

Technical Reference Manual

Nordberg® MP® Series Cone Crusher



FOREWORD

This Technical Reference Manual provides guidance to first time operators of the Crusher as well as providing technical procedures as a reference for the experienced crusher operator. Read — study — and keep for future reference.

Illustrations and instructions guide the operator through correct procedures for checking, installing, operating and maintaining the Crusher and accessories. Separate instruction manual supplements for the lubrication system, hydraulics and crusher drive are now included in the MP Cone Crusher Technical Reference Manual.

Operating techniques outlined in the book are basic. Operating skills and additional techniques will develop as the operator gains knowledge of the Crusher and its capabilities.

Continuing improvement and advancement of product design may result in changes to your new machine which may not be included in this publication, however each publication is reviewed and revised, as required, to up-date and include appropriate changes in the later editions.

The description and specifications in this manual were in effect at the time this manual was approved for printing. Metso Minerals reserves the right to discontinue models at any time and to change specifications or design, without notice and without incurring obligation.

Whenever a question arises regarding your Crusher, or this publication, please consult your Metso Minerals representative for the latest available information.

This manual is to be used as a general guide concerning technical information. All technical information required for correct installation of your crusher must be obtained from the installation drawings and technical data furnished for your particular Crusher.

SAFETY

Basic rules regarding safety in and around a crushing plant are outlined in *Section 0*, entitled *Safety* of the main cone crusher instruction manual.

Operator safety and the safety of others depends upon reasonable care and judgement in the operation of this Crusher. A careful operator is good insurance against an accident.

Most accidents, no matter where they occur, are caused by failure to observe and follow simple fundamental rules or precautions. For this reason most accidents can be prevented by recognizing hazards and taking steps to avoid them before an accident occurs.

Regardless of the care used in the design and construction of this type of equipment, there are conditions that cannot be completely safeguarded against without interfering with reasonable accessibility and efficient operation. Warnings are included in this instructional manual to highlight these conditions.

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Section 0

Safety

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0.1 INTRODUCTION

0.1.1 General

This manual, together with specific instruction manuals for individual equipment, has been prepared by Metso Minerals to increase the knowledge and awareness of all persons involved in the operation, supervision, service and maintenance of crushing and screening equipment with regard to safety and operations. A copy of this manual must be provided to and studied by each person entering the machine areas of the Crushing Plant, or otherwise involved in the operation of the Crushing Plant. It is the responsibility of the Owner to always keep this manual and other written instructions either in the Crushing Plant or its vicinity for Operator reference.

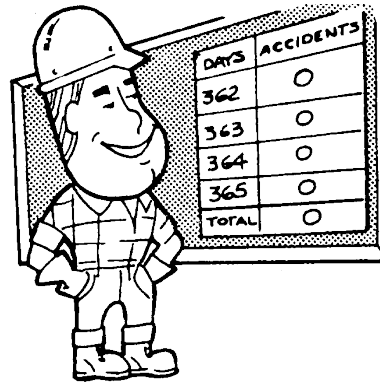
Knowledge of the machines and the potential hazards they present are essential to a safe workplace. Knowledge of and compliance with all state, provincial, and federal safety laws, safety regulations, and Crushing Plant safety procedures, warnings and instructions also are essential to a safe workplace. Failure to do so can result in serious injury or death.

When in doubt — don't! Never bypass instructions or procedures to save time. Never place foreign items, tools, rods, or any part of your body into an operating machine. Never reach over, around or beyond safety devices. Never operate a machine if safety devices are missing or disabled. Never replace an OEM safety device with a non-OEM device.

Never service equipment until all potentially moving parts are secured and power has been locked out and tagged out to prevent unexpected movement.

The Operator is responsible for using care and common sense at all times.

Remember, safety is everyone's business. You are responsible not only for your safety, but for the safety of those around you.



Read this manual carefully. Know its contents. If you have any questions, contact your Metso Minerals representative without delay for advice. Keep in mind that there are different types of risks, hazards and injury types (see *Section 0.2.3 Typical Risks in Crushing Plant Working Environment*), which are related to each other. Foresee and prevent such risks and hazards as well as resulting injuries and other consequences from occurring by all available means. Never compromise when the question is safety!

Metso Minerals, as the machinery manufacturer and supplier, regards safety as of utmost importance, and deems the following as essential prerequisites to the safe operation of the Crushing Plant:

- That the Owner makes available this manual, before using the machinery, to each person involved with the operation, supervision, service, or maintenance of the Crushing Plant.
- That compliance with and adherence to this manual be mandated and supervised by the Owner.
- That all personnel involved in the operation, supervision, service, or maintenance of the Crushing Plant become familiar with the contents of this manual prior to such involvement.
- That every person involved in the operation, supervision, service, or maintenance of the Crushing Plant be properly trained and have adequate professional skills as required for the performance of the respective tasks.

- That all visitors to the Crushing Plant be properly informed of applicable safety precautions and risks, and that safety precautions be adequately maintained and in connection with any such visits, including, but not limited to, adherence to this manual.

No changes shall be made in the operation of the machinery supplied by Metso Minerals or the contents of this manual without express written approval of Metso Minerals. All operation, service, maintenance, handling, modifications, or other use of Crushing Plant equipment and/or systems is the responsibility of the Owner. Metso Minerals shall not be liable for any injury, death, damage or cost caused by any act or omission on the part of the Owner, Operator or other personnel, agents, contractors, vendors, or others. All applicable safety rules, regulations, standards, instructions, and procedures must be followed; as must be those of this manual as well as any other instructions, specifications, and recommendations by Metso Minerals.

This manual is based upon the safety laws, rules and regulations in effect on the date hereof. The owner and operator bear sole responsibility for complying with any amendments, additions or other changes to safety law, rules or regulations arising subsequent to the date on which this manual was drafted.

Although these instructions are intended to be as comprehensive as possible, there may be hazards that cannot be anticipated, hazards associated with a particular work-site or hazards covered by special company safety programs. The information contained in this manual is not intended to replace safety codes, insurance requirements, federal, state and local laws, rules and regulations.



If you have questions or concerns regarding safety aspects of machinery supplied by Metso Minerals, contact us before using, operating, servicing or repairing the machinery.

NOTICE

Safe operation of the machine requires alertness and safety-consciousness on the part of all operating personnel. It should be operated only by knowledgeable and trained personnel.

0.1.2 Definitions:

“Crushing Plant” means a combination or part of various equipment, components, systems and parts for crushing and/or screening of rock, minerals, recycling or other crushable materials. For the purposes of this manual, the Crushing Plant also means stand-alone crushing or screening equipment as applicable. Throughout this manual, words such as “machine”, “machinery”, “equipment” and “crusher” are used interchangeably to refer to the Crushing Plant and its component parts.

“Owner” means the entities or individuals who own or lease the Crushing Plant and/or the entities or individuals who are in charge of operating and/or servicing the Crushing Plant.

“Operator” means the individuals who either operate the Crushing Plant or perform actual maintenance, service, repairs, supervision or any other activity on or for it.

“This manual” means, as applicable, these general safety instructions, together with any specific instructions for individual equipment, as amended from time to time, provided by or on behalf of Metso Minerals.

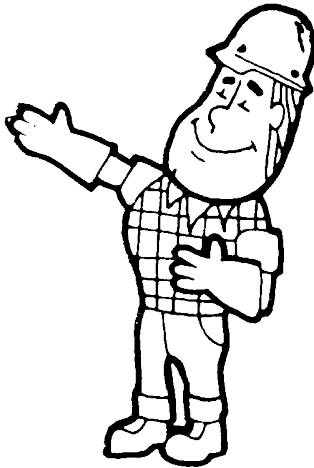
0.2 GENERAL SAFETY INSTRUCTIONS FOR A CRUSHING PLANT OR PLANT ENVIRONMENT

0.2.1 Safe Products and the Crushing Plant

All machines require human involvement. Like any other heavy machinery, a Crushing Plant has inherent dangers that must be identified, understood and taken into account in order to avoid accidents and injuries. Metso Minerals, as machinery manufacturer and supplier, is committed to promoting safety at the Crushing Plant by providing safety devices and features, and by providing training, services, manuals and instructions.

0.2.2 Safety and You

Safety is everyone's responsibility; safety is your responsibility.



Safety is the concern of all personnel. With your actions, you participate in establishing the safety of the working environment.

Metso Minerals products are designed and constructed with safety in mind. The machines incorporate high quality safety features.

To assure safe operation, all personnel must be alert when operating or working on or around the machine. Be aware of real and potential hazards. Only properly trained personnel should operate, supervise, maintain, or service the machine.

Personnel must carefully study all aspects of the specific machine, including:

- operating instructions
- service, trouble-shooting and maintenance instructions
- automated features and motions of the machine
- specific safety features and instructions

NOTICE

- *If unsure of any procedure, check the operation manuals and/or contact your supervisor before proceeding.*
- *Follow all lockout and safety procedures before entering the machine.*
- *Be constantly aware of the location of each worker on or around the machine.*
- *Observe all safety instructions.*
- *Do not remove or disable any guard, safety device, sign or warning.*
- *Report any item that needs attention, repair, replacement, or adjustment.*

0.2.2.1 Objective

The objective of these instructions is to minimize risks and to avoid or prevent accidents and injuries. Accidents are often caused by carelessness or disregard of important instructions.

Knowledge of the machine operation and continuous safety training are necessary for a safe working environment.

Safety can be summarized in three main themes:

- MACHINE KNOWLEDGE
- SAFE OPERATION AND MAINTENANCE
- GOOD HOUSEKEEPING

0.2.2.2 Safety Signs, Labels And Symbols

The following symbol is used in this manual and on the machine to call attention to instructions which will help prevent machine related injuries.

When you see this symbol on your machine or in this manual, be alert to the potential for personal injury.



Figure 0-1 Alert Symbol

This manual uses the alert symbol, with words such as DANGER, WARNING or CAUTION, to alert you and other Crushing Plant personnel of actions or conditions that pose a potential safety hazard, with an attending risk of personal injury (including death) or property damage. The machine also displays safety signs, labels and tags at appropriate points to show safety risks that may exist.



Sign	Description
DANGER	Immediate hazards or unsafe practices that will result in severe personal injury or death.
WARNING	Hazards or unsafe practices that could result in severe personal injury or death.
CAUTION	Hazards or unsafe practices that could result in minor personal injury or equipment damage.

Figure 0-2 Danger, Warning, Caution Signs and their Meaning

This manual uses another convention to communicate information which, if not followed, will affect the performance of the equipment or cause damage to the equipment. This is indicated by the word NOTICE!

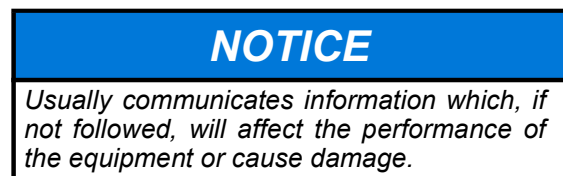


Figure 0-3 Important notice and its meaning

While such conditions and practices do not pose an immediate threat of personal injury, the damage that occurs over time can be hazardous.

0.2.2.3 Some General Safety Instructions

1. Do not remove, cover or disable any installed safety devices, guards, warning signs or tags. They are attached to equipment to warn personnel of possible danger and prevent injury. Use OEM replacements in the event any safety devices, warning signs or tags become damaged or unreadable. Observe all instructions. Keep warnings signs and tags clean, visible and readable. (Warning signs are listed and their locations described in the machine safety instructions.)
2. Make sure that all required walkways, handrails, barriers, safety devices, and guards are in place before starting the machine. Do not use non-OEM walkways, handrails, barriers, safety devices or guards, when such items are available from OEM.
3. Keep the machine itself and the area around the machine clean and clear of obstructions. Be aware of dust, smoke or fog, which may obscure your vision.
4. Wipe up any substance, such as spilled oil, grease, water or ice, which may cause a person to slip or fall. Good housekeeping practices prevent injuries. Be a good housekeeper. Keep the machine environment and walkways clean and free from oil, grease, rags, cables, chains, buckets, rocks and other obstructions. Keep loose parts in a toolbox or return them there promptly.
5. Keep clothing and all parts of the body away from nip points and rotating or moving equipment. Be especially alert to avoid contact with parts that move intermittently.
6. Know the weight limitations of lifting devices and their loads. Never detach a lifting device from a load until the load is stable and secured from unintended movement.
7. Do not climb or stand on equipment other than in areas, which are designed for that purpose. Do not overreach.
8. Emergency-Stop buttons should be tested on a regular schedule for proper operation, as should electrical interlocks and related limit switches. Safety defects should be repaired prior to continuing operation, and thereafter tested and certified for appropriate operation by skilled personnel.
9. Personal protective equipment and safety uniforms, safety shoes, helmets, safety glasses, heavy gloves, ear protection devices etc. should be used at all times. Safety shoes should be used by all personnel entering into the Crushing Plant. Persons with loose clothing, neck ties, necklaces, unprotected long beard or long hair should not go near the machine. Wrist watches and rings can be dangerous. Rings should be removed or covered with tape. Keep your pockets free of loose objects.
10. Keep all non-operating and non-trained personnel clear of the Crushing Plant at all times. Injury or death may result if this is not done.
11. The equipment at the control panel should be handled with care. Do not place objects on the keyboard, color display or other equipment. All equipment can fail if put in contact with liquids, or excessive heat or excessive humidity. Allow good air flow around the equipment at all times. Keep magnets away from computer components, particularly hard drives and PLC cabinets.
12. A knowledgeable and properly trained Operator familiar with this manual, safety requirements, and automatic operation of the machine should be stationed at the controls whenever the machine is operating.
13. Do not consume any alcoholic beverages or other intoxicants before coming to work or while on the job. Do not operate the Crushing Plant after taking any medicines, tranquilizers or other drugs, which can impair the senses.
14. Familiarize yourself with the safety signs on the Crushing Plant. Never remove or damage any safety signs, nameplates or other safety related warnings, symbols or components. Replace them as necessary with OEM equipment.
15. Do not paint over safety signs, name plates or warnings.

⚠ WARNING

Only qualified and properly trained operators and servicemen should operate or service the machine. Everyone else should stay clear of the machine when it is operating, or under service or maintenance!

0.2.2.4 Safety Instructions after Start-up

1. After equipment has been started, check all gauges and instruments to be sure that everything is operating properly.
2. Shut down immediately if any improper readings are observed.
3. Test all controls for proper functioning.
4. Listen for and report any unusual noises.
5. Recheck alarms or other warning and safety devices.
6. Do not take a chance with a defective machine. **Report it to your supervisor.**

0.2.2.5 Report a Defective Machine

Inspect your machine daily. Check for loose, worn or damaged parts. Report or correct any unsafe conditions immediately, and do not operate the machine until they have been corrected.

Even a minor defect can become serious. Report any machine defects to your supervisor.

0.2.2.6 Stopping Safely

Be sure equipment is stopped before:

- cleaning
- servicing
- lubricating
- checking belt tension
- removing housing covers
- working on the hydraulic system
- making repairs
- or attempting to clear a plugged cavity.

NOTICE

Make no checks, adjustments or repairs of any kind while the equipment is in operation.

0.2.2.7 Blasting



The use of the Crusher Plant's radio control device is strictly forbidden during blasting operations, as it may cause a premature explosion. Move the mobile Crushing Plant far enough away from dangerous area when blasting. Do not store or transport explosives on mobile crushing plant or screening plants.

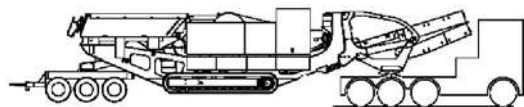
0.2.2.8 Portable Plants

If the Crushing Plant includes of portable equipment (i.e. crushing and screening equipment mounted on trailers), trailer footing or cribbing is extremely important for safe operation. Your machine must be on as solid and level footing as possible. If the ground is not naturally level, it must be leveled so that the unit will operate safely and effectively. The ground must support the weight of entire unit and keep it from sinking or shifting. Use heavy timber mats as needed. Trailers must be raised so that trailer wheels do not touch the ground.

Place jacks at designated jacking locations. Consult the portable plant instruction manual if these are not marked on the chassis. Typically the four corners are supported along with points in between where crusher, screen or feeder forces are concentrated. Jacks must be used in pairs directly opposed to each other. After correct height and level are achieved, adjust each jack until vibrations are reduced to a minimum. Insert locking pins if so equipped. If holes for locking pins do not align, loosen the jack and place metal shims under the jack until the holes align.

Periodically recheck the trailer footing for stability.

0.2.2.9 Mobile Equipment Transportation



Use only appropriate transportation and lifting equipment with adequate capacity. Provide a supervisor to direct lifting operations. Follow all disassembly and assembly instructions carefully. Disconnect all external power supplies before moving any part of the equipment. Transport or hoist components and handle any parts in accordance with the instructions and advice provided. Fasten the lifting equipment only to the points meant for lifting. Use only proper means of transport with adequate transporting capacity. Fasten the load carefully. For lifting use only the fastenings shown in instructions. Secure all component parts of the equipment immediately after loading to avoid any accidental shifting. Attach required warning signs to the load.

When moving your trailer, check bridges before crossing. Make sure they will support the weight of the machine. Check clearances under bridges, for overhead lines or any overhead obstruction. Never travel with near capacity loads. Check local laws, especially on weight limitations. When travelling on the highway make sure all headlights, clearance lights and tail lights are on, as applicable. Use proper traffic warning flags and signs.

Remove all shipping brackets before re-starting the Crushing Plant. Carefully assemble all of the parts previously disassembled. Perform any start up in accordance with the instruction manual.

After the system is running, check all gauges and instruments to see that they are working correctly. Check that all controls function normally and properly. Listen for unusual noises. Shut system down immediately if any component of the system does not operate normally.

0.2.3 Typical Risks in Crushing Plant Working Environment



Even though every Metso Minerals machine is designed with many safety features, it is impossible to design out all safety risks. There are potential hazards, that must be recognized and avoided. Noise levels may interfere with normal discussion when the machine is operating. By their nature, Crushing Plant and auxiliary equipment can create dust. Crushing itself and some other machine processes may momentarily obstruct the view of some machine parts. In general, high levels of respirable silica and other dust in the air may expose Operator to health risks for lung disease depending upon the length and amount of exposure and type of material being crushed. In addition, there are some risks or hazards which cannot be completely guarded or avoided because of interference with machine operations. Accordingly, working on the Crushing Plant requires constant alertness by all personnel in the area. Accidents happen unexpectedly. Below are some typical hazards and types of accidents of which everyone working at, on or around the Crushing Plant should be aware.

Typical Hazards

- nips, gaps, and pinch points
- poor housekeeping
- elevated or narrow working areas
- lifting and shifting heavy loads
- cranes and mobile cranes
- sharp edges
- high-pressure hydraulic equipment
- electrical equipment and power lines

- automatic functions and unexpected start-ups
- toxic and corroding agents
- machine inertia
- hot surfaces and fires
- zinc
- conveyor belts
- dust
- noise and vibration
- improper work methods
- rotating equipment and moving components
- ejection of material from the crusher
- falling material from conveyors, and from loading, unloading and feeding operations
- crushing cavity

These typical hazards are discussed more fully in *Section 0.2.3.1* of this chapter. Be aware of these hazards. All personnel working on or around the machine should be properly trained in avoiding these hazards.

Typical Injury Types

- crushing
- slipping, tripping and bumping
- falling
- cutting
- entanglement
- burns and electrical shocks
- respiratory organ illnesses
- asphyxiation

0.2.3.1 Typical Hazards

Nips, Gaps, and Pinch Points

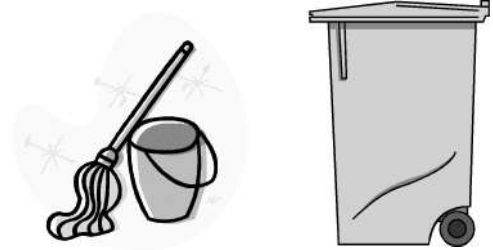


An ingoing nip is formed by drive devices such as belt and pulley, chain and sprocket or gears. Similarly, a pinch point may be formed by rotating or moving equipment.

DANGER

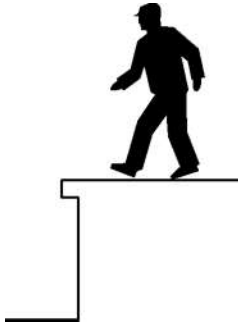
Nips and gaps are serious hazards in a Crushing Plant. They are usually guarded by nip guards, railings, or location. In all cases, extreme care must be taken to avoid nips, gaps, and pinch points or serious injury or even death may occur.

Poor Housekeeping



Promote good housekeeping. Keep machine environment, walkways, platforms etc. clean and dry and free of debris. Oily or wet machine environment, walkways, platforms, steps and hand rails are slippery. In cold weather, watch out for ice and snow. Wet spots, especially near electrical equipment, are dangerous. Return tools to their proper place after use. Even then extreme caution should be used. Follow established Crushing Plant safety procedures. Clean slippery deposits from walkways, ladders and floors. Tidiness provides a safer working environment by preventing or reducing tripping, slipping, fire hazards and electrical shocks.

Elevated or Narrow Working Location



Crushing Plants are tall structures. The walkways and platforms, designed to be used during machine operation, are furnished with railings to help prevent falling.

When working on an elevated surface be aware of machine movements and other activities in the area. Do not run on the walkways. Do not reach over or beyond walkway railings while the machine is running. Do not stand on railings or toe plates.

There may be narrow access routes for maintenance purposes. Do not use these routes while the machine is operating.

Do not enter any close quarters within the Crushing Plant when the machine is operating.

Lifting and Shifting Heavy Loads



• Cranes

Crushing Plants, like any other type of mechanical equipment, require regular periodic maintenance. One of the most flagrant Crushing Plant safety violations is the use of inadequate and unsafe lifting equipment. Although a Crushing Plant is a finely tuned piece of equipment, the internal parts of a Crushing Plant should be assembled and disassembled with crane facilities that have the capability of gently and slowly lifting and lowering the various parts that make up a Crushing Plant.

Do not use chain hoists (chain blocks) to assemble or disassemble a Crushing Plant. These lifting devices lack the stability and robustness required in lifting and positioning heavy components.

Do not use impact hammer boom or any other equipment which are not designed for lifting, for assembly or disassembly purposes.

Affix the load securely to its destination. Never detach a lifting device from a load until the load is stable and secured from unintended movement.

When it comes to safety, don't compromise!

NOTICE

When using a crane, always operate within the rated capacity of the crane. The safe rated capacity includes weight of hook, block and any materials handling devices such as cables, slings, spreader bars, etc. Subtract the weight of all these items from the rated capacity to find the true maximum weight load that can be handled safely. Always follow the crane manufacturer's operational and safety instructions.

NOTICE

The weight indicated on machine plates tells the weight of standard configuration. In many cases the actual weight may differ greatly from that indicated on a machine plate due to, casting variations, options, or ancillary equipment. Always verify the weight of the object you are lifting before attempting to lift it.

• Mobile cranes

Safe ratings are based on operating the crane on firm, level ground. Outriggers must be properly extended and/or lowered whenever required. Avoid fast swings, hoists or sudden braking. These can cause overloads. Do not handle large, heavy loads in strong winds. When moving your crane, check bridges before crossing, make sure they will support the total weight in question. Check clearances under bridges for overhead electrical lines and any overhead obstruction. Be sure your hitcher is clear before starting lift. Make sure the load is securely attached.

NOTICE

When using a mobile crane, always operate within the rated capacity of the machine to avoid buckling the boom or tipping.

Take the following precautions when lifting heavy loads:

- Follow all established Crushing Plant procedures.
- Follow all instructions and safety procedures recommended by the crane manufacturer.
- Plan the lifting and maintenance procedures in advance. Read and understand specific instructions for proper use of lifting equipment prior to using (e.g., instructions of the machine, lifting device and local regulations).
- Clean the working environment beforehand to prevent slipping and tripping hazards.
- Make sure that the crane and other lifting devices such as chains and slings have sufficient capacity and are in good working order.
- Do not attempt to ride or sit on moving loads.
- Be sure that crane operators, riggers and other personnel are properly trained.
- Rig the load firmly to prevent any unintended movement and assure stable and accurate positioning.
- Make sure nobody is below or in the path of the load and transfer routes are clear and proper protective clothing and gear are used.

Sharp Edges



Sharp edges may occur on any metal structures. Equipment damage may uncover or produce unexpected sharp edges. Sharp edges may inflict deep and serious cuts. Wear protective gloves when handling materials, parts, etc. with sharp edges. Repair or guard detected sharp edges immediately.

High-Pressure Equipment — Hydraulic or Air



⚠ WARNING

Hydraulic oil under pressure can penetrate body tissue causing serious injury and possible death. When troubleshooting a hydraulic system for leaks, always use a mirror, cardboard, wood or other appropriate techniques as a detector. DO NOT USE YOUR BARE HANDS. If you are injected with hydraulic oil or any other fluid, immediately seek treatment from a doctor trained in the treatment of penetrating fluid injuries.

High pressure oil can be dangerous. Relieve all pressure before opening or removing any hydraulic or air pressure lines, valves, fittings, etc. Use a mirror, cardboard or other appropriate techniques to look for leaks. Do not touch pressurized components since the pressure from a pin hole leak is so strong that it can easily penetrate the skin or eyes. Always exercise caution when handling hydraulic devices.

Regularly check the condition of hoses, pipes, valves and various connections. Replace them as necessary.

Before starting any maintenance work, stop all hydraulic pumps, lock out pump motors, and depressurize the system, bringing all components to a zero energy state. Remember to also depressurize the accumulators through the bleed valve for each accumulator. Do not disconnect any hoses until the actuator has been brought to a zero energy state and properly secured.

Bleed the hydraulic system regularly to remove entrapped air that may interfere with normal expected machine operation or cause a hazard during maintenance.

WARNING

Poorly tightened or damaged hydraulic components may create dangerous jets of fluid. Before restarting the machine, be sure that the hydraulic system is ready for operation, and personnel are clear of affected areas.

WARNING

Machine parts may move unintentionally and cause a risk of injury. Before restarting the machine, make sure that all personnel are clear of affected areas where machine movement may occur.

Electrical Equipment



Be especially cautious when working with or near electrical equipment. An electric shock can be fatal. Crushing Plant electrical outlets must be grounded and have ground fault interruption protection. Tools plugged into the outlets must be double insulated. Never expose electrical equipment to mechanical damage or humidity. Protect all electrical equipment from direct contact with water or high humidity.

Protect electrical devices that move as part of the machine from dirt and mechanical damage. Regularly check the operability of these devices.

DANGER

There is a risk of an electric shock, if sufficient precautions are not taken. An electric shock can be fatal.

For maintenance work, disconnect all devices from electric and hydraulic power sources and follow Crushing Plant lockout procedures.

The lockout program, locks, tags and the blocking/restraining devices provided are designed for your protection. Your responsibility is to follow the program and use the proper equipment.

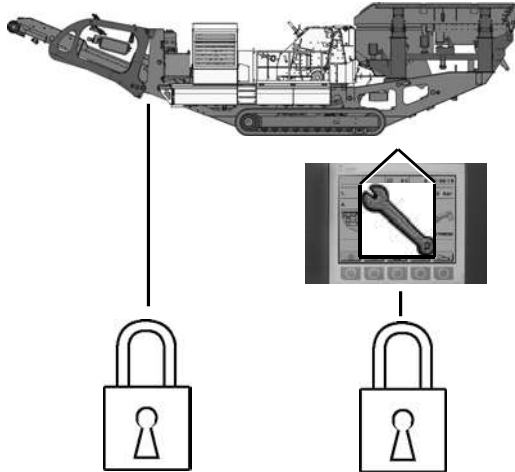
Remember:

- Follow procedures.
- Stay alert.
- Do not take anything for granted.
- Verify lockout.
- Each person working on the unit must have his own lock with only 1 key.
- Tag must identify the work being done and the person(s) who locked and tagged the control.
- Locks and tags are changed with each shift that comes on.

Work to prevent injury or death. Follow proper procedures at all times!

Maintenance, repair and installation of electrical equipment must be performed only by qualified personnel who are familiar with the machinery and equipment in question.

Automatic Functions and Unexpected Start-Ups



Unexpected start-ups during maintenance:

- Lock out and tag machine controls before performing maintenance or repairs to avoid unexpected start-up. Failure to properly lock out the machine can lead to injury or death. Someone may accidentally start the machine from the control room or an unexpected occurrence may activate a control. For example, a power surge may alter the logic of the control system status causing an unexpected machine movement or sequence.

WARNING

Machine parts may move unintentionally and cause a risk of injury. Absence of safety functions may cause dangerous machine movements.

Do not tamper with limit switches or other safety devices included in the system.

DANGER

If danger zones are not respected during machine operation or maneuvers there is a risk of serious injury or death.

Many devices operate automatically, following certain sequences which have been programmed into the logic system (e.g., programmable logic controller, microcontroller, relay system or similar). The danger zone is any area within the confines of moving machine elements, feed material or beneath any objects being lifted. Do not enter these danger zones unless the machine has been properly safeguarded according to the Crushing Plant lockout procedure and manufacturer's instructions.

Welding Equipment



Weld repairs are to be performed only by qualified personnel. Welders and welder's helpers must wear protective clothing and equipment.

Precautions must be taken when torch cutting and/or welding due to the health hazards posed by many metals. Anyone performing these types of procedures should avoid breathing the fumes. Such procedures should be done outdoors or in a well ventilated area with either a separate clean air supply provided to the mechanic or with local exhaust of fumes. Please refer to EU, OSHA, MSHA, or other applicable standards as appropriate. One of the most frequently used tools around the Crushing Plant is the cutting torch. Crushing Plants which are equipped with hydraulic components and/or conveyor belts and/or v-belts should have these components depressurized and adequately covered with flame-proof material so that sparks, weld spatter, etc., cannot reach these areas. Ruptured high pressure hydraulic lines will quickly vaporize the hydraulic fluid as it reaches

the atmosphere. This vaporized fluid can quickly become a mass of flames, resulting in severe burns for personnel in the immediate area. Adequate precautions should be made to avoid contact with these components. Never perform welding or torch cutting activities in the presence of flammable materials. When cutting or welding on a plant with gasoline or diesel units, cover fuel filler caps with several layers of wet shop cloths.

⚠ WARNING

Risk of injury. Fire may break out. Never perform welding or torch cutting activities in the presence of flammable materials.

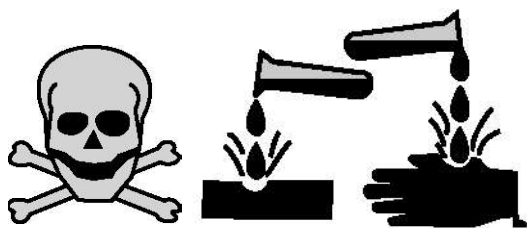
NOTICE

All maintenance personnel who use cutting and/or welding torches should be advised if there are hydraulic components in the immediate area in which they are working.

⚠ CAUTION

Contact Metso Minerals or its authorized representative prior to any welding of major Crushing Plant components such as main frame, adjustment ring, bowl, etc. Performing welding on the Crushing Plant components can be detrimental. Before welding, always verify that material is weldable! Failure to do so may result in weldment failure and present a risk of injury and/or property damage.

Toxic, Corroding and Irritating Agents

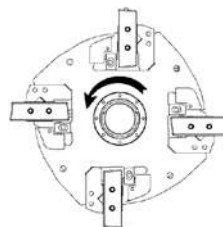


Before handling chemicals, carefully read the safety instructions from the supplier of the respective chemical. Hazardous chemicals may be in use. Wear protective clothing, gloves, boots, glasses, and respirator when necessary.

Refer to the MSDS (Material Safety Data Sheets) and Crushing Plant procedures for handling of these materials.

Avoid prolonged contact with fluids, such as gasoline, diesel fuel, hydraulic oil and cleaning solvents, which may cause skin irritation or other reactions.

Machine Inertia



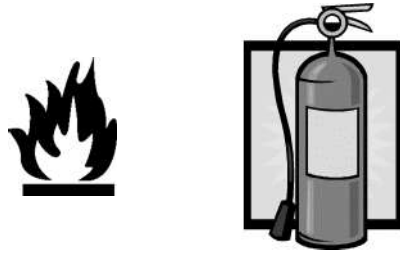
Due to the large inertial forces of the Crushing Plant and Crushing Plant components, the machine can not be stopped abruptly. This is potentially hazardous to personnel. All personnel must stay clear of rotating elements and other moving parts until the machine has come to a complete stop. Regularly inspect the structural elements to maintain safe operation.

Hot Surfaces and Fires



There are hot surfaces on Crushing Plants. Protective gloves and coveralls help protect against burns. Be aware of hydraulic system, hoses, fittings, and pipes. Regularly inspect and observe high temperature lines, and fluid lines for leaks or damage. On mobile equipment be cautious around the engine because of exhaust gases.

When in contact with hot temperatures, or when heated themselves, some hydraulic oils may ignite at around 392°F (200°C). Attention must be paid to the condition of hydraulic hoses and couplings. Remove immediately oil spills from floor, walkways, and pits. Fix all sources of oil leaks and clean up spills.



It is recommend to equip the Crushing Plant with manual fire extinguishing equipment. Legislation and regulations about suitable equipment may vary by country. Familiarize yourself with applicable standards. Personnel must also be trained properly to be able to use fire extinguishing equipment.

A trained person with sufficient fire extinguishing equipment must be present during welding maintenance work. Cold water on hot metal surfaces may cause a violent explosion. Monitoring after welding must be arranged as required by laws and regulations. If no other regulations apply, monitoring time is a minimum of one half hour.

Fire Hazards



- Do not smoke while refueling, or when handling fuel containers.
- Shut off engine when refueling and use extra caution if engine is hot.
- When pouring fuel into the tank, ground the funnel or spout against the filler neck to avoid static electric spark.
- Do not use gasoline or diesel fuel for cleaning parts. Good commercial, nonflammable solvents should be used.
- Do not smoke while using flammable cleaning solvents. Whenever possible, use non-flammable cleaning solvents.
- Do not let greasy, oily rags accumulate in a poorly ventilated area. Store oily rags

and other combustible material in a safe place.

- Never use an open flame to check fuel, battery electrolyte or coolant levels, or to look for hydraulic leaks anywhere on the equipment. Use a flashlight. Know where fire extinguishers are kept, how they operate, and for what type of fire. Check regularly, at least monthly, to be sure they are in the working area.
- Do not weld or cause open flame in the presence of flammable materials.
- In the event of a fire, shut down the Crushing Plant, hydraulic power unit and lubrication system if this can be safely done. Warn other people in the area and commence fire fighting activities according to applicable rules. It is the responsibility of the Owner to maintain proper training and instructions in these respects.



Know the location of first aid kits and know how to use them. Know where to get emergency help.

Epoxy Versus Zinc



Many Crushing Plants require some type of backing when replacing the crushing members. Epoxy resin backing compounds have almost completely eliminated the possibility of workers being accidentally burned due to molten zinc either spilling or exploding when it comes in contact with wet surfaces. When epoxy backings are used, care should also be taken when removing the liners with a cutting torch. Do not use molten zinc as backing material. Use epoxy only according to specific instructions from the manufacturer.

Conveyor Belts



Crushing Plant Dust

⚠ WARNING

Do not use conveyor belts as walkways. Do not climb on them. Always stay clear of any falling or dropping materials or components. Never attempt to stand on, walk on, or step across a conveyor. Never stand below a running conveyor. Do not use loose clothing, neck ties, necklaces or other loose items when near conveyors or other moving or rotating equipment. Emergency pull cords should be used only in case of emergency. Do not use them for routine stoppage of conveyor. Never attempt to service the conveyor while it is energized. Keep in mind hazardous nip points.



By their nature, Crushing Plant and auxiliary equipment such as chutes, transfer stations, screens, etc. can create dust and, if not contained, the dust can escape into the air. In general, high levels of dust (particularly, respirable silica) in the air can create a hazard of lung disease, depending upon the concentrations of dust, the length of exposure, and the type of material being crushed. Dust protective devices and dust warnings may be required by OSHA, MSHA or local laws.

The Owner and Operator of the Crushing Plant must identify the material being crushed and ascertain whether respirable dust from the application poses a health hazard to personnel in the vicinity of the Crushing Plant. If the material presents such a hazard the Owner and Operator must take all necessary measures to ensure that personnel are protected from the dust. Such measures include, but are not limited to providing dust collection system, using water spray bars at the feed and discharge points, crusher transfer points and screens and providing adequate personal respiratory protection devices to workers.

Crushing with a choke level may also reduce the amount of dust issuing from the Crushing Plant itself. Because the configuration of each rock crushing installation is different, Metso Minerals recommends that the Owner and Operator consult Metso Minerals or a dust consultant about possible alternative means of dust reduction.

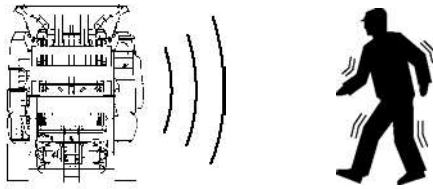
NOTICE

Metso Minerals highly recommends that dust protective devices such as an appropriate respirator be worn by anyone exposed to airborne dust to prevent its inhalation.

⚠ WARNING

Breathing dust may be hazardous to the health of anyone working at, on, or around the Crushing Plant. It can cause serious or fatal respiratory diseases including silicosis! It is the responsibility of the Owner and Operator to determine the necessity and adequacy of protective devices and warnings, to provide them, and to ensure that they are used and followed!

Noise and Vibration



• Crushing Plant Noise

A Crushing Plant by its very nature is noisy and the auxiliary equipment found at, on or around the Crushing Plant such as chutes, transfer stations, screens, etc., can at times be noisier than the Crushing Plant itself. Typical Crushing Plant noise level while crushing ranges from 100 dB to 110 dB measured at 1 m (3 ft) from the Crushing Plant.

Metso Minerals recommends wearing ear protection at, on and around Crushing Plant, particularly when the noise level exceeds 85 dB. It is recommended that the Owner develop a signalling communication system in noisy environments to reduce the risk of accidents. Proper machine maintenance and replacement of worn parts can help reduce noise.

The most commonly applied noise reduction procedures are:

- use of isolation techniques
- equipment enclosures
- operator enclosures
- silencers

Allowable noise levels and exposure limits are regulated by various agencies such as EC, OSHA, MSHA, etc. Refer to applicable safety regulations for permissible noise exposures, and take steps to ensure compliance with those regulations.

• Vibration

Long term exposure of Operator to vibration may result in detrimental health effects. There is an increased risk of falling on a vibrating platform. Avoid standing on a vibrating Operator's platform or walkway.

Unexpected or excessive vibrations may be a sign of wear and/or maintenance needs. Excessive vibrations associated with a portable crushing or screening plant is frequently caused by improper cribbing.

It is recommended to regularly monitor vibration levels of machine components including, but not limited to:

- bearings
- shafts
- rollers
- structural members (including conveyor frames, walkways, platforms, hoppers, chutes, etc.)

Improper Work Methods



Improper work methods and motions may cause physical injuries. Use suitable tools, cranes or jacks for moving large and heavy objects. Overreaching and improper support for loads may lead to injuries to the back or other parts of the body. If you are unsure of proper work methods, contact your safety director or other person responsible for ensuring the safety at your work place.

When lifting equipment by hand, protect your back by lifting close to your body and using your legs without twisting. Use hoists whenever possible. Stand clear of hoisted loads and lifting slings.

Rotating Equipment and Moving Components



Rotating and moving components provide pinch points, snagging possibilities and other potential hazards. Keep clear of all moving parts until they come to a complete stop. Do not use any body part, tool or other foreign object to attempt to stop, adjust, clear, or clean any area in proximity to moving equipment such as vibrating feeder, conveyor belts, drives or other rotating parts of the crusher. Engaging in such activities can result in severe personal injury, including death.

Crushers, designed to operate within a specific RPM range for maximum efficiency, are typically checked with a tachometer. Make sure that any access openings have a protective cover in place at all times except when RPM readings are being taken. Never change sheave combinations without first consulting your Metso Minerals representative. Do not use sheaves with damaged rims or spokes.

Ejection of Objects from the Crushing Plant



Ejected objects from the Crushing Plant may cause bodily injury. For example, rock can be thrown several meters (several yards) into the air out of the crushing cavity during operation. Ejected materials may include rock, tramp metal, metal rods and work implements. Do not stand in front of the feed opening or look into the crushing cavity while the crusher is operating. Never attempt to clear jam on feeder, crushing cavity or conveyors when the system is energized.

Falling Material from Conveyors, Loading, Unloading and Feeding Operations



Rocks or other objects may fall from conveyors during loading, unloading and feeding operations. Impact of falling material may cause serious bodily injury. To assure safe operation, all personnel must be alert when operating or working at or around the machine. Wear proper protective clothing (including an approved safety helmet) and protective devices. Keep all non-operating and non-trained personnel clear of the Crushing Plant at all times.

Never walk under any equipment included in loading, feeding, crushing, conveying, discharging or stockpiling material.

0.2.3.2 Typical Injury Types

Crushing



In general, avoid areas where you may be exposed to expected or unexpected machine movements. Crushing injuries typically occur either between two rotating or moving parts, or between a moving component and a stationary object.

Keep all body parts, clothing and tools away from areas where they may get trapped, pinched, or crushed, or otherwise come into contact with moving parts on the Crushing Plant. When moving equipment, be sure the path is clear. Horns and lights, where provided, are for your safety to alert you of moving objects. Pay attention to all such devices.

Slipping, Tripping, and Bumping



Items such as hoses, tools, etc., on walkways and Crushing Plant floors impede movement and create a tripping and slipping hazard. Good housekeeping reduces the risks considerably.

Personnel should wear safety shoes that reduce the risk of slipping and provide protection against falling objects or crushing. Hydraulic oil leaked or spilled on the floor must be cleaned up immediately.

To help avoid injury, be aware of parts positioned close to the floor level or protruding machine components, changes in elevation of platforms, walkways, and narrow access points. It is recommended that safety shoes be worn at all times. Wear an approved safety helmet and other safety equipment as appropriate.

Falling



Use only designated access routes designed for the purpose, for example walkways and platforms. Walkways and platforms are furnished with railings designed to meet applicable standards. However, in some work phases, railings or platforms may have to be temporarily shifted aside. In those cases, special caution signs or temporary barriers must be used when working on the machine. Use personal fall protection gear, temporary barriers, interlocks, or other warning devices where appropriate. Never attempt to operate, service, or repair the Crushing Plant without first ensuring proper protection against falling. Guards that are moved aside must be installed immediately after maintenance work and before the machine is returned to operation. Never climb or stand on areas of the Crushing Plant not specifically designated for that purpose.

WARNING

Do not operate any equipment until all guard rails and safety devices have been re-installed or returned to their proper operating condition. Failure to do this could result in serious injury or death.

KEEP THE AREA CLEAN!

Cutting



Do not reach in or enter:

- the movement paths of cutting equipment
- between moving machine components
- between moving loads and machine structures

Entanglement



To avoid entanglement, avoid wearing loose clothing that could be caught by rotating shafts, conveyors, and other moving parts and materials. Remove neckties, necklaces, rings, and other jewelry before performing work assignments. Also protect a long beard or hair from entanglement.

Do not touch a rotating roller, sheave, pulley, idler or moving conveyor belts with any body part or work implement, as you may become entangled and pulled into a hazardous area.

Never attempt to service, repair, or troubleshoot any moving part of the Crushing Plant while it is energized or otherwise capable of movement.

WARNING

Keep safety gates, shrouds, guards, and other protective devices in place and in good working condition at all times. Test emergency stop, electrical interlocks, and related limit switches frequently.

Burns and Electrical Shocks



Protective gloves and coveralls help protect against burns. Be cautious around and near hydraulic system hoses, fittings and pipes. Regularly inspect and repair leaking or damaged high temperature lines and fluid lines.

To avoid electrical shocks:

- Power must be shut off and locked out before any servicing or maintenance work is done. Unplug or disconnect all auxiliary motors and equipment.
- DO NOT drill blindly into beams, electrical cabinets or other enclosures.

Avoid any contact between moisture or other fluid and electrical equipment.

Impact from Ejected Materials



There are several hazards related to falling, flying or otherwise ejected materials when the Crushing Plant is being operated or serviced. For example, rock can be thrown several meters (several yards) into air out of crushing cavity during operation. Ejected materials may include rock, tramp metal, metal rods and work implements. Keep the safety grate down during the operation. Wear proper protective clothing (including an approved helmet) and protective devices. Always use properly maintained and approved tools and work methods. Stay clear from the path of ejected materials, also during lifting, assembly and disassembly operations.

Removal of tramp iron jammed between the crushing members is extremely dangerous. Follow the instructions in the instruction manual.

Do not stand in front of the feed opening or look into the crushing cavity while the crusher is operating.

0.2.4 Personal Protective Equipment and Clothing

Personal protective equipment and clothing such as foot protection, helmet, hearing protection, dust protective devices, safety glasses or other personal protective clothing and equipment should be worn at all times. All equipment should be maintained in accordance with applicable standards. Respirators, goggles, protective masks, gloves, boots, and other such equipment shall be cleaned and disinfected before being used by another employee. The Owner and Operator are responsible for ensuring that all eye, head, respiratory, and ear protection conforms to applicable standards.

NOTICE

Always use right size of protective equipment.

NOTICE

It is the responsibility of the Owner and Operator to determine the necessity and adequacy of protective devices and warnings, to provide them, and to ensure that they are used and followed.

0.2.4.1 Hearing Protection



Noise level in the machinery area may exceed 85 dB, and exposure to the machinery area in such circumstances without adequate hearing protection may lead to hearing loss. Therefore, users must be provided with appropriate hearing protection of the type and to the extent required by law.

0.2.4.2 Eye and Face Protection



General requirements should include:

- The Owner should ensure that personnel for the machine area use appropriate eye or face protection when exposed to eye or face hazards such as flying material, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors.
- The Owner should ensure that affected personnel use eye protection that includes side protection from flying objects.
- The Owner should ensure that affected personnel who wear prescription lenses while engaged in operations that involve possible eye hazards wear eye protection that incorporates the prescription in its design, or wear eye protection that can be worn over the prescription lenses without disturbing the proper position of the prescription lenses or the protective lenses.

0.2.4.3 Respiratory Protection



Respiratory protection is required when the air contains contamination such as harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors. The primary objective is to protect the health of workers.

Respiratory protection must be provided by the Owner when such equipment is necessary to protect the health of personnel. The Owner shall provide the respiratory protection and training programs, which are applicable and suitable for the purpose intended and comply with the latest requirements

and recommendations of health authorities and regulatory agencies.

⚠ CAUTION

The area should be well ventilated. Epoxy fumes can cause nausea or eye or skin irritation.

NOTICE

The enormous degree of convenience as well as the high safety factor involved when using plastic backing agents has made the use of molten zinc for Crushing Plant liner backing obsolete. See 0.2.3.1.

⚠ WARNING

Breathing dust may be hazardous to the health of anyone working at, on, or around the Crushing Plant.

NOTICE

Metso Minerals highly recommends that adequate dust-protective devices such as a respirator be worn by anyone exposed to airborne dust, particularly silica dust, to prevent its inhalation.

0.2.4.4 Foot Protection



The Owner shall ensure that affected personnel use protective footwear when working in areas where there is a danger of foot injuries due to falling or rolling objects piercing the sole, and where feet are exposed to electrical or chemical hazards.

0.2.4.5 Head Protection



The Owner should ensure that affected personnel wear a protective helmet approved by OSHA, MSHA (or by other applicable authority) when working in areas where there is a potential for head injuries from falling objects or walking throughout areas with low head clearance.

The Owner should ensure that a protective helmet designed to reduce electrical shock hazard is worn by personnel when near exposed electrical conductors which could contact the head.

0.2.4.6 Hand Protection



The Owner should ensure that personnel use properly sized appropriate hand protection when hands are exposed to hazards such as those from skin absorption of harmful substances, cuts or lacerations, abrasions, punctures, chemical burns, thermal and electrical burns, and harmful temperature extremes.

0.2.4.7 Safety Harnesses



The Owner should ensure that any person working on elevated areas not protected by railings, or on hazardous places must wear suitable safety

equipment, including safety harnesses, if there is a risk of falling. Confined spaces may also require safety harnesses.

0.2.4.8 Work Clothing



The Owner should ensure that personnel wear appropriate clothing to help protect against hazardous material and hot surfaces. Loose clothing can get caught in a nip, shaft, or other moving machine components.

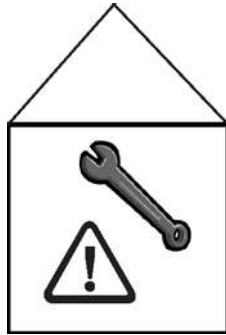
0.2.4.9 Tools




The Owner should ensure that personnel use appropriate tools for the job. Use tools that are specially designed to break away or are easily released to help avoid certain accident situations such as unexpected movement at a nip point or a rotating shaft. Under no circumstances must tools be allowed to come into contact with moving parts while the Crushing Plant is energized.

When working in humid or damp environments, use hydraulic tools or electrical tools that are suitably grounded, double insulated, or have ground fault interruption circuits.

0.2.4.10 Safety Locks and Tags



Follow all lock-out tag procedures. Refer to appropriate standards and instructions provided by Metso Minerals.

 **DANGER**

For maintenance work, disconnect all devices from electric power sources. Bring all hydraulic gravity or spring loaded devices to a zero-energy state. Follow lockout procedures.

The lockout program, locks, tags and the blocking/restraining devices provided are designed for Operator protection. It is the Operator's responsibility to follow the program and use the proper equipment.

Remember:

- Follow procedures.
- Stay alert.
- Do not take anything for granted.
- Verify lockout.
- Tag must identify the work being done and the person(s) who locked and tagged the control.
- Locks and tags are changed with each shift that comes on.

Work to eliminate injury and death. Follow proper procedures at all times!

0.3 MACHINE SAFETY

0.3.1 Protective Devices and Accessories for Machine Safety

0.3.1.1 Overview

The machine system has many built-in safety features. Owners and Operators should make themselves familiar with the function and purpose of each feature and make sure all of the features are enabled. Owners and Operators should never attempt to defeat, bypass or disable any safety features. If any of the features are defeated or become disabled, the machine should not be operated until corrective action is taken and all safety features are restored.


0.3.1.2 Emergency-Stop (E-Stop)



Use the emergency stop when injury may occur or human life is in danger from continued operation of the machine. This provides the quickest, most sure way to stop the machine. Due to the large inertial forces of the Crushing Plant and Crushing Plant parts and components, the machine can not be stopped abruptly.

Large red emergency stop buttons are typically located in control panels near the vicinity of danger points.

Emergency stops can be, and often are, in the form of pull cords that run parallel to conveyors and surround hazards.

 **WARNING**

On large complex systems, the E-stop may control only those components that are in the immediate area.

The location of local E-stop buttons may vary on different machines; therefore the locations of these buttons must be verified from the operating and maintenance manuals specific to the equipment and/or from proper training.

In emergency stop situations, the objective is to stop the machine as soon as possible to minimize potential injuries while maintaining the structural integrity of the machine.

CAUTION

Emergency stop not only stops the machine but often it may initiate other protective sequences.

NOTICE

It may be necessary to engage reset switches before movement can resume.

0.3.1.3 Safety Interlocks

A safety interlock is a device that will interrupt the supply of electricity, hydraulic oil or compressed air to an actuator or motor. A machine already in operation may need to stop quickly due to Operator error, safety violations, or an unexpected machine event. For example, a safety gate may be interlocked to stop a machine if the gate is opened while the machine is running.

Interlocks can also be used to prevent sudden unexpected movement of a machine function or component.

During operation, the logic system (e.g., programmable logic controller, microcontroller, relay system or similar device) controls the functions of the machine. Interlocks built into the system employ limit switches and other sensors to help assure proper machine operation.

IT IS IMPORTANT THAT INTERLOCKING ARRANGEMENTS ARE NOT REMOVED, MODIFIED OR BYPASSED, AND THAT THEY ARE CORRECTLY ADJUSTED. LIMIT SWITCHES, AND OTHER SENSORS MUST BE KEPT IN GOOD WORKING ORDER.

Electric Motors



Electric drives and motors may be controlled to stop or reduce speeds, as determined by the safety interlocks at a particular location.

Hydraulic System



Components that help protect the hydraulic system include certain valves, such as hose burst valves, pressure relief valves, counterbalance valves and pilot-controlled throttle valves as well as pressure transducers and drain valves for pressure accumulators. Metso Minerals uses these components where applicable in the hydraulic systems to minimize the potential for hazardous situations to occur.

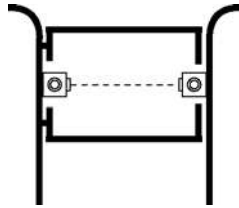
A hose break valve functions to lock up if fluid flow is discharged too rapidly from an actuating cylinder, as happens if a hose breaks and the loads react to gravity.

The pressure relief valve prevents the system pressure from rising beyond system capabilities. It helps protect the entire fluid system and any operators in the vicinity from bursting hoses and components.

The pilot-controlled throttle valve helps prevent uncontrolled actuator movements.

Pressure transducers monitor the system pressure for information or control purposes.

Safety Gates



Some safety gates are designed so that opening or closing of the gates will prevent or stop a specific machine function in that area. Hydraulic or electric limit interlock switches may cut off the drive or actuator power or initiate an emergency stop mode.

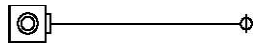
For specific operation, see later sections of this manual.

WARNING

Safety gates must not be opened during normal machine operation. Exceptions to this rule are defined in the operating instructions.

Safety gates may also be opened for maintenance purposes when the machine has been stopped. Follow all lockout procedures.

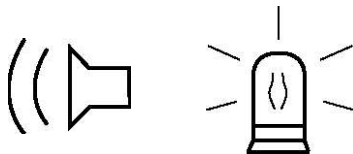
Cable Switches



Cables or ropes connected to the electrical switches can be used as interlocks also. They may stop machine function in areas where control panels cannot be closely located but where Operators may be working. Know the locations of E-stop pull cords for conveyors.

0.3.1.4 Additional Warning Devices

Horns and Lights



If visual contact between work places is obstructed or if communication is difficult, sound and/or light signalling devices may be used before starting the

machine or a machine function. The warning device for start-up should operate so that personnel are given sufficient time to move to a safe distance from the machine. It is the responsibility of the Owner to ensure that the Crushing Plant is always equipped with required horns and lights.

Safety Signs and Labels



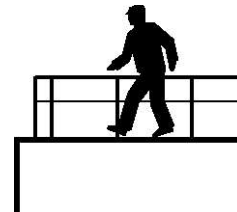
Safety signs have colors to determine the degree of hazard in particular areas. These signs must not be removed. Temporary placement of safety signs and danger tags should also be used on the control panels to warn of maintenance work and lockout situations.

Obey all warning and safety signs on the machine and in the manual.

Safety Warning Colors

Color of safety warnings are typically safety yellow.

0.3.1.5 Walkways, Service Platforms, Ladders and Railings



The design of walkways, ladders and railings follow standards and regulations for the application. The walkways provide access to the machine. Safe operating procedures must be followed when on walkways. Never stand, walk or climb in or on any area of the Crushing Plant not designated for such activity. If an area of the Crushing Plant must be accessed and cannot be reached by designated walkways, ladders, or platforms, then the Owner and Operator must make all necessary arrangements for safe access to the area, including but not limited to safe lifting devices and fall protection.

CAUTION

Extreme caution must always be used on machine walkways.

0.3.2 Transport

Observe the following precautions before transporting the Crusher Plant:

1. Chock chassis tires securely whenever connecting or disconnecting chassis from tractor or dolly.
2. Check tire pressure. Use a protective cage or a clip-on type air chuck and remote in-line valve and gauge when inflating tires. Never exceed maximum inflation pressures of the tire or rim.
3. Check tightness of wheel lug nuts before transport and check frequently during transport.
4. Check that brake system operates correctly.
5. Observe maximum axle and tire loading capacities.
6. Protect components being transported using appropriate shipping braces and blocking material.
7. Travel may be limited to daylight hours only, depending on your specific plant and applicable state regulations.
8. Follow recommended limits on towing speed.
9. Make sure all lights are on and that they are operating correctly.
10. Use traffic warning flags, signs and lights as required.
11. Before moving the Crushing Plant, check all roadways and bridges on the route for weight limits.
12. Check clearance of bridges, overhead lines and other overhead obstructions.
13. Follow all applicable laws and regulations.

0.3.3 Towing

Observe the following precautions before towing the Crusher Plant or its components:

- Check if towing is allowed for each individual equipment.

0.3.4 At the work-site

0.3.4.1 Precautions

Observe the following minimum precautions at the work-site:

1. Know the locations of underground and overhead powerlines and other potential hazards.
2. Select the work-site with care. The ground must be firm, level and able to support the weight of the entire plant. Make sure there is enough room for loading ramps, loaders, conveyors, etc., and for safe maneuvering of trucks and loaders.
3. Check that cribbing is secure and that plant has not shifted or settled.
4. Make sure that electrical cables are protected from wear and traffic.
5. Follow pre-operation checks and start-up procedure covered in the individual manual supplied with your specific unit equipment. Check that all fluid and lubrication systems are at the correct level and that there are no leaks. Low fluid levels can lead to serious hydraulic failures. Low oil or grease can lead to machine seizure, damage to other components, and to human injury.
6. Check equipment for warning tags which indicate that maintenance is being carried out and/or that an unsafe condition exists. Tag out conditions must be cleared before operation.

0.3.4.2 During operation

Keep watch

Do not rely too much on automated systems. Observe Crushing Plant equipment while the system is running. Pay attention to unauthorized persons approaching the site as well as any unusual behavior of the equipment (uncommon noise, vibration, smell, reduced output, etc.).

Clearing

Crushers Plant equipment can become plugged and stall because of power failures, surges of material or other unplanned events. Clearing a Crusher is potentially very hazardous. Shut down the system

completely, lock and tag out all applicable controls and follow all instructions in the instruction manual of your specific crusher.

0.4 SAFETY DURING MAINTENANCE AND REPAIR

NOTICE

Never tamper with safety devices or attempt to modify or eliminate safety devices installed at the factory.

0.4.1 General Information and Safety Lockouts

Detailed instructions for the operation of the machine can be found in following sections of the manual. Because each machine section may incorporate unique functions, some of which may be automated, maintenance personnel should be knowledgeable of the operation of the machine sections in order to perform the maintenance and repair work as safely as possible.

DO NOT COMPROMISE SAFETY DUE TO TIME PRESSURES.

FOLLOW ALL CRUSHING PLANT SAFETY AND FIRE PREVENTION PROCEDURES.

Before starting any repair, maintenance or troubleshooting work on the machine, ensure the following:

- Know the whereabouts of all personnel in, on, at and around the machine.
- Never service any machine or component without first referencing its maintenance manual.
- Before handling chemicals, refer to the MSDS (Material Safety Data Sheets) and Crushing Plant procedures for handling of these materials.
- If you have not been trained to perform the required repairs, maintenance or troubleshooting, or you are unsure how to safely perform the activity - STOP! Never attempt to repair, maintain or troubleshoot any aspect of the Crushing Plant unless you are thoroughly trained for the activity and understand how to perform the activity in a safe manner.
- Be sure to coordinate all repair and maintenance work with other Crushing Plant operations.
- Use lockout and warning signs to inform others that maintenance and repair work are in progress. These signs should only be removed (after all work has been completed) by the person who has placed them there.
- Transmit all knowledge of the maintenance work to the succeeding shift.

0.4.2 Mechanical Safety During Maintenance and Repair



0.4.2.1 General

⚠ DANGER

Follow all established lockout procedures. Refer to the appropriate standards.

For repair, maintenance or troubleshooting work, disconnect all devices from electric, pneumatic and hydraulic power sources and follow lockout procedures.

The lockout instructions, locks, tags and the blocking/restraining devices provided are designed for your protection. Your responsibility is to follow the instructions and use the proper equipment.

Remember:

- Follow procedures.
- Stay alert.
- Do not take anything for granted.
- Verify lockout.
- Tag must identify the work being done and the person(s) who locked and tagged the control.
- Locks and tags are changed with each shift that comes on.

Work to eliminate injury and death. Follow proper procedures at all times!

NOTICE

Block up and support parts as necessary to prevent any unexpected motion when performing maintenance.

NOTICE

Be sure all mechanical components are brought to a zero energy state including all spring driven devices, cylinders, accumulators, drive shafts, pulleys, rollers, gears, etc., prior to entering the machine and performing the work. Never attempt to perform repair, maintenance, or troubleshooting work on or in proximity to energized mechanical components.

A certain amount of work must be done in the immediate area of the crushing equipment during the normal course of operations on a day-to-day basis. The following are some of the do's and don'ts to be followed as part of normal equipment operating procedures.

- **Do not** perform maintenance on moving machinery. This includes such items as adding lubricating oil or greasing parts of the equipment while it is in operation.
- **Do not** put hands or feet on the release cylinders which protect the equipment from tramp iron overloads while the equipment is in operation.
- **Do** check the manufacturer's recommendations for periodic maintenance procedures. These maintenance procedures are designed to not only avoid damage to the equipment but also avoid harm to the operator as well.
- **Do** avoid spillage around the equipment. Plant operators should make it a habit to keep the area immediately adjacent to the equipment free from this type of spillage which could cause unsuspecting personnel to trip and fall.
- **Never** stand in front of the feed opening or look into the crushing cavity while the crusher is operating.
- **When using a crane** to raise or lower a load keep all personnel clear of the area.
- **Never** walk, stand, crawl or lay under any load hanging from a crane.

0.4.2.2 Fire Safety During Maintenance and Repair



Observe all regulations on fire safety. Sources for fires include, but are not limited to the following:

- Sparks from grinding.
- Flames and molten metal from welding or torching.
- Electrical arcing.
- Spontaneous combustion.
- Smoking.

Before starting any work take the following steps to prevent a fire hazard:

- Properly dispose of rags with combustible material to avoid spontaneous combustion.
- Move flammable materials 10 m (33 ft) or more away from any fire hazard.
- Clean up all debris.
- Clean up all oil spills and leaks.
- Remove any source of flammable gases, liquids or solids.
- Use proper electrical grounding techniques for welding.
- Provide adequate fire extinguishing equipment; inspect such fire equipment regularly.
- Arrange for qualified personnel to guard against fire while welding, cutting, or heating operations are being performed, as well as a sufficient period of time after the work is completed.
- Protect yourself and others from sparks with proper personal protective equipment and clothing.

0.4.2.3 Preventive Maintenance

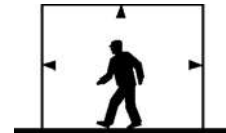
Preventive maintenance will both increase safety and be economically beneficial. It is more safe and economical to replace a worn part during a scheduled shut-down than to repair a broken device

in the middle of a production cycle. A machine or device that is not in proper condition, and that has been left without regular maintenance and inspections, is a safety risk to its user. For instance, without lubrication a bearing may fail, bringing a production line down. Furthermore, the hot bearing may present a fire hazard or cause skin burns.

Some preventive maintenance suggestions for a machine include:

- Observe the maintenance and lubrication instructions of the machine and equipment suppliers.
- Keep the machine and surrounding area clean and orderly.
- Monitor the vibration levels of the machine to help detect loose or worn parts or impending bearing failure.
- Monitor the power consumption of motors to help detect early failures.
- Repair all leaks as soon as possible to prevent more serious conditions. Repair fuel leaks immediately.
- Monitor the condition of pipes and tubes enclosed in ducts; repairing possible leaks.

0.4.2.4 Confined Spaces



A confined space means a space that:

- is large enough and so configured that a person can enter and perform assigned work; and
- has limited or restricted means for entry or exit (for example, the crushing cavity, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry); and
- is not designed for continuous employee occupancy.

Certain confined spaces may require an entry permit program to allow entry. Be sure that all applicable procedures are followed. If you have questions contact your Crushing Plant supervisor for more information.

⚠ DANGER

Confined spaces may contain high concentrations of gases which may cause injury or death. Follow all established safety procedures.

0.4.3 Electrical Safety During Maintenance and Repair



0.4.3.1 General

⚠ DANGER

Follow all established lockout procedures.

For maintenance work, disconnect all devices from electric, pneumatic and hydraulic power sources and follow lockout procedures.

The lockout instructions, locks, tags and the blocking/restraining devices provided are designed for your protection. Your responsibility is to follow the program and use the proper equipment.

Remember:

- Follow procedures.
- Stay alert.
- Do not take anything for granted.
- Verify lockout.
- Tags must identify the work being done and the person(s) who locked and tagged the control.
- Locks and tags are changed with each work shift.

Work to eliminate injury and death. Follow proper procedures at all times!

Be sure all electrical components are brought to a zero energy state including capacitors and similar electrical devices.

Before maintenance work:

- Be sure all control power supplies are turned off, disconnected, and lock out procedures have been followed.
- Confirm that **ALL** power sources are disconnected. Some electrical devices may be supplied by more than one power source.
- Be aware that multiple voltage levels may exist in some junction boxes.
- Ensure that during lockout procedures, locks and signs are appropriately attached, and subsequently removed only by the person who installed them after all work is completed. Follow Crushing Plant lockout instructions for placement and removal.
- For testing and troubleshooting, clear all personnel from the machine just as though the machine were being returned to production mode. Reactivate the necessary power supplies and perform the tests. Then disconnect all power supplies and follow lockout instructions before further maintenance work is performed.
- Be sure electrical supply voltage is disconnected before drilling into any structural frame members. Electrical cables may be inside.
- Verify that electric motors are disconnected before starting any maintenance work, thereby preventing the supply of electricity to the motor. Generally the disconnects are located in the drive control room. Each person performing maintenance work should install their lock and sign the lockout tag.
- Always turn off electrical power before disconnecting electrical cables.

0.4.3.2 Electrical Fault Situations

Electrical faults may be caused by component failures such as loose or damaged wiring.

Diagnostics are provided through pilot lights, alarms, and help messages.

NOTICE

Electrical connections can and do loosen due to vibration in transit and thermal expansion of the wires and lugs in operation. This is especially true after initial delivery, break in and after major relocation. Loose connections increase current draw, which can result in false trips, intermittent circuits, and burned-out components. As part of the start-up, check and retighten as necessary all electrical connections in the electrical enclosure. Repeat after the first forty to fifty hours of operation. This work must be performed by properly trained personnel.

NOTICE

Improper phasing will damage backstops in conveyor drive reducers and may damage hydraulic system components.

0.4.3.3 Program Changes

⚠ WARNING

Changes to Metso Minerals' supplied control program should be made only by Metso Minerals personnel. Faulty program code may cause the machine to behave unexpectedly. Any changes to interlock circuitry must be made with extreme caution and be reviewed and approved in writing by Metso Minerals before implementation.

An electric outlet may be supplied in the logic center and control cabinet for programming purposes only. Do not connect any electrical tools to this outlet. The tool may cause electrical disturbances in the machine control system. This could alter the machine control program and cause unpredictable machine operation.

NOTICE

Do not use the logic center or control cabinet's outlet for anything other than a programming device!

0.4.4 Hydraulic Safety During Maintenance and Repair

⚠ DANGER

Follow all established lockout procedures.

For maintenance work, disconnect all devices from electric, pneumatic and hydraulic power sources and follow lockout procedures.

The lockout instructions, locks, tags and the blocking/restraining devices provided are designed for your protection. Your responsibility is to follow the program and use the proper equipment.

Remember:

- *Follow procedures.*
- *Stay alert.*
- *Do not take anything for granted.*
- *Verify lockout.*
- *Tag must identify the work being done and the person(s) who locked and tagged the control.*
- *Locks and tags are changed with each shift that comes on.*

Work to eliminate injury and death. Follow proper procedures at all times!

Before proceeding with any repair, maintenance or diagnostic procedures on the hydraulic system, bring all components to a zero energy state, including cylinders, accumulators, spring loaded hydraulic devices, circuitry between valves and actuators, etc.

- Mineral and other oils and additives can cause skin irritation. Inhaled oil mist can also cause internal irritation, headache or nausea. Avoid repeated exposure to these materials. Use appropriate personal protective equipment.

- Purge entrapped air from the hydraulic system. Entrapped air in the hydraulic system can cause erratic and unexpected movements.
- Oil mist in the work area or oil leaking onto floors and walkways will cause a serious risk of slipping. Clean up all spills and repair leaks immediately.
- Hydraulic oil temperature may be extremely high;

⚠ WARNING

Elevated temperatures levels can be hazardous and may cause severe burns. Wait until machine cools down before doing maintenance or repair.

- A mixture of air and oil mist may explode at higher temperatures. Hydraulic oil spilled on hot machine surfaces may start a fire.
- Pressurized hydraulic hoses should not be handled with bare hands since high-pressure leaks may easily penetrate the skin. Hydraulic fluid pressure in the hoses may exceed 3000 PSI/210 bar/21MPa.

⚠ WARNING

Hydraulic oil under pressure can penetrate body tissue causing serious injury and possible death. When troubleshooting a hydraulic system for leaks, always use a mirror, cardboard, wood or other appropriate techniques as a detector. DO NOT USE YOUR BARE HANDS. If you are injected with hydraulic oil or any other fluid, immediately seek treatment from a doctor trained in the treatment of penetrating fluid injuries.

Hydraulic hoses are subject to wear and tear. Pressurized hoses tend to straighten up, bend or twist due to reaction forces. Replace all weakened or deteriorated hoses promptly. Keep hoses properly clamped and secured to help prevent being whipped by broken hoses.

- Avoid letting dirt and other impurities into the system while doing maintenance work. Use lint free cloths for cleaning the hydraulic components system.
- When changing a cylinder, or other hydraulic device, plug all open ports and hose ends. Catch spilled oil in a suitable storage device and avoid introducing dirt into the system. Dispose of all waste fluids as presented by law.
- Tighten disconnected pipe and hose couplings immediately after reinstallation. Before finishing the work, check all parts and connections that have been serviced or repaired.
- Before starting up the pumps, make sure that maintenance work is completely finished in all work areas. When starting up the pumps, stay at a distance from the areas which were repaired.
- Before opening the main valves, make sure that there is no one working between any parts of the machine, since pressurization of the system may cause machine motion.
- Once the system is in the pressurized state, test repaired system for proper operation before putting system back into production.

Check the system for possible leaks after repair. Leaking fittings must not be tightened when under pressure. To seal threaded fittings, use appropriate sealing rings or a sealing compound suitable for hydraulics. Use a mirror, cardboard or other appropriate techniques.

NOTICE

Never adjust pressure relief valves higher than settings specified.

0.4.5 General Maintenance Work

The following are some of the do's and don'ts to be followed as part of normal Crushing Plant procedures

- Do not perform any maintenance on moving machinery. This includes such items as adding lubricating oil or greasing parts while the crusher is in operation.

- Never clear a jam on or in the feeder, crushing cavity or conveyors when system is energized.
- Do not put hands or feet on the release cylinders, which protect the crusher from tramp iron overloads while the crusher is in operation.
- Do check the manufacturer's recommendations for periodic maintenance procedures. These maintenance procedures are designed to not only avoid damage to the equipment but also to avoid harm to the Operator.
- Do avoid spillage around the crusher. Operator should make it a habit to keep the area immediately adjacent to the crusher free from spillage, which could cause people to trip and fall.
- Never stand in front of the feed opening or look into the crushing cavity while the crusher is operating.
- When using a crane or other lifting device to raise or lower a load keep all personnel clear of the area.
- Never detach a lifting device from its load until the load is securely affixed at its designation, or steps have been implemented to prevent the load from unintended shifting or falling.
- Never walk, stand, crawl or lay under any load hanging from a crane or other lifting device.
- Store and secure hazardous materials in restricted areas. Mark materials clearly and make sure any federal or other labelling regulations are followed.
- Store gasoline, diesel fuel, hydraulic oil, cleaning solvent and any other flammable material in a cool, dry, ventilated and secure location.
- Avoid spills of fuels, oils, lubricants, or antifreeze. If spills occur, contain and neutralize them with an approved agent and dispose of them properly.
- Use only quality Metso replacement parts. Handle parts carefully to prevent damage to machined surfaces. Machined surfaces may have sharp edges. Replace fasteners with the same type, size and quality as the original parts.

⚠ WARNING

Never start and run a diesel or gasoline engine in an enclosed area that is not ventilated. Although carbon monoxide is odorless and colorless, it is deadly.

0.5 SAFETY PLATES

0.5.1 Safety Plates — ANSI



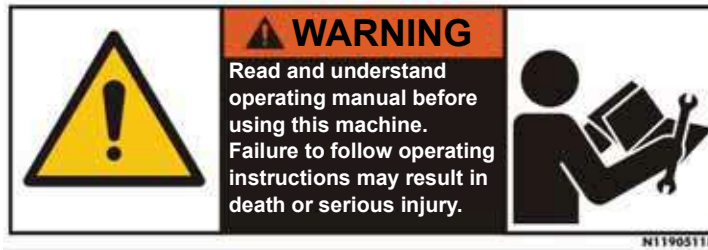






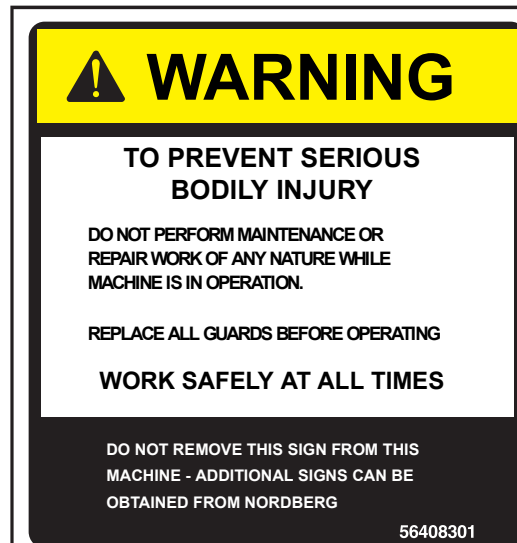
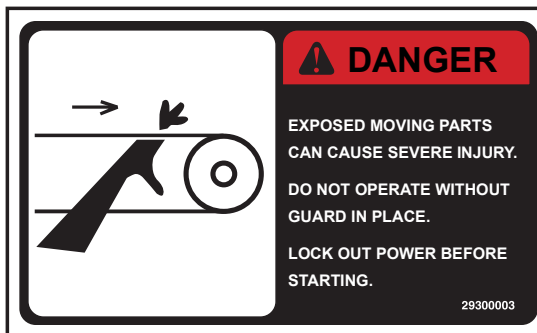












0.5.2 Safety Plates — EN



Do not stand in the vicinity of the crusher when the engine is running.



Do not stand in the vicinity of the crusher when the engine is running.



Do not stand on the machine.



There are moving parts behind the protecting cover.
Do not open the cover when the engine is running.



Do not go near the feeder when the engine is running.



Do not go under the machine when the engine is running.



Mind the hot surface.



Mind the high-pressure liquid.



Stay away from the powerful magnet.



Read the user instructions.



Do not open the hatch when the rotor is moving.



Lock the rotor before entering the crusher.



Watch out for material dropping from the conveyor.



Watch out for material dropping from the bucket.



Rotation direction of the vibrator.



Switch off the radio control before blasting.



Emergency stop.



Conveyor emergency stop.



Conveyor emergency stop wire.



Do not open the main current switch when the engine is running.



Close the hatch before lowering the conveyor.



Stay away from the crusher cavity.



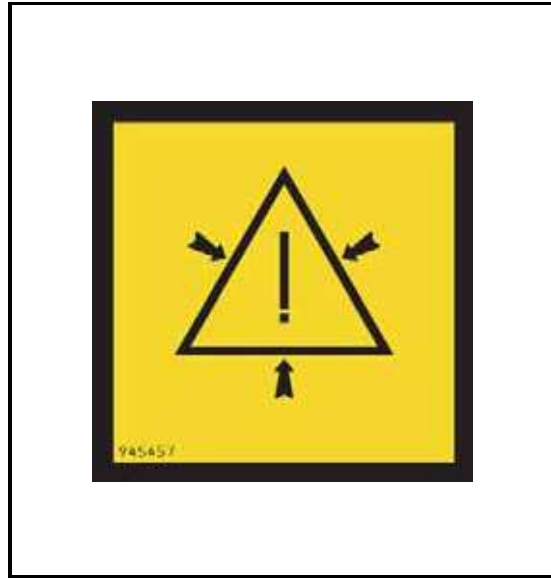
Do not step under the conveyor.



Use a safety rod to prevent the crusher from closing.



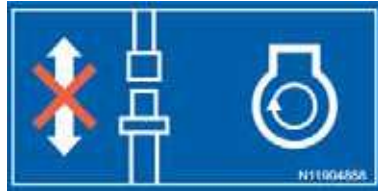
Do not insert tools in the crusher cavity when the engine is running.



Pressure accumulator.



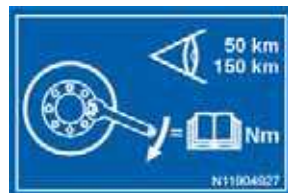
Do not open the hatch when the engine is running.



Do not attach or detach hydraulic connection when the engine is running.



Keep the door closed when the engine is running.



Tighten the wheel nuts to the specified torque when changing tires.
Check the tightness of the nuts after 50 km (30 miles) and 150 km (93 miles).



Use the pin to lock the conveyor before moving the machine.



Use the pin to lock the conveyor before starting the crushing.



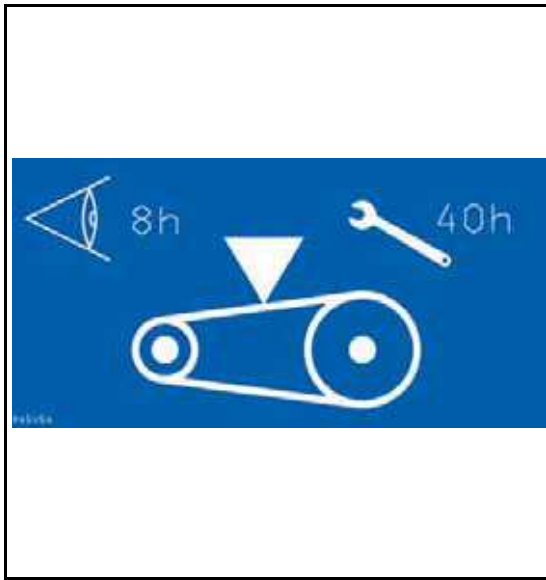
Oil.



Oil recommendation.



Use of respirators required.



Inspect every 8 hours and tighten every 40 hours.



Lock the catch.



Use of hearing protectors required.



Use of helmet required.



Greasing point.



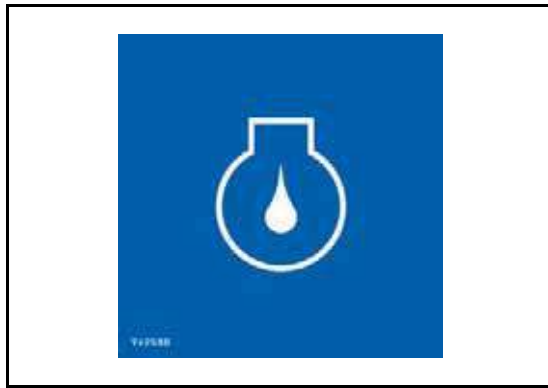
Check every 8 hours.



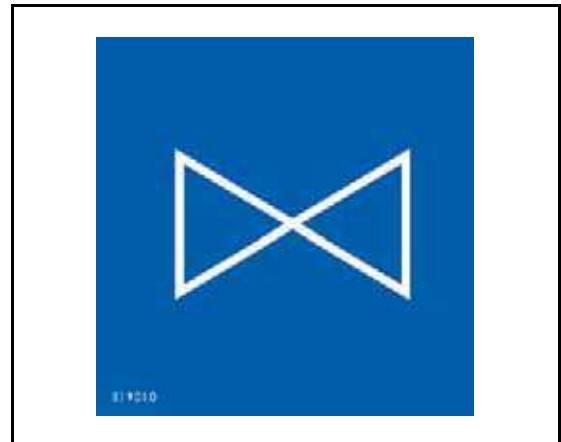
Fuel tank.



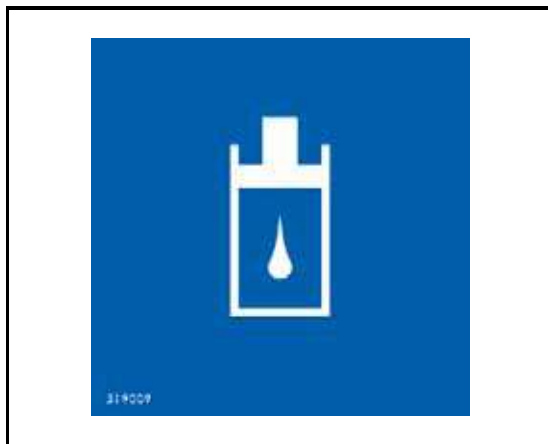
Use of eye shields required.



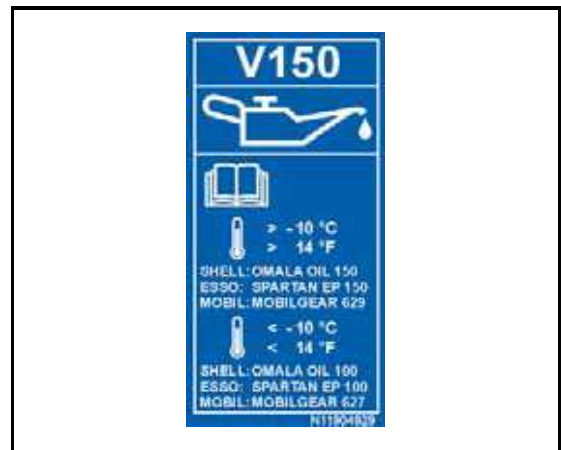
Engine oil.



Valve.



Hydraulic oil.



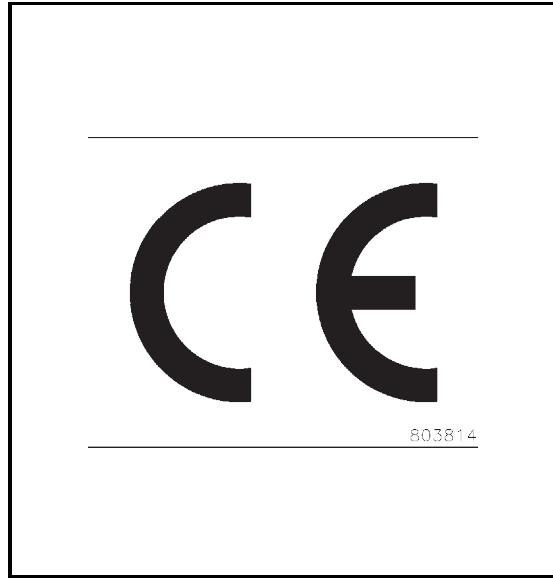
Oil recommendation.



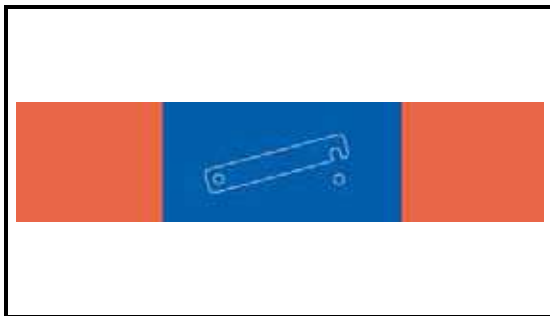
Coolant.



DANGER! Electric shock.



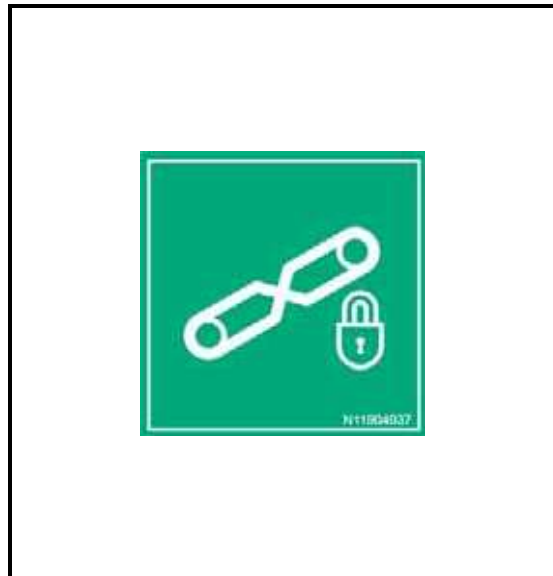
CE mark.



Fastening flat bar.



People using pacemakers must not go near the magnet.



Conveyor safety switch.

Section 1

General Crusher Information

1.1	Introduction	1-1
1.2	Initial Inspection	1-1
1.3	Information Furnished	1-1
1.4	Repair Parts	1-1
1.5	Crusher Terminology	1-1
1.6	Optimizing Crusher Capacity	1-2
1.7	Selection of Proper Liners	1-3

1.1 Introduction

This Instruction Book has been prepared to assist you, the user, and those entrusted as operators, in the installation, operation, and maintenance of the Nordberg® MP®* Cone Crushers.

The information contained herein will serve to acquaint you with the construction of the Crusher and as an aid in gaining the general knowledge necessary for efficient operation and maintenance.

When operating the Crusher certain safeguards must be taken during use. These precautions are defined in the following instructions, and will help to prevent the problems that arise because of improper operation or maintenance.

It is strongly recommended that the contents of this book be read, understood and put in practice prior to installation and during operation of the Crusher.

1.2 Initial Inspection

It is strongly recommended that as soon as possible after receipt of the Crusher, a careful check be made for any possible damage which might have been incurred during transit. A careful check should also be made to be sure that nothing has been lost and that all items on the Bill of Lading, Freight Bill or Manifest can be accounted for. If any shortages or damages are discovered, these should immediately be brought to the attention of the respective carrier so that necessary claims can be processed without any undue delay.

1.3 Information Furnished

The following installation drawings and data for your particular Crusher are provided.

- mounting and clearance drawing
- oil piping drawings for the Crusher and lubricating system
- drawings and bulletins for the auxiliary equipment not manufactured by Metso Minerals
- all other drawings or informational data that might be required for your specific installation

A Parts Manual containing the various assembly drawings pertaining to your Crusher will be sent

under separate cover at a later date; usually immediately after the Crusher has been shipped. This manual illustrates and identifies each and every part used in the assembly of the machine and is to be used when ordering spare or replacement parts.

1.4 Repair Parts

Metso Minerals endeavors to carry an ample supply of parts in stock to provide prompt and efficient service on all orders for repairs and replacements.

To avoid delay, and the possibility of incorrect parts being furnished, the following information should be given:

- crusher size
- the serial number of the Crusher which is stamped on the crusher name plate as well as on the cover of the Parts Manual
- exact quantity of each part ordered
- complete name and part code number as shown in the Parts Manual
- Complete shipping instructions. Advise whether shipment is desired by Mail, Express, Surface, or Air Freight.

For proper operation, only genuine factory parts should be installed. These are guaranteed as to accuracy, workmanship, and material.

1.5 Crusher Terminology

Throughout this manual certain terms will be used in describing the Crusher and its operation. In order that there will be no possibility of confusion or misunderstanding, these terms are defined as to their usage in the manual.

Feed — The raw material that is to be crushed.

Liners — The bowl liner and mantle are the crushing members and are commonly referred to as liners.

Cavity — The internal contour formed by the two crushing members.

Parallel Zone — With the liners in their closest relationship during the gyrating cycle, the lower portion of both the bowl liner and mantle, for some distance, will be parallel to each other. This area is known as the parallel zone.

* MP® and Nordberg® are registered trademarks of Metso Minerals, Inc.

Feed Opening (Closed Side) — The smallest distance between the top of the crushing members as measured when the two crushing members are at their closest relationship during their gyrating cycle.

Feed Opening (Closed Side) — Determines the maximum size of feed. As a general rule, the maximum size of feed should not exceed the closed side feed opening.

Feed Opening (Open Side) — The largest distance between the top of the crushing members as measured when the two crushing members are at their farthest relationship during their gyrating cycle.

Discharge Setting — The distance between the bottom of the crushing members as measured at the point where the two crushing members are at their closest relationship during their gyrating cycle. This discharge setting regulates product size.

Minimum Discharge Setting — The smallest permissible distance between the bottom of the crushing members as measured when the two crushing members are at their closest relationship during the gyrating cycle.

Discharge Opening — The distance between the bottom of the crushing members as measured at the point where the two crushing members are at their farthest relationship during their gyrating cycle. This wide opening permits rapid discharge of the crushed material.

Feed Size — Is equal to the square opening of wire cloth through which the material can pass.

Example

A 50 mm (2") feed size is any material which can pass through a screen that has 50 mm (2") wire cloth.

Product Size — The size equal to the square opening of wire cloth through which the material can pass after it has been crushed.

Capacity — The output of the Crusher computed in tons per hour.

Open Circuit Operation — The type of operation where precise uniformity of product size is not considered to be of prime importance and the feed is run through the Crusher but once.

Closed Circuit Operation — The type of operation where precise uniformity of product size

is important and the product is screened after passing through the Crusher and the material which does not pass through the screen is returned to the Crusher.

1.6 Optimizing Crusher Capacity

The Crusher is one component of the circuit. As such, its performance is in part dependent on the proper selection and operation of feeders, conveyors, screens, supporting structure, electric motors, drive components and surge bins. Where used, attention to the following factors will enhance crusher capacity and performance.

- proper selection of crushing chamber for material to be crushed
- a feed grading containing proper distribution of the particle sizes
- controlled feed rate
- proper feed distribution 360° around the crushing chamber
- discharge conveyor sized to carry maximum crusher capacity
- properly sized scalping and closed circuit screens
- automation controls
- adequate crusher discharge area

The following factors will detract from crusher performance.

- sticky material in crusher feed
- fines in crusher feed (smaller than crusher setting) exceeding 10% of crusher capacity
- excessive feed moisture
- feed segregation in crushing cavity
- improper feed distribution around circumference of crushing capacity
- lack of feed control
- inefficient use of recommended connected horsepower
- insufficient conveyor capacity
- insufficient scalper and closed circuit screen capacities

- insufficient crusher discharge area
- extremely hard or tough material
- operating Crusher at less than recommended full load countershaft speed

Capacities are based on results obtained from installations worldwide, crushing the broadest range of ores, rocks and minerals. To determine effect of individual conditions, consult Metso Minerals.

1.7 Selection of Proper Liners

Through extensive research and study, Metso Minerals has developed a varied line of crushing members covering a wide range of feed and product sizes. Since there are so many variable conditions and types of operation to be considered, it would be difficult to list each type of liner that would be best suited for each individual condition and type of operation.

If for any reason, it is felt that unsatisfactory wear life was obtained from the original liners, Metso Minerals suggests that the bowl liner and mantle be torch cut open so that the contour of the bowl liner and mantle can be traced onto a sheet of cardboard

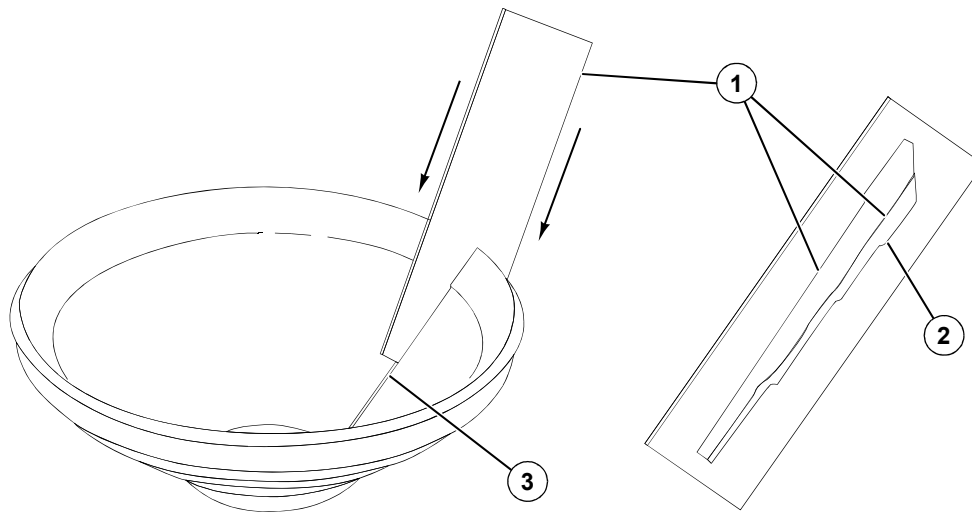
or heavy paper and the traced contours sent to the factory, in order that the exact concentration of wear can be determined, refer to Figure 1-1.

Another bowl liner and mantle can then be recommended which will have a different contour at these wear points.

In order to properly answer any inquiry, it is important that the following information be included:

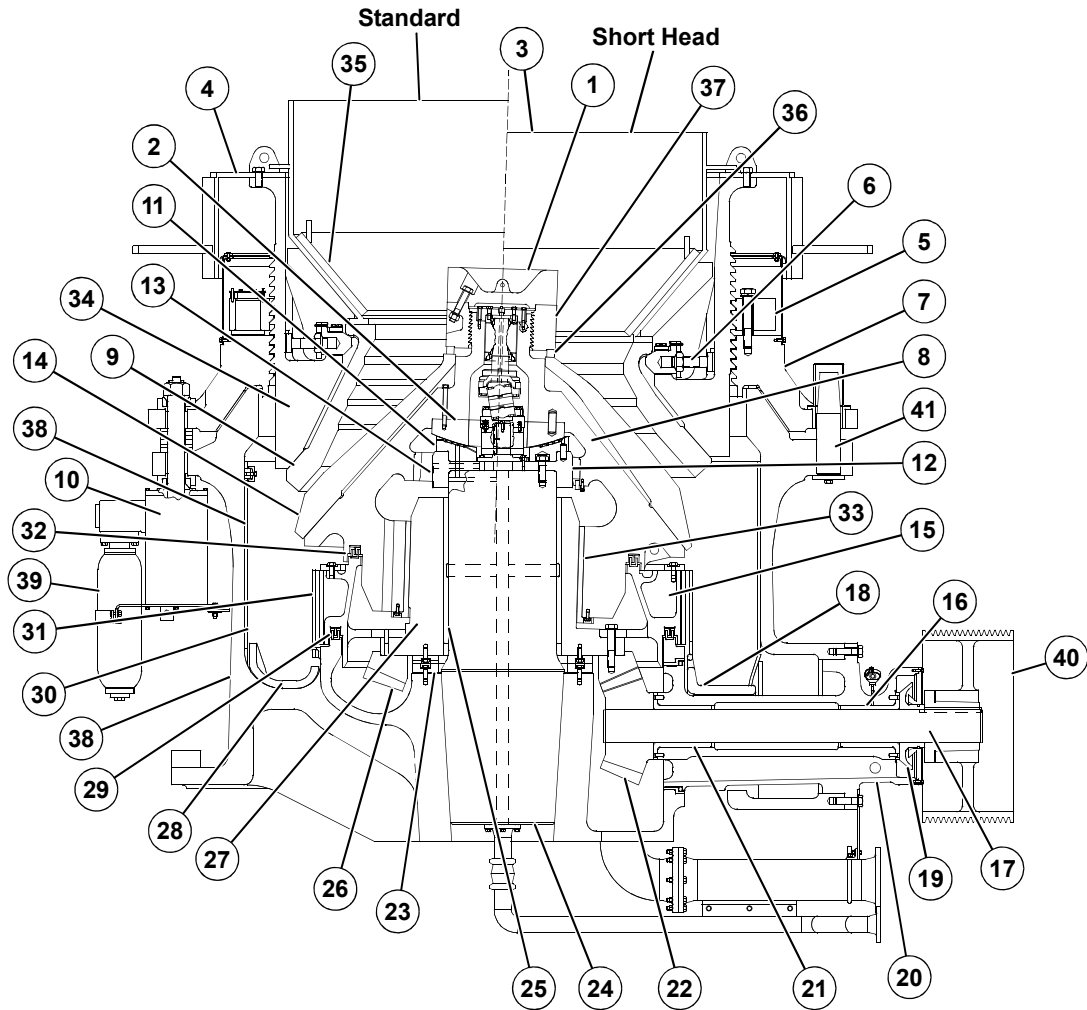
- feed gradation
- type of feed. (i.e. granite)
- product gradation
- circuit diagram complete with screen cloth openings and all crusher settings
- part numbers of current mantle and bowl liner
- crusher power draw
- crusher capacity

To operate continuously with liners having a crushing cavity unsuited to the operation, results in uneconomical wear of the liners, poor crushing efficiency and, in some instances, abuse to the Crusher.



Callout	Description
1	Trace worn contour on cardboard or heavy paper inserted in cut
2	Original contour
3	Torch cut through mantle or bowl liner

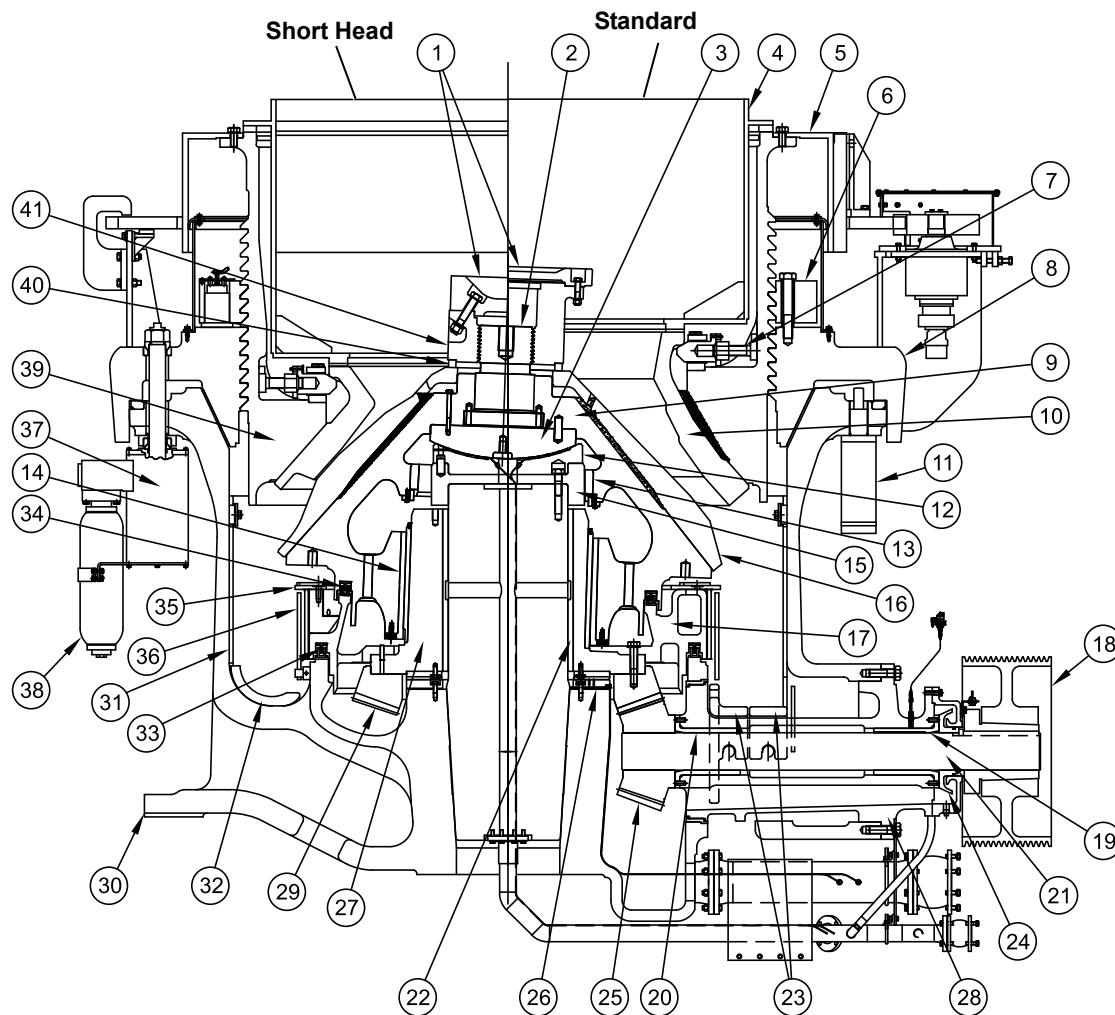
Figure 1-1 Obtaining Wear Contour



Callouts

1	Feed plate	9	Bowl liner	17	Countershaft	26	Gear	33	Lower head bushing
2	Head ball	10	Tramp release cylinder	18	Countershaft box guard	27	Eccentric	34	Bowl
3	Hopper	11	Socket liner	19	Oil flinger	28	Arm guard	35	Feed cone
4	Adjustment cap	12	Upper head bushing	20	Countershaft box	29	T- and U-seal (lower)	36	Torch ring
5	Clamping ring	13	Socket	21	Inner countershaft bushing	30	Main frame liner	37	Locking nut
6	Wedge bolt assembly	14	Mantle	22	Pinion	31	Counterweight stationary shield	38	Main frame
7	Adjustment ring	15	Counterweight	23	Upper and lower thrust bearing	32	T- and U-seal (upper)	39	Accumulator
8	Head	16	Outer countershaft bushing	24	Main shaft			40	Crusher sheave
				25	Eccentric bushing			41	Main frame pin

MP800 General Arrangement



Callouts

1	Feed plate	8	Adjustment Ring	17	Counterweight	25	Pinion	34	T-and U-seal (Upper)
2	Head Stub Bolt	9	Head	18	Sheave	26	Upper and Lower Thrust Bearing	35	Counterweight Guard
3	Head Ball	10	Bowl Liner	19	Outer Countershaft Bushing	27	Eccentric	36	Counterweight Stationary Shield
4	Hopper	11	Clearing Jack	20	Inner Countershaft Bushing	28	Countershaft Box	37	Release Cylinder
5	Adjustment Cap	12	Socket Liner	21	Countershaft	29	Gear	38	Accumulator
6	Clamping Ring	13	Upper Head Bushing	22	Eccentric Bushing	30	Main Frame	39	Bowl
7	Wedge Bolt Assembly	14	Lower Head Bushing	23	Countershaft Box Guard	31	Main Frame Liner	40	Torch Ring
		15	Socket	24	Oil Flinger	32	Arm Guard	41	Locking Nut
		16	Mantle			33	T-and U-seal (Lower)		

MP1000 General Arrangement

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Section 2

General Installation Information

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2.1 Foundation

The mounting and clearance drawing which is furnished will provide guidance on the mounting locations and size of the foundation bolts as well as location of the crusher drive motor. A typical mounting and clearance arrangement is shown at the beginning of this section. Refer to Figure 2-1 for the MP800 or Figure 2-2 for the MP1000. A solid level foundation of proper proportion and durability is of utmost importance to the successful operation of the Crusher.

suitable equipment must be provided for handling heavy crusher components during erection or during the replacement of the crushing liners or other worn parts. Size requirements for hoisting equipment including cables, slings and shackles can be determined by referring to Table 2-2 for the MP800 or Table 2-4 for the MP1000. These tables give the complete MP800 and MP1000 weights as well as weights of subassemblies that require frequent handling.

NOTICE

Foundation must be acceptable for loadings. Obtain technical data sheets with foundation loads from Metso Minerals. It is customer's responsibility for proper design and construction.

2.2 Crusher Clearance Dimensions

A well planned installation is an absolute necessity for the ultimate success of the Crusher. One of the major considerations to be given the construction of the foundation is crusher clearances. Refer to Table 2-1 for the MP800 or for the MP1000, Table 2-3.

Sufficient head room should be provided above the Crusher for the removal of the head and bowl assemblies. Enough room should be provided at the side of the foundation for the removal of the countershaft box assembly. Consideration should also be given to the additional clearance required for the feeding arrangement, such as; chuting, feed hopper and other auxiliary equipment. Adequate clearance should also be provided for the discharge compartment, conveyor and related equipment. In order to accurately determine crusher clearances. Refer to Figure 2-3 and Table 2-1 for the MP800 or for the MP1000, Table 2-3 as well as the mounting and clearance drawing.

CAD (Computer Aided Drafting) template files are available on request for the MP Cone Crushers.

2.3 Crusher and Sub-Assembly Weights

Another factor to be considered when designing the foundation and also a factor to be considered when planning overhead lifting equipment is crusher weights. An overhead crane, a rubber or track mounted mobile crane, a chain hoist or other

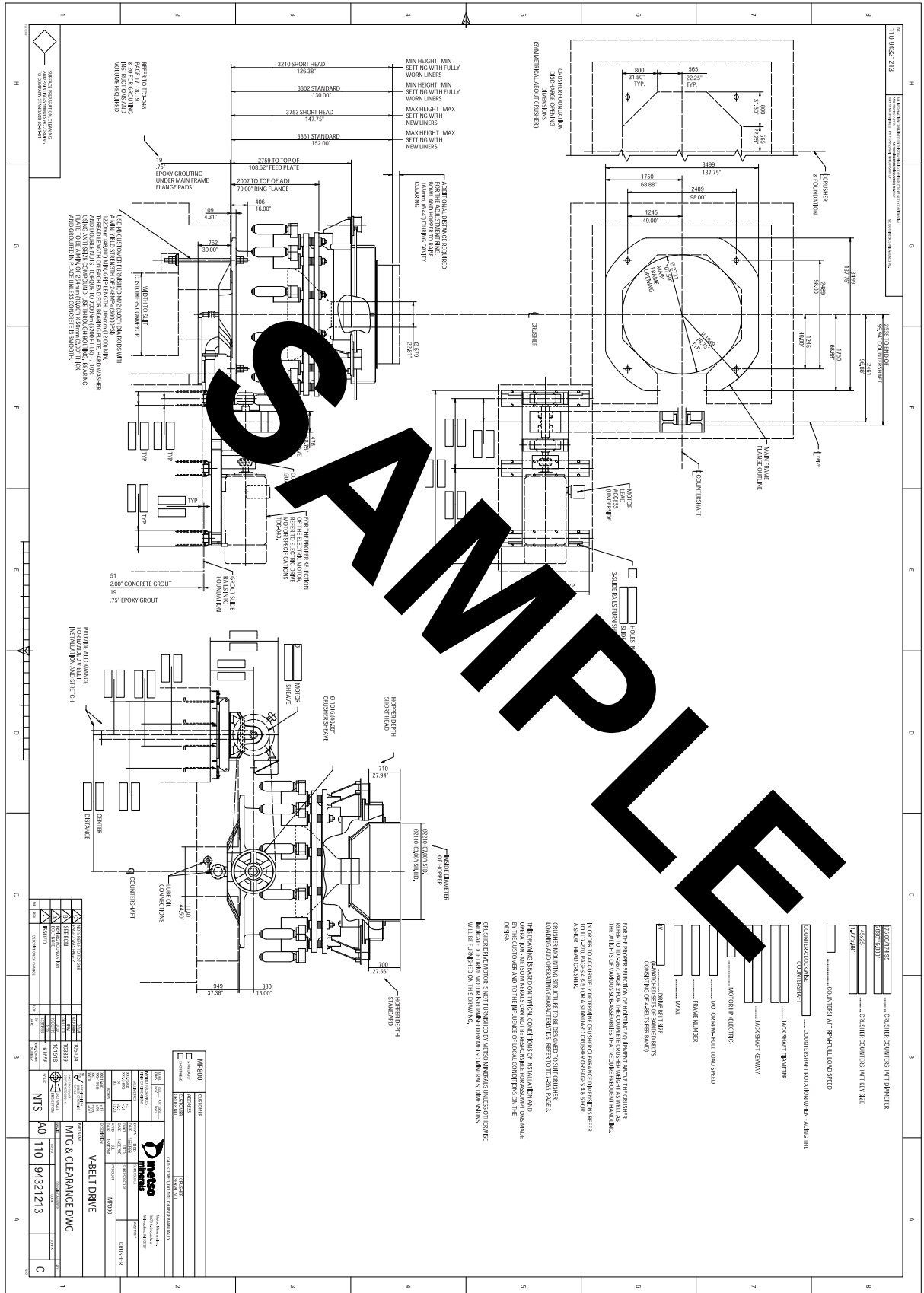


Figure 2-1 Typical MP800 Mounting and Clearance Drawing

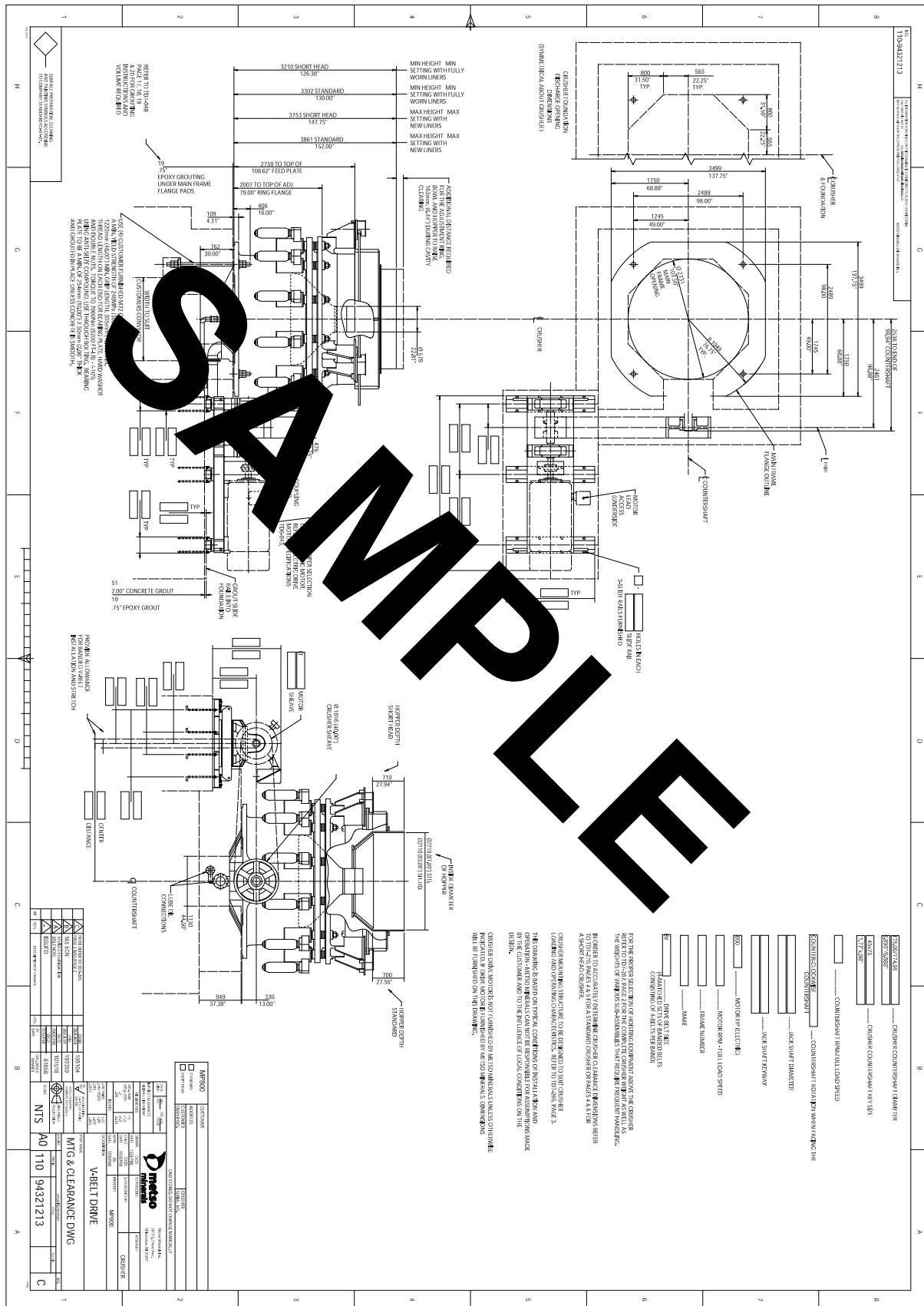


Figure 2-2 Typical MP1000 Mounting and Clearance Drawing

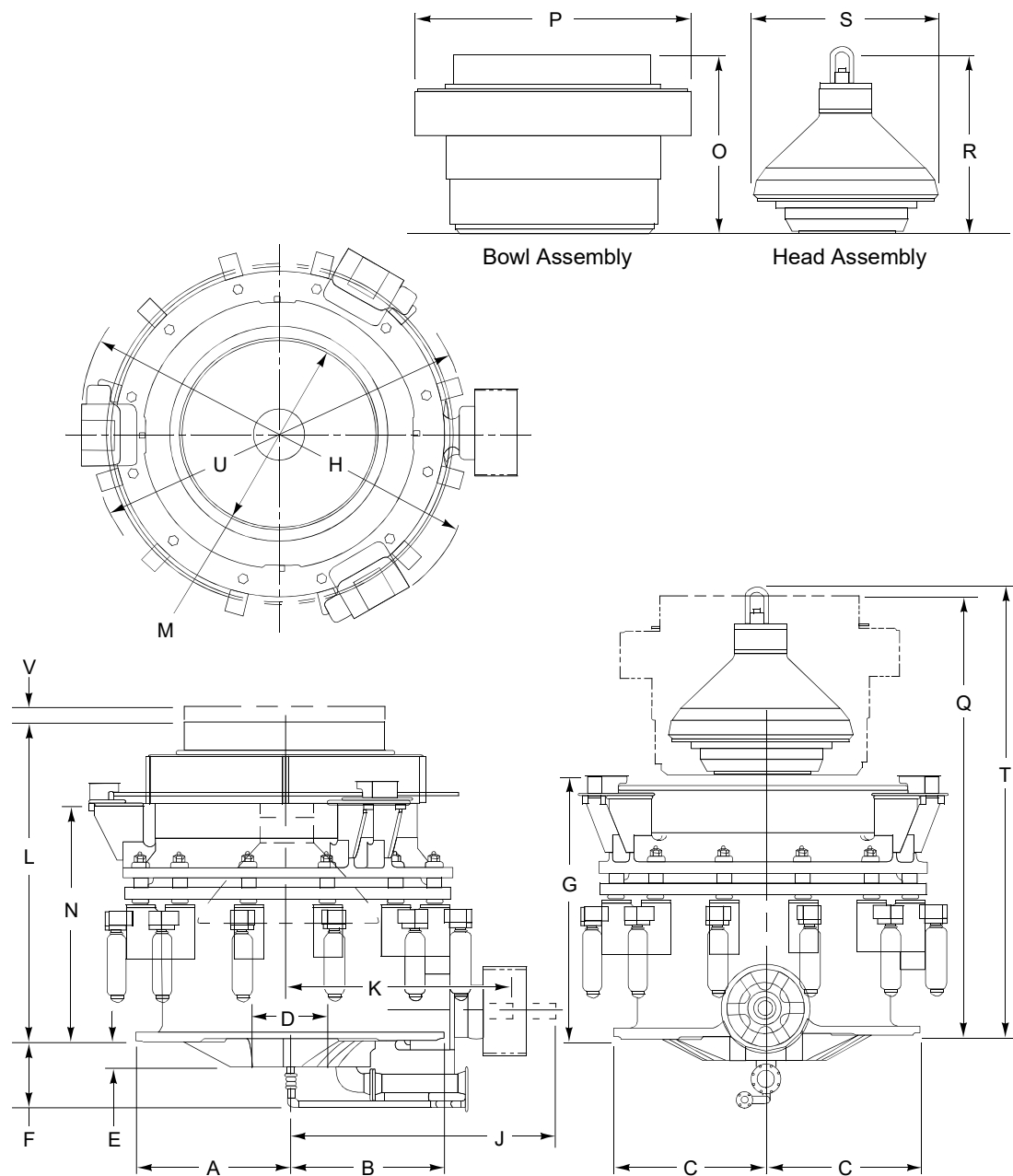
**Figure 2-3 MP800 Clearance Dimensions**

Table 2-1 MP800 Clearance Dimensions (refer to Figure 2-3)

Callout	Description	Standard mm (in.)	Short Head mm (in.)
A	Main frame flange	1750 (5' 8-7/8")	1750 (5' 8-7/8")
B	Main frame flange	1750 (5' 8-7/8")	1750 (5' 8-7/8")
C	Main frame flange	1750 (5' 8-7/8")	1750 (5' 8-7/8")
D	Main frame hub diameter	875 (2' 10-7/16")	875 (2' 10-7/16")
E	To bottom of main frame hub	280 (11")	280 (11")
F	To bottom of oil piping	762 (2' 6")	762 (2' 6")
G	To top of bowl drive pinion guard	3385 (11' 1-1/4")	3385 (11' 1-1/4")
H	Adjustment ring maximum diameter	4550 (14' 11-1/8")	4550 (14' 11-1/8")
J	Clearance required for removing countershaft assembly	3881 (12' 8-13/16")	3881 (12' 8-13/16")
K	To end of countershaft	2538 (8' 3-15/16")	2538 (8' 3-15/16")
L	Maximum height to top of feed hopper	3860 (12' 8")	3752 (12' 3-3/4")
M	Inside diameter of feed hopper	2210 (7' 3")	2110 (6' 11-1/16")
N	To top of feed plate	2758 (9' 0-5/8")	2758 (9' 0-5/8")
O	Overall height of bowl assembly	2133 (7' 0")	1964 (6' 5-5/16")
P	Adjustment cap maximum diameter	3170 (10' 4-13/16")	3170 (10' 4-13/16")
Q	Clearance required for removing bowl assembly	5518 (18' 1-1/4")	5399 (17' 8-9/16")
R	Overall height of head assembly	2110 (6' 11-1/16")	2110 (6' 11-1/16")
S	Head or mantle maximum diameter	2114 (6' 11-1/4")	2083 (6' 10")
T	Clearance required for removing head assembly	5495 (18' 0-3/8")	5545 (18' 0-3/16")
U	Tramp release side to side	4280 (14' 0-1/2")	4280 (14' 0-1/2")
V	Additional upward travel due to clearing stroke	163 (6-7/16")	163 (6-7/16")

Table 2-2 MP800 Crusher and Sub-Assembly Weights

Assemblies	Weights kg (lbs)
Crusher complete	120,570 (265,850)
Main frame, adjustment ring, clamp ring, clamping cylinders, tramp release, eccentric, socket, countershaft box, countershaft and crusher sheave	72,450 (159,750)
Main frame, adjustment ring, clamp ring, clamping cylinders, and tramp release	61,855 (136,390)
Main frame, including main shaft and main frame liners	41,450 (91,400)
Bowl, bowl liner, adjustment cap and hopper	26,000 (57,340)
Head assembly, mantle and lifting plate	15,960 (35,200)
Countershaft box, countershaft and crusher sheave	3,195 (7,045)
Eccentric assembly (including counterweight)	7,985 (17,604)
Socket	355 (785)
Socket liner	235 (520)
Mantle	6000 (13,320)
Bowl liner	7460 (16,450)
Tramp release cylinder assembly (including accumulator)	453 (1000)
Hydraulic power unit (dry – no oil)	1,164 (2,566)
Package lube system (water cooled) (dry – no oil)	4,046 (8,920)
Package lube system (air cooled) (dry – no oil)	3,492 (7,700)
Skid mounted air cooler package (dry – no oil)	2,087 (4,600)
Since various assembly combinations are available in each crusher size, and because of manufacturing variations, the weights shown above are approximate.	

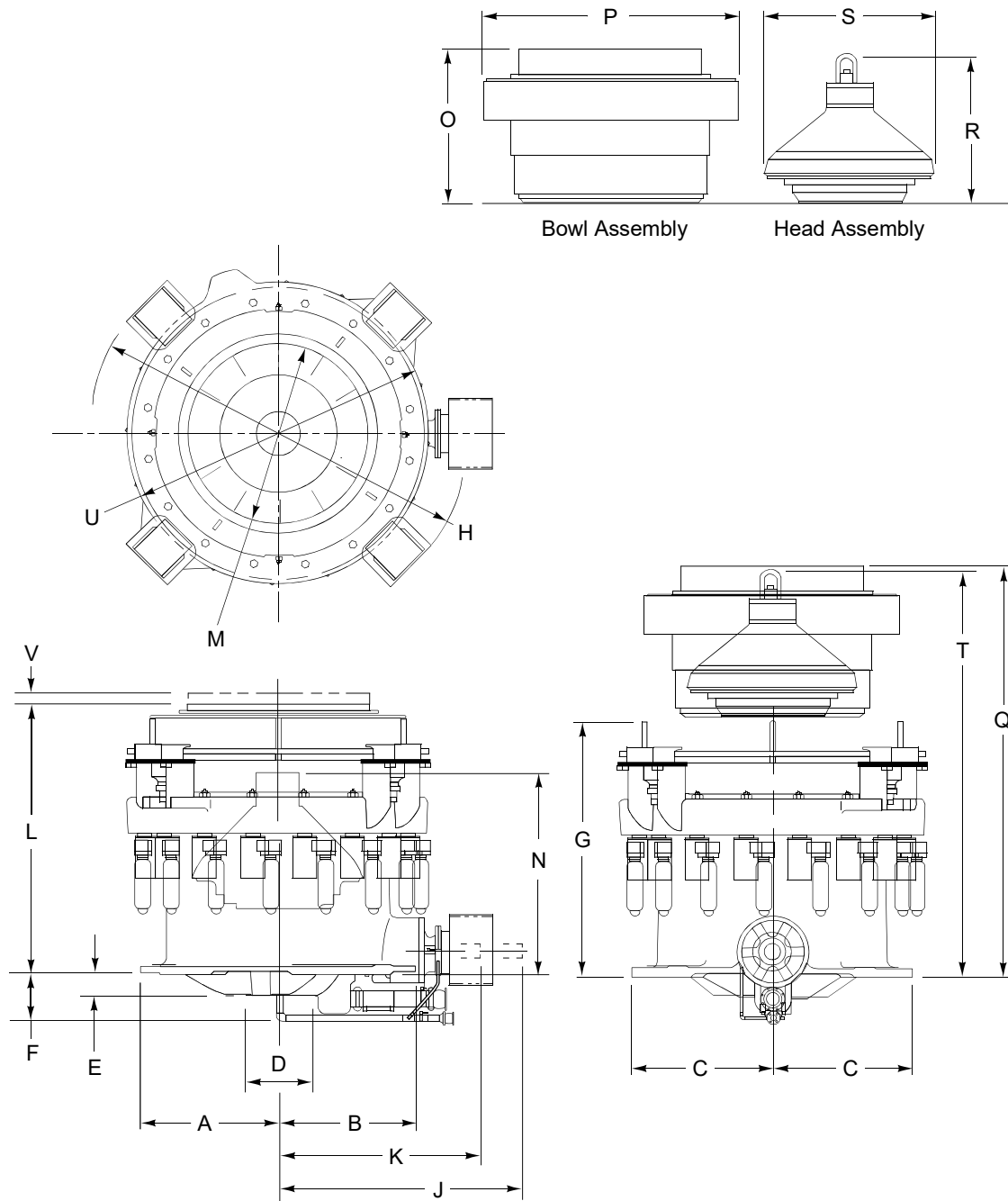


Figure 2-4 MP1000 Clearance Dimensions

Table 2-3 MP1000 Clearance Dimensions (refer to Figure 2-4)

Callout	Description	Standard mm (in.)	Short Head mm (in.)
A	Main frame flange	1950 (6' 4-3/4")	1950 (6' 4-3/4")
B	Main frame flange	2000 (6' 6-3/4")	2000 (6' 6-3/4")
C	Main frame flange	1950 (6' 4-3/4")	1950 (6' 4-3/4")
D	Main frame hub diameter	975 (3' 2-3/8")	975 (3' 2-3/8")
E	To bottom of main frame hub	310 (1' 0-3/16")	310 (1' 0-3/16")
F	To bottom of oil piping	670 (2' 2-3/8")	670 (2' 2-3/8")
G	To top of turning brackets	3660 (12' 0-1/8")	3660 (12' 0-1/8")
H	Adjustment ring maximum diameter	5360 (17' 7")	5360 (17' 7")
J	Clearance required for removing countershaft assembly	4320 (14' 2-1/16")	4320 (14' 2-1/16")
K	To end of countershaft	2855 (9' 4-3/8")	2855 (9' 4-3/8")
L	Maximum height to top of feed hopper	3926 (12' 10-9/16")	3993 (13' 1-3/16")
M	Inside diameter of feed hopper	2530 (8' 3-5/8")	2490 (8' 2-1/16")
N	To top of feed plate	3026 (9' 11-1/8")	2935 (9' 7-9/16")
O	Overall height of bowl assembly	2186 (7' 2-1/16")	2180 (7' 1-13/16")
P	Adjustment cap maximum diameter	3550 (11' 7-3/4")	3550 (11' 7-3/4")
Q	Clearance required for removing bowl assembly	5896 (19' 4-1/8")	5890 (19' 3-7/8")
R	Overall height of head assembly	2323 (7' 7-1/2")	2127 (6' 11-3/4")
S	Head or mantle maximum diameter	2392 (7' 10-3/16")	2369 (7' 9-1/4")
T	Clearance required for removing head assembly	6033 (19' 9-1/2")	5837 (19' 1-13/16")
U	Tramp release side to side	4610 (15' 1-1/2")	4610 (15' 1-1/2")
V	Additional upward travel due to clearing stroke	150 (5-15/16")	150 (5-15/16")

Table 2-4 MP1000 Crusher and Sub-Assembly Weights

Assemblies	Weights kg (lbs)
Crusher complete	150,494 (331,782)
Main frame, adjustment ring, clamp ring, clamping cylinders, tramp release, eccentric, socket, countershaft box, countershaft and crusher sheave	94,231 (207,744)
Main frame, adjustment ring, clamp ring, clamping cylinders, and tramp release	80,929 (178,418)
Main frame, including main shaft and main frame liners	46,781 (103,134)
Bowl, bowl liner, adjustment cap and hopper	33,112 (73,000)
Head assembly, mantle and lifting plate	17,573 (38,742)
Countershaft box, countershaft and crusher sheave	4,113 (9,067)
Eccentric assembly (including counterweight)	8,900 (19,620)
Socket	474 (1,045)
Socket liner	360 (794)
Mantle	5,538 (12,209)
Bowl liner	5,837 (12,869)
Tramp release cylinder assembly (including accumulator)	453 (1000)
Hydraulic power unit (dry – no oil)	1,250 (2,756)
Package lube system (water cooled) (dry – no oil)	4,046 (8,920)
Package lube system (air cooled) (dry – no oil)	3,492 (7,700)
Skid mounted air cooler package (dry – no oil)	2,730 (6,020)
Since various assembly combinations are available, and because of manufacturing variations, the weights shown above are approximate	

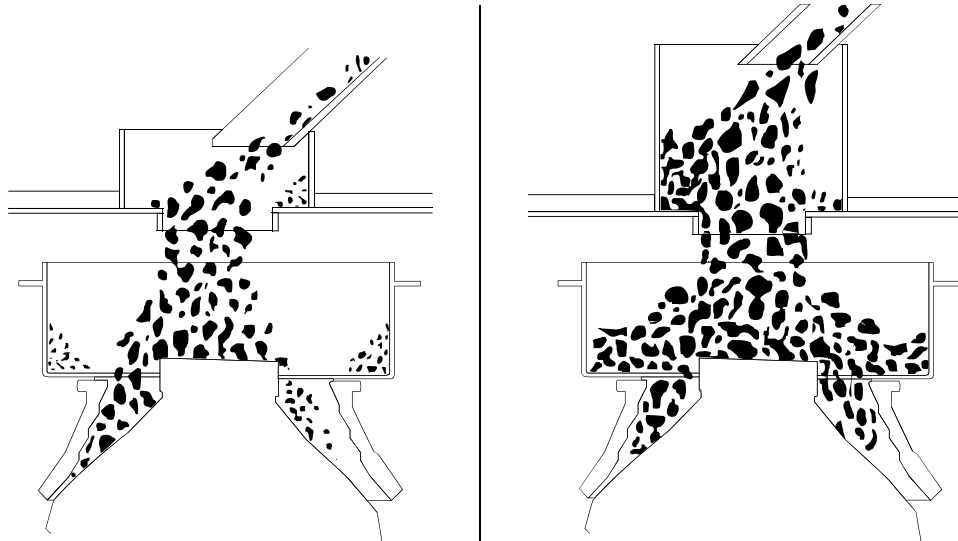
2.4 Feed Arrangement

The feed material going to the Crusher must be controlled to keep the Crusher from overflowing, to keep the Crusher from drawing too much power and to keep the crushing forces within the design limits (crushing force overload is exhibited by adjustment ring motion relative to the mainframe; called ring bounce). This is usually done by locating a surge bin with a variable speed feeder directly ahead of the Crusher so that the rate of feed can be adjusted based on the cavity level, power draw and adjustment ring vibration levels.

The presentation of the feed material into the crushing cavity is also important. The feed material should not drop more than 4' into the Crusher from the feeder or chute. The preferred arrangement is shown on the drawing provided as part of the installation drawing package called "suggested feed arrangement". Here we show the basic design of

the feed arrangement that should include a rock box. The feed material should overshoot the center of the Crusher and impact into a dead bed rock box which has a feed chute that can be located so that the feed material will impact onto the center of the crusher feed plate. This design provides the limit to feed velocity required. It also provides the centering of feed into the Crusher and will reduce the segregation of fine versus coarse material due to the mixing in the dead bed rock box. Refer to Figure 2-5.

If the feed particles are very large, it may not be possible to use a feed chute due to bridging which can occur with the restriction of the feed chute. In these cases, a larger diameter hole with wear protection, can be used to direct the cascade of material out of the rock box and onto the feed plate of the Crusher.



Incorrect Method of Feed	Correct Method of Feed
Here the incoming material passes through one side of the feed opening, causing uneven distribution.	Here the incoming material falls on the feed plate properly.
Results of uneven distribution are:	Results of even distribution are:
<ul style="list-style-type: none"> • reduced capacity • oversize product • excessive adjustment ring movement • maximum bearing pressure • maximum power consumption 	<ul style="list-style-type: none"> • maximum capacity • uniform product • minimum adjustment ring movement • minimum bearing pressures • minimum power consumption

Figure 2-5 Feed Arrangement

Lesser feed arrangements will have a direct effect on the performance of the Crusher. If the feed rate control point is farther from the Crusher or if a scalping screen is located between the feed rate control and the Crusher, the additional lag time for the change in feed rate will mean that the Crusher will have to run at a lower average feed rate to avoid overload.

If the velocity of the feed material is too high, the feed can drop too far down into the Crusher, especially when the feed is first introduced to the Crusher. This will result in very erratic power draw and could lead to ring bounce due to the high reduction done in the first blow to the feed particles.

A preferred circuit diagram is shown as Figure 2-6.

NOTICE

Regardless of application, place a screen ahead of the Crusher in the circuit to remove fine or sticky material from the feed prior to crushing. This will eliminate packing, excessive adjustment ring movement and inefficient operation. A metal detector can also be installed to remove metallic objects, such as tramp iron which would cause adjustment ring movement.

The feeding equipment must be of adequate size so as to maintain maximum feed conditions to the Crusher. Various crusher feed plate configurations are available to suit your operating conditions.

NOTICE

It is important to control the speed of material entering the Crusher. Material dropped from a high distance into the Crusher can pass almost entirely through the open side of the cavity. Material falling to the bottom of the cavity without being crushed will cause an abnormal amount of ring bounce. This results in severe main frame seat damage. A rock ladder, rock box, or similar velocity reduction device must be used if the material drop into the cavity exceeds 2.4 m (96") or more.

The correct and incorrect methods of feed and feed box construction are shown in Figure 2-5. Also refer to the suggested feed arrangement drawing, which was furnished with the installation drawing package for your Crusher.

Whenever possible, the control philosophy should be to operate the Crusher in a choke fed manner. This means that there will be an excess of feed material that will build up in the crushing cavity to fill the crushing chamber and cover the feed plate. The target level in the crushing cavity should be 300 mm (12") above the top of the feed plate. This will ensure uniform spread of feed around the crushing cavity and prevent offset feed conditions from developing. It also evens out the power draw to allow a higher average power draw which translates into higher production. It is also a fact that a choke fed Crusher will produce a finer product size at the same setting as another unit operated without a choke fed cavity.

In order to maintain a consistent feed level in the crushing chamber, consideration must be given in the design of the feed arrangement for the installation of a level sensing device. We normally recommend ultrasonic type level sensors which can provide an analog output proportional to the cavity level for good control of the feeder. Contact resistance probes and microwave devices have also been used with success.

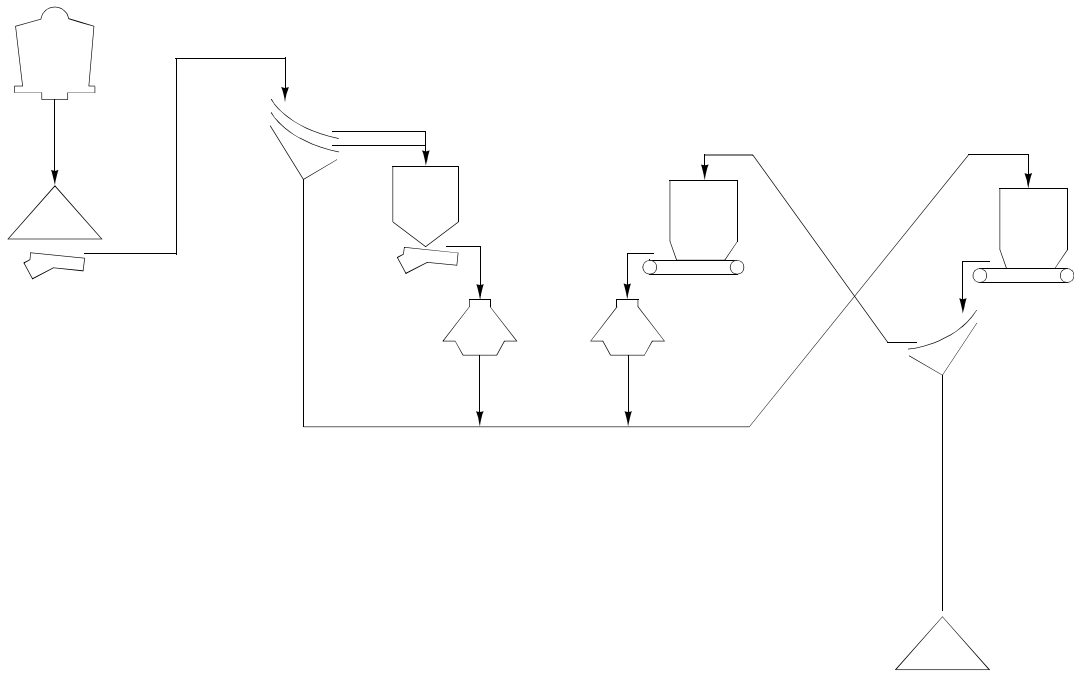


Figure 2-6 Suggested Circuit Diagram for Optimum Crusher Productivity

2.5 Discharge Arrangement

Since the discharge arrangement varies with each installation, a discharge compartment or chute is not furnished with the Crusher. Either metal or wood may be used for the discharge compartment. An inspection door should be provided in the compartment so that the inside of the compartment is readily accessible for cleaning or inspection. A shelf or ledge should be constructed within the discharge compartment. The shelf will provide a dead bed of crushed material on which the falling material will hit. The shelf will absorb much of the impact before the material falls onto the conveying equipment, adding considerable life to such equipment.

If a chute is to be used, the slope of the chute must be more than 45° with the horizontal and, if material is very sticky, the angle of inclination should be increased.

There should be sufficient clearance, between the main frame and the bottom of the discharge compartment and between the discharge opening or chute and the conveying belt or elevator. Adequate clearance at these points will prevent material from clogging the discharge area and causing it to build

up under the head and interfere with the operation of the Crusher. This will ensure a free unimpeded discharge of crushed material.

2.6 Type of Drive

The standard recommendation for driving the Crusher is through a V-belt drive. The V-belt drive is particularly desirable because of, first its feature which prevents crusher shock loads from being transferred to the crusher motor and, secondly, its ability to carry surge loads without a resultant loss in crusher speed.

The V-belt drive can consist of either single or banded belts. See Figure 2-7.

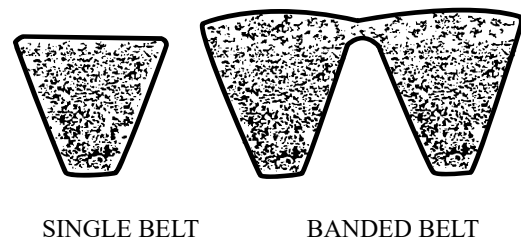


Figure 2-7 Belt Cross Sections

The narrower belts are designed for compactness of drive, drive economy and reduced overhung load. Banded belts are single belts unitized with a common cover to prevent belt whip or turnover. Banded belts fit all standard sheaves, however, banded belts should be limited to only 2 or 4 individual belts banded together.

If the motor sheave is to be located directly ABOVE the countershaft or within 30° of the crusher vertical centerline, the factory must be informed as to the position of the drive sheave, so that the OUTER countershaft bushing can be properly installed.

The Crusher may also be direct driven, that is, coupling connected to a driving motor.

Any problems related to the crusher drive should be submitted to the factory for suggestions.

2.7 Crusher Motor

The recommended electrical driving motor is a crusher duty squirrel cage induction motor; continuous rated, with normal starting torque (approximately 125%) and normal breakdown torque (approximately 200%) with $\pm 10\%$ acceptable voltage variance. It is recommended that crusher motors of the horsepower used with MP Crushers be equipped with reduced voltage starters.

Abrasive resistant insulation and stator thermostats (an internal protective device) are suggested. The motor can either be open drip-proof or totally enclosed fan cooled.

To maintain continuous service of the recommended operating horsepower level shown on the mounting and clearance drawing, an electric motor with 1.15 service factor is required. If a service factor of 1.0 is used, the horsepower rating appearing on the motor's nameplate should be approximately 15% higher than the recommended operating horsepower. However, the crusher power draw is to be held to the horsepower shown on the mounting and clearance drawing.

With the V-belt drive, slide rails under the jack shaft drive base are required to provide allowance for the V-belt take-up due to belt stretch and for belt installation.

If a direct drive is used, care should be taken when ordering the motor that the motor shaft extension and bearings are adequately sized for a direct drive

application. The motor shaft diameter must be able to withstand peak torque. The motor manufacturer should contact Metso Minerals regarding the gear mesh frequency for motor design. The motor will also require special consideration for shock and vibration.

All horsepower ratings referred to on mounting and clearance drawings are based on electric horsepower.

2.8 V-belt Drive

It is important that this entire section be completely read before installing and tensioning the V-belt drive.

2.8.1 Initial Installation of V-belt Drive

For the initial installation or when reassembling the V-belt drive, proceed as follows:

1. Clean all oil, grease or rust from the sheave grooves.
2. Make certain that the sheaves are correctly aligned and that the shafts are parallel.
3. Never force belts onto sheaves. Always shorten the center distance until belts can be slipped on easily. To determine the minimum allowances for shortening or lengthening the center distance between sheaves, see Table 2-5.

After calculating a center distance from a standard pitch length make provision that the centers can be moved closer together by the amount shown in Figure 2-8 and Table 2-5 to facilitate installing the belts without injury. Also, the centers should be adjustable over the calculated distance by an amount as shown in the last column of Table 2-5 because of manufacturing tolerance and possible stretch and wear of belt.

4. Always use a matched set of belts and use new belts of the same manufacture. Never mix worn and new belts.
5. Frequently check the tension on a new drive during the first day of operation.

2.8.2 Tensioning the V-belt Drive

Tensioning the drive is a term used when force is applied to the V-belt by some method to provide the wedging action between the V-belt and the sheave. This wedging action provides the ability for a V-belt to transmit power from the motor sheave to the crusher sheave.

Proper belt tensioning is the most important factor in the successful operation of a V-belt drive. The best tension is the lowest tension at which the belts will not slip under maximum peak loads. Too much tension shortens belt life, increases bearing wear, and can lead to bearing problems. Overtight belts can cause early failure and should be avoided. It is suggested to monitor the temperature of the countershaft box after tensioning belts to avoid possible bearing problems resulting from over tensioning.

Various methods of tensioning V-belts have been established. Two simplified methods will be described in the following paragraphs; Tension-Deflection and Percent (%) of Elongation. Either of these two methods will provide satisfactory belt tension. Each has certain advantages for a given type of belt.

The Tension-Deflection method should be used on drives with standard V-belts. The Percent Elongation method is preferred on drives with banded V-belts. If a tension device or spring scale is not available the Percent Elongation method may be used for standard V-belts.

There are different conditions that exist for the drive that require different tensioning procedures. These different tensioning procedures will permit a running-in of the countershaft bushing and proper tensioning of the V-belts. These procedures are described in the following paragraphs.

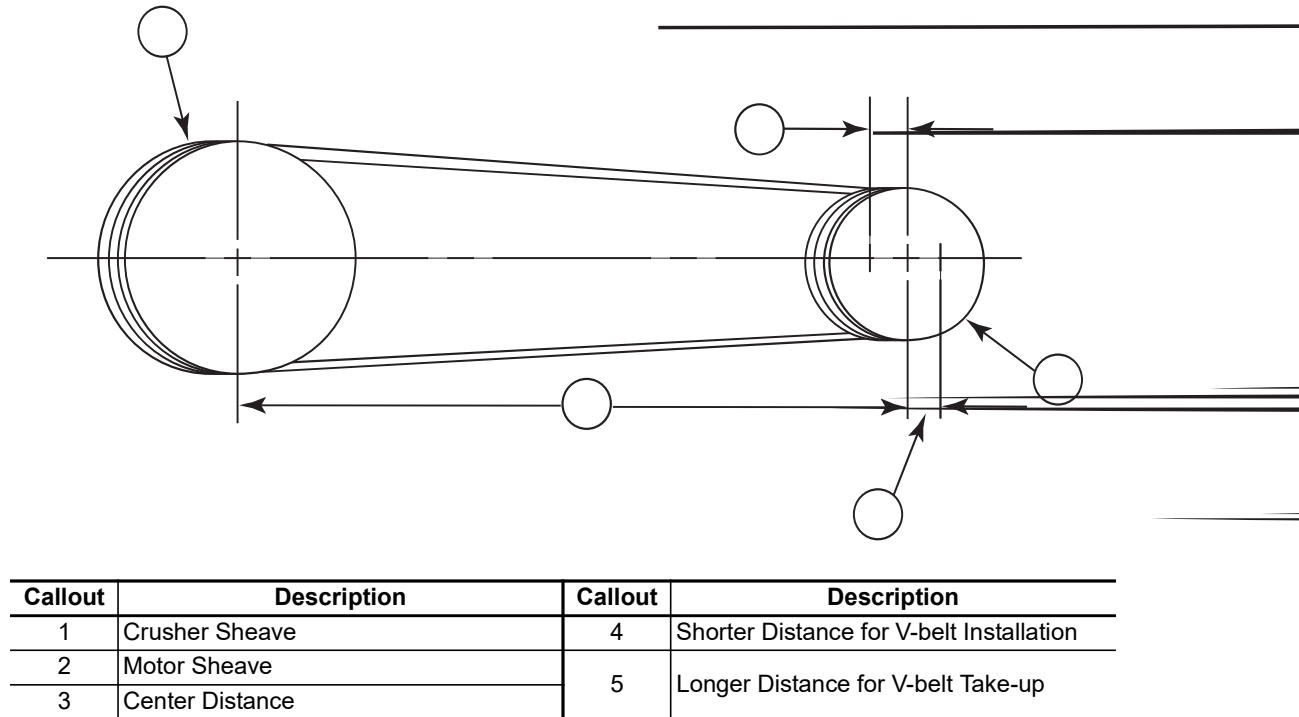
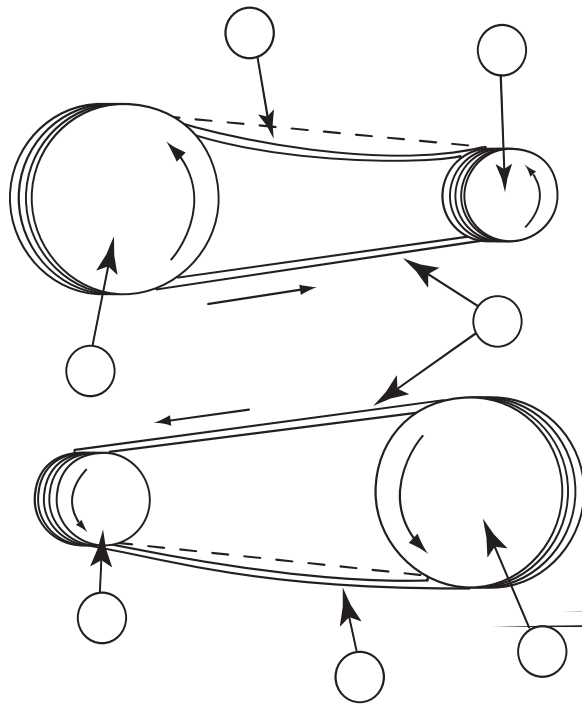


Figure 2-8 V-belt Installation and Take-up Allowances

Minimum Allowance mm (inches) Below Center Distance For Installation of Belts			
Belt Length* mm (inches)	V-belt Section		Minimum Allowance Above Center Distance For Stretch and Wear All Sections
	8V	8V Power Band	
630 (25) thru 1199 (47)	—	—	25 (1)
1200 (47) thru 1999 (79)	—	—	35 (1-3/8)
2000 (79) thru 2749 (108)	40 (1-1/2)	85 (3-3/8)	40 (1-1/2)
2750 (108) thru 3499 (138)	40 (1-1/2)	85 (3-3/8)	45 (1-3/4)
3500 (138) thru 4499 (177)	40 (1-1/2)	85 (3-3/8)	55 (2-1/8)
4500 (177) thru 5499 (216)	45 (1-3/4)	90 (3-1/2)	65 (2-1/2)
5500 (216) thru 6499 (256)	45 (1-3/4)	90 (3-1/2)	85 (3-3/8)
6500 (256) thru 7999 (315)	45 (1-3/4)	90 (3-1/2)	95 (3-1/2)
8000 (315) thru 9999 (394)	50 (2)	100 (4)	110 (4-3/8)
over 10,000 (394)	50 (2)	100 (4)	140 (5-1/2)

* In each group the range is to, but not including the second length.

Table 2-5 V-belt Installation And Take-up Allowances



Callout	Description
1	Crusher Sheave
2	Motor Sheave
3	Tight Side
4	Slack Side - Note Bow or Sag in Belt

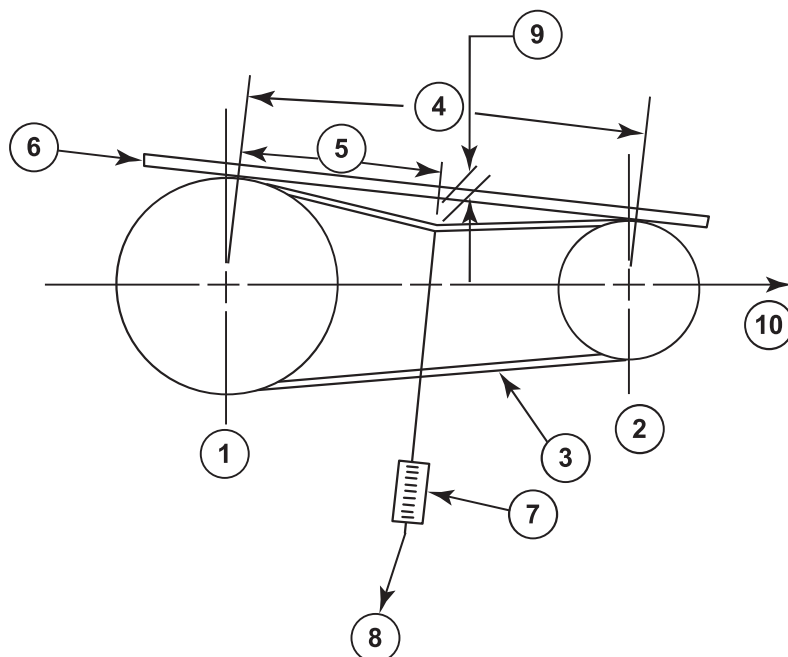
Figure 2-9 Determining Slack Side

2.8.3 Tension-Deflection Method

General method for determining amount of deflection based on the force applied.

1. Reduce the center distance so that the belts may be placed over the sheaves and in the grooves without forcing them over the sides of the grooves. Arrange the belts so that both the top and bottom spans have about the same sag. Apply tension to the belts by increasing the center distance until the belts are snug. See Figure 2-9.
2. Place a straight edge across the top of both sheaves. See Figure 2-10.
3. Measure the span length.
4. Using a tension device or spring scale at right angles to the center of the span length, apply a force to the device or scale great enough to deflect one of the belts the equivalent of 0.016 times millimeters of span length (0.016 times inches of span length).

Estimate the average deflection for all belts, not concentrating on either the strongest or the weakest belt.
5. The force should approximate the forces in Table 2-6 for a properly tensioned drive. These forces are for individual belts and must be multiplied by the number of belts per band if banded belts are being used.



Callout	Description	Callout	Description
1	Crusher Sheave	6	Straight Edge
2	Motor Sheave	7	Spring Scale
3	Belt	8	Force (Per Table)
4	Span Length	9	Deflection 0.4 mm (1/64") for each 25mm (1") of Span Length
5	1/2 Span Length	10	Pull

Figure 2-10 Tension-Deflection Method

2.8.4 Example for New V-belts

V-belt section = Standard 8V belt

Span length (center distance) = 3226 mm (127")

Deflection force (from Table 2-6) = 13.6 Kg.
(30 lbs.)

Deflection = 3226 mm (127") x 0.016 = 51.5 mm
(2.03")

Therefore, on a NEW installation with a standard 8V section belt and a span length of 3226 mm (127"), the belt should deflect 51.5 mm (2.03") with a spring force of 13.6 Kg. (30 lbs.) for a properly tensioned drive.

Standard Belt

Belt Type	Belt Section	Minimum Tension	Maximum Tension	Initial Tension
Optibelt or Gates	8V	Kgs (Lbs) 13.6 (30)	Kgs (Lbs) 17.7 (39)	Kgs (Lbs) 17.7 (39)
Other Brands	8V	Consult Metso Minerals		

Note: These forces are for individual belts and must be multiplied by the number of belts per band if banded belts are being used.

Table 2-6 Deflection Forces

SEE THE APPROPRIATE FOLLOWING SECTION FOR THE CORRESPONDING CONDITIONS REGARDING NEW OR EXISTING BELTS AND NEW OR EXISTING COUNTERSHAFT BUSHINGS.

2.8.5 Tensioning Procedure for Standard V-belts for a New Crusher Installation When a New Countershaft Bushing with new V-belts Has Been Installed

1. Tension the belts to the MINIMUM TENSION shown in Table 2-6.
2. Run the Crusher WITHOUT material for a period of 2 hours. See INITIAL START-UP AND BREAK-IN PROCEDURE in *Section 11*.
3. After the 2 hour period retension the belts to the INITIAL TENSION shown in Table 2-6.
4. After completing the 6 hours of reduced load running, the belts tension should be checked to ensure it is above the MINIMUM TENSION shown in Table 2-6. If the tension is not above the MINIMUM TENSION then retension to the MAXIMUM TENSION shown in Table 2-6.
5. After 1-4 hours of full load operation the belts should be checked and if necessary retensioned so that the force is between the MINIMUM and MAXIMUM TENSION shown in Table 2-6.
6. After 24-48 hours, it is well to check the belt tension to see if the force on the belts is between the MINIMUM and MAXIMUM TENSION shown in Table 2-6. Retension if necessary.

2.8.6 Tensioning Procedure for Standard V-belts When a New Countershaft Bushing Has Been Installed and Using the Existing V-belts

1. Tension the belts to the MINIMUM TENSION shown in Table 2-6.
2. Run the Crusher WITHOUT material for a period of 2 hours. See INITIAL START-UP AND BREAK-IN PROCEDURE in *Section 11*.

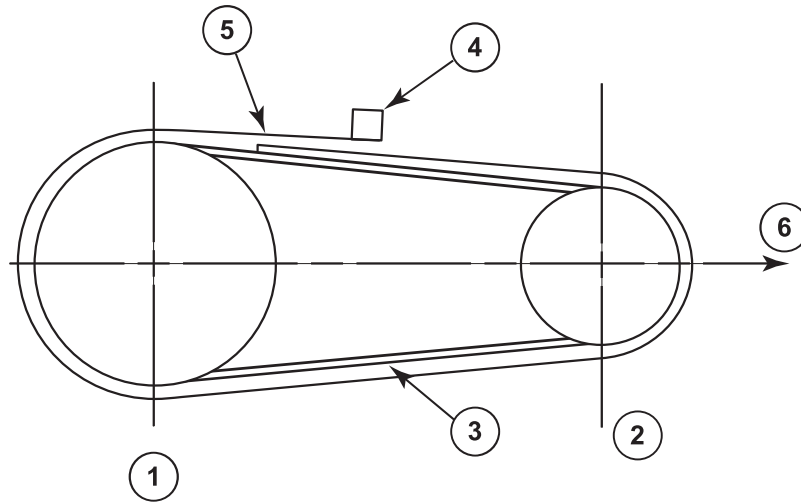
3. After the 2 hour period, retension so that the force is between the MINIMUM and MAXIMUM TENSION shown in Table 2-6.
4. After 24-48 hours, check the belt tension to see if the force on the belts is between the MINIMUM and MAXIMUM TENSION shown in Table 2-6. Retension if necessary.

2.8.7 Tensioning Procedure for Standard V-belts When New V-belts Have Been Installed With Existing Countershaft Bushing

1. Tension the V-belts to the INITIAL TENSION shown in Table 2-6.
2. After 1-4 hours of full load operation, the belt tension should be checked to ensure it is between the MINIMUM and MAXIMUM TENSION shown in Table 2-6. Retension if necessary.
3. After 24-48 hours, it is well to check the belt tension to see if the force on the belts is between the MINIMUM and MAXIMUM TENSION shown in Table 2-6. Retension if necessary.

2.8.8 Retensioning Procedure for Standard V-belts Using Existing V-belts

1. Retension the belts so that the force on the belts is between the MINIMUM and MAXIMUM TENSION shown in Table 2-6.



Callout	Description	Callout	Description
1	Crusher Sheave	4	Steel Tape
2	Motor Sheave	5	Tape Reading
3	Belt	6	Pull

Figure 2-11 Percent of Elongation Method

Standard and Banded Belts

Belt Type	Belt Section	Crusher	Minimum Multiplier	Percent	Maximum Multiplier	Percent
Standard Optibelt	8V	MP800	0.005	0.5	0.006	0.6
		MP1000	0.006	0.6	0.007	0.7
Banded Optibelt	8V	MP800	0.006	0.6	0.007	0.7
		MP1000	0.007	0.7	0.008	0.8
Gates	8V	Tension Deflection Method Recommended				
Other Brand Belts	8V	Consult Metso Minerals				

Table 2-7 Elongation Factors

2.8.9 Percent Elongation Method

General method for tensioning V-belt drives.

1. With the V-belts or bands on the drive at NO tension, measure the outside circumference (slack O.C.) of the belts or bands.
2. Record this measurement to the nearest millimeter (1/16").
3. Multiply this recorded length by a elongation factor multiplier which is shown in Table 2-7 and add this amount to the initial measurement.
4. Elongate the belt to this new reading.

EXAMPLE

Type belt = Standard 8V

(Optibelt for MP1000)

Initial tape reading = 9017 mm (355")

Elongation factor (from Table 2-7) = 0.006 (Multiplier) which is 0.6% (percent)

New length reading = 9017 mm (355") initial reading + [9017 mm (355") initial reading x 0.006 elongation factor] = 9017 mm (355") + 54 mm (2-1/8") or 9071 mm (357-1/8").

Therefore, on an installation with an 8V belt and an outside circumference measurement of 9017 mm (355"), the motor sheave should be moved away from the crusher sheave until the steel tape reads 9071 mm (357-1/8") for a properly tensioned drive.

5. Periodic belt tension checks must be made and if retensioning becomes necessary, decrease the center distance until there is no tension on the belts or bands, then measure the outside circumference (slack O.C.) of the belts or bands. Retension the drive following the method just described.

It must be pointed out that the TENSION-DEFLECTION METHOD is the preferred method of tensioning V-belts unless using banded belts.

Usually the first sign that indicates retensioning is necessary is belt slippage. This slippage will show up in loss of power and speed at the crusher sheave and in a high rate of belt and sheave groove wear. These conditions are usually accompanied by belt "squeal" and also a heating up of belts and sheaves. These conditions are readily apparent and can be detected by simply looking, listening, and feeling.

2.8.10 Tensioning Procedure for Standard or Banded V-belts for a New Crusher Installation or When a New Countershaft Bushing With New V-belts Has Been Installed

1. Tension the belts or bands to a value that is obtained by using the MINIMUM MULTIPLIER as shown in Table 2-7.

2. Run the Crusher WITHOUT material for a period of 2 hours. See INITIAL START-UP AND BREAK-IN PROCEDURE in *Section 11*.
3. After the 2 hour period, retension the belts or bands to the MAXIMUM MULTIPLIER as shown in Table 2-7.
4. After 1-4 hours of full load operation, the belts or bands should be checked and if necessary retensioned to the MINIMUM MULTIPLIER as shown in Table 2-7.
5. Periodic belt or band tension checks must be made and if retensioning becomes necessary, the tensioning process should be repeated and the tension set to the MINIMUM MULTIPLIER as shown in Table 2-7.

2.8.11 Tensioning Procedure for Standard or Banded V-belts When a New Countershaft Bushing Has Been Installed and Using the Existing V-belts or Bands

1. Tension the belts or bands to a value that is obtained by using the MINIMUM MULTIPLIER as shown in Table 2-7.
2. Run the Crusher WITHOUT material for a period of 2 hours.
3. Periodic belt or band tension checks must be made and if retensioning becomes necessary, the tensioning process should be repeated and the tension set to the MINIMUM MULTIPLIER as shown in Table 2-7.

2.8.12 Tensioning Procedure for Standard or Banded V-belts When New Belts Have Been Installed With Existing Countershaft Bushing

1. Tension the belts or bands to a value that is obtained by using the MAXIMUM MULTIPLIER as shown in Table 2-7.
2. After 1-4 hours of full load operation the belts or bands should be checked and if necessary retensioned to the MINIMUM MULTIPLIER as shown in Table 2-7.
3. Periodic belt or band tension checks must be made and if retensioning becomes necessary, the tensioning process should be repeated and the tension set to the MINIMUM MULTIPLIER as shown in Table 2-7.

2.8.13 Retensioning Procedure for Standard or Banded V-belts Using Existing Bands or Belts

1. Periodic belt or band tension checks must be made and if retensioning becomes necessary, the tensioning process should be repeated and the tension set to the MINIMUM MULTIPLIER as shown in Table 2-7.

2.9 V-belt Precautions

Some of the do's and don'ts in connection with proper V-belt drive operation are as follows:

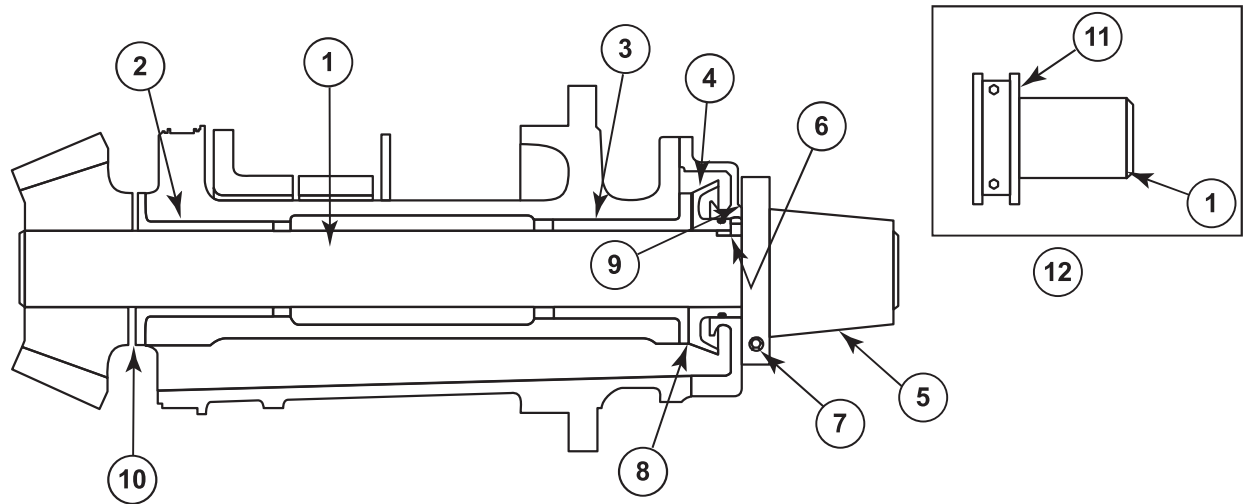
1. DO - Check belt tension frequently during the first few days of run-in operation. When the belts have had time to become seated in the sheave groove, retension the belts. New belts have a certain amount of initial stretch and will require additional tensioning.
2. DON'T - Overtighten belts as too much tension shortens both belt and bearing life. Maintain uniform tension. Idle belts should appear snug or tight; in motion, they have a slight sag on the slack side.
3. DO - Keep drives well ventilated as heat build-up over 60°C (140°F) causes belt life to become shortened. The sides of the belt guard must be designed to allow for adequate circulation of air. Either perforated plate or expanded metal is ideal for this type of application.
4. DON'T - Allow any oil or grease to come in contact with the belts as excessive oil causes the rubber to swell and the belts to fail prematurely.
5. DO - Make V-belt drive general inspections on a periodic basis. The following points should be checked at each inspection.
 - a. Loss of crusher speed - check tension.
 - b. Unequal stretch - check for internal breaks.
 - c. Excessive elongation - check for overload.
 - d. Belt softening or swelling - check for oil or grease.
 - e. Belt hardening and cracking - check for excessive heat.
6. Values from Table 2-6 and Table 2-7 are based on V-belts that are of typical construction. If V-belts of other construction are used the tension obtained from using these values may result in too high of a tension and could result in bushing or motor bearing failure.
7. Monitor the temperature of the countershaft box after tensioning belts to avoid possible

bearing problems resulting from over tensioning. Reduce belt tension if countershaft box exterior temperature increases and exceeds oil drain line temperature by 3°C (5°F) or more.

NOTICE

Monitor countershaft bushing RTD and reduce belt tension if temperature increases and exceeds oil drain line temperature by 6°C (10°F) or more.

8. After any belt tensioning adjustment, the countershaft coast down time should be rechecked. A significant decrease from previous readings may indicate that the belts have been overtensioned.



Callout	Description	Callout	Description
1	Countershaft	8	Tight (no gap)
2	Inner countershaft bushing	9	No clearance (tight)
3	Outer countershaft bushing	10	Measure end float here
4	Oil flinger		• 1.5 mm (0.060") to
5	Sheave bushing		• 0.8 mm (0.030")
6	Sheave key	11	Set collar (for direct drive or shipping)
7	Clamp screw	12	For Direct Drive or Shipping

Figure 2-12 End Float - V-belt Drive

2.10 Checking End Float

If the countershaft box was shipped completely assembled, the end float was set correctly at the factory; but, as it is important for the proper operation of the Crusher, recheck the end float. The countershaft must be free to move in and out. See Figure 2-12 and check end float as follows:

1. Pull the pinion end of the countershaft until the oil flinger is tight against outer countershaft bushing flange.
2. Use a feeler gauge to measure the gap (end float) between the pinion and countershaft bushing. The end float should be between 1.5 mm (.060") and 0.8 mm (0.30"). If not, obtain correct end float as described under COUNTERSHAFT BOX ASSEMBLY in Section 4.

2.11 Crusher Sheave Installation (V-belt Drive)

To install a crusher sheave with a removable bushing, see Figure 2-13 and proceed as follows:

1. Refer to the oil piping drawing and install all oil piping.
2. Remove the split tapered bushing from the sheave by unscrewing the combination take-up and back-off capscrews, if bushing has not been installed.
3. Check that the tapered surface and bore of the bushing, the tapered bore of the sheave and the countershaft, are clean and free of burrs, scratches and all foreign matter, such as paint, dirt and lubricants.
4. Gently tap the sheave key into the countershaft keyway with a light hammer, if key and bushing has not been installed.

5. Loosen the clamp screw and slide the bushing onto the countershaft aligning the sheave key and keyway. If necessary, insert a wedge (example: screwdriver) into bushing slit to aid in installation of bushing. Tighten clamp screw when bushing is tight against oil flinger.
6. Move countershaft in and out to recheck end float. See CHECKING END FLOAT earlier in this section.
7. Slide the sheave over the bushing being careful to keep the bolt holes lined up with the tapped holes in the bushing flange.
8. Insert the take-up bolts through the bolt holes and alternately tighten each bolt a small amount until all bolts are tightened to a final torque value identified in Table 2-8 based on the size of the sheave bushing. Do not lubricate the bolt threads or the tapped holes. When the sheave is finally positioned a clearance of approximately 10 mm (.375") should exist between the face of the sheave hub and the flange of the bushing. No attempt should be made to take up this clearance as this clearance assures the proper fit and grip between sheave bushing and countershaft. Follow the torque requirements closely; overtightening the take-up bolts could cause the sheave to crack.

2.12 Crusher Sheave Removal

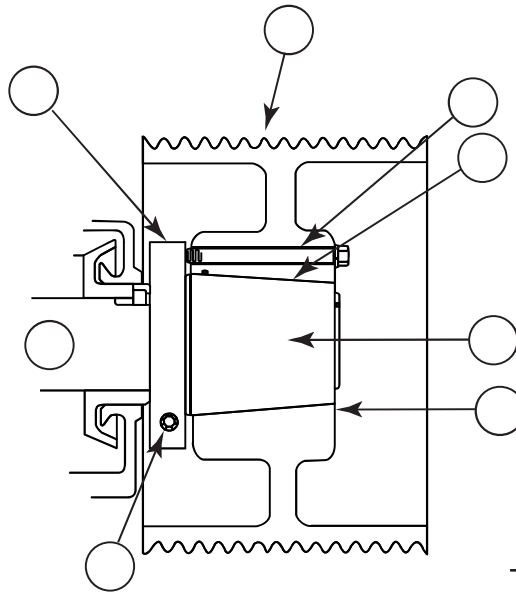
To remove the crusher sheave, refer to Figure 2-13 and proceed as follows:

1. Remove the take-up capscrews and thread two of them into the tapped holes in the hub of the sheave. Using the two capscrews as back-off bolts, exert pressure by tightening them against the flange of the bushing, breaking the sheave grip on the bushing cone. Remove the sheave.

NOTICE

Should there be difficulty "breaking" the fit between the sheave and bushing, tap the end of the shaft or bushing with a babbitt hammer while maintaining back-off bolt pressure, until the sheave is loose enough to remove.

2. Loosen sheave bushing clamp screws.
3. If necessary, insert a wedge such as a screwdriver into the split in the bushing flange and remove the bushing.



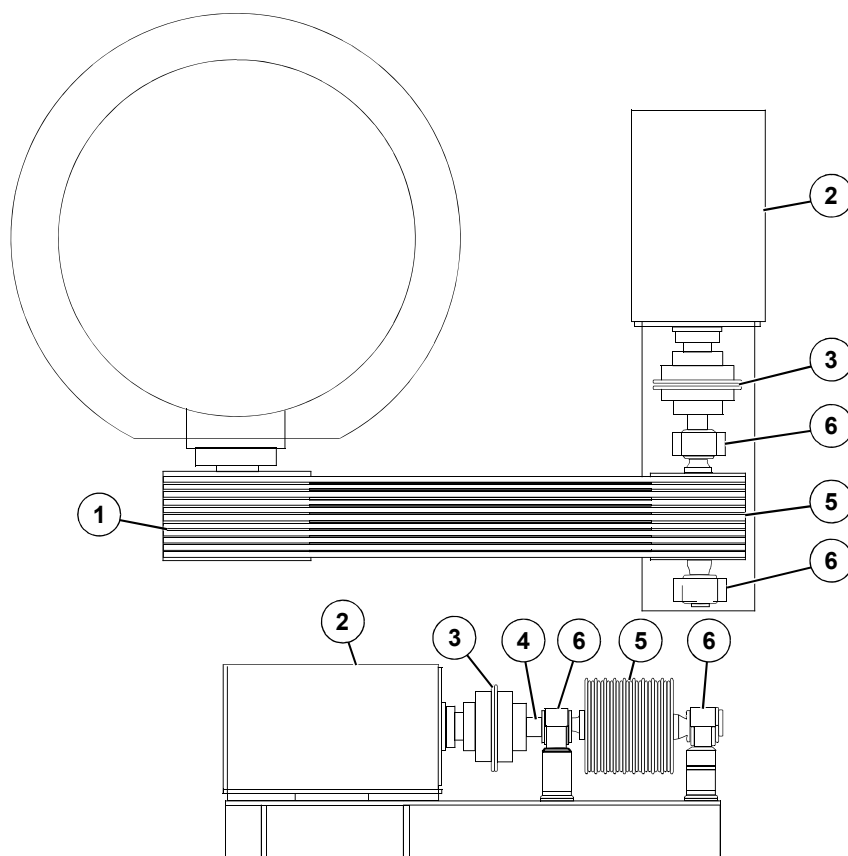
Callout	Description	Callout	Description
1	Countershaft	5	Tapered Surfaces
2	Sheave	6	Combination Take-up and Back-off Capscrews
3	Sheave Hub	7	Flange Diameter
4	Bushing	8	Clamp Screw

Figure 2-13 Sheave Assembly

2.13 Jack Shaft Drive

Due to the large belt pull the motor shaft and bearings must handle, a system with the motor sheave mounted directly on the shaft would require

a special crusher drive motor that is very expensive. To minimize motor cost, we recommend a jack shaft drive design (refer to Figure 2-14) for use in conjunction with our recommended V-belt drive.



Callout	Description	Callout	Description
1	Crusher sheave	4	Jack shaft
2	Electric motor	5	Motor sheave
3	Flexible coupling	6	Pillow block

Figure 2-14 Recommended Jack Shaft Drive Arrangement

2.14 Direct Drive

Flexible Coupling Removal

Remove the flexible coupling half from the countershaft as described in the coupling manufacturer's instructions.

Flexible Coupling Installation

(See Figure 2-15)

For the initial installation or when reassembling the flexible coupling on a direct drive arrangement, proceed as follows:

1. Disassemble the coupling.

2. Inspect both the driving and driven shafts and coupling bores, making sure they are free from burrs, scratches, and all foreign matter. Be sure the keys fit the shafts and coupling halves properly.
3. Since the coupling halves are mounted on both the crusher countershaft and motor shaft with an interference fit, heat the coupling hub to a temperature of approximately 96°C (175°F) above ambient temperature and install on the shaft as quickly as possible.

NOTICE

Do not heat the coupling hub over 135°C (275°F) as the flange or gap portion of the coupling could become damaged from excessive heat. A chemical marking device which melts at a predetermined temperature should be used to insure uniform and safe heating.

⚠ WARNING

Use heavy well insulated gloves when handling the heated coupling halves.

IDENTIFYING SIZE SHEAVE BUSHING FOR PROPER TORQUE REQUIREMENTS		DO NOT USE ANY LUBRICANTS		
		PROPER TORQUE WHEN USING TORQUE WRENCH	PROPER WRENCH PULL WHEN USING OPEN END OR SOCKET WRENCH	
BUSHING FLANGE DIAMETER MILLIMETERS (INCHES)	SIZE AND THREAD OF TAKE-UP CAPSCREWS (INCHES)	NEWTON METERS (FOOT POUNDS)	WRENCH LENGTH MILLIMETERS (INCHES)	WRENCH PULL KILOGRAMS (POUNDS)
229 (9)	3/4-10	305 (225)	381 (15)	82 (180)
254 (10)	7/8-9	407 (300)	381 (15)	109 (240)
298 (11-3/4)	1-8	610 (450)	457 (18)	136 (300)
381 (15)	1-1/8-7	814 (600)	610 (24)	136 (300)
451 (17-3/4)	1-1/4-7	1017 (750)	610 (24)	170 (375)

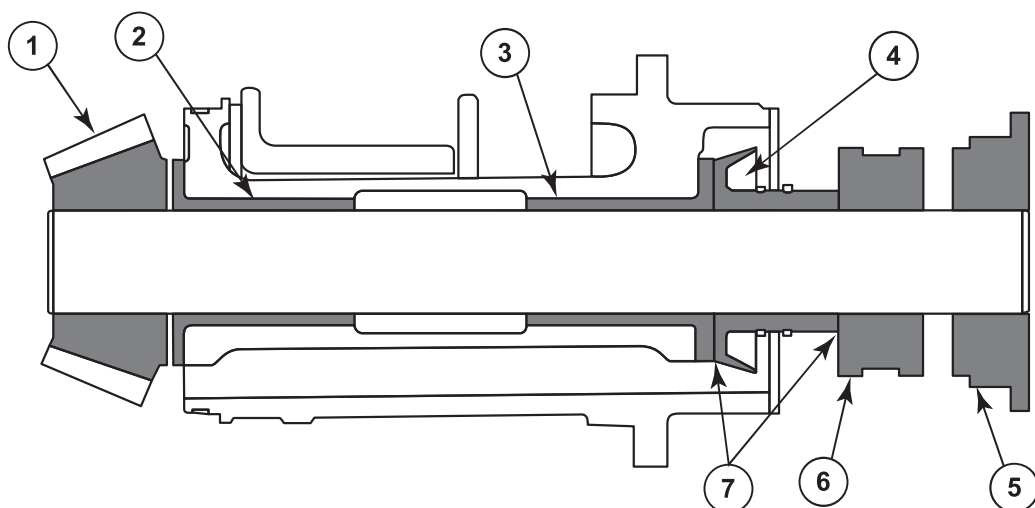
Table 2-8 Take-up Capscrew Torque Requirements

4. Measure the shaft diameter and the bore of the coupling as it is being heated to be sure the bore is slightly larger than the shaft. If the coupling has been heated properly, no trouble should be encountered in positioning the coupling on the shaft. Make sure the keyways are properly aligned.
5. Drive in the keys.
6. In order to provide the proper countershaft end float using a direct drive arrangement, a safety set collar has been installed on the countershaft. See Figure 2-15.

NOTICE

Recheck the end float by moving the countershaft axially, in and out, as described earlier in this manual.

7. Align the coupling as described in INITIAL ALIGNMENT OF FLEXIBLE COUPLING.



Callout	Description	Callout	Description
1	Pinion	5	Flexible Coupling
2	Inner Countershaft Bushing	6	Safety Set Collar
3	Outer Countershaft Bushing	7	Tight
4	Oil Flinger		

Figure 2-15 End Float - Direct Drive

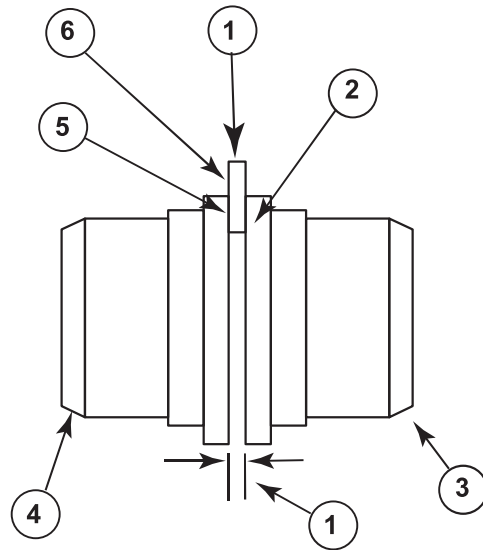
Initial Alignment Of Flexible Coupling

For the initial installation or when reassembling the flexible coupling on a direct arrangement, it is always desirable to align the couplings as accurately as possible for the longest coupling life and minimum vibration. After the coupling halves have been properly installed on the shafts, bring the two halves together and proceed to align the coupling as follows:

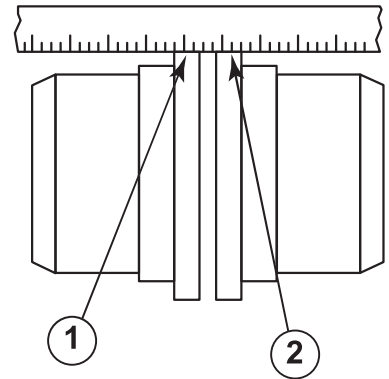
1. Check the gap and angular alignment by measuring the distance between the coupling halves, at four places, 90° apart, around the circumference of the coupling as shown on Figure 2-16. To measure the gap, use a feeler gauge or inside calipers or a dial indicator with a magnetic base. Coupling halves must be aligned so that all four measured dimensions DO NOT vary more than 0.38 mm (0.015").

If any of the four measured dimensions varies more than the 0.38 mm (0.015"), it would indicate excessive angular misalignment.

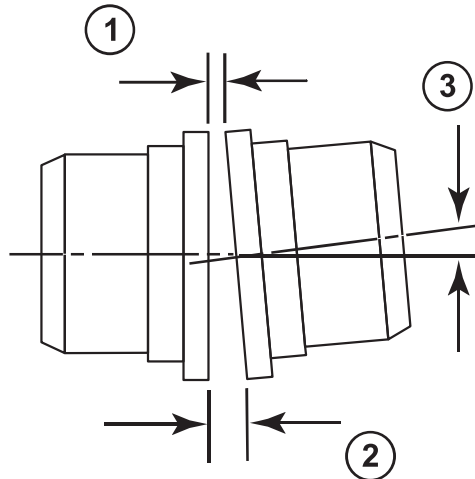
2. Check parallel alignment by laying a straight edge across the outside diameter of the coupling halves, at four places, 90° apart, around the circumference of the coupling. See Figure 2-16. Align so that the straight edge rests squarely on both coupling halves. Check with a feeler gauge or with a dial indicator. Parallel misalignment should NOT exceed 0.38 mm (0.015").
3. Gap, angular and parallel alignment are important whenever using a flexible coupling to drive a Crusher.
4. A safety set collar must be installed on the crusher countershaft to provide the proper countershaft end float or running clearance. Refer to the instructions in Section 4 for the proper installation of set collar.



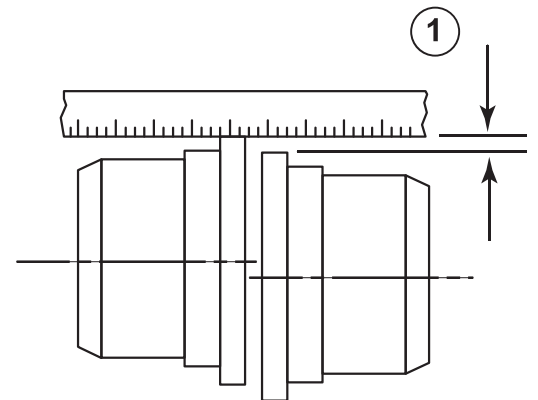
1. Equal Gap
2. Check with Feeler Gauge for Proper Gap and Angular Alignment on Other Coupling Half at This Point — Check at 90° Intervals
3. Driving Half of Coupling (Motor)
4. Driven Half of Coupling (Crusher Countershaft)
5. Hold Key Stock Tight against Coupling Half at This Point
6. Use Key Stock for Checking Gap

CORRECT GAP AND ANGULAR ALIGNMENT

1. Hold Straight Edge Tight Against Coupling Half at This Point
2. Check with Feeler Gauge for Proper Parallel Alignment on Other Coupling Half at This Point — Check at 90° Intervals

CORRECT PARALLEL ALIGNMENT

1. Gap
2. 0.38 mm (0.015") Maximum Gap and Angular Misalignment
3. Angular Misalignment

INCORRECT GAP AND ANGULAR ALIGNMENT

1. 0.38 mm (0.015") Maximum Parallel Misalignment

INCORRECT PARALLEL ALIGNMENT**Figure 2-16 Coupling alignment**

2.15 Piping Information

Section 10, describes in detail the proper type of oil, its temperature and regulation, as well as the equipment that is used or could be used in the crusher lubrication system. It should be noted that the lubricating system for the Crusher is designed for 8.6 BAR (200 PSI) **maximum** operating pressure.

Consult piping drawings furnished to show the pipe and pipe fittings supplied with the Crusher and any other lubricating equipment. Pipeline layout will vary to suit local conditions. Two influencing factors should be considered in the layout of both feed and drain lines; the pipeline should be as short and as direct as possible, without dead pockets or other flow obstructions and the drain line should have a minimum pitch of 25 mm (1") for every 305 mm (12") of pipe used.

NOTICE

Avoid vertical drop sections in drain line.

It is necessary that all piping be checked for internal cleanliness, that all chips and cuttings be removed to safeguard the oil pump. Take proper precautions to clean out weld slag and other contaminants.

2.16 General Assembly and Disassembly Information

Nordberg MP Cone Crushers are shipped in subassemblies.

In succeeding sections, detailed instructions will be given covering the assembly and disassembly of the various crusher components. Starting with the main frame, the remaining components are discussed in their normal assembly sequence.

Before installing any of these crusher parts, check that the protective coating applied to all machined surfaces for shipment has been removed and that all parts are clean and free from grit and dirt, especially oil passages and pipes.

All machined surfaces and threads that may have possibly been damaged in shipment must be restored to the proper condition before assembly. After cleaning, lightly oil all bearing surfaces and machined surfaces of mating parts with the exception of the Bowl, Adjustment Ring, and Clamping Ring threads which should be treated with a special thread lubricant (supplied by Metso Minerals) before applying the special grease with molybdenum disulfide additive shown in Section 11.

Due to the size of the MP800 and MP1000 Crushers, special precautions must be followed during the removal and installation of certain components. Be sure to follow all applicable safety practices regarding lifting equipment including proper hand signals. Also, make sure that all lifting equipment and associated devices such as slings, hooks and hardware are of sufficient capacity to support the weights involved.

The repair instructions in various sections of this manual make reference to the lifting instructions contained in that section. Handle components only as shown in the illustrations in that section. Do not use an alternative component handling method without first consulting Metso Minerals, Inc. (See *Special Tools* for items required for component handling.)

2.17 General Maintenance Information

When performing any maintenance work on the Crusher, the following general precautions should be observed:

- When removing parts with machined or bearing surfaces which may rust, they should be well oiled or covered with a rust preventive, if they are kept out of the Crusher for any length of time.
- Use additional caution when handling any parts which have bearing surfaces or a machined surface that has close tolerances.
- When disassembling any parts with bearing or machined surfaces, protect these surfaces from coming in contact with the ground by using wooden blocking.
- Bronze liners or bushings should be handled with extreme care. Excessive ramming or pounding on this soft material may cause warping or springing of such parts.

- Clean thoroughly and oil all machined parts before installing them in the Crusher. Do not replace a bearing surface without coating it with oil.
- When assembling two mating parts that require either a press or sliding fit, coat the contacting surfaces with a light coating of oil. This will act as a lubricant and prevent rusting in place.
- Head and eccentric bushings are to be stored vertically, stored in any other position could cause the bushings to become out of round or elliptical. Great difficulty could consequently be encountered when installing them in the Crusher. In some instances installation would be impossible.
- All bowl, adjustment ring, clamping ring, head and locking nut thread surfaces are to be coated with a special grease with molybdenum disulfide additive. The specification for this grease is shown in *Section 11*.
- Parts can be damaged by the use of poor techniques where thermal procedures are required. The following cautions should be followed during thermal procedures.
 - Whenever possible, heating should be performed with an immersion oil bath or a temperature controlled oven.
 - Targeted temperatures must not be exceeded. Damage to parts may occur.
 - Cutting torches are unacceptable as heating elements. The concentrated heat from a cutting torch results in hot spotting that may distort parts and adversely affect induction hardened parts. Localized heating can also create microscopic stress cracks.
 - Propane or acetylene equipment that is specifically designed for heating purposes must be used.
 - If flame heating must be used to assemble gearing, avoid direct flame contact with the induction hardened areas. Warm the bore and faces slowly. Let the heat soak to the outside.
 - When heating parts for removal, apply heat rapidly and evenly. Remove the item without delay to minimize thermal transfer to the parent object.
 - Do not “quench cool” heated items with liquids. If rapid cooling is indicated, it should be limited to motion of ambient air (fan or compressed air stream).

2.18 Minimum Recommended Spare Parts List

The following is a list of the minimum spare parts which should be on hand at all times to ensure a minimum of down time.

- bowl liner
- bowl liner bolts
- mantle
- torch ring
- thrust bearing shims (1 set)
- thread lubricant (12 10 oz. cans)

It is to be understood that this list contains only the minimum complement of spare parts and if the crusher installation is either in a remote location or consists of several Crushers, this list should be expanded. Therefore, consult Metso Minerals for a suggested list of spare parts for your particular operation.

Before storing any spare parts, check that the protective coating applied before shipment is still intact.

Finally, when replacing any bushings, bearings or major parts and when the Crusher is being started for the first time, it is advisable to run the parts in. Refer to the information described in the paragraph entitled *Initial Start-Up and Break-In Procedure* in *Section 11*.

2.19 Special Tools

Only tools which are not readily available through commercial supply houses are furnished with your Crusher.

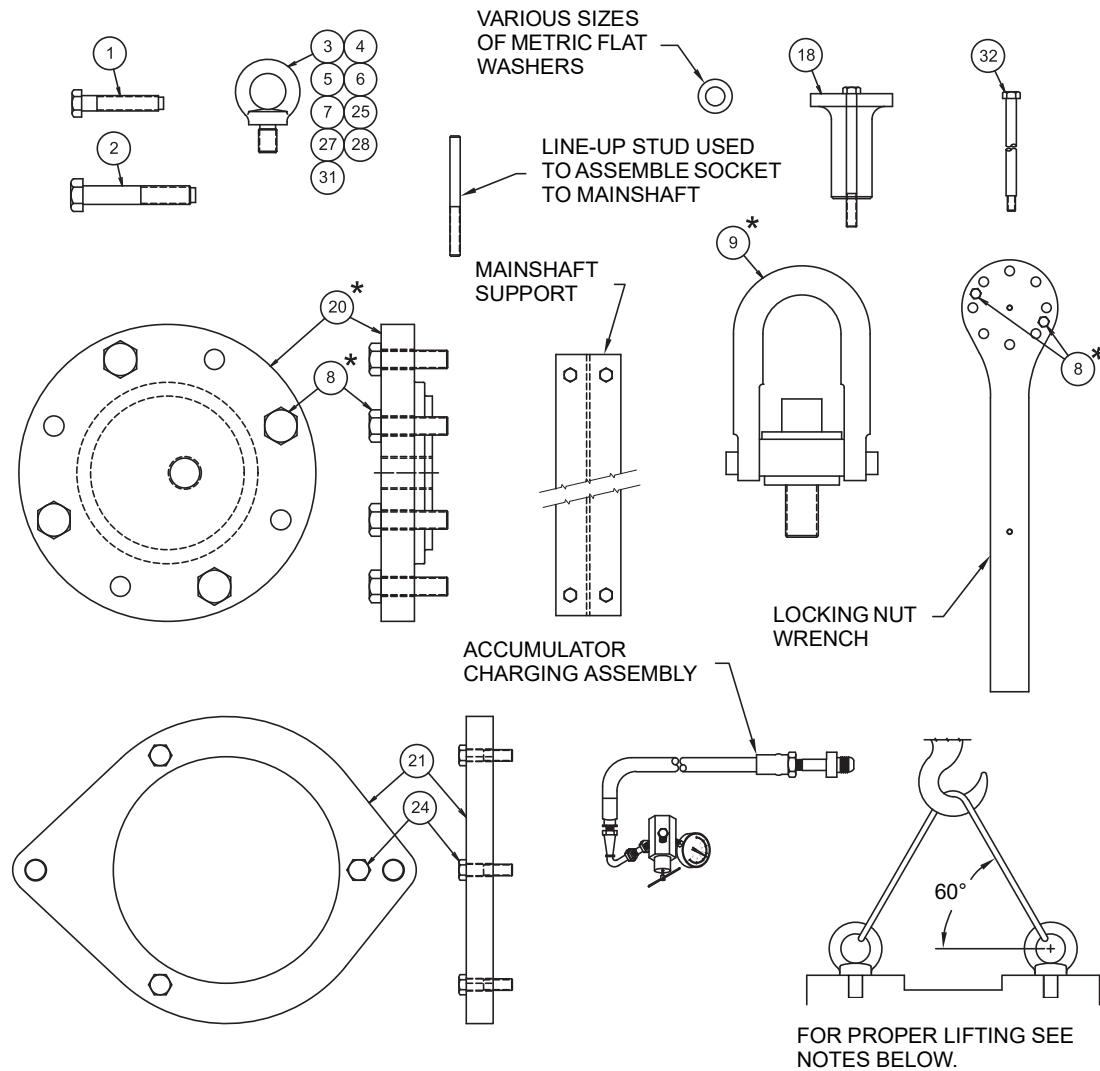
These tools consist of all the lifting ring bolts necessary for handling the equipment; head lifting plate, accumulator gauging and charging assembly, eccentric lifting ring, jackscrews, etc.

All of the tools are painted the same color as the Crusher for immediate identification and shipped in a separate box.

Figure 2-17 for the MP800 and Figure 2-18 for the MP1000 show the type of tools furnished. Refer to the appropriate figure as listed in each section for the desired component handling operation.

Figure 2-19 shows the Backlash Measuring Tool which is designed to measure the backlash at the pinion pitch diameter of either spiral bevel gear sets or straight bevel gear sets. The tool is designed to fit over the end of the countershaft where it exits the side of the Crusher. The fit of the tool on the shaft is very close so the end of the shaft, as well as the keyway, must be clean and free of burrs. It also helps to use some light oil to ease the tool on and off the shaft. Figure 2-19 shows that the tool has two lines near the end of the handle that mark the pinion pitch diameter of spiral bevel pinion gear and straight bevel pinion gear. See *Checking or Adjusting Backlash and Root Clearance* in Section 5 for the procedure for measuring backlash using the circumferential motion method. A displacement gauge can be used to measure the amount of circumferential motion, measured perpendicular to the surface of the handle directly above the location of the pinion pitch diameter mark for type of gear set provided with your Crusher.

The backlash measuring tool for the MP800 or the MP1000 is available from your local Metso Minerals representative.



Notes for Correct Lifting:

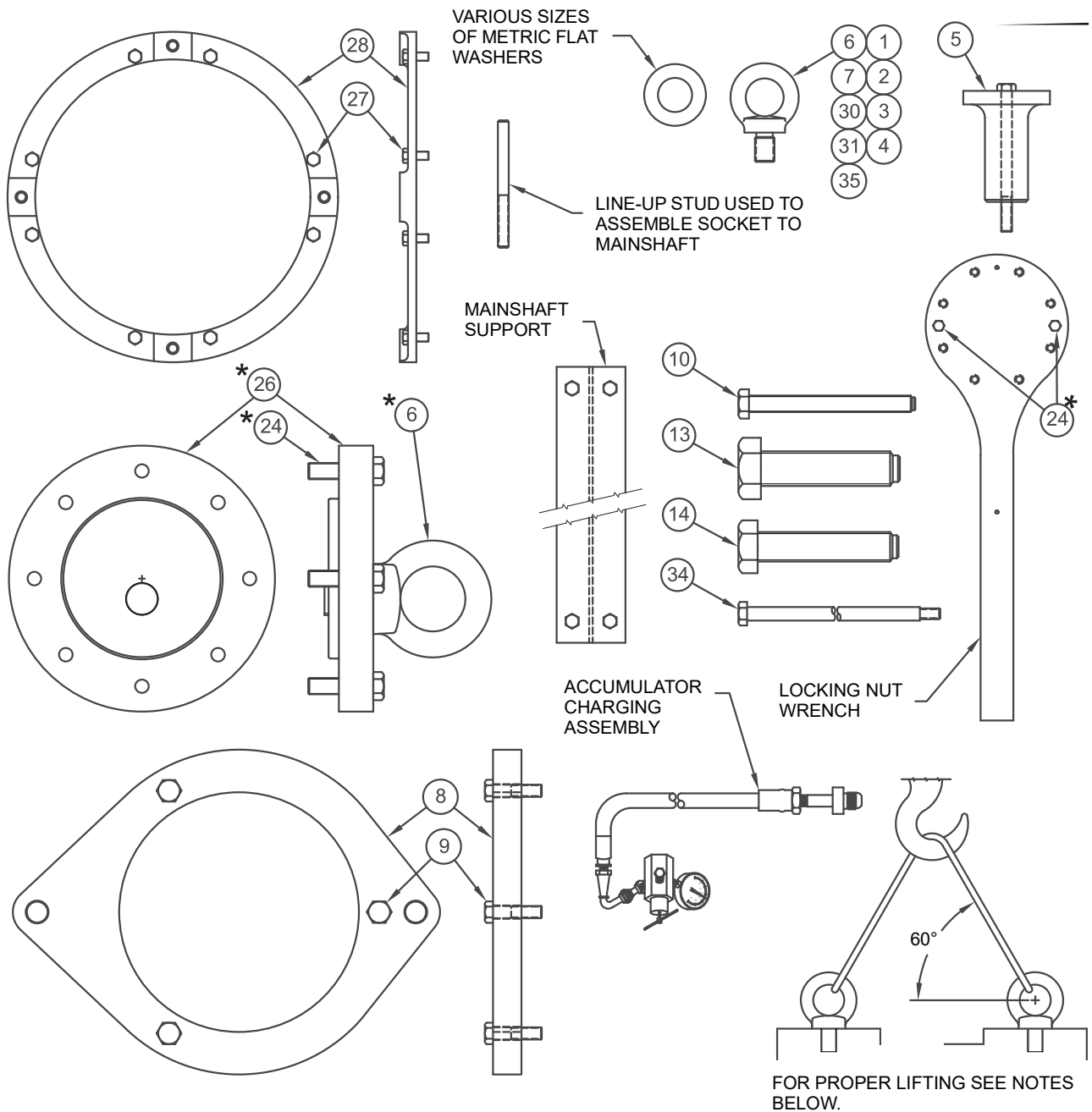
1. Lifting ring bolts must always be screwed tight in such a way that they fit flush against the bearing surface.
2. Any loading at right angles to the plane of the eye is not permissible.
3. Metric washers shall be inserted if necessary to avoid incorrect loading.
4. Per diagram shown above, do not lift at any angle less than 60°.
5. If threaded portion of eyebolt protrudes past the bottom of the plate, add washers under the shoulder of the eyebolt so threads are fully engaged.

* Refer to head assembly drawing, for the requirement of these items.

Figure 2-17 MP800 Special Tools

Description (See <i>Tools Assembly</i> in customer-specific parts book for Metso replacement part numbers.)																								
	Bowl Lifting Pins	Eccentric Lifting Ring	3-HHCS M30 x 130	Head Lifting Plate	4-HHCS M36 x 130	1-M64 Swivel Hoist Ring																		
Item Number	18	21	24	20	8	9	27	3	3	4	5	6	28	28	7	7	25	1	2	4	31	32	28	
Head assembly with mantle and locking nut (without feed plate)				X	X	X																		
Head assembly with locking nut (without mantle and feed plate)				X	X	X																		
Upper head bushing								X																
Lower head bushing										X														
Head ball										X														
Locking nut											X													
Socket liner									X															
Socket															X									
Main shaft																X								
Main frame pin												X												
Main frame pin bushing							X																	
Lower thrust bearing								X																
Upper thrust bearing								X																
Clamping ring															X									
Counterweight														X										
Counterweight guard											X													
Eccentric bushing									X															
Eccentric without counterweight													X											
Eccentric assembly		X	X														X							
Gear															X									
Drive ring															X									
Locking nut wrench										X														
Head assembly (for turning head over with or without mantle)				X	X	X																		
Bowl (for turning bowl over without bowl liner and adjustment cap)	X																							
For pulling countershaft box assembly into main frame																			X					
For removing socket liner from socket																		X						
For removing socket from main shaft																			X					
Spindle																				X				
Backstop Clutch																					X			
Driveshaft Assembly																							X	
Torque Limiter & Cover Plate										X														
Keeps driveshaft upright while installing the head assembly																						X		

Table 2-9 MP800 Special Tools



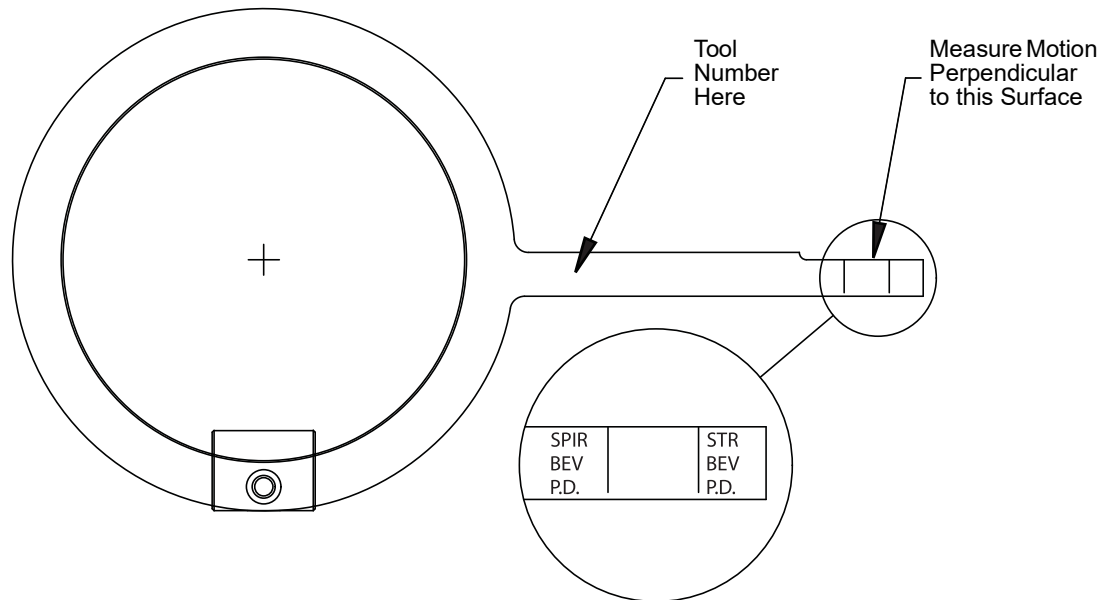
Notes for Correct Lifting:

1. Lifting ring bolts must always be screwed tight in such a way that they fit flush against the bearing surface.
 2. Any loading at right angles to the plane of the eye is not permissible.
 3. Metric washers shall be inserted if necessary to avoid incorrect loading.
 4. Per diagram shown above, do not lift at any angle less than 60°.
 5. If threaded portion of eyebolt protrudes past the bottom of the plate, add washers under the shoulder of the eyebolt so threads are fully engaged.
- * Refer to head assembly drawing, for the requirement of these items.

Figure 2-18 MP1000 Special Tools

Description														
	Item Number	5	8	9	26	24	6	6	1	30	2	2	2	7
Head assembly with locking nut (with or without mantle, without feed plate)					X	X	X							
Upper Head Bushing								X						
Lower Head Bushing											X			
Head Ball													X	
Locking Nut													X	
Socket Liner												X		
Socket											X			
Main Shaft														X
Main Frame Pin													X	
Main Frame Pin Bushing								X						
Lower Thrust Bearing									X					
Upper Thrust Bearing									X					
Countershaft													X	
Clamping Ring													X	
Counterweight													X	
Eccentric Bushing											X			
Eccentric without Counterweight		X	X										X	
Eccentric Assembly		X	X										X	
Gear													X	
Drive Ring													X	
Locking Nut Wrench											X			
Back Stop Clutch														X
Head assembly (for turning head over with or without mantle)				X	X		X							X
Bowl (for turning bowl over without bowl liner and adjustment cap)	X													
For installing and removing countershaft box assembly from main frame													X	
For removing socket liner from socket													X	
For removing socket from main shaft														X
Keeps driveshaft upright while installing the head assembly														X
For removing spindle										X				
For removing driveshaft assembly													X	
For removing torque limiter and cover plate									X					

Table 2-10 MP1000 Special Tools

**Figure 2-19 Backlash Measuring Tool**

2.20 Protecting the Crusher Against Rust Corrosion

To protect your Crusher from rust corrosion during seasonal shutdown or for outdoor storage (winter or summer), the following protective measures are recommended:

NOTICE

If the recommendations listed below are followed, a Crusher stored outdoors should have 6 - 12 months of rust protection.

1. Remove the bowl, feed plate, head, socket and eccentric assemblies. Disconnect the oil drain line at the bottom of the main frame and the oil pressure inlet at the bottom of the main shaft. Make sure that all piping and the hole in the bottom of the main shaft are sealed with blind flanges and gaskets.
2. Use a wide paintbrush to paint all inside surfaces of the main frame with rust preventive lubricating oil.

Use lubricating oil which has a rust preventive blend that is designed for the protection of internal parts of enclosed assemblies such as engines, compressors, pumps, gear sets, and hydraulic assemblies. Metso Minerals suggests the use of Mobilarma 522 or equivalent. The rust preventives function by displacing water from metal surfaces, by forming strong water-resistant films on the surfaces, and by absorbing water in the system into a water-in-oil emulsion. These products provide as much as 30 to 40 times the protection against rust as high quality lubrication oils that have not been especially formulated to prevent rust.

In most applications, the residual rust preventive film left by these products need not be flushed away or otherwise removed when the Crusher is to be filled with lubricating oil and put into normal service.

Generally, 208 liters (55 U.S. gallons) is sufficient to coat a Crusher. The viscosity of the oil should be in the 150 to 300 SSU at 38°C (100°F) range.

3. Using the paintbrush, coat the lower thrust bearing, the outer surface of the main shaft, and all exposed surfaces of the pinion with rust preventive oil. Remove the countershaft box oil feed hose from the side of the countershaft box. Place a funnel in the hole at the countershaft box and pour oil into the countershaft box while rotating the countershaft. Approximately 20 liters (5 U.S. gallons) will be required to coat the entire countershaft box area. Some leaking will occur from the drive end of the countershaft box, this is normal.

Reinstall the oil feed hose to the countershaft box.

4. Fill the lubricating hole in the main shaft with Mobilarma 522 or equivalent until the hole is filled with oil, then drain.
5. Coat the outer surface of the eccentric, the bore of the eccentric bushing, the gear and the upper thrust bearing with Mobilarma 522 or equivalent.
6. Brush a coating of the special oil onto the head ball, the bore of the upper and lower head bushings, machined surfaces of the head above the head ball (if the Crusher uses a clutch style antispin device some additional disassembly may be required) and all areas of the head adjacent to the T-seal.
7. Reinstall the eccentric assembly and the socket assembly. Apply a coat of the special oil to the bearing surface of the socket liner and the exposed surfaces of the socket. Install the head assembly and then the feed plate.
8. Fill the oil tank on the power unit with similar rust preventive oil having a viscosity of 150 SSU at 38°C (100°F). 380 liters (100 U.S. gallons) are required for the entire hydraulic system. Make sure the oil is compatible with the oil specified for operation of the Crusher as well as a hydraulic system where neoprene, polyurethane, bronze, nickel, chrome, steel and iron are used.

The hydraulic tramp release, clamping, bowl clearing and bowl turning mechanisms must be operated to assure that the power unit and

all hydraulic components have been thoroughly coated with rust preventive.

When the Crusher is put back into service, drain the oil from the hydraulic tank and refill with the oil specified for the operation of your crusher.

9. Brush or spray a light-bodied petroleum solvent containing a substantial amount of a polar rust preventive additive having strong attraction for metal surfaces, on the bowl, adjustment ring and clamping ring threads.

The additive should have excellent ability to wet metal surfaces in the presence of water; as a result it strongly resists displacement from the surface by water. The solvent should evaporate quickly and leave a thin, transparent, greasy film. The material should be suitable for light and moderate service, for example, protected outdoor storage. It should be applied at plant operating temperature by any convenient means (brushing, rolling or spraying) and the film need not be removed when the Crusher is placed in operation.

Then cover the threads with a liberal amount of lithium based grease NLGI No. 1 containing a minimum of 3% molybdenum disulfide.

10. Then reinstall the bowl assembly into the Crusher and cover the entire adjustment cap and hopper with a sheet of 8 mil. **black** polyethylene to prevent water from seeping into the Crusher and corroding the bowl and adjustment ring threads. This sheeting is available in 6.1M (20') by 30.5M (100') rolls. Black is recommended, as transparent sheeting will deteriorate four times faster than black. Use bracing under the sheeting to ensure that the sheeting does not sag and that any water falling on top of the sheeting will be shed. The end of the countershaft box and countershaft should also be covered. Steel strapping or banding is an ideal method of holding the polyethylene sheeting in place.
11. Reconnect the oil inlet and drain lines. The oil adhering to the metal surfaces is all that is needed for proper rust protection.

2.21 Storage of a Crusher

Where it is necessary that the Crusher be shipped or stored dismantled, the various subassemblies must be protected more thoroughly, as the procedures described in *Protecting the Crusher Against Rust Corrosion* earlier in this section are for metal surfaces that are not directly exposed to the elements; sun, wind, rain, snow, etc.

The following additional protective measures are recommended in those instances where a Crusher must be shipped or stored dismantled and the various subassemblies exposed to the elements.

The following is Metso Minerals recommendations for preparation for storage (up to one year) of a crusher.

NOTICE

For those parts stored outdoors unprotected, exposed to the elements, the following recommendations should provide up to 12 months of protection against rust corrosion for machined surfaces. For those parts stored indoors, the following recommendations should provide up to 24 months of protection against rust corrosion for machined surfaces.

The crusher must be disassembled as described below and all unpainted surfaces and small holes must be coated with at least 4 mils (0.10 mm [0.004 inches]) (2 coats) of CRC Industries SP 400 (corrosion inhibitor) or equivalent. For applications in wet or very humid conditions, CRC 3-36 should be applied first for complete moisture displacement. Allow CRC 3-36 to dry 2 to 4 hours before applying SP 400. Allow SP 400 coating to dry completely prior to crating or covering components. All crated components must be stored indoors or in a container of some sort where there will be no condensation or collection of water on surfaces or floor.

If the Crusher is fully assembled it must first be disassembled into its major assemblies. All components are to be stored indoors except for the main frame, adjustment and clamp ring assembly, head assembly and bowl and hopper assembly.

If the Crusher is to be stored upon receipt of shipment, it may already be partially disassembled and many components may already be in crates.

Use the following procedures to prepare components and subassemblies for extended storage whether the Crusher is fully assembled or received as subassemblies.

When the Crusher or any of its components are brought out of storage, all fluids must be drained completely and the components refilled with the fluids required for proper operation. Flushing with the specific oil to be used in the unit would be required only if the Mobilarma 522 or equivalent is contaminated or has water in it. All machined surfaces and all surfaces that are in the flow path of the lubrication oil that were coated with a corrosion inhibitor must be thoroughly cleaned with solvents prior to assembly.

1. **Crusher Disassembly** — Remove the bowl, bowl liner and hopper assembly by unscrewing the bowl (refer to *Section 8*). Remove the head assembly. If the Crusher is equipped with a clutch style antispin device, refer to *Section 7* for partial disassembly of antispin prior to removal of the head. Remove the clutch style antispin if the Crusher is equipped with such a device. Remove the socket liner and the socket from the main shaft (refer to *Section 6*). Remove the eccentric assembly and counterweight from the main frame (refer to *Section 5*).
2. **Main Frame Assembly** — Remove the lower thrust bearing and shims from the main frame and coat all surfaces with CRC Industries SP 400 (corrosion inhibitor). Store lower thrust bearing and shims indoors. If the Crusher was equipped with a clutch style antispin device, collect the antispin parts removed from the main shaft and coat with Mobilarma 522 or equivalent. Place the antispin device in a crate and store indoors. Plug the oil piping supply port at the bottom of the main shaft with a 150# SAE blind flange and gasket. Temporarily plug the side ports on the main shaft and fill the oil piping supply line with Mobilarma 522 or equivalent. After draining the oil from the main shaft, replace the blind flange and gasket on the bottom of the main shaft, wipe off any excess oil and coat the exposed surfaces of the main shaft with CRC Industries SP 400 (corrosion inhibitor) or equivalent. Pack waste rags soaked in Mobilarma 522 or equivalent into the open

holes of the main shaft. If the main frame is to be left outdoors exposed to the elements, it is recommended that the main shaft be covered to prevent corrosion due to exposure.

Remove the countershaft box assembly and pour Mobilarma 522 or equivalent oil into the countershaft box while rotating the countershaft. Approximately 20 liters (5 U.S. gallons) will be required to coat the entire countershaft box area. Some leaking will occur from the drive end of the countershaft box, this is normal. After all internal surfaces have been coated with the rust preventive oil, drain the countershaft box and plug all ports with metal SAE O-ring plugs. Coat all exterior unpainted surfaces with CRC Industries SP 400 (corrosion inhibitor) or equivalent. Coat the O-ring and wear ring with Mobilarma 522 or equivalent and place in a heat sealed plastic bag. Crate the countershaft box assembly along with the associated parts and store indoors.

Remove the clearing cylinders. Turn cylinder upside down and remove plastic port plug or any hydraulic fitting. Push the piston all the way down and fill the cylinder with Mobilarma 522 or equivalent. Drain clearing cylinder and plug port with an SAE O-ring plug. Turn cylinder upright and coat all unpainted surfaces with CRC Industries SP 400 (corrosion inhibitor) or equivalent. Crate the cylinder in an upright position and store indoors.

All interior and exterior unpainted surfaces of the main frame must be coated with CRC Industries SP 400 (corrosion inhibitor) or equivalent. The main frame can be stored outdoors exposed to the elements but covering the mainframe with a sheet of 8 mil. **black** polyethylene to prevent water from seeping into the Crusher will provide added protection against corrosion. The covering must be supported with bracing and positioned to shed any water away from the component.

3. **Adjustment Ring** — Remove all hoses; plug both ends of each hose with plastic plugs to prevent contamination and store in a crate

indoors. Remove all clamping cylinders from the clamp ring and fill each cylinder with Mobilarma 522 or equivalent. Drain each cylinder and plug port with a metal SAE O-ring plug. Coat all unpainted surfaces with CRC Industries SP 400 (corrosion inhibitor) or equivalent. Place cylinders in a crate with plug facing up and store indoors. Remove the clamp ring and coat any unpainted surfaces on the adjustment ring and clamp ring with CRC Industries SP 400 (corrosion inhibitor) or equivalent. Reinstall clamp ring without clamping cylinders. Cover the threads of the adjustment ring and clamp ring with a liberal amount of lithium based grease NLGI No. 1 containing a minimum of 3% molybdenum disulfide. Remove the adjustment cap seal and place in a heat sealed plastic bag along with an appropriately sized bag of desiccant.

Desiccant can be purchased in various sizes based on the volume of the packaged area, the length of storage time and the conditions in which the package is stored. Desiccant bags are available from most packaging and shipping companies.

4. Tramp Release Cylinder Assemblies — Remove the nut and cone and coat parts with CRC Industries SP 400 (corrosion inhibitor) or equivalent. Check the precharge on the accumulator to insure it is between 5 and 15 psi. Remove the mounting bracket from the bottom of the cylinder and place the cylinder on its side with the boss facing upward. Remove the O-ring plug from the port just above the accumulator and fill the cylinder with Mobilarma 522 or equivalent. Do not remove the plugs from the two side ports. Filling the cylinder this way will allow oil to enter the accumulator. When the cylinder and accumulator are full install an SAE O-ring plug in the port. Approximate volume of oil required per cylinder and accumulator is 15 liters (4 gallons). Coat the unpainted surfaces on the outside of the cylinder assembly with CRC Industries SP 400 (corrosion inhibitor) or equivalent. Replace the mounting bracket and place the assembly in a crate on its side with the

accumulator facing up. Store the crate indoors.

5. Eccentric Assembly — Remove the counterweight and gear from the eccentric assembly. Coat all surfaces with CRC Industries SP 400 (corrosion inhibitor) or equivalent. Because these parts are in the normal flow path of the lubricating oil when the Crusher is running, it is recommended that these parts be stored indoors or are covered by a tarpaulin if stored outdoors.
6. Head Assembly — Apply a coating of at least 4 mils (0.10 mm [0.004 inches]) (2 coats) of CRC Industries SP 400 (corrosion inhibitor) or equivalent to the head ball, the bore of the upper and lower head bushings, machined surfaces of the head above the head ball (if the Crusher uses a clutch style antispin device some additional disassembly may be required) and all areas of the head adjacent to the T-seal.
7. Bowl and Hopper Assembly — Remove the hopper and adjustment cap from the bowl to expose the wedges and hardware used for mounting the bowl liner. Coat all hardware and unpainted surfaces with CRC Industries SP 400 (corrosion inhibitor) or equivalent. There is no need to coat the surfaces of the bowl liner. Clean the threads of the bowl and recoat with CRC Industries SP 400 (corrosion inhibitor) or equivalent. Cover the threads of the bowl with a liberal amount of lithium based grease NLGI No. 1 containing a minimum of 3% molybdenum disulfide. Apply a coating of Mobilarma 522 or equivalent to the fasteners and remount the adjustment cap to the bowl. The assembly can now be stored outside exposed to the elements. To reduce corrosion due to exposure the bowl and hopper assembly can be covered with a sheet of 8 mil. **black** polyethylene to prevent water from seeping into the Crusher. The covering must be supported with bracing and positioned to shed any water away from the component.
8. Hydraulic Power Unit — Remove the fill plug from the top of the reservoir and drain any existing oil from the tank. Remove the top of the filter inside the cabinet. Start filling the filter housing with Mobilarma

- 522 or equivalent, the oil will eventually flow through the pump and into the suction line, then into the reservoir. When the oil starts to enter the reservoir close the ball valve on the suction line inside the cabinet, this will trap the oil in the pump. Continue adding oil to the filter housing until full. Replace the top of the filter. Place (3) 2-kg (4.4 lbs.) packages of desiccant inside the hydraulic tank, insuring that they will not come in contact with the oil from filling the pump. Replace the fill plug on the hydraulic reservoir. Place (3) 2-kg (4.4 lbs.) packages of desiccant inside the cabinet. Place (1) 2-kg (4.4 lbs.) package of desiccant inside the electrical enclosure mounted on the side of the cabinet. Place (1) 2-kg (4.4 lbs.) package of desiccant inside the Local Control Station enclosure. Seal the entire hydraulic power unit cabinet with shrink-wrap to reduce the intrusion of humid air into the cabinet. Do not seal off the air breather on the top of the hydraulic tank with the shrink-wrap. Store indoors.
9. Hydraulic Drive Assembly — Remove the hydraulic drive assemblies which includes the hydraulic motor, brake, gear reducer and pinion from the adjustment ring. Drain any existing fluids and refill with Mobilarma 522 or equivalent. Plug all ports with SAE O-ring plugs. Coat all unpainted surfaces with CRC Industries SP 400 (corrosion inhibitor) or equivalent. Place assemblies in crate on their side with ports facing up. Remove the drive skirt and place in a heat sealed plastic bag along with an appropriately sized bag of desiccant.
 10. Package Lube System — Drain any existing oil from the lube oil tank and plug all ports with SAE O-ring plugs. Replace the drain and feed lines with 150# SAE blind flanges and gaskets. Place (1) 2-kg (4.4 lbs.) package of desiccant inside the electrical enclosure mounted on the side of the lube oil tank. Place (5) 2-kg (4.4 lbs.) packages of desiccant inside the lube oil tank on top of the screen basket.
 11. Package Air Cooler Systems — Plug all 1/2" pipe ports with metal pipe plugs. Replace the 2 bottom and 1 top 3 inch lines with SAE 150# blind flanges with gaskets. Replace the other top 3 inch line with an SAE 150# blind flange and gasket with 1" female NPT threads in the center of the blind flange. Install 1" close nipple, 90-degree elbow, 6" long nipple and 1" pipe cap into 1" NPT hole. Prior to capping off the 6" long pipe nipple with the 1" pipe cap, fill the air cooler (radiator) with Mobilarma 522 or equivalent. Make sure all air is removed from the radiator, and then drain oil. After oil is drained close or cap off all ports to radiator.
 12. All hydraulic hoses are to have plastic push in plugs on both ends of the hose to prevent contamination. All hoses are to be crated and stored indoors and not exposed to excessive heat.
 13. All electrical instruments are to be stored in heat sealed plastic bags along with an appropriately sized bag of desiccant.
 14. Inspect parts stored outside once every month and immediately after any significant weather event. Clean and recoat parts as necessary.

Inspect parts stored indoors once every two months, clean and recoat parts as necessary. Replace desiccant packs every six months or as necessary.
- General notes:
- All holes including tapped holes are to have waste rags that have been soaked in Mobilarma 522 or equivalent packed into them.
- Miscellaneous mounting hardware and hydraulic fittings are to be removed, coated with Mobilarma 522 or equivalent, and stored in a heat sealed plastic bag and kept with the parent component. Do not reuse any fasteners that have been torqued during assembly.
- All components stored outdoors are to be placed on top of cribbing or pallets to raise them off the ground. Any components placed on wood after coating with CRC Industries SP 400 (corrosion inhibitor) or equivalent, the coating must be thoroughly dry before placing on wood. A vapor barrier between the wood and the component must be provided by using a layer of heavy duty waxed non-absorbent paper or asphalt impregnated paper.

When storing the Crusher for an extended period of time (longer than one year) it is recommended that a replacement part for the upper and lower “T” and “U” seals as well as a replacement for all outer seals on shaft components be kept on hand.

When Crusher is put back into service, closely monitor the condition of the filters and the lubrication oil in order to avoid any problems caused by contamination.

2.22 Long Term Storage of a Crusher

The following is Metso Minerals recommendations for LONG TERM STORAGE (up to two years) of a crusher

When storing a Crusher for a period of no more than two years, follow the procedure described in *Storage of a Crusher* earlier in this section along with these additional recommendations.

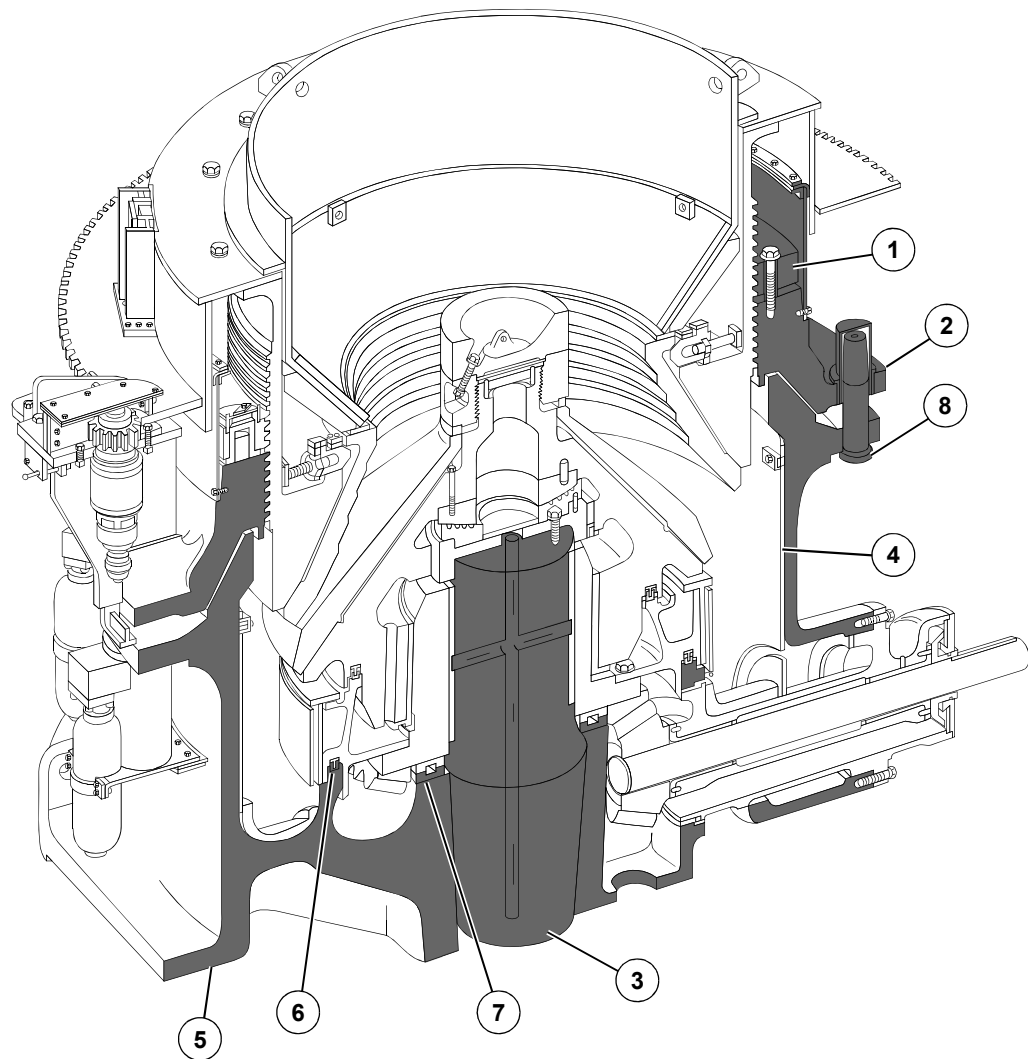
After components are received at the long-term storage facility they must be inspected for any damage to the protective coatings and any area that has had the coating rubbed off must be recoated with 4 mils (0.10 mm [0.004 inches]) (2 coats) of CRC Industries SP 400 (corrosion inhibitor) or equivalent. All components are to be stored indoors except for the main frame, adjustment ring, head assembly and bowl and hopper assembly. The components to be stored outdoors must first have any plastic wrap removed, the corrosion inhibitor coating inspected for proper coverage and the component completely covered with a tarpaulin. The tarpaulin must be supported by bracing and positioned to shed any water away from the component.

When the Crusher or any of its components are brought out of storage, all fluids must be drained completely and the components refilled with the fluids required for proper operation. Flushing with the specific oil to be used in the unit would be required only if the Mobilarna 522 or equivalent is contaminated or has water in it. All machined surfaces and all surfaces that are in the flow path of the lubrication oil that were coated with a corrosion inhibitor must be thoroughly cleaned with solvents prior to assembly.

Section 3

Main Frame, Adjustment Ring, Tramp Release & Clearing Jack Assemblies

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Callout	Description	Callout	Description
1	Clamping ring	5	Main frame
2	Adjustment ring	6	U-seal
3	Main shaft	7	Lower thrust bearing
4	Mainframe liner	8	Main frame pin

Main Frame, Adjustment Ring, Tramp Release and Clearing Jack Assemblies

3.1 Description

This section covers the main frame, adjustment ring, tramp release and clearing jack assemblies.

The main frame, which is securely bolted to a foundation, provides a rigid support for the remaining Crusher components.

The main frame liners hung from the inside of the frame as well as arm guards are replaceable and protect the inside of the frame from wear. Another replaceable item is the eccentric counterweight guard, located around the outside of the gear well that protects the outside diameter of the eccentric counterweight from excessive wear during operation.

The adjustment ring, which sits on top of the main frame, is threaded on its inside diameter to provide the means of adjusting the bowl assembly. A threaded clamp ring on top of the adjustment ring is forced upward by a series of hydraulic clamping cylinders positioned between the clamp ring and the adjustment ring. The clamp ring holds the bowl tightly against the slanted side of the adjustment ring threads preventing the bowl from shifting or rotating during the crushing process. A dust shell attached to the adjustment ring shields the clamping cylinders and bowl threads from outside contaminants. Hydraulic (Tramp) release cylinders which extend between the main frame and the adjustment ring, hold the adjustment ring firmly to the main frame against normal crushing forces. Excessive forces created by improper operation or by passing an uncrushable object will pull the cylinder rod upward. Oil will be displaced from the upper cylinder chamber into the accumulators further compressing the nitrogen gas within the accumulator. Once the overload has passed and crushing forces normalize, the compressed nitrogen will return the oil to the cylinder, the cylinder rods will retract and the adjustment ring will again seat itself on the main frame. Alignment pins attached to the main frame project upward through holes in the adjustment ring to guide the ring back to its original position.

A thrust bearing is bolted to the main frame around the base of the main shaft. It supports the weight of the eccentric assembly. Two RTDs are field installed to monitor the temperature of the oil exiting the lower end of the eccentric bushing. These RTDs are located just inside the inner diameter of the lower thrust bearing.

Shims inserted under the thrust bearing determine gear and pinion backlash and root clearances.

A molded, nonmetallic U-seal, cemented into an annular groove around the perimeter of the gear well, engages a molded T-seal attached to the counterweight providing a labyrinth type seal that protects the gear, pinion and bearing surfaces from dust infiltration. The labyrinth seal surfaces do not contact during normal operation.

The stationary main shaft serves as a support for the socket and provides a spindle around which the eccentric revolves.

3.2 Assembly Instructions

3.2.1 General

The main frame, adjustment ring and tramp release components will be shipped disassembled. For assembly of main frame components, follow the procedures in the *Maintenance* portion of this section.

3.2.2 Crusher Installation

If the Crusher is to be placed directly on a concrete foundation, the main frame must be grouted into place. If a sole plate is to be placed on a concrete foundation, for mounting the Crusher, it also has to be grouted into place. Use a high performance epoxy grouting. For the type of epoxy grouting and procedure, refer to the epoxy grouting technical sheets that were furnished with the crusher installation drawings. If the technical data sheets are not available, contact the factory.

If the Crusher is to be placed on a steel structure, the main frame must be shimmed into place due to warpage or irregularities of the steel structure. Contact Metso Minerals for structural and machining requirements.

To install the Crusher on a steel structure, proceed as follows:

1. Remove all weld slag and spatter from the top of the steel structure in those areas that would be under the four main frame machined mounting pads.
2. Torch cut four spacers, to the same shape, or contour, as the machine main frame mounting pads. The spacers should be 6 mm (0.25") thick with a hole to clear the crusher anchor bolts. Then place the spacers over the

crusher anchor bolts and onto the steel structure.

3. Attach a suitable sling or slings to the lifting bosses at the bottom of the main frame flange.

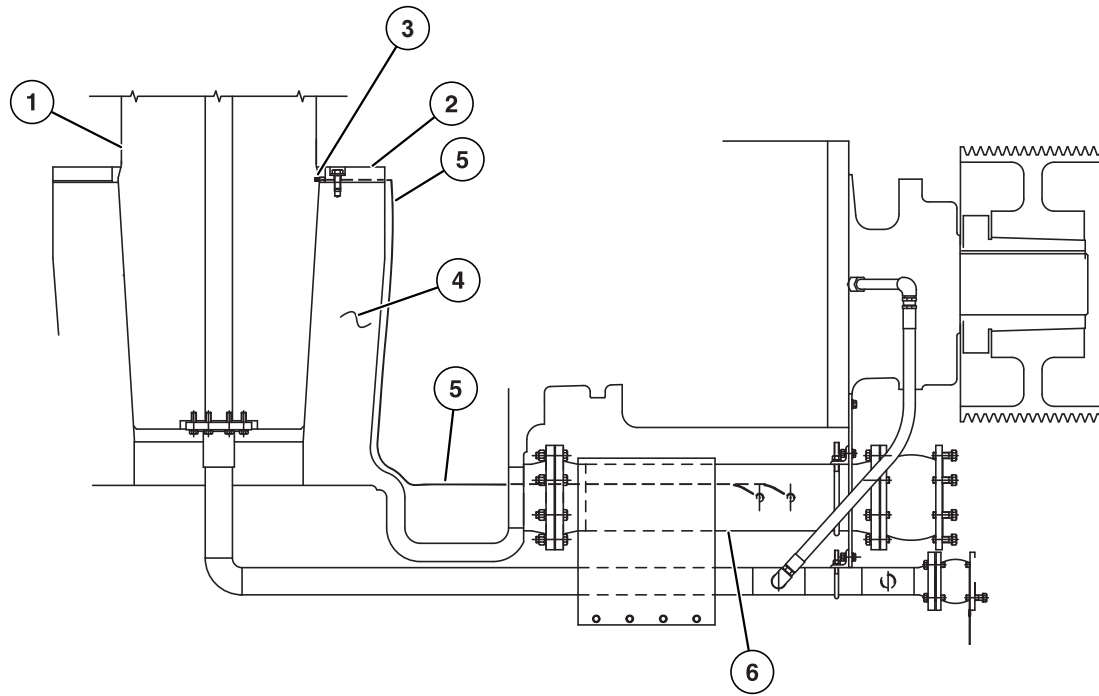
WARNING

Do not use the lifting lugs on the adjustment cap for lifting the entire machine. These lugs are not strong enough to lift the entire Crusher. Serious personal injury or severe damage to the Crusher could result.

4. Carefully lift the main frame and place it in position on the steel structure on top of the spacers.
5. Level the Crusher by inserting shims, the same shape as the spacers from step 2, with U-shaped slots to clear the crusher anchor bolts as they are inserted in place. Partial shims may be used to provide for more uniform support over the entire main frame pad machined surface. Use the top of the main shaft to level the Crusher in both directions.
6. When the shims have been properly positioned under the frame machined pads, tack weld the shims and spacers to the steel structure so they cannot vibrate out.
7. Tighten the Crusher firmly to the structure. The anchor bolts used should be sufficient length to pass through the full depth of the support beams (18" free length or greater).
8. After tightening the Crusher firmly to the structure, recheck if the Crusher is level.
9. The anchor bolts should be checked for tightness and re-tightened at the following time intervals: one week, one month, six months, and one year.

3.2.3 Oil Temperature RTDs

The two eccentric bushing oil temperature RTDs should be installed. They are mounted to the mainframe and pass out through the side holes in the drain line. Refer to Figure 3-1.



Callout	Description	Callout	Description
1	Main shaft	4	Main frame
2	Lower thrust bearing	5	RTD cable
3	RTD Sensor	6	Drain line

Figure 3-1 Eccentric Bushing RTD Installation

3.3 Maintenance

3.3.1 Main Frame Liner and Arm Guards

⚠ WARNING

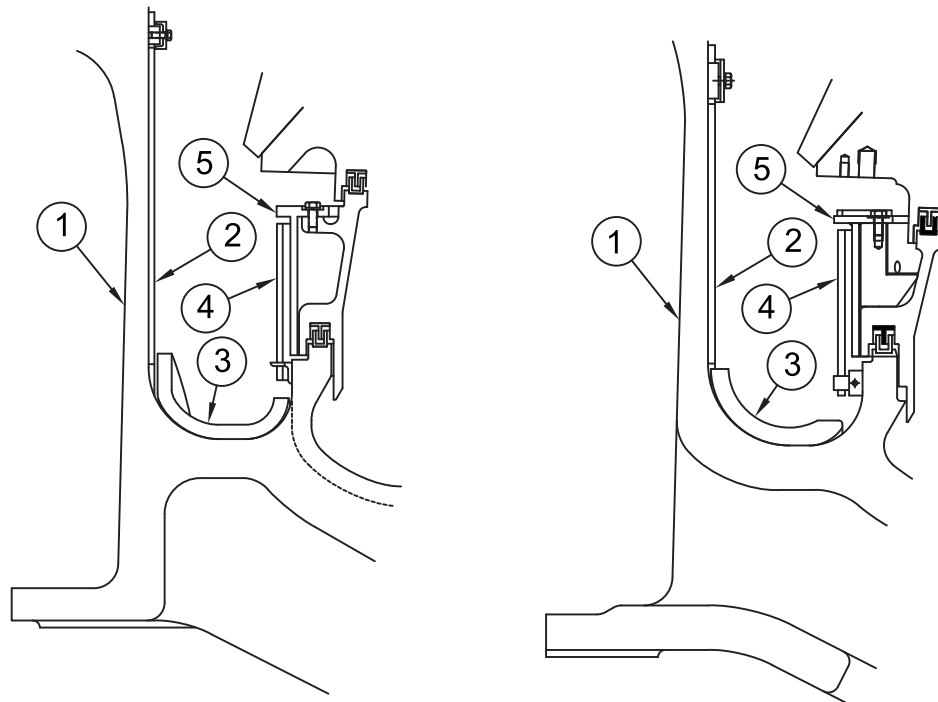
Do not weld lift lugs onto Arm Guards. These components are made of a material that is not readily weldable. Any attempt to lift new or worn Arm Guards into or out of the Crusher by means of a welded on attachment can result in the Arm Guard breaking free of the attachment and falling, potentially causing serious injury or possible death.

When the Crusher is down for a liner change, inspect the main frame liner and arm guards for wear (refer to Figure 3-2).

On the MP800 it will be necessary to remove the counterweight guard and stationary guard (if used) in order to remove or install the arm guard.

On the MP1000 it will be necessary to remove the stationary guard (if used) in order to remove or install the arm guard.

A replacement main frame liner will be shipped in sections. These sections are hung on blocks on the inside of the main frame shell. A bolt through the liner clamp holds the liner in place.

**MP800****MP1000**

Callout	Description
1	Main frame
2	Main frame liner
3	Arm guard
4	Stationary guard
5	Counterweight guard

Figure 3-2 Main Frame Liner and Arm Guard

3.3.2 Main Shaft Replacement

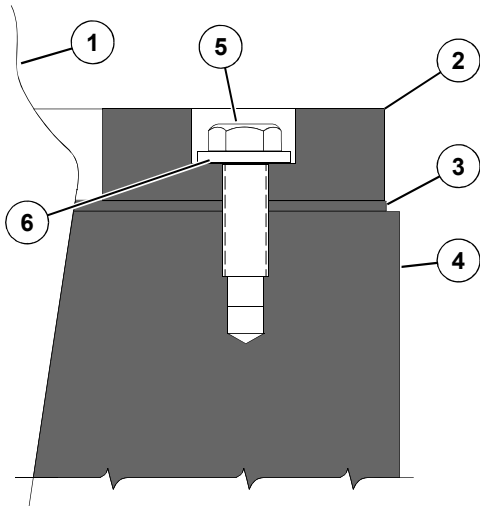
The need to replace a main shaft should be extremely rare. Due to the importance of obtaining the proper fit between the main shaft and the main frame hub, removal and installation of the main shaft should be performed only by a factory representative who has the proper training and equipment.

3.3.3 Lower Thrust Bearing and Shim Replacement

To replace a damaged or worn lower thrust bearing or to add shims to restore proper gear and pinion backlash and/or root clearance, proceed as follows and refer to Figure 3-3:

1. To gain access to the thrust bearing, it will first be necessary to remove the Bowl, Head, Socket and Eccentric Assemblies. Refer to the appropriate sections that follow for information on removing these assemblies.
2. Remove the capscrews and spring washers holding the lower thrust bearing in place.

3. Thread a ring bolt into each of the two tapped holes in the thrust bearing.
4. Attach a suitable lifting device to the ring bolts and carefully lift the thrust bearing over the main shaft. Replace the two eccentric bushing oil temperature RTDs, if necessary.
5. Check the replacement thrust bearing and the thrust bearing shims that are to be added to be sure there are no burrs or upset edges that would prevent the bearing or shims from lying flat against the main frame with full surface contact.

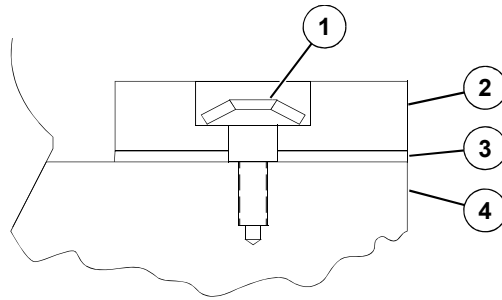


MP1000 and MP800

Callout	Description
1	Main shaft
2	Lower thrust bearing
3	Shims
4	Main frame
5	Capscrew
6	Spring washer

Figure 3-3 Lower Thrust Bearing and Shim Replacement

6. Refer to *Adjusting Gear Backlash for Wear* in Section 5, to determine the correct amount of shims to be installed. Any additional shims to be added are placed on the top of the existing shim stack. If a new thrust bearing is to be installed, remove the ring bolts from the old bearing and install them in the new bearing. Lower the thrust bearing in place making sure that all holes are properly aligned with the holes in the main frame hub. Make sure bearing is fully and squarely seated on the shims.
7. MP800 and MP1000 models:
 - a. Place a spring washer into each counterbored hole in the thrust bearing with the incline up. Refer to Figure 3-4.
 - b. Insert and turn all the capscrews until they all are snug against the spring washers.
 - c. Alternately tighten each capscrew a small amount until a torque value of 470 Nm (345 ft. lbs.) is obtained on each capscrew.



Callout	Description
1	Spring washer
2	Lower thrust bearing
3	Shims
4	Main frame

Figure 3-4 Spring Washer Placement

3.3.4 Seal Replacement

The U-shaped seal installed around the gear well portion of the main frame is normally not subjected to contact or wear. However, if the seal is damaged in any way, it is important that it be replaced. The seal prevents oil leakage and protects the precision machined surfaces of the gear, pinion, and bearings from harmful dust infiltration. Replace the seal as follows (refer to Figure 3-5):

1. Remove the damaged seal and completely clean out any adhesive that remains in the seal groove. Use a sharpened chisel or stiff putty knife to cut through the seal and scrape the old adhesive out of the groove.

WARNING

Provide adequate ventilation when using chemicals and glue when replacing the seal to prevent inhalation of fumes.

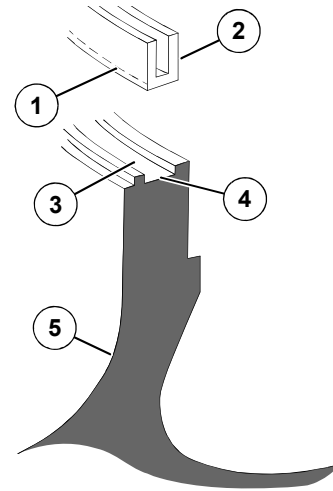
2. Thoroughly clean the groove with an oil free solvent and allow to dry. Use alcohol or acetone.
3. The new seal is molded and comes in four segments, thoroughly clean the bottom and up each side surface 10 – 15 mm (0.39 – 0.59") of the seal using coarse sand paper to remove the surface shine before cementing the seal in place.

These seals were coated with a mold release agent which allows the seal to be removed from their mold during manufacture. In order for the seal to adhere properly to the adhesive used to hold the seal in the groove in the frame, this release agent must be completely removed.

NOTICE

If the mold release agent is not completely removed, the seal could come loose during operation.

4. Before gluing the segments into the frame, first place three of the segments in the groove as the fourth segment will have to be trimmed on one end to fit into the remaining space. Make sure the end of the segment is cut square to the end of the adjacent segment to insure a strong bond when gluing the segments into the frame.



Callout	Description
1	Apply activator to bottom and sides of U-seal
2	U-seal
3	Apply adhesive to sides and bottom of frame seal groove
4	Frame seal groove
5	Main frame

Figure 3-5 Installing Frame U-Seal

5. Apply **activator** in a very thin film to **bottom of seal**. If an excessive amount of activator is applied, a partially cured bond may result.

NOTICE

Make sure to also clean the ends of the segments, then coat one end with activator and the other end with adhesive.

6. Sparingly apply **adhesive to bottom of groove**. Apply only enough adhesive to ensure minimal squeeze out.
7. Position the seal into the groove as soon as possible after adhesive application. Maintain enough force on the bottom of the seal so that there is pressure contact between the seal and the bottom of the groove. A handling bond is attained in approximately three minutes.

3.3.5 Main Frame Pins and Pin Bushings

The main frame pins prevent the adjustment ring from rotating in respect to the main frame and also guide the adjustment ring back to its original position when the ring lifts due to tramp iron or packed material in the crushing cavity (refer to Figure 3-6). Repeated adjustment ring lift is not normal, is not an acceptable method of operation, and can usually be corrected by proper feeding and correct crusher settings.

NOTICE

Allowing the adjustment ring to bounce will void the warranty.

Incorrect operation with excessive ring movement will result in wear of main frame pins and worn pin bushings. See below for proper procedure for checking for bushing wear. Any wear on the main frame pin bushing is easily checked once the pin covers are removed. Due to the rotation of the head in relationship to the bowl, the adjustment ring will want to rotate in the opposite direction as the head rotation. Since this force will be acting on the adjustment ring in one direction only, the main frame pins and the pin bushing in the adjustment ring will have a tendency to wear on one side only.

Excessive pin or bushing wear will result in a concentration of wear on the release cylinder rods in the area where the rods pass through the main frame. The main frame pins and the pin bushings should be replaced when they show signs of excessive wear. Since excessive pin wear is unusual, the main frame pins will rarely require replacement.

⚠ WARNING

Prior to performing maintenance work on any part of the Crusher, lockout and tag all electrical power supplied to the power unit and Crusher and release stored pressure in all hydraulic circuits. Death or serious injury may result if the Crusher systems are activated while personnel are in, on or near the Crusher. Turn the POWER OFF/ON switch located on the local control station to the OFF position and lock out and tag the power supply to the power unit and Crusher. Depressurize the hydraulic circuits by opening (turn counter-clockwise) the needle valves located at the hydraulic power unit cabinet. This will vent the pressurized oil in the circuits back to tank but it will not release the nitrogen pre-charge pressure in the clamping circuit accumulator found inside the power unit or the tramp release circuit accumulators shared by the tramp release cylinders. Do not perform maintenance on any accumulator until the hydraulic circuits have been depressurized and the nitrogen pre-charge pressure is safely released.

Replace pin bushing as follows:

1. Lock out and tag all electrical power supplied to the power unit and Crusher and depressurize the clamping and tramp release circuits by opening the clamping cylinder and tramp release cylinder needle valves located on the side of the hydraulic power unit at the hose connection area.
2. Remove the pin covers to inspect the pin bushings for wear. If the pin bushings show excessive wear continue with the replacement procedure.
3. Slightly lift the adjustment ring off the frame and rotate the ring to center the main frame pins in the bushings. Refer to Figure 3-7 for correct lifting of adjustment ring.
4. Once the pin is centered, remove the bushing by prying the bushings out.

5. To install a new pin bushing, pack the bore of the replacement bushings with dry ice for two to three hours to shrink the bushings for easy installation into the adjustment ring. Simply slide the new bushings into the adjustment ring and install the pin cover.

NOTICE

Wrap the outside of the bushing in a few layers of fiber glass insulation to prevent the external build-up of frost which could hinder the installation of the bushing in the adjustment ring. This also helps to achieve a more thorough cooling.

⚠ WARNING

Use heavy, well insulated gloves when handling dry ice. Handling dry ice without the proper protection could result in severe burns.

If the pin can not be removed by this method then cut out the center of the pin with a lance, then retry step 3.

4. Heat the pin boss on the frame to ease installation. Drive the new pin in the main frame by sledging. The pins must be seated against the bottom of the counterbored hole in the frame.
5. Fasten the main frame pin to the frame with large diameter washer, lockwasher and capscrew.
6. Slightly lift the adjustment ring off the frame and turn the ring clockwise until the ring comes in contact with the main frame pins. With the ring against the pins, lower the ring onto the frame.
7. Close the release cylinder needle valve on the side of the power unit, then activate the power unit and repressurize the tramp release cylinders.

6. Slightly lift the adjustment ring off the frame and turn the ring clockwise until the ring comes in contact with the main frame pins. With the ring against the pins, lower the ring onto the frame.
7. Close the clamping and tramp release cylinder needle valves located on the side of the power unit, then activate the power unit and repressurize the clamp and tramp release circuits.

Replace the pins as follows:

1. Lock out and tag all electrical power supplied to the power unit and Crusher and depressurize the clamping and tramp release circuits by opening the clamping cylinder and tramp release cylinder needle valves located on the side of the hydraulic power unit at the hose connection area.
2. Remove capscrew, lockwasher and large diameter washer from the underside of each main frame pin to be replaced.
3. Force the worn pin out through the top of the main frame using a hydraulic jack centered under the pin. Heating of the frame boss may be required.

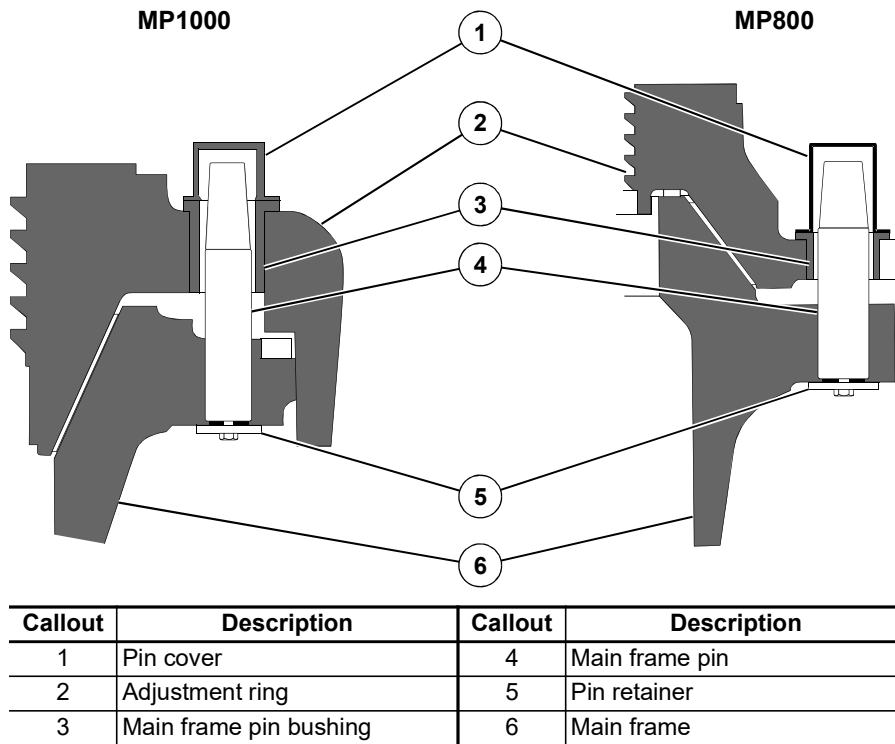


Figure 3-6 Main Frame Pins and Pin Bushings

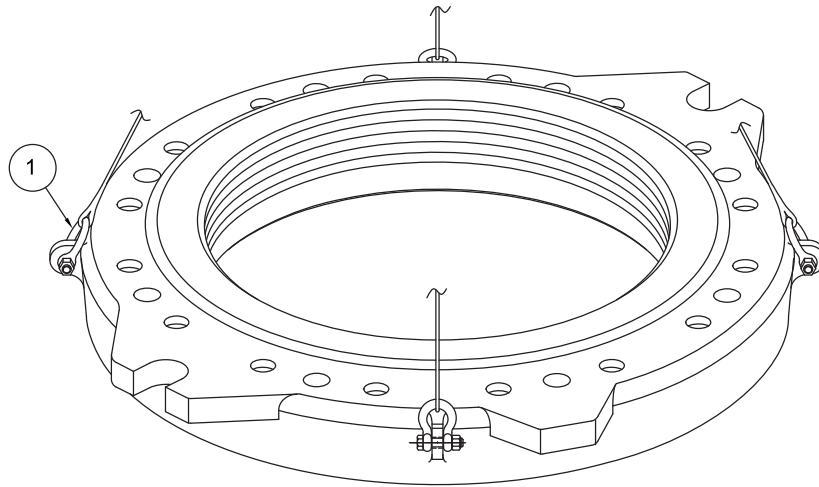
3.4 Main Frame Seat Liner and Fulcrum Bar

3.4.1 General Information

Periodically, the main frame seat liner and fulcrum bar should be inspected for wear. Due to irregularity in feed to a Crusher and the slight rubbing action between the adjustment ring and main frame seat liner, there is a certain amount of wear.

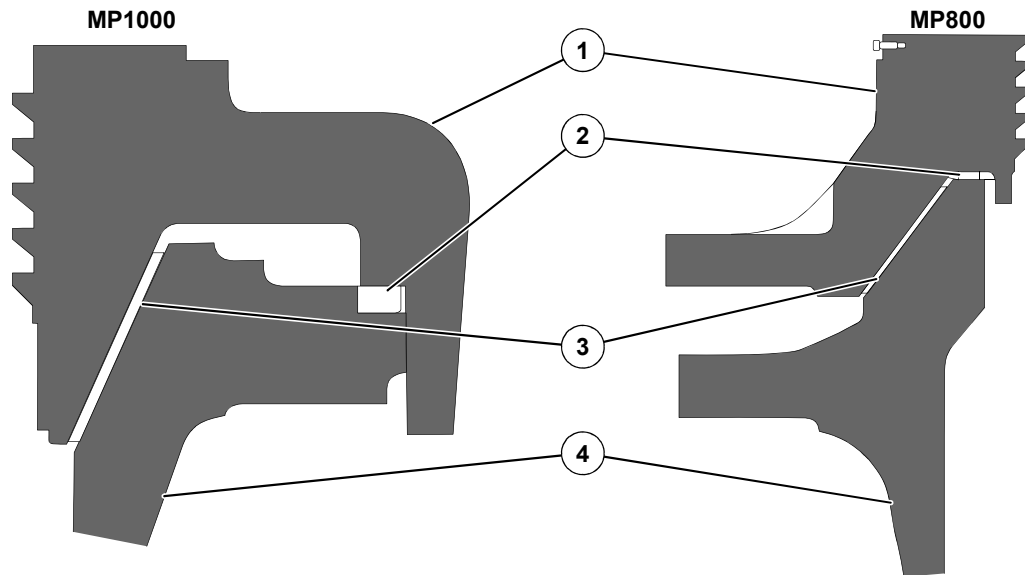
Should there be an excessive amount of adjustment ring movement, this wear could be increased. Refer to Figure 3-8.

The fulcrum bar is very important as it permits the adjustment ring to tilt and recenter properly when the ring raises due to a piece of tramp iron passing through the crushing cavity.



Callout	Description
1	Install Shackles and attach lifting slings (four places)

Figure 3-7 Lifting Adjustment Ring



Callout	Description
1	Adjustment ring
2	Main frame fulcrum bar
3	Bronze main frame seat liner
4	Main frame

Figure 3-8 Main Frame Seat Liner and Fulcrum Bar

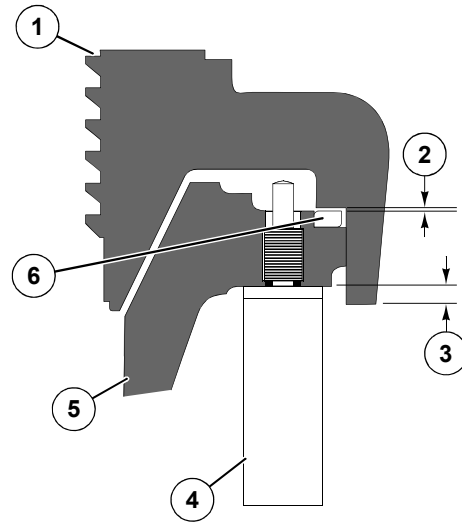
3.4.2 Main Frame Seat Liner Wear

To determine exactly how much wear is taking place on the main frame, proceed as follows:

MP1000

1. Starting at the countershaft box and in line with a clearing jack, identify on the outside surface of the adjustment ring four spots 90° apart by stamping or painting the numbers 1, 2, 3, and 4.
2. Measure the distance from the clearing jack mounting boss, located on the underside of the main frame flange, to the bottom surface of the adjustment ring at the four numbered spots as shown on Figure 3-9. Record these measurements.
3. At periodic intervals remeasure these points and compare them to the original dimensions. Comparing the two sets of dimensions will show at a glance how much wear has taken place and if the wear is even all the way around the Crusher. Due to casting and machining variations this is the only accurate method in which wear can be determined.
4. When any one of the four check dimensions measures more than the initial recorded dimensions by the amount shown on Table 3-1 the seat liner and fulcrum bars need replacing. This much vertical wear means that only 5 mm (0.19") of material is left on the seat liner.

The 10 mm (0.38") difference between the two measurements indicates the seating surface has worn and, according to the table, the seat liner and fulcrum bars need replacing.



Callout	Description
1	Adjustment ring
2	1.6 mm (0.062") to 5 mm (0.196") gap required after new main frame fulcrum bars and seat liner are installed
3	Measure wear here
4	Clearing jack
5	Main frame
6	Main frame fulcrum bar

Figure 3-9 Determining Seating Surface Wear (MP1000)

MP800

1. Starting at any release cylinder, identify, on the outside surface of the adjustment ring flange, four spots 90° apart by stamping or painting the numbers 1, 2, 3 and 4.
2. Measure the distance from the top of the adjustment ring flange to the bottom surface of the upper main frame flange at the four numbered spots as shown in Figure 3-10. Record these measurements.
3. At periodic intervals remeasure these points and compare them to the original dimensions. Comparing the two sets of dimensions will show at a glance how much wear has taken place and if the wear is even

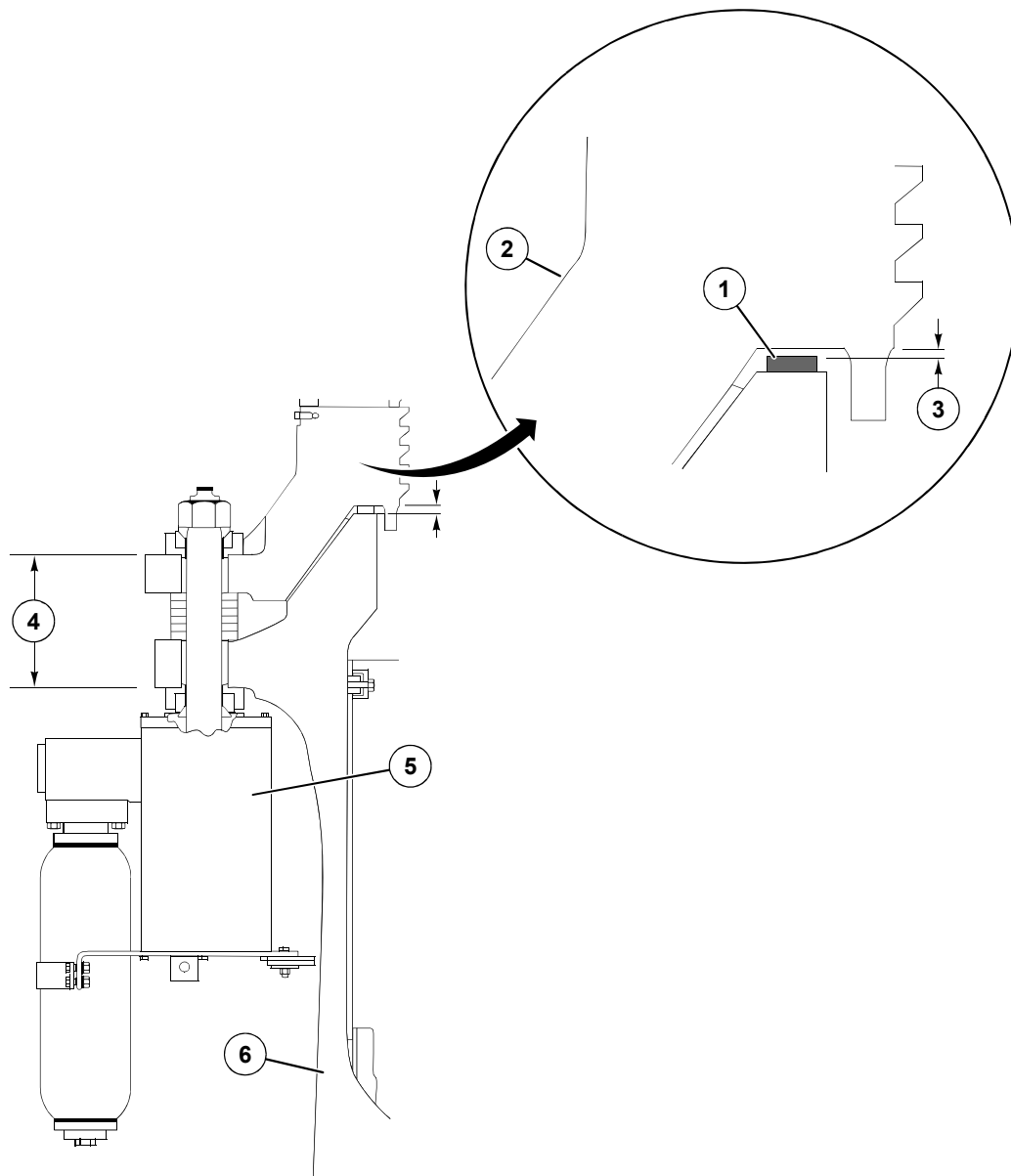
all the way around the Crusher. Due to casting and machining variations this is the only accurate method in which wear can be determined.

4. When any one of the four check dimensions measures less than the initial recorded dimensions by the amount shown in Table 3-1 the seat liner and fulcrum bars need replacing. This much vertical wear means that only 5 mm (0.19") of material is left on the seat liner.

The 8 mm (0.32") difference between the two measurements indicates the seating surface has worn and, according to the table, the seat liner and fulcrum bars need replacing.

Table 3-1 Seat Liner Wear

MP800		MP1000	
Maximum Vertical Wear	8 mm (0.32")	Maximum vertical wear	10 mm (0.38")
Example:		Example:	
Original recorded measurement	350 mm (13.78")	Periodic dimensional check	50 mm (2.00")
Periodic dimensional check	342 mm (13.46")	Original recorded measurement	40 mm (1.62")
Difference	8 mm (0.32")	Difference	10 mm (0.38")



Callout	Description	Callout	Description
1	Main frame fulcrum bar	4	Measure wear here
2	Adjustment ring	5	Release cylinder
3	2 mm (0.080") to 5 mm (0.196") gap required after new main frame fulcrum bars and seat liner are installed	6	Main frame

Figure 3-10 Determining Seating Surface Wear (MP800)

3.4.3 Main Frame Seat and Fulcrum Bar Installation

There is a gap between the main frame fulcrum bar and adjustment ring fulcrum surface that is to be maintained when seat liners and fulcrum bars are replaced. Refer to Figure 3-9 for the MP1000 or Figure 3-10 for the MP800.

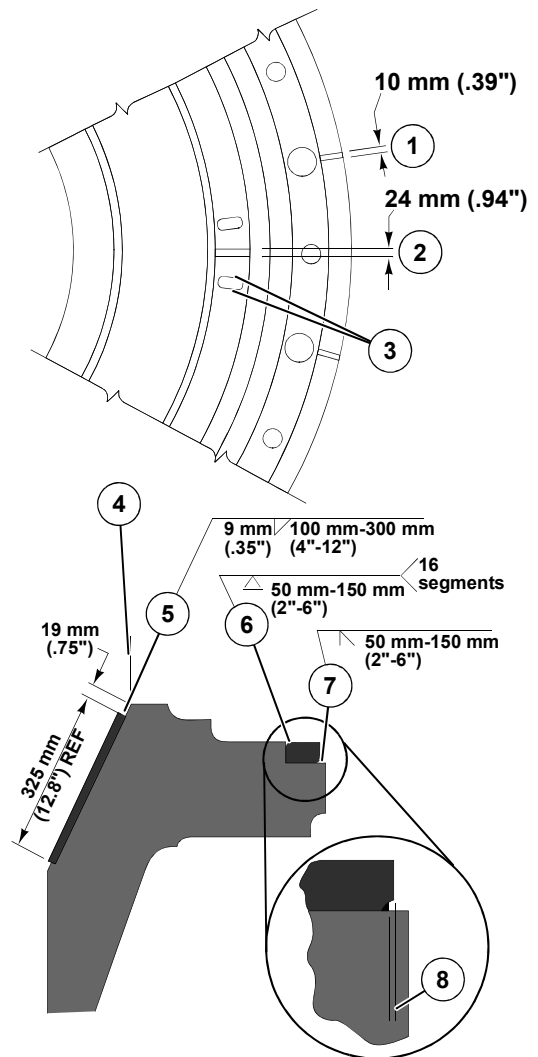
Over a long period of time, the adjustment ring conical seating surface will experience wear, even though it seats on a bronze frame seat liner. If enough adjustment ring wear occurs, the desired gap between the frame fulcrum bars and adjustment ring fulcrum surface will not be obtainable even though a new seat liner and fulcrum bars have been installed. It is very important that this gap is maintained when new seat liners and fulcrum bars are installed so the adjustment ring seats properly on the bronze frame seat liner and not on the frame fulcrum bars and adjustment ring.

If the adjustment ring is allowed to rest on the fulcrum bars instead of on the frame seat liner, major adjustment ring failure could occur. The procedure for seat liner, fulcrum bar replacement and possible adjustment ring rework is as follows.

MP1000

For the following procedure refer to Figure 3-11.

1. Remove worn bronze main frame seat liner and fulcrum bar.
2. The replacement main frame seat liner and fulcrum bar will be shipped in segments.
3. Position the seat liner at the dimension shown and weld using 4 mm (0.16") weld rod which meets AWS E Cu AL-A2 or R Cu AL-A2 specification. Do not butt vertical joints.
4. When using these 4 mm (0.16") weld rods reverse polarity and use between 130 to 190 amps. The main frame seat and seat liner must be preheated to 20°C (68°F) to 40°C (105°F).
5. Weld the fulcrum bar as shown.
6. After welding a new seat liner and fulcrum bar to the main frame place balls of clay or putty around the top outside corner of the main frame flange.



Callout	Description
1	Typical gap between fulcrum bar segments
2	Typical gap between seat liners
3	9 mm (0.37") typ. braze length. Braze along sides of slot only — 16 places
4	3280 mm (129.13") diameter
5	Braze along top of segments
6	Weld typ. 16 segments
7	Weld typ. 16 segments
8	5 mm (0.20") weld must be recessed to this dimension

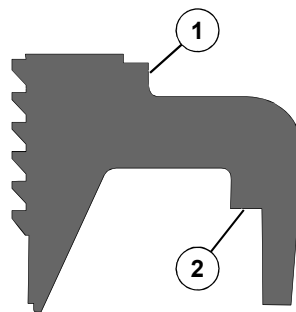
Figure 3-11 MP1000 Main Frame Seat Liner and Fulcrum Bar

7. Then lower the adjustment ring on the frame. When the adjustment ring is properly seated, the clay or putty will compress, showing the exact amount of clearance between the adjustment ring and the main frame.

Example MP1000:

1.6 mm (0.0625")	–	Minimum clearance required between new main frame fulcrum bars and adjustment ring fulcrum surface from Figure 3-9
–.8 mm (0.031")	–	Thickness of clay balls
.8 mm (0.031")	–	The amount of material to be machined off the adjustment ring fulcrum surface to obtain minimum distance from Figure 3-9. Refer to Figure 3-12 for location of adjustment ring fulcrum surface.

8. Lift the adjustment ring from the frame and measure the thickness of the clay or putty balls.
 - a. If the clay ball thicknesses are less than 1.6 mm (0.0625") the minimum distance shown in Figure 3-9, then the adjustment ring fulcrum surface is to be machined to obtain the minimum clearance. Refer to the example above.
 - b. If the clay ball thicknesses are more than 5 mm (0.196"), the maximum distance shown in Figure 3-9, then the adjustment ring fulcrum surface is to be built up with weld and machined to obtain at least the maximum clearance. If weld build up is required, then contact Metso Minerals for weld and machining procedures.



Callout	Description
1	Adjustment ring
2	Adjustment ring fulcrum surface (this area to be machined)

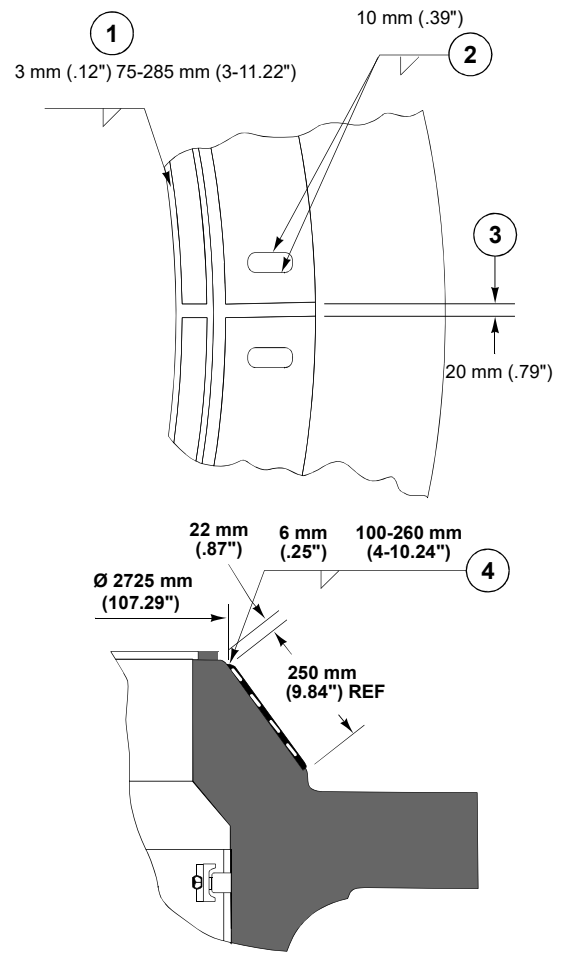
Figure 3-12 MP1000 Adjustment Ring Fulcrum Surface

MP800

For this procedure refer to Figure 3-13.

1. Remove worn bronze main frame seat liner and fulcrum bar segments.
2. The replacement main frame seat liner and fulcrum bar will be shipped in segments.
3. Position the seat liner at the dimension shown and weld using 4 mm (0.16") weld rod which meets AWS E Cu AL-A2 or R Cu AL-A2 specification. Do not butt vertical joints.
4. When using these 4 mm (0.16") weld rods reverse polarity and use between 130 to 190 amps. The main frame seat and seat liner must be preheated to 20°C (68°F) to 40°C (105°F).
5. Weld the fulcrum bar as shown.
6. After welding a new seat liner and fulcrum bar to the main frame place balls of clay or putty around the top outside corner of the main frame flange.
7. Then lower the adjustment ring on the frame. When the adjustment ring is properly seated, the clay or putty will compress, showing the exact amount of clearance between the adjustment ring and the main frame.

8. Lift the adjustment ring from the frame and measure the thickness of the clay or putty balls.
 - a. If the clay ball thicknesses are less than 2 mm (0.080") the minimum distance shown in Figure 3-9 then the adjustment ring fulcrum surface is to be machined to obtain the minimum clearance. Refer to the following example:
 - b. If the clay ball thicknesses are more than 5 mm (0.196"), the maximum distance shown in Figure 3-10, then the adjustment ring fulcrum surface is to be built up with weld and machined to obtain at least the maximum clearance. If weld build up is required, then contact Metso Minerals for weld and machining procedures.

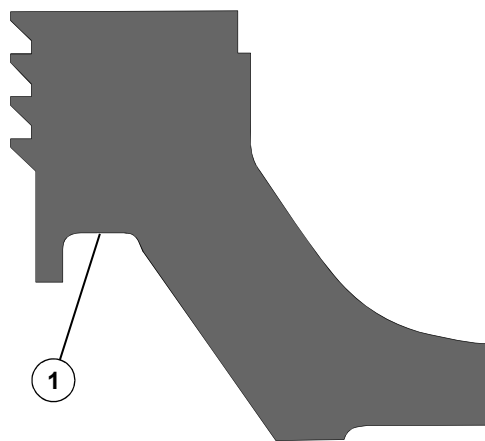


Callout	Description
1	4 Segments
2	Braze along sides of slots only — 18 places
3	Typ. gap between seat liner and fulcrum bar segments
4	6 Segments

Figure 3-13 MP800 Main Frame Seat Liner and Fulcrum Bar

Example MP800:

2.0 mm (0.080")	—	Minimum clearance required between new main frame fulcrum bars and adjustment ring fulcrum surface from Figure 3-10
–1.0 mm (0.040")	—	Thickness of clay balls
1.0 mm (0.040")	—	The amount of material to be machined off the adjustment ring fulcrum surface to obtain minimum distance from Figure 3-10. Refer to Figure 3-14 for location of adjustment ring fulcrum surface.



Callout	Description
1	Adjustment ring fulcrum surface (this area to be machined)

Figure 3-14 MP800 Adjustment Ring Fulcrum Surface

3.4.4 Tramp Release Cylinder and Accumulator Removal

A leaking cylinder requires immediate attention. External leakage will be visible by oil and dirt accumulations on the cylinder. Oil leakage at the cylinder will result in loss of pressure at the release system pressure gauge. If the system loses pressure and requires repeated recharging, an oil leak should be suspected.

Due to the size and weight of the accumulator it is necessary to remove and install the tramp release cylinder and accumulator as an assembly. For safety it is also recommended to release the nitrogen pressure in the accumulator prior to removing the tramp release cylinder and the

accumulator from the Crusher. Refer to *Accumulator Replacement* later in this section for the process of safely releasing the nitrogen pressure from the accumulator.

Remove a leaking cylinder for replacement or repair as follows (refer to Figure 3-12):

⚠ WARNING

Prior to performing maintenance work on any part of the Crusher, lockout and tag all electrical power supplied to the power unit and Crusher and release stored pressure in all hydraulic circuits. Death or serious injury may result if the Crusher systems are activated while maintenance work is being performed. Turn the POWER OFF/ON switch located on the local control station to the OFF position and lock out and tag the power supply to the power unit and Crusher. Depressurize the hydraulic circuits by opening (turn counter-clockwise) the needle valves located at the hydraulic power unit cabinet. This will vent the pressurized oil in the hydraulic circuits back to tank.

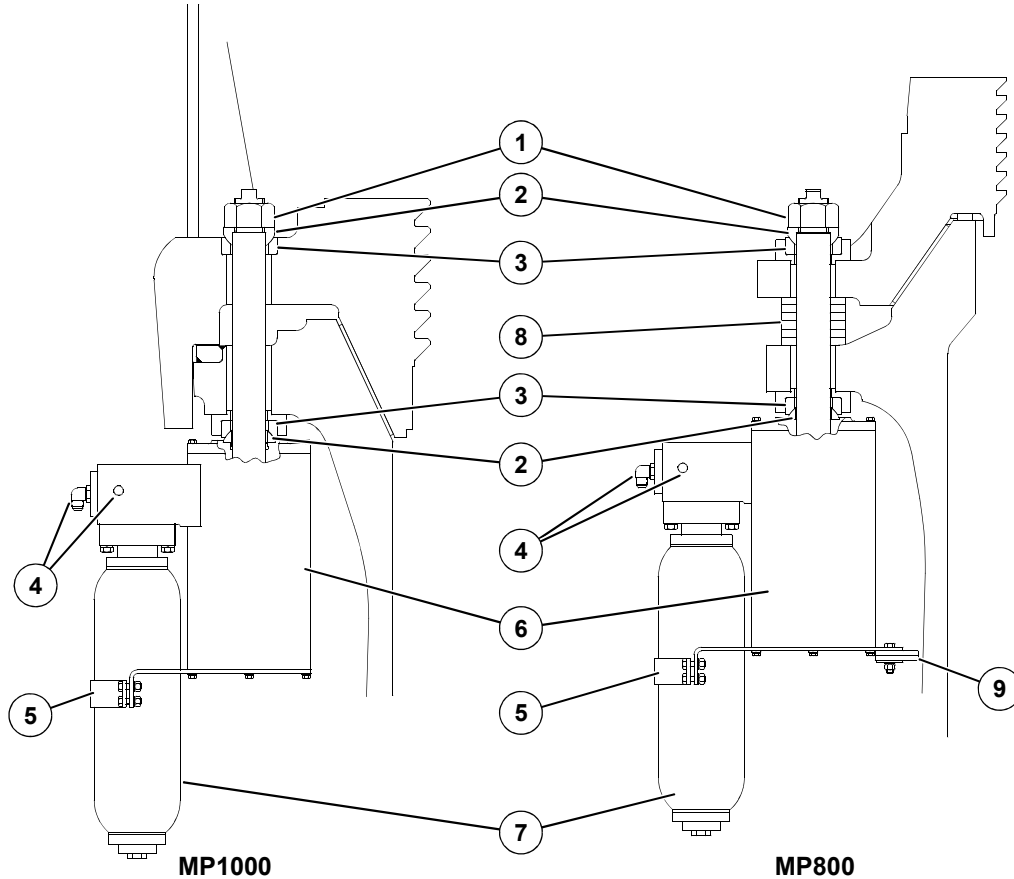
⚠ WARNING

Do not attempt to disconnect any of the hydraulic connections without first insuring that the system has been depressurized. Disconnecting a hose while under high pressure is dangerous due to the high velocity of the escaping oil and due to the possibility of being struck by the free end of a whipping hose.

1. Index the drive ring so that one of the two 50 mm (1.97") diameter holes is directly above and in line with the tramp release cylinder that is going to be removed for servicing. On more recent Crushers, these holes have been provided in the drive ring for handling the tramp release cylinder, if your Crusher does not have these holes in the drive ring contact Metso Product Support Department for instructions on how and where to add the holes.

2. Lock out and tag all electrical power supplied to the power unit and Crusher and depressurize the clamping and tramp release circuits by opening the clamping cylinder and tramp release cylinder needle valves located on the side of the hydraulic power unit at the hose connection area. Verify that the pressure gauges (PI-1 for the clamping cylinder circuit and PI-2 for the tramp release circuit) read zero pressure.

3. Disconnect the release circuit hoses on both sides of the tramp release cylinder. If the release cylinder to be removed has the hose from the power unit connected to it, remove the hose from the elbow on front of the cylinder as well. Refer to Figure 3-15. Cap or plug open ports and hose ends to prevent loss of oil and entry of dirt.



Callout	Description	Callout	Description
1	Rod nut	6	Tramp release cylinder
2	Bearing cone	7	Accumulator
3	Bearing cup	8	Rod seal
4	Hose connection	9	Bumper
5	Clamp segment		

Figure 3-15 Tramp Release Cylinder and Accumulator

4. Release the nitrogen pressure from the accumulator. Refer to *Accumulator Replacement* later in this section for the process of safely releasing the nitrogen pressure from the accumulator.
5. Thread an M20 eyebolt into the end of the cylinder rod. The eyebolt must be turned down completely so that the shoulder of the eyebolt is seated on the top surface of the cylinder rod. The M20 eyebolt used must have a diameter not to exceed 72 mm (2.83") in order to pass through the rod nut.
6. Lower a lifting sling from an overhead crane through the hole in the drive ring and connect to the eyebolt with a shackle. The shackle and sling used to connect to the eyebolt must have adequate capacity and a width not to exceed 72 mm (2.83") in order to pass through the rod nut. The lifting sling must have adequate length to enable the cylinder to drop to the floor or platform before the hook on the overhead crane hits the drive ring.
7. Take up any slack in the lifting sling. If an overhead crane is not available, scaffolding can be built to support a chain hoist to remove the tramp release cylinder assembly.

⚠ WARNING

Provide safe work platforms for all maintenance and operational requirements. Death or serious injury may result from a fall from an unstable or inadequate work platform. Work platforms must be anchored to provide adequate stability and must be structurally able to support the loads sustained during any maintenance operation. Workers must also be prepared with fall arrest harness equipment. Follow all OSHA, MSHA and site specific guidelines for the requirements of working from elevated platforms.

8. Remove the rod nut and bearing cone from the threaded end of the cylinder rod.
9. Slowly lower the tramp release cylinder to the floor or platform and remove the shackle and eyebolt from the cylinder rod.

10. Remember to remove the rod nut and bearing cone from the sling above the adjustment ring.

11. Refer to *Section 12* for tramp release cylinder re-building instructions.

3.4.5 Tramp Release Cylinder and Accumulator Installation

Due to the size and weight of the accumulator it is necessary to remove and install the tramp release cylinder and accumulator as an assembly.

Install a new or repaired cylinder as follows:

1. Index the drive ring so that one of the two 50 mm (1.97") diameter holes in the drive ring is above and directly in line with the mounting location of the tramp release cylinder that is being installed. On more recent Crushers, these holes have been provided in the drive ring for handling the tramp release cylinder, if your Crusher does not have these holes in the drive ring contact Metso Product Support Department for instructions on how and where to add the holes.
2. Lock out and tag all electrical power supplied to the power unit and Crusher and depressurize the clamping and tramp release circuits by opening the clamping cylinder and tramp release cylinder needle valves located on the side of the hydraulic power unit at the hose connection area. Verify that the pressure gauges (PI-1 for the clamping cylinder circuit and PI-2 for the tramp release circuit) read zero pressure.
3. With the tramp release cylinder on the floor or platform directly below its mounting location on the adjustment ring, slide the lower bearing cone onto the cylinder rod with the bevel pointing away from the cylinder and seat it on the cylinder head. Then coat the bevel of the cone with "never seize". Note that the release cylinder boss and the lower bearing cup should still be in place on the underside of the main frame.

4. Thread an M20 eyebolt into the end of the cylinder rod. The eyebolt must be turned down completely so that the shoulder of the eyebolt is seated on the top surface of the cylinder rod. The M20 eyebolt used must have a diameter not to exceed 72 mm (2.83") in order to pass through the rod nut.
5. Lower a lifting sling from an overhead crane through the hole in the drive ring. Thread the rod nut then the upper bearing cone with the bevel pointing down onto the sling before passing the sling through the hole in the adjustment ring and main frame down to the floor or platform. For the **MP800** also locate the rod seal between the flanges of the adjustment ring and main frame before the sling is passed through the holes in the adjustment ring and main frame.

If an overhead crane is not available, scaffolding can be built to support a chain hoist to install the tramp release cylinder assembly.

WARNING

Provide safe work platforms for all maintenance and operational requirements. Death or serious injury may result from a fall from an unstable or inadequate work platform. Work platforms must be anchored to provide adequate stability and must be structurally able to support the loads sustained during any maintenance operation. Workers must also be prepared with fall arrest harness equipment. Follow all OSHA, MSHA and site specific guidelines for the requirements of working from elevated platforms.

6. Connect the sling to the eyebolt with a shackle. The shackle and sling used to connect to the eyebolt must have adequate capacity and a width not to exceed 72 mm (2.83") in order to pass through the rod nut.
7. Carefully raise the tramp release cylinder rod through the hole in the main frame and adjustment ring.

8. With the threaded end of the cylinder rod above the top of the adjustment ring, first coat the bearing cone with "never seize" then slide the bearing cone over the top of the rod until it seats on the flange just below the threads. Then screw the rod nut onto the rod end until it bottoms out on the bearing cone.
9. Lower the tramp release cylinder until the bearing cone seats in the bearing cup and the lifting sling slackens. Disconnect the lifting sling and unscrew the eyebolt from the end of the cylinder rod. Plug the threaded hole at the end of the cylinder rod with an M20 bolt or with grease to protect the threads and keep the hole from filling up with dirt.
10. Rotate the release cylinder so the manifold block on the cylinder is pointing outward from the Crusher.
11. Reconnect the tramp release system hoses to the release cylinder. Pressurize the accumulator with nitrogen to the proper pre-charge pressure. Refer to *Checking Pre-Charge Pressure and Charging the Accumulator (Tramp Release System)* in *Section 12* for information on pressurizing the accumulator to the pre-charge pressure.

NOTICE

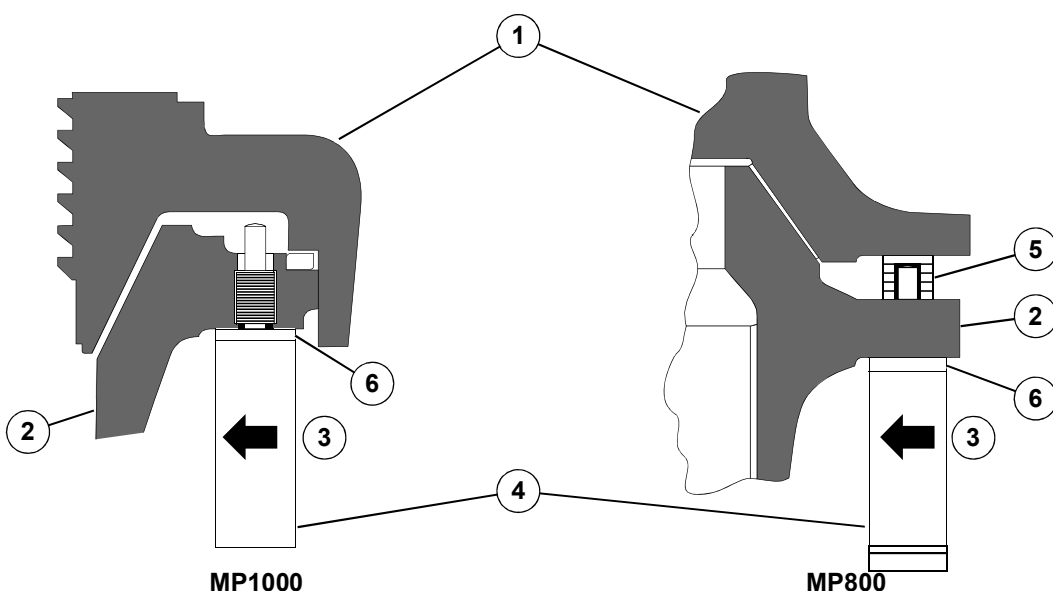
Do not pump oil into the tramp release circuit before the accumulators are pre-charged with nitrogen. This could damage the bladder and necessitate an accumulator replacement.

12. After the cylinder is installed and all connections completed, the system must be bled to remove any entrapped air. The system is then to be pressurized and checked for leaks. Refer to *Section 12* for information on bleeding and checking the tramp release system.

3.4.6 Clearing Jack Removal

A leaking clearing jack is a condition which should prompt attention. A leaking cylinder will result in the ring not raising during a clearing operation. Leaky seals could also cause the ring to creep down after being raised during a clearing operation. To remove a leaking cylinder for replacement or repair proceed as follows (refer to Figure 3-16):

1. Lock out and tag all electrical power supplied to the power unit and Crusher.
2. Disconnect hose from the cylinder. Plug and cap open ports to prevent loss of oil and prevent the entry of dirt.
3. Attach a sling around the cylinder, and attach the free end of the sling to a suitable lifting device. Take up the slack in the sling.
4. Attach a pipe strap wrench around the cylinder head of the clearing jack and turn the jack in a counterclockwise direction as seen from below the cylinder and as shown in Figure 3-16.
5. After the jack is free of the main frame flange slowly lower the cylinder until the cylinder push rod clears the underside of the main frame flange.
6. Refer to *Section 12* for clearing jack cylinder rebuilding instructions.



Callout	Description
1	Adjustment ring
2	Main frame
3	Unscrew
4	Clearing jack cylinder
5	Rod seal
6	Tack weld

Figure 3-16 Clearing Jack Cylinder

3.4.7 Clearing Jack Installation

Install a new or repaired cylinder, as follows:

1. Push the jack push rod into the cylinder until the piston bottoms.
2. Attach a sling around the cylinder, and to a suitable lifting device.
3. Carefully lift the cylinder and position the cylinder rod up into the frame flange.
4. With the cylinder in place, attach pipe strap wrench around the jack cylinder head and turn the jack in a clockwise direction until the head is tight against the main frame flange.
5. Tack weld head of clearing jack to main frame as shown in Figure 3-16.

On the MP800 make sure the cylinder rod goes through the rod seal, located between the flanges of the adjustment ring and main frame. This seal prevents dirt from accumulating around the cylinder rod and main frame. Accumulation of dust and dirt in this area could cause premature piston seal failure.

6. Connect the clearing jack circuit hoses to the bottom of the cylinder.
7. After the cylinder is installed and all connections completed, the system must be bled to remove any entrapped air. The system is then pressurized and checked for leaks. Refer to *Section 12* for information on bleeding and checking the system.

3.4.8 Accumulator Replacement

A faulty accumulator, either the nitrogen gas escaping to atmosphere or a leak in the internal bladder, is a serious condition that requires immediate attention (refer to Figure 12-13). In either instance, the accumulator will completely fill with oil. Since the gas or pre-charge has escaped or leaked from the bladder, the tramp release arrangement will not function properly. Oil which is normally displaced from the tramp release cylinder into the accumulators when uncrushable material or overloads are encountered, cannot compress the nitrogen gas within the accumulator bladders, thereby creating excessive forces within the crusher's components.

The accumulator gas pressure should be checked every 200 hours (1 month). If the accumulator gas pressure is not at its normal pre-charge level, 69 BAR (1000 PSI) or is unable to sustain the recommended level of normal operating pressure, the accumulator should be removed and replaced. Replace a faulty accumulator as follows:

WARNING

Prior to performing maintenance work on any part of the Crusher, lockout and tag all electrical power supplied to the power unit and Crusher and release stored pressure in all hydraulic circuits. Death or serious injury may result if the Crusher systems are activated while maintenance work is being performed. Turn the POWER OFF/ON switch located on the local control station to the OFF position and lock out and tag the power supply to the power unit and Crusher. Depressurize the hydraulic circuits by opening (turn counter-clockwise) the needle valves located at the hydraulic power unit cabinet. This will vent the pressurized oil in the hydraulic circuits back to tank.

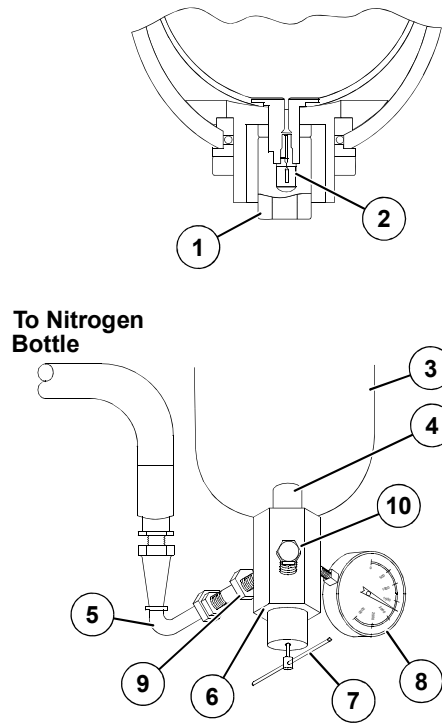
WARNING

Do not attempt to disconnect any of the hydraulic connections without first insuring that the system has been depressurized. Disconnecting a hose while under high pressure is dangerous due to the high velocity of the escaping oil and due to the possibility of being struck by the free end of a whipping hose.

WARNING

Releasing stored pressure in the hydraulic circuits does not relieve the gas pre-charge pressure held in the accumulators. Death or serious injury may result from a sudden and explosive release of pressure. Follow all maintenance procedures when servicing accumulators.

1. Lock out and tag all electrical power supplied to the power unit and Crusher and depressurize the clamping and tramp release circuits by opening the clamping cylinder and tramp release cylinder needle valves located on the side of the hydraulic power unit at the hose connection area.
2. Verify that the pressure in the clamping and tramp release circuits has been relieved by confirming that the pressure reading on **pressure indicator/transmitter PIT-1 and PIT-2** have both gone to zero.
3. Release the nitrogen gas pre-charge pressure in the accumulator while the accumulator is still mounted to the crusher following the steps below. Even if you suspect that the bladder has ruptured and all nitrogen gas has escaped it is still recommended to go through the procedure of releasing any residual pressure left in the accumulator.
4. Remove the valve guard from the bottom of the accumulator and then the valve cap from the gas valve stem as shown in Figure 3-17.



Callout	Description
1	Valve guard
2	Valve cap
3	Accumulator
4	Gas valve stem
5	Swivel
6	Air valve/dust cap
7	T-handle
8	Pressure gauge
9	Tank valve
10	Bleeder valve

Figure 3-17 Depressurizing the Accumulator Bladder

5. Obtain the charging and gauging assembly furnished with the special tools.

The charging assembly is required to connect the gauging assembly to a nitrogen bottle in order to increase the pre-charge in the accumulator to the proper pressure. It consists of a 3 m (10 ft.) length of hose attached to a swivel connector on one end and a gland nut and gland on the other end.

The gauging assembly consists of an adapter, bleeder valve, tank valve and pressure gauge which are attached as one unit directly to the gas valve stem on the accumulator. When attached to the accumulator, the gauging assembly enables gas pre-charge to be checked. The charging assembly is only used when charging the accumulators; pressure readings can be taken and excess pressure bled off with just the gauging assembly.

6. Remove the 3 m (10 ft.) hose from the gauging assembly at the swivel connector. Turn the T-handle on the adapter **open** (counter clockwise) until the handle can no longer be turned. The bleeder valve screw must be **closed** (turn clockwise).
7. Thread the adapter onto the accumulator's gas valve stem. Tighten the adapter hand tight and then tighten an additional quarter turn to compress the sealing washer in the adapter to prevent gas leakage.

NOTICE

Do not over tighten the gauging assembly adapter. Excess torque can twist off the valve stem and/or distort the copper sealing washer in the adapter causing leakage.

8. Turn the T-handle on the adapter **closed** (turn clockwise) until the shaft inside the adapter fully depresses the valve core in the gas valve stem on the accumulator.
Then slowly **open** (turn counter clockwise) the bleeder valve screw until the nitrogen gas begins to escape. Allow all of the gas to escape to the atmosphere. When the pressure gauge on the adapter reads zero (0) pressure, the accumulator is considered empty. Remove the gauging assembly from the accumulator.
9. Reinstall the washer and valve cap on the gas valve stem. Reinstall the valve guard on the bottom of the accumulator.

10. Due to the physical size and weight of the accumulator it is necessary to remove the tramp release cylinder and accumulator as an assembly. Refer to *Tramp Release Cylinder and Accumulator Removal* earlier in this section.
11. After removing the tramp release cylinder and accumulator, lay the assembly in a horizontal position on a flat surface.
12. Remove the hex nuts, lock washers and cap screws from the clamp segment around the accumulator body and remove the clamp segment from the accumulator bracket.
13. Remove the hex head cap screws from the accumulator flange and separate the accumulator from the release cylinder, being careful not to damage the flange.
14. Clean the hex head cap screws and tapped holes in the release cylinder boss with Loctite Safety Solvent 75559, alcohol or acetone.
15. Install a new O-ring in the flange groove of the replacement accumulator.
16. Position the replacement accumulator on the flat surface, apply Loctite 271 to the cap screws and install the accumulator on the tramp release cylinder. Tighten the cap screws to 470 Nm (345 ft-lb).
17. Install the clamp segment and attaching hardware.
18. After the accumulator is installed, the tramp release cylinder can be remounted on the Crusher. Refer to Tramp Release Cylinder and Accumulator Installation earlier in this section.
19. Pre-charge the replacement accumulator with nitrogen. Refer to *Checking Pre-Charge Pressure and Charging the Accumulator (Tramp Release System)* in Section 12 for instructions on pre-charging the accumulator.

NOTICE

Do not pump oil into the tramp release circuit before the accumulators are pre-charged with nitrogen. This could damage the bladder and necessitate an accumulator replacement.

20. Reinstall all hose connections to the cylinder, bleed the air from the tramp release circuit and pressurize the system and check for leaks. Refer to *Bleeding the Tramp Release Circuit* in Section 12 for instructions on bleeding and pressure testing the tramp release circuit.

3.4.9 Accumulator Bladder Replacement

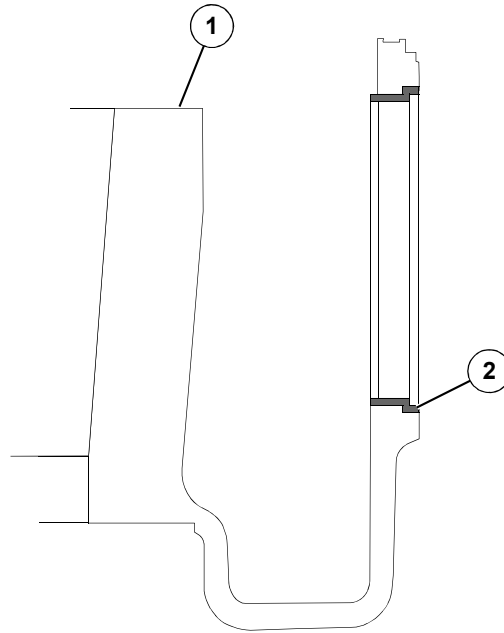
For accumulator bladder replacement procedure, refer to *Accumulator Repair* in Section 12.

3.4.10 Main Frame Ring Replacement

A frame ring has been installed into the main frame at the inner countershaft box as shown in Figure 3-18. The purpose of this ring is to eliminate the need of having to remove the frame from the foundation to rework the inner bore (due to excessive bore wear). If excessive bore wear occurs, all that need be done is to replace the frame ring. To replace the frame ring proceed as follows:

1. Remove the following components to gain access to the ring:
 - Bowl (Section 8)
 - Head (Section 7)
 - Socket and Socket Liner (Section 6)
 - Eccentric (Section 5)
 - Countershaft Box (Section 4)
2. Drive the ring out of the frame bore from inside the pinion well toward the outside.
3. Clean frame bore, inspect and measure diameters. Convey this information to Metso Product Support Department for possible rework requirements.
4. Clean the new frame ring O.D. with Loctite Safety Solvent 75559, alcohol or acetone.
5. Cool ring to at least the temperature difference between ring and frame defined in Figure 3-19.

6. Install ring into frame. Allow temperatures of the Ring and Frame to normalize before installing countershaft box into frame.



Callout	Description
1	Main frame
2	Main frame ring

Figure 3-18 Main Frame Ring

3.4.11 Adjustment Ring Installation

The adjustment ring assembly consisting of the dust shell, pin bushing, pin covers, clamping ring and clamping cylinders has been shipped assembled as one unit (refer to Figure 3-20).

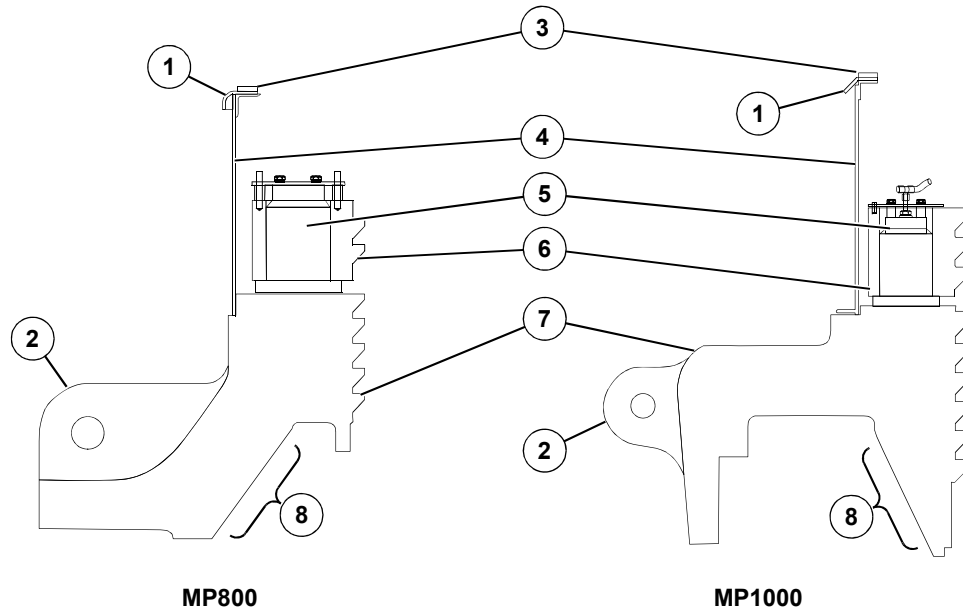
To assemble the adjustment ring assembly onto the main frame do the following:

1. Attach shackles and lifting slings to the lift lugs, four on the MP1000, three on the MP800, located on the outside diameter of the adjustment ring. Refer to Figure 3-7 and Figure 3-20.
2. Coat the Adjustment Ring seat with a lithium base grease, NLGI No.1 containing a minimum of 3% molybdenum disulfide.

3. Place the adjustment ring assembly onto the main frame so that the clamping cylinder hose connection is located opposite the countershaft box. As the adjustment ring is lowered over the main frame pins, rotate the ring in a clockwise direction so the main frame pin bushings in the adjustment ring touch the main frame pins as shown in Figure 3-21. Then lower the ring in this position and allow it to seat on the frame.

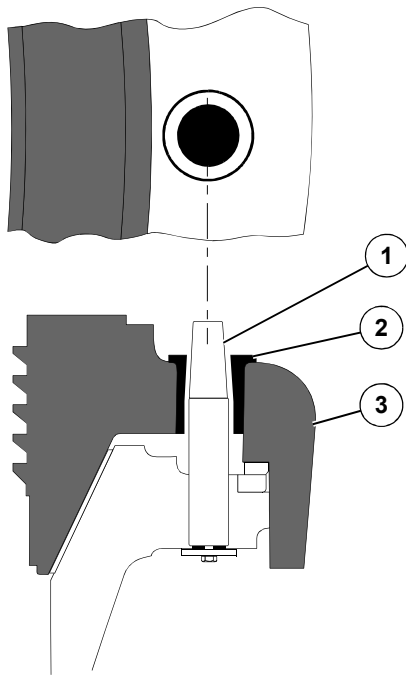
MP800	MP1000
56°C (101°F)	50°C (90°F)

Figure 3-19 Temperature Differences Required to Install Frame Ring



Callout	Description	Callout	Description
1	Adjustment cap seal	5	Clamping cylinder
2	Lifting ear	6	Clamping ring
3	Clamp segment	7	Adjustment ring
4	Dust shell	8	Adjustment Ring seat area

Figure 3-20 Adjustment Ring Assembly



Callout	Description
1	Main frame pin
2	Main frame pin bushing
3	Adjustment ring

Figure 3-21 Adjustment Ring Pin Bushing

3.4.11.1 Adjustment Ring Vibration Detection

Both the MP800 and MP1000 have four vibration sensors located on the adjustment ring. The sensors are wired back to a single enclosure. The vibration sensors are used to monitor ring bounce, a condition which is NOT NORMAL and IS NOT AN ACCEPTABLE METHOD OF OPERATION. Refer to the *MP Cone Crusher Mechanical Control Logic* document for more information. Also, refer to Figure 3-22.

Four vibration sensors are mounted on the adjustment ring and are wired to the MCM modules housed in a remotely mounted enclosure. The sensors monitor the movement of the adjustment ring (ring bounce) and indicate problems requiring correction to protect the crusher.

When using the vibration detection system, you must establish analog warning and alarm setpoints. To do this:

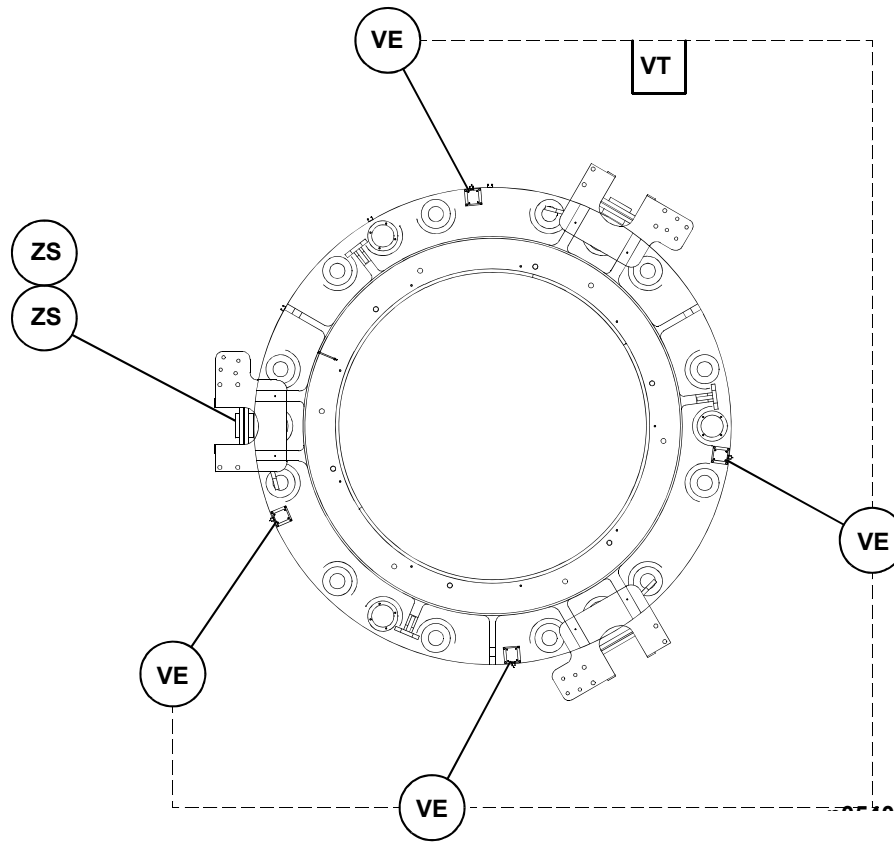
1. Create a limited amount of ring bounce by adjusting the Crusher setting while monitoring the analog output readings from the MCM Modules.
2. When ring bounce is detected, select the highest analog value and use that as your alarm setpoint. Calculate a value that is 10% less than the alarm setpoint to establish the warning setpoint.
3. Next, program the control to take the following corrective actions based on the four analog signals.
 - a. Instantaneously indicate which of the four sensor signals reach the established warning set-point. This signal or signals should not interrupt the feed but only alert the operator that the Adjustment Ring is on the verge of moving and that corrective actions should be taken to correct the problem(s) before the alarm set-point is reached and the feed is shut down.
 - b. Interrupt the feed to the Crusher if either of the following two conditions occur:

Any of the four sensor signals exceed the established alarm set-point for a period of 10 seconds.

or

If there are five occurrences of a three second continuous signal above the alarm set-point in a two minute period.

Corrective actions may include, but are not limited to, adjustment of the Crusher setting and/or correction of poor feed conditions. Alarm conditions during no-load operation, feed start, feed stop and adjustment under load can be ignored.



Callout	Description
VE	Vibration Sensor
VT	Vibration Transmitter
ZS	Proximity Sensor

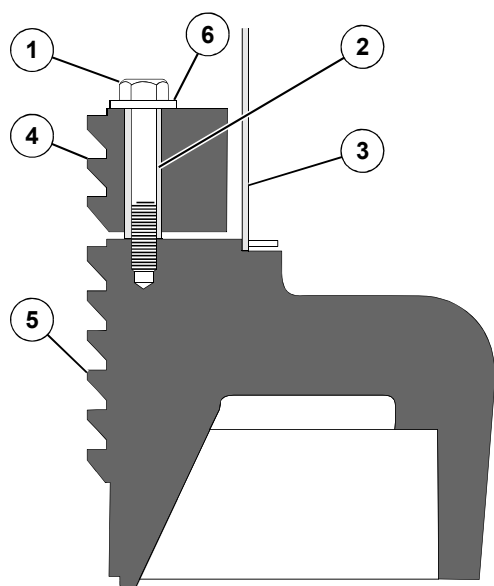
Figure 3-22 Vibration Sensor Locations (MP800 Shown)

3.4.12 Adjustment Ring Disassembly

The various sealing and clamping components that are associated with the adjustment ring can be detached and removed from the adjustment ring while the adjustment ring is left in place on the main frame. Main frame seat liner or fulcrum bar replacement will, however, require that the adjustment ring be removed from the main frame.

To detach and remove the adjustment ring components, proceed as follows:

1. Remove the bowl assembly as instructed in *Section 8*.
2. If the clamping ring is to be removed from the adjustment ring, then first remove the dust shell from the adjustment ring by removing the series of capscrews and lockwashers installed around its lower flange and then lift the shell off the ring.
If the clamping ring is not to be removed from the adjustment ring, then proceed to step 6.
3. Remove the hex head bolts and spacers that are used to hold the clamp ring when the bowl assembly is rotated. There are eight bolts and spacers on the MP1000 and six on the MP800. Refer to Figure 3-23.



Callout	Description
1	Clamping ring capscrew
2	Spacer
3	Dust shell
4	Clamping ring
5	Adjustment ring
6	Washers (MP800 only)

Figure 3-23 Clamping Ring Capscrews

4. Make sure the clamping circuit is depressurized by opening the clamping cylinder needle valve located at the power unit. Make sure the pressure gauge in the clamping circuit reaches zero (0) pressure. Then disconnect the hose that runs from the adjustment ring up through the clamp ring from the elbow.
5. Install a M36 ring bolt in each of the two tapped holes in the clamp ring and carefully lift the clamp ring and the clamping cylinders off the adjustment ring.
6. The adjustment cap seal is a continuous rubber ring and is detached by removing the attaching capscrews and hex nuts. The new seal is positioned around the perimeter of the dust shell. Metal clamp segments are positioned at the top on the dust shell and the parts are held together by capscrews and hex nuts shown in Figure 3-20.

7. If the adjustment ring is to be taken off the frame, all the tramp release cylinders have to be removed from the Crusher as described under *Tramp Release Cylinder and Accumulator Removal* in this section. Also disconnect the following hoses, plug or cap all open ports:

MP1000

- a. The clamping cylinder supply hose at the adjustment ring.
- b. The two hydraulic motor supply hoses and the brake supply hose from the tees on the adjustment ring.

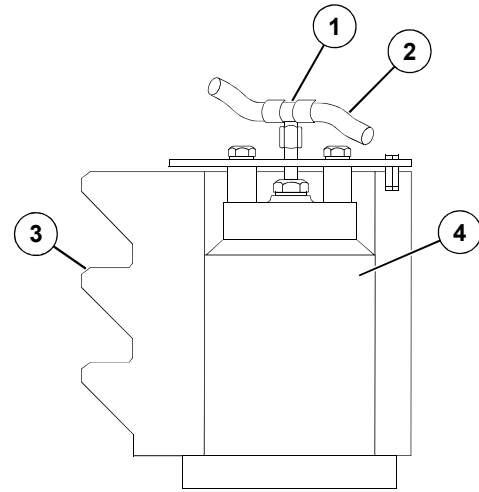
MP800

- a. The four supply hoses, for the hydraulic motors, brake and clamping cylinders, at the manifold block mounted on the adjustment ring.
8. Attach shackles and lifting slings to the lift lugs, four on the MP1000, three on the MP800, located on the outside diameter of the adjustment ring. Refer to Figure 3-7 and Figure 3-20.
 9. Carefully lift the adjustment ring off the main frame and set on blocking.

3.4.13 Clamping Cylinder Removal

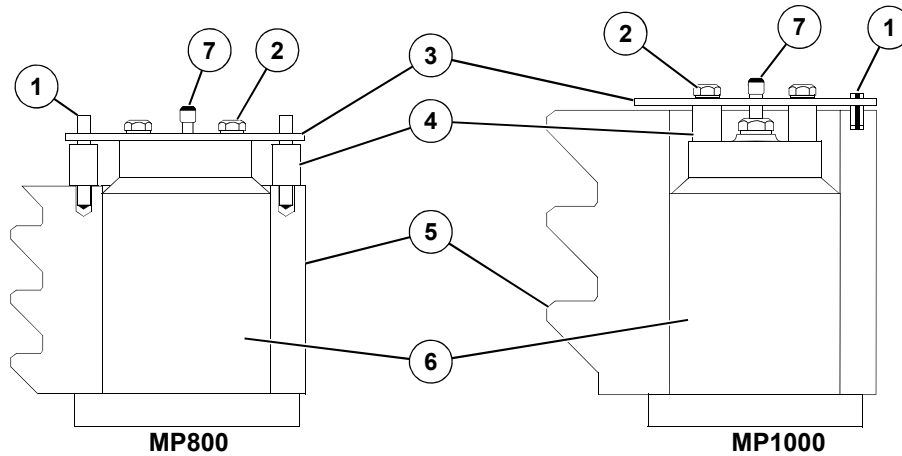
Remove a faulty clamping cylinder as follows:

1. Remove the clamping ring as described in steps 1 through 5 under *Adjustment Ring Disassembly* in this section.
2. Set the clamping ring on wood blocking at least 310 mm (12") off the floor.
3. Remove the hoses and tee or elbow from the top of the cylinder. Refer to Figure 3-24.
4. Put blocking between the floor and the clamping cylinder that is being removed. The blocking is required so the cylinder will not fall out of the clamp ring as the cylinder is free to slide out of the ring when the bolts are removed in step 5.



Callout	Description
1	Tee
2	Hose
3	Clamping ring
4	Clamping cylinder

Figure 3-24 Clamping Cylinder Removal



Callout	Description
1	Dowel
2	Mounting bolt
3	Mounting bracket
4	Spacer
5	Clamping ring
6	Clamping cylinder
7	Hydraulic fitting

Figure 3-25 Clamping Cylinder

5. Remove the mounting bolts from the top of the clamping cylinder refer to Figure 3-25.
6. Carefully slide the cylinder out of the clamping ring.

3.4.14 Clamping Cylinder Disassembly and Repair

For clamping cylinder disassembly and repair procedure, refer to *Section 12* under *Clamping Cylinder Rebuilding*.

3.4.15 Clamping Cylinder Installation

To install a new or rebuilt clamping cylinder into the clamping ring, refer to Figure 3-24 and proceed as follows:

1. With the clamping ring on blocking (a minimum of 310 mm (12") coat the clamping cylinder with "Never Sieze," then slide the cylinder up into its mating hole in the clamping ring until it bottoms. Then block the cylinder in place to hold it up.

NOTE: On the MP1000 make sure the hydraulic fitting is screwed into the top of the cylinder before sliding the cylinder into the clamping ring.

2. MP1000
 - a. Turn the clamping cylinder so the mounting holes are in line with the dowel in the clamping ring.
 - b. Place the two spacers on the cylinder and centered on the two tapped cylinder mounting holes.
 - c. Place the mounting bracket, with it engaging the dowel, on the spacers. Then bolt in place with the mounting bolts.

MP800

- a. Turn the clamping cylinder so the mounting holes are in line with the dowels in the clamping ring.
- b. Place a spacer over each dowel.
- c. Place the mounting bracket, with it engaging the dowels on the cylinder, then bolt it in place with the mounting bolts.

3. Install the tee or elbow and hoses to the top of the cylinder using Loctite 545 thread sealant on the fitting connections.
4. To mount the clamping ring onto the adjustment ring, follow the procedure under *Adjustment Ring Assembly* in this section.

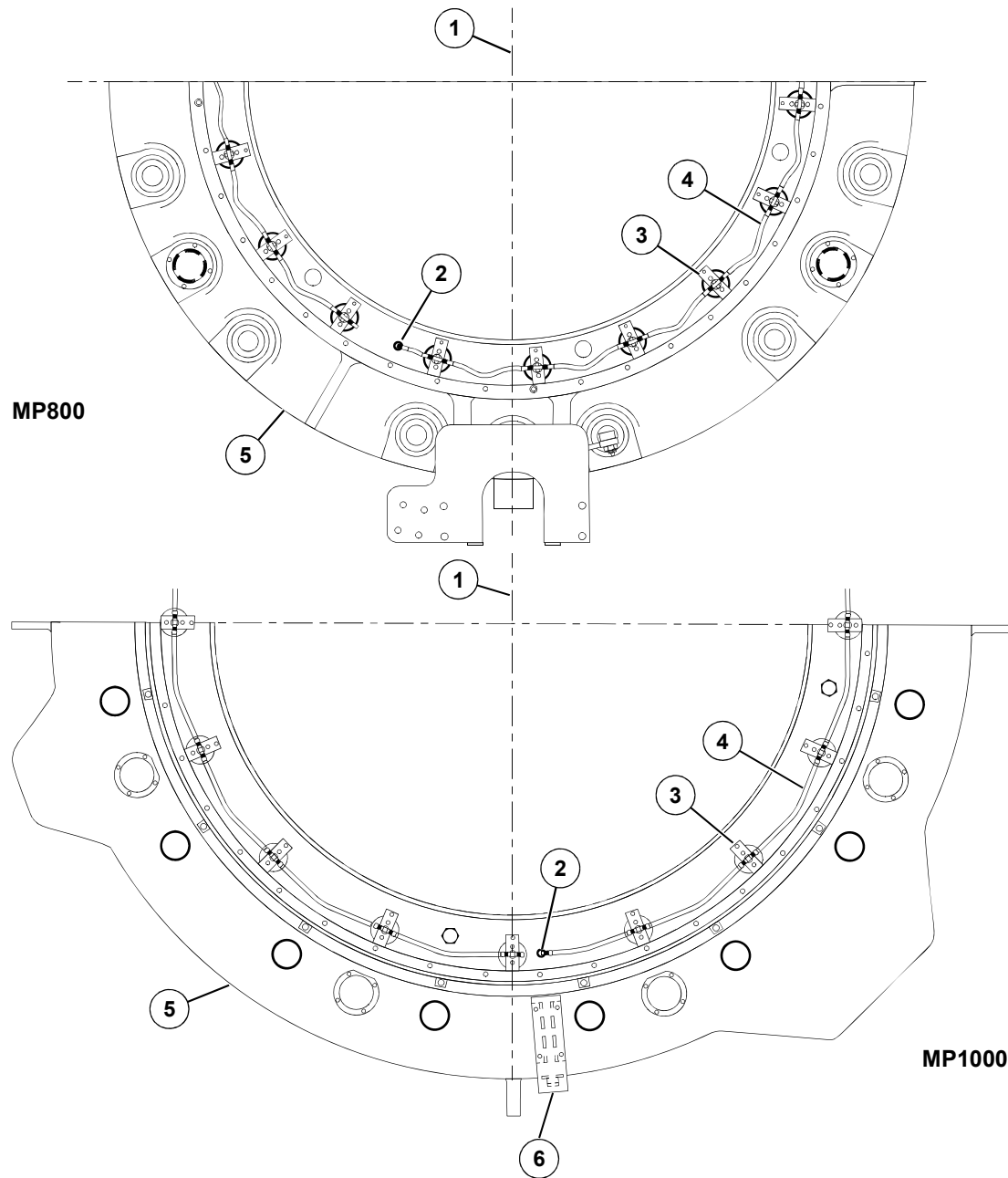
3.4.16 Adjustment Ring Assembly

After inspection, repairs or replacement of parts, the adjustment ring is placed back on the main frame and the associated parts are assembled as follows:

1. If the adjustment ring was removed liberally coat the adjustment ring seat with a lithium base grease, NLGI No. 1 containing a minimum of 3% molybdenum disulfide. If the adjustment ring was not removed and just the clamping ring removed from the adjustment ring, proceed to step 4.
2. Attach shackles and lifting slings to the lift lugs, four on the MP1000, three on the MP800, located on the outside diameter of the adjustment ring. Refer to Figure 3-7 and Figure 3-20.
3. Turn the adjustment ring so the clamping cylinder hose connection, on the outside of the ring, is opposite the countershaft box, then lower the ring on the frame. As the adjustment ring is lowered over the main frame pins, rotate the ring in a clockwise direction so the main frame pin bushings in the adjustment ring touch the main frame pins. Refer to Figure 3-21. Then lower the ring in this position and allow it to seat on the frame.
4. Install an M36 ring bolt in each of the two tapped holes in the clamp ring and lift the clamp ring.
5. Before lowering the clamp ring onto the adjustment ring, turn the clamp ring so the 50 mm (2") dia. hole is vertically in line with the hose connected to the top of the adjustment ring. Slowly lower the clamp ring over this hose and onto the adjustment ring. Refer to Figure 3-26.
6. Insert spacers and hex head capscrews that keep the clamp ring in place while turning the bowl in or out inside the crusher. Turn the capscrews into the adjustment ring until they bottom on the spacers. There are eight

bolts and spacers on the MP1000 and six on the MP800. Refer to Figure 3-23.

7. Connect the elbow to the hose that runs from the top of the adjustment ring and up through the clamp ring. Then connect the hose between the first cylinder and elbow.
8. Reassemble the dust shell to the adjustment ring by aligning the matching holes and installing the lockwashers and attaching capscrews.



Callout	Description	Callout	Description
1	Centerline of countershaft	4	Hose
2	Ø 50 mm (2") hole in clamp ring	5	Adjustment ring
3	Clamping cylinders	6	Hose guard

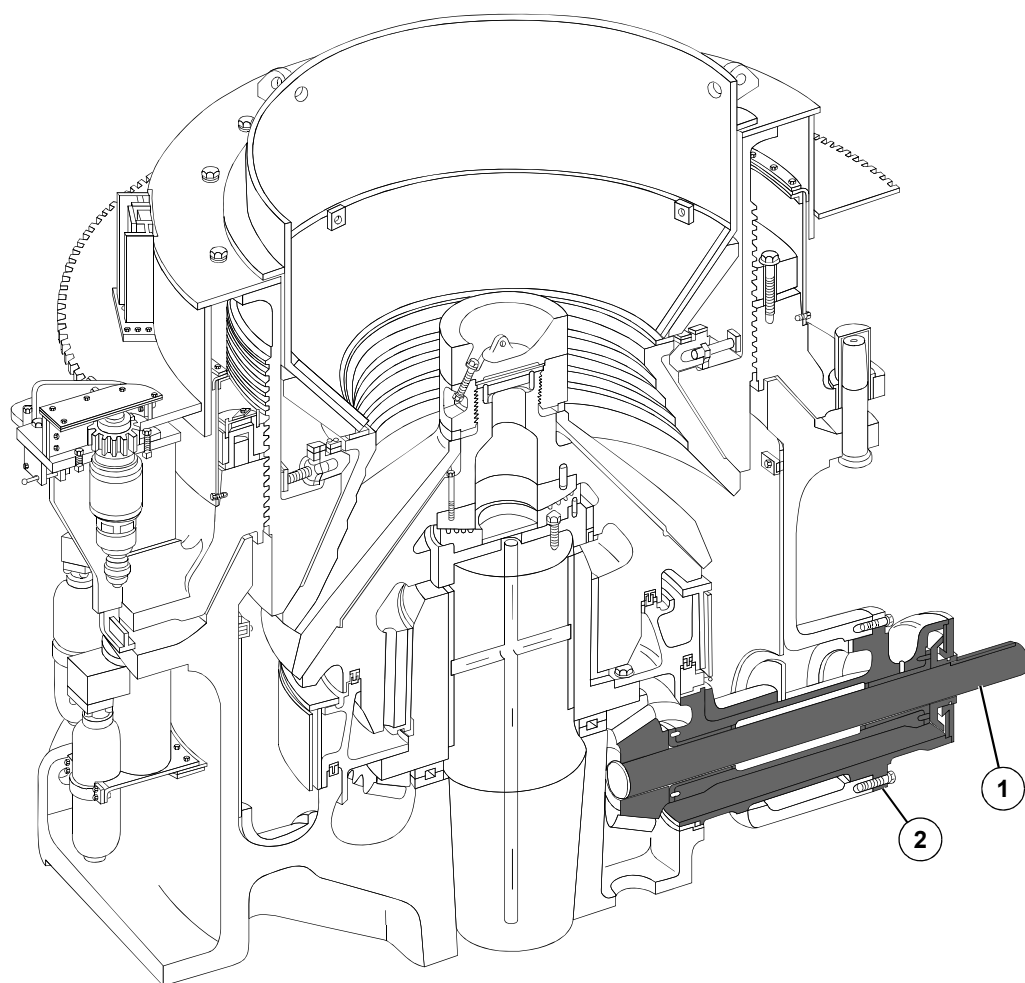
Figure 3-26 Clamping Cylinder Hose Connections

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Section 4

Countershaft, Countershaft Box & Sheave Assemblies

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Callout	Description
1	Countershaft
2	Countershaft box

Countershaft and Countershaft Box

4.1 Description

This section covers the countershaft box, countershaft and crusher sheave assemblies. Power is transmitted from the initial power source to the countershaft through a V-belt or a direct drive. The countershaft, which has a bevel pinion attached to it, in turn drives the gear on the eccentric assembly. The countershaft is supported within two sleeve bearings or bushings. These bushings are pinned to the countershaft box to prevent any possibility of bearing rotation. The outer countershaft bearing temperature is monitored by an RTD with a 4-20mA signal. The spring-loaded probe on the RTD makes direct contact with the bearing through a compression fitting mounted in the countershaft box. The flanges on the countershaft bushings support the axial thrust loads from either the pinion or the oil flinger. The oil flinger, keyed or pressed to the drive end of the countershaft, removes the oil from within the countershaft box by centrifugal force. A housing covering the flinger is so designed as to allow the oil to drain back to the Crusher for reuse. The countershaft box has a force fit in the main frame and is firmly held in place with large diameter capscrews. An O-ring between the inner mating surfaces of the box and frame, provides an oil tight seal. A box guard protects that portion of the countershaft box which is exposed to wear from falling material.

4.2 Assembly Instructions

4.2.1 Countershaft Box Assembly Installation

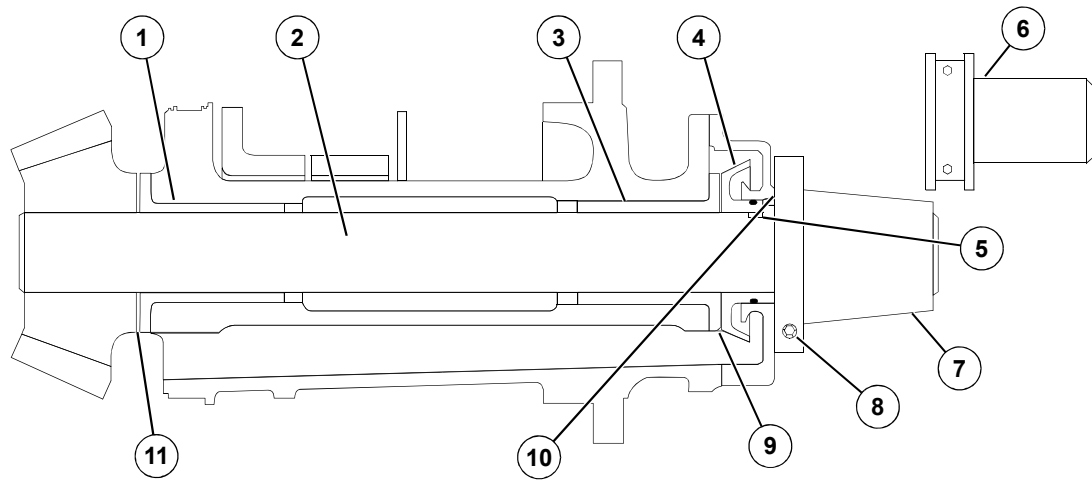
Procedures for assembling the various components are given in the *Maintenance* portion of this section. The countershaft box is to be installed in the main frame as follows:

1. The countershaft box, countershaft, pinion, bushings, oil flinger and flinger cover are shipped fully assembled to make up the countershaft box assembly. Also mounted on the sheave end of the countershaft is either the tapered sheave bushing or a safety set collar for these Crushers that are direct drive driven. Even though the end float was factory set, sometimes during shipping the end float is lost. Therefore the end float is to be checked before the countershaft box assembly is assembled to the Crusher. Refer to Figure 4-17 for proper end float. It is important for the proper operation of the

Crusher that the proper end float is maintained. The countershaft must be free to move in and out. To check the end float do the following:

- a. Pull the pinion end of the countershaft until the oil flinger is tight against outer countershaft bushing flange. Refer to Figure 4-1.
- b. Use a feeler gauge to measure the gap (end float) between the pinion and countershaft bushing. The end float should be between 1.5 mm (0.060") and 0.8 mm (0.030"). If the end float is correct proceed to step 2 if not proceed to step c.
- c. First loosen the sheave bushing clamp screw, refer to Figure 4-1, and slide the bushing off the countershaft. If necessary insert a wedge (e.g. screwdriver) into the bushing slit to aid in sliding the bushing. If a safety set collar is mounted on the countershaft just remove it.
- d. On MP1000 Crushers remove the oil flinger housing. Refer to Figure 4-3. For the MP800 remove the countershaft box cover. Refer to Figure 4-2.
- e. If the gap is too small then heat the flinger to a temperature of approximately 30°C (50°F) above ambient and bump the sheave end of the countershaft until the proper gap (end float) is obtained.

If the gap is too large then insert a feeler gauge of proper thickness as specified in step b between the pinion and countershaft bushing. Next clamp the pinion as shown in Figure 4-15. Then heat the flinger as specified above and push it until it is tight against the countershaft bushing. Allow the flinger to cool before removing the clamp and feeler gauge.



Callout	Description	Callout	Description
1	Inner countershaft bushing	7	Sheave bushing
2	Countershaft	8	Clamp screw
3	Outer countershaft bushing	9	Tight
4	Oil flinger	10	No clearance (tight)
5	Sheave key	11	Measure end float here. 1.5 mm (0.060") to 0.8 mm (0.030")
6	Set collar (direct drive)		

Figure 4-1 End Float — V-Belt Drive

WARNING

Always use heavy insulated gloves when handling heated parts.

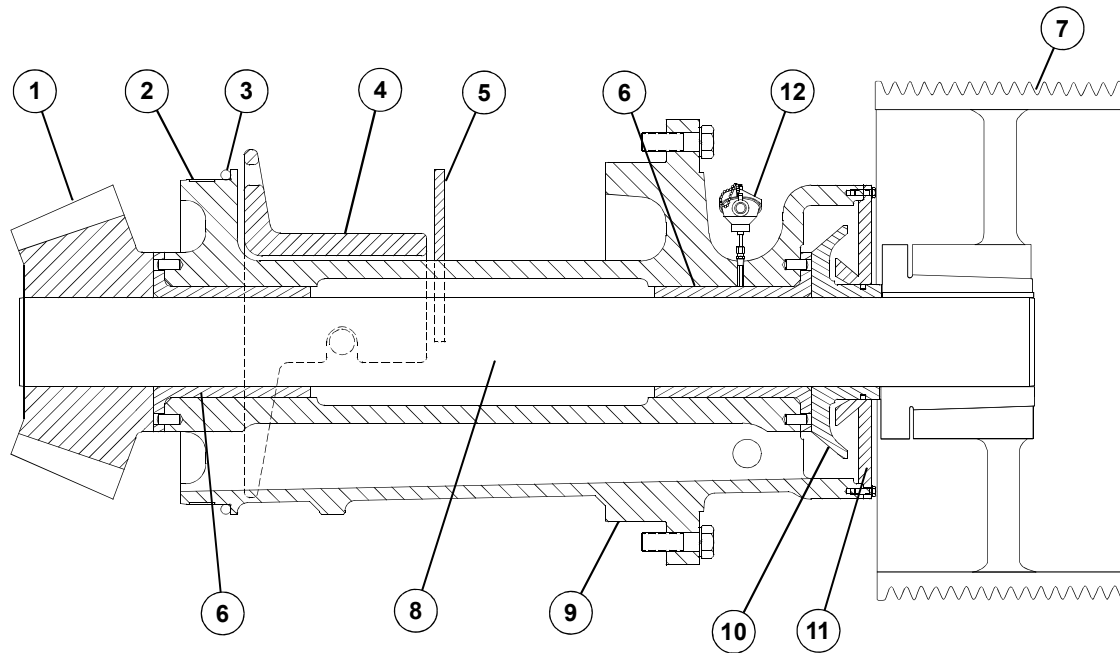
- f. Mount the flinger housing, MP1000, or the countershaft box cover, MP800, on the countershaft box.
- g. Slide the sheave bushing onto the countershaft until it is tight against the oil flinger. Then tighten the bushing clamp screw. (For a safety set collar, mount it on the countershaft and tight against the oil flinger.)
2. Coat the large diameter O-ring (which can be found in one of the packing boxes) with clean grease and stretch it over the machined diameter at the pinion end of the countershaft box. Refer to Figures 4-2, 4-3 and 4-4. This O-ring prevents oil leakage

from between the countershaft box and main frame.

3. There is also a flexible, plastic-like wear ring that is to be installed in a groove on the countershaft box. The wear ring eliminates fretting that can occur between the countershaft box and main frame.

This wear ring is split. Place the wear ring in the groove in the pinion end of the countershaft box and hold the ring in position by gluing each end of split to countershaft box. Using Eastman 910 adhesive (or equivalent). There may be a small gap at split or one end may have to be trimmed to suit. Refer to Figure 4-4.

If there is no glue available then tape the ends with masking tape to hold the wear ring in place. Do not use electrical or duct tape.

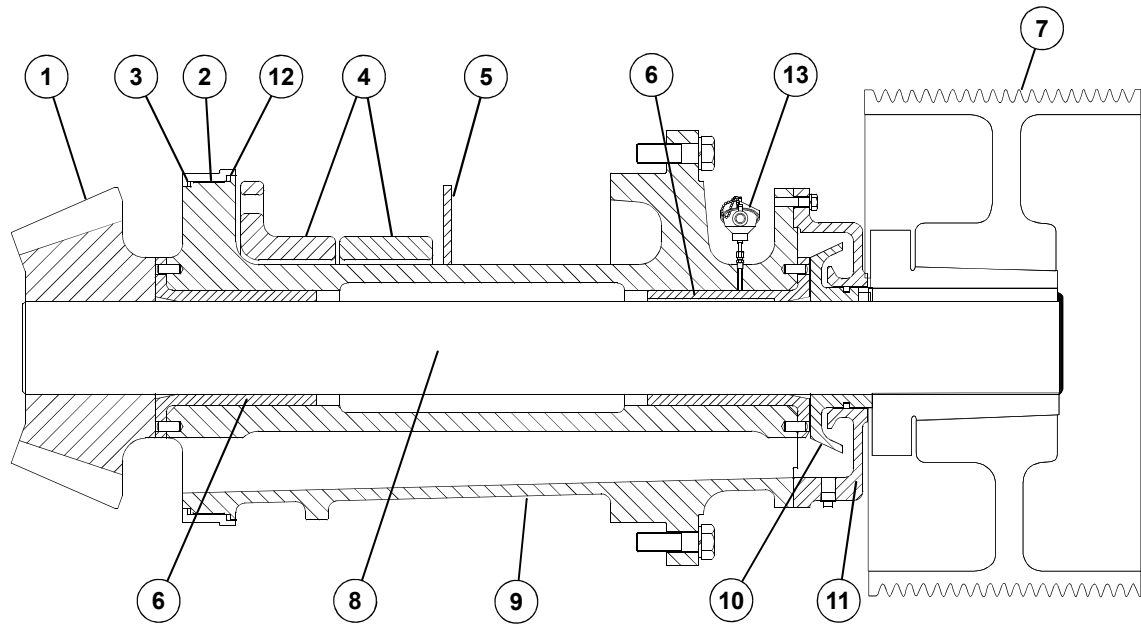


Callout	Description	Callout	Description
1	Pinion	7	Sheave assembly
2	Wear ring	8	Countershaft
3	O-ring	9	Countershaft box
4	Box guard	10	Oil flinger
5	Box shield	11	Countershaft box cover
6	Bushing	12	Countershaft bushing RTD

Figure 4-2 Countershaft, Countershaft Box and Sheave Assembly (MP800)

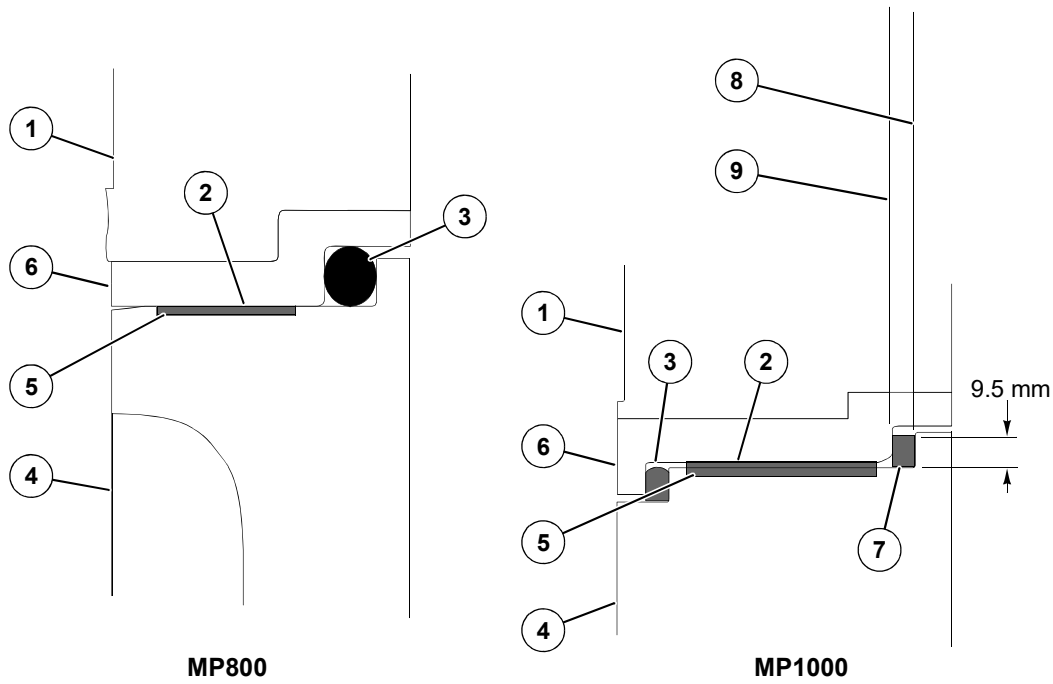
On the MP1000 only apply a sealant, Silastic RTV732 (or equivalent) to the inner surface of box flange and install seal. Then install the rectangular seal and apply Silastic RTV732 to exposed face of rectangular seal just prior to installing box into frame. Refer to Figures 4-2, 4-3 and 4-4.

4. With an overhead crane and suitable lifting slings, lift the countershaft box assembly and carefully insert it into the frame as far as possible. Then lower the box and allow the countershaft box pinion end flange to rest on the frame.
5. Remove the sling from the pinion end of the box. Then lower the sling, just removed, through the inside of the frame to raise the pinion end of the box.
6. Slide the box toward the inner frame, fit as far as possible keeping the box centering lug centered on the frame support guide pad. Refer to Figure 4-5.



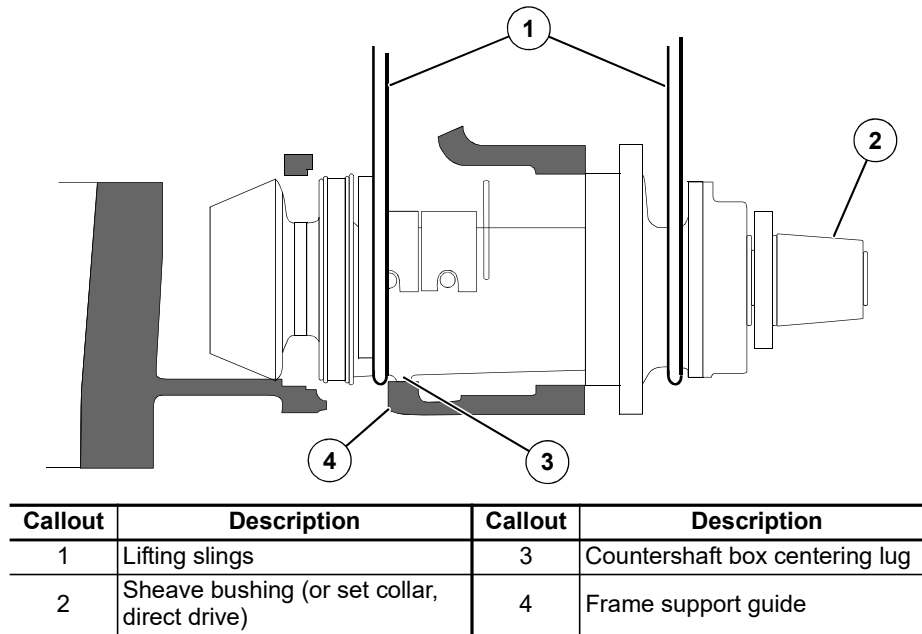
Callout	Description	Callout	Description
1	Pinion	8	Countershaft
2	Wear ring	9	Countershaft box
3	O-ring	10	Oil flinger
4	Box guards	11	Flinger housing
5	Box shield	12	Rectangular seal
6	Bushing	13	Countershaft bushing RTD
7	Sheave assembly		

Figure 4-3 Countershaft, Countershaft Box and Sheave Assembly (MP1000)

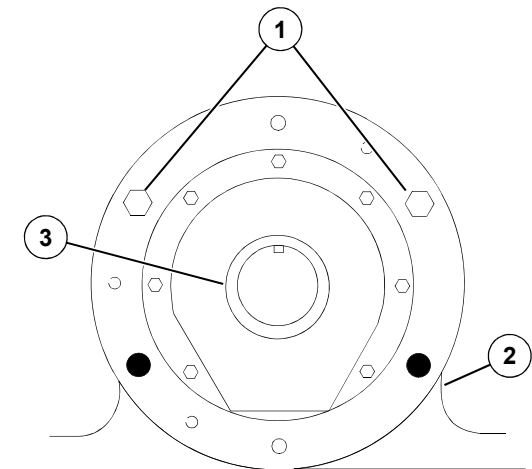


Callout	Description	Callout	Description
1	Main frame	6	Frame ring
2	Coat this surface with a thin film of grease	7	Rectangular seal
3	O-ring	8	Coat this surface with Silastic before mounting seal onto countershaft box
4	Countershaft box	9	Coat this surface of seal with Silastic <u>just prior</u> to installing box into frame
5	Wear strip		

Figure 4-4 Countershaft Box Seal

**Figure 4-5 Installing Countershaft Box Assembly**

7. Lower the pinion end of the countershaft box, again making sure the countershaft box centering lug rests on the main frame guide support.
8. Insert two M42 x 220 LG, for the MP1000, or M36 x 220 LG for the MP800 hex head pull-in capscrews into the tapped holes in the main frame at the position shown in Figure 4-6. These pull-in capscrews are part of the tools that came with the Crusher.
9. Alternately tighten each pull-in capscrew a small amount, to prevent binding, until there is a 50 mm (2.0") gap between box flange and main frame as shown in View 2 of Figure 4-7.
10. Remove the two pull-in capscrews and place spacers or a stack of washers, 50 mm (2.0") thick onto the capscrews. Reinstall them into the frame. Again alternately tighten each bolt until a 20 mm (0.75") space between the countershaft box flange and main frame is obtained as shown in Views 3 and 4, Figure 4-7.



Callout	Description
1	Place countershaft box pull-in capscrews in locations shown
2	Countershaft box flange
3	Oil flinger housing

Figure 4-6 Countershaft Box Pull-In Capscrew Placement

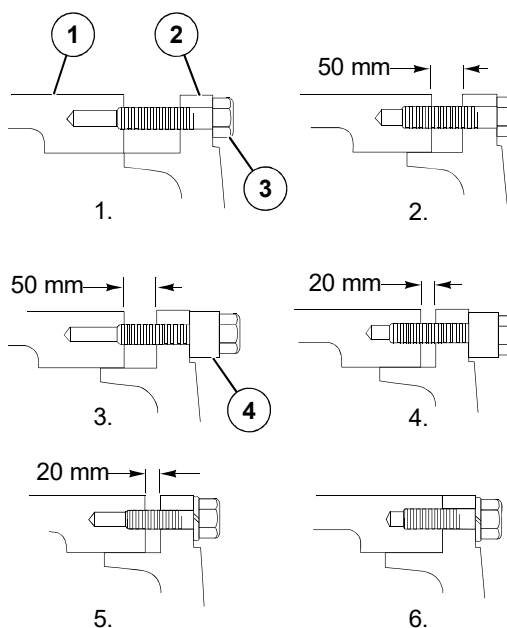
11. Remove the two pull-in capscrews and install six M42 x 140 mm LG capscrews for the MP1000 or six M36 x 120 mm LG capscrews for the MP800 along with their lockwashers. Then alternately tighten each bolt a small amount until the countershaft box flange is tight against the frame as shown in Views 5 and 6, Figure 4-7.

12. Place the countershaft box guard over the countershaft box while aligning the slots in the guard with the lugs on each side of the countershaft box.

4.2.2 Crusher Sheave Installation (V-Belt Drive)

To install a crusher sheave with a removable bushing, proceed as follows (refer to Figure 4-8):

1. Refer to the oil piping drawing and install all oil piping.
2. Remove the split tapered bushing from the sheave by unscrewing the combination take-up and back-off capscrews, if bushing has not been installed on the countershaft.
3. Check that the tapered surface and bore of the bushing, the tapered bore of the sheave and the countershaft, are clean and free of burrs, scratches and all foreign matter, such as paint, dirt and lubricants.
4. Gently tap the sheave key into the countershaft keyway with a light hammer, if key and bushing has not been installed.
5. Loosen the clamp screw and slide the bushing onto the countershaft aligning the sheave key and keyway. If necessary, insert a wedge (e.g. screwdriver) into the bushing slit to aid in installation of bushing. Tighten clamp screw when bushing is tight against oil flinger.
6. Move countershaft in and out to recheck end float. Refer to step 1 under *Countershaft Box Assembly* earlier in this section.



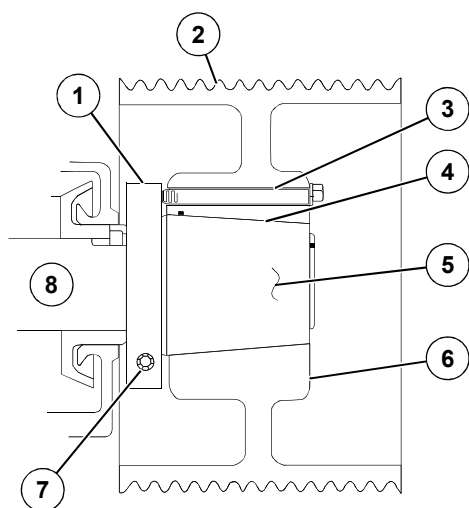
Callout	Description
1	Main frame
2	Countershaft box
3	Pull-in capscrew
4	50 mm thick spacer

Figure 4-7 Forcing Countershaft Box Into Main Frame

7. Slide the sheave over the bushing being careful to keep the bolt holes lined up with the tapped holes in the bushing flange.

NOTICE

Do not apply any type of lubricant on the tapered bore of the sheave or tapered O.D. of the split sheave bushing.



Callout	Description
1	Flange diameter
2	Sheave
3	Combination take-up and back-off capscrews
4	Tapered surfaces
5	Bushing
6	Sheave hub
7	Clamp screw
8	Countershaft

Figure 4-8 Sheave Assembly

- Insert the take-up bolts through the bolt holes and alternately tighten each bolt a small amount until all bolts are tightened to a final torque value. Refer to Table 4-1 for proper torque values for the MP1000 and MP800. Do not lubricate the bolt threads or the tapped holes. When the sheave is finally positioned a clearance of approximately 10 mm (0.375") on the MP1000 or 6 mm (0.25") on the MP800 should exist between the face of the sheave hub and the flange of the bushing. No attempt should be made to take up this clearance as this clearance assures the proper fit and grip between sheave bushing and countershaft. Follow the torque requirements closely. Overtightening the take-up bolts could cause the sheave to crack.

Table 4-1 Crusher Sheave Take-up Bolt Torque

Crusher Size	No. of Bolts	Sheave Take-Up Bolt Torque
MP1000	5	1017 Nm (750 ft.lbs)
MP800	4	813 Nm (600 ft.lbs)

4.2.3 Crusher Sheave Removal

To remove the crusher sheave and proceed as follows (refer to Figure 4-8):

- Remove the take-up capscrews and thread two of them into the tapped holes in the hub of the sheave. Using the two capscrews as back-off bolts, exert pressure by tightening them against the flange of the bushing, breaking the sheave grip on the bushing cone. Remove the sheave.

NOTICE

Should there be difficulty breaking the fit between the sheave and bushing, tap the end of the shaft or bushing with a babbitt hammer while maintaining back-off bolt pressure, until the sheave is loose enough to remove.

- Loosen sheave bushing clamp screw.
- If necessary, insert a wedge such as a screwdriver into the split in the bushing flange and slide the bushing off the countershaft.

4.2.4 Flexible Coupling Removal

Remove the flexible coupling half from the countershaft as described in the coupling manufacturer's instructions.

4.3 Maintenance

4.3.1 Countershaft Box Disassembly

Disassemble the countershaft box and countershaft assembly for replacement of bushings, pinion or other worn parts, as follows (refer to Figure 4-9):

- To gain access to the countershaft box, it will be necessary to remove the bowl, head, and lift the counterweight.

2. Remove all oil and blower piping that would interfere with the removal of the box. Plug and cap all open ports.
3. Remove the crusher sheave at this point as described under *Crusher Sheave Removal* earlier in this section. This is done primarily to prevent damaging or breaking the sheave during box removal.
4. Remove applicable drive connection as follows:

V-belt drive

Remove crusher sheave as described under *Crusher Sheave Removal*, step 1, earlier in this section.

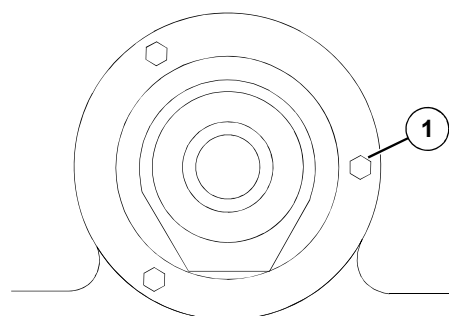
Direct drive

If the Crusher is driven directly by the crusher drive motor, remove the drive motor and the flexible coupling half that is mounted on the countershaft as described in the coupling manufacturer's instructions.

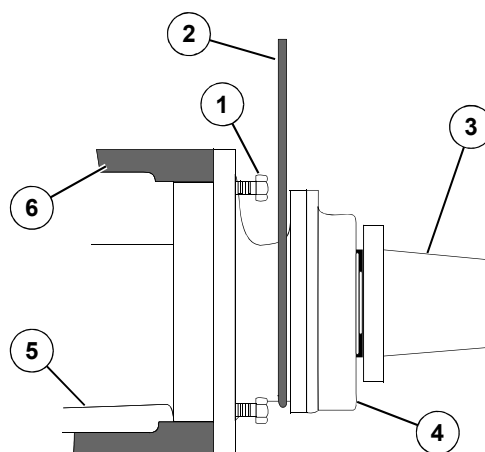
5. Remove the countershaft box guards.
6. Remove the capscrews holding the countershaft box to the main frame.
7. Attach a lifting sling around the countershaft box, sheave end as shown in Figure 4-9. Then pull up on the sling to obtain a slight tension. This sling is required so the box will not drop when the outer countershaft box turn is pulled out of the frame.
8. Install the special jacking screws, that are furnished with the machine, into the three equally spaced tapped holes in the outer flange of the box.
9. Alternately tighten each jackscrew a small amount to prevent binding in the frame.

NOTICE

If there is an exceptionally tight fit, heat may be applied to the main frame at the outer countershaft box fit to assist in removal. Heat the frame housing to approximately 55°C (100°F) above ambient temperature.



End View



Callout	Description
1	Jacking screw(s)
2	Lifting sling
3	Sheave bushing
4	Oil flinger housing
5	Countershaft box
6	Main frame

Figure 4-9 Removing Countershaft Box

10. Continue tightening the jackscrews until the outer countershaft box fit is free of the frame.
11. Attach a sling around the pinion end of the countershaft box as shown in Figure 4-5, then lift the box slightly and slide it as far out of the frame as possible.
12. Lower the pinion end of the box and allow the countershaft box pinion end flange to rest on the main frame.

13. Remove the lifting sling from around the pinion end of the countershaft box then attach the sling just removed around the box on the outside of the Crusher as close to the countershaft box frame opening as possible.
14. Lift the countershaft box slightly and move it out far enough until the pinion end countershaft box flange is in the outer bore of the main frame countershaft box opening. Then lower the pinion end and allow the pinion end flange to rest in the frame box bore.
15. Reposition the pinion end lifting sling so a balanced lift of the countershaft box assembly is obtained. Then remove the assembly completely out of the Crusher.
16. Remove the flinger housing on the MP1000. On the MP800 remove the countershaft box cover.
17. Heat the oil flinger to approximately 30°C (50°F) above ambient temperature

WARNING

Use heavy, well insulated gloves when handling the heated oil flinger.

18. Place a pry bar between the flinger and the countershaft box and exert moderate pressure. Once the flinger starts to move, grasp each side of the flinger and pull the flinger straight off the shaft.
19. Pull the countershaft out of the countershaft box.

4.3.2 Pinion Replacement

Whenever the countershaft box is out for inspection or replacement of parts, it is advisable to inspect the pinion for wear or broken teeth. Pitting or galling on the face of the teeth are good indications of excessive wear. This can be due to improper tooth contact resulting from an incorrect quantity of shims being placed under the lower thrust bearing, by overloading the Crusher or using excessively dirty oil. A worn pinion is more susceptible to tooth breakage. Also, running on a worn pinion could lead to structural damage in other parts due to vibration. Excessively worn pinions should be replaced. To get maximum benefit from new parts,

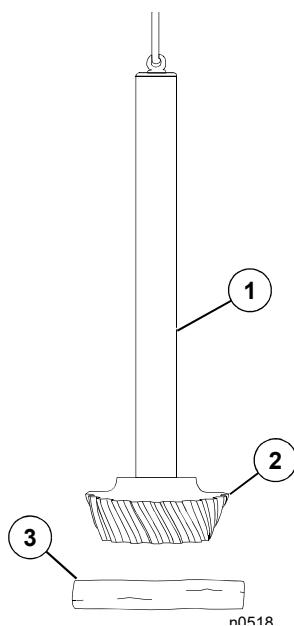
it is recommended that gear and pinion be replaced at the same time. If a new pinion is run with a worn gear, the root clearance must be checked as instructed under *Checking or Adjusting Backlash and Root Clearance* in Section 5. To replace the pinion, proceed as follows:

1. Remove the countershaft assembly from the countershaft box and place the countershaft on suitable wooden blocking.
2. Insert an M36 ring bolt on the MP1000, or an M20 ring bolt on the MP800, into the end of the countershaft opposite the pinion and hang from a crane as shown in Figure 4-10.
3. Heat the pinion with a torch to approximately 100°C (180°F) above ambient temperature. Repeatedly bump the pinion with a heavy wooden ram while continuously moving the flame around the outside of the pinion. Keep bumping the pinion until the pinion falls free of the countershaft.

WARNING

Use heavy, well insulated gloves when handling the heated pinion.

4. Heat the replacement pinion, in an oil bath or with a torch (adjusted to a low heat) to approximately 90°C (160°F) above ambient. Quickly place the pinion on wood blocking and lower the countershaft into the pinion to where the shaft protrudes out of the pinion bore. This is best accomplished by clamping a piece of bar stock across the center of the pinion with two pieces of 5 mm (0.197") shim stock for the MP1000 or 10 mm (0.393") shim stock for the MP800 between the bar and pinion as shown in Figure 4-11. The bar will act as a stop and the pinion can then be pushed onto the shaft until the bar bumps against the end of the shaft. Do not tack weld the bar to the pinion.

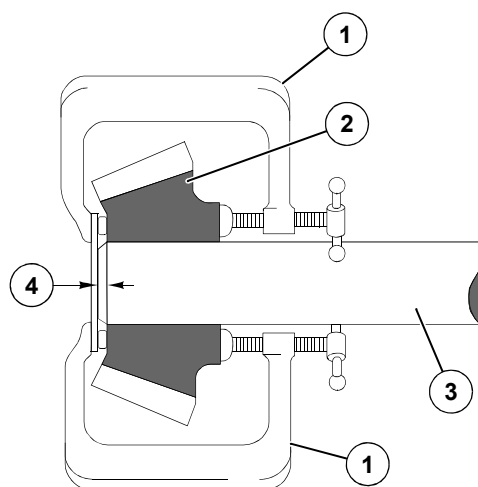


Callout	Description
1	Countershaft
2	Pinion
3	Wood blocking

Figure 4-10 Pinion Removal

NOTICE

If the pinion cools and becomes hung up on the shaft, reheat the pinion with a torch while bumping the pinion with a wooden ram. Remember to continuously keep the flame moving around the outside of the pinion to avoid any high heat concentration in one spot.



Callout	Description
1	"C" Clamp
2	Pinion
3	Countershaft
4	MP1000 — 5 mm (0.197") MP800 — 10 mm (0.393")

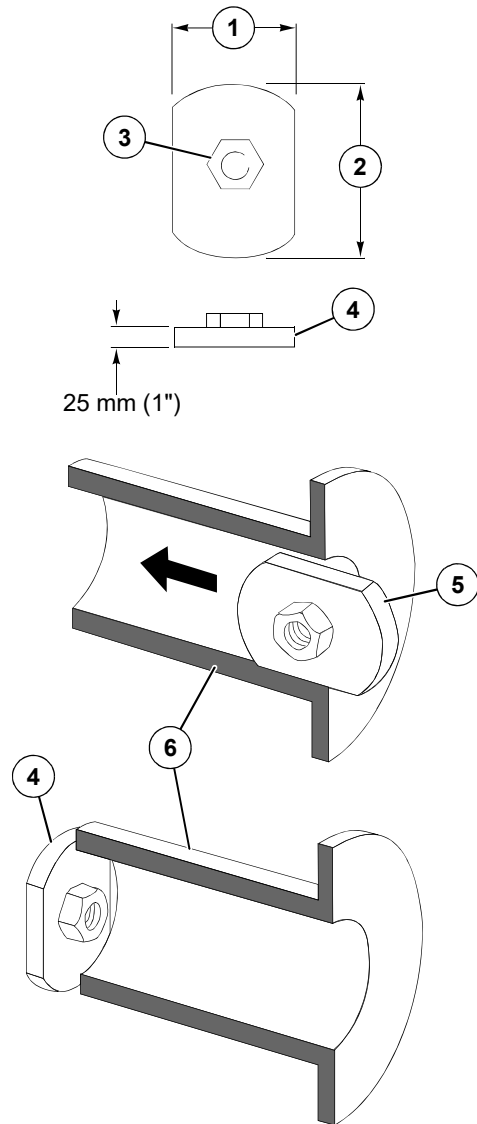
Figure 4-11 Installing Pinion

4.3.3 Countershaft Bushing Removal

When a bushing becomes worn and replacement is necessary, the bushing may be loose in the box. In instances such as this, the bushing is simply slid from the box without difficulty. Due to extreme limits of manufacturing tolerances, the countershaft bushings may have had a slight interference fit within the countershaft box. If such is the case, removal will be more difficult. To replace the countershaft bushings that have such a press fit or those that have seized in the box because of a build up of heat due to inadequate lubrication or from overloading the Crusher, proceed as follows:

1. Remove the countershaft box from the main frame and the countershaft from the countershaft box as described under *Countershaft Box Disassembly*.

2. Construct a steel centering plate as shown in Figure 4-12.
3. Slide the narrow portion of the plate through the bushing until the plate is behind the bushing as shown. Turn the centering plate 90° so that the outer edge of the plate will bear against the bushing.
4. While holding the plate in position, thread a 1" (25 mm) diameter rod into the nut which is welded to the center of the plate. The rod must be a few inches longer than the bushing and threaded on both ends.
5. Place a 25 mm x 75 mm x 305 mm (1" x 3" x 12") steel bar over the other end of the rod and hold firmly in place with a hex nut.
6. Insert a long timber or pipe through the opposite end of the countershaft box and ram against the centering plate. Refer to Figure 4-13. Should the bushing remain tight within the countershaft box, the following alternate method utilizing a jacking procedure is suggested to remove bushings. Refer to Figure 4-14 and proceed as follows:
7. Using the same centering device as previously described and in the same manner except for a much longer rod and steel bar, place wooden blocking between the steel bar and the countershaft box flange.
8. Using the threaded rod as a jackscrew, tighten the hex nut until the flange of the bushing is pulled against the steel bar.
9. Unscrew the nut and place additional blocking under the bar and tighten the hex nut until the bushing is again pulled against the bar.
10. If necessary, repeat step 9 until the bushing is free.



Callout	Description
1	Flats are to be smaller than inside diameter of bushing
2	Diameter of plate to be larger than inside of bushing
3	Weld 25 mm (1") hex nut to plate
4	Centering plate
5	Slide centering plate through bushing and turn 90° to bear against end of bushing
6	Countershaft bushing

Figure 4-12 Centering Plate

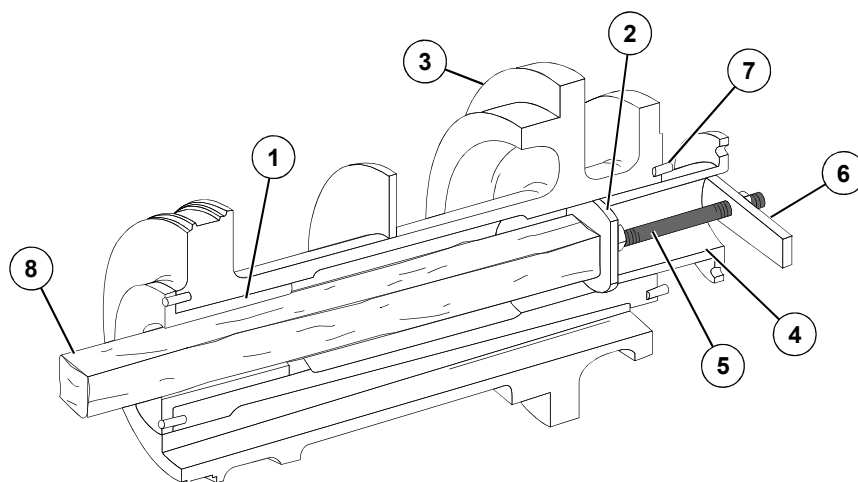
4.3.4 Inspection Prior to Bushing Installation

As a precautionary measure prior to installing a new bushing, check the diameter of the bore in the countershaft box.

The bushings are machined to provide a fit of 0.025 mm (0.001") tight to 0.050 mm (0.002") loose. The inside diameter of the bore and the outside diameter of the bushing should be checked to make certain their diameters meet these tolerances. Should the interference be more than the 0.030 mm (0.001"), the box must be

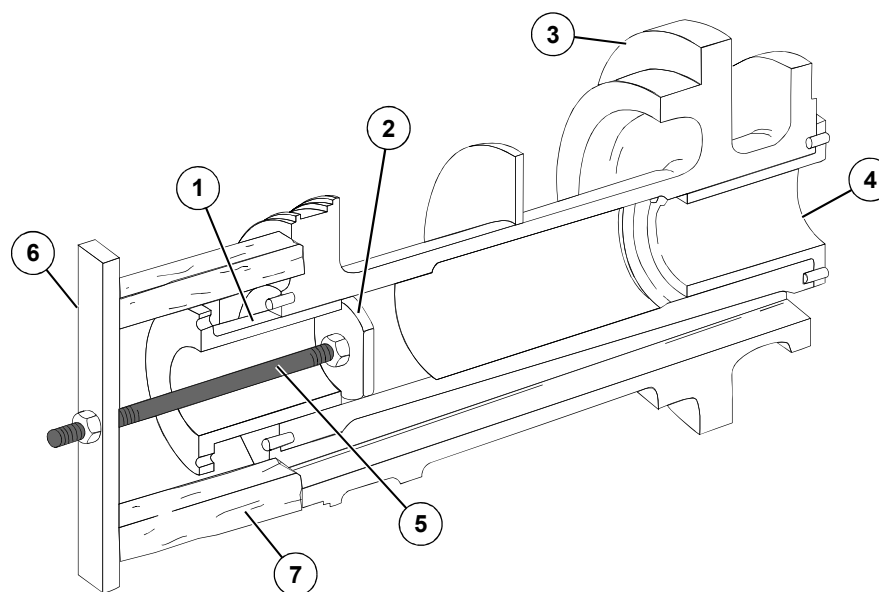
remachined to meet these limits. An excessive interference fit can cause the bushing to collapse or the bushing bore to become smaller thereby reducing the clearance between countershaft and bushing. If the bore is found to be smaller than when originally machined, this bore shrinkage can usually be attributed to extreme heat.

Check the shaft itself for straightness or run out. With the shaft between centers, the run out should not exceed a total of 0.102 mm (0.004"). If more than 0.102 mm (0.004"), the countershaft should be replaced.



Callout	Description	Callout	Description
1	Inner countershaft bushing	5	Threaded rod
2	Centering plate	6	Flat bar
3	Countershaft box	7	Dowel
4	Outer countershaft bushing	8	Timber

Figure 4-13 Countershaft Bushing Removal by Ramming



Callout	Description	Callout	Description
1	Inner countershaft bushing	5	Threaded rod
2	Centering plate	6	Flat bar
3	Countershaft box	7	Blocking
4	Outer countershaft bushing		

Figure 4-14 Countershaft Bushing Removal by Jacking

If the bore of the bushing has become smaller from excessive pressure when installing into an undersize countershaft box bore or if a bent countershaft is used, the bushing could seize onto the shaft.

Should the shaft be twisted it is to be discarded and a new one installed.

4.3.5 Countershaft Bushing Installation

When both the countershaft and countershaft box have been thoroughly inspected and found to be satisfactory, the new bushings can be installed. Should the bushings have a loose fit within the box, just slide the bushings in over the dowels, taking care that the oil groove in the bore is positioned as described in step 1. If an interference fit occurs, pack the replacement bushings in dry ice as described in step 2 and proceed as follows:

- Both countershaft bushings, inner and outer are identical. However, their position in the bore may differ. Determine the proper

location of the bushing oil groove in relation to the countershaft box as follows:

Bushing — Sheave End

When standing looking at the crusher sheave end of the box, the countershaft box bushing, that is to be assembled to the sheave end, is to have its axial groove at a 12 o'clock position.

Bushing — Pinion End

When standing looking at the pinion end of the box the bushing, that is to be assembled to the pinion end, is to have its axial groove located at a 3 o'clock position.

- Pack the bore of the replacement bushings with dry ice for two to three hours to shrink the bushings for easy installation into the countershaft box. Approximately 50 kg (100 lbs) of dry ice will be required for both countershaft bushings.

NOTICE

Wrap the outside of the bushing in a few layers of fiberglass insulation to prevent the external build-up of frost which could hinder the installation of bushing in the countershaft box. This also helps to achieve a more thorough cooling.

⚠ WARNING

Use heavy, well insulated gloves when handling the dry ice. Handling dry ice without protection could result in severe burns.

NOTICE

If the countershaft box is at a temperature of 40°C (75°F) or higher, plain ice can be used as a substitute for dry ice. Measure the outside diameter of the bushing and the bore of the countershaft box to determine when the bushing has cooled sufficiently.

3. Very quickly slide bushings into bore of countershaft box making sure the axial groove is positioned correctly as described above.

After a new countershaft box bushing has been installed, follow break-in procedure found in Section 11. Also follow V-belt tensioning procedure found in Section 2.

4.3.6 Countershaft Box Assembly

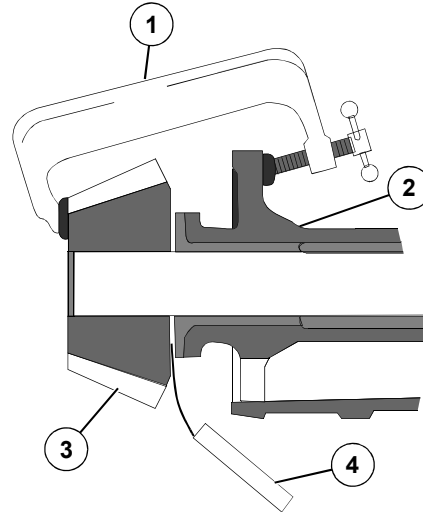
Whenever the countershaft box assembly is removed for inspection or replacement of parts, it is advisable to replace the MP1000 O-ring and seal or the O-ring on the MP800 at the inner flange between the countershaft box and main frame (refer to Figure 4-1).

These items may have developed a permanent set over the years and the resiliency necessary for an effective seal may have been lost. The O-rings and seal are inexpensive and not worth an unexpected oil leak.

Assembly is the reverse procedure of disassembly with the following exceptions:

1. Insert the countershaft assembly in the countershaft box.

2. Insert a feeler gauge of proper thickness, as specified in Figure 4-17, between the pinion and countershaft bushing.
3. To hold the countershaft stationary, place a large “C” clamp so that the pinion is clamped to the countershaft box flange as shown in Figure 4-15. An alternate method for holding the countershaft would be to place the pinion against a firm bearing wall or similar support.



Callout	Description
1	“C” Clamp
2	Countershaft box
3	Pinion
4	Feeler gauge

Figure 4-15 Holding the Countershaft Assembly

4. The oil flinger is equipped with a piston ring to provide an oil seal between the flinger and the flinger housing. Check that the piston ring can be freely turned in the specially machined groove in the flinger. Carefully file off any nicks or burrs that may have formed on the piston ring, causing the piston ring to bind in the flinger. Replace the piston ring if necessary.

⚠ WARNING

Use heavy, well insulated gloves when handling the heated oil flinger.

5. MP1000

If the oil flinger is not being replaced follow instructions in 5(a) before proceeding to step 6. If the oil flinger is being replaced follow instructions in 5(b) before proceeding to step 6.

- a. Heat the oil flinger to a temperature of approximately 30°C (50°F) above ambient temperature then line up the flinger key with the countershaft keyway and quickly slide the flinger onto the countershaft until it is tight against the face of the countershaft bushing.

If resistance is encountered, place a block of wood across the face of the flinger and force the flinger on the shaft by ramming against the timber. The flinger is properly installed when it is tight against the face of the outer countershaft bushing.

- b. A new replacement oil flinger will have no key welded to it. To mount the flinger follow the instructions in 5(a) only keep the flinger key slot aligned with the countershaft keyway and weld the flinger key to the countershaft keyway as shown in Figure 4-16.

MP800

Heat the oil flinger to approximately 30°C (50°F) above ambient temperature then quickly slide the flinger onto the countershaft until it is tight against the face of the countershaft bushing.

If resistance is encountered, place a block of wood across the face of the flinger and force the flinger on the shaft by ramming against the timber. The flinger is properly installed when it is tight against the face of the outer countershaft bushing.

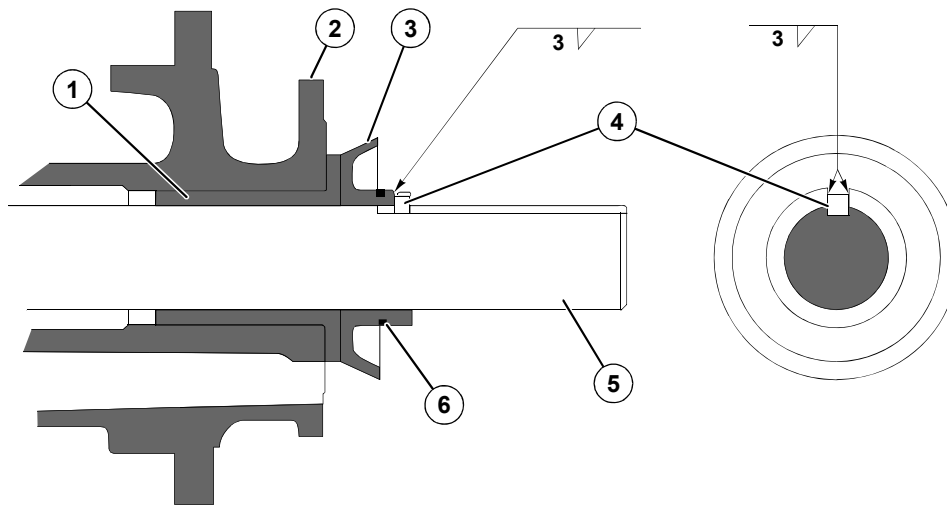
6. MP1000

Apply a light coat of grease to one side of the flinger housing gasket. Stick the greased side of the gasket against the countershaft box aligning the holes in the gasket with the tapped holes in the box.

MP800

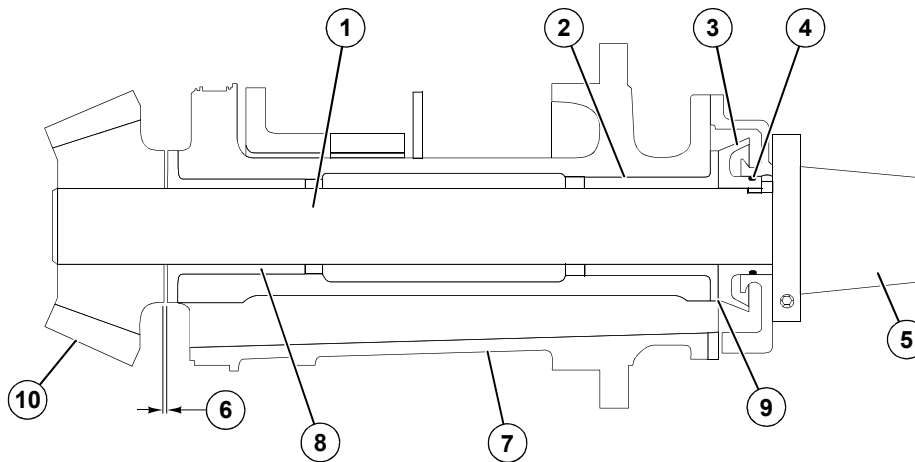
Using a sealant, Silastic RTV732 as a gasket, apply it to the face of the countershaft box before bolting the countershaft box cover to the countershaft box.

7. Check the bore inside the flinger housing on the MP1000 or cover on the MP800 before assembling it to the countershaft box. The bore must be **smooth**. If a groove is **beginning** to wear into the bore of these parts from the piston ring, the bore must be machined smooth. A groove worn in the housing or cover can cause the piston ring to lock in the flinger housing or cover making future removal of these parts extremely difficult, if not impossible. Replace the flinger housing or cover if a groove is worn in the bore of these parts.
8. Push the housing or cover over the piston ring and position the clearance holes in the housing flange or cover with the tapped holes in the countershaft box.
9. Insert the capscrews through the clearance holes in the housing flange or cover and thread them into the tapped holes in the box. Tighten the capscrews in a criss cross pattern until all are thoroughly tightened.
10. Mount the crusher sheave split bushing onto the countershaft as outlined in the crusher sheave installation (V-belt drive), found earlier in this section, steps 3 to 6. For a safety set collar, mount it on the countershaft and tight against the oil flinger.



Callout	Description	Callout	Description
1	Countershaft box bushing	4	Flinger key
2	Countershaft box	5	Countershaft
3	Oil flinger	6	Piston ring

Figure 4-16 MP1000 Flinger Key



Callout	Description	Callout	Description
1	Countershaft	6	0.8 mm (0.030") to 1.5 mm (0.060") end float
2	Outer countershaft bushing	7	Countershaft box
3	Oil flinger	8	Inner countershaft bushing
4	Piston ring	9	Tight
5	Sheave bushing	10	Pinion

Figure 4-17 End Float

4.3.7 Oil Leakage from Drive End of Countershaft Box

MP1000

Should oil begin to leak out of the oil flinger housing at the drive end of the countershaft box, it may be either the gasket between the flinger housing and countershaft box has failed or the piston ring between the flinger and flinger housing has been damaged or worn and requires replacement.

MP800

Either the Silastic between the countershaft box cover and countershaft box has failed or the piston ring between the flinger and cover has been damaged or worn and requires replacement.

Check for a dirt build-up in the long cored hole in the countershaft box, just below the countershaft. Such a build-up of dirt would restrict oil flow from the flinger.

It is also possible that the cause of the oil leakage is the inability of the oil to drain away fast enough from the Crusher especially when the oil is cold. Minimum pitch is 25 mm (1") for every 300 mm (12") of drain pipe used.

Also check the inside of the main drain line hose or piping for any obstructions, such as dirt build-up or a collapsed hose that may restrict oil flow.

Any of these items just described could cause the oil to back up and leak out of the flinger housing area.

4.3.8 Oil Leakage from Pinion End of Countershaft Box

If there is oil leakage out from between countershaft box and main frame at the inner fit, the seals and wear strip need replacing. To replace the wear strip and rings do the following:

MP1000

1. Remove the countershaft box assembly, following the instructions as outlined in removing countershaft box from main frame.
2. Once the box has been removed, inspect the inner bore of the frame. If this bore is excessively worn, replace the frame ring as outlined under *Main Frame Ring Replacement* in Section 3.

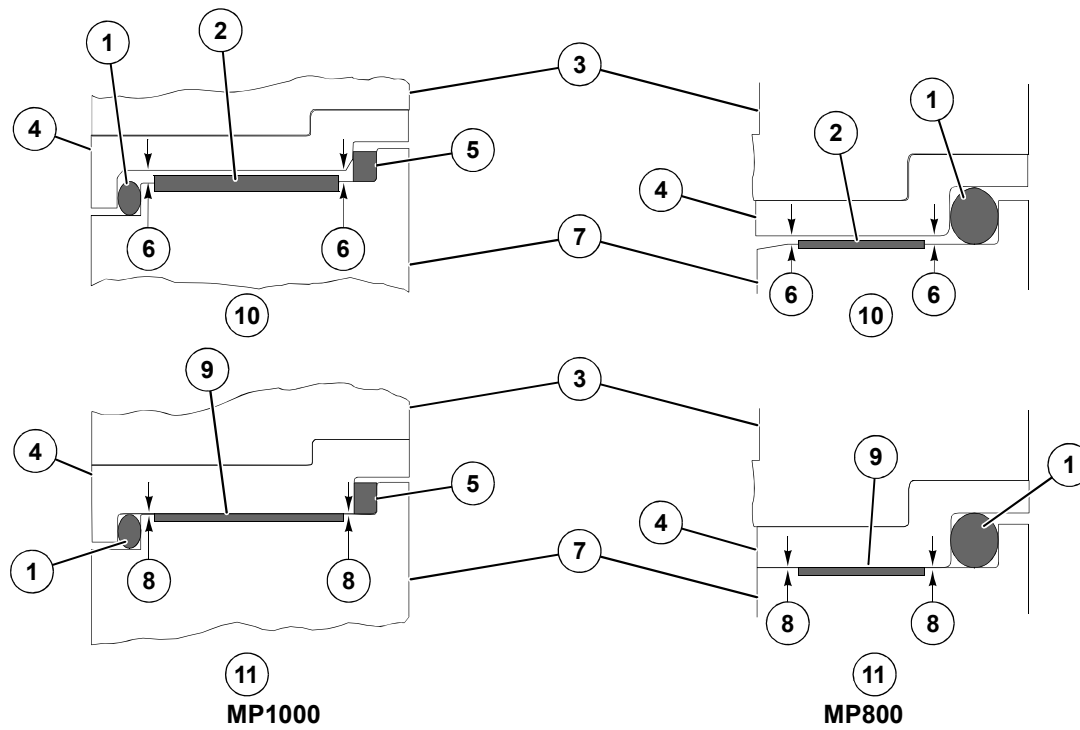
3. Remove the front O-ring, wear ring and rectangular seal from the countershaft box. Remove all the Silastic that was used to hold the rectangular seal in place. Any Silastic in the main frame bore should be removed also.
4. Inspect the countershaft box surfaces on both sides of the wear ring groove. If the wear ring was allowed to wear until the countershaft box turn is allowed to work on the frame ring bore, refer to Figure 4-18, the box must be reconditioned. Contact the factory for the procedure for reconditioning the countershaft box seal area.
5. If the countershaft box seal area is in good condition then replace the seals and wear ring and reinstall the countershaft box assembly as described under *Countershaft Box Assembly Installation*.

The rectangular seal is glued in place with Silastic. Whenever the countershaft box is removed this seal will be destroyed.

Therefore the rectangular seal must always be replaced whenever the countershaft box is removed from the main frame.

MP800

1. Remove the countershaft box assembly, following the instructions as outlined in removing countershaft box from main frame.
2. Once the box has been removed, inspect the inner bore of the frame. If this bore is excessively worn, replace the frame ring as outlined under *Main Frame Ring Replacement* in Section 3.
3. Remove the O-ring and wear ring from the countershaft box.
4. Inspect the countershaft box surfaces on both sides of the wear ring groove. If the wear ring was allowed to wear until the countershaft box turn is allowed to work on the frame ring bore, refer to Figure 4-18, the box must be reconditioned. Contact the factory for the procedure for reconditioning the countershaft box seal area.
5. If the countershaft box seal area is in good condition then replace the O-ring and wear ring and reinstall the countershaft box assembly as described under *Countershaft Box Assembly Installation*.



Callout	Description	Callout	Description
1	O-ring	7	Countershaft box
2	Wear ring	8	No space on worn area
3	Main frame	9	Worn wear ring
4	Frame ring	10	New wear ring
5	Rectangular seal	11	Excessively worn wear ring
6	Clearance		

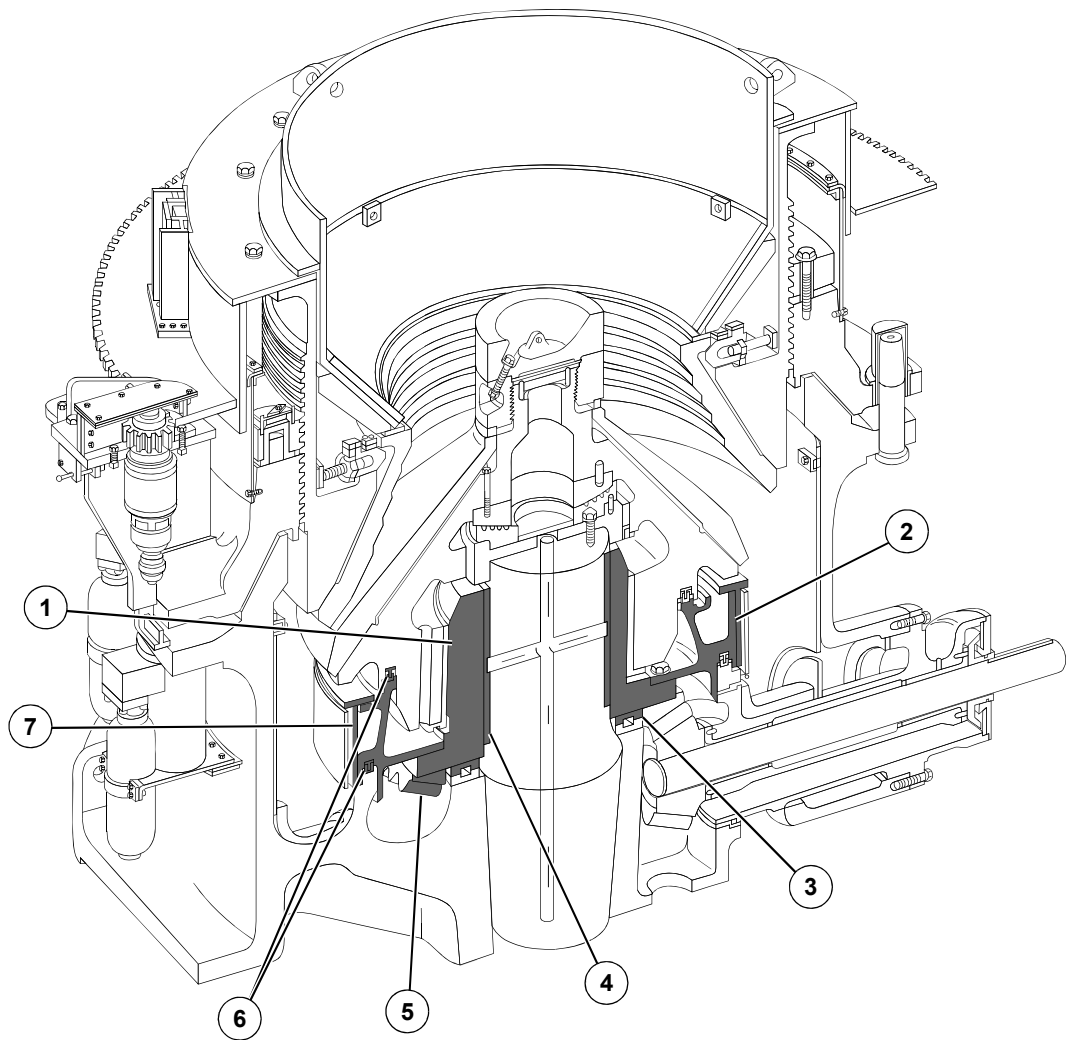
Figure 4-18 Countershaft Box Seals

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Section 5

Eccentric Assembly

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Callout	Description
1	Eccentric
2	Counterweight
3	Upper thrust bearing
4	Eccentric bushing
5	Gear
6	T & U seals
7	Counterweight guard

Eccentric and Counterweight Assemblies

5.1 Description

This section covers the eccentric assembly including the eccentric, eccentric bushing, gear and counterweight. The eccentric which has an offset bore provides the means whereby the head follows an eccentric path during each cycle or rotation. An eccentric bushing locked into the eccentric bore provides the bearing surface for the main shaft.

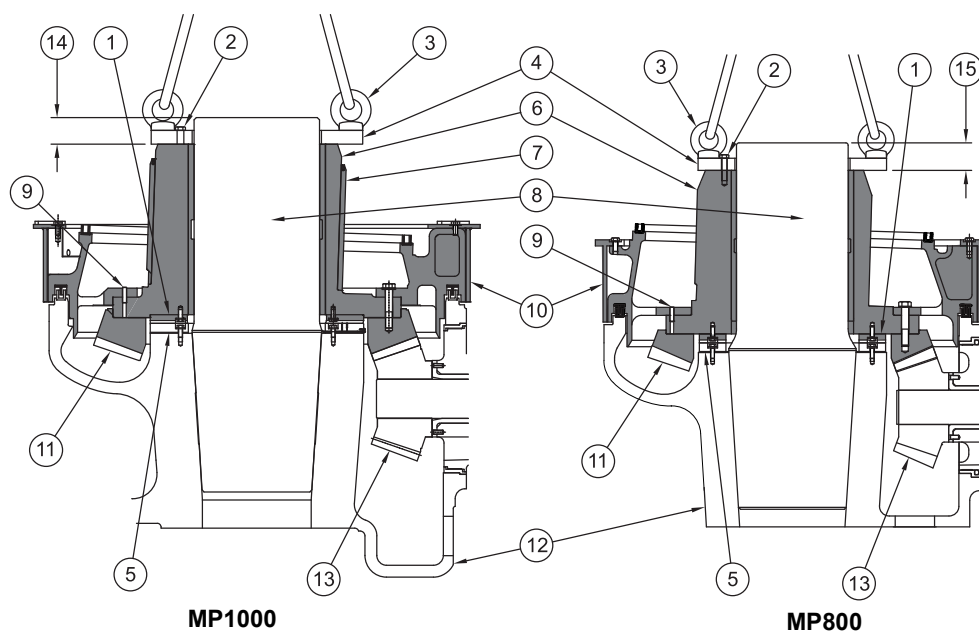
Note that although not part of the eccentric assembly, an eccentric bushing **Resistance Temperature Detector** (RTD) is mounted to the mainframe just beneath the lower edge of the eccentric bushing. This RTD monitors the temperature of the oil exiting the lower end of the eccentric bushing.

A large bevel gear bolted to the bottom of the eccentric is driven by the pinion on the countershaft. The eccentric rotates around the stationary main shaft. The entire assembly is

supported by a set of thrust bearings; the upper thrust bearing is bolted to the bottom of the eccentric and the stationary lower thrust bearing is bolted to the main frame. Backlash and root clearance between gear and pinion teeth are maintained in this assembly by the addition or subtraction of shims inserted beneath the lower thrust bearing.

The counterweight installed on the eccentric has a light and heavy side and is positioned so as to reduce the unbalanced forces created by the motion of the head assembly. Protecting the MP1000 counterweight from falling discharging material is the counterweight guard bolted to the counterweight. Refer to Figure 5-1.

Protecting the MP800 counterweight is a counterweight guard that is bolted to the counterweight. Refer to Figure 5-1.



Callout	Description	Callout	Description
1	Upper thrust bearing	9	Couterweight location dowel
2	M30 Capscrews	10	Counterweight guard
3	Ring bolts	11	Gear
4	Lifting ring	12	Main frame
5	Lower thrust bearing	13	Pinion
6	Eccentric	14	135 mm (5.31")
7	Eccentric Sleeve	15	140 mm (5.51")
8	Main shaft		

Figure 5-1 Eccentric Assembly Installation

Molded, nonmetallic stationary T-seals and U-seals, cemented into grooves around the top and bottom of the counterweight provide a labyrinth type seal that prevents oil leakage and protects the gear, pinion and bearing surfaces from dust infiltration.

5.2 Assembly Instructions

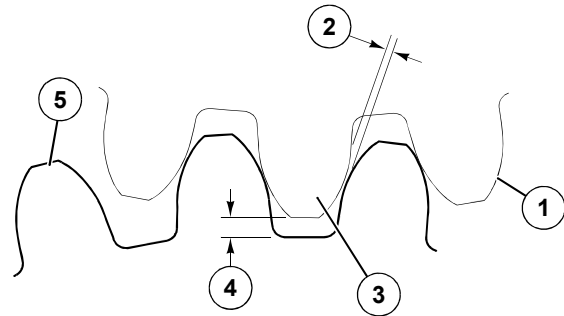
5.2.1 Eccentric Assembly Installation

Procedures for assembling the various components are given in the *Maintenance* portion of this section (refer to Figure 5-1). The eccentric assembly is to be installed as follows:

1. Thoroughly clean the outside and top surface of the main shaft, the gear well surfaces of the main frame and the bore of the eccentric bushing. Remove any nicks, scratches and burrs. Clean the top surface of the lower thrust bearing fastened to the main frame and the bottom surface of the upper thrust bearing bolted to the underside of the eccentric.
2. The bolts holding the lower thrust bearing to the main frame should be checked for tightness. They should be tightened to a torque value of 470 Nm (345 ft. lbs) without lubrication.
3. The bolts holding the upper thrust bearing to the eccentric should be checked for tightness. They should be tightened to a torque value of 373 Nm (275 ft. lbs) without lubrication.
4. Turn the countershaft slightly until a pinion root is in a vertical position as shown in Figure 5-2.
5. Fasten the lifting ring (furnished with the special tools) to the top of the eccentric using the tapped holes in the top of the eccentric. Install two ring bolts, also furnished with the special tools, into the lifting ring. Refer to Figure 5-3 for correct lifting of eccentric assembly. Apply a light coat of oil to the main shaft, eccentric bushing and both thrust bearings.
6. Connect a suitable lifting device to the ring bolts and carefully lower the eccentric assembly over the main shaft. The beveled edge of the eccentric bushing will help center the assembly. Lower the assembly

until the upper thrust bearing is resting on the lower thrust bearing. Also position one of the large cored kidney shaped slots in the counterweight directly over the pinion. It may be necessary to rotate the eccentric slightly to fully mesh the gear into the pinion.

7. Be sure the gear and pinion have properly meshed and are in their correct relationship to each other. This can be checked by measuring the distance the shaft extends out of the eccentric bore. This distance is approximately 135 mm (5.31") for the MP1000 or 140 mm (5.51") for the MP800 as shown in Figure 5-1. Refer to *Checking or Adjusting Backlash and Root Clearance* in this section for procedure for checking backlash and root clearance.



Callout	Description
1	Gear
2	Backlash
3	Gear tooth must be vertical to take an accurate measurement
4	Root clearance
5	Pinion

Figure 5-2 Checking Backlash and Root Clearance

5.2.2 Checking or Adjusting Backlash and Root Clearance

The proper method of setting a set of gears on a new or older Crusher is to try to obtain the recommended backlash. There are two accepted methods for determining the backlash between the pinion and the gear. The first method is to measure the circumferential motion of the countershaft at a radial distance out from the countershaft that

matches the pitch diameter of the pinion. A tool is available for this method and Tables 5-1A, B (MP800) and 5-2A, B (MP1000) list the backlash requirements based on the type of gear set provided with your Crusher. A distance out from the countershaft greater than the pitch diameter of the pinion can be used but a correction factor must be applied to calculate the corresponding circumferential motion at that distance. See the formulas in Table 5-4 for measuring circumferential motion at a larger diameter than the pitch diameter of the pinion. The second method for measuring backlash is to measure it directly by the use of feeler gauges. This method is used only on the straight bevel gear sets because you need to measure the backlash at the center of the tooth face. See Tables 5-3A (MP800) and 5-2C (MP1000) for acceptable levels of backlash when using this method.

If the backlash measured using either one of these two methods is outside the acceptable range, the backlash must be adjusted by adding or taking out the appropriate amount of shim thickness from under the lower thrust bearing. See Tables 5-3A, B for the appropriate amount of shim thickness to add or take away based on the amount of backlash change required.

When setting the height of the eccentric to achieve an acceptable level of backlash, be aware that the eccentric rests on top of the upper and lower thrust bearings. These two parts are designed to lap together which will reduce the backlash slightly. For this reason it is important to continue to check the backlash at regular intervals. It is also the reason it is a common practice to set the backlash at the high end of the acceptable range. If in the process of lowering the eccentric to reduce the backlash on a worn set of gears, the root clearance reaches the minimum limit, the root clearance will then be the limiting factor to assure that the teeth do not bottom out. Refer to Figure 5-2.

Care must be used to see that the worn profile does not interfere with the tips of the gear or pinion teeth as the pinion is rotated. It may be necessary to remove by grinding any ridge that may have formed to provide clearance for the tip of the teeth to pass.

NOTICE

V-belts or flexible coupling must be loose before proceeding with the measurements.

To check or adjust backlash or root clearance, proceed as follows:

5.2.2.1 For Spiral Bevel Gear Sets

Because of the spiral cut on the gear teeth, it is not possible to measure the backlash at the center of the tooth face with feeler gauges. The only acceptable way to measure the backlash on spiral bevel gear sets is by the circumferential motion measurement method.

1. Remove all clearance between the eccentric bushing and the main shaft by placing a hydraulic jack between the inside diameter of the frame and counterweight, in line with the counterweight location dowel in the eccentric flange, pushing the thick side of the eccentric towards the main shaft. Use only enough force as is required to slide the eccentric assembly toward the main shaft. Using excessive pressure could tip the eccentric assembly and give incorrect readings. While maintaining pressure on the eccentric, pull the countershaft outward to take up the end float and rotate the shaft clockwise and counter-clockwise to reach the limits of motion allowed by the backlash. Using a dial indicator, measure the circumferential motion at the outside diameter of the pinion pitch diameter. Refer to Table 5-1A (MP800) and 5-2A (MP1000) for the acceptable level of circumferential motion and minimum root clearance. A tool is available that slides onto the countershaft and has marks at the pinion pitch diameters for both the spiral bevel and the straight bevel gear sets (refer to Figure 2-19). Make sure that you are measuring the circumferential motion at the correct pinion pitch diameter mark. If other circumferential diameters are used for measurement, use the equations shown in Table 5-4.
2. Then measure and note the root clearance.
3. If the backlash and/or root clearance is found to be less than that which is specified in Table 5-1A (MP800) or Table 5-2A (MP1000), the eccentric assembly is to be removed and metal shims of the proper thickness are to be added under the lower thrust bearing as described in *Section 3* under *Lower Thrust Bearing and Shim Replacement*. Refer to Table 5-3A. Adding shims will raise the eccentric assembly and move the gear away from the pinion, thereby increasing the backlash and root clearance.

Should the measurements be more than specified, metal shims of the proper thickness must be removed.

NOTICE

On MP series units that are assembled and tested prior to shipment to the customer, shims placed beneath the lower thrust bearing when the Crusher left Metso Minerals are of the required thickness to provide proper backlash and root clearance. These shims, while placed in the Crusher initially for backlash adjustment, are primarily used for wear compensation.

5.2.2.2 For Straight Bevel Gear Sets (Circumferential Measurement Method)

Follow the procedure as noted above for the spiral bevel gear sets, but see Tables 5-1B (MP800), 5-2B (MP1000) for acceptable levels of backlash and Table 5-3B for the effects of adding or removing shim thickness.

5.2.2.3 For Straight Bevel Gear Sets (Direct Backlash Measurement Method)

1. Remove all clearance between the eccentric bushing and the main shaft by placing a hydraulic jack between the inside diameter of the frame and counterweight, in line with the counterweight location dowel in the eccentric flange, pushing the thick side of the eccentric toward the main shaft. Use only enough force as is required to slide the eccentric assembly toward the main shaft. Using excessive pressure could tip the eccentric assembly and give incorrect readings. While maintaining pressure on the eccentric, pull the countershaft outward to take up the end float and rotate the shaft clockwise and counter-clockwise to reach the limits of motion allowed by the backlash.
2. To check the backlash, rotate the countershaft until the pinion tooth just touches the gear tooth. Measure and note the clearance on the opposite side of the tooth with a feeler gauge at the center of the tooth. The feeler gauge is to be long enough to measure the clearance at the center of the gear and pinion tooth face. Note that a feeler gauge of at least 6 inches (152.4 mm) in

length will be required to reach the center of the tooth. Refer to Tables 5-3A (MP800) and 5-2C (MP1000) for the acceptable level of backlash and minimum root clearance.

3. Then measure and note the root clearance.
4. If the backlash and/or root clearance is found to be less than that which is specified in Table 5-3A (MP800) or Table 5-2C (MP1000), the eccentric assembly is to be removed and metal shims of the proper thickness are to be added under the lower thrust bearing as described in *Section 3* under *Lower Thrust Bearing and Shim Replacement*. Refer to Table 5-3B. Adding shims will raise the eccentric assembly and move the gear away from the pinion, thereby increasing the backlash and root clearance. Should the measurements be more than specified, metal shims of the proper thickness must be removed.

NOTICE

On MP series units that are assembled and tested prior to shipment to the customer, shims placed beneath the lower thrust bearing when the Crusher left Metso Minerals are of the required thickness to provide proper backlash and root clearance. These shims, while placed in the Crusher initially for backlash adjustment, are primarily used for wear compensation.