requirements ,procedures and practices
- Introductory manufacturing skills
- Applying Procedures including all work instructions, standard operating procedures, formulas/ recipes, batch sheets, temporary instructions and similar instructions provided for the smooth running of equipment and processes
- Identifying Product, materials and equipment requirements for job(s)

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to**:**

- Identify Workplace requirements ,procedures and practices
- Develop Introductory manufacturing skills
- Apply Procedures including all work instructions, standard operating procedures, formulas/ recipes, batch sheets, temporary instructions and similar instructions provided for the smooth running of equipment and processes
- Identify Product, materials and equipment requirements for job(s)

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If your performance is satisfactory proceed to the next learning guide,
7. If your performance is unsatisfactory, ask your trainer for further instructions

Information Sheet 1- Identifying Workplace requirements ,procedures and practices

1.1 Workplace requirements for operating lapidary machinery

As it has been defined before, lapidary is the art of cutting or fashioning gemstones. The cutting/fashioning of gemstones involve different machining operations which are intended to be performed on different lapidary machines designed for a specific purpose. Those machines have to be installed in a well arranged and ventilated shop. This is because some of the gemstone cutting machines are very sensitive and may malfunction if not carefully placed in a clean shop. Example lapidary machines and equipment may include drills, trim saws, slab saws, flat laps, grinders, tumblers ,drills and others.

1.2 Lapidary Workshop characteristics

The workshop must have a well-ventilated room with a good source of natural light. A machine for cutting and polishing generates noise and vibrations, therefore the lapidary workshop must to be set in an appropriate location to operate in harmony with its environment.

1.3 General safety procedures and practices

The following are general safety guidelines that a lapidary should use.

- wear eye protection at all times when using the Lapidary Equipment. Safety goggles shall be made available for use.
- Tie back long hair ensuring it is kept at a safe distance from the Lapidary Equipment
- Do not wear open toed shoes or sandals in the Lapidary Workshop. Full covered shoes or runners only.
- Remove any large rings and any long necklaces before using the Lapidary Equipment.
- Do not be under the influence of drugs, alcohol, or any other mind altering substance when using the Lapidary Equipment

- Receive an orientation by a Supervisor or Assistant Supervisor on the proper and safe use of the Lapidary Equipment prior to its use.
- The Lapidary equipment shall not be used in conjunction with any of the following potentially toxic materials: Shell,-Bone, Malachite and other known toxic material

Self-check 1	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I Short Answer Questions

1. List at least 5 safety procedures that a lapidary should perform?
2. List the at least 3 lapidary machines that can be considered as occupational equipment requirements.
3. What are potentially toxic materials that should not be used in conjunction with lapidary equipments?

Note: **Satisfactory rating – 3 points** **Unsatisfactory – below3 points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 2- Introductory manufacturing/lapidary skills

2.1 Definitions

Lapidary can also be defined as manufacturing of products/jewels from gemstones.
The basic lapidary skills include :

- Operating basic lapidary machinery
- Mounting gem material on the machine
- Slabbing gemstones
- Tumbling of gemstones
- Cabbing gemstones
- Triming
- Polishing slabs by using lap

Slabbbing- is slicing of gem material into different thicknesses on which other designs of products can cut out or it can be polished as it is for different purposes.

Tumbling –is the process of gemstone polishing by putting gemstone in a revolving barel containing coolant mixed with appropriate polishing compounds.

Cabbing- also called cabochon making is the an art of producing lapidary products with generally a flat bottom and a domed top termed as cabochon. A cabochon (cab)

is a highly polished, convex-cut, **un faceted stone.**

Trimming- cutting of a small amount of unnecessary part from the gem material using small gem saws(trim saws).

2.2 Lapidary equipment

There are a variety lapidary equipment like saws, grinders, and polishers used to create cabochons and other related lapidary projects.

2.2.1 **Slab saw**

Slab saws are used to cut rocks into slices or slabs. The resulting slabs can be polished as display specimens or used to create cabochons. Commonly available saws include a 10 inch, 14 inch, and 18 inch and 36 inch slab saw.

2.2.2 **Trim saws**

Trim saws are used to cut slabs and other small rock. Most frequently, trim saws are used to cut away the excess rock around a cabochon design as marked on a slab using a template. Mineral oil and water are common coolant and lubricant while trimming stones. Saw with less than or equal to 10 inch diameter are termed as trim saws.

Fig:Trim saw

Fig: Slab saw

Fig:Band saw

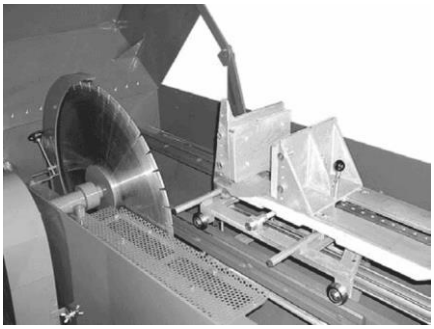

Fig: Slab saw

2.2.1 Parts of gemstone slab saw

The slab saw machinery has about 9 basic parts which are describe using the following figure.

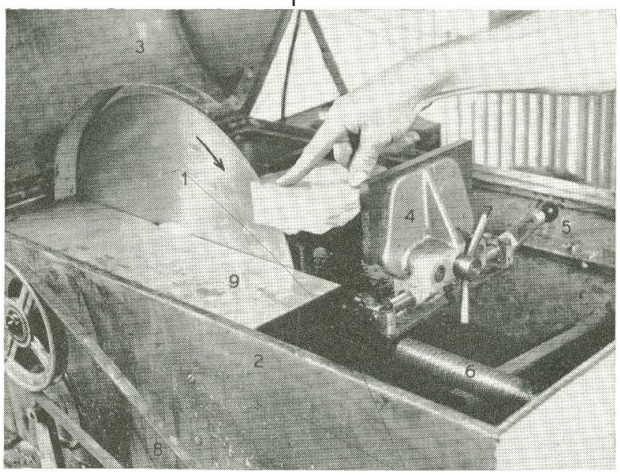

Fig: A Slabbing Saw Showing All Essential Parts. 1. Saw blade, 16" diameter. 2. Coolant tank and supporting frame for all moving parts. 3. Splash hood in raised position. 4. Carriage clamp (note wooden jaws). 5. Cross-feed crank for moving rough gemstone laterally. 6. Carriage drive screw. 7. Clamp tightening screw. 8. Vee-belt drive from motor. 9. Shelf for catching slabs.

2.2.2 Types of gem saw blades

There are generally two types of blades for discussion in this level. These are notch rim and sintered rim.

A. Notch-rim blades

For common sawing, the mild steel blade is most popular. It comes in a large variety of sizes and thicknesses and can be obtained with a light, medium, or heavy charge of diamond. This kind is also the least expensive. The method of charging consists of slotting the entire outside edge of the blade with evenly spaced notches about 1/8" in depth, the powder is introduced in each slot, and the rim of the blade is carefully rolled under pressure to close the metal over the diamond. The rolling action also expands the rim so that the saw is able to cut a groove somewhat thicker than the web and thus prevent binding. Because of the method of manufacture, these blades are known as "notch-rims."

B. Sintered-rim blades

In another process, diamond powder is mixed with metal powder and compressed into a thin hoop. This is then heat-treated, or "sintered," until the particles fuse together. The hoop is then soldered to a steel disk and forms what is called the "sintered-rim" saw. Both the notch-rim and sintered-rim blades are used extensively by amateurs, but the notch-rim is preferred because it is much less expensive and seems to do the job about as well as the other.

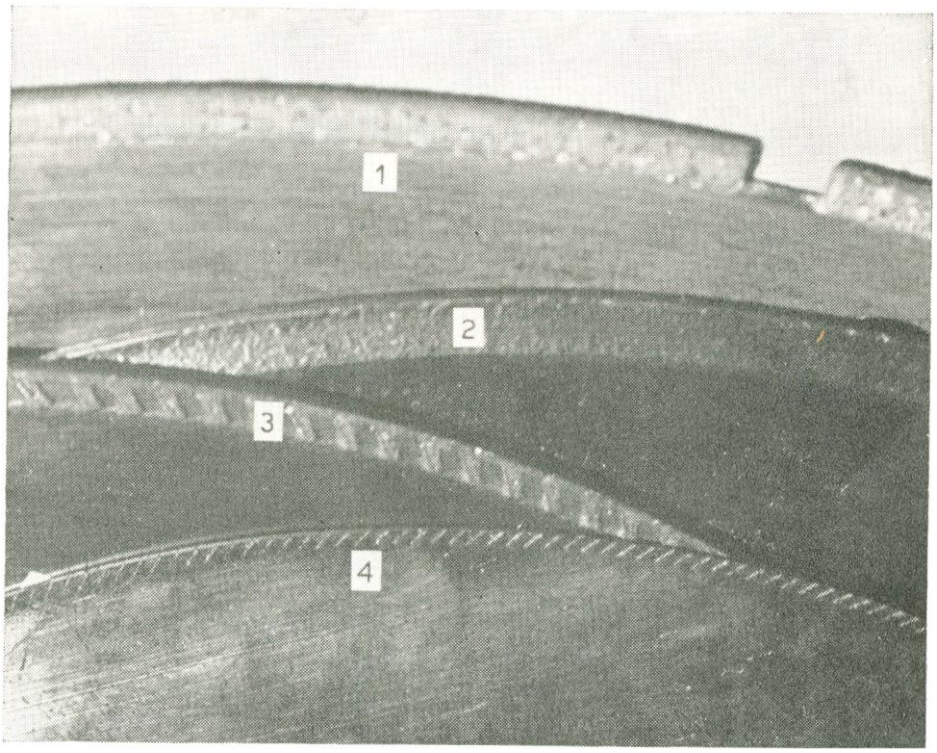

Figure . A Series of Diamond Saws Showing Various Methods of Charging. 1. Heavy-duty segmented sintered-rim saw. 2. Ordinary sintered-rim saw. 3. Ordinary notch-rim saw. 4. Special thin bronze notch-rim saw.

Figure above illustrates the edges of several standard diamond-charged saw blades to show the methods of charging. The saw blade at the bottom of the illustration is made of phosphor bronze and is scarcely thicker than a playing card!

The cutting action of all diamond saws is the same. When the' stone is fed to the blade, it scrapes off the metal until a particle of diamond is exposed; at this instant the saw begins to cut. As more diamond is exposed, performance is improved and

the saw is then said to be "broken in."

2.2.3 Grinders

The workshop provides a full set of diamond based grinding and sanding wheels. These wheels are mounted on arbors and are used in sequence to shape, sand, and polish cabochons and other stones. When using the grinding wheels one works from the lowest grit to the highest, removing scratches, ridges and flat spots along the way. There are generally two types of gem grinders depending on their size. These are smaller grinders called as Genie grinders and the bigger grinders called as Titan grinders. They shown as below.

Fig: Genie grinder

Fig: Titan grinder

2.2.4 Laps

There are two types of lapping machines. These are rotary laps and vibratory laps.

The laps allow one to grind and polish a flat surface on a stone. The machine is equipped with several diamond disks; one moves from the coarsest disk to the finest disk to obtain a high gloss polish. While polishing, water is supplied to the disk through a dripper. Excess water is collected in a small collector.

Fig: Rotary lap

Fig: Vibratory lap

2.2.5 Tumblers

There are two types of rock/ gemstone tumblers.

- Rotary
- Vibratory

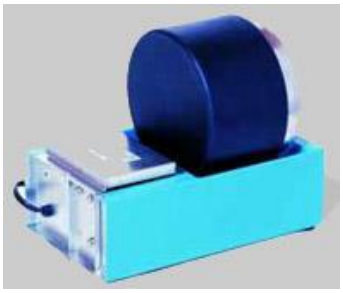

Fig: Rotary tumbler

Fig: Vibratory tumbler

Self-Check – 2	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. What are the basic skills of lapidary ?(**1pt**)
2. Mention two types of tumblers.(**1pt**)
3. What is slabbing?(**1pt**)
4. List at least four lapidary machines(**2Point**s)

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 3- Applying Procedures provided for the smooth running of equipment and processes

3.1 Basic operating procedures of lapidary equipment

The guide lines describe below are basic and to be noted before starting and during operating machineries.

C. Read owners manual before use

Before using the equipment, ensure that the person operating this machine has read and understands all of the instructions in the manual. Precaution is the best insurance against accidents. Read and understand all safety precautions, messages, warnings and hazard symbols. You are responsible for your own safety.

D. Always use safety glasses

Safety glasses should always be worn when working around power tools. In addition, a face, dust mask or respirator should be worn if a cutting operation is dusty. Everyday eyeglasses only have impact resistant lenses and may not prevent eye injury - they are NOT safety glasses.

E. Use proper apparel

Do not wear loose clothing, gloves, neckties, rings, bracelets or other jewelry that may be caught in moving parts. Non-slip footwear is recommended. Wear protective hair covering to contain long hair. Hand protection (plastic gloves) and a shop bib are recommended during sawing to prevent stains to clothing. Avoid prolonged exposure of skin to the sawing lubricant and wash skin immediately after contact. Do not touch the work material until the motor is off and the machine has come to a complete stop.

F. Always use hearing protection

To reduce the possibility of hearing loss, always use hearing protection when operating power equipment.

G. Keep guards in place

In order to prevent injury, never operate the saw without the guards in place!

H. Remove adjusting keys and wrenches

Form a habit of checking to see that keys and adjusting wrenches are removed from the power tool before it is turned on.

I. Electrical shock

Never touch electrical wires or motor components while the motor is running. Exposed, frayed or worn electrical wiring and plugs can be sources of electrical shock that could cause severe injury or burns.

Use the GFCI (Ground Fault Circuit Interrupter Switch) included with the unit attached to the main motor power cord plug and keep plugged into the power receptacle outlet source.

J. Reduce the risk of unintentional starts

Make sure the ON/OFF switch is in the OFF position before plugging in a power tool.

K. Rotating or moving parts

Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds or guards removed.

L. Check for damaged or worn parts

Before using a power tool, check for damaged parts. A guard or any other part that is damaged should be carefully checked to determine if it would operate properly and perform its intended function. Always check moving parts for proper alignment or binding. Check for broken parts and mountings and all other conditions that may affect the operation of the power tool. A guard, or any damaged part, should be properly repaired or replaced.

M. Use recommended accessories and parts

Consult the owner's manual for recommended accessories and parts. Using improper parts and accessories may increase the risk of personal and/or bystander injury.

N. Use the proper extension cord

If using an extension cord, make sure it is in good condition first. When using an extension cord, be sure to use one heavy enough to carry the current your product will draw. An undersized cord will cause a drop in line voltage that will result in a loss of power and overheating.

O. Use a ground fault circuit interrupter

Use of a Ground Fault Circuit Interrupter (GFCI) between the end of power cord and wall outlet is required at all times.

P. Use the proper power source

This tool is only to be used with a 120 volt 60 HZ power source. Insure power source is at least 15 amps and 110 to 120 volts. Low voltage current can adversely effect electric motor performance and overall life.

Q. Use the recommended cooling and lubricating fluids

Never operate a tool dry that requires coolant or lubricant. This can lead to shortened tool life, tool damage and personal injury.

R. Maintain tools with care

Keep the diamond blade sharp, the sawing lubricant clean and reservoir filled to the correct level for the best and safest performance. Always follow the maintenance instructions for sharpening the blade, lubricating and servicing the Cab Combo Workshop.

3.2 Basic operating procedures of slab saw

Self-Check – 3	**Written test**

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. What is the advantage of reading operation manual of a machine?
2. What is lubrication?

3. How can type of apparel that an operator wears affect protection level from accidents?

Note: **Satisfactory rating -3 points** **Unsatisfactory – below 3points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 4- Identifying Product, materials and equipment

4.1 Lapidary products

There are different types of products that can be manufactured by lapidary. The products may require simple to relatively complex operations. Among the products the following are common

- **Tumbled stones**-which are mass produced by using tumblers
- **Cabochons-** a product with a flat bottom and domed top which can be produced from reasonable natural rough sizes or slabbed stone. The are polished on grinder machines using differently charged wheel.
- **Faceted stones-** produced using faceting machines
- **Beads**-basically round in shape which is produced from slabs that are sliced by size. Here the lapidary basically uses slab saw and grinders.
- **Slabs-** slices of gemstone which are cut and polished for different purposes. For example : tiling ,performs for cabochons, etc
- Other products

4.2 Gem materials for lapidary product

The lapidary uses different gemstone rough to manufacture products. The products require from semi-precious to very expensive precious varieties of gemstone. The type of products may determine the varieties and properties of gemstones that they require. For example faceted gems are usually transparent and relatively precious. Example Diamond, ruby, sapphire, opal, transparent quartz crystals are better to be faceted. Semi-precious gemstones like jasper, obsidian, agate, chert, chalcedony, are used to produce other lapidary products as mentioned above.

4.3 Equipments required to manufacture lapidary products

To manufacture different lapidary products, different tools and equipments are required . The equipments are designed for a specific product. Some machines like slab and trim saws are multi-purpose, i.e used to slab or trim pre-forms which are used to manufacture different products. Others , like faceting machines are used only to produce faceted products.

Generally, the following equipments are common in lapidary workshop.

Equipments

- Tumblers
- Slab saws
- Trim saws
- Grinders
- Faceting machines
- Carving foredomes
- Gem drills
- Rock lathes
- Polishing laps
- Band saw etc---

and the cutting tools

- ❖ Saw blades
- ❖ Grinder wheels
- ❖ Polishing laps
- ❖ Bands and other consumables including different abrasive and polishing compounds are also available for abrasion and finishing of gemstones.

Self-Check –4	**Written test**

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. List down at least 4 lapidary products (4 pts).
2. Mention at last 5 gemstones that a lapidary uses to produce products(5).

3. What is the equipment used to make cabochons?(1pts)

Note: **Satisfactory rating - 10 points** **Unsatisfactory – below10 points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

LG #04	LO #2- Control hazards

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics :

- Identifying ***Hazards*** in the production work area
- Assessing risks arising from hazards
- Implementing Measures to control or avoid risks in line with procedures and duty of care to fellow workers
- Checking that safety guards and gates
- Making other miscellaneus checks

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able

- Identify ***Hazards*** in the production work area
- Assess risks arising from hazards
- Implement measures to control or avoid risks in line with procedures and duty of care to fellow workers
- Check that safety guards, gates etc are in position and are operational
- Make other checks required by standard operating procedures and manufacturer's instructions

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
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4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
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7. If your performance is unsatisfactory, see your trainer for further instructions

Information Sheet 1- Identifying Hazards in the production work area

1.1 Definitions

Hazard: Anything (e.g. condition, situation, practice, behaviour) that has the potential to cause harm, including injury, disease, death, environmental, property and equipment damage. A hazard can be a thing or a situation.

Hazard Identification: This is the process of examining each work area and work task for the purpose of identifying all the hazards which are "inherent in the job". Work areas include but are not limited to machine workshops, laboratories, office areas, agricultural and horticultural environments, stores and transport, maintenance and grounds, reprographics, and lecture theatres and teaching spaces. Tasks can include (but may not be limited to) using screen based equipment, audio and visual equipment, industrial equipment, hazardous substances and/or teaching/dealing with people, driving a vehicle, dealing with emergency situations, construction. This process is about finding what could cause harm in work task or area.

Risk: The likelihood, or possibility, that harm (injury, illness, death, damage etc) may occur from exposure to a hazard.

Risk Assessment: Is defined as the process of assessing the risks associated with each of the hazards identified so the nature of the risk can be understood. This includes the nature of the harm that may result from the hazard, the severity of that harm and the likelihood of this occurring.

Risk Control: Taking actions to eliminate health and safety risks so far as is reasonably practicable. Where risks cannot be eliminated, then implementation of control measures is required, to minimise risks so far as is reasonably practicable.

A hierarchy of controls has been developed and is described below to assist in selection of the most appropriate risk control measure/s.

Monitoring and Review: This involves ongoing monitoring of the hazards identified, risks assessed and risk control processes and reviewing them to make sure they are working effectively.

1.2 Hazards of the work area

There are so many hazards that the lapidary may be encountered with. The following are among these:

- **Asbestosis, silicosis-** lung diseases caused by inhaled silica dusts from gemstones that contain silica (e.g., quartz, granite, sandstone, soapstone) and asbestos
- **Cance**r- caused by asbestos and crystalline silica.
- **Skin/eye burns**- caused by calcium oxide, lime, silica, aluminum, iron compounds, and small amounts of magnesia, sodium, chromium, sulfur, and potassium compounds respiratory effects if inhaled, and gastrointestinal burns if ingested.
- **Chips** may be hazardous to the eyes. Wear eye protection and carve away from the body.
- **Overloads**- Lifting heavy stones can be hazardous. Lift carefully to avoid injuries.
- **Chemical hazards** caused from direct contact with polishing chemicals, cooling oils, gases, glues, etc may damage our skin, eye, and their diffusion is very dangerous for our respiratory system.
- **HIV/AIDS**- may be transmitted if we use cutting tools like knives, blades, etc when used in common.

  Thus, the lapidary should be aware of those mentioned and other health hazards

⇒ **electrocution or burns**- caused by the use of lapidary equipment including but not limited to the use of arbours, trim saws, slab saws, flat laps, and flexible shaft machines;

⇒ flying or falling rocks or debris; and slips and falls.

Other common hazards also include:

- Gases and liquids under pressure
- Moving machinery
- cutting edges
- Eelectrical equipment
- Environments subject to heat, noise, dusts or vapours

1.3 Causes of accidents while working with machinery

The common causes include:

- ♦ Loose clothing, hair, jewelry being caught in moving parts.

- Materials ejected from the machine when it is operational.
- Inadvertent starting of the machine.
- Slipping and falling into an unguarded nip.
- Contact with sharp edges, e.g., cutting blade.
- Making adjustments while the machine is operational.
- Unauthorized operation of machines.
- Lack of preventive maintenance.

1.4 Hazards related with the machines

A. Rotating machine parts give rise to nip points. Examples are
   - Rotating gears
   - Belt and its pulley
   - Chain and sprocket
   - Between grinding wheel and tool rest
   - Between rotating and fixed parts

B. - Rotating parts operating alone
   - Shafts
   - Couplings

C. Reciprocating and sliding motions
   - To and fro moving parts

Self-Check – 1	**Written test**

Name…… ID…… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. What is **hazard**?(2pts)

2. What are the causes of accidents while working with machinery?(2Pts)
3. Define silicosis ?(2pts)

Note: Satisfactory rating - 6 points Unsatisfactory – below-6points

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 2- Assessing risks arising from hazards

2.1 Risk management

Risk assessment is very important to eliminate or reduce risks that lapidaries may be encountered.

2.2 Procedures for risk assessment

The risk assessment procedure can best be illustrated in the following way.

Step 1: Identify Hazards

In general, hazards are likely to be found in the following;

- Physical work environment,
- Equipment, materials or substances used,
- Work tasks and how they are performed,

- Work design and management

In order to identify hazards the following are recommended:

(i) Past incidents/accidents are examined to see what happened and whether the incident/accident could occur again.

(ii) Employees be consulted to find out what they consider are safety issues, I.e. ask workers about hazards near misses they have encountered as part of their work. Sometimes a survey or questionnaire can assist workers to provide information about workplace hazards.

(iii) Work areas or work sites be inspected or examined to find out what is happening now. Identified hazards should be documented to allow further action. The work environment, tool and equipment as well as tasks and procedures should be examined for risks to WHS.

(iv) Information about equipment (e.g. plant, operating instructions) and Material Safety Data Sheets be reviewed to determine relevant safety precautions.

(v) Welcome creative thinking about what could go wrong takes place, i.e. what hazardous

Step 2: Assess Risks

Risk assessment involves considering the possible results of someone being exposed to a hazard and the likelihood of this occurring.

A risk assessment assists in determining:

- How severe a risk is
- Whether existing control measures are effective
- What action should be taken to control a risk
- How urgently action needs to be taken.

A risk assessment should include:

(i) Identify factors that may be contributing to the risk,

(ii) Review health and safety information that is reasonably available from an authoritative source and is relevant to the particular hazard,

(iii) Evaluation of how severe the harm could be. This includes looking at the types of

injuries/illnesses/harm/damage that can result from the hazard, the number of people exposed, possible chain effects from exposure to this hazard.

(iv) Evaluation of how a hazard may cause harm. This includes examining how work is completed, whether existing control measures are in place and whether they control the harm, looking at infrequent/abnormal situations as well as standard operating situations. A chain of events related to a risk may need to be considered.

(v) Determining the likelihood of harm occurring. The level of risk will increase as the likelihood of harm and its severity increases. The likelihood of harm occurring may be affected by how often the task is completed, in what conditions, how many people are exposed to the hazard and for what duration.

(vi) Identify the actions necessary to eliminate or control the risk; and

(vii) Identify records that it is necessary to keep to ensure that the risks are eliminated or controlled.

Other risk factors should also be identified as they may contribute to the risk: including

(viii) The work premises and the working environment, including their layout and condition,

(ix) The capability, skill, experience and age of people ordinarily undertaking work,

(x) The systems of work being used; and

(xi) The range of reasonably foreseeable conditions.

The process of assessing the risk is undertaken by reviewing any available information about the hazard and by using your personal work experience about what sort harm the hazard could create and how likely this would be to happen. When determining how likely it is that a person could be exposed to a hazard, consideration needs to be given to these “exposure factors”:

(i) Whether there are any other risk factors that increase the likelihood of exposure?

(ii) How often is the person exposed (frequency)?

(iii) or how long is the person exposed (duration)?

(iv) How many people are exposed?

(v) the likely dose to which the person is exposed?

(vi) any legislative or recommended exposure levels required by statutory authorities.

2.3 **Risk rating**

Risk can be rated by using the following risk matrix.

Table1: Risk rating matrix

Consequences (C)	Likelihood (L)				
	Rare	Unlikely	Possible	Very Likely	Certain to Occur
Catastrophic	moderate	moderate	high	critical	critical
Major	Low	moderate	moderate	high	critical
Moderate	Low	moderate	moderate	moderate	high
Minor	very low	low	moderate	moderate	moderate
Insignificant	very low	very low	low	low	moderate

self-Check – 2	**Written test**

Name…… ID…… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. What is the importance of assessing risk?(2)
2. What are the major steps for risk assessment?(1)
3. Mention the four areas that hazards are likely to be found.(4)

Note: Satisfactory rating - 7 points Unsatisfactory – below7 points

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 3- Implement measures to control or avoid risks

3.1 Controlling Risks

Once a risk rating is determined, each hazard must have its existing risk control measures evaluated using the Evaluation of Control Effectiveness Table. This allows for determination of any additional requirement necessary.

Evaluation of Control Effectiveness Table

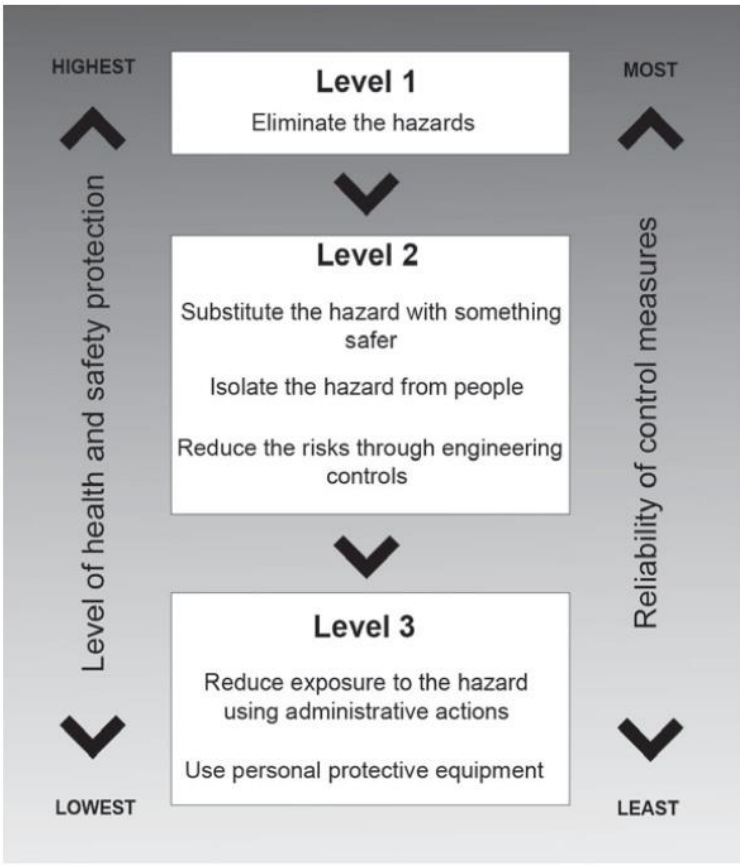
Well Designed Control ?		Effectively Implemented ?	
3	Needs improvement	3	Deficient *(b)*
2	Adequate	2	Marginal
1	Strong	1	Effective

3.2 Implement additional risk controls

Having identified the hazards in your workplace, assessed their risks and reviewed the existing controls, all hazards must be managed before people are hurt, become ill or there is damage to plant, property or the environment. The management of risks in the workplace requires eliminating risks so far as reasonably practicable in the first instance. Where elimination is not possible, then risks should be **minimised**, so far as reasonably practicable. All hazards that have been assessed should be dealt with in order of priority. The most effective control option/s should be selected to eliminate or minimise risks. The Hierarchy of Controls (see diagram below) ranks control

options from highest level of protection and reliability to lowest. This should be used to determine the most effective controls.

Hierarchy of Controls



- **Level 1** Control Measures – Eliminate the Hazard

The most effective control measures eliminate the hazard and associated risks. This can be achieved through removing the hazard or selecting alternate products or equipment to eliminate the risk. If a hazard cannot be eliminated then risks can be minimised by lower control measures

- **Level 2** Control Measures

These are used to minimise the risks and involve on or a combination of the following;

(i) **Substitute the hazard:** substitute a substance, method or material to reduce the risk or the hazard

(ii)**Isolate the hazard:** separate the hazard from the workplace or people, For example;

a. Chemical store room, or a laboratory kept locked except to an authorised person.

b. Lock out procedures on faulty equipment.

c. Appropriate guarding for machinery.

(iii) **Use engineering controls**: modify existing machinery or plant or purchase different machinery or plant to provide a physical solution if the part is degraded. For example;

a. slab saw splash hoods

b. Guard rails.

- **Level 3** Control Measures

These are control options which should be considered last as they do not control the source of the hazard but rely on human behaviour or supervision and are therefore less effective. They include;

(iv) Administrative Procedures: develop work methods or procedures to reduce the conditions of risk, for example:

a. Written Safe Operating Procedures

b. Job rotation to restrict hours worked on difficult jobs.

c. Staff trained in the correct operating procedures.

(v) Use Personal Protective Equipment (PPE) and training in its use:

offer the lowest level of protection and should only be used as a last resort to deal with the hazard, where the hazard cannot be removed or reduced by any other means, for example:

a. Handling of chemicals – gloves, safety glasses, aprons.

b. Protecting eyes from flying particles.

c. Protecting feet – safety boots.

Consultation with workers is required in the selection and implementation of control measure in the workplace. Controls may need to be trialled to determine effectiveness and workers should be involved in the feedback process. Each

measure must have a designated person and date assigned for the implementation of controls. This ensures that all required safety measures will be completed and documented.

Step 5: Monitor and Review

Hazard identification, risk assessment and control is an on-going process. Therefore, regularly review the effectiveness of your hazard assessment and control measures at least every 3 years. Make sure that you undertake a hazard and risk assessment when there is a change to the workplace including when work systems, tools, machinery or equipment

change. Provide additional supervision when new employees with reduced skill levels or knowledge are introduced to the workplace. The effectiveness of control measures can be checked through regular reviews as well as consultation with workers. Maintaining records of the risk management process assists when undertaking subsequent reviews or risk assessments as it demonstrates decision making processes and informs how controls were intended to be implemented.

Self-Check – 3	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. Describe hierarchy of risk control levels (2)
2. Which risk control level is the most effective?(1)
3. What is PPE?(2)

Note: Satisfactory rating -5 points Unsatisfactory - below 5 points

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 4- Checking safety guards and gates

4.1 Checking the right position of safety guards, gates

Before operating lapidary machinery, it is very important to perform pre-operational checks. This aids to eliminate or greatly reduce the occupational risks. These include tightening the rotating part, closing the guard, checking the power balance for the machine, firmly tighten the stone safely etc. generally, applying the following safety recommendations.

4.2 Safety guidelines for equipment

Different equipments have their respective different safety guidelines that should be applied. Guidelines for some of the common equipments are described as below:

4.2.1 Grinder/polishing machine

Abrasive wheels and grinding machines come in many styles, sizes, and designs. Both bench-style and pedestal (stand) grinders are commonly found in the lapidary industry. These grinders often have either abrasive wheels, or multiple abrasive wheels of varying grit and one special-purpose wheel such as a leather buffing wheel.

These types of grinders normally come with the manufacturer's safety guard covering most of the wheel, including the spindle end, nut, and flange projection. These guards must be strong enough to withstand the effects of a bursting wheel - such as those made of carbide. In addition, a tool work rest and transparent shields are often provided

For safety, the following guidelines will be used.

1. Think through the entire job before starting work
2. Wear appropriate personal protective equipment (ie: eye, face, hearing etc.).
3. Do not mix incompatible dusts (such as steel and aluminum).
4. Never start machine unless all guards are in place, properly designed and adjusted.
5. Beware of moving machinery parts.
6. Keep work area clean. Foreign materials may cause poor footing.
7. Use a dust collection system, if provided

4.2.2 Slab saw safety

The following should be thought before using slab saw.

- Think through the entire job before starting work.
- Make certain that the rock is firmly clamped to the cutting platform.

- Make certain that the face of the rock to be cut is perpendicular to the saw blade and that the blade will not be bent as it cuts.
- Wear appropriate personal protective equipme
- Never start machine unless all hoods and guards are in place, properly designed and adjusted.
- Beware of moving machinery parts.
- Keep work area clean. Foreign materials may cause poor footing.
- Immediately report all machinery malfunctions to a shop supervisor.
- Ensure that the operator is properly trained and has read the owners operation manual

4.3 General machine safety recommendations

It is basic common sense that all who use a machine should be required to read the manufacturer's instructions before using the machine! The following standard shop rules can be adapted to use by operators

1. Maintain machines and equipment in good condition.
2. No work may be performed using power tools unless at least two people are in the shop area and can see each other.
3. Proper personal protective equipment is to be available and used.
4. Loose clothing, long hair, etc must be contained so that it cannot be caught in rotating equipment.
5. Do not wear loose clothing, jewelry, gloves, etc. when operating shop equipment - wear appropriate clothing for the job.
6. Never use a rag near moving machinery.
7. Only work on one stone at a time. This is done in order to assure both safety and that all members have an opportunity to use the equipment during the shop open hours.
8. If you have not worked with a particular material before, check or consult with an experienced member about specific precautions to be taken while working with the material. Also, ask a shop supervisor before cutting any unusual material.
9. . Always check to see if a machine is clear of other objects before using it and notify a supervisor if you find equipment inoperable or in disrepair.
10. All machines must be operated with all guards and shields in place.

11. Think through the entire job before starting work, and ask a supervisor to check the preparation of your rock in a saw or your use of a polishing unit or grinder. Keep the floor around machines clean, dry and free from trip hazards. Do not allow stone chips to accumulate

12. Do not eat in the area of machine use.

Self-Check – 4	**Written test**

Name…… ID…… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. What is the importance of knowing the right positions of emergency switches?(1pt)
2. What is the advantage of working in the clean and organized workshop?(1pt)
3. What are the general machine workshop safety recommendations?(1pt)

Note: Satisfactory rating -3 points Unsatisfactory – below3 points

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 5- Making other miscellaneous checks

5.1 Making checks required by standard operating procedures

The general recommended guidelines for the safe operation of lapidary machinery is presented in information **sheet- 4** of of Lo2 of this guide. But different machines have their different standard operating procedures which are described in the manufacturer′ operation manual. Thus, the lapidary technician should carefully read this manual and habituate it to apply during operating the machinery. To present some example here, the standard operating procedure of the slab is described as follows:

5.2 Manufacturer's operating instructions for slab saw

The following are sample standard instructions of slab manufacturer:

1. Safety glasses must be worn when using this equipment.

2. Roll the saw out into the center of the storage room. You need sufficient space around the saw so you can set up the rocks for cutting and to provide a work area while using the saw.
3. Before plugging in the saw, turn the saw blade by hand to make sure nothing is binding and there is sufficient oil. The oil should run down the blade after it has been manually rotated. Plug the motor into the wall outlet. Make sure the cord is not causing a tripping hazard.
4. **Filling the Saw:** To determine the correct amount of light oil to add, simply pour the oil slowly onto the saw table while the saw is running. The correct fill level has been

   reached when a steady stream flies off the blade and hits the table in front of the blade. You can also see it leaving the blade guard and hitting the plastic cover.
5. **Clamping the rock in the vise:**
6. **Use of the Cross Feed to determine thickness of slab to be cut**
7. **Slabbing**
8. Cleaning and storing the machine:
   - Turn off and unplug the machine before cleaning.
   - Remove any stone scraps from the saw table.
   - Using the plastic card, scrape the oil from the top tray around the saw blade into the slot surrounding the blade. This oil goes back into the oil reservoir.
   - Wash and dry the plastic shield and replace it on the saw.
   - After all other equipment is placed back on the storage shelves roll the saw back

     between the shelves for storage.

Self-Check – 5	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test 1: short Answer Questions

1. What is standard operating procedure of a machine?
2. What are the standard procedures to clean and store the slab saw?
3. What is importance of applying standard procedures while operating a machine?

Note: Satisfactory rating -3 points Unsatisfactory - below 3 points

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating:

LG #05	LO #3- Prepare equipment for operation as required

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics :

- Performing pre-start up checks
- Reporting Suspected unusual or non-standard product, materials and equipment
- Notifying team members on the intended equipment function and start up.
- Checking and supplying Materials to equipment
- Starting up the item of equipment as required.
- Bringing Specified conditions and building steady operating rate

This guide will also assist you to attain the learning outcome stated in the cover page.

Specifically, upon completion of this Learning Guide, you will be able to**:**

- Perform pre-start up checks
- Report Suspected unusual or non-standard product, materials and equipment
- Notify team members on the intended equipment function and start up.
- Check and supply Materials to equipment
- Startup the item of equipment as required.
- Bring specified conditions and build steady operating rate

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If your performance is satisfactory proceed to the next learning guide,
7. If your performance is unsatisfactory, ask your trainer for further instructions

Information Sheet 1- Performing pre-start up checks

1.1 Pre-start up checks

It is important to carry out a series of checks before using a piece of machinery. This is

particularly important in situations in which a number of people use the same machine. Larger companies and organisations usually have a system of checks, and a maintenance department that will deal with reported defects. Individuals working alone or in small teams will be responsible for checking and maintaining their own machines. Learners should be able to follow a checklist to ensure that they complete all the

necessary checks. This may mean using either a pre-set format .

Pre-start up checks are confirmations made by operators to prove that whether the machine is in the right setting and condition. If the results of pre-operatioal checks are bad, the machine should be reset and rechecked till normal operating characteristics are brought. The checks may include tightness of clamps, position of guards, installation types, level of the coolant, etc.Forexample, the level of coolant can be checked by letting the blade of the slab saw rotate by hand and inspecting whether it is toching the coolant or not. the the b The checks can be performed by using checklist of attributes.

1.2 Types of pre-startup checks

There areseveral checks that should be performed before going operating machinery . among those checks the following are common and general checks.The pre-start up checks include:

- visual checks
- completing checklists
- checking that safety guards, gates etc are in position and are operational
- other checks required by standard operating procedures and manufacturer's instructions

1.3 Benefits of pre- start up checks

In a machine or equipment pre-start inspection, the operator uses a checklist to perform a standardised routine inspection before using the machine or equipment. A pre-start checklist normally covers the exterior and interior condition of the machine or equipment as well as operational aspects including mechanical and electrical systems, fluid levels and safety devices such as alarms, fire extinguishers and first-aid kits. A pre-start checklist inspection intends to identify defects and safety hazards before operation.

1.3.1 Safety Benefits of Pre-Start Checks

When heavy vehicles and their associated equipment or mobile plant are not maintained, they have the potential to cause serious injury or, in severe cases, death. Therefore, the main aim of a pre-start checklist inspection is to insure a vehicle or piece of equipment is safe to use. For many businesses, machine and equipment pre-start checklist inspections form the foundation of both their machine fleet and equipment maintenance schedule and their workplace safety policy. This is because unsafe conditions identified through pre-start checklist inspections can be assessed for potential hazards and risks, and control measures can be put in place to reduce the likelihood of equipment failure or personal injury. In this way, pre-start checklist inspections also help promote a strong culture of workplace safety.

1.3.2 Financial Benefits of Pre-Start Checklists

Although the main objective of a pre-start checklist inspection is safety, conducting regular machine and equipment pre-start checks has financial benefits. By identifying minor issues before using a vehicle or piece of equipment, relatively quick and inexpensive repairs can be made before minor issues turn into major problems that are expensive to fix and cause unexpected downtime. Further, as minor issues can often be fixed on-site, pre-start checklist inspections can also help prevent expensive costs associated with on-road or off-site breakdowns such as hefty call-out fees, towing fees or shipping costs for replacement parts sent to a remote location. In short, a pre-start checklist inspection will help keep your machines and equipment well maintained and prevent financial losses associated with unexpected breakdowns and unplanned downtimes

Self-Check – 1	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test 1: short Answer Questions

1. What is the safety benefit of pre-start up checks?(2 pts)
2. What is the economic benefit of pre-start up checks?(2pts)
3. How can we check the level of coolant in the reservoir of the slab saw machine?(1pt)

Note: Satisfactory rating -3 points Unsatisfactory - below 3 points

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating:

Information Sheet 2- Reporting Suspected unusual or non-standard product, materials and equipment

2.1 Non standard product, materials and equipment

Products , materials and equipment are termed as non standard when the deviate the predefienned specifications. Non standard products are unusual products that can be produced by equipments lacking lacking consistency in qulity production. This may be because of improper equipment set ups, depreciation in precision of equipment, the quality of imput materials and skill of lapidary.

Unusual materials are the inputs that are out of prespecifed quality limits. The material attributes to be considered here may include size of the material, type of the material, shape of the material, and generally its physical and chemical and its technological properties.

Unusual equipment characteristics are those which are new and abnormal conditions that equipments may experience usually after a long time service. The characteristics of nonstandard equipment may include

- Low production rate
- Production of defective parts
- Unusual noise
- Overheating
- Abnormal vibration etc

2.2 Reporting non-standard products,materials and equipment

Modern manufacturing workshops have standard and a well organized problem identification and reporting system to reolve it with in short period possible.

Therefore a lapidary as a manufacturer should inspect non conforming products, materials and equipments.

Non conforming products mean the quality of products deviate from prespecified requirements of the customer or the manufacturer. Likewise, non conforming materials and equipments are respectively deviating materials and equiments.

Since production of defective products which are related with defective material, defective equipment and other additional factors is a loss of economy. Therefore,nonstandard products , materials and equipment should reported to the concened body to resolve the problem. Moreover non standard equipment may cause safety problems too.

Self-Check – 2	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test 1: short Answer Questions

1. Mention at least 4 non standard equipment characteristics.(4pts)
2. What do we mean by non standard material.(1pt)
3. What is the importance of reporting production of non-standard products?(2pts)

Note: Satisfactory rating -7 points Unsatisfactory - below 7 points

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating:

Information Sheet 3- Notifying team members on the intended equipment function and start up

3.1 Notification

Notification is awaring individuals about something which they do not know. Notification an important part of communication to do the work with common understanding within members.

3.2 On job training on equipment functions and start up

Team members which are not familiar with intended functions and starting up procedures of the the machine need a clear information on it. Therefore, to notify for all members of the team, on job traing has to be given on the target equipment .

Self-Check – 3	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test 1: short Answer Questions

1. What is the use of notification?(2)
2. What do we mean by on job training?(2)
3. What will be the problem if an individual member tries to operate the machine without having basic understanding about its operation?(1pt)

Note: Satisfactory rating -5 points Unsatisfactory - below 5 points

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating:

Information Sheet 4- Checking and supplying Materials to equipment

4.1 Checking materials

The gem material to be suppled for test should be selected as per the size and type requirements. Forexample, the size of the rough to be slabbed by gem saw should not exceed from radius of the saw blade. If the size exceedsthe radius of thesaw blade, the blade can not cut through depth of the rough. Thus, this makes the cut unsuccessful. The other thing that should be understood is all kinds of gemstones may not be slabbed by one kind of gem saw. Gemstones with usually small size and with less hardness should be slabbed with smaller saws. This is may have different advantages including saving of the material from damage because of high impact loads from bigger machines. The otheradvantage thing is to reduce wastage of material especially of expensive gem materials because of thicker blades.

To check the materials, different measument techniques and tools can be used.

4.2 Supplying materials to equipment

After conducting checks on the material requirements, the material satisfiying the check points has to be supplied to the equipment.

Self-Check –4	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test 1: short Answer Questions

1. How can size of rough stone affect slabbing operation?(2pts)
2. Why slabbing of small roughs by bigger machines uneconomical?(1pt)
3. Why we check materials before suppling them into the machine?(1pt)

Note: Satisfactory rating -4 points Unsatisfactory - below 4 points

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating:

Information Sheet 5- Starting up the item of equipment as required

5.1 Doble checking the equipment

Before starting up the equipment, any of the concerns on the equipment have to be double checked once again based on the standard work requirements before starting up the equipment.

5.2 Starting up the equipment

After final check about the work requirements, the equipment will be started up following its operating procedures.

Self-Check – 5	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test 1: short Answer Questions

1. What is the purpose of repeatly checking conditions of equipment before starting up it?
2. Why do we follow operating procedures while starting up the equipment ?

Note: Satisfactory rating -3 points Unsatisfactory - below 3 points

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating:

Information Sheet 6- Bringing Specified conditions and building steady operating rate

6.1 Bringing Specified conditions

Specified conditions are the conditions that are suitable to do the required task. Thes conditions may be brought by repeated trial and error approach through setting.

The conditions may be forexample:

- **The level of the coolant that is optimum for the blade to deliver fluid to gem material**
- **Speed of the machine that is appropriate and favours tha blade cut the gem material without overheating**
- **The pressure level of the pump that is capable of delivering appropriate amount of coolant to cutting area**
- **The postion of the hood of grider machine such that it does not totch any rotating part of the mattion**
- **etc**

6.2 Building steady operating rate

After bringing the required and specified conditions, it is important to fix the conditions to use for further project production. The conditions should long for production time period with out fluctuations for consistency to meet the prespecified conditions.

Self-Check – 6	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test 1: short Answer Questions

1. What do we mean by steady?(1pt)
2. What are specified conditions?(2pts)
3. If the conditions set are not complying with prespecified ones, what will happen ?(1pt)

Note: Satisfactory rating -4 points Unsatisfactory - below 4 points

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating:

LG #06	LO # 4 Operate equipment
Instruction sheet	

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Monitoring *equipment operating conditions*
- Recognizing Conditions and characteristics which indicate a *problem*
- Monitoring Product characteristics
- Maintaining Supply of materials and removal of products
- keeping equipment and work area clean, organized and in safe condition

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, **upon completion of this learning guide, you will be able to**:

- Monitor *equipment operating conditions*
- recognize Conditions and characteristics which indicate a *problem*
- monitor *Product characteristics*
- maintain Supply of materials and removal of products
- keep equipment and work area clean, organized and in safe condition

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
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6. If your performance is satisfactory proceed to the next learning guide,
7. If your performance is unsatisfactory, see your trainer for further instructions

Information Sheet 1- Monitoring equipment operating conditions

1.1 Introduction

Approximately half of all operating costs in most processing and manufacturing operations can be attributed to maintenance. This pushes for studying any activity that can potentially lower these costs. Machine condition monitoring and fault diagnostics is one of these activities. Machine condition monitoring and fault diagnostics can be defined as the field of technical activity in which selected physical parameters, associated with machinery operation, are observed for the purpose of determining machinery reliability. Once the reliability of a machine has been estimated, this information can be used for many different purposes. Loading and maintenance activities are the two main tasks that link directly to the information provided. The ultimate goal in regard to maintenance activities is to schedule only what is needed at a time, which results in optimum use of resources. Having said this, it should also be noted that condition monitoring and fault diagnostic practices are also applied to improve end product quality control and as such can also be considered as process monitoring tools. With this in mind, this information sheet will address a description of what is meant by machinery failure and probable causes of failure. The level of understanding require here is inspecting the operation condition and make corrective adjustments, if it is simple to respond and otherwise report to the supervisor. Here diagnosing complex cases is beyond this level.

1.2 Machinery/ equipment Failure

Most machinery is required to operate within a relatively close set of limits. These limits, or operating conditions, are designed to allow for safe operation of the equipment and to ensure equipment or system design specifications are not exceeded. They are usually set to optimize product quality and throughput (load) without overstressing the equipment. Generally speaking, this means that the equipment will operate within a particular range of operating speeds. This definition includes both steady-state operation (constant speed) and variable speed machines, which may move within a broader range of operation but still have fixed limits based

on design constraints. Occasionally, machinery is required to operate outside these limits for short times (during start-up, shutdown, and planned overloads).

The main reason for employing machine condition monitoring and fault diagnostics is to generate accurate, quantitative information on the present condition of the machinery. This enables more confident and realistic expectations regarding machine performance.

Having at hand this type of reliable information allows for the following questions to be answered with confidence:

- Will a machine stand a required overload?
- Should equipment be removed from service for maintenance now or later?
- What maintenance activities (if any) are required?
- What is the expected time to failure?
- What is the expected failure mode?

Machinery failure can be defined as the inability of a machine to perform its required function. Failure is always machinery specific. For example, the bearings in a conveyor belt support pulley may be severely damaged or worn, but as long as the bearings are not seized, it has not failed. Other machinery may not tolerate these operating conditions. A computer disk drive may have only a very slight amount of wear or misalignment resulting in noisy operation, which constitutes a failure.

There are also other considerations that may dictate that a machine no longer performs adequately. Economic considerations may result in a machine being classified as obsolete and it may then be scheduled for replacement before it has "worn out." Safety considerations may also require the replacement of parts in order to ensure the risk of failure is minimized.

1.3 Causes of Failure

When we disregard the gradual wear on machinery as a cause of failure, there are still many specific causes of failure. These are perhaps as numerous as the different types of machines. There are, however, some generic categories that can be listed.

- Deficiencies in the original design,
- Material or processing,
- Improper assembly,
- Inappropriate maintenance, and
- Excessive operational demands may all cause premature failure.

Self-Check – 1	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. What is machinery failure?(1pt)
2. List atleast 5 generic causes of machinery failure?(5pts)

3. What is maintenance cost?(1pt)

Note: **Satisfactory rating - 7points** **Unsatisfactory - below 7points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 2- Recognizing Conditions and characteristics which indicate a problem

2.1 Recognizing Conditions

Monitoring of operating conditions of machines is realized by recognizing occurring machine conditions and problem indicating characteristics. In reality, there are various conditions and problem characteristics of machines that an operator can sense and recognize.

2.2 Abnormal **characteristics**

The following are some of the common conditions that indicate problems

- Overheating of machines
- abnormal sound/noisy from normal
- Change in processing speed
- Failure to discharge coolant
- Failure to feed load
- Production of defective parts etc**.**

Recognizing the conditions of the equipment and thus identifying problem indicating signs or characteristics should be a basic task for machine operator to safeguard him/herself the equipment and to find economical solutions to problems that can affect productivity in manufacturing.

A lapidary in this level is required to recognize various operations and problem indicating characteristics. After identifying problem indicating conditions, a remedy should be given for simple problems and it is advisable to immediately report the problems which are beyond the level.

Self-Check – 2	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. List the abnormal conditions of a machine?
2. What is the probable cause for overheating of a machine?
3. How can we detect the abnormalities in machines?

Note: **Satisfactory rating - 3points** **Unsatisfactory – below 3points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 3- Monitoring Product characteristics

3.1 Monitoring

Monitoring is the controlling over of parameters of may be a product or a process such that deviations will be reduced. Product characteristic monitoring is controlling of the the manufacturing processes or machines depending on the product characteristics keeping their levels within prespecifed limits.

Generally product characteristics may include product quality, production rate, defect rate. If the quality and rate of production are diminishing and rate of production of defective products are increasing, then this shows that either production machine or equipment or the processes parameters are in the the wrong conditions. Thus, decisions about equipment and process conditions can be made from product characteristics.

Understanding of product characteristics is essential to determine machine and process conditions. The proper condition of a machine operation may lead to a manufacturing of an intended product quality whereas an improper operation condition of a manufacturing machine may produce defective product.

3.2 Product quality characteristics

Product quality characteristics are the attributes of the product that can describe the physical and mechanical properties of the product.

Therefore the characteristics of a product can determine the selection of machines and their operating conditions. The product quality characteristics include:

1. Product quality
- Level of surface finish
- Accuracy
- Size etc.

2. Production rate
- High production rate
- Medium production rate

- Low production rate

3. Defect rate

- High rate of defective parts produced
- Medum rate of defective parts produed
- Low rate of defective parts produced
- Non defective parts produced.

By monitoring the product characteristics, we can assure quality of the product. This can be realized by selecting right machines and monitoring their manufacturing operations.

Self-Check – 3	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. List at least 4 lapidary product characteristics(4pts).
2. What is the importance of knowing product characteristics while monitoring?(1)
3. How can characteristic of a product affect machine operation requirements?(1)

Note: **Satisfactory rating - 6points** **Unsatisfactory – below 6points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 4- Maintaining Supply of materials and removal of products

4.1 supply of materials

The smooth and consistent feed of the inputs to a manufacturing unit/system require a strong supply chain. To supply the raw materials, there should be a material warehouse or store. In our case the materials can be gemstone roughs. The supply should be secured by making friendly relations with gem rough collectors.

Maintaining supply of materials as well as proper removal of products enhances productivity of a gemstone product manufacturing sector.

The materials to be supplied may include:

- Gemstone rough
- Pre-formed slabs
- Pre –polished stones etc

4.2 Removal of products

The products should also be removed and properly stored. While removing the products, care should be taken to reduce risk of injuries because of improper approaches used to dismantle products from machines. Thus, safe guidelines should be utilized while removing products from machines.

Here the products may be:

- Gemstone slabs
- Tumbled stones
- Polished slabs etc

Self-Check –4	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. What is warehouse?(1pt)
2. What is the advantage of maintaining a strong material supply chain?(2pts)
3. What are the materials to be supplied to a manufacturing system?(2pts)

Note: **Satisfactory rating - 5points** **Unsatisfactory – below 5points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 5- keeping equipment and work area clean, organized and in safe condition

5.1 Cleaning equipment and work area

After completion of operation the equipment and the work shop should be cleaned. They should be kept in safe condition making ready for future use. By principle of **KIZEN,** this is termed as **shine**

- Shine means keep everything swept and clean.
- Shine is a way to keep everything in top condition so, when someone needs to use something, it is ready to be used.
- When Shine, we can't avoid inspecting the item at the same time. Therefore **Shine** and Inspect come together.

Therefore, kaizen should be applied in lapidary workshops

5.2 Benefits of cleaning

Cleaning provides the following general benefits

- Clean and comfortable workplace.
- Increase visibility to defects when it occurs.
- Helps to maintain safer workplace.
- Good working environment increase morale.

Early detection of machinery and equipment failure is possible

Self-Check –5	**Written test**

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. What is KAIZEN?(1pt)
2. Mention at least 5 benefits of cleaning(5pts)
3. How can cleaning increase safety of operators?(1pt)

Note: **Satisfactory rating - 7points** **Unsatisfactory – below 7points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

LG #07	**LO # 5 Prepare equipment for shut down**

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Performing emergency pause, stop or shutdown as required
- Ensuring equipment to be free of product or purge/clean as required
- Shutting down Equipment in accordance with procedures
- Making sure equipment and area is left in a safe condition and ready for *need*

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, **upon completion of this learning guide, you will be able to**:

- Perform emergency pause, stop or shutdown as required
- Ensure equipment to be free of product or purged as required
- shut down Equipment in accordance with procedures

- Make sure equipment and area is left in a safe condition and ready for *need*

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If your performance is satisfactory proceed to the next learning guide,
7. If your performance is unsatisfactory, see your trainer for further instructions

Information Sheet 1- Performing emergency pause, stop or shutdown

1.1 Performing emergency pause

During operation of machinery, the machine or an operator may be encountered with an accident. For example: The carriage may exceed the limit and make collisions with other body,

- ✓ Fire may be produced because of high heat generate by friction
- ✓ The cloth of the operator can be caught by the rotating part of the machine ,etc.

At times of emergent accidents like listed above and others, it is difficult to save machine and life of operators by procedurally shutting down the machine. At times of emergency, there are emergency switches provided on the machine to immediately pause the its operation and thus save the life and the machine.

NOTE: At time of accident, pause the machine by using emergency switch!

1.2 Removing products

The products should be removed after switching off the machine. Attempting to pick up the product while the machine is running is very dangerous .Picking up should be performed after every moving part of the machine is in static condition.

1.3. shutting down the machine

Machines have their safe shutting down procedures. It is advisable to shut machines following their procedures, if there is an accident. This is because the procedures designed for safe restoration of machine parts. To shut down the faceting machine, stop rotational speed, make direction of rotation at neutral and press on/off switch.

1.4 Cleaning and storing equipment

As a manufacturing workshop rule, the equipment and the work area should be properly cleaned and arranged. The equipment should be stored at proper position ready for future use.

The equipment should also be inspected for its normality, and its areas of friction like tool guides, gear boxes, etc should be lubricated to reduce heat that may be produced by friction causing chipping and breaking down of the parts.

Self-Check – 1	**Written test**

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. What will be your immediate action if your friend's cloth is caught by the rotating parts of a machine?(1pt)
2. Before cleaning the machinery, what are the activities that should be performed?(2pts)
3. What do mean by emergency pause?(1pt)

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 4 points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 2- Ensuring equipment to be free of product or purge/clean as required

2.1 Removing products

The products should be removed after switching off the machine. Attempting to pick up the product while the machine is running is very dangerous .Picking up should be performed after every moving part of the machine is in static condition.

2.2 Cleaning the equipment

After removing and storing the product the machine has to be cleand as per standard procedures to make it in safecondition for further use. While cleaning, it is important to consider the following issues:

- Type of detergent to be used
- Type sweeping or washing brush used

Equipments with its complex metallic parts whch can rust should not be cleaned by bare water. This should be cleaned by mixes of oily fluids that can cover metallic surfaces from external environment and thus reduce rust

Self-Check – 2	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. Why don't we attempt to pick up the product during the machine is running?(1pt)
2. what will be the problem when we clean complex metallic parts of machies with only normal water?(2pts)
3. Mention at least 2 moving parts of a running machine that can cause injury to operator?(2pts)

Note: **Satisfactory rating - 5points** **Unsatisfactory – below 5points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 3- Shutting down Equipment in accordance with procedures

a. ***Shutting down equipment***

Machines have their safe shutting down procedures. It is advisable to shut machines following their standard procedures . This is because the procedures designed for safe restoration of machine parts. For example,to shut down the faceting machine, stop rotational speed, make direction of rotation at neutral and press on/off switch.this shows that standard shutting down procedures safeguardthe machine and the operator too.

b. Definition of Lock out

Lockout-tagout (LOTO) or **lock and tag** is a safety procedure which is used in industry and research settings to ensure that dangerous machines are properly shut off and not started up again prior to the completion of maintenance or servicing work.

Modern machinery can contain many hazards to workers, from things like electrical, mechanical, pneumatic or hydraulic sources. Therefore, care must be taken to prevent the problem

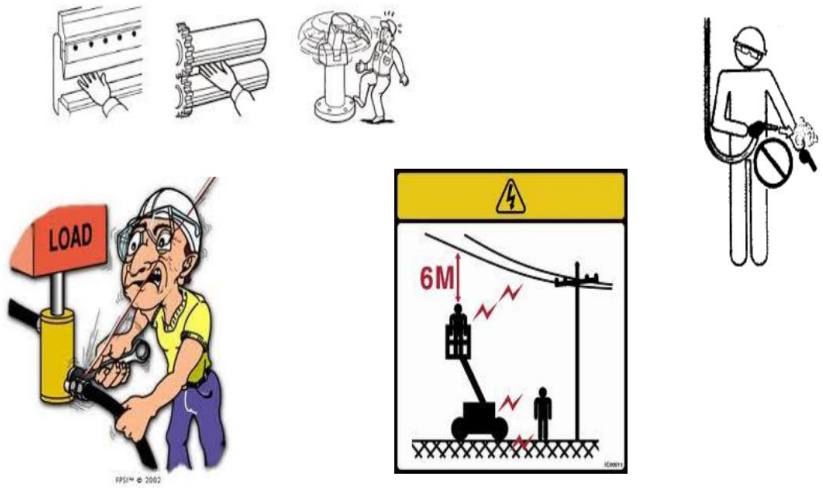

Fig : workers harmed by different hazards

c. Isolation

Disconnecting or making safe the equipment involves the removal of all energy sources and is known as *isolation*. The steps necessary to isolate equipment are often documented in an *isolation procedure* or a *lockout tagout procedure*. Isolation involves the following Processees:

- Identify the energy source(s)
- Isolate the energy source(s)
- Lock and Tag the energy source(s)
- Prove that the equipment isolation is effective

Self-Check – 3	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

4. Describe isolation processes(4pts).
5. What is isolation ?(1)
6. What are the advantages of shuting down down equipment by following standard procedures? (1pt)

Note: **Satisfactory rating - 6points** **Unsatisfactory – below 6points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 4- Making sure equipment and area is left in a safe condition and ready for *need*

5.3 Safe conditions of equipment and work area

As a manufacturing workshop rule, the equipment and the work area should be properly cleaned and arranged. The equipment should be stored at proper position ready for future use.

The equipment should also be inspected for its normality, and its areas of friction like tool guides, gear boxes, etc should be lubricated to reduce heat that may be produced by friction causing chipping and breaking down of the parts.

5.4 Importance of machinery safety

keeping of machinery in good conditions is very important as its improper handling may cause injuries and other damages in the following ways

- People can be hit and injured by moving parts of machinery or ejected material.

  Parts of the body can also be drawn into or trapped between rollers, belts and pulley drives.
- Sharp edges can cause cuts and severing injuries, sharp-pointed parts can stab or puncture the skin, and rough surface parts can cause friction or abrasion.
- People can be crushed both between parts moving together or towards a fixed

  part of the machine, wall or other object, and two parts moving past one another can cause shearing.
- Parts of the machine, materials and emissions (such as steam or water) can be

  hot or cold enough to cause burns or scalds and electricity can cause electrical

  shock and burns.
- Injuries can also occur due to machinery becoming unreliable and developing faults due to poor or no maintenance or when machines are used improperly through inexperience or lack of training.

5.5 Safe work area

The type of work area determines the occupational safety level that can be achieved. A neat, pleasant and well organized workshop is safer than arandom and crouded space. Organized and neat work area has so many advantages with respect to different perspectives:

- It increases more of workers
- It reduces safety of workers as it reduces obstacles during movement
- It enables to effectively utilize space
- It helps to increase safety of machines

Self-Check –4	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. What are the advantages of keeping neat work area?(2pts)
2. What are the common areas of an equipment that should be inspected to prove its normality?(2pts)
3. Mention at least 4 ways that operators can be injured because of improperly handled machinery ?(2pts)

Note: **Satisfactory rating - 6points** **Unsatisfactory – below 6points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

LG #08	LO # 6 Adjust and maintain machine

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Selecting maintenance tools and equipments
- Carrying out routine maintenance and adjustments

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, **upon completion of this learning guide, you will be able to**:

- Select maintenance tools and equipments
- Carry out routine maintenance and adjustments

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If your performance is satisfactory proceed to the next learning guide,
7. If your performance is unsatisfactory, see your trainer for further instructions

Information Sheet 1- selecting maintence tools and equipments

1.1 Maintenace tools

To maintain tools and equipments, selection of the right maintenance tool is the first task to be done before attempting to erect malfunctioning of the equipment. Basic Tools and test equipment to get the job done include:

- Basic hand **tools** (multipurpose screwdriver, commonly used standard wrenches, adjustable wrench, commonly used Allen screw wrenches).
- Various pliers (e.g., needle nose pliers, lineman's pliers, pump pliers).
- Wire strippers.
- Flashlight.
- Storage. High-quality **tool** storage--both stationary and portable--can help keep **tools** organized and boost efficiency. ...
- Battery platform. If the **maintenance** staff is not yet completely cordless with portable power **tools**, it's time to make that switch. ...
- Power **tools**. ...
- Hand **tools**. ...
- Flashlights. ..
- **Electric tools**..
- Repair kits.

1.2. Handling maintenance tools and equipment

The handling of maintenance tools and equipment should be in such a way that it will be well organized easly accessible. It should be complete to excute the task without postponding proplem solving activitied due to deffieciency of it. In practice, it should be generally handlable within a kit for simplicity of handling.

Self-Check –1	**Written test**

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

4. Mention at least 5 equipment maintenance tools?(5pts)
5. What is maintenance tool kit?(2pts)
6. What will be the problem when maintenance tools are put at differet positions without organization ?(1pts)

Note: **Satisfactory rating - 8points** **Unsatisfactory – below 8points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 2- carryout routine maintenance

2.1 Definitions

Maintenance: is a process of extending the lifetime of equipment or at least mean time to the next failure whose repair may be costly

Replacement: Restoration wherein a device is removed and one in better condition is put in its place; if the device is failed, it is replaced by a working one

Predictive Maintenance: A maintenance carried out when it is deemed necessary, based on periodic inspections, diagnostic tests or other means of condition monitoring.

Overhaul: Maintenance or repair requiring major effort and resulting in a significant improvement of the device's condition

Repair: Restoration where in a failed device is returned

Routine maintenance refers to any maintenance task that is done on a planned and ongoing basis to identify and prevent problems before they result in equipment failure. Some common routine maintenance includes regular inspections or service work. These can be carried out on a time-based schedule or on a usage-based schedule. Routine maintenance tasks are usually fairly straightforward. They typically do not require specialized maintenance training, skills, or equipment to complete. Because of that, routine maintenance can be carried out by staff outside of the maintenance depart ment, such as machine operators.

Typical examples of routine maintenance include:

- Lubricating, cleaning, or adjusting machinery
- Inspecting equipment to ensure proper operation and safety
- Replacing parts that show deterioration
- Checking, testing, and maintaining safety equipment, such as safety barriers, fire extinguishers, or alarm systems
- Checking for and replacing damaged signage or utilities, like light bulbs
- General workplace maintenance, such as cleaning floors, replacing HVAC filters, and washing windows, trash removal, and landscaping

2.2 Types of machine or equipment maintenances

Maintenance strategies can be divided into three main types: (1) run-to-failure, (2) scheduled, and (3) condition-based maintenance. Each of these different strategies has distinct advantages and disadvantages, which will be described below.

(1) **run-to-failure(Breakdown)**

Run-to-failure, or breakdown maintenance, is a strategy where maintenance, in the form of repair work or replacement, is only performed when machinery has failed. In general, run-to-failure maintenance is appropriate when the following situations exist:

- The equipment is redundant.
- Low cost spares are available.
- The process is interruptible or there is stockpiled product.
- All known failure modes are safe.
- There is a known long mean time to failure (MTTF) or a long mean time between failure (MTBF).
- There is a low cost associated with secondary damage.
- Quick repair or replacement is possible.

An example of the application of run-to-failure maintenance can be found when one considers the
standard household light bulb. This device satisfies all the requirements above and therefore the most cost-effective maintenance strategy is to replace burnt out light bulbs as needed.

(2) **Scheduled (Preventative) Maintenance**

This is the practice of identifying production equipment needing maintenance attention before its performance gets to the point that product quality is reduced or an unplanned shutdown occurs

When specific maintenance tasks are performed at set time intervals (or duty cycles) in order to maintain a significant margin between machine capacity and actual duty, the type of maintenance is called scheduled or preventative maintenance. Scheduled maintenance is most effective under the following circumstances:

- Data describing the statistical failure rate for the machinery is available.
- The failure distribution is narrow, meaning that the MTBF is accurately predictable.
- Maintenance restores close to full integrity of the machine.
- A single, known failure mode dominates.
- There is low cost associated with regular overhaul/replacement of the equipment.
- Unexpected interruptions to production are expensive and scheduled interruptions are not so bad.
- Low cost spares are available.
- Costly secondary damage from failure is likely to occur.

An example of scheduled maintenance practices can be found under the hood of your car. Oil and oil filter canges on a regular basis are part of the scheduled maintenance program that most car owners practice. A relatively small investment in time and money on a regular basis acts to reduce (but not eliminate) the likelihood of a major failure taking place. Again, this example shows how when all, or most, of the criteria listed above are satisfied, overall maintenance costs are minimized.

(3) **Condition-based (Predictive, Proactive, Reliability Centered, On-Condition) maintenance.**

Condition-based maintenance (which is also known by many other names) requires that some means of assessing the actual condition of the machinery is used in order to optimally schedule maintenance, in order to achieve maximum production, and still avoid unexpected catastrophic failures. Condition based maintenance should be employed when the following conditions apply:

- Expensive or critical machinery is under consideration.
- There is a long lead-time for replacement parts (no spares are readily available).
- The process is uninterruptible (both scheduled and unexpected interruptions are excessively costly).
- Equipment overhaul is expensive and requires highly trained people.
- Reduced numbers of highly skilled maintenance people are available.

- The costs of the monitoring program are acceptable.
- Failures may be dangerous.
- The equipment is remote or mobile.
- Failures are not indicated by degeneration of normal operating response.
- Secondary damage may be costly.

An example of condition-based maintenance practices can again be found when considering your car, but this time we consider the tires. Regular inspections of the tires (air pressure checks, looking for cracks and scratches, measuring the remaining tread, listening for slippage during cornering) can all be used to make an assessment of the remaining life of the tires and also the risk of catastrophic failure. In order to minimize costs and risk, the tires are replaced before they are worn out completely, but not before they have given up the majority of their useful life. A measure of the actual condition of equipment is used to utilize maintenance resources optimally.

General Overview of Maintenance Approaches

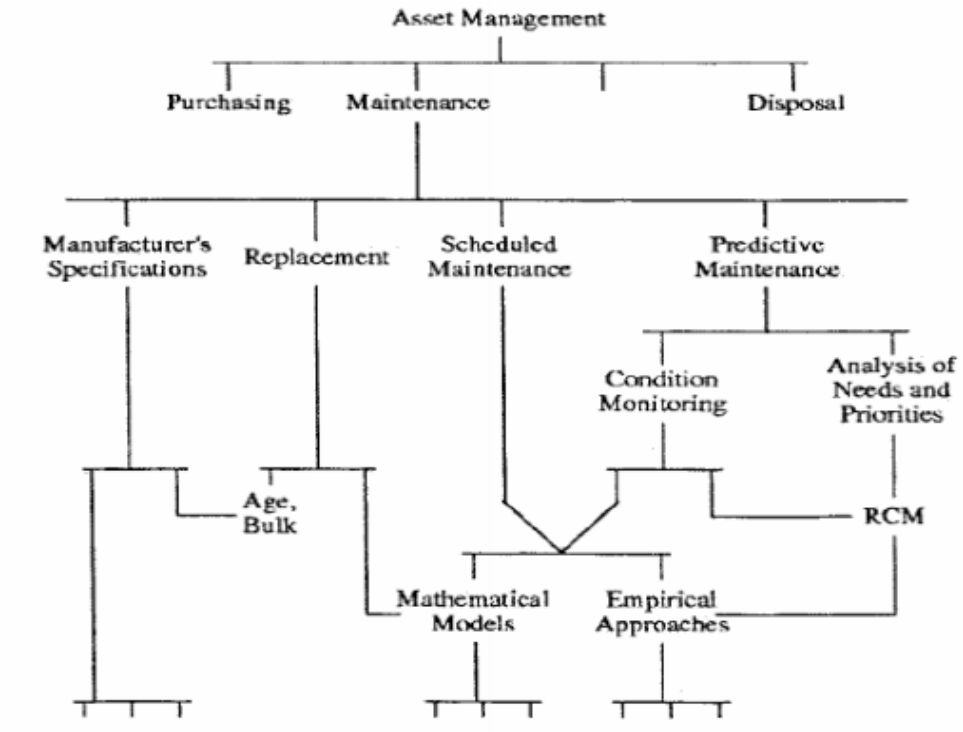

Fig. 1. Overview of maintenance approaches.

Self-Check – 2	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

1. What is maintenance?(1pt)
2. List down different types of machine maintenances and describe each.(2pts)
3. What is the difference between maintenance and repair ?(2)
4. What is preventive maintenance?(1pt)

Note: **Satisfactory rating –6 points** **Unsatisfactory - below 6 points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Information Sheet 3- Cleaning and lubricating

a. Cleaning

Cleaning is one of the fundamental parts of routine maintenance that shorl be performed continuously after completion of the job. This can also be performed following the cleaning schedule of the production workshop. Everybody which is working with the machine and the trained individuals that can be assigned for this are responsible for keeping the hygiene of the shop as well as machines, equipments and concerned tools

The consumable for the cleaning task may basically include:

- Cotton cloth
- Washing detergents
- Water
- Brush

b. Lubrication of machines and equipments

The parts of machines where two parts scrub together and the ones that are apt to the environmental reaction like oxidation that may cause rust should be lubricated by lubricants to solve the problems of failure. The lubricant commonly used is the machine grease and other lubricating oils can also be appled.

c. Importance of lubrication

Lubrication has basically the following advantages:

- Reduces the friction between the mating moving parts and thus reduces heat generated on the parts that can cuase failure of the parts
- It protects the reactive metallic parts from the atmospheric air and thus reduces oxidation.
- It reduces power consumption of the operation as it enhances ease of free movement of the mating parts
- etc

Self-Check – 3	Written test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Test I: Short Answer Questions

- what are the advantages lubricating the machinery?(3pt)
- what is the commonly used lubricant that should be applied on the friction areas of the machine.(2pts)
- List the material inputs/consumables that are used to clean the machinery and equipment ?(2)

Note: **Satisfactory rating –7 points** **Unsatisfactory - below 7 points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Reference Materials

- Lapidary machinery manufacturer manual (Lapidary Equipment and Supply Catalogue)
- Basic machine operation and maintenance manual www.portmoodyrockclub.com (Workshop Rules & Guidelines)
- maintaining Health and Safety at Workplace: Employee - ERIC https://files.eric.ed.gov › fulltext
- Gemstone technical training manual - Levin Sources http://www.levinsources.com › assets › pages ›
- GEMSTONE TECHNICAL TRAINING MANUAL - Levin Sources http://www.levinsources.com › assets › pages › W...
- Managing Maintenance Resources-A.Kelly, Butterworth-Heinemann.
- Handbook of Maintenance Management-Levitt Joe
- https://www.globalsecurity.org/military/library/policy/navy/nrtc/14310_ch1.pdf

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