TERRASOURCE™ GLOBAL

SERVICE MANUAL

CUSTOMER:	REDACTED FOR PRIVACY
END USER:	REDACTED FOR PRIVACY
PROJECT ORDER NUMBER:	REDACTED FOR PRIVACY
PURCHASE ORDER NUMBER:	REDACTED FOR PRIVACY
BRAND AND MACHINE TYPE:	JEFFREY RADER 45 WBE-SS
UNIT SERIAL NUMBER(S):	REDACTED FOR PRIVACY

MANUAL CREATED: 1/6/2021

GUNDLACH CRUSHERS

JEFFREY RADER UNITED STATES • CANADA • SWEDEN

Pennsylvania Crusher Since 1905

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SECTION 1

Jeffrey Rader
General Crusher / Hammermill

(Catalog Number 234484)

Serial No._____

Order No._____

Model No._____

Equipment Manual
116-2 e_2012-12

THE FOLLOWING WARNINGS APPLY SPECIFICALLY TO ALL CRUSHER, HAMMERMILL, PULVERIZER, & GRINDING EQUIPMENT MANUFACTURED AND SUPPLIED BY TERRASOURCE GLOBAL, AND ARE INTENDED TO HELP PROTECT BOTH PERSONNEL & EQUIPMENT. ALL PERSONNEL INVOLVED IN THE INSTALLATION, OPERATION & MAINTENANCE OF JEFFREY RADER EQUIPMENT MUST FOLLOW ALL GOVERNMENT & RECOGNIZED SAFETY CODES, SPECIFICALLY WITH ISO / OSHA / MSHA.

ALL PERSONNEL MUST READ AND UNDERSTAND THESE WARNINGS.

NEVER . . . . start the equipment unless the personnel in the immediate area are notified.

NEVER . . . . start or operate the equipment with any guards, doors or covers open, or open any guards, doors or covers while the equipment is operating. All rotating components must be covered.

NEVER . . . . perform any type of inspection or maintenance unless the equipment is stopped and all sources of energy are electrically locked out or blocked from operation. Equipment must be attempted to be restarted to verify that the power and other energy sources have been disconnected before any work is performed.

NEVER . . . . climb or stand on or over the equipment while it is operating. Never sit, stand on or perform any type of inspection or maintenance on or near any rotating component unless it is mechanically prevented from rotating and motor is electrically locked out.

NEVER . . . . feed material to the equipment unless the rotating components are running at operating speed. Always stop infeed before stopping equipment.

NEVER . . . . use the equipment for any purpose other than the original specified use, and do not make any modifications whatsoever unless approved by TerraSource.

NEVER . . . . attempt to make any adjustments to the equipment while feeding material.

NEVER . . . . attempt to clear a plugged feed or discharge chute by poking with a rod or similar device while the equipment is operating.

NEVER . . . . feed any explosives or combustibles into the equipment, or use explosives to free any plugging or build-up.

NEVER . . . . look or reach into the infeed/discharge to inspect or remove material while equipment is operating.

NEVER . . . . increase or decrease the speed of the equipment without written approval from TerraSource.

NEVER . . . . operate the equipment in the wrong direction of rotation. Never attempt to reverse the direction of the rotor unless it is stopped.

NEVER . . . . be in the vicinity of the crusher while it is operating without wearing hearing and eye protection, and any other required PPE (Personal Protective Equipment).

Always refer to the Jeffrey Rader equipment manual supplied with the equipment for additional safety information, instructions, and warnings. If you do not have an equipment manual, do not understand the above warnings, or have any safety questions concerning safe operating and maintenance procedures of this equipment, please feel free to contact a TerraSource representative at the following office locations. Additional contact information can be found on the Internet at WWW.TERRASOURCE.COM.

TerraSource Global
215 Parkway East, Suite A
Duncan, SC 29334
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A. Overview and Safety

A.1. Preface

This manual is provided as a guide to personnel involved with the installation, operation, and maintenance of Jeffrey Rader equipment. Operators, Inspectors, and Maintenance personnel of Jeffrey Rader equipment should read and become familiar with the general procedures and information contained within this manual. In addition we recommend that this manual be kept readily available for reference before beginning any work associated with equipment.

Safety precautions and instructions for awareness and information on potential hazards are found throughout this manual. Due to the complexities of the systems in which this equipment is used and the environment in which it operates, situations may arise which are not directly discussed in detail in this manual. When such a situation arises, past experience, availability of equipment, intelligence and common sense play a large part in what steps are to be taken. In addition, a service representative is available to answer your questions, perform inspections and safety reviews, provide operator training, and supervise maintenance crews upon request.

Please feel free to contact a technical or service representative at the following office locations. Additional contact information can be found on the Internet at WWW.TERRASOURCE.COM.

TerraSource Global
215 Parkway East, Suite A
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Tel. 604-299-0241
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A.2. General Safety

All parts of the equipment and the system into which it is placed must be installed, operated, and maintained in keeping with sound safety practices. This manual contains safety information designed to be used in two ways: first as a primary reference for operators and plant maintenance personnel, providing them with details and explanations of operational and maintenance safety procedures; and second as a training tool within your plant's safety program.

Safety begins with properly designed and manufactured equipment. To that end, TerraSource Global has designed this equipment with safety in mind. The following general safety standards have been used in the design and manufacture of the equipment; additional standards will be used in equipment that is sold into specific countries or areas of the world as required:

OSHA 29 CFR 1910	USA Code of Federal Reg., Occupational Health and Safety
ASME B15.1b	American Society Mech. Eng., Mech. Power Transmission Safety
ASME B20.1a	American Society Mech. Eng., Conveyor & related safety stds
NFPA 70e	USA National Fire Protection Assoc., National Electric Code Part 1, Electrical Safety in the Workplace
EN ISO 12100	European Community General Principles of Design

2A 2006/42/EC or EG	European Community Machinery Directive (complete machines with drives attached)
2B 2006/42/EC or EG	European Community Machinery Directive (partly completed machines without drives attached)
2006/95/EC	European Community Electrical Directive
EN 60204-1	European Community Safety of Machinery, Electrical Equipment

However, the use of the equipment is subject to certain hazards that cannot be met by mechanical means alone, but by the exercise of intelligence, care, and common sense in its use. Once the equipment is shipped, TerraSource Global has no direct control over its installation, operation, inspection, maintenance. For this reason, **safety in the field is the responsibility of the user**.

Any maintenance other than inspection, cleaning, or obvious repair due to wear should be discussed with your technical or service representative. Certain design parameters are utilized in the construction of this equipment, making allowances for moderate wear and normal environmental conditions that could affect corrosion, erosion, or impact. Severe wear, operating equipment at higher or lower speeds, increasing horsepower/kilowatt power, severely corrosive environments, material tramp and rocks, etc. can render the equipment un-safe or hazardous to operate and should be discussed with your TerraSource representative.

The following notes provide basic safety guidelines that should be incorporated into a comprehensive safety program at your plant. See manual 000-1 Safe Operating Procedures for additional safety information regarding the use of Jeffrey Rader equipment.

- Do not remove warning signs from the equipment. If warning signs become damaged, contact TerraSource for replacements.
- Make certain that all barriers, covers, and guards are in place before starting the equipment.
- Keep aisles around equipment clear of unnecessary or potentially hazardous articles.
- Wipe up spilled oil, grease, or water to minimize the risk of slips and falls.
- Keep loose clothing, long hair, jewelry and all parts of the body away from moving machinery parts.
- Keep away from belt and chain drives.
- Wear appropriate safety protection equipment as required by the job and environment. This includes hard hats, safety goggles, hearing and eye protection, dust masks, safety shoes, and any additional PPE (personal protective equipment) required by the plant.
- Read and understand all safety related information in this manual.

A.3. Warning Signs

Signs of various types are posted throughout this manual and on the equipment to warn the end user of potential hazards associated with the operation of this machinery. These signs aid in the safe and efficient operation of this equipment, and it is recommended that periodic inspection of all signs be included in the machines inspection program.

The following standards are used for warning signs on Jeffrey Rader equipment; additional standards may be used in equipment that is sold into specific countries or areas of the world as required:

ANSI Z535	American National Standards Institute, Safety Alerting Stds
ANSI A13.1	American National Standards Institute, Pipe Marking Stds

EN 61310	European Community, Safety of Equipment, Indication, Marking, and Actuation
ISO 3864-2	International Standards Organization, Stds for Safety Symbols

If signs are missing, damaged or illegible, they should be cleaned or replaced to ensure the safe operation of the equipment. Replacement warning signs are available for a nominal charge by contacting the TerraSource representatives at one of the addresses listed in Section A.1. Refer to Section B.5. for a complete listing of warning signs.

Signs used in this manual and on Jeffrey Rader equipment use the following signal words to emphasize important and critical instructions.

⚠ DANGER

Danger is used to indicate an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

⚠ WARNING

Warning is used to indicate a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

Caution is used to indicate a potentially hazardous situation which, if not avoided, may result in minor or moderate injury or property damage.

NOTICE

Notice is used for special important instructions, but not hazard related.

A.4. Lockout/Tagout Procedures

When performing inspection or maintenance on Jeffrey Rader equipment, always follow Lockout/Tagout Procedures as required by the following standard organizations; additional standards may be used in equipment that is sold into specific countries or areas of the world as required:

OSHA 29 CFR 1910	USA Code of Federal Reg., Occupational Health and Safety, sub-sections .147, .269, .333
ANSI Z244.1	American National Standards Institute, Control of Hazardous Energy
NFPA 70e	USA National Fire Protection Assoc., National Electric Code Part 1, Electrical Safety in the Workplace
CSA Z460	Canadian Safety Assoc., Control of Hazardous Energy
EN ISO 12100	European Community General Principles of Design
EN ISO 11161	European Community Safety of Machinery, Integrated Manufacturing System

Refer to the maintenance section of your manual prior to performing any maintenance. If the specific topic is not covered, contact TerraSource before proceeding.

Lockout/Tagout Procedures are intended to protect personnel working on or around the equipment by preventing accidental start up and exposure to hazardous energy release such as electrical shocks and stored energy. The procedure requires that individual locks and tags are placed on controls, shutoff switches, valves, or other devices to prevent usage until the person who installed the lock removes it. Never attempt to operate any control device when it is in LockOut/TagOut while personnel are inspecting or working on the equipment.

Proper Lockout/Tagout Procedures must include:

1. A documented and established site policy on the steps to follow for lockout and tagout such as:
    a. Notify all affected people including supervisors before lockout or tagout is used.
    b. Shut off the affected machine, equipment, system or function.
    c. Disengage, isolate or release energy supply or source.
    d. Apply individual locks and tags on controls, or other devices to prevent usage.
    e. Try or test the equipment to check that the energy has been removed before service or maintenance.
    f. Entry allowed to equipment
2. Employee training on proper Lockout/Tagout Procedures for the facility.
3. Identification and location of shutoff switches and controls that isolate hazardous energy are predetermined at the facility.
4. After inspection or maintenance is complete all individuals must remove their Lockout/Tagout. After all LockOut/TagOuts are removed, notify the appropriate personnel that all inspection and maintenance has been completed and the energy or power can be restored.
5. A documented and established procedure must be in place to handle locks that must be forcibly removed, to ensure that all conditions are safe before removal.

A.5. Confined Spaces Procedures

Certain areas of this equipment may be considered a Confined Space, or a Permit Required Confined Space, per the following standards; additional standards may be used in equipment that is sold into specific countries or areas of the world as required:

OSHA 29 CFR 1910	USA Code of Federal Reg., Occupational Health and Safety, sub-section .146
ANSI Z117.1	American National Standards Institute, Safety Requirements for Confined Spaces
CSA Z1006	Canadian Safety Association, Management of Work in Confined Spaces

If the equipment is so designated, a warning sign will be posted, and a documented and established site policy must detail the steps to follow before any entry is allowed. These procedures, along with LockOut/TagOut, must be followed before any entry is attempted into a confined space or permit required confined space. In some cases, the equipment may not be able to be physically entered, but may contain a possibility of dangerous dust loadings, gasses, temperatures, or other conditions which may be identified and proper precautions taken before any work is performed.

A.6. Safety of Materials

A system of providing material safety for workers and workplaces has been created and adopted in most areas of the world. TerraSource will supply this information on customer request; all requests must include the equipment name, part name or part number, and project or serial number, and additional specific information that may also be required fulfill the request. Inquiries concerning material safety information can be addressed to the TerraSource Engineering Dept. at one of the locations listed in Section A.1.

MSDS	USA, Material Safety Data Sheet System
WHMIS	Canada, Workplace Hazardous Materials Information System
REACH	European Community, Registration, Evaluation, Authorization & Restriction of Chemicals System

A.7. Equipment in Explosive or Hazardous Atmospheres

If special ordered, most Jeffrey Rader equipment can be supplied to handle and operate in dust rated hazardous zones. In these cases, special design, risk assessments and manufacturing considerations will be taken to the equipment as supplied, and special installation, operation, inspection, and maintenance procedures will be required to operate the equipment safely.

NFPA 68	USA National Fire Protection Assoc., Explosion Protection by Deflagration Venting
NFPA 69	USA National Fire Protection Assoc., Explosion Prevention Systems
NFPA 70 Article 500	USA National Fire Protection Assoc., National Electric Code, Hazardous (Classified) Locations
NFPA 61	USA National Fire Protection Assoc., Prevention of Fires & Dust Explosions in Agricultural and Food Processing Facilities
NFPA 484	USA National Fire Protection Assoc., Standard for Combustible Metals
NFPA 664	USA National Fire Protection Assoc., Prevention of Fire and Explosions in Wood Processing and Woodworking Facilities
EN 1127-1	European Community, Explosive Atmospheres, Exp Prevention & Protection (also known as ATEX)
EN 60079-0	European Community, Explosive atmospheres
ISO/IEC 80079-34	European Community, Potentially Explosive Atmospheres-Application of Quality Systems

B. General Information

B.1. Introduction

The sections of this manual have been written to provide information in receiving, inspecting, installing, start-up, operating and maintaining your Jeffrey Rader crusher. It is important to read carefully this manual before receiving your crusher, to have a thorough understanding of the equipment and its operation. Do not hesitate to contact your local TerraSource Representative to answer any questions you may have or provide additional special instructions your particular application may require.

⚠ CAUTION

Failure to follow the instructions and procedures outlined in this manual could void your Warranty.

Section C contains pertinent information on what to do when you first receive your crusher. Of particular importance is the handling of the rotor and bearings and subsequent storage instructions. Many problems and start-up delays can be avoided with proper receiving and storage precautions.

Prior to installing your crusher, the installation and lubrication instructions must be read thoroughly. Important topics here include adequate foundations and proper lubrication of your crusher.

The remaining sections present valuable information on operating and maintaining your crusher for many years of reliable service and production of a suitable product for sustained profits. Reading and following the safety information in each section is essential.

B.2. Crushing Methods

Crushing refers to the physical reduction in size of any given material. Basically there are five (5) ways to reduce a material – by impact, attrition, shearing, compression, and tumbling. Most crushers use a combination of crushing methods. TerraSource crushers/hammermills employ one or more of the first four crushing methods.

Impact, as used in crushing terminology, refers to the sharp, instantaneous impingement of one moving object against another.

Attrition is the term applied to the reduction of material by rubbing action between two surfaces and is primarily a grinding action.

Shear crushing is accomplished by a trimming or cleaving action rather than the rubbing action associated with attrition.

Compression, as the name implies, is accomplished by squeezing the material between two surfaces.

There are three (3) major categories of crushers. These are primary crushers, intermediate or secondary crushers and fine (tertiary, quaternary, etc.) crushers. Crushers are used for the initial reduction of run-of-mine (ROM) or run-of-quarry (ROQ) material down to product size ranging from eight inches to one inch size. Intermediate crushers obtain further reductions of already crushed materials down to very fine piece sizes.

B.3. Jeffrey Rader Crusher Types

Primary Impactor – Rockbuster and Coalbuster

The Rockbuster (Coalbuster) is composed primarily of a heavy rotor with fixed impeller bars and a series of adjustable breaker bars. The material is fed through the opening over a hydraulically operated feed plate into the path of the rotor and is broken through the initial impact. Further reduction occurs with impact of material on material and impact of material on the breaker bars.

Primary – Roll Crushers

The roll crushers used in primary applications are heavy duty Jeffrey Rader Double Roll Crushers. Jeffrey Rader Roll Crushers utilize massive rolls with heavy teeth enclosed in extra thick steel housings.

Large lumps of material are broken by impact of the heavy teeth striking the projecting parts of these large lumps in contact with the roll surfaces. Smaller lumps in the convergence zone between the rolls are sheared by the teeth and then compressed between the crushing surfaces.

Secondary – Hammermills

The Hammermill consists of a series of either swing or rigid hammers and usually includes screen bars for final product sizing. The material is initially reduced in the upper chamber by impact, is further reduced by shear as it passes the breaker bar, and is finally reduced by attrition as the hammers force the material over and through the screen bars.

Secondary – Roll Crushers

This category incorporates both the Single Roll and Double Roll units. The Single Roll crusher has one roll rotating toward an adjustable breaker plate. The teeth first strike the feed with an impact and sledging action. Then they shear the material against the breaker plate as they move downward past the breaker plate.

Finally, they force the feed with pressure between the roll and the breaker plate obtaining reduction by compression.

The Double Roll Crusher has two revolving rolls. One of the rolls revolves in fixed bearings while the other roll revolves in movable bearings held in place with heavy safety relief springs. The action is similar to that in the single roll with the additional feature of two rolls tending to pull the material down toward the center for further reduction due to compression.

Shredders

Jeffrey Rader Shredders are used in both primary and intermediate category applications. They are primarily a hammermill type action with special hammers and rotors designed to reduce material by shear due to the cutting and shredding action of the hammers on such materials as wood, rubber and other fibrous materials.

Every Jeffrey Rader Crusher is equipped with one or more mechanical means, as well as speed, to vary the finished product size. With open discharge units. (Rockbusters, reversible Impactors,

Mud Hogs, etc.) product size can be controlled by moving breaker bars or breaker plates closer to or farther away from the crushing elements.

Hammermills are equipped with screen grates or perforated plates across the discharge area to size the product. Varying the opening in the grates or plates will change product size.

Double and Single Roll Crushers utilize adjustable roll centers or breaker plates.

All Jeffrey Rader Crushers (except Rockbusters) can be varied as to the size, shape, number, and arrangement of hammers, teeth, or other crushing elements to produce the desired product size. These, along with the other adjustments discussed, make Jeffrey Rader Crushers very flexible as to product size produced.

B.4. Component Description

Jeffrey Rader Crushers consist of the rotor(s), with shaft(s) and hammers (if applicable), bearings with lubrication system, housing with liners, and drive. Detailed description for particular type crusher, with identifying figures, appear in the specific Supplemental Manuals.

It is important that installation and operating personnel become familiar with the terminology associated with crusher parts. A complete description of the crusher parts, including Jeffrey Rader catalog numbers, is found on the Parts List Drawing supplied with each order. The Parts List Drawing is mailed separately when the crusher is shipped from our factory. Information as to recommended spare parts and instructions for ordering parts are contained in the Specific Instruction Manual for your particular type crusher.

B.5. Crusher Application

Jeffrey Rader Crushers are ordered and manufactured for a specific application. While Jeffrey Rader crushers are versatile and have been applied to the reduction of a variety of materials producing various sizes of products, the adjustments, construction materials, design and fabrication of your crusher have been determined for a specific application. Should there be any question as to the intended service or last minute changes in application, contact your TerraSource Representative.

⚠ CAUTION

The use or misuse of the crusher for service exceeding the prescribed service requirements may void your Warranty.

B.6. Standard Model Information

The Jeffrey Rader Crusher is manufactured of high quality components, and machined, fabricated and assembled with great care. The Rotor Assembly, Hammers, Bearings, and Housings are designed to withstand normal overloads and impact loadings that can be expected in crusher and hammermill applications.

All units will have attached to the frame a metal nameplate. On this nameplate is stamped the TerraSource Job Number, Model Number and Serial Number. This information should be referred to whenever the unit requires service or spare parts.

B.7. Optional Features

Below is a partial listing of optional features that may be selected at the time of order. In many cases, features may be added to existing units, contact a TerraSource representative for more information on in-field modifications.

- Electric Motor(s) by TerraSource
- Sub-Bases for the Crusher and Drive Motor
- Couplings or Belt Drive arrangements
- Optional material selections for internal wear parts for increased life
- Rotor Assembly shaft speed sensing
- Optional Easy Access arrangement with hydraulic opening assist system for opening the unit for maintenance access
- Vibration Sensors
- Oil lubricated Bearings and Oil Circulating Systems
- Bearing Temperature Monitoring Systems
- Special preparation, primer and paint as required

B.8. Crusher Safety Warning Signs

Safety warning signs are used on Jeffrey Rader Crushers, should any of the signs on the unit be missing, damaged, or illegible, they should be cleaned or replaced to ensure the safe operation and maintenance of the Crusher. Replacement warning signs are available for a nominal charge by contacting a product representative at one of the addresses listed in Section A.1.

C. Installation

C.1. Shipping, Handling, & Storage

When shipping by truck, the crusher should be placed on wooden cribbing and bound to the flatbed trailer using the lifting slots only. Chains or straps may be used to tie these points to the flatbed trailer. Do not use chains or straps across the main housing or any other part of the crusher. Under no circumstances should the crusher unit be secured by the rotor, shafting, or bearings within the unit.

Where possible, your crusher has been shipped as a complete assembly. However, due to size and weight limitations, large crushers will be shipped in two or more subassemblies. Whenever possible, sub-bases (when included as part of the order) will be attached to the crusher unit. Carefully inspect your crusher assembly(s) upon receipt of shipment for any damage or missing parts. Report any damage immediately to the carrier. Also contact TerraSource to help assist in appraising the damages or loss during shipping, and to instruct in required repairs or replacement so that your warranty remains valid.

When using a sub-base, the drive motor must not be installed on the sub-base before lifting the crusher and sub-base into place. Any other optional separate drive bases must not be attached to the main frame or sub-base of the crusher while lifting into position.

⚠ WARNING

Personal injury or property damage may occur if equipment used to lift the Crusher does not have a rated load capability greater than the weight listed on the certified drawings. Care should always be taken to insure adequate capacity in any equipment used to lift or move the equipment. Lifting line angles must exceed 45 degrees from horizontal. A spreader bar should be used when moving the Crusher off the shipping truck or into its final operating position.

When handling the crusher during unloading and erection, care should be taken to avoid damage by dropping or improper use of slings. Small, completely assembled crushers should be rigged with the slings around, under or laced through the heavy support members of the lower main frame. Never sling from the bearing housing or shaft when lifting the entire crusher. Large crushers will be shipped in two (2) or more subassemblies and the same care for handling these should be taken.

Special care is required when handling rotor assemblies. These should be rigged with the slings inboard of the bearings and as close to the heavy rotor section as possible. Rotors of the disc type should be rigged with a spreader (see Figure 1) between the slings to prevent damage to the discs. Never lift a rotor from the hammer pins, bearing housings, or the outboard ends of the shaft.

The surface finish on crusher shafting is critical and should be protected from gouges, dents and scratches when using a sling.

Any damage incurred from shipping should be reported to both TerraSource and the shipping carrier involved as soon as possible after receipt of the Crusher.

Equipment will be shipped with all bare metal surfaces primered or coated with a suitable shipping rust protectant, such as Cosmoline. If the equipment is to be stored before installation, unpack or uncrate the equipment immediately, clean off existing protectant, clean any rust or dirt that may have accumulated during shipment, and recoat with a suitable rust protectant.

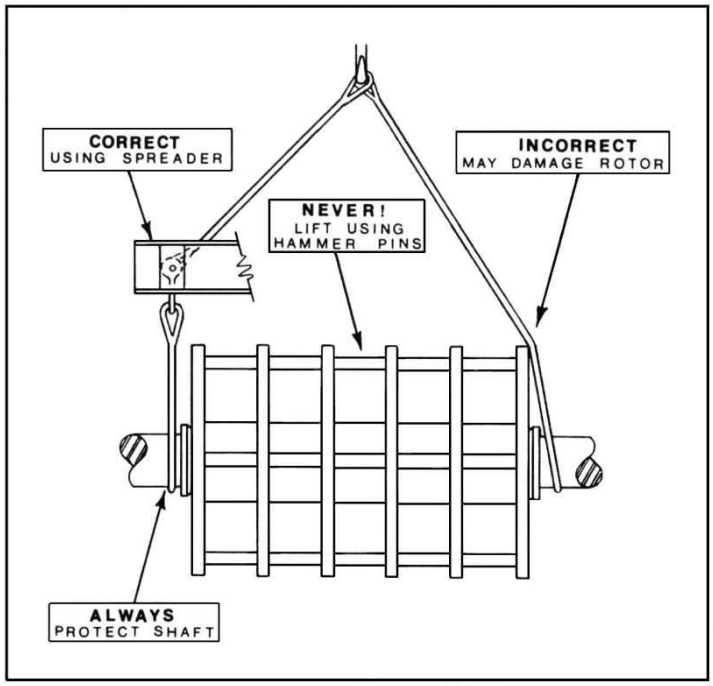


Figure #1- Lifting the Rotor Shaft

C.2. Storage Procedures

Additional instructions for extended storage can be found in the Jeffrey Rader Long Term Storage Manual 000-2.

C.2.a. Short Term (less than 12 weeks)

Before erection, for a period of less than twelve (12) weeks after unloading, the crusher and auxiliary equipment should be stored on cribbing or suitable shoring to keep them free of dirt, mud and water and placed under cover.

Without protection, anti-friction bearings can be damaged beyond repair in one or two weeks. Moisture accumulation during storage, in the form of condensation inside the bearing housing, is a major cause of damage. Covering all bearings with waterproof canvas or plastic sheet will give protection against the weather but will not eliminate the effect of humidity. Only storage in a dry, heated area will fully protect against rust damage in a humid environment. Turn the rotor shaft by hand every four (4) weeks and re-lubricate the bearings. If the crusher will not be operated for twelve (12) weeks, but before twelve months (12) after shipment, further precautions are required (See Long-Term Protection).

In addition, cover the feed opening of the crusher with canvas or plastic sheet to prevent dust, dirt and the elements from entering the crusher. Rain or snow could corrode interior parts; in crushers with hammers, the hammers could bind on their pins causing an imbalance in the rotor. These hammers must be lubricated with a light oil to free them on their pins.

When the storage period is over and startup is within 2 weeks:

1. Remove protective covering if stored outside.
2. Remove protective coating from shafts and exposed finished surfaces.

3. Reread handling procedures to insure that equipment is not damaged during installation.
4. For Oil Lubricated Bearings only, drain run-in oil from Bearings. Then flush and clean bearings with a non-corrosive petroleum solvent. Replace run-in oil with proper lubricant (see LUBRICATION section).

C.2.b. Long Term (less than 12 Months)

In addition to the short-term precautions in Section C.2.a., the following protection is required for long-term storage: The bearings on Jeffrey Rader crushers are protected against rust for only twelve (12) weeks after shipment, provided the bearings are protected from weather, dust and dirt. For longer storage periods of up to twelve (12) months, or long shutdown, the bearings need long-term protection. On new equipment, check your order to see if TerraSource has provided long-term protection. If you have not ordered long-term protection, the following procedures must be followed.

- Thoroughly clean the outside of the bearing housings and the area around them so dirt will not drop or be blown into the open bearings. Remove the bearing cap and all the lubricant. Thoroughly clean and flush all internal surfaces of the bearing and housing with petroleum solvent to remove all traces of dirt and sludge. Allow the solvent to drain from the bearing and housing. Removal of the lower half of the housing will make the work easier. If the lower half is not removed, the shaft must be raised enough to allow the outer ring to be rotated. Melt a preservative ("Rust Veto Heavy", manufactured and distributed by Houghton International www.houghtonintl.com) or equal by placing the estimated quantity that will be required in a container. Then, as with a double boiler, place this in a larger container of water. Slowly heat the water until all of the preservative is melted and has reached a temperature of 150 – 170F (66-77C)

⚠ CAUTION

Melted Preservative may burn in direct contact with skin. To prevent injury, use extreme caution when working with this or similar materials.

- Immediately after cleaning, thoroughly coat all the outside surfaces and cavities of the bearing with melted preservative. Work the preservative between and around all of the rollers. Hand rotate the bearing to help distribute the preservative and to assure complete coverage of the interior surfaces. (A long spout, pump type oil can or a similar dispenser can be used for interior surfaces).

- Coat all surfaces of the locking assembly, shafting, ring seals and interior surfaces of the housing, the split between base and cap, etc. with "Rust Veto Concentrate"* or equal. Remove the oil sight gauge, if used, and plug the connection in the housing. Reassemble the pillow block. (If an external lubricating system is used, disconnect and plug all feed and return line connections to the housing). After reassembly is complete, seal around each shaft at the housing with preservative.

- If the unit is outside, the housings must be protected from the weather by covering with plastic sheet or waterproof canvas. (Storage in a dry heated area is preferred.)

When the storage period is over and startup is within 2 weeks:

1. Remove protective covering if stored outside
2. Clean any dust and dirt from bearing housing and surrounding area.
3. Clean and flush the preservative from the bearings. This is accomplished by using a non-corrosive petroleum solvent heated to 100-120F (38-49C).

⚠ CAUTION

Be absolutely sure all lubrication grooves and ports in the outer ring of the bearings and all openings in the housing are clean and free from any foreign materials. In most cases the bearing housing will have to be disassembled to insure thorough cleaning.

4. Replace preservative with proper lubricant (see Section F.2).

C.2.c. Extended Term (over 12 Months)

In the event the crusher is stored or out of service for more than twelve (12) months, repeat the above procedure in Sections C.2.a. and C.2.b. For extremely long periods of inactivity, new parts may be required to put the crusher back in service. In these situations, the advice of a TerraSource Service Representative may be helpful.

Equipment that has been erected and is not in operation will require the same protection. Exposed finished surfaces on parts like bearing seats, shafting, etc. should be coated with heavy grease or other protective material and covered for protection from the weather. (Clean all finished surfaces before start-up.)

If equipment is to be stored longer than 12 months, and the equipment due to size or weight cannot be stored in the above parameters, it is strongly recommended that the motors and bearings be removed from the equipment and stored in a controlled environment. Lubrication and hydraulic systems, cylinders, air and hydraulic tubing, etc. require protection from dirt and grit as well as moisture and should be given as much protection as possible, dry, clean, inside storage is recommended.

C.2.d. Storage of Electrical Equipment

Electrical controls and motors, like bearings, are very susceptible to permanent moisture damage and should be protected. Unlike a bearing, the moisture damage cannot be seen in most cases. A clean, warm, dry area is the best protection.

Push-button control stations, junction boxes, small to medium horsepower motors, etc., if located outside, should be weather-proof by design, and additional weather protective coverings usually are not required, but will, of course, provide additional protection.

For detailed protection instructions, read the manufacturer's instruction sheets, which are included in your Parts Catalog.

C.3. Mounting and Supports

No attempt will be made in this manual to cover all aspects and procedures required for proper erection of crushing equipment and related support machinery. Jeffrey Rader equipment requires mechanically sound erection procedures to be used during the installation of the crusher. The following are general instructions and procedures which, in addition to the above, TerraSource considers essential for proper erection and operation. If there are any questions or additional instructions required, please contact your TerraSource Representative and always refer to the serial number of your crusher.

The foundation structure for all mechanical equipment, and especially for crushers, should be as level and as dimensionally accurate as possible and structurally capable of supporting the developed loads. The type of structure and the design of footings are determined by plant procedures and local soil conditions.

In cases where TerraSource has supplied a sub-base, the sub-base must not be considered as a structural support member for the crusher. Do not cantilever or rely on any TerraSource supplied sub-base for crusher support unless that sub-base has been specifically designed for that purpose.

The main supporting structure for the crusher should be designed in accordance with applicable codes and human safety requirements. TerraSource also highly recommends that whether the crusher support is new or to be modified from an existing structure, that a proper structural & foundation review is performed by a qualified structural designer.

The natural frequency of the structure or foundation must be greater than 2.0 times the operating frequency (RPM) of the crusher. If the optional sub-base is installed, it is recommended that the interior portions of the sub base be filled with concrete to add mass and help dampen dynamic vibrations during operation. The weight of the sub-base, concrete, motor, motor mount, infeed chutework, outfeed chutework, etc. must be taken into account during the design of the supporting structure. As a general rule of thumb, many structures that have provided good support have a structure total weight that is 2-3 times heavier than the crusher unit/base/motor combination. Structural bracing (X-Cross above the Crusher foundation and K-Diagonal below the Crusher foundation) is also recommended whenever possible to prevent excessive flexibility in the structure.

The foundation must be designed to carry one (1) x machine weight as a static load and (1.5) x machine weight as a dynamic load.

These two loads added together equal the foundation load in the vertical plane. Foundation design requires the capability of carrying (1) x machine weight load in the horizontal plane.

⚠ CAUTION

Use only certified crusher assembly drawings furnished by TerraSource for foundation design.

During operation of the unit, it can be expected that dynamic imbalance forces from the uneven feed of material, small sized tramp, or imbalance from Swing Hammer movement will be seen on a regular basis. In most cases, these small imbalance forces occur very quickly, and will not be of a significant magnitude or time duration, with respect to the design guidelines given above. Consideration should be given during the design of the foundation/structure, reinforcement, and fasteners that are of a vibration-resistant design to minimize the possibility of foundation/ structure loosening over time.

On a very infrequent basis, it is possible for the crusher to see larger imbalance loads, such as from extremely large tramp material. Due to the relatively high RPM, large mass and high tip speed of the rotating assembly, these forces can be extremely large, and unfortunately difficult to estimate in direction and magnitude. This is due to the random shape of the tramp and its potential random orientation between the rotating parts of the crusher. This in effect becomes a statistical analysis; sometimes the tramp will pass through the unit in such a way as to not ever become solidly wedged between the rotor assembly and the discharge grates, and sometimes it will. In the first case, a low or moderate transfer of energy will be seen; in the latter it could be extremely high. This latter loading, though not common, must be accounted for in some capacity during the design of the supporting structure. For this reason, it is highly recommended that the final design of the crusher support structure is reviewed by a qualified structural designer, knowledgeable and competent with the support issues of high-inertia hammermill/crusher type equipment.

When installing the crusher, take all precautions to protect the interior components from damage, particularly from welding and falling objects.

To compensate for any inaccuracy of the foundation or support plates of the equipment, the use of grout and shims is recommended to assure proper contact between the support plate and foundation and to facilitate leveling.

The area contact between the support plate of a crusher and foundation is more critical than other types of equipment due to the magnitude of the dynamic loads that can be developed. The contact area should be evenly distributed over the entire support plate with no large gaps. The support plate area directly under the bearings should have 100% contact.

Auxiliary equipment supports and erection should be given the same care as that required for the crusher. Alignment between rigidly connected units must be maintained along with proper foundation connections.

The horizontal centerline of the rotor shaft should be level per Figure #2. This will eliminate a possible side thrust load on the bearings. A thrust load of any magnitude continually applied can cause premature bearing failure.

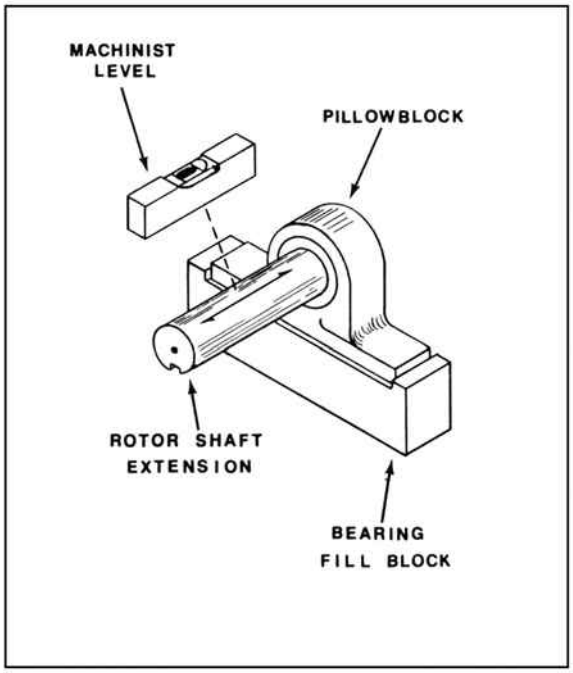


Figure 2, Rotor Shaft Leveling

Small crushers are normally installed as one unit and the rotor will be factory assembled in the crusher and the bearing mounting bolts properly torqued.

With a machinist's level on top of the shaft, level the rotor with shims and then grout between the support plate and the foundation. The crusher housing need not be level when the rotor is level.

After the rotor is level, the crusher housing should be leveled perpendicularly to the shaft. For larger units, the lower housing can be leveled from the bearing fill blocks or directly on the bearing pedestal (see Figure 3). During the leveling operation, alignment with other auxiliary equipment must be maintained. It is suggested that each unit be set, leveled and aligned, but not permanently grouted and anchored until all equipment is in place and final adjustments have been made.

The recommended torque values for various bolts are found in Section F.7.

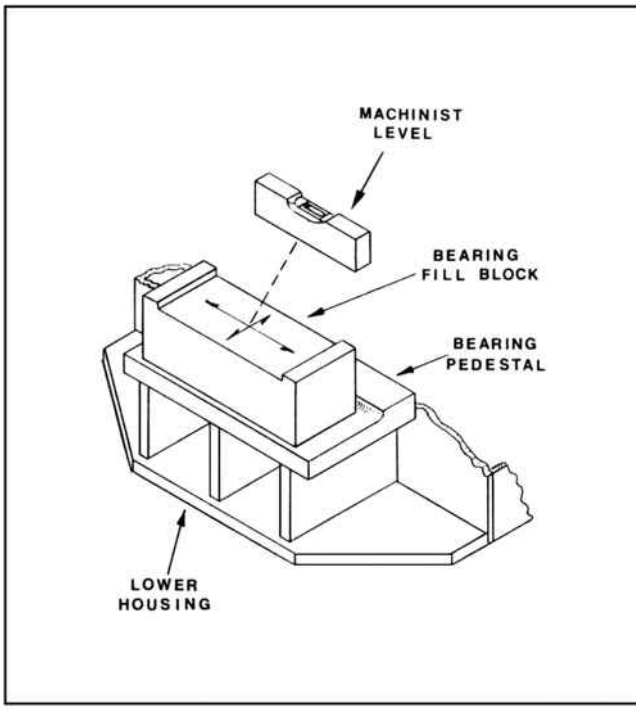


Figure 3, Leveling Lower Housing

C.4. Service Access

To provide access for weekly inspections and maintenance, a service platform should be located at the same level as the crusher mounting pads, conforming to all safety requirements. The service platform should be a minimum of 3'-6" (1.0 m) on the sides. Hammer Pins will need to be removed from at least one end of the unit. Either end can be used, but usual practice is to provide for Hammer Pin removal from the end opposite the motor/drive location. Dimensional information for Hammer Pin removal access is listed on the general assembly drawings.

Pay careful attention to maintenance access requirements shown on the certified drawings will allow necessary clearance to open the various parts for servicing.

Should it not be possible to maintain the recommended minimum clearances, pay close attention to the certified drawings. Some parts of the crusher may be difficult to remove with less than the recommended minimum clearances. Contact TerraSource for specific recommendations in tight installations.

⚠ DANGER

Plant personnel must be kept out of the infeed, outfeed, and maintenance areas of the crusher during operation. Forcible ejection of tramp materials can cause severe injury or death.

If it is necessary to have plant personnel located in the area with the crusher, consideration should be given to providing some form of safety barrier to protect personnel from high-speed tramp material that may be ejected from the machine during operation. Carefully consider the arrangement of equipment, design of the barriers, and all other personnel safety issues if any barriers are to be erected. If it is planned to have the crusher bearings lubricated while the unit is

operating, all safety considerations must be taken to insure the safety of the individual doing the re-lubrication. The addition of remote lubrication fittings located away from the equipment should be considered to improve safety.

Even in the best hammermill layouts, access consideration needs to be given to unplugging or removing bridged infeed material from the infeed chute. This access needs to be restricted, and very specific training provided to personnel who perform these job functions.

A compressed air supply at the crusher maintenance platform to operate pneumatic wrenches and to clean parts of accumulated dust and foreign matter is highly recommended.

C.5. Infeed Requirements

To achieve the maximum wear life from the internal wear parts, the infeed should be as free as possible of all rocks, tramp steel & iron, or any other hard, non-crushable objects. Infeed to the crusher should be uniform as possible, and any surges must be within the design capacity of the model being used. Surges are defined as a temporary material infeed rate up to 150% of the design rate for a period of 5 seconds or shorter. For example, if a crusher is designed for 40 TPH, the maximum surge rate of 60 TPH cannot last longer than 5 seconds before returning 40 TPH or less. If the increased infeed rate lasts longer than 5 seconds, the crusher unit may be undersized, the unit may be overfed, or a larger motor may be required to keep the Rotor Assembly spinning. Infeed material must conform to the specifications that were given on the purchase order. Maximum size pieces should not exceed ten (10) percent of feed, and should be randomly spaced. Surges resulting from large piece size must not exceed (5) five seconds duration or overloading the Crusher can result.

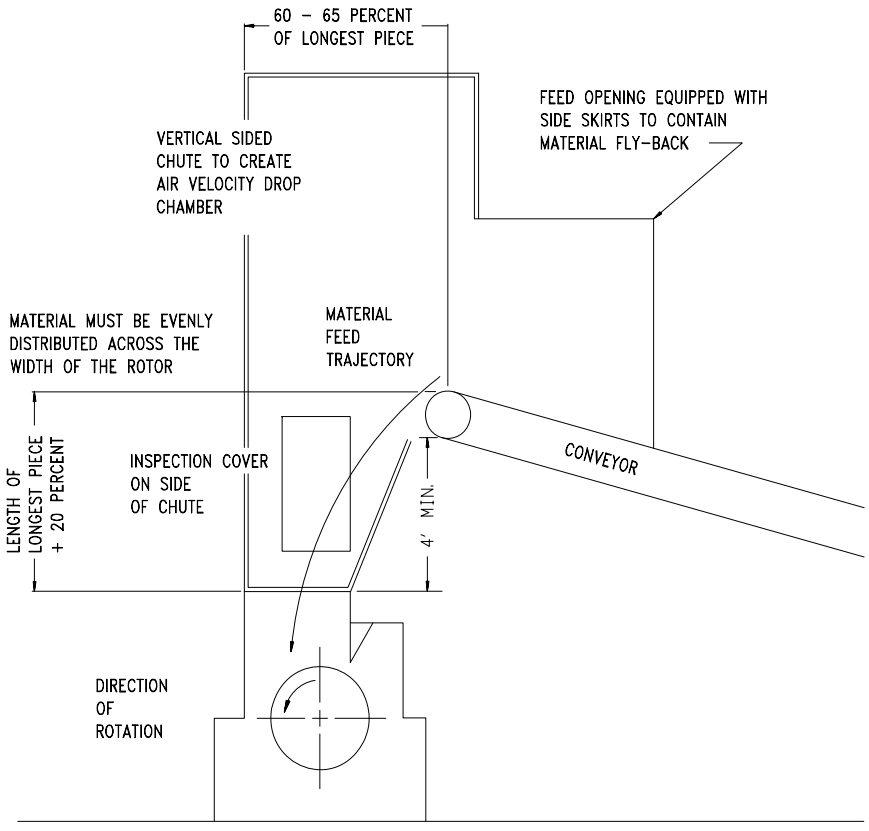


Figure #4- Infeed Recommendations

⚠ WARNING

Do not assume that the crusher can process any size bark, wood or any other material that can pass the infeed opening. See Section E.2 for infeed material guidelines.

NOTICE

The infeed to the crusher must be distributed as evenly as possible across the full width of the rotor to take advantage of the full capacity of the Crusher. If the feed is concentrated in one area, full design rate through the unit cannot be expected, and material reduction may not meet target efficiencies.

Avoid feeding material from the end of the Crusher, or at any angle that that does not allow full and even distribution to the Rotor

Normally the entry of feed material into the crusher should be in the same direction as rotor rotation (perpendicular to the rotor axis). Feeding from either end of the crusher (parallel with the rotor axis) will not allow proper distribution of the material across the width of the rotor. Feeding against, or opposite to, rotor rotation will increase the rejection or flyback of the material by the crushing members. The top most portion of the infeed chute area must be enclosed to prevent material from being ejected with considerable force from the crusher rotor assembly.

As mentioned above, the infeed chute work must not be supported by the crusher, or any of its supports. Access doors for maintenance and clearing jams are always recommended, but need to be properly located and secured to prevent opening during operation. Place access doors on the ends of the chutework as shown in Figure #4.

⚠ WARNING

Never operate a crusher in the wrong rotation direction. Each machine has a specific rotation direction, and rotation labels are located on the housing to indicate the proper rotation direction for operation.

The direction of rotor rotation for a crusher is fixed by design and cannot be changed except for units specifically designed to be reversible. Improper rotation can result in component damage.

C.6. Outfeed Requirements

The outfeed of the crusher will most commonly consist of a typical rubber conveyor belt with standard belt loader, generally arranged perpendicular to the rotor axis of the crusher. The material exits from the bottom of the crusher vertically out one side and near 45 degrees on the other side. If the outfeed device must be run parallel to the rotor axis, have some provisions to supply some form of deflector in the discharge chute to prevent the belt conveyor from being unevenly loaded across its width.

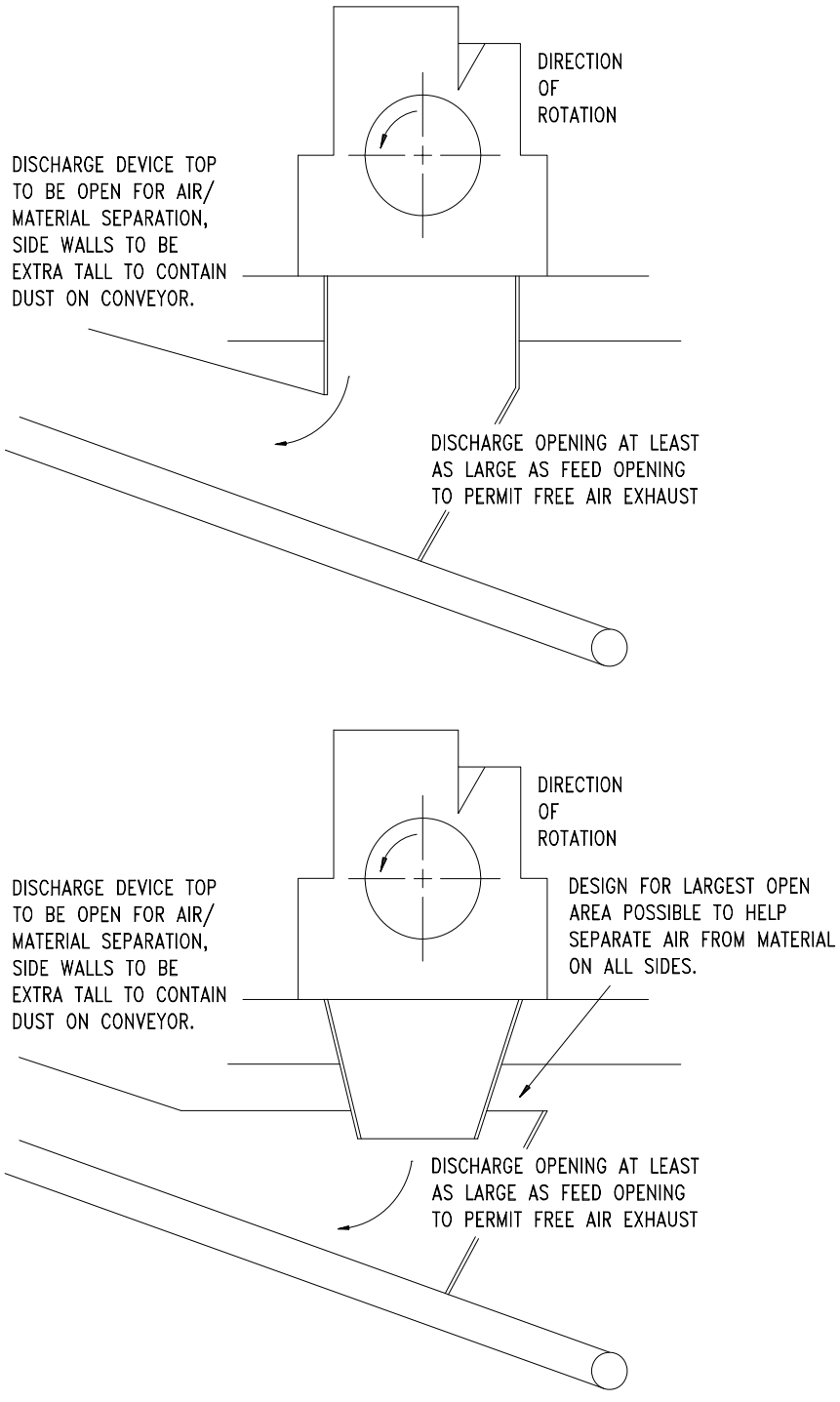


Figure #5- Outfeed Recommendations

NOTICE

Discharge material from the crusher will commonly be of greater volume, or fluffed, after being processed. Make sure that the discharge chutework and conveyors are designed with this extra volume in mind, it is not uncommon for material to be 2 – 3 times more volume at the discharge than the infeed.

The material being processed by a crusher must at all times be removed at a rate at least equal to or greater than the discharge rate of the crusher. If material is allowed to build up in the discharge area, it can cause excessive wear to crushing members and could plug or stall the crusher. Sufficient surge capacity should be allowed in the design of all outfeed chutes should the outfeed equipment be shut down without warning, allowing for at least 1 1/2 to 2 minutes of capacity during crusher time-out. Material must never be allowed to build-up in the discharge hopper, as this can lead to plugging, stalling and high wear of the crusher internal parts.

All crushers have a tendency to move air through the unit as material is fed in and out of the machine, due to the high speed rotation of the Rotor Assembly with hammers attached. The top of the outfeed device must allow for and promote the free discharge of air that is moved through the crusher during operation. An open top and extra tall side skirt boards or walls will help settle out dust in the air that is moved through the crusher with the material (see Figure #5). In general, avoid reducing the cross-sectional area of the discharge opening as it transitions from the crusher discharge flange to the discharge conveyor system, as this only increases the velocity of the airflow in a localized area and can cause dusty conditions.

Access doors for maintenance and clearing jams are always recommended, but need to be properly secured to prevent opening during operation.

C.7. Electrical Requirements

C.7.a. Electric Motors

The certified drawings call out the specific horsepower and input speed for a given crusher model. An amperage display of the crusher motor should be provided on the operators control panel or MCC. Recommended controls for the crusher include simple start and stop buttons, as well as remote jog buttons.

General specifications for the crusher drive motor are as follows:

- TEFC, 1.15 Service Factor
- Class F Insulation System, Class B Temp Rise
- Crusher Duty, 200%-250% Pull-Out Torque 180%-220% Locked Rotor Torque
- NEMA B (in most cases) or NEMA C

C.7.b. Optional Rotation Sensing

As an option, TerraSource can supply the crusher with a rotation sensor, which can be integrated into the customer's control system to warn of a low speed condition on the Rotor Assembly. This signal can then be used to shut down the infeed to the crusher before plugging the crusher infeed chute and unit.

If supplied, the sensor will be located on the end of the Rotor Assembly Shaft opposite the drive. The probe and its mount will be attached and adjusted during final shop

inspection. If supplied, see the Rotation Sensor Appendix for more information on the sensor and installation information.

C.7.c. Oil Lubrication System

Depending on the application and customer's requirements, TerraSource may supply a circulating oil system as part of the bearing supply. This system will have a small oil reservoir, pump, and drive motor, as well as various electrical controls. The purpose of this system is to circulate and cool the lubricating oil to prevent overheating and short bearing life. If an Oil Lubrication System is supplied, see the Oil Lubrication System Appendix for more information on the circulating motor and controls. Typically the Oil Circulation System will be located in a convenient location near the crusher, but below the outlet fitting in the bearing, such that gravity can return the oil to the tank.

C.7.d. Hydraulic Opening Access System

On some models, TerraSource supplies a hydraulic opening assist system to allow easier access into the crusher for inspection and maintenance. The portable HPU uses a 1 Hp, 120 Volt single phase electric motor to pump the hydraulic fluid. The start, stop and directional controls are included directly on the unit. See the Hydraulic Opening Assist Appendix for more information on this system.

C.7.e. Bearing Temperature & Vibration Monitors

As an option, TerraSource can supply temperature & vibration monitors on the Bearing housings, to detect and warn the operators of an excessive heating or vibration conditions in the Bearings, before damage can occur. If supplied, see the Bearing Temperature / Vibration Monitor Appendix for more information on the monitors and installation information

Unless otherwise stated by the Bearing manufacturer, the Bearing temperature should not exceed 180^{O} F. (82^{O} C.) during operation. During cold weather, Bearings should be allowed to warm to 80^{O} F. (27^{O} C.) before feeding material to the Crusher.

C.7.f. Electrical Lock-Out

Standard plant procedure for locking out the crusher must follow the Lockout/Tagout Procedures outlined in Section A.4. The crusher must be locked out during any inspection or service. This also includes any clean-out procedures where the crusher infeed is plugged or bridged over with material. Failure to do so may result in serious or fatal injury. Electrical power for the crusher motor must be disconnected and locked in the "OFF" position before any of the crusher access doors, guards or covers are opened.

In addition, equipment adjacent to the crusher may require Lockout during inspection and maintenance. Determine all equipment in the system that requires Lockout before opening any part of the crusher for inspection or maintenance.

C.7.g. System Interlocking

The crusher should be interlocked as follows. Whenever possible, the crusher should not be stopped with material in the unit. This will require that the unit be Locked-Out/Tagged-Out, and the material removed by hand. Do not try to start a crusher with material in the unit, as it will only cause the jammed material to compress more tightly and increase the difficulty in removing it later, in addition to developing high starting loads, and stress drive components beyond reasonable limits.

1. During the start-up of the crusher, a delay timer must be added to allow the crusher to reach full operating speed (could be up to 15 seconds or even longer) for starting any infeed equipment. If the crusher does not come up to full speed during the start-up process, the outfeed devices and crusher must be shutdown.

2. Interlock the outfeed device motor circuits with the crusher so that the crusher cannot start unless the outfeed device is operating. Should the outfeed device(s) fail, the infeed to the crusher must be immediately stopped, and the crusher allowed to time-out, removing all material from the crusher before shutting down the crusher drive motor. Time-out should be for at least one minute.

3. Interlock the crusher motor circuits with the infeed device so that the infeed cannot start unless the crusher is operating at full speed (use a timer if necessary). Should the infeed device fail, the crusher must be allowed to time-out, removing all material from the unit before shutting down the crusher motor. Time-out should be for at least one minute.

4. If optional Rotation Sensing is used, interlock the rotation sensor into the mill control system so that if the crusher drops below 75% of its normal full speed during operation, the infeed system will immediately shut down. During this sequence, the crusher and its outfeed system should continue to operate.

   If the optional Rotation Sensing system sees the crusher drop below 50% of its normal full speed during operation, the mill control system should immediately shut down the crusher and the infeed system. Allow the outfeed system to continue to operate.

5. If optional Bearing Temperature / Vibration Monitors are used, follow all instructions provided in the Bearing Temperature / Vibration Monitor Appendix. Normally, these systems will be set up to warn the operators of excessive temperatures and/or vibrations without automatically shutting down equipment. In some cases, system with dual setpoints may be used to allow a warning at a lower setting, and shut down at a higher setpoints. If the Bearing Temperature / Vibration Monitors are connected to shut down equipment, interlock so that the equipment is shut down in a normal fashion (infeed first, crusher timed out, then outfeed conveyors). Follow all recommendations of the bearing manufacturer in the establishing of temperature set points.

6. If optional Oil Lubrication Systems are used, follow all instructions provided in the Oil Lubrication Systems Appendix. Interlock the crusher motor circuits with the Oil Lubrication System so that the crusher drive motor cannot start unless the Oil Lubrication System is operating. If the Oil Lubrication System shuts down during operation, the infeed device must be shut down, and the crusher must be allowed to time out, removing all material from the unit before shutting down the crusher drive motor.

C.8. Oil Lubrication System (Optional)

A circulating oil system for the bearings of the crusher may be specified as an option. The advantage to a circulating oil system is that it can also be used to help remove heat from the bearings during operation. Cleanliness cannot be overemphasized during the installation, flushing, operation and maintenance of the oil lubrication system. Flexible connections at the crusher bearings are recommended.

The circulating oil system must be located so that the return line tank connection is a minimum of 24 inches (0.61m) below the bearing outlet, or such that the return lines will have a minimum of 10 degrees continuous slope to the tank, whichever gives the greater drop.

The location of the hydraulic system is not restricted as above, and may be located in any convenient place. Keeping it close to the crusher will eliminate long runs of connecting tubing, which could be damaged. The location for each system should provide protection from dust, dirt and physical damage. Access for inspection and maintenance is desirable.

The foundation load for the system is the total weight of the unit plus the required oil. Dynamic loading need not be considered. However, excessive vibration from adjacent equipment should be dampened or isolated to help prevent a malfunction of the system components, particularly the pressure switch.

All rigid or flexible connecting piping, tubing or hose must be clean and free of rust, scale, grit, dirt, chips, etc. and of the proper physical strength for the pressures involved. (See the Specific Instruction Manual for your model and type of crusher.). Additional information can also be found in the Oil Lubrication System Appendix of this manual.

Just before startup, it is recommended that the oil lubrication system be flushed to remove any contamination. After all interconnecting lines are in place, but before the connection to the bearings or cylinders is made, short-circuit the system by connecting the feed lines to the return lines or connect the two cylinder lines together and operate the system under pressure for a period of several hours. During this period, a hydraulic system with more than one circuit should have the directional control valves cycled a number of times so all lines will be cleaned of loose foreign materials.

After this test run procedure is complete, all filter cartridges should be replaced. If the filter element indicates a large amount of contaminants were present, an oil change may be required. Do not connect the bearings or cylinders to the system until this oil change, if necessary, has been completed.

D. Start-up Check Off Sheet

The following list is provided to assist with the check-out of the Jeffrey Rader Crusher. The crusher must be **Locked Out** before starting this procedure.

_____ 1. Check the alignment of the H.S.S. Coupling or V-Belt drive as supplied. See the Drive Appendix for additional information.

_____ 2. If the Hydraulic Opening Assist option has been provided, see the Hydraulic Opening Assist appendix for all start-up & safety information. The system must be fully checked out & able to operate before continuing the crusher check-out.

_____ 3. Check for any ledges or obstructions that would interfere with the material flow in the infeed and discharge chutework.

_____ 4. Check all mounting bolt fasteners and all other mechanical fasteners used to secure the crusher to the structure. Check sub-base and motor mounting bolts.

_____ 5. Open the unit and check for any foreign material inside the internal portions of the unit.

⚠ WARNING

The Rotor Assembly consists of heavy Hammers. In some installations, Swing Hammers may be used. If Swing Hammers are used, the Swing Hammer can unexpectedly rotate over center, creating pinching, crushing, and unexpected rotation due to changing center-of-gravity conditions.

Use great care while rotating the Rotor Assembly to prevent severe personal injury. Always follow all Lock-out/Tag-out procedures before working in the drum.

_____ 6. Rotate the unit slowly and carefully (using an approved tool to keep hands away from the Hammers on the Rotor Assembly) and listen for any interference between the Rotor Assembly and the Housing. Correct any interference that may be encountered before proceeding.

Make sure all Hammer Pin Retainer bolts are tight to values given in Section F.7. Close all interior access points and secure with fasteners in all available locations, and tighten to values given in Section F.7.

_____ 7. Remove the upper halve of the split pillow block bearings, and check for contamination in all interior portions of the Bearing Housing.

- If grease is used, fill the interior volume of the lower housing 1/3 to 1/2 full. Inject additional grease into the cavities between the bearing rollers. Use the grade of grease recommended in Section F.2.

- If oil is used, insure that the static oil level is to the height recommended by the bearing manufacturer. Use a grade of oil recommended in Section F.2.

Reinstall the upper halve of the Bearing, and torque cap and Bearing base bolts to the values given in Section F.7.

_____ 8. Close any remaining access doors, and re-install all drive covers, coupling guards and belt drive guards that have been removed for checkout.

_____ 9. Check and record the ambient vibration (both velocity and displacement measurements) in all planes at the Crusher bearings before start-up. See Figure 6 for axis orientation.

Ambient	Infeed End Velocity	Infeed End Displacement	Discharge End Velocity	Discharge End Displacement
Vibration 'X' Axis				
Vibration 'Y' Axis				
Vibration 'Z' Axis				
Amb. Temp., Average				

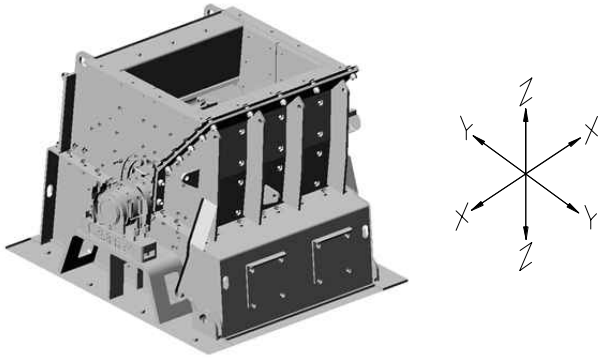


Figure #6 – Orientation Axis

_____ 10. If supplied, check the operation of the Oil Lubrication System motor, pump and piping. The system should have already been cleaned and flushed per Section C.8. Run the unit and check for proper flow and leaks. Flow can be checked by slightly loosening a fitting on the pressurized side of the pump, and checking for a positive fluid flow.

_____ 11. Restore electrical power to the crusher drive motor, and jog for correct rotation. The crusher will be designed to operate in only one specific direction, with rotation arrows on each end of the unit showing the correct rotation direction. The motor does not need to be disconnected for this check.

During this check, listen for any abnormal sounds of interference inside the Housing, and correct if necessary. When using Swing Hammers, it is normal to hear the hammers swing into the rotor shaft at very slow speeds.

_____ 12. Start the crusher and let run for 45 minutes minimum w/o material. Listen for any abnormal sounds indicating misalignment, vibrations, or abnormal temperatures at the bearings. Record vibration amplitudes in all planes at the bearings, see Figure 6 for axis orientation.

@15 min w/o material	Infeed End Velocity	Infeed End Displacement	Discharge End Velocity	Discharge End Displacement
Vibration 'X' Axis				
Vibration 'Y' Axis				
Vibration 'Z' Axis				
Bearing Temp, Top Half				
Bearing Temp, Bottom Half				

@30 min w/o material	Infeed End Velocity	Infeed End Displacement	Discharge End Velocity	Discharge End Displacement
Vibration 'X' Axis				
Vibration 'Y' Axis				
Vibration 'Z' Axis				
Bearing Temp, Top Half				
Bearing Temp, Bottom Half				

@45 min w/o material	Infeed End Velocity	Infeed End Displacement	Discharge End Velocity	Discharge End Displacement
Vibration 'X' Axis				
Vibration 'Y' Axis				
Vibration 'Z' Axis				
Bearing Temp, Top Half				
Bearing Temp, Bottom Half				

_____ 13. Test all related interlocking systems for proper operation to the rest of the system (see Section C.7.).

_____ 14. With the crusher and its related infeed and outfeed systems operating, begin feeding the system with a material at about 1/2 the normal rate. Observe the infeed and discharge of material from the crusher, and monitor consumed amperage to verify proper operation. Slowly increase to full rate, monitoring the operation of the system. Record vibration amplitudes in all planes and bearing temperatures at 30 min, 1 hour, 3 hours, and 6 hours of operation with material. See Figure 6 for axis orientation.

@30 min w/ material	Infeed End Velocity	Infeed End Displacement	Discharge End Velocity	Discharge End Displacement
Vibration 'X' Axis				
Vibration 'Y' Axis				
Vibration 'Z' Axis				
Bearing Temp, Top Half				
Bearing Temp, Bottom Half				

@ 1 Hour w/ material	Infeed End Velocity	Infeed End Displacement	Discharge End Velocity	Discharge End Displacement
Vibration 'X' Axis				
Vibration 'Y' Axis				
Vibration 'Z' Axis				
Bearing Temp, Top Half				
Bearing Temp, Bottom Half				

@3 Hours w/ material	Infeed End Velocity	Infeed End Displacement	Discharge End Velocity	Discharge End Displacement
Vibration 'X' Axis				
Vibration 'Y' Axis				
Vibration 'Z' Axis				
Bearing Temp, Top Half				
Bearing Temp, Bottom Half				

@6 Hours w/ material	Infeed End Velocity	Infeed End Displacement	Discharge End Velocity	Discharge End Displacement
Vibration 'X' Axis				
Vibration 'Y' Axis				
Vibration 'Z' Axis				
Bearing Temp, Top Half				
Bearing Temp, Bottom Half				

	Infeed End Velocity	Infeed End Displacement	Discharge End Velocity	Discharge End Displacement
Vibration 'X' Axis				
Vibration 'Y' Axis				
Vibration 'Z' Axis				
Bearing Temp, Top Half				
Bearing Temp, Bottom Half				

	Infeed End Velocity	Infeed End Displacement	Discharge End Velocity	Discharge End Displacement
Vibration 'X' Axis				
Vibration 'Y' Axis				
Vibration 'Z' Axis				
Bearing Temp, Top Half				
Bearing Temp, Bottom Half				

The Crusher is now ready for operation.

E. Operation

Different types of crushers (see Section B for description) all have basic operating procedures. The variations will be explained in the Specific Instruction manual for your type of crusher. Efficient and economical operation depends on following proper operating procedures. The following paragraphs outline some common procedures.

E.1. Operational Safety

When operating the Jeffrey Rader Crusher, it is extremely important to follow all safety rules and procedures. The Crusher has been ruggedly designed and will handle a substantial amount of abuse. However, this equipment can cause severe personal injury or death if all safety precautions are not observed. The following safety precautions are in addition to those stated in Sections A.2., A.3., & A.4. of this manual. This listing is not intended as a complete listing of all hazards that could be encountered in a Crusher installation, due to different applications and environments that the machinery can be placed. In addition, all applicable federal, state, local and individual plant safety rules and regulations must be considered, or in some cases may alter the following listing:

- **This equipment can cause death or severe personal injury if all safety precautions are not taken. Lockout/Tagout this equipment anytime inspection or maintenance is to be performed. All procedures listed in this section require Lockout before proceeding, unless otherwise noted. This also includes all clean-out procedures where the Crusher and/or it's infeed/discharge is plugged or bridged over with material. In addition, equipment adjacent to the Crusher may require Lockout during Crusher inspection and maintenance. Determine all necessary Lockout requirements before any work is performed.**

- **Plant personnel must be kept out of the infeed, outfeed, and maintenance areas of the Crusher during operation. Forcible ejection of tramp materials can cause severe injury or death.**

- **Never start, jog or operate the Crusher without all guards, covers, and any other safety devices in place. Any additional guards, shrouds or covers that have been installed in the infeed and discharge areas to shield personnel must also be in place during operation.**

- **Before starting the Crusher, the operator must ensure that all personnel are clear of the unit and notified of its potential start-up and operation.**

- **Only personnel with the proper training and authority of their supervisor should be allowed to operate and perform maintenance on the Crusher.**

- **Never modify the rotational speed of the Crusher without first contacting and getting written approval from TerraSource. Personal injury and damage to the Crusher can result.**

- **Do not make any changes, alterations, or modifications to the Crusher without first contacting and getting written approval from TerraSource.**

- **Personnel in the area with the Crusher while in operation must wear all personal protection equipment (hard hats, safety glasses, hearing protection, etc.) specified by the plant.**

- **Do not use the Crusher for any purpose or material other than what is was originally designed and sold to perform, per the TerraSource proposal and customer purchase order. This includes any hazardous material as defined by this manual. Feeding different materials into the unit than what it was specifically designed for can cause overload, excessive wear or other hazardous conditions which can result in personal injury, death, or equipment damage.**

- **Eliminate any tramp materials from the Crusher infeed, as increased wear, equipment damage and personal safety risks increase with high levels of non-crushable materials through the Crusher.**

- **Do not feed material into the Crusher unless it is operating at full speed. Plugging and stalling of the Crusher can result. Except in emergency situations, always stop the infeed and allow the Crusher to time-out with the mills interlocking system**

- **Do not climb on, stand, or otherwise loiter around the Crusher during operation.**

- **Do not make any adjustments to the Crusher while in operation.**

- **Always use an approved tool and procedure to turn the rotor assembly of the Crusher. Never use any body part (hand, arms, foot, etc.) to turn the rotor assembly.**

- **If the Crusher is equipped with swing hammers, expect some imbalance and noise as the swing hammer rotates over-center and swings into its stop limits at very slow speeds.**

- **Never attempt to clear a plugged infeed or outfeed chute or hopper while the Crusher is in operation. Never use any body part (hand, foot, etc.), pole, rod, or any other tool to try to dislodge material in the infeed or outfeed while the Crusher is operating. Never use any explosive or combustible device to dislodge plugged materials.**

- **Never attempt to repeatedly restart a Crusher with material jammed inside the main housing, until the unit is Locked-Out, opened, and all internal parts cleared of the jammed material.**

- **Never expose any body part (hand, arm, face, etc.) to the infeed or outfeed areas of the Crusher during operation. Never inspect or remove material samples from internal areas of the Crusher during operation.**

- **Due to the large mass and inertia of the Crusher internal rotor assembly, a few minutes are required for all rotation to stop. Do not open or remove**

any door, cover, or guard until all rotation has stopped. Do not attempt to stop the Rotor Assembly mass with hands, tools or any other device.

- **The Hydraulic Opening Assist system (if supplied) can contain stored energy in the form of high pressure hydraulic oil during its operation and during certain maintenance sequences. See the Hydraulic Opening Assist appendix for more information.**

Contact TerraSource should there ever be any question on how to operate the Crusher or its related equipment safely.

E.2. Material Pre-conditioning Requirements

The Crusher for any given installation is carefully manufactured and matched to the installation and application. In the selection process for the Crusher, the projected horsepower, performance and infeed rate for the unit is matched to the infeed material, infeed material size and desired discharge material size for the customer's end use. For this reason, should any of the infeed or discharge requirements change, contact TerraSource. In most cases, it is possible to alter the configuration of the Crusher to meet the new requirements.

⚠ WARNING

Do not feed materials into the Crusher other than those specifically designated in the purchase order to TerraSource. This includes any hazardous material as defined by this manual. Feeding different materials into the unit than what it was specifically designed for can cause overload, excessive wear or other hazardous conditions which can result in personal injury, death, or equipment damage.

The life of wear parts in the Crusher is directly affected by the infeed material and other environmental conditions. Infeed material is usually stated as an average with a maximum size not to be exceeded. The Crusher is designed to handle materials at the average size at the specified rates.

If a high volume of the maximum size material is expected to be fed through the Crusher, the infeed rate must be correspondingly reduced to avoid plugging the unit. In other words, maximum size material can only be fed on a limited, occasional basis to the Crusher, and whenever this occurs the infeed rate must be reduced to avoid plugging.

Material is considered oversize if it is above either the average or maximum sizes. It is important to remember that the Crusher is not designed to be able to process everything and anything that can fit through the infeed flange.

⚠ WARNING

Eliminate any tramp materials from the Crusher infeed, as increased wear, equipment damage and personal safety risks increase with high levels of non-crushable materials through the Crusher.

Tramp material is defined as any material that was not originally intended as the primary infeed material, and is generally considered to be non-crushable in nature, such as metal or rocks. If tramp materials are run through the Crusher on a regular basis, it must be understood that increase wear life and possible equipment damage will almost certainly occur.

The infeed rate of the Crusher should not exceed the design capacity and limits for the model size as stated in the purchase order and the unit provided. Infeed to the Crusher should be uniform as possible, and any surges must be within the design capacity of the model being used. Surges are defined as a temporary material infeed rate up to 150% of the design rate for a period of 5 seconds or shorter. For example, if a Crusher is designed for 40 TPH, the maximum surge rate of 60 TPH cannot last longer than 5 seconds before returning 40 TPH or less. If the increased infeed rate lasts longer than 5 seconds, the Crusher unit may be undersized, or a larger motor may be required to keep the internal rotor spinning. Maximum size pieces should not exceed ten (10) percent of feed, and should be randomly spaced. Surges resulting from large piece size must not exceed (5) five seconds duration or overloading the Crusher can result.
Many of the internal components of the Crusher are sized and arranged specifically for a given process requirement. Crusher infeed must be as consistent as possible, wide swings in feed rate can cause excessive power consumption, potential for stalling and plugging, and inconsistent outfeed material classification. The infeed rate should never exceed the ability of the discharge equipment to remove the outfeed material.

⚠ CAUTION

Operating the Crusher with an infeed surge rate greater than the outfeed system can handle will eventually stall and jam the unit. Take all precautions to prevent stalls and plugging of the Crusher, to prevent excessive downtime and increased manpower

⚠ WARNING

Do not use the Crusher for any purpose or material other than what it was originally designed and sold to perform.

The Jeffrey Rader Crusher is not normally designed or manufactured to operate handling hazardous materials or in a hazardous environment. Hazardous materials are those classified as explosive, flammable, toxic, or otherwise dangerous to personnel if not completely contained inside the equipment during operation. If the Crusher is to be operated in any of the above environments, or handle any form of hazardous material, contact TerraSource for a complete review of the application.

E.3. Basic Crusher Operation

⚠ WARNING

Only personnel with the proper training and authority of their supervisor should be allowed to operate and perform maintenance on the Crusher.

Assuming adequate controls, as outlined previously, controlling the Crusher under operation is a simple matter. The infeed volume to the unit is the major concern, as the Crusher has very limited surge capacity, and once the infeed rate is exceeded, a corresponding decrease in infeed rate is required to allow the Crusher to recover. The limited surge capacity in most cases will show up as an over-amp condition at the motor. Therefore, the production rate to the Crusher should be paid attention to, as well as the amp draw of the motor. A surging infeed is not desirable, as it will cause extra stress on the drive, varying outfeed material classification and a stronger possibility of a plugging than with a metered infeed.

A concentration of the feed in one area of the rotor will result in a reduction of the effective capacity and will produce high localized wear. An evenly distributed and continuous feed rate, across the rotor width, is the most efficient and economical method of operation. Erratic feeding (from no load to a near overload) can only result in power demand peaks and an unpredictable capacity rate. Erratic feeding, if extreme, can also plug and stall the crusher. Also bridging could occur. On most crushers, stalling will require downtime to remove the feed material from the crushing chamber and could cause damage to rotor parts, motor bearings and other equipment.

⚠ CAUTION

Never operate a crusher in the wrong direction, the unit can be seriously damaged. Each machine has rotation labels to indicate proper rotor direction. If rotation direction is not clear, contact TerraSource at one of the locations in Section A.1 for clarification.

Normally the entry of feed material into the crusher should be in the same direction as rotor rotation. Feeding against, or opposite to, rotor rotation will increase the rejection or flyback of the material by the crushing members. Feeding from either end of the crusher will not allow proper distribution of the material across the width of the rotor.

The direction of rotor rotation for a crusher is fixed by design and cannot be changed except for units specifically designed to be reversible. Improper rotation can result in component damage.

⚠ WARNING

Never modify the rotational speed of the Crusher without first contacting and getting written approval from TerraSource. Personal injury and damage to the Crusher can result, and void all warranties.

Rotational speed of the Rotor Assembly with Hammers can drastically affect the operating characteristics of the Crusher. In most cases, changes in rotational speed are predictable, but both advantages and disadvantages will be apparent in any change.

In general, increasing Rotor Assembly speed has the following effects:

- Can make a finer outfeed material size
- Can change the capacity of the Crusher
- Can increase the wear rate of the internal wear parts
- Can make the Bearing lubrication system inadequate
- Can decrease torque at main Rotor Shaft for the same horsepower
- Can decrease Bearing life
- Can increase vibration

Decreasing the Rotor Assembly speed can have the following effects:

- Can make a larger outfeed material size
- Can decrease the wear rate of various parts
- Can change the capacity of the Crusher
- Can reduce the impact force of the Hammers
- Can increase torque at main Rotor Shaft for the same horsepower
- Can increase Bearing life

Speed is a critical function in the operation of crushing equipment. As indicated, a variation or change in speed alone will produce some very predictable results. However, if some other modification to the crusher is made at the same time as the speed change, the expected result could be altered in either direction or could be completely nullified. If speed, or any other change that could affect the operation of your crusher is contemplated, your TerraSource Representative is available for advice and consultation.

⚠ CAUTION

Every Crusher has a maximum speed above which it cannot be safely operated. Refer to the specific Instruction Manual for your maximum speed.

⚠ WARNING

Do not climb on, stand, or otherwise loiter around the Crusher during operation.

Do not make any adjustments to the Crusher while in operation.

Do not make any changes, alterations, or modifications to the Crusher without first contacting and getting written approval from TerraSource Corporation.

Never expose any body part (hand, arm, face, etc.) to the infeed or outfeed areas of the Crusher during operation. Never inspect or remove samples from the internal areas of the Crusher during operation.

Installations where tramp materials cannot be avoided should always routinely inspect the Crusher installation for internal rotor damage, which may first be indicated by vibration. In cases

where the vibration is monitored on a regular basis, having a severe vibration occur suddenly is reason to shut-down the Crusher, **Lock-Out / Tag-Out**, and open the unit up for inspection. Never operate a severely vibrating Crusher without understanding that there is an increased chance of injury and equipment damage, as well as structural and foundation damage.

⚠ WARNING

If a Crusher begins to vibrate suddenly and/or excessively during operation, the unit must be immediately shutdown and inspected. It is possible that a single hammer has been damaged, throwing off the balance of the total assembly. Excessive vibration can cause equipment damage and subsequent personal injury.

During operation of the Crushers with Swing Hammers, there can be occasions where the Hammer will 'freeze' or lock in a position where the Hammer is not in its most fully extended position. When this happens, an increase in vibration will be felt on the Crusher, and possibly in the supporting structure itself. In severe cases, this vibration will require that the unit be shut-down, **Lock-Out / Tag-Out**, and the hammer freed manually. Mild cases of vibration can sometimes be corrected while the unit is in operation by directing a running water hose into the Crusher infeed chutework. The extra water can sometimes help work loose a hammer that is locked by a piece of bark or wood. If the water doesn't immediately free the locked hammer, shut-off the infeed device to the Crusher, and while the water continues into the infeed chute, shut-down and restart the unit several times to try to free the hammer. If this is not successful after several attempts, it will be required to shut-down the Crusher, **Lock-Out / Tag-Out**, open the unit, and manually remove all debris and free the hammer(s) that are frozen. In some installations, the locking of hammers may occur more frequently than at other locations, often due to the material being handled or other environmental conditions, and in these installations additional downtime may need to be scheduled to help reduce frozen hammer vibration issues.

The above issue is somewhat different than cases where the Swing Hammers freeze or lock in the most fully extended position. In this case, the crusher will continue to operate just as before, with no perceptible change in vibration or operation. This is completely acceptable for operation. In many cases, the unit will operate in this fashion for a lengthy time, and only when the unit is shut-down for hammer maintenance will it be found that the Hammers are frozen in the fully extended position. Frozen or locked hammers are only a concern when the hammer is not fully extended.

During cold weather, the Bearings should be allowed to warm to 80^{O} F. (27^{O} C.) before feeding material to the Crusher.

E.4. Starting and Stopping the Crusher

⚠ DANGER

Plant personnel must be kept out of the infeed, outfeed, and maintenance areas of the Crusher during operation. Forcible ejection of tramp materials can cause severe injury or death.

⚠ WARNING

Never start, jog or operate the Crusher without all guards, covers, and any other safety devices in place. Any guards, shrouds or covers that have been installed in the infeed and discharge areas to shield personnel must be in place during operation.

Due to the large mass and inertia of the Crusher internal rotor assembly, a few minutes are required for all rotation to stop. Do not open or remove any door, cover, or guard until all rotation has stopped. Do not attempt to stop this mass with hands, tools or any other device.

Before starting the Crusher, the operator must ensure that all personnel are clear of the unit and notified of its potential operation.

Personnel in the area with the Crusher while in operation must wear all personal protection equipment (hard hats, safety glasses, hearing protection, etc.) specified by the plant.

⚠ WARNING

Do not feed material into the Crusher unless it is operating at full speed. Plugging and stalling of the Crusher can result. Except in emergency situations, always stop the infeed and allow the Crusher to time-out with the mills interlocking system.

Never attempt to operate the Crusher in the wrong direction of rotation for the Hammers being used. Do not attempt to reverse the direction of the motor during start-up or jogging without the motor being completely at rest.

During startup of the crusher, the discharge device(s) must be started first and their operation verified before starting the crusher. The crusher can then be started, give at least one or two minutes for the unit to come up to speed before starting the infeed conveyor(s). In cold weather,

it is a good idea to let the crusher run empty for 15-30 minutes to warm the bearings and the lubricating oil or grease. If possible, start the infeed rate at approx. half the maximum capacity of the unit to verify proper operation for a short time before increasing to the normal capacity and operation.

During the shut-down of the crusher, the infeed device(s) should run empty for at least 2 minutes before shut-down, this gives the crusher sufficient time for all material to be processed and emptied out of the crusher. This is important to reduce the chance of plugging of the crusher discharge plates or grates, because if a plug occurs the crusher must be LockedOut/TaggedOut, the unit opened and material cleaned out manually. Once the infeed device(s) have been be cleared of all the material, the crusher should be shut-down. Leave the discharge conveyor operating until the crusher rotor comes to a complete stop.

E.5. Jammed and Stalled Conditions

⚠ WARNING

Jeffrey Rader Crushers cannot be restarted after being stalled until the material is removed. This is a time consuming, manual operation. Take all possible precautions to avoid jamming or stalling the Crusher.

The feed rate for any unit (open or restricted discharge), should never exceed the capacity of the takeaway equipment to remove the output of the crusher. A crusher operating continuously with a feed rate greater than the discharge capacity and/or the ability of the takeaway to remove the surge load will eventually stall the crusher.

Even in the best layouts, it is possible to jam or stall the Crusher. This may be due to an overload, the entry of tramp, surging infeed, or any number of other reasons.

It is always recommended to do everything possible to avoid jamming or stalling the Crusher system. Downtime can be excessive if the unit is stalled on a frequent basis, requiring substantial manpower and time to remove the plugging. Investigate the reason for the jammed condition, and do everything possible to eliminate conditions that contribute to jams and stalls in your specific installation. Should an overload or stall condition be encountered, it is extremely important to follow the instructions below.

⚠ DANGER

This equipment can cause death or severe personal injury if all safety precautions are not taken. Lockout/Tagout this equipment anytime inspection or maintenance is to be performed. This includes all clean-out procedures where the Crusher and/or the infeed/discharge is plugged or bridged over with material.

In addition, equipment adjacent to the Crusher may require Lockout during Crusher inspection and maintenance. Determine all necessary Lockout requirements before any work is performed.

Jams and stalls can take three basic forms.

- Plugged Infeed: Infeed to the Crusher is plugged, where material is bridged in the infeed in such a way that the Crusher continues to operate at full speed, but material does not pass through the unit. The discharge device is operating properly. See Section E.5.a. for instructions to remove the jammed material.

- Plugged Crusher: The Crusher is plugged internally where the motor cannot turn the Rotor Assembly. At this point, the infeed chute and any chutework above will most likely also be filled or plugged with material. The discharge device is operating properly. See Section E.5.b. for instructions to remove the jammed material.

- Plugged Discharge: The discharge of the Crusher has plugged. In this case, the discharge device may have failed, or material may have built-up in the discharge chutework. In this condition, most likely the Crusher and its infeed will have been filled and plugged. See Section E.5.b. for instructions to remove jammed material.

E.5.a. Plugged Infeed

Material that is plugged only in the infeed area tends to be easier to remove than material that jams in the Crusher or its discharge opening,

⚠ WARNING

Never attempt to clear a plugged infeed while the Crusher is operating. Always Lockout the motor electrical circuits during any cleanout operation.

Never use any body part (hand, foot, arm, leg, etc.), pole, rod, or any other tool to attempt to dislodge material in the infeed or outfeed while the Crusher is in operation.

Never use any explosive or combustible device to dislodge plugged materials.

⚠ WARNING

Always Lockout/Tagout the Crusher drive and any necessary adjacent equipment before attempting to remove plugged materials.

Due to the large mass and inertia of the Crusher internal rotor assembly, a few minutes are required for all rotation to stop. Do not open or remove any door, cover, or guard until all rotation has stopped. Do not attempt to stop this mass with hands, tools or any other device.

1. With the Crusher drive Locked Out, remove the bolts securing the Access Door in the Crusher Infeed Chute. Use care when removing the final bolts, as the door may open with some force if it is packed full of infeed material.

2. With the infeed Access Door open, using an approved tool (pole, rod, etc), remove as much of the infeed material as possible from the chutework area.

3. Try to extract the material from the Infeed Chute without getting material down into the Hammer circle of the Crusher. If material does not get into the Crusher Hammer circle, attempt to slowly spin the Rotor Assembly using an approved tool.

⚠ WARNING

Always use an approved tool and procedure to turn the Rotor Assembly of the Crusher. Never use any body part (hand, arms, foot, etc.) to turn the Rotor Assembly.

Do not attempt to turn the Rotor Assembly by using a pipe wrench or similar tool on the Rotor Shaft.

If the Crusher is equipped with Swing Hammers, expect some imbalance and noise as the Swing Hammer rotates over-center and swings into its stop limits.

If the Rotor Assembly can be turned at least 2-3 revolutions, the Crusher is sufficiently clean for operation.

4. Reinstall the Access Door with properly sized fasteners to the specifications given in Section F.7. of this manual. Install any other guards, covers, or access doors that may have been opened during the removal of the jammed material.

Remove the Crusher LockOut. The Crusher is ready for operation.

E.5.b. Plugged Crusher (& Discharge)

Material that is plugged inside the Crusher can be difficult to remove, as the material will be twisted and compressed inside the housing. In this condition, it is not possible to restart the drive to "clear" the unit, it must be cleaned internally before returning to operation.

⚠ WARNING

Never attempt to repeatedly restart a Crusher with material jammed inside the Housing, until all the jammed material has been safely removed from all internal components.

Never use any explosive or combustible devices to dislodge plugged materials.

⚠ WARNING

Always Lockout/Tagout the Crusher drive and any necessary adjacent equipment before attempting to remove plugged materials.

1. With the Crusher drive Locked Out, remove the bolts securing the Access Door in the Crusher upper chutework. Use care when removing the final bolts, as the Access Door may open with some force if it is packed full of infeed material.

2. With the Access Door open, using an approved tool (pole, rod, etc), remove as much of the infeed material as possible from the chutework area.

3. If the discharge opening is plugged, remove the bolts from the access door in the discharge chutework below the Crusher. Use care when removing the final bolts, as the door may open with some force if it is packed full of material. Remove all material from the discharge chutework of the Crusher following all necessary safety considerations and using the approved site procedure for clearing the discharge chutework.

4. Using a pry bar or pole, begin removing material from around the Rotor Assembly, If necessary, turn the Rotor Assembly using an approved tool to free material that is compressed between the Hammers and the Discharge Grates.

⚠ WARNING

Always use an approved tool and procedure to turn the Rotor Assembly of the Crusher. Never use any body part (hand, arms, foot, etc.) to turn the Rotor Assembly.

Do not attempt to turn the Rotor Assembly by using a pipe wrench or similar tool on the Rotor Shaft.

If the Crusher is equipped with Swing Hammers, expect some imbalance and noise as the Swing Hammer rotates over-center and swings into its stop limits.

Pay special attention to the areas around the Discharge Grates. If the Rotor Assembly can be turned at least 2-3 revolutions, the Crusher is sufficiently clean for operation.

5. Reinstall the Access Door(s) and discharge access door with properly sized fasteners to the specifications given in Section F.7 of this manual. Install any other guards, covers, or access doors that may have been opened during the removal of the jammed material.

Remove Crusher LockOut. The Crusher is ready for operation.

E.6. Wear Parts in the Crusher

As the Crusher operates, the internal parts will wear at a rate determined by the amount of material going through the unit, moisture content, amount of sand, grit and dirt in the material, and speed of the rotor & hammers. As the Crusher internal parts become worn, the required HP to process the same rate of material will begin to increase, while the material in the discharge will remain nearly constant in size (unless a failure of the Discharge Grate occurs, in which case the discharge material will very quickly increase in size). At some point, the internal wear components will require replacement, renewable liners are furnished at all locations that can wear. These liners should be replaced if worn to the extent that they no longer protect the main parts and frame of the crusher. In most crushers, there is no adjustment for wear to maintain operating clearances. If the crusher has a hinged breaker plate, this part can allow for some adjustment of clearances for wear by moving the breaker plate closer to the hammers.

During the first six months of Crusher operation, monitor the amp draw of the motor. After several cycles of replacing Hammers, Discharge Grates, and other internal wear surfaces, a pattern will develop which will guide each installation to a maintenance frequency for each item, which can then be planned and performed on a regularly scheduled basis to avoid unnecessary downtime.

The main wear parts of the Crusher include the Hammers, Discharge Grates, Breaker Plates and various Wear Liners inside the infeed and discharge openings. Maintaining and replacing these wear parts is very important to providing consistent material sizing and long-term performance efficiency of the crusher, as well as preventing damage to the crusher frame.

E.7. Material Sizing in the Crusher

The parameters that affect the sizing of the discharge material are:

- Speed of the Rotor
- Hole or slot spacing in the discharge screen or grate
- Type and quantity of hammers

Contact TerraSource if a change in the discharge material size is required, in many cases the existing equipment can be modified to give the desired output. All internal wear parts mentioned in Section E.6. must be good shape for proper material sizing, proper sizing cannot be expected out of worn parts.

F. Maintenance

Maintenance is the most important aspect of the efficient and profitable operation of any industrial machine. Jeffrey Rader crushers are no exception, due to the nature of material reduction equipment, internal parts are constantly wearing at varying rates due to impact and abrasion. Variations in material, particle size, capacity, feed and discharge systems will require adjustment of the suggested maintenance schedule to suit your application. Also, the crusher environment will determine the frequency of performance of some maintenance items. Conditions such as rapid or extreme changes in temperature, excessive dust and dirt, high concentrations of corrosive fumes or vapors will necessitate more frequent maintenance.

The Jeffrey Rader Crusher has been designed to be easily serviced. The equipment is designed for fast access to all serviceable components to reduce downtime to a minimum. The useful life of any piece of equipment can be extended by consistent and sound maintenance practices.

⚠ DANGER

This equipment can cause death or severe personal injury if all safety precautions are not taken. LockOut/TagOut this equipment anytime inspection or maintenance is to be performed. This includes all clean-out procedures where the Crusher and/or it's infeed/discharge is plugged or bridged over with material.

In addition, equipment adjacent to the Crusher may require Lockout during Crusher inspection and maintenance. Determine all necessary Lockout requirements before any work is performed.

⚠ DANGER

All procedures listed in this section require LockOut/TagOut before proceeding, unless otherwise noted.

Additional safety precautions that should be taken when working on the Crusher are as follows:

- **Never start, jog or operate the Crusher without all guards, covers, and any other safety devices in place. After all inspection and maintenance is complete, always re-install all guards, covers and shields that were removed.**
- **Only personnel with the proper training and authority of their supervisor should be allowed to perform maintenance on the Crusher. Do not allow un-trained personnel to distract authorized personnel while working on the Crusher.**
- **Always inform the Crusher operator before beginning any inspection or maintenance sequence.**
- **Never work on the Crusher alone. Always work with at least two persons, in the case of an accident, the additional worker(s) can summon assistance.**

- **Never modify the rotational speed of the Crusher without first contacting and getting written approval from TerraSource. Personal injury and damage to the Crusher can result.**

- **Do not make any adjustments to the Crusher while in operation.**

- **Do not make any changes, alterations, or modifications to the Crusher without first contacting & getting written approval from TerraSource.**

- **Personnel working on the Crusher must wear all personal protection equipment (hard hats, safety glasses, hearing protection, etc.) specified by the plant.**

- **Provide adequate ventilation and/or proper personal protective devices whenever any welding, cutting, grinding, etc is performed on the Crusher.**

- **Never attempt to clear a plugged infeed or outfeed chute or hopper while the Crusher is in operation. Never use any body part (hand, foot, etc.), pole, rod, or any other tool to try to dislodge material in the infeed or outfeed while the Crusher is operating. Never use any explosive or combustible device to dislodge plugged materials.**

- **Due to the large mass and inertia of the Crusher internal Rotor Assembly, a few minutes are required for all rotation to stop. Do not open or remove any door, cover, or guard until all rotation has stopped. Do not attempt to stop the Rotor Assembly mass with hands, tools or any other device.**

- **After Lockout, during certain maintenance sequences the Rotor Assembly may become imbalanced. Always mechanically lock the Rotor Assembly using the supplied locking device to prevent its unexpected rotation during maintenance. Make sure that personnel are clear of the Rotor Assembly before removing or releasing the locking device.**

- **Always use an approved tool and procedure to turn the Rotor Assembly of the Crusher. Never use any body part (hand, arms, foot, etc.) to turn the Rotor Assembly. Do not attempt to turn the Rotor Assembly by using a pipe wrench or similar tool on the Rotor Shaft.**

- **If the Crusher is equipped with Swing Hammers, expect some imbalance and noise as the Hammers rotate over-center and swing into their stop limits.**

- **Never install V-Belts on the Crusher sheaves by turning the Rotor Assembly. Imbalances within the Rotor Assembly can un-expectantly move the sheave & V-Belts, causing pinching and severe injury.**

- **The Hydraulic Opening Assist system (if supplied) can contain stored energy in the form of high pressure hydraulic oil during its operation and during certain maintenance sequences. See the Hydraulic Opening Assist Appendix for more information.**

F.1. Preventative Maintenance Schedules

The maintenance schedule proposed in this manual is for average conditions and moderate duty i.e., plants operating one shift per eight (8) hour day, 40 hours per week. For installations operating more or less than 40 hours per week, this suggested schedule should be adjusted accordingly.

We recommend that the maintenance schedule be written and posted in an appropriate location for operations and maintenance personnel. Completed and signed maintenance reports will form a valuable record for ordering replacement parts and scheduling repairs. The schedule below can be used or a similar form created to maintain a written log of inspections of the Crusher.

MAINTENANCE LOG

Crusher Ser. # _____ Particle Size Target _____ Inspected By _____
Orig. Order # _____ Hammer Size _____ Date _____
Equipment # _____ Screen Opening _____
Material _____ Lube System _____
Tonnage _____

	Inspection Item or System	Insp. Interval						Condition						Action Taken and Notes	
		Daily	Weekly	Monthly	13 Wk.	26 Wk.		OK	Adjust	Repair	Replace	Lube	Clean	Corrective Actions & Special Notes	Date
SAFETY	LockOut/TagOut	✓													
	PPE in Use	✓													
	Area Clean	✓													
	Other Safety Issues	✓													
CRUSHER	Bolts & Clamps	✗		✓											
	Rotor	✓													
	Rotor Balance					✓									
	Hammers	✓													
	Hammer Pins				✓										
	Liners	✓													
	Screen Grates	✓													
	Brg Mtg Bolts	✓													
	Bearing Housing	✓													
	Bearings				✓										
	Bearing Seals				✓										
	Lube System	✓													
	Filters		○	✓											
	Hydraulics	✓													
	Safety Devices				✓										
DRIVE	Control Wiring					✓									
	Motor Elect. Conn.					✓									
	Motor Mounting					✓									
	Motor Bearings					✓									
	Flexible Couplings					✓									
	V–Belts		✓												
	Sheaves		✓												
	Reducer			✓											
	Guards	✓													
MISC	Feed System	✓													
	Discharge System	✓													
	Other Equip.	✓													

✗ Only for the first 40 hours after startup
○ Only for the first 160 hours after startup

The Crusher should be checked over on a regular schedule shown below to maximize operator safety and the systems usable life. Always inspect the Crusher carefully for damage, signs of improper operation or malfunction, and listen for odd noises that may signal the need for a more thorough investigation.

In a normal application, contamination of the Bearing lubricant will usually occur from entry of dirt, grit, and other foreign particles from the outside environment. The area that the Crusher is located will help to determine the Bearing lubrication method and type that will be used, as well as the intervals between grease or oil changes. Intervals between grease or oil changes given in this section are typically based on issues with contamination, as opposed to the working life of the lubricant.

The schedule given below is based primarily on hammermill type crushers, but applies generally to all types. Specific instructions for your crusher are in the Specific Instruction manual. The items given may not be inclusive. Any items not covered should be added to the list and become a part of the maintenance routine. Remember, maintenance is a continuous process of planned inspection, repair and replacement of parts. Such a program will insure long life and a minimum of lost production due to equipment breakdown.

F.1.a. First Month Operation Maintenance Schedule

Lockout before any inspection or adjustment

During the first hours of Crusher operation, careful attention must be paid to bearing operating temperatures. Chart actual bearing temperatures and ambient temperature - vs- time until a predictable history is seen.

Daily Inspection-

- Insure Hammers (on Hammermill Crushers) are free on their Pins.
- Note wear on Hammers and rebuild or replace if necessary
- Replace Hammers with cracks or ends broken immediately
- Visually inspect all Liners for wear, replace if necessary
- Retorque all bolts (Bearing hold down, Bearing split cap bolts, Housing split line and foundation bolts, Wear Liner bolts, etc. per Section F.7. Replace any broken bolts.
- Inspect welds on Rotor, Screen Grates, etc. for cracks, repair immediately
- Clean dirt from around Bearing seals
- Check and refill oil level on static oil bearing lubrication systems.
- Check for leaks on circulating oil bearing lubrication systems. Check oil levels on reservoir & refill as necessary. Check heat exchanger for proper operation.
- Check all guards and covers are in place, and function properly.
- Check auxiliary equipment for proper operation, repair as required.
- During operation, check for unusual vibration, noise, and high Bearing temp.

Weekly (40-60 Hours) Inspection-

- Check high wear points to determine if resurfacing is needed. Wear should not proceed beyond the point where the rebuilding cost is excessive or where the part is permanently damaged and must be replaced.
- Change all filters on optional oil lubrication circulation systems and optional hydraulic opening systems.
- Add a small amount of grease to grease lubricated bearings (see Section F.3.)
- Check grease, oil, and hydraulic lines for damage, repair if necessary.
- Check drive components for alignment, belt tension, wear, or other damage, readjust and repair if necessary.

During operation, check material flow through crusher, note abnormal conditions (uneven feed, surging, material build-up, etc. Correct if possible.
Readjust & repair any auxiliary items noted from Daily inspections.

F.1.b. Normal Operation Maintenance Schedule:

Lockout before any inspection or adjustment

Daily Inspection-

Insure Hammers (on Hammermill Crushers) are free on their Pins.
Note wear on Hammers and rebuild or replace if necessary
Replace Hammers with cracks or ends broken immediately
Visually inspect all Liners for wear, replace if necessary
Inspect welds on Rotor, Screen Grates, etc. for cracks, repair immediately
Clean dirt from around Bearing seals
Check and refill oil level on static oil bearing lubrication systems.
Check for leaks on circulating oil bearing lubrication systems. Check oil levels on reservoir and refill as necessary. Check heat exchanger for proper operation.
Check all guards and covers are in place, and function properly.
Check auxiliary equipment for proper operation, repair as required.
During operation, check for unusual vibration or noise, Bearing temperature

Weekly (40-60 Hours) Inspection-

Check high wear points to determine if resurfacing is needed. Wear should not proceed beyond the point where the rebuilding cost is excessive or where the part is permanently damaged and must be replaced.
Add a small amount of grease to grease lubricated bearings (see Section F.3.)
Check grease, oil, and hydraulic lines for damage, repair if necessary.
Check drive components for alignment, belt tension, wear, or other damage, readjust and repair if necessary.
Readjust & repair any auxiliary items noted from Daily inspections.

Monthly (160-240 Hours) Inspection-

Retorque all bolts (Bearing hold down, Bearing split cap bolts, Housing split line and foundation bolts, Wear Liner bolts, etc. per Section F.7. Replace any broken bolts.
Change all filters on optional oil lubrication circulation systems and optional hydraulic opening systems.
On static oil bearing lubrication systems, drain oil, flush dirt and/or sludge, and refill with oil.
On circulating oil bearing lubrications systems, check oil gage ports & air relief valves for proper operation.
Perform welding and hard surfacing to rebuild hammers or impellers to original shape.
Investigate and correct any unusual conditions not on Daily or Weekly reports.

3- Month (520-880 Hours) Inspection-

Inspect and clean all equipment and repair/replace all worn/damaged parts.
Open bearing housings and thoroughly clean interior of bearings. Check for signs of wear, replace if excessive wear or damage is found. Check seals for damage or wear, replace if needed. Refill with lubricant and reassemble the bearing housing.

On Hammermill type Crushers, if hammers have not been replaced, remove one row of hammers and inspect pin hole in hammer for wear or cracks, replace hammers if excessive wear or cracks are found. Check hammer pin for wear, replace if needed.

Inspect drive system V-Belts (if used) for wear, cracks, fraying, opening at seams, uneven stretch, and belt alignment. Replace all belts if any wear/damage is found.

Inspect drive system coupling (if used), regrease and check fastener torque.

Check all guards and covers are in place, and function properly.

During operation, check for material build-up, surging infeed, unusual operation.

6- Month (1040-1560 Hours) Inspection-

On Hammermill Crushers, remove all hammers and hammer pins and check rotor balance. Replace worn hammers and pins if necessary.

On direct drive Crushers, disassemble the coupling, remove grease and thoroughly clean, replace worn parts. Reassemble and lubricate per coupling manufacturer's recommendations.

Clean dust from control enclosures, check for loose connections and damaged insulation.

Check motor manufacturer's instructions for possible relubrication of motor bearings, following recommendations for type and amount of lubricant. Do not over-grease, this is a major cause of motor failure.

Check speed switch for proper operation and interlocking (if used).

Check Crusher electrical interlocking with the rest of the system.

F.2. Lubrication Information

The lubricating medium is the lifeblood for equipment with rotating parts. A lubricant of improper type or quantity can damage bearings and rotating members.

Jeffrey Rader lubricant specifications represent high quality products and are, of necessity, general in nature. Unusual variations in environment will make some performance specifications more important than others. Lubricant suppliers can furnish performance test data for their products which will correlate with the specifications given in this manual. We suggest that you obtain this test data from your suppliers so that you may judge the quality of their products in an objective manner.

There is no intention to influence the purchase of lubricants from any one supplier. The trade names listed are for those products, which their respective manufacturers have recommended to TerraSource to meet Jeffrey Rader's specifications concerning performance requirements. Lubricant specifications are listed here as a convenience to users of Jeffrey Rader equipment. For additional details and other lubricant recommendations, refer to the Jeffrey Rader Machinery Lubricants Manual 000-9. Lubricants that are not applied to the Bearings properly, or are of the wrong type can damage the Bearings, seals and other rotating parts. Always use the highest quality lubrication products that are available.

The following items will require lubrication service at intervals listed in Section F.1. as specified.

- HSS Coupling (if used):
  (Lock-Out Required) See Drive Appendix

- Hyd. Opening Assist system (if used):
  (Lock-Out Required) Check the oil level in the unit every six months. Fill with premium quality hydraulic oil conforming to all requirements given in the Hydraulic Opening Assist System Appendix.

- Rotor Shaft Bearings: See information below
  (Lock-Out requirements vary by type of lubrication and specific maintenance sequence being performed.)

F.2.a. Grease Lubrication

Grease is generally used for normal operating speeds or when a customer desires a grease lube over oil. Grease is essentially oil that is suspended in a thickened base, soap is commonly used. The base keeps the oil suspended, and as the Bearing moves through the grease mixture, the lubricating oil is passed onto the Bearing. The heat of the Bearing also releases the oil from the base, and grease adjacent to the Bearing releases and absorbs the oil from the Bearing as required.

Because of this complicated process, selection of the proper grease for an application is critical. Removal of heat from the Bearing elements and Bearing operating temperature are the most important considerations. Other important factors include the ambient Bearing temperature, humidity and environmental conditions, speed, load, and frequency of lubrication. All these factors must be taken into account when choosing a grease lubricant. In many cases, it is recommended to consult a lubrication manufacturer for the proper lubricant for to meet the specific installations requirements.

Always refer to the Bearing lubrication requirements of the Bearing manufacturer. When using grease, bearing housings must be maintained at 1/3 of the total inside volume of the lower housing with grease. Using less or more grease than recommended can cause overheating. This is especially true in over-greasing, as the grease mass will be churned and whipped, increasing the temperature of the grease without providing the lubrication storage capability necessary for lubricating the Bearing.

After a certain time period, all greases will begin to break-down. This can occur by depletion of the oil contained within the soap base near the Bearing, or by contamination, oxidation, and chemical break-down of the oil itself. All greased-style Bearings incorporated on the Crusher will include a re-lubrication fitting on the Bearing, which allows the introduction of new grease into the rolling elements. During grease re-lubing, grease may or may not be purged out of the seal areas around the Rotor Shaft. After a certain amount of re-lubrication cycles (generally every three months), it is recommended to **LockOut** the Crusher, remove the upper split housing of the Bearing, and remove all the old grease inside the housing and re-fill the housing and the Bearing element with new grease.

If it is planned to have the Crusher Bearings greased while the unit is operating, all safety considerations must be taken to insure the safety of the individual doing the re-lubrication. Any necessary guards and shields to prevent injury must be in place, the operator notified, and all other plant safety and safety instructions noted in this manual must be observed. The addition of grease lines and lubrication fittings located away from the equipment should be considered to improve safety.

Some Jeffrey Rader Crushers are equipped with sleeve bearings. Sleeve bearings may or may not utilize a dispensing device that will inject a small amount of grease into a bearing at a predetermined rate and time interval. If there is any doubt as to the amount

of grease in a bearing, a safe rule is to add grease slowly as the bearing operates until the first sign of grease appears at either seal.

Determination of the re-greasing interval depends on a number of operating factors. The quantity of grease remaining is not a measure of the time interval between re-greasing. Only the grease, which is immediately adjacent to and in contact with the bearing, takes part in the lubrication. The grease in this location may gradually cease to lubricate due to the depletion of the oil, leaving just the soap base, whereas the grease further removed from the bearing may still be in good condition. The kind of grease used and the operating speeds are important factors to be considered. An accurate prediction of the time the grease will last under certain conditions cannot be made. In applications where elevated temperature, high speed, severe contamination, high humidity or other extreme conditions are encountered, particularly with open type bearings, accelerated deterioration of the grease will take place. Under these conditions, periodic inspection during the first few weeks of operation will provide the best determination of the required frequency of re-greasing.

Model	RPM	Re-Grease Volume oz.	Re-Grease Volume cubic cent.	Re-Grease interval hours
Mini-Mill	1800	0.9	26.6	8800
Mini-Mill Horiz	1800	0.9	26.6	8800
Mini-Mill Horiz	1450	0.9	26.6	10200
Mini-Mill Horiz	1200	0.9	26.6	11800
30AB	1800	1.1	32.5	900
34AB	1800	1.5	44.4	800
34WBSS	1800	2.1	62.1	900
40WBSS	1800	2.6	76.9	500
44WB	1450	2.6	76.9	900
	1200	2.6	76.9	1300
45WB	1450	2.6	76.9	900
	1200	2.6	76.9	1300
47WB	1450	4.1	121.3	500
	1200	4.1	121.3	800
54WB	1200	4.1	121.3	800
55WB	1200	4.1	121.3	800
56WB	1200	4.1	121.3	800
58 WB	1200	5.5	162.7	500
59WB	1200	5.5	162.7	500
66WB	1200	5.5	162.7	500
	900	5.5	162.7	1000
68WB	1200	7.6	224.8	300
	900	7.6	224.8	700
610WB	1200	7.6	224.8	300
	900	7.6	224.8	700
76WB	1200	7.6	224.8	300
	900	7.6	224.8	700
30WBH	1800	1.1	32.5	900
	1450	1.1	32.5	1400
	1200	1.1	32.5	1900
34WBH	1800	2.6	76.9	500
	1450	2.6	76.9	900
	1200	2.6	76.9	1300
45WBH	1450	2.6	76.9	900
	1200	2.6	76.9	1300
47WBH	1450	4.1	121.3	500
	1200	4.1	121.3	800
54WBH	1200	4.1	121.3	800
56WBH	1200	4.1	121.3	800
58WBH	1200	5.5	162.7	500
68WBH	900	7.6	224.8	700

Model	RPM	Re-Grease Volume oz.	Re-Grease Volume cubic cent.	Re-Grease interval hours
30FT	1200	1.1	32.5	1900
	900	1.1	32.5	2700
	630	1.1	32.5	4300
	450	1.1	32.5	6300
34FT	1200	2.1	62.1	1900
	900	2.1	62.1	2700
	630	2.1	62.1	4300
	450	2.1	62.1	6300
40FT	1050	2.6	76.9	1600
	750	2.6	76.9	2700
	370	2.6	76.9	6600
45FT	1000	2.6	76.9	1700
	525	2.6	76.9	4300
	350	2.6	76.9	7000
56FT	760	4.1	121.3	1800
	525	4.1	121.3	3100
	450	4.1	121.3	3800
	270	4.1	121.3	7000
59FT	760	5.5	162.7	1300
	525	5.5	162.7	2300
	450	5.5	162.7	2800
	270	5.5	162.7	5400
611FT	630	7.6	224.8	1300
	425	7.6	224.8	2300
	350	7.6	224.8	3000
	250	7.6	224.8	4600
4236E	1200	4.1	121.3	800
4254E	1200	6.8	201.1	800
4272E	1200	5.5	162.7	500
4284E	1200	5.5	162.7	500
6460E	1200	7.6	224.8	700
	900	7.6	224.8	1200
30CS	760	1.1	32.5	3400
34CS	760	1.5	44.4	3200
40CS	630	1.5	44.4	4100
	630	2.6	76.9	3400
45CS	570	1.5	44.4	4600
	570	2.6	76.9	3900
56CS	450	3.0	88.7	4700

⚠ CAUTION

The above schedules are for normal installations. Abnormal conditions such as elevated temperature, severe dirt and dust, high humidity or chemical vapors may necessitate more frequent lubricant checks and changes.

The above schedule does not represent the time grease will last. It should be understood that the time given is the time after which it is advisable to take the suggested action in order to safeguard grease or oil lubricated bearings on and around crusher units.

Grease Specifications:

Jeffrey Rader Lubricant No. 81 – EP Multi-Purpose Grease:

A highly stable multi-purpose EP grease suitable for anti-friction bearing lubrication at temperatures from –5 to +250F (-21 to +121C) and meeting the following specifications.

NLGI Grade No 2
Worked Penetration (ASTM D-217) at 60 Strokes 265-295
Maximum Change 60 to 10,000 Strokes 10%
Timken Test Load (ASTM D-2509) at 400 rpm ..... 40 lbs.
Minimum Dropping Point (ASTM D-556)..... 350 F (177C)
Oil Viscosity (ASTM D-88) at 100F (38C) 700-1000 SSU (154-220 mm^2/s)
Oxidation (ASTM D-942) Maximum psi Drop Per 100 hrs 5 (34.5kPa)
Copper Corrosion (ASTM D-1261) 24 hrs at 212F (100C) ..... Pass
Wheel Bearing Test (ASTM D-1263) Maximum Loss at 220F (104C) 5%
Water Washout Test (ASTM D-2164) Maximum Loss at 100F (38C) 5%
at 175F (79C)..... 15%
Soap Base ..... Lithium

Below is a list of typical products recommended to meet the above specifications:

Shell Alvania EP #2 or #3
Mobilux EP #2
Gulfcrown Grease EP #2

F.2.b. Oil Lubrication

The oil lubrication of bearings falls into one of two general groups. The most commonly used is the static type, with a sump or reservoir of oil in the housing in which the bearing rotates. The other type is the circulating system where oil is pumped into the top of the housing, allowed to flow down through the bearing, and is drained from the lower portion of the housing and returned to an oil reservoir tank.

Bearing size, operating speed and temperature, induced loading, and possible contamination are some of the factors that determine the type of oil lubrication used (static or circulating).

In the normal environment surrounding a crusher installation contamination of the oil from an external source is a much greater problem than oil deterioration. Therefore, the time interval necessary for flushing and replacement is more dependent upon environmental conditions of the installations than the expected lubricating life of the oil.

Therefore, the cost for flushing and re-lubricating a bearing is small when compared to the long downtime that may be required, plus the actual replacement cost of the bearing, if you encounter a failure. The schedules given below have been established as a guided for flushing oil-lubricated bearings and lubrication systems. These schedules are based on anticipated contamination rather than oil life.

Oil Specification:

Jeffrey Rader Lubricant No. 73-A – Bearing Lubricant:

This lubricant should be a turbine quality mineral oil, which may be used for either static or circulating oil systems. A minimum viscosity of 100 SSU (21 mm^2/s) must be maintained at the bearing operating temperature. For winter use, or cold starting temperatures, it is recommended that a similar quality lubricant can be used having a pour point of at least 20F (11C) below the cold start temperature. The following specifications have been approved by the bearing manufacturer for lubricants in specific applications:

ASTM Viscosity Grade No. S1000 (C220)
AGMA Lubricant No. 5
Viscosity Range at 100F (38C) ..... 918-1122 SSU (202-247 mm^2/s)
Viscosity (ASTM D-88)
at 100F (38C) ..... 900 SSU (198 mm^2/s) minimum
at 210F (99C) ..... 75 SSU (14.4 mm^2/s) minimum
Viscosity Index ..... 60 minimum

Below is a list of a few typical products that meet the suggested specifications:

GULF HARMONY 220	SHELL TELLUS 71
TEXACO REGAL R&O 220	ARCO DURO S-1000
TEXACO REGAL R&O 320	CHEVRON OC TURBINE OIL 220
MOBILE DTE BB	EXXON NUTO 93

F.2.b.1 Static Oil Lubrication

Static lubrication requires a given level of oil in the housing. Each housing is equipped with a sight gage and the required level for that bearing is indicated by notches in the gage and/or a scribed line on the glass. ALWAYS check the oil level with the bearing at rest and all oil drained back into the sump. Make-up oil should be added only while the bearings are at rest. During operation, the actual or visual oil level will be somewhat below the gage markings (this is normal).

Static Oil Lubrication Schedule:

After first 32 hours of operation – drain and flush.
After every 240 hours of operation – drain and flush.
After every 480 hours – drain, open housing, clean and flush.

⚠ CAUTION

The above schedules are for normal installations. Abnormal conditions such as elevated temperature, severe dirt and dust, high humidity or chemical vapors may necessitate more frequent lubricant checks and changes.

F.2.b.2 Circulating Oil Lubrication

A Jeffrey Rader crusher utilizing a circulating oil system will maintain the required oil level and/or flow for complete bearing lubrication and cooling as long as the oil system is properly adjusted and operating correctly, and as long as a sufficient oil level is maintained in the reservoir.

The oil reservoir of the circulating oil system should be filled to the level indicated by the sight gage located on the oil tank and should be checked daily. Any make-up oil should be added with the system at rest. During operation, the oil level will fall somewhat below the gage marking. As in Static Lubrication, this is normal.

Circulating Oil Lubrication Schedule:

After first 48 hours of operation – change filter.
After every 240 hours of operation – change filter.
After every 480 hours of operation – drain and flush.
After every 720 hours of operation – drain, open, clean and flush bearing and system tank.
Make-up oil should be added to the system as required.

⚠ CAUTION

The above schedules are for normal installations. Abnormal conditions such as elevated temperature, severe dirt and dust, high humidity or chemical vapors may necessitate more frequent lubricant checks and changes.

F.3. Weld Repair and Hardfacing

Periodic inspection should be made to check for wear and possibility of need for replacement parts. The hammers are the parts most subject to wear. Several types of hammers are available and the type of hammer furnished with a unit is dependent on the infeed material to be handled. The standard hammers furnished for general usage are of medium or high carbon heat-treated stock, some of which are made double ended or with multiple impact edges to allow more than one use before the hammer is fully worn. After the corners are worn they can be rebuilt to shape with "build-up" rod and then coated a maximum of 1/8" with hardcoat rod or they can be replaced with a new set. Most hammers have at least two wearing corners and the same note as above applies to reversing corners.

During the course of maintenance on the Crusher, some welding and/or hardfacing will be required to repair or restore certain wear surfaces and structural elements of the unit. It is very important that all weld and hardfacing repair work be done by certified welders, following proper welding codes, guidelines, and accepted practice. One widely known standard is the American Welding Society (AWS), this organization maintains a complete set of welding standards that can be used for all Crusher welding and hardface work. All cutting, burning & welding work done in the field must follow all plant safety procedures and regulations.

⚠ WARNING

Certain parts on the Crusher are manufactured of high hardness alloys, and are not possible to re-welded or hardfaced. These high hardness parts are not easily distinguished from alloys that can be welded and hardfaced. Trying to weld or hardface a high hardness alloy part can result in complete failure of that part in a very short period of time, and can run the risk of serious damage to the Crusher. Contact TerraSource to help determine if a certain part can be re-welded or hardfaced.

Metal parts to be welded shall be clean and free of all dirt, oil, grease, paint, and any other substance detrimental to the quality of the weld. Any cracks must be completely gouged or ground out beyond the visible boundaries of the original crack. Provide sufficient width of the removed areas to allow the welding electrode or wire to be positioned for proper weld penetration.

The repair of a crack in the weld or base metal of a crusher housing requires a repair weld deposit of the same size as originally used. For complete information on weld and hardface instructions, see the following Supplement Manuals:

116-28 Low Carbon Alloy Hammer Repair and Hardfacing Instructions
116-29 Manganese Hammer Repair and Hardface Instructions
116-30 Medium Carbon Alloy Hammer Repair and Hardfacing Instructions

The following are general instructions and procedures for Low Carbon Alloy materials:

Surface Preparation. Remove grease and oil with a solvent, rust and dirt with a wire brush. Using ARCAIR (or equal) gouging, or grinder, COMPLETELY remove the crack. The sides of the prepared area must be chamfered to an included angle of 40-60 degrees to allow the electrode to penetrate into the root of the prepared joint.

Preheating. Preheating is not required except for bringing the area to be welded up to 70-100F (21-38C). Preventing the weld area from dropping below this temperature until the welding is completed will greatly improve the quality of the weld and is strongly recommended.

Electrode and Application. A small diameter (3/16 inch or 4.76 mm maximum) low hydrogen E7018 stick electrode deposited in straight stringer beads is recommended. All slag must be removed prior to making another pass. All welding must be free from undercuts, inclusions and blowholes. After the weld has been brought to size, allow it to cool slowly. DO NOT QUENCH!!

⚠ CAUTION

If the internal Rotor Weldment is to be welded or hardfaced, always attach the welder ground lead to the Rotor Weldment. Never allow welding current to pass through the Bearings of any machine, as the current is strong enough to damage the Bearing and cause premature failure.

The area to be welded should be preheated to welding codes determined on the section thickness that is being worked on any material that are not mild steel. If a weld repair is being done to the Rotor Weldment, pay very close attention to all pre-heat and post-heat requirements in the welding code. After applying the welds, the welded areas should be allowed to cool slowly, to avoid quenching the metal and causing a brittle condition.

If using welding rod, use low hydrogen E7018 rod that has been in a new container or baked in a low temperature oven to remove all traces of moisture. Welds should be made in small beads, using multi-pass techniques and layout to prevent any warpage or distortion in the parts. All slag and splatter must be removed before making overlaying passes. Maintain heat in thick sections during the welding process. All welds must be free of undercuts, cold laps, excessive splatter, inclusions and any other defect.

All welds must be inspected visually after completion, if any weld is suspicious in appearance, the weld should removed in an acceptable manner and re-applied, or the suspicious weld should be inspected by a non-destructive technique (magnetic particle, ultrasonic, x-ray, etc.). All welding deficiencies found by these inspections must be corrected and re-inspected.

If hardfacing is being applied to wear areas, many of the above guidelines apply, but always refer to the hardfacing manufacturer's application recommendations. The amount of hardfacing that can be applied will vary depending on the part and its wear characteristics. There are many different types of hardfacing available, each has its own advantages and disadvantages. Some considerations that need to be taken into account in the selection of hardface materials are:

- Impact Resistance
- Abrasion Resistance
- Corrosion Resistance
- Temperature Resistance
- Ease of application (is specialized welding machinery involved?)
- Cost of hardface materials -vs- anticipated life

⚠ WARNING

Anytime welding or hardfacing is performed on the internal Rotor Weldment or Hammers, consideration must be given to rebalancing the rotating assembly. Do not assume that welding has been done "evenly" to prevent dangerous imbalance in the high speed rotating assembly.

Always follow recommendations in Section F.4. and F.5 for proper balance and vibration reduction.

The amount of hard-surfacing required depends on your particular application. There are many types of hard-surface welding rods to choose from depending on the amount of resistance to wear desired due to impact and abrasion. Some are listed below. TerraSource has standardized on Lincoln Electric welding products listed below. If your welding engineer has an equivalent, it will accomplish the same purpose.

(a) Medium-carbon low-alloy steel rods: These materials have excellent impact strength and reach full hardness as deposited, but only fair to poor abrasion resistance. They are generally used for build-up of severely worn steel parts. Lincoln's Jet-LH BU-90 is a typical welding rod in this group.

(b) Semi-austenitic alloy rods: These materials have improved abrasion resistant while retaining moderate impact strength. In addition these alloys work-harden rapidly. Lincoln's Abrasoweld is a typical material in this group.

(c) Chromium-carbide and tungsten carbide alloys: These materials have the highest abrasion resistance of the hard-surfacing materials. Their impact resistance is poor. They are generally used as a cover for the buildup rods in group (a). Examples of typical Chromium-carbide rods are Lincoln's Faceweld 1 (less impact strength than Abrasoweld, but better abrasion resistance); and Faceweld 12 (exceptional abrasion and corrosion resistance, but lowest impact strength of the Lincoln products).

Actual field conditions for a crusher may require a rod with more or less resistance to either impact or abrasion, depending on the material being processed. The above list is intended as a guide to help in the selection of rod properties for a given application.

Welding required for the proper maintenance of internal rotor parts is specialized for varying materials use and the functions they perform. Detailed instructions for welding rotors are given in the Specific Instruction manual for your crusher type.

F.4. Balancing of the Rotor Assembly

All Rotor Assemblies are dynamically balanced for their top operating speed after construction in the assembly shop. The Rotor Assembly consists of the Rotor Shaft, Rotor Discs, Hammer Pins, Hammer Pin Retainer, and Hammer Pin Retainer fasteners. During the dynamic balance process, the Rotor Assembly is balanced using small weights added and permanently welded to the Rotor End Discs at each end of the assembly. The balance weights fit into a recess at the ends just above the Hammer Pin swing diameter.

During the course of operation and over time, the Rotor Assembly may require rebalancing, due to a repair or wear resurfacing of certain parts of the Rotor. During the repair/welding/resurfacing process, care must be taken to control weight distribution to maintain a minimum vibration level. If extensive repair of the Rotor Weldment is required, TerraSource always recommends that the Rotor be removed from the Crusher frame and sent out for proper dynamic balancing.

If the plant has access to vibration analysis equipment, it is preferable to measure and record the vibration levels over time. This will allow monitoring the condition of the equipment over time and establishing points at which specific maintenance will be required. Using this method, it is possible to determine when Bearings and Hammers will require replacement, as well as help determine damaged components.

If it is suspected that the Rotor has occurred damage or is bent, it is recommended to Lock-Out / Tag-Out the Crusher, and remove all hammers from the Rotor Assembly. Reinstall the hammer pins and retainers, and close all doors and covers, restore electrical power to the Crusher, restart the unit, and check the vibration readings at the bearings without the hammers in place. The bare Rotor Assembly should be well below the following maximum vibration values in any radial plane.

Maximum Normal Operating Speed (RPM)	Maximum Peak-To-Peak Vibrating Amplitude in Mils (mm), with Hammers in place	
	Crusher Tip Path Diameter 42" and under	Crusher Tip Path Diameter Greater than 42"
500	5.0 (0.13)	10 (0.25)
600	5.0 (0.13)	10 (0.25)
700	5.0 (0.13)	9.4 90.24)
800	5.0 (0.13)	9 (0.23)
900	5.0 (0.13)	8.7 (0.22)
1000	5.0 (0.13)	7.7 (0.20)
1200	5.0 (0.13)	6.6 (0.17)
1800	5.0 (0.13)	-- --
2400	5.0 (0.13)	-- --

In many cases, for one reason or another, it is not practical to send out the Rotor Assembly for dynamic balance. If this is the case, follow the recommended instructions below for rebalancing the Rotor Weldment with it still located in the housing.

a. **<u>Lockout the Crusher & all necessary adjacent equipment.</u>**

b. Disconnect the motor from the Rotor Assembly by removing the HSS Coupling or V-Belt Drive.

c. Remove all Hammer Pins, Hammers, Impellers, etc. from the Rotor.

d. At this point, the Rotor should turn easily in the Bearings. If the Rotor does not turn easily, check for material wedged between the end discs and the Housing. If necessary, remove the Bearing upper housing caps, inspect the Bearing elements and determine the reason for the rotor not turning easily. The Rotor Weldment must turn smoothly and freely before proceeding to the next step.

e. Check the run-out of the Rotor using a dial indicator mounted to the lower housing. Check the Rotor Weldment in several locations to determine if the Rotor Shaft is bent or deformed. If the Rotor Shaft is bent or otherwise deformed, the Rotor Assembly must be removed and replaced with a new Rotor.

f. Roll the Rotor over by hand several times, noting where the Rotor comes to rest. If the Rotor comes to rest at different locations each time it is moved, the Rotor is most likely in reasonably close static balance. Also check if the Rotor Weldment comes to rest without a “back and forth rocking” motion, then the Rotor Weldment is most likely statically balanced. If it always comes to rest in the same place, mark the upper top of the rotor as the “light” point. Verify that the “light” point of the Rotor does not conform with an extreme reading from the dial indicator check, further indicating a bent shaft.

g. When the light point of the Rotor Weldment is established, add temporary weight by trial and error until the Rotor Weldment appears balanced per F.4.f. After the required amount of weight is established, split the weight into two equal halves (one for each end), and also reduce the counterweight by the estimated amount of weld that will be required to firmly attach it to the Rotor. For example, if a five pound weight is required for balancing and one pound of weld metal is required for welding this weight; the balance weight must be reduced from five pounds to four pounds. Attach the counterweight to the Rotor end discs. Recheck the balance and repeat as required. The basic Rotor is now as closely balanced as possible without the aid of special equipment.

h. Without Hammer Pins, Hammers, Impellers, etc., remove all tools and close all access doors. Reinstall the HSS Coupling or V-Belt drive per Section F.6.a or F.6.b. Reinstall all guards and covers that were removed. Remove the LockOut from the Crusher motor and start the motor. Check the exterior Housing for any excessive vibration, gauging by feel and sound if the level of vibration is acceptable.

i. **Lockout the Crusher & all necessary adjacent equipment.**

j. If the level of vibration in the Rotor Weldment is still unacceptable, repeat all the above steps and contact TerraSource. If the level of vibration is acceptable, reassembly of the rest of the Rotor Assembly can take place. See Sections F.5. for installation information.

If it becomes necessary to use electronic vibration analyzing equipment, the hammers and pins should be removed so that the basic rotor can be balanced. Rechecking and adjusting the hammer weight for the complete rotor is advisable. See the table above for recommended vibration levels for use with a vibration analyzer. The values indicated in the table are for a rotor assembly complete with hammers and all components.

If the unbalanced vibration amplitude exceeds the maximum limit, the unit must be rebalanced. Care must be taken to balance below or at the maximum levels shown.

NOTICE

Proper balancing procedures are extremely important for low vibration of the Crusher, structure, extended life of bearings, prevention of bolt loosening, etc.

TerraSource can furnish trained and experienced service representatives with electronic vibration analysis equipment for precise electronic balancing should you require this service. For further information contact a TerraSource representative at one of the locations in Section A.1.

F.5. Hammer Balancing

The Hammers that attach to the Hammer Pins are not a part of the dynamically balanced assembly discussed in Section F.4. To maintain a safe and trouble free operation, consideration must be given to balance when replacing or rebuilding rotating parts. Field balancing is a matter of weight being evenly and systematically distributed on the total rotating mass.

⚠ WARNING

Never place an unweighed Hammer into a Rotor Assembly. Never place Hammers that have been weighed randomly onto the Rotor Assembly without equalizing and balancing the weight. Severe vibration and equipment damage may result.

All units will be operating with some degree of imbalance and corresponding vibration amplitude. This is satisfactory as long as it is within a reasonable limit (see Section F.4.). With very little effort, the maintenance crew can economically keep the crusher within the vibration range desired or as originally shipped. Hammers or impeller bars are subject to the most wear and are the most critical items in maintaining good balance. Each new or rebuilt hammer should be weighed and distributed as per Figures 6, 7, or 8. These figures show swing type hammers, but the same procedure and principles applies for any hammer, impeller bar or weld deposit. The more accurately the weight is distributed, the lower the vibration level will be. Never indiscriminately place a single hammer or impeller in a rotor. Always counterbalance with an equal weight per applicable distribution diagram. It is recommended that replacement hammers be kept in pre-weighed sets.

Rebuilding and Balancing:
To extend their usable life, crushers with rotors of the spider arm type and those with solid rotors will require deposits of hard surfacing and/or build-up rod in areas where wear is likely to occur. This procedure must be closely controlled to assure proper weight distribution and maintain a reasonable vibration level. The weld deposits cannot be weighed as you weigh a replacement part, so some other method must be used. One way to predetermine to what length an electrode of a given type and size will be burned. Do the required welding, burning each stick to the determined length and drop the dead ends into a tub or can.

After the hard surfacing or build-up is complete in one location, count the number of ends. In this way, and equal amount of weld can be deposited in the required location for necessary counter-balance.

NOTICE

While hard surfacing or rebuilding, always counterbalance the rotor. Otherwise, the rotor may become so out of balance that special dynamic balancing equipment will be required to be used to restore balance to an acceptable vibration level.

Each Rotor Assembly can be thought of in terms of Rows and Columns. TerraSource defines a Row as the longitudinal line that is in the parallel to rotation of the shaft (each Hammer Pin defines a Row). Columns are each circular spacing between rotor discs on the Rotor Assembly. Each individual Hammer, Hammer Spacer, Rotor Gate, and Rotor Lug must be weighed on an accurate scale, with adequate capacity. The accuracy of the scale must be at least 0.1 lbs (0.05 kg), preferably 0.05 lbs (0.023 kg). Mark the weight on each hammer with a paint stick or permanent marker.

In machines having three rows of hammers, all hammers should be weighed, marked and divided into three stacks. These stacks should have as near as possible equal weight so that when assembled in the machine the total weight on each hammer pin will be the same. In this arrangement, hammers will occupy all hammer pin locations.

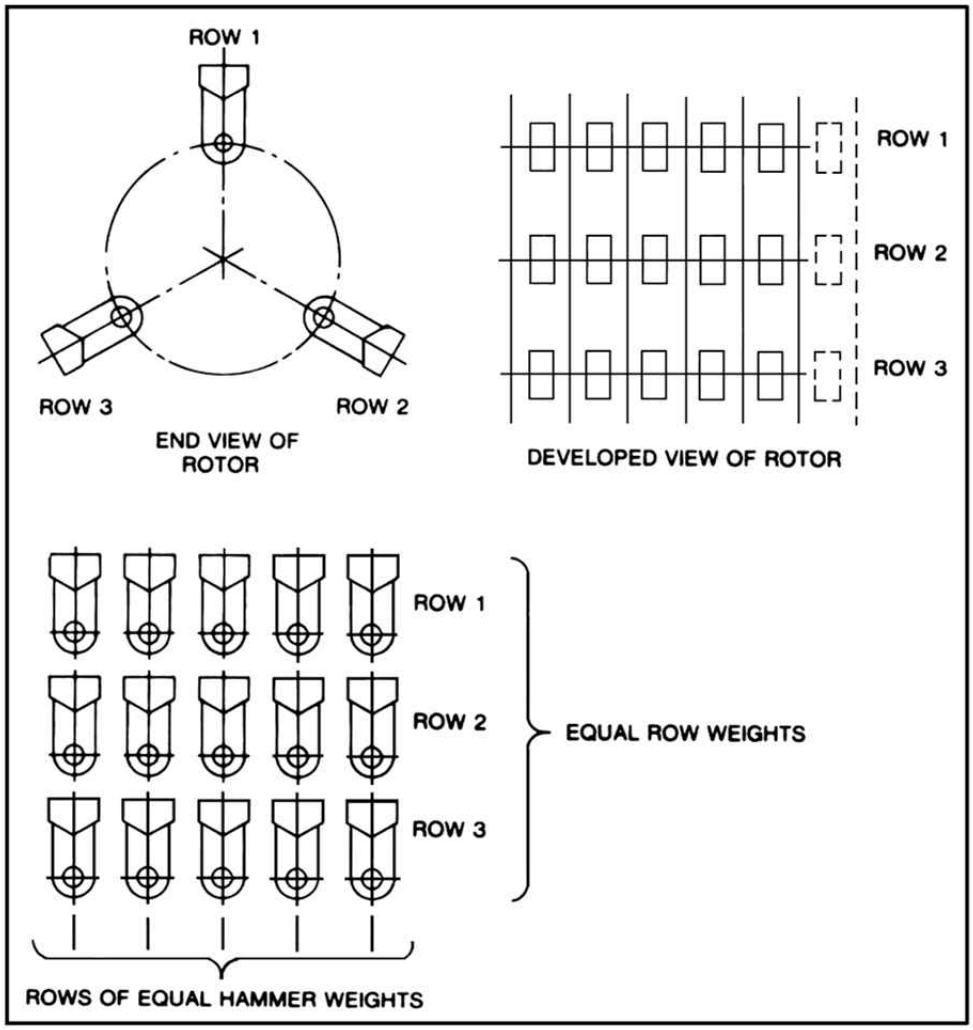


Figure #7, Typ. Hammer Distribution, 3 Solid Rows

In machines having four rows of hammers, the hammers should be weighed, marked and divided into four stacks. These stacks will not necessarily have the same weight due to the fact that when four rows are used, there are not always the same number of hammers per row, as shown in Figure #8 ('staggered' arrangement). Units with four rows can also be arranged in a 'solid' arrangement similar to Figure #7, where the hammers will occupy all available hammer pin locations. In any case, care must be taken so that when assembled in the machine the rows directly opposite each other in the rotor will have equal weights.

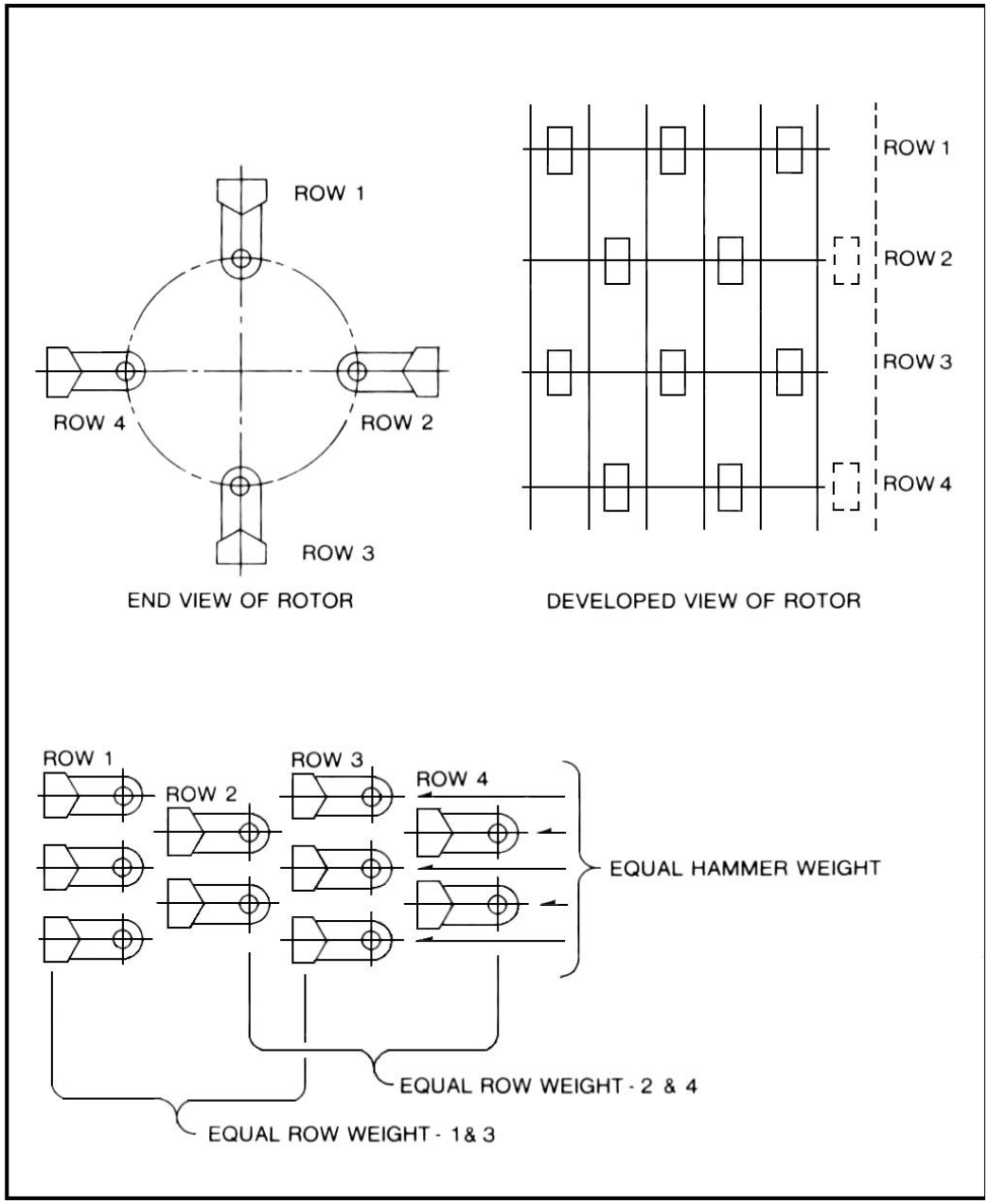


Figure #8, Typ. Hammer Distribution 4 Staggered Rows

In machines having six rows of hammer, the hammers should be weighed and marked as above and divided into six stacks. These stacks will not necessarily have the same weight due to the fact that when six rows are used, there are not always the same number per row, as shown in Figure #9 ('staggered' arrangement). Units with six rows can also be arranged in 'solid' arrangement as described previously. In any case, care must be taken so that when assembled in the machine, the odd number rows, 1, 3, 5 will have equal weights and the even rows, 2, 4, 6 will have equal weights. If this is done the rotor should be in balance.

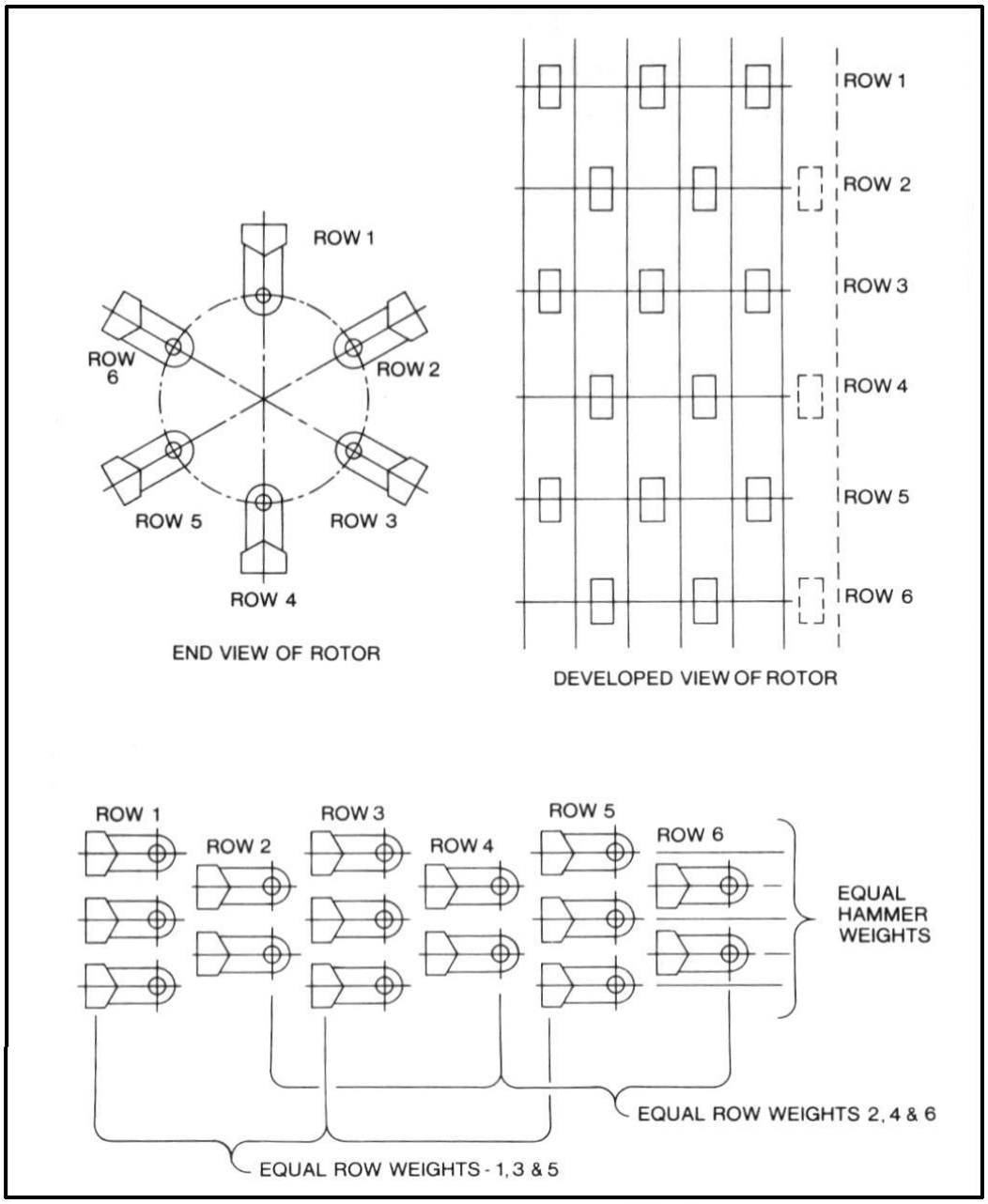


Figure #9, Typ. Hammer Distribution 6 Staggered Rows

The balanced arrangement requirements of the Hammers in the Crusher can ultimately be summed in the following statements:

Balance Criteria for Jeffrey Rader Crushers	Hammer Wt. <100# [45 kg]	Hammer Wt. 100# - 200# [45 kg – 91 kg]	Hammer Wt. >200# [91 kg]
Total weight of all Hammers in opposing Rows (180^{O} apart), must be less than this value difference in totaled weight	0.25 lb [0.11 kg]	0.25 lb [0.11 kg]	0.25 lb [0.11 kg]
Hammers in each column less than this value difference in weight	0.25 lb [0.11 kg]	0.50 lb [0.23 kg]	1.00 lb [0.45 kg]

Hammers can be arranged in a variety of patterns to achieve the best balanced condition. In most cases, a combination is possible to use the Hammers in the condition that they arrive. In some cases, a Hammer may be excessively light or heavy due to pattern or mold shifts during manufacture. The Hammer is still acceptable from a strength and fitness for usage standpoint, but the difference in weight makes weight compatibility with other Hammers difficult. In these cases, the Hammer may either have material removed or added by grinding or welding to change the weight. Make sure that the Hammer is of a material type and hardness compatible with welding if the addition of material is desired. When welding or grinding on Hammers, keep the Hammer cool and avoid overheating to prevent softening of the metal. Welding or grinding should be done only in locations of the Hammers that are not highly stressed or in significant wear areas. On request, TerraSource will supply a balance sheet for complete sets of hammers, contact one of the offices listed in Section A.1.

Once the Hammers have been installed on the Rotor, the unit should be closed be closed and all fasteners installed, and the unit readied for operation. Restore electrical power to the Crusher motor, and restart the unit. Check the unit for excessive vibration before beginning to feed material. Excessive vibration at this point may be caused by the accidental installation of a hammer in the wrong location of the Rotor Weldment, especially if the vibration was not present before the Hammer change out. Any excessive vibration must be checked out and remedied before infeed material is put to the unit.

After installation of a properly balanced and arranged set of new Hammers onto a properly balanced Rotor Weldment, the following vibration values in any radial plane should not be exceeded.

Maximum Normal Operating Speed (RPM)	Maximum Peak-To-Peak Vibrating Amplitude in Mils (mm), with Hammers in place	
	Crusher Tip Path Diameter 42" and under	Crusher Tip Path Diameter Greater than 42"
500	5.0 (0.13)	10 (0.25)
600	5.0 (0.13)	10 (0.25)
700	5.0 (0.13)	9.4 90.24)
800	5.0 (0.13)	9 (0.23)
900	5.0 (0.13)	8.7 (0.22)
1000	5.0 (0.13)	7.7 (0.20)
1200	5.0 (0.13)	6.6 (0.17)
1800	5.0 (0.13)	-- --
2400	5.0 (0.13)	-- --

The above readings assume a properly supported Crusher structure and foundation, as outlined in Section C.2.

F.6. Periodic Maintenance

The following components will require service and maintenance on a periodic schedule:

- HSS Coupling (if supplied) Section F.6.a.
- V-Belt Drive (if supplied) Section F.6.b.
- Bearing Maintenance Section F.6.c.
- Wear Liner Maintenance Section F.6.d.

F.6.a. HSS Coupling Maintenance (Direct Drive Only)

1. **Lockout the Crusher & all necessary adjacent equipment.**

2. Remove the HSS coupling guard.

   - If the HSS coupling is to be re-lubricated only, locate the re-lubrication fitting on the coupling cover. If the cover does not have a re-lubrication fitting, remove the cover bolts and the outer cover. Follow the manufacturer's lubrication recommendations in the Drive Appendix. When complete, replace the cover and fasteners, and re-torque to specifications given in Section F.7. Skip ahead to step F.6.a.4.

   - If the coupling is damaged and/or the hubs require servicing, remove the cover bolts and the outer cover. Remove the fasteners holding the motor to its support base, and move the motor to allow access to both hubs.

3. See the Drive Appendix for the make and model of HSS Coupling used on the Crusher, including complete instructions for its removal, maintenance, and reinstallation. The coupling must be mounted and aligned per the manufacturer's instructions. In many cases, the manufacturer will recommend that the coupling be installed with an interference fit, follow all manufacturers' recommendations for installation of the coupling halves. When the mounting and alignment is complete, replace the cover and fasteners, and re-torque to specifications given in Section F.7.

4. Replace all guards and covers.

Remove Crusher LockOut. The Crusher is ready for operation.

F.6.b. V-Belt Maintenance (V-Belt Drive Only)

When maintenance is required on the V-Belt drive, use the following procedure

1. **Lockout the Crusher & all necessary adjacent equipment.**

2. Remove the V-Belt drive guard.

   - If only the V-Belt tension and alignment is to be checked, follow all the recommendations and inspection guidelines given in the Drive Appendix. Follow all manufacturers' recommendations for proper belt tension to prevent slippage. If the belt tension must be adjusted, loosen any locking bolts on the motor slide base, and re-tension the V-Belts as necessary. When complete, replace all fasteners, and re-torque to specifications given in Section F.7. Skip ahead to step F.6.b.4.

   - If the V-Belts or sheaves are to be replaced, move the motor as close as possible to the Crusher, reducing the center distance to minimum. Remove the V-Belts and/or the worn sheaves as required.

⚠ WARNING

Never install V-Belts on the Crusher sheaves by turning the Rotor Assembly. Imbalances within the Rotor Assembly can un-expectantly move the sheaves & V-Belts, causing pinching and severe injury. Damage to the V-Belts can also result.

3. Use only V-Belts of similar type to those being removed. Most installations require a belt that is banded across the top, where several V-Belts are joined together to prevent individual belts from turning in the grooves. See the Drive Appendix for recommendations and installation information on the alignment and tensioning of the sheaves and V-Belt drive. Follow all manufacturers' recommendations for proper belt tension to prevent slippage. Make sure that all sheave bushings are tightened to manufacturer's recommendations.

4. Replace all guards and covers.

Remove Crusher LockOut. The Crusher is ready for operation.

F.6.c. Bearing Maintenance

Even with the best maintained systems, Bearing failures can occur. In many cases, Bearing failure is the end result of an event or prior operating conditions, which eventually deteriorate the Bearing to requiring replacement. In the design of the Crusher, TerraSource has made the Bearing area easy to maintain.

Determine if just one or both of the Bearings requires replacement. Generally, it is recommended that Bearings be replaced individually, one at a time at each end of the unit. Removable upper housing caps are not interchangeable with lower housings, they are machined as a unit and must always be used as a matched set. Additional instructions on Bearing removal and installation can be found in the Bearing Appendix.

1. **Lockout the Crusher & all necessary adjacent equipment.**

2. Open the Crusher housing. Check over the interior portions of the Crusher for any internal damage that may have been caused if the Bearing failure was major.

⚠ WARNING

Always use an approved tool and procedure to turn the Rotor Assembly of the Crusher. Never use any body part (hand, arms, foot, etc.) to turn the Rotor Assembly.

⚠ WARNING

Do not attempt to turn the Rotor Assembly by using a pipe wrench or similar tool on the Rotor Shaft.

If the Crusher is equipped with Swing Hammers, expect some imbalance and noise as the Swing Hammer rotates over-center and swings into its stop limits.

3. If the Bearing to be removed is on the drive end of the unit, follow the instruction in Section F.6.a. or F.6.b. and remove either the HSS Coupling or the V-Belt Drive. Remove all coupling halves and sheaves/bushings from the Rotor Shaft.

4. Remove the top upper cap from the Bearing housing. Loosen and remove the fasteners holding the lower Bearing housing to the Bearing Filler Block, and the Bearing Filler Block to the main Lower Housing. Remove any alignment keystock that may be around the perimeter of the Bearing Housing as required to allow the Bearing Support Pedestal to be removed.

5. Most of the parts that will be removed are heavy, and should be lifted using a hoist or chain fall whenever possible. Always insure that adequate lifting capacity is available for the removal of the Bearings, housings, and lifting of the Rotor Assembly during Bearing maintenance.

6. Rig the end of the Rotor Assembly to be supported during the Bearing replacement. Place a strap under and around the main Rotor Shaft, take-up the slack, and raise the Rotor Assembly just enough to have clearance under lower bearing housing. Support the lower Bearing Housing, and remove any shim package that may be present between the lower bearing housing and the Bearing Filler Block. Remove the Bearing Filler Block horizontally. Once the Bearing Filler Block is removed, the lower Bearing housing can be lowered and removed horizontally out from under the Bearing elements on the shaft. Also remove the outer aluminum labyrinth seal ring is being removed. Clean the majority of grease from Bearing and Bearing housing, and inspect for damage or signs of excessive wear.

7. TerraSource has supplied the Rotor Shaft with holes for hydraulic bearing removal. This method employs high pressure hydraulics to lubricate and expand the inner race of the bearing to make removal of the bearing a simple task. Hydraulic pressure can also be of assistance when re-installing the bearing in place. If the bearing is to be reused, it is highly recommended that the hydraulic bearing removal system be used for dismounting the bearing from the taper seat on the Rotor Shaft.

   The holes for the hydraulic bearing removal injection point are located on the ends of the rotor shaft. At the drive end, a very long hole is provided from the end of the shaft, with a short cross-drilled hole intersecting the first about in the middle of the tapered seat of the bearing. A metal pipe plug is used to seal the hole until it is to be used. At the idler end of the Rotor Shaft is a similar arrangement, but with a shorter hole down the end of the shaft. In many cases, the mill will already have access to a high pressure hand pump and hoses/fitting for using the hydraulic bearing removal system. If not, a kit may be rented or purchased, the following kit is recommend and can be purchased from TerraSource if desired.

⚠ WARNING

When using hydraulic removal dismounting, it is very important to only back-off the Bearing Locknut several turns (Do Not Remove the Locknut). The hydraulic pressure is high enough that the Bearing can and will fly right off the end of the shaft when the inner race is expanded off the taper seat if the Locknut is not there to stop the Bearing.

8. Following the Bearing manufacturer's instructions, disengage the locking tab of the Bearing Lockwasher from the Bearing Locknut. Using a proper sized spanner wrench, remove the Locknut and Lockwasher. Reinstall the Lock Nut if hydraulic bearing removal is going to be used for dismounting, and then follow all instructions provided with the kit. If hydraulic bearing removal is not going be used for dismounting, and if the Bearing is to be reused, make sure that a bearing puller is used to dismount the Bearing, and that the puller applies its force to the inner race of the Bearing. Never pull from the outer race if the Bearing is to be reused. If the Bearing is not to be reused, any method to remove the Bearing is acceptable, as long as the Rotor Shaft is not damaged. Also remove the inner Labyrinth Seal from the Rotor Weldment Shaft.

9. Carefully inspect any parts that are to be reused. Always use a new Lockwasher against the Bearing, never try to reuse one that has been in service. Also check for any damage in the Rotor Shaft threads for the Locknut, and make sure that the Locknut spins freely on the threads of the Rotor Shaft.

Reassembly is the opposite of removal. Additional instructions are in the Bearing Appendix. TerraSource always recommends installing a new Bearing as opposed to reusing Bearings. Read and follow all Bearing manufacturers' installation and operation information before beginning. Work in as clean an area as possible.

Measure the unmounted clearance of the new Bearing before installing on the Rotor Shaft. This clearance must be reduced during fitting the Bearing to the Rotor Shaft by a very specific amount per the manufacturer's recommendations.

Apply a light coating of oil to the inner race tapered bore and the Rotor Shaft taper seat. Also apply oil to the threads on the locknut. Assemble the inner Aluminum Labyrinth Seal onto the Rotor Shaft, then carefully slide the new Bearing onto the tapered portion of the Rotor Shaft. Assemble the Locknut (no Lockwasher at this time) onto the Rotor Shaft, and begin tightening the Locknut using the proper spanner wrench while checking the clearance of the Bearing. If the hydraulic bearing removal system was used to dismount the original bearing, reinstalling it at this time and applying some pressure will reduce the amount of torque needed to be applied to the locknut. The clearance in the Bearing must be reduced by the amount specified by the manufacturer, usually given as a range. TerraSource recommends that the amount of reduction be targeted in the middle of the range.

After the proper reduction of clearance in the Bearing is achieved, depressurize and remove the hydraulic pump (if used), and then carefully remove the Locknut without disturbing the Bearing, and install the Lockwasher. Reinstall the Locknut, fully tighten against the Lockwasher and Bearing. Install the Lockwasher tab into the slots on the Locknut to prevent the Locknut from loosening.

Reinstall the lower Bearing housing, Bearing Fill Block (if used), and any shims that were removed earlier. Insert the fasteners for the Filler Block to both the Lower Housing and the lower Bearing housing in place and tighten to specifications given in Section F.7.

If the Bearing is to be grease lubricated, using a nozzle and inject grease into all internal cavities of the Bearing rolling elements. Then fill the housing cavity approx. 1/3 full of high quality grease. If the Bearing is to be oil lubricated, fill the housing with high quality oil to the specified level. See Section F.2. for more information on grease and oil requirements. Install the upper Bearing housing and fully tighten all fasteners.

After all parts have been installed, carefully turn the Rotor Assembly with an approved tool and check for proper clearance and any areas of interference. Correct all issues that are found. Reinstall all keystock pieces that may have been removed from around the Bearing Lower Housing and Filler Block.

Reinstall the HSS Coupling or V-Belt Drive if removed, see Sections F.6.a. or F.6.b.

Carefully close all access doors. Install the properly sized fasteners and tighten to the specifications given in Section F.7. of this manual. Install any other guards, covers, or access doors that may have been opened during the maintenance sequence.

Remove Crusher LockOut. The Crusher is ready for operation.

F.6.d. Hammer Maintenance

Refer to the certified drawings provided with your equipment to see the recommended arrangement and orientation of the hammers and number of rows utilized, contact TerraSource if additional clarification is needed. To replace the Hammers in the Crusher, follow these general instructions:

1. **Lockout the Crusher & all necessary adjacent equipment.**

2. Open the Crusher housing to access the hammers. Remove the access covers or shaft sealing plates at each end of the Crusher to access the ends of the hammer pins.

3. Normally the hammer pin will be removed from the end of the Crusher opposite the drive. Make sure there is room to withdraw the hammer pin fully, and provide support for the removed pin. On larger units, arrange for a hoist to support the hammer pin when removed.

4. Revolve the rotor assembly so the hammer row to be removed is in the 12:00 position, and in-line with the hammer pin removal hole in the Crusher frame. Tighten the rotor friction lock bolts on both ends of the Crusher to prevent the rotor from turning. If the Crusher does not have rotor friction lock bolts available, block the rotor assembly from turning.

5. Remove cotter pins, retaining rings, or retaining plates from both ends of the rotor assembly on the hammer pin to be removed.

6. Using a combination of pushing from the drive end, and pulling from the idler end, begin moving the hammer pin slowly away from the drive end of the Crusher. As the pin moves down the length of the rotor, each hammer will be released one at a time and can be lifted out of the Crusher through the access openings (if the hammers are to be reversed or another wear surface used, keep the hammers in the order they are removed). Continue until all hammers in the row are released.

7. Clean all hammer pin holes in the rotor, and clean the hammer pin itself of all debris. Check the hammer pin for wear and replace if necessary

If the hammers being removed are to be reversed or another wear surface used, the hammers should be placed in the same locations they were removed from. New hammers to be used must be balanced per the instructions given in Section F.5. of this manual. Install the new hammers in the opposite sequence of removal, making sure to orient the hammers correctly for the direction of rotation. TerraSource recommends that new hammers be installed before going to the next row, this will keep the rotor somewhat balanced. After all hammers and the hammer pin is back in place, carefully remove the rotor friction lock or blocking, being aware that there can exist a slight imbalance due to the combination of worn & new parts until all hammers in all rows have been replaced.

When all hammers have been replaced or reversed, make sure that all cotter pins, retaining rings, or retaining plates are correctly located or fastened to the rotor assembly at both ends (if fasteners are used, make sure all bolts are torqued per Section F.7.). Replace the access covers or shaft sealing plates, close-up the Crusher housing, and torque all fasteners to Section F.7. Install any other guards, covers, or access doors that may have been opened during the maintenance sequence.

Remove the Crusher Lockout. The Crusher is ready for operation.

F.6.e. Discharge Screen / Grate Maintenance

Jeffrey Rader Crushers utilize round hole plate screens or bar-type openings to form the grate section in the discharge area below the spinning Rotor with Hammers. These Discharge Grates will be manufactured in sections to make easier replacement, and to allow different opening sizes in the approx. 180 degree circumferential sweep area of discharge grates. Refer to the certified drawings provided with your equipment to see the recommended arrangement and orientation of the discharge grate parts, and contact TerraSource if additional clarification is needed. To replace the Discharge Screen / Grates in the Crusher, follow these general instructions:

1. **Lockout the Crusher & all necessary adjacent equipment.**

2. Open the Crusher housing to access the Hammers and Grates. In most cases, the Grates can be removed without first removing the Hammers from the Rotor, however, if Grate removal is scheduled at the same time as a Hammer change, there will be more access room for Grate removal and installation work. If the Hammers are to be removed, remove one row at a time until all rows have been removed, marking the hammers so that their original location is documented if the hammers will be reused. For additional information, see Section F.6.d.

3. Tighten the Rotor friction locks or block the rotor to prevent rotation.

4. Remove any side wear liners necessary to begin removing the Grates

5. Many Crushers will have a front and rear Breaker, which provides a transition wear surface between the Discharge Grates and the upper Housing wearplates. Remove the Breaker Bar.

6. Some Crusher will have one or more shim(s) located under the Breaker Bar. Note the number and location of each shim(s) and remove.

7. Begin removing the first Discharge Grate section by pulling upward along the circular track at each end of the Crusher. A hoist may be required in some installatons due to the mass of the Discharge Grate and/or to overcome packed material between the Discharge Grate and the circular track. As each piece is removed, note the size of each discharge grate opening and its orientation as removed from the Crusher.

8. Continue until all Discharge Grates / Screens have been removed.

9. Remove the opposite side Breaker Bar from the Crusher.

NOTICE

Make sure that all parts are oriented correctly for the direction of rotation of the Rotor and Hammers. If the parts are installed backwards, higher power consumption, plugging, lower infeed rates, and improper discharge sizing are possible.

Carefully clean all parts of the circular track on each end of the Housing. Inspect all parts that have been removed for wear. Breaker Bars can be rotated so that a fresh leading edge is oriented towards the inside of the unit against the direction of rotation. Make sure

that all shims that will be reused are in good shape. Reassembly is the reverse of disassembly.

F.6.f. Wear Liner Maintenance

Due to the highly abrasive nature of many materials that will be processed in the Crusher, particular attention must be paid to the Wear Liners located throughout the unit. Some Wear Liners will wear very quickly, others will take longer to wear to the same point. Renewable liners are furnished at all locations that can wear. These liners should be replaced if worn to the extent that they no longer protect the main parts and frame of the Crusher. Follow these general instructions:

1. **Lockout the Crusher & all necessary adjacent equipment.**

8. Open the Crusher housing. Locate the wear liners to be replaced.

9. If necessary, remove the Crusher Hammers (Section F.6.d.) and/or Discharge Screens/Grates (Section F.6.e.) to allow access to the liners to be replaced.

10. If the worn liner is of sufficient size and weight, rig a lifting and support system with come-along or chain-fall hoist. Remove the worn liners by loosening and removing the bolted fasteners holding the liner in place.

11. Install the new liner with new fasteners. Fully torque the fasteners to the levels shown in Section F.7. of this manual.

12. Reinstall any Hammers or Discharge Screens / Grates that were removed.

13. Install any other guards, covers, or access doors that may have been opened during the maintenance sequence.

14. Remove the Crusher LockOut. The Crusher is ready for operation.

F.7. Bolt Torque Specifications

During the course of maintenance on the Crusher, it is very important to torque all bolted fasteners to the proper levels to avoid loosening in service. All bolted fasteners on the Crusher are SAE Grade 5. Any replacement fastener must be equivalent to the bolt it replaces. All specifications below are for lubricated threads.

Imperial Sized Fasteners

Bolt Size	SAE Grade 2	SAE Grade 5	SAE Grade 8
1/4- 20 UNC	4.2 ft-lb [5.7 N-m]	6.3 ft-lb [8.5 N-m]	9.0 ft-lb [12.2 N-m]
1/4- 28 UNF	4.7 ft-lb [6.4 N-m]	7.2 ft-lb [9.8 N-m]	10.0 ft-lb [13.6 N-m]
5/16- 18 UNC	8 ft-lb [11 N-m]	13 ft-lb [18 N-m]	18 ft-lb [24 N-m]
5/16- 24 UNF	9 ft-lb [12 N-m]	14 ft-lb [19 N-m]	20 ft-lb [27 N-m]
3/8- 16 UNC	15 ft-lb [20 N-m]	23 ft-lb [31 N-m]	35 ft-lb [47 N-m]
3/8- 24 UNF	17 ft-lb [23 N-m]	25 ft-lb [34 N-m]	35 ft-lb [47 N-m]
7/16- 14 UNC	24 ft-lb [33 N-m]	35 ft-lb [47 N-m]	50 ft-lb [68 N-m]
7/16- 20 UNF	27 ft-lb [37 N-m]	40 ft-lb [54 N-m]	60 ft-lb [81 N-m]
1/2- 13 UNC	35 ft-lb [47 N-m]	55 ft-lb [75 N-m]	80 ft-lb [108 N-m]
1/2- 20 UNF	40 ft-lb [54 N-m]	65 ft-lb [88 N-m]	90 ft-lb [122 N-m]
9/16- 12 UNC	55 ft-lb [75 N-m]	80 ft-lb [108 N-m]	110 ft-lb [149 N-m]
9/16- 18 UNF	60 ft-lb [81 N-m]	90 ft-lb [122 N-m]	130 ft-lb [176 N-m]
5/8- 11 UNC	75 ft-lb [102 N-m]	110 ft-lb [149 N-m]	160 ft-lb [217 N-m]
5/8- 18 UNF	85 ft-lb [115 N-m]	130 ft-lb [176 N-m]	180 ft-lb [244 N-m]
3/4- 10 UNC	130 ft-lb [176 N-m]	200 ft-lb [271 N-m]	280 ft-lb [380 N-m]
3/4- 16 UNF	140 ft-lb [190 N-m]	220 ft-lb [298 N-m]	310 ft-lb [420 N-m]
7/8- 9 UNC	125 ft-lb [169 N-m]	320 ft-lb [434 N-m]	450 ft-lb [610 N-m]
7/8- 14 UNF	140 ft-lb [190 N-m]	350 ft-lb [475 N-m]	500 ft-lb [678 N-m]
1-8 UNC	190 ft-lb [258 N-m]	480 ft-lb [651 N-m]	680 ft-lb [922 N-m]
1-14 UNF	210 ft-lb [285 N-m]	540 ft-lb [732 N-m]	760 ft-lb [1030 N-m]
1 1/8- 7 UNC	270 ft-lb [366 N-m]	590 ft-lb [800 N-m]	970 ft-lb [1315 N-m]
1 1/8- 12 UNF	300 ft-lb [407 N-m]	670 ft-lb [908 N-m]	1080 ft-lb [1464 N-m]
1 1/4- 7 UNC	380 ft-lb [515 N-m]	840 ft-lb [1139 N-m]	1360 ft-lb [1844 N-m]
1 1/4- 12 UNF	420 ft-lb [569 N-m]	930 ft-lb [1261 N-m]	1510 ft-lb [2047 N-m]
1 1/2- 6 UNC	650 ft-lb [881 N-m]	1460 ft-lb [1979 N-m]	2370 ft-lb [3213 N-m]
1 1/2- 12 UNF	730 ft-lb [990 N-m]	1640 ft-lb [2224 N-m]	2670 ft-lb [3620 N-m]

Metric Sized Fasteners

Bolt Size	Class 8.8	Class 10.9	Class 12.9
M5 x 0.80	3.4 ft-lb [4.6 N-m]	4.9 ft-lb [6.6 N-m]	5.7 ft-lb [7.7 N-m]
M6 x 1.00	5.8 ft-lb [7.9 N-m]	8.3 ft-lb [11.3 N-m]	9.7 ft-lb [13.2 N-m]
M7 x 1.00	10 ft-lb [14 N-m]	14 ft-lb [19 N-m]	16 ft-lb [22 N-m]
M8 x 1.25	14 ft-lb [19 N-m]	20 ft-lb [27 N-m]	24 ft-lb [33 N-m]
M10 x 1.50	28 ft-lb [38 N-m]	40 ft-lb [54 N-m]	47 ft-lb [64 N-m]
M12 x 1.75	49 ft-lb [66 N-m]	69 ft-lb [94 N-m]	81 ft-lb [110 N-m]
M14 x 2.00	78 ft-lb [106 N-m]	111ft-lb [150 N-m]	130 ft-lb [176 N-m]
M16 x 2.00	121 ft-lb [164 N-m]	172 ft-lb [233 N-m]	202 ft-lb [274 N-m]
M18 x 2.50	167 ft-lb [226 N-m]	238 ft-lb [323 N-m]	279 ft-lb [378 N-m]
M20 x 2.50	235 ft-lb [319 N-m]	337 ft-lb [457 N-m]	394 ft-lb [534 N-m]
M22 x 2.50	321 ft-lb [435 N-m]	460 ft-lb [624 N-m]	537 ft-lb [728 N-m]
M24 x 3.00	407 ft-lb [552 N-m]	582 ft-lb [789 N-m]	681 ft-lb [923 N-m]
M27 x 3.00	597 ft-lb [809 N-m]	854 ft-lb [1158 N-m]	998 ft-lb [1353 N-m]
M30 x 3.50	809 ft-lb [1097 N-m]	1158 ft-lb [1570 N-m]	1353 ft-lb [1834 N-m]
M33 x 3.50	1101 ft-lb [1493 N-m]	1576 ft-lb [2137 N-m]	1842 ft-lb [2497 N-m]
M36 x 4.00	1415 ft-lb [1918 N-m]	2024 ft-lb [2744 N-m]	2366 ft-lb [3208 N-m]

The work performed and the physical unbalance of the rotating crushing member will cause vibration. This vibration can damage bearings, foundations, and shake nuts and bolts loose in a matter of hours. Bolted fasteners play a critical part in the operation of the Crusher. Because of the high speed, rotating and vibrating conditions that the Crusher sees during operation, fasteners must be checked for proper tightness at the recommendations specified in Section F.1. Keeping the vibration low through proper preventative maintenance and attention to the removal of tramp before the Crusher infeed can greatly reduce bolt loosening and manpower associated to retightening fasteners. When bolts loosen, vibrations in the structure, foundations, bearings, etc. can increase the loads to the point of failure of the bolts and all components.

Improperly tightened fasteners can fail very quickly. Properly sized fasteners that are also properly torqued do not prematurely loosen. During maintenance sequences, if bolts, nuts, or washers are damaged by cracks, elongation, reduction of area, or other deformations, they must be replaced. This is extremely important were the external and internal thread form is concerned. If the two elements are not easily assembled by hand, the amount of torque used to assemble them increases, reducing the amount of preload that the fastener can clamp the parts together with.

Whenever fasteners must be removed and installed, a calibrated and certified torque wrench must be used. Always follow the instructions given in Section F.1. on checking bolted fasteners in the Crusher installation. During the first week of operation, all bolted fasteners must be checked on a daily basis to insure proper clamp load. Critical areas to check are the bearing hold down bolts, split cap bolts, and main housing and foundation bolts. Note that on the header plate that Helicoil inserts are used to maintain thread integrity.

F.8. Special Tools

The following special tools are required and/or helpful in working on Jeffrey Rader Crushers.

- A set of large size wrenches and sockets
- Large capacity torque wrenches
- Bearing spanner wrench for tightening Bearing Locknut
- A slide hammer to help pull the Hammer Pins out of the Rotor Assembly.
- Cable puller / come-along to pull the Hammer Pins out of the Rotor Assembly
- Hydraulic Bearing Removal Pump kit, including hand pump, hoses, & fittings for bearing replacement

F.9. Troubleshooting Guidelines

TROUBLE	PROBABLE CAUSE	SOLUTION
1. Crusher will not operate.	1. No electrical power.	1. Check fuses and replace if blown. 2. Check wiring for broken or loose connections and repair if necessary.
	2. Motor burned out.	1. Replace motor.
	3. Crusher bearing seized.	1. Check oil or grease supply and replace bearing.
	4. V-Belts broken.	1. Replace belts and check for cause (see V-BELT MAINTENANCE).
	5. Material blocking or bridged.	1. Lock out disconnect switch and inspect inside of crusher. Remove blockage if necessary. Relieve bridging.
	6. Mechanical interference inside crusher.	1. Lock out disconnect switch and inspect inside of crusher. Remove interference and repair any damaged parts.
2. Low crushing capacity.	1. Insufficient feed.	1. Check feed system for malfunction and correct as required.
	2. Incorrect rotor speed.	1. Check original assembly drawing for correct speed and revise if different from actual running speed.
	3. Wet, sticky material.	1. Eliminate from feed.
	4. Hammers, impeller, rotor badly worn.	1. Rebuild if necessary. Check to see that feed is uniform across crusher opening or rotor width.
	5. Belts slipping.	1. Readjust belt tension.
	6. Discharge restricted due to material build-up caused by insufficient takeaway capacity.	1. Clean out discharge. Redesign of discharge chutes may be necessary or increase takeaway capacity.
	7. Feed not uniform across opening.	1. Correct feed system to deliver material uniformly across feed opening.
	8. Insufficient motor horsepower.	1. Increase horsepower. Check with your Jeffrey Rader Representative for the maximum allowable horsepower.
	9. Feed blocked.	1. Clean out infeed. Redesign of feed chute may be required or reduce rate.
3. Excessive vibration	1. Crusher anchor bolts loose.	1. Re-torque anchor bolts (see THREADED FASTENERS section).
	2. Foundation not solid or uneven.	1. Check foundation and repair.
	3. Rotor out of balance.	1. Rebalance rotor (see BALANCING).
	4. Broken or missing hammers.	1. Replace and rebalance (see BALANCING).
	5. Shafts misaligned.	1. Realign shafts.
	6. Bearing hold-down bolts loose.	1. Re-torque bolts.

TROUBLE	PROBABLE CAUSE	SOLUTION
4. Excessive wear.	1. Feed not uniform across opening.	1. Correct feed system to deliver material uniformly across feed opening.
	2. Tramp material in feed.	1. Take measures to eliminate tramp material.
	3. Abrasive feed material.	1. Remove abrasives from feed.
5. Bearings overheating.	1. Insufficient lubricant.	1. Check lubrication system and correct any blockages.
	2. Lubrication deteriorated or contaminated.	1. Clean bearings and replace lubricant.
	3. Incorrect internal clearance.	1. Check and readjust if required (see BEARINGS – Repair section).
	4. Bearing over-loaded due to bent shaft.	1. Repair or replace shaft as necessary.
	5. Wrong lubricant for bearing operating temperature.	1. Change lubricant.
	6. Misaligned bearings.	1. Check clearance between shaft and seal with a feeler gauge. Clearance should be the same at 90 degree intervals around the shaft on line seals. Note the drag on the gauge as it is pulled out. This drag should be the same at 90 degree intervals around the shaft at each bearing. Readjust housings in slotted holes if misalignment is found.
6. Undersize product.	1. Screen openings too close.	1. Increase screen openings.
	2. Rotor speed too fast.	1. Decrease rotor speed for most materials. For some materials, this will not work. Consult TerraSource before any speed change.
	3. Too many hammers.	1. Reduce number of hammers evenly around rotor, so that balance is maintained. This is not always possible, and for some applications not desirable. Consult TerraSource before changing hammer arrangement.
7. Oversize product.	1. Screen openings too far apart.	1. Decrease screen openings.
	2. Rotor speed too slow.	1. Increase rotor speed for most materials. However, on some materials this will not work. Consult TerraSource before any speed change.
	3. Worn hammers or rotor.	1. Rebuild or replace hammer or rotor as necessary.
	4. Too few hammers.	1. Increase hammers evenly around rotor so that balance is maintained. This is not always possible, and for some applications, not desirable. Consult TerraSource before changing hammer arrangement.

G. Recommended Spare Parts

The following items are recommended spare parts that should be kept on hand at all times. The complete callout for the following items can be found in the Certified and Parts List drawings for this job, and are included as part of this manual. This includes necessary ordering information, including drawing numbers (part numbers) that are required to fill orders. When ordering spares, it is helpful to have the original TerraSource / Jeffrey Rader / Jeffrey Job Number and Model Number from the metal nameplate located on the Crusher frame.

Many parts of the Crusher are made special for TerraSource, using special tolerances and materials. Contact your TerraSource product representative for all replacement parts. It is suggested that high-wear items such as hammers, impeller bars, breaker bars, screen bars, and breaker plate liners, be ordered well in advance. Not all items are stocked. Those parts, which are in stock, are subject to prior sale and may be unavailable when you require them. A regular review of your maintenance log will suggest parts that you should have on hand in the event of an unexpected failure.

Drive Appendix

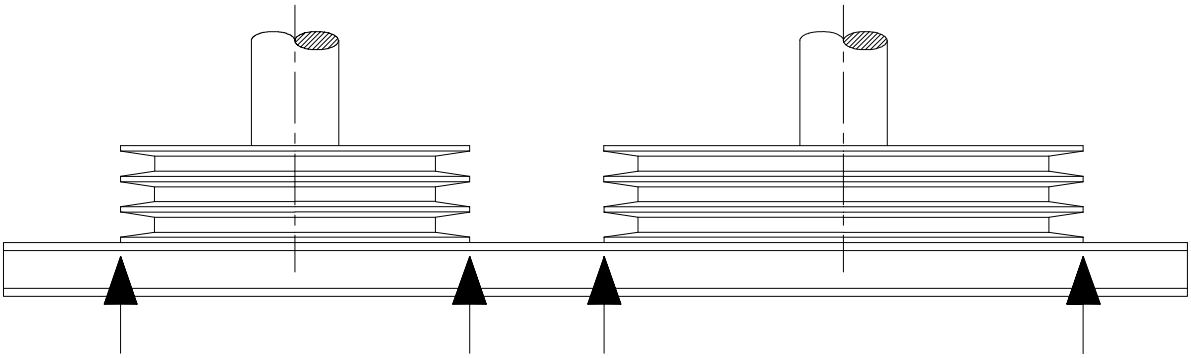
The power transmission device connecting the driving motor to the driven crusher is a key link in all crushing systems. Improper installation and poor maintenance of drive equipment will inevitably cause needless shutdowns due to equipment failure.

Installing V-Belts:
V-Belt and Sheave drives are very common method of driving equipment, they are extremely flexible in controlling speed and will take a lot of abuse. In many installations, a V-Belt Drive can act as a torque overload device, preventing or controlling the amount of torque that can be put into equipment by slipping, thereby notifying the operator that adjustment may be needed, or that an overload is occurring. Improper alignment, insufficient tension and incorrect belt matching are the three most common causes for premature failure, yet are the easiest to overcome.

⚠ WARNING

This equipment can cause death or severe personal injury if all safety precautions are not taken. Lockout/Tagout this equipment anytime inspection or maintenance is to be performed. All procedures listed in this section require Lockout before proceeding, unless otherwise noted.

Alignment of sheaves is achieved by using an accurate straight edge or tightly stretched chalk line.



STRAIGHTEDGE TOUCHES SHEAVES AT ALL POINTS INDICATED BY ARROWS

Level the drive motor shaft in the same way the rotor shaft was leveled (see Section C.3.). This will insure that sheaves are angularly aligned. Next, place the straight edge or chalk line across the face of one pulley and check the other pulley for axial and parallel alignment. Since any misalignment will decrease belt life, the time spent for nearly perfect alignment at installation will repay itself by reducing downtime and maintenance costs. Sheaves should be pushed onto the shafts as far as possible, to reduce overhung load on the bearings. Fully tighten the sheave bushings, and double check the alignment as stated above, repeat the alignment process as required to ensure as perfect alignment as possible.

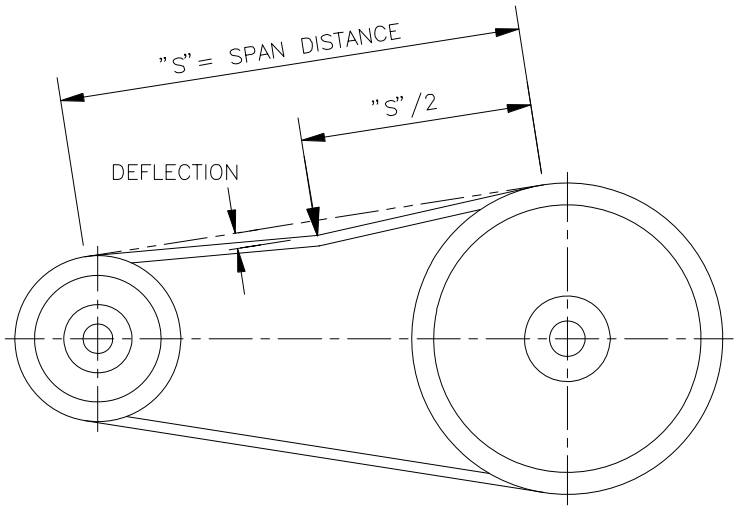
Inspect the V-Belts before installation on the sheaves. On multiple V-Belt installations, new V-Belts should be checked for the proper length, or “Matched” or to ensure that when the V-Belts are tensioned, that each belt is approximately equal in tension and horsepower carrying capability. If V-Belts are to be re-used, check each belt for cracks, splits, tears, worn coverings, or other defects that may cause a shortened V-Belt life. If in doubt, use new V-Belts. It is not recommended to mix worn and new V-Belts in a single drive.

When installing the driving belts on the aligned sheaves, move the adjustable drive base to reduce the shaft center distance as much as possible. Never stretch or force a belt over the sides of the sheave or grooves. Recheck the drive sheave alignment any time the motor base is moved. Place the belts in the sheave grooves, making sure all the slack in each belt is on the same side of the drive (see Figure 5). Adjust the centers to take

up the slack until the belts are fairly taunt and well-seated in the grooves. To correctly tension the V-Belts, use the following procedure:

1a. Measure the span length “S” as illustrated. Find the 1/2 way point of the span, and mark with a felt tip pen.

2a. Determine the amount of deflection required in inches by multiplying the span length “S” by 0.0156. For example, if the span distance is 80”, the amount of deflection required would be 80” x 0.0156 = 1.248” or almost 1 1/4”. In metric units, 2032mm x 0.0156 = 31.7mm. Stretch a string along the span distance “S”, and when the V-Belt is deflected and deflection force is measured, the string will act as a reference point allowing the measurement of the deflection.



3a. Using a simple spring scale or a belt tensioning tool, determine the amount of force necessary to deflect each V-Belt to the required deflection. If the V-Belts are banded together at the top, determine the force necessary for the group of belts, and divide the force by the number of belts to get the necessary force per belt. When applying the force to banded belts, lay a steel bar or narrow block of wood across the banding to distribute the force evenly to all belts. If more than one banded belt is used on a drive, do each band separately.

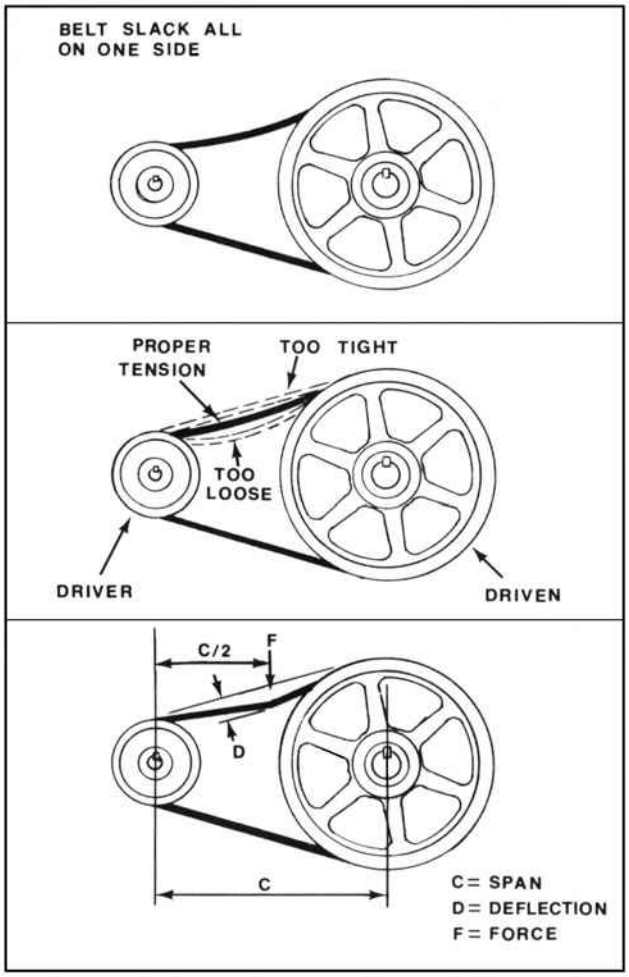
4a. While the following tables below can be used for general reference, TerraSource highly recommends that the latest manufacturer’s specifications be used for determining if the V-Belts are properly tensioned. If the sheave diameter range, RPM, or speed ration is not listed on this table, it is very important to contact the manufacturer for proper tensioning information. Adjust the belt center distances as required to achieve the proper deflection force for the proper amount of belt deflection. When using new V-Belts, it is advisable to tension to the maximum levels to compensate for some stretch of the V-Belts during the initial operation of the drive.

V-Belt Cross Section	Small Sheave Dia. Range in Inches	Small Sheave RPM Range	Speed Ratio Range	Deflection Force Lbs Minimum	Deflection Force Lbs Maximum
5VX	4.40 - 4.65 4.90 - 5.50 5.90 - 6.70 7.10 - 8.00 8.50 - 10.90 11.80 - 16.00	1200 - 3600 1200 - 3600 1200 - 3600 600 - 1800 600 - 1800 400 - 1200	2.00 to 4.00	9.0 10.0 11.0 13.0 14.0 15.0	13.0 15.0 17.0 19.0 20.0 23.0
5V	7.10 - 8.00 8.50 - 10.90 11.80 - 16.00	600 - 1800 600 - 1800 400 - 1200	2.00 to 4.00	11.0 13.0 14.0	16.0 18.0 21.0
8V	12.50 - 17.00 18.00 - 24.00	600 - 1200 400 - 900	2.00 to 4.00	28.0 32.0	41.0 48.0
B & BX	4.6 5.0 - 5.2 5.4 - 5.6 6.0 - 6.8 7.9 - 9.4	1160 - 1800	2.00 to 4.00	5.1 5.8 6.2 7.1 8.1	7.4 8.5 9.1 10.0 12.0
C & CX	7.0	870 - 1800	2.00 to 4.00	9.1	13.0

	7.5 8.0 - 8.5 9.0 - 10.5 11.0 - 16.0			9.7 11.0 12.0 14.0	14.0 16.0 18.0 21.0
D & DX	12.0 - 13.0 13.5 - 15.5 16.0 - 22.0	690 - 1200	2.00 to 4.00	19.0 21.0 24.0	27.0 30.0 36.0

5a. After the V-Belt drive has been properly tensioned, double check the alignment of the drive sheaves.

During the initial operation of the V-Belt drive, for the first week, monitor the tension of the V-Belts on a frequent basis. There will normally be a rapid drop in tension during this run-in period, and it may require re-tensioning the drive several times during the first week. During operation of the V-Belt drive, check that there is a slight bow in the slack side of the drive. During highly loaded operation, the slack will increase slightly, this can be used a visual guideline of the load on the equipment. Listen for any belt squeal at start-up and during operation. It is normal to hear a small amount of belt squeal during start-up of some machinery, especially when starting high inertia loads. Under no circumstances should any belt squeal be heard at loaded conditions. During maintenance service, with the equipment properly locked out, check the temperature of the sheaves in the V-Groove. If the temperature is above 140° F. (60° C), and the heat cannot be explained from another source, then the drive is slipping and should be re-tensioned.



Use the following guidelines for long life on V-Belt Drives:

- Check alignment of sheaves. Shaft should be parallel.
- Maintain uniform tension. Idle belts should appear snug: in motion they have a slight sag on slack side.
- Avoid heat. Above 140F (60C) rubber is over-cured and belt life is shortened.
- Keep drives well ventilated. Avoid heat build-up.
- Never mix belts on drive. Use new belts of the same brand.
- Always use matched sets of belts.
- Never use belt dressing, as this makes belts soft, reducing life.
- Worn sheaves reduce belt life. Check sheaves frequently.
- Oil bearings carefully. Oil accidentally spilled on belts cause rubber to swell and belts to fail prematurely.
- Never force belts onto sheaves. Always release the take-up.
- Equalize slack before tightening: all the slack should be at the top

TROUBLE – WHAT TO LOOK FOR – HOW TO CORRECT IT:

Loss in Driven Speed
Check for slip. Shut down drive – test sheave temperature by feel. A slipping belt will heat sheave excessively.
Check for proper tension.

Localized Wear:
Check belt cross section dimensions. If narrow – pulley is spinning.
If full – internal breakdown with resultant swell.

Unequal Stretch
Internal breaks. Broken strength member.

Excessive Elongation
Check for overload. Check for internal breaks. Check amount for take-up since initial installation.

Ply Separation
Excessive tension, if premature. Defective belt.

Opening of Cover Seams
Check for oil or rubber solvent on belt.

Abnormal Cover Wear
Check for worn sheave, slip, heat, chemical fumes, obstructions or abrasive condition.

Belt Softening or Swelling
Check for oil or rubber solvent.

Belt Cover Hardening and Cracking
Check for excessive heat and chemical fumes.

Some additional tips to achieve the best results and longest life from a V-Belt Drive:

- The best tension for a V-Belt drive is the lowest tension at which the belts will not slip under the highest load condition.
- Too much tension shortens V-Belt and bearing life.
- Keep V-Belts and sheaves clean and free of any foreign materials that can cause slippage.
- Do not use V-Belt Dressings
- If a V-Belt slips, go through the tensioning procedure. Do not allow the V-Belt to continue to slip
- Periodically check the sheaves for wear or damage to the V-Groove. A V-Groove that is worn and allows the V-Belt to sit into the bottom of the groove cannot be expected to transmit is normal amount of horsepower.
- Avoid heat build-up in the belts by keeping the drive well ventilated.
- Contact Jeffrey Rader or the V-Belt supplier for questions or problems with a V-Belt drive.

Info. from: Gates Heavy Duty V-Belt Drive Design Manual 14995-A, ©1999 Gates Rubber Company, Denver CO

Installing Flexible Couplings:

⚠ WARNING

This equipment can cause death or severe personal injury if all safety precautions are not taken. Lockout/Tagout this equipment anytime inspection or maintenance is to be performed. All procedures listed in this section require Lockout before proceeding, unless otherwise noted.

Crushers that operate on a one-to-one speed ratio with the drive motor can use a flexible coupling to transmit torque. The following instructions apply to sizes 60T thru 140T Falk Steelflex Tapered Grid Couplings. For other coupling types, consult manufacturers' instruction manuals. Only standard mechanics tools, wrenches, a straight edge and feeler gages are required to install Falk Steelflex couplings. Falk Couplings sizes 60 thru 90 are furnished for clearance fit with set screws. Sizes 100 and larger are furnished for an interference fit without set screws. Heat hubs with interference fit in an oil bath to a maximum of 275F (135C) to mount. The oil flashpoint must be 350F (177C) or higher.

1b. Mount Seals and Hubs – Clean all metal parts using a nonflammable solvent. Lightly coat seals with grease and place on the shafts before mounting hubs. Mount heated hubs on their respective shafts so the hub face is flush with the end of its shaft. Tighten the set screws.

⚠ WARNING

Use care in handling heated hubs to avoid injury due to burns.

2b. Gap and Angular Alignment – Use a spacer bar equal in thickness to the normal gap specified in the Table below. Insert the spacer bar to the same depth at 90 degree intervals around the hub and measure the clearance between the bar and the hub face with feeler gages. The difference in minimum and maximum measurements must not exceed the ANGULAR limit specified in the Table below.

COUPLING SIZE	GAP – IN (MM)			ALIGNMENT LIMITS – IN (MM)		COVER BOLT TORQUE IN – LBS. (NEWTON-M)	MAX SPEED RPM
	MIN	NORMAL	MAX	OFFSET (MAX)	ANGULAR (MAX)		
60T	.062(1.59)	.125(3.17)	.188(4.77)	.010(.254)	.010(.254)	200(22.6)	4350
70T	.062(1.59)	.125(3.17)	.188(4.77)	.010(.254)	.010(.254)	200(22.6)	4125
80T	.062(1.59)	.125(3.17)	.250(6.35)	.010(.254)	.010(.254)	200(22.6)	3600
90T	.062(1.59)	.125(3.17)	.250(6.35)	.012(.305)	.012(.305)	200(22.6)	3600
100T	.062(1.59)	.188(4.77	.375(9.52)	.012(.305)	.012(.305)	260(29.4)	2440
110T	.062(1.59)	.188(4.77)	.375(9.52)	.012(.305)	.012(.305)	260(29.4)	2250
120T	.062(1.59)	.250(6.35)	.500(12.7)	.012(.305)	.012(.305)	650(73.4)	2025
130T	.062(1.59)	.250(6.35)	.500(12.7)	.012(.305)	.012(.305)	650(73.4)	1800
140T	.062(1.59)	.250(6.35)	.500(12.7)	.015(.381)	.015(.381)	650(73.4)	1650

3b Offset Alignment – Align the motor shaft with hub so that a straight edge rests squarely (or within the limits of the Table above) on both hubs at 90 degree increments around the hubs. Check this alignment with a feeler gage. The clearance must not exceed the OFFSET limit specified in the Table. Tighten all motor mounting

bolts and repeat steps 2 and 3. Realign the coupling if necessary. Note: Use a dial indicator for more accurate alignment measurements.

4b. Insert Grid – Before inserting the coupling grid, pack the gap between the hub faces and the grooves of the hubs with grease recommended in the Section F.3. When grids are furnished in two or more sections, install them so that all cut ends extend in the same direction; this will permit cover installation. Spread the grid slightly to pass it over the coupling teeth and set the grid(s) with a soft mallet.

5b. Pack with Grease and Assemble Covers – Pack the spaces between and around the grid with as much grease as possible and wipe off excess flush with the top of the grid. Position the seals on the hubs to line up with grooves in the cover. Position the gaskets on the flange of the lower cover half and assemble the covers so that the match marks are on the same side. Secure the cover halves with fasteners and tighten to the torque specified in the Table above. Make certain that the lubrication plugs are installed in their holes and the coupling guard is reinstalled before removing the LockOut/TagOut.

⚠ WARNING

This equipment can cause death or severe personal injury if all safety precautions are not taken. Lockout/Tagout this equipment anytime inspection or maintenance is to be performed. All procedures listed in this section require Lockout before proceeding, unless otherwise noted.

6b. Periodic Lubrication – After proper LockOut/TagOut, remove the coupling guard and remove both lubrication hole plugs and insert grease fitting. Fill with the recommended or equivalent lubricant until an excess appears at the opposite lubrication hole. Make certain that the lubrication plugs are installed in their holes and the coupling guard is reinstalled before removing the LockOut/TagOut.

7b. Coupling Disassembly and Grid Removal – When it is necessary to disconnect the coupling, after proper LockOut/TagOut, remove the cover halves and grid. A round rod or screwdriver that will conveniently fit into the open loop ends of the grid is required. Begin at the open end of the grid section and insert the rod or screwdriver into the loop ends. Use the teeth adjacent to each loop as a fulcrum and pry the grid out radially in even, gradual stages, proceeding alternately from side to side.

Bearing Appendix

Additional Information for working with Bearings on Jeffrey Rader Crushers

1. Split Sleeves: The two halves of a split sleeve bearing are machined in pairs and must be stocked and installed as a pair. The halves are not interchangeable.

   To replace, remove the bearing housing cap on each end of the shaft. (It will be necessary to lift the shaft slightly in order to remove the lower half of the sleeve.)

   Clean and deburr the housing before installing the new sleeve. Check your parts list drawing to assure that all dowel pins, end caps and grease fittings are in place. Lightly coat the outside surface of each half of the sleeve with a soft grease.

2. Anti-friction Bearing (one-piece housing): The mounting and dismounting instructions are as follows: Mounting and Dismounting.

   (a) Check the surface of the shaft and its ends for burrs. Lightly coat the shaft with a graphite and oil solution or a soft grease.

   (b) Slip the bearing with housing on the shaft, position it on the support, and bolt the housing securely in place.

   (c) Tighten both locking collar setscrews firmly onto the shaft. This assures positive shaft location.

   (d) To dismount, reverse the above procedure.

3. Anti-friction Bearings (split housing): The anti-friction bearings used on Jeffrey Rader crushers are mounted on the shaft with an interference fit. This is accomplished either by using a tapered seat on the shaft, or by shrinking the bearing on a straight shaft seat. Also on relatively few bearings, a tapered adapter sleeve is used. The degree of interference or forced fit depends on bearing size and type.

   If a bearing must be removed and is suitable for further service, the same care must be used as for mounting a new bearing. Normally, if a bearing that is serviceable must be dismounted, work on the rotating crushing member between the bearings may be required. Therefore, removal of the complete assembly with the pillow blocks intact is preferable. The assembly can then be moved to a suitable work area for dismounting the bearings.

   The following instructions are for dismounting a single bearing, with the same rotating member in place in the crusher. To dismount a serviceable bearing, begin with adequate and proper tools.

   (a) Study parts list drawings until you are familiar with the assembly.

   (b) Thoroughly clean the outside of the housing and the area around it.

   (c) For units equipped with bearing fill blocks (see Figure 2, page 5) remove the housing hold-down bolts from both bearings. Raise the shaft and pillow block just enough (1/16 to 1/8 in. or 1.56 to 3.125 mm) so the fill block can be removed. Remove the fill block and support the bearing housing base so it will not drop when the cap is removed.

   (d) Unbolt the shrouds on each side of the housing (if so equipped) and slide them out and away from the housing. (See parts list drawings.) Remove the housing cap and lower the housing base and remove this base. (NOTE: Fill blocks and housing parts can be very heavy and may require lifting equipment.)

   (e) For units without bearing fill blocks, remove the bearing housing hold-down bolts from the housing on each side of the crusher. Remove any covers, crusher housing parts, or internal liners that would

prevent the shaft and each pillow block from being raised to a distance equal to the drop of the pillow block (dimension from the center line of shaft to the bottom of the housing). Raise the shaft and support it in place on each side of the crusher. Leave the housing, in which the bearing to be dismounted is located, free so that the cap and base can be removed.

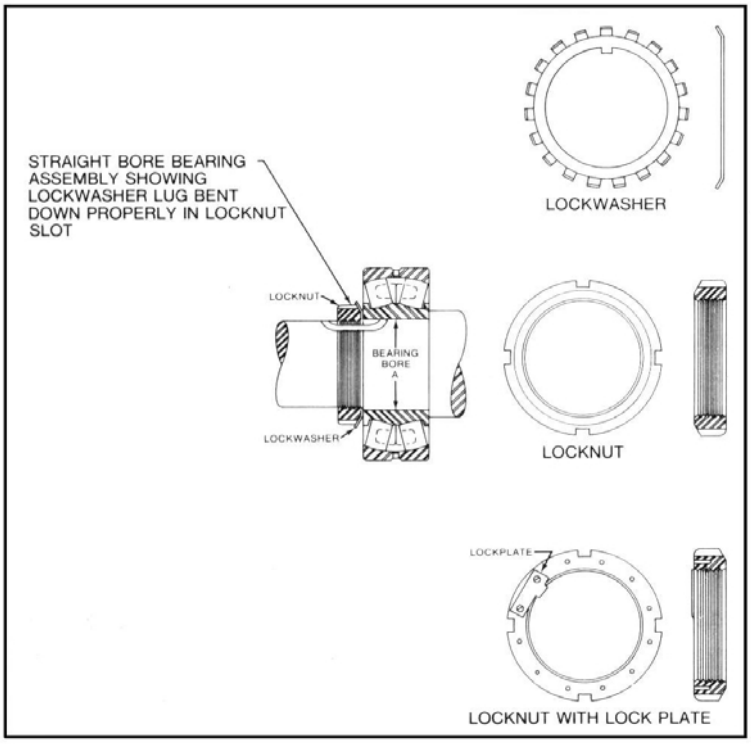
(f) Provide adequate protection and clean surrounding for parts after removal. (If a part requires cleaning, do it before storing with clean parts.) Wrap the bearing in clean oil-proof paper while awaiting re-assembly.

(h) Bend the tang of the lockwasher out of the locknut before attempting to remove the locknut. Some locknuts are equipped with a lock plate instead of a washer; this lock plate must be removed (see Figure 9). Always use a new lock washer when reassembling.

(i) Rotate the locknut counter clockwise (when looking toward the shaft end) and leave locknut on the shaft. The bearing cannot be removed from the shaft seal or adapter. (See HYDRAULIC DISMOUNTING.)

(j) When removing a serviceable anti-friction bearing with an interference fit, NEVER pull or apply force through the outer ring to move the inner ring. ALWAYS apply the required force evenly to the inner ring.

If the bearing is unserviceable, or will never be reused, it can be dismounted by any method THAT WILL NOT DAMAGE THE SHAFT.



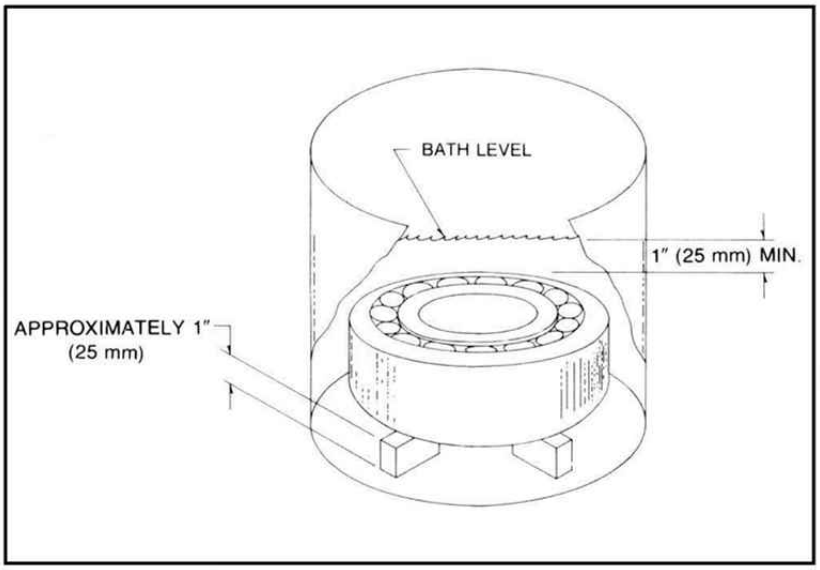
4. Mounting Cylindrical Bore Bearings: All cylindrical bore anti-friction bearings used in Jeffrey Rader crushers are mounted with an interference fit. To prevent bore and shaft damage, they are heated (expanding the bore enough to be slipped onto the shaft) and then allowed to shrink onto the seat. The same procedure is recommended for field mounting. Heating should only be done by submerging the bearing in a clean bath consisting of 20% soluble oil in water (one part oil to four parts water by volume). Set the bearing on spacers or a rack to keep it about one inch (25mm) off the bottom of the container and fill the container to a minimum of one inch (25mm) over the bearing (see Figure 20). Slowly bring the bath mixture to a boil and allow sufficient expansion for it to be slipped over the shaft seat.

With the bearing setting off the bottom of the container, and covered with the oil-water mixture, it cannot be overheated. The mixture is not flammable, drains off easily and leaves an oil film. The film is sufficient for rust protection while assembling the complete pillow block, provided the bearing is to be immediately installed.

⚠ WARNING

The Bearing will be at about 215^{O} - 230^{O} F. (102^{O} – 110^{O} C.). Hand protection must be used when handling heated Bearings.

NOTE: The oil bath level should be at least one inch (25 mm) above the bearing. The container and bath mixture must be clean and free of all corrosive materials.



⚠ WARNING

The boiling point for the oil / water mixture will be 215^{O} - 230^{O} F. (102^{O} – 110^{O} C.). Use extreme care when handling the container and the Bearings.

Leave the bearing in the boiling bath until all steps leading to the actual placement of the bearing on the shaft have been completed. Check and recheck parts list drawing to assure all parts that assemble around the shaft on the inboard side of the bearing are in place. Remove bearing from the boiling bath and allow excess mixture to drain. Quickly but carefully align the bearing and shaft, and slip the bearing onto its seat and firmly against the shaft shoulder or spacer. With the lockwasher, locknut and spanner wrench, clamp the bearing tight. As the bearing cools, tighten the locknut to remove the small axial shrinkage of the inner ring. Do this several times until the temperature of the bearing is about the same as that of the shaft. When the bearing cools down, tighten the locknut with a spanner wrench and a hammer. Tighten the locknut so a tab on the lockwasher lines up with the slot in the locknut. Bend this tab down into the slot to keep the locknut from backing off.

Slowly rotate the outer ring and bring the ring and the rollers into correct relative position with the inner ring. **Do not use force.** Check parts list drawings. Reassemble the remaining parts and lubricate properly (see Section F.2 for Lubrication information).

5. Mounting Tapered Bore Bearings: The fit of bearings with a tapered bore is determined by the amount the bearing is forced onto the tapered seat of the shaft or adapter sleeve. This lateral movement up the taper expands the inner ring, reducing the internal radial clearance or looseness of the bearing rollers. The reduction of this clearance by a pre-determined amount for a given bearing is the determining factor for the proper bore to shaft fit. Therefore, the un-mounted internal radial clearance for the bearing must be known.

To determine the internal radial clearance of an unmounted spherical roller bearing. Stand the bearing upright on the outer ring and block it to prevent rolling. With one hand, rotate the inner ring in a back and forth motion on the rolls to properly seat them on the inner ring, the outer ring against the center guide ring between the two rows of rollers. While doing this, keep the correct relative position between the inner and outer rings. Use a feeler gage .003 or .004 in. (.076 or .102 mm) thick, with a usable length longer than the rollers in the bearing. Insert this blade between the two (2) uppermost rollers in the same row to approximately 1/8 – 1/4 in. (3.125 – 6.25 mm) beyond the inside end of the rollers. With the blade against the inside surface of the outer ring, slide it toward the uppermost roller. The blade should slip between this roller and the inside of the outer ring. Repeat with the next .005 in. (.0127 mm) thicker blade until one will not pass. (DO NOT FORCE). Bring the blade that will not pass up against the uppermost roller and outer ring. Then with the other hand on the inner ring. SLOWLY AND GENTLY rotate the roller directly under the feeler blade. Now, with a combined swiveling motion and a slight snap or whip, withdraw the blade. If the blade seems to become looser during the swiveling and withdrawal, repeat with the next .0005 in. (.0127 mm) thicker blade. The un-mounted internal radial clearance for this bearing will be the thickness of the blade that can be swiveled and withdrawn when the next thicker blade jams.

Repeat this same procedure in at least two (2) other locations by resting the bearing on a different spot on the outer ring, and measuring over different rollers in the row. Either repeat this procedure for the other row of rollers or measure each row alternately using the same procedure. An accurate, constant measurement is required.

Rewrap the bearing and store in a clean, dry area until it is mounted. Should the bearing become dirty or contaminated while measuring the clearance, it should be cleaned before being rewrapped (see CLEANING).

6. Seating and Internal Reduction. (Dry Mounting): Check your parts list drawing to see that all parts that must be mounted around the shaft inboard of the bearing are in place. Coat the shaft or sleeve seat with a very light film of oil. (Leave the surface between the sleeve and shaft clean and dry.) Check the proper location of the sleeve. Place the bearing on the tapered shaft seat or adapter sleeve seat. With a firm, steady motion, move the bearing up the taper as far as it will go. If the bearing comes to a solid, hard stop, the inner ring bore is in metal-to-metal contact with the seat. Internal reduction begins at this point with the forced axial movement of the bearing up the tapered seat.

   Dry mounting of smaller bearings without hydraulic assistance can be accomplished with a spanner wrench (never a drift or chisel), a hammer and the bearing locknut. Liberally coat the shaft or sleeve locknut threads and the contact surface between the bearing inner ring and the locknut with a mixture of a heavy lubricating oil and powdered graphite. With the locknut in contact with the bearing inner ring (leave the lockwasher out at this time), rotate the nut clockwise and force the bearing onto the seat. The axial movement will be approximately sixteen (16) times the required internal clearance reduction. Example, if .004 in. (0.1 mm), reduction is required, the inner ring will move .004 x 16 = .064 in. (0.1 x 16 = 1.6 mm) or approximately 1/16 in. (1.56 mm) from the metal-to-metal or zero point. As stated, the axial movement is only approximate. To insure the proper bearing clearance, the reduction of internal clearance must be measure before the estimated axial movement is reached. This prevents the bearing from being driven up too tight. (See Table 4 for proper reduction).

   The procedure for measuring the required reduction of the internal radial clearance during mounting is the same as described previously except for two situations that must be considered. One, the bearing inner ring is now rigidly connected to the shaft and cannot be easily rotated. The other is when the outer ring is unsupported; the weight of the bearing hanging on the inner ring means the unloaded rollers are now at the bottom of the bearing. The point of clearance is between the lowest roller and the inner ring due to the weight of the roller and outer ring. In small and medium size bearings, the roller weight can be overcome and lifted by the feeler blade. In large bearings where considerable roller weight is involved (some roller can weigh as much as 5-6 lbs or 2.2 – 2.7 kg), a means must be provided to raise the outer ring so the measurement can be made at the top of the bearing. (When reducing the internal clearance, the outer ring must be free.) Continue to reduce the internal clearance and continue the gauging procedure until the proper reduction is made. With large bearings, where the outer ring cannot be rotated

while measuring, the feeler blade must be passed through the clearance and withdrawn with the swiveling motion previously described for gauging un-mounted bearings.

Recommendations for Driving a Spherical Roller Bearing onto a Tapered Seat

Bearing Bore Mm		Reduction in Radial Internal Clearance inch (mm)		Minimum Permissible Final Clearance After Mounting Bearing with Clearance Inch (mm)
OVER	INCLUDING	MINIMUM	MAXIMUM	C3
40	50	.0010 (.0250)	.0012 (.0300)	.0012 (.0300)
50	65	.0012 (.0300)	.0015 (.0375)	.0014 (.0350)
64	80	.0015 (.0375)	.0020 (.0500)	.0016 (.0400)
80	100	.0018 (.0450)	.0025 (.0625)	.0020 (.0500)
100	120	.0020 (.0500)	.0028 (.0700)	.0025 (.0625)
120	140	.0025 (.0625)	.0035 (.0875)	.0030 (.0750)
140	160	.0030 (.0750)	.0040 (.1000)	.0035 (.0875)
160	180	.0030 (.0750)	.0045 (.1125)	.0040 (.1000)
180	200	.0035 (.0875)	.0050 (.1250)	.0040 (.1000)
200	225	.0040 ((.1000)	.0055 (.1375)	.0045 (.1125)
225	250	.0045 (.1125)	.0060 (.1500)	.0050 (.1250)
250	280	.0045 (.1125)	.0065 (.1625)	.0055 (.1375)
280	315	.0050 (.1250)	.0075 (.1875)	.0060 (.1500)
315	355	.0060 (.1500)	.0085 (.2125)	.0065 (.1625)
355	400	.0065 (.1625)	.0090 (.2250)	.0075 (.1875)
400	450	.0080 (.2000)	.0105 (.2625)	.0080 (.2000)
450	500	.0085 (.2175)	.0110 (.2750)	.0090 (.2250)

7. Lockwasher and Nut: After the proper clearance reduction is made, remove the locknut and wipe the shaft or sleeve threads, the face of the bearing inner ring, and the outside surface of the nut with a clean, lint-free paper to remove any excess oil and graphite mixture. Place the lockwasher on the shaft against the bearing ring with the inner prong toward the bearing and in the slot of the sleeve or keyway in the shaft. Replace the locknut with chamfered side toward the washer and bearing. With a spanner wrench and hammer, drive the nut up tight, but do not reduce the clearance of the bearing any further. Line up a slot in the locknut with the closest tab on the lockwasher in the tightening direction and bend the tap down into the slot (see Figure 9, page 24)

8. Cleaning Bearings:

⚠ CAUTION

Use extreme caution in the storage and handling of petroleum solvents, due to their explosive nature. Consult your local fire marshal or safety officer for safe storage and handling procedures of these potentially dangerous materials.

⚠ WARNING

Never energize the motor of a Crusher with the Bearing Cap removed, or when the Bearing has a flushing or cleaning fluid in the housing. Always rotate using an approved tool.

Oils and grease should be removed in the early stages of deterioration or contamination to avoid unnecessary difficulty.

Oils can be drained and the bearing flushed or washed with petroleum solvent. This solvent should then be thoroughly drained and the bearings rinsed with hot, light grade oil and drained before adding new lubricant.

Grease is more easily replenished with the new grease in the early stages of deterioration (provided the housing is so designed). However, bearings which are dismantled are more easily cleaned, in that solvents can be used more freely. Badly oxidized oil and grease require a very thorough cleaning. The following methods for cleaning can also be used for the lubrication system components.

(a) Cleaning Dismantled Bearings:
Place the bearings in a basket and suspend the basket in a clean container of petroleum solvent and soak (preferably overnight). When the lubricant is badly oxidized, place the bearing in hot (180-200 F, 82-93 C) light oil; agitating the basket with bearings occasionally through the oil and then let soak (preferably overnight).

Another method is to boil the bearing in a water-based emulsified cleaner, which is a water-diluted solvent blended with a coupling agent to form a cleaner with a higher and safer flashpoint. If this method is used, the bearing should be drained after soaking and dried until the water has completely evaporated. The bearing should then be washing in another clean container of petroleum solvent. Each bearing should be cleaned by revolving the bearing partly submerged in the solvent, turning slowly and using a brush. If necessary, to dislodge remaining particles before finally rotating the inner race relative to the outer race. Once the bearings are clean, they should be rotated by hand in light oil to completely remove the solvent, then coated with petroleum If the bearings are not to be immediately reassembled, wrap them in a clean oil-proof, lint-free paper for storage.

⚠ CAUTION

Use of chlorinated solvents is not recommended in cleaning the Bearings because of potential corrosion. Compressed air is also not recommended in cleaning Bearings in that the moisture in the compressed air could cause rusting.

(b) Cleaning Assembled Bearings:
For cleaning mounted bearings, hot (180-200 F, 82-93 C) light oil should be flushed through the housing while slowly rotating the shaft by hand. Badly oxidized grease and oil can be removed by flushing the housings with hot water diluted with emulsified solvents, and again slowly rotating the shaft by hand. The cleaning solution must then be drained thoroughly by rotating the shaft and then flushed with hot, light oil, and again drained in some instances, an intermediate flushing with a light mineral solvent (see cleaning oils) may be required after using the emulsion.

(c) Cleaning Oils:
Light transformer oils, or automotive flushing oils are recommended. Do not use any oil heavier than SAE 10.

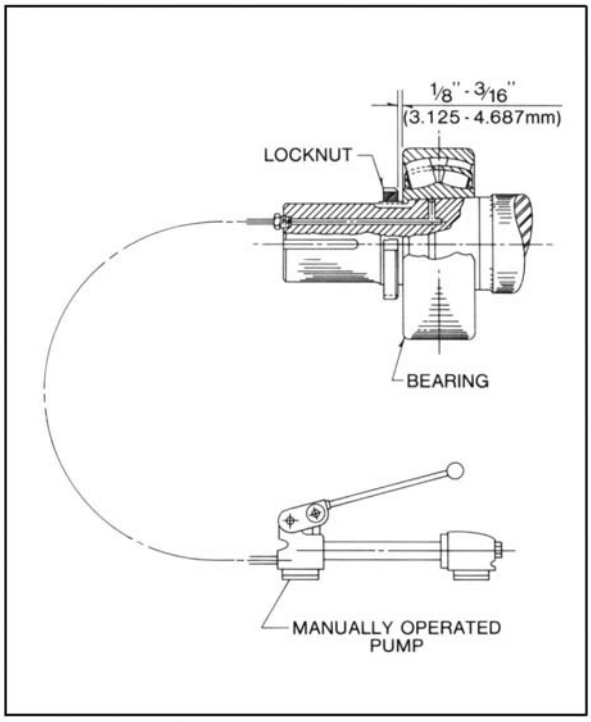
9. Hydraulic Mounting and Dismounting of Tapered Bore Bearings:
Crushers equipped with tapered bore bearings have the shaft drilled and grooved for hydraulic mounting and dismounting of the bearing. This method uses the principle of nearly complete removal of friction at the interface of the mating parts by injecting a lubricant under high pressure between the two surfaces. The equipment required consists of a manually operated pump capable of delivering 10,000 psi (69,000 kPa) pressure with extreme pressure type hose and a non-return valve.

(a) Hydraulic Dismounting:

⚠ WARNING

The release of the fit of a tapered bore Bearing from its shaft seat can be complete and sharp. The Lock Nut should be left on the shaft to act as a stop to prevent the Bearing from flying off the end of the shaft and injuring nearby personnel.

Pump oil between the mating surfaces and the bearing will release instantly. Fretting corrosion may make the dismounting more difficult. In this case, a rust-dissolving hydraulic fluid should be used, especially for bearings that have been in service for a long time.



⚠ CAUTION

Use a minimum of 400 SUS (88 mm^2/s) oil or soft, semi-fluid grease to prevent scoring of the shaft and loss of pressure that is possible with some hydraulic oils. Never use a solvent.

(b) Hydraulic Mounting:

The dry mounting of bearings with tapered bores (as previously described) using only the locknut, a spanner wrench and hammer is slow, hard work, even for a relatively small bearing. As the size increases, seating the bearing for internal clearance reduction becomes more difficult, and in the large sizes is nearly impossible. Therefore, all of our crushers utilizing tapered bore bearings are equipped for the oil injection or hydraulic method of mounting.

Use the same pre-mounting procedures and preparations as for the dry-mounting method. Also clearance reduction gauging during seating procedure is the same for hydraulic mounting. Only the amount of hard work is reduced.

Place the bearing on the shaft and bring it to a metal-to-metal fit on the seat. Properly install the locknut and washer and firmly tighten the locknut with a spanner wrench. Make the hydraulic connection between the pump and shaft (see Figure 11, page 27). While one person maintains hydraulic pressure, another can easily rotate the locknut with the spanner and drive the bearing onto the tapered seat for the required clearance reduction. (Release the hydraulic pressure while gauging clearance reduction). After required reduction is obtained, lock the bearing and assemble the remaining parts. Lubricate properly and test run.

10. Test Run: After a bearing has been remounted, it should be test run for a sufficient period of time (three to six hours) to determine the following:

    (a) Quietness of Operation: Any unusual noises should be investigated and corrected at once. A scraping or rubbing sound could be misalignment of a seal ring or roller cage. Rumbling or unevenness may be due to dust or lint particles. A whistling sound is usually the result of improper or insufficient internal clearance and/or lubrication.

    (b) Operating Temperature: When a bearing is put into operation, an increase in temperature is to be expected. The rise will usually be gradual and more or less at a steady rate. At some point, the change will taper off and the temperature will remain constant over a long period of time. If little or no change, up or down, is noted for one to two hours, the operating temperature has been reached. It should not exceed 175°F (80 C) and should preferably level off at 160° F (71 C) or less.

⚠ WARNING

If at any time the bearing (not the housing) temperature exceeds 180^{O} F. (82^{O} C) during a test run or a normal production run, the Crusher should be shut down normally and the cause for the high temperature investigated and corrected.

Investigate any unusual noises or excessive bearing temperatures immediately. Correct the condition before any further operation. **NOTE**: The temperature at the interface of rollers and races will be 15-20° F (8-11 C) higher than the outside of the bearing housing. Example: if you have a housing temperature of 150° F (66 C), the bearing will be 165 to 170° F (74 to 94 C).

If you are unable to hold your hand on the housing, this may not indicate an abnormal operating temperature. Use a good thermometer or other temperature measuring device. The operating temperature of a bearing will not remain constant from day to day or even from morning until evening. A change in load ambient temperature, excess or inadequate lubrication, or dirt, may result in a temperature change. Small gradual changes are normal. A sudden and rapid rise, however, is cause for investigation.

Bearing Temperature / Vibration Monitor Appendix

Crusher bearings that are to be equipped with thermistor probes will not have the probes or the mounting heads assembled to the bearing housing when shipped. The installation of this device is simple. If your unit is so equipped, full instructions and sketches will appear in the Specific Instruction Manual for your type crusher.

Unless otherwise stated by the bearing manufacturer, the bearing temperature should not exceed 180^{O} F. (82^{O} C.) during operation. During cold weather, bearings should be allowed to warm to 40^{O} F. (4^{O} C.) before feeding material to the crusher.

Normally, these systems will be set up to warn the operators of excessive temperatures without automatically shutting down equipment. In some cases, systems with dual setpoints may be used to allow a warning at a lower temperature, and shut down at a higher temperature. If the Bearing Temperature Monitors are connected to shut down equipment, interlock so that the equipment is shut down in a normal fashion (infeed first, crusher timed out, then outfeed conveyors). Follow all recommendations of the bearing manufacturer in the establishing of temperature set points.

Hydraulic Opening Assist System Appendix

The optional Easy-Access feature incorporates the upper front housing pivoting away from rotor creating access to the internal components of the crusher. The pivoting housing is powered by simple hydraulic system. The feature allows quicker access to maintain liners, rotor, hammers or hammer tips and screen grates. Along with the access in the front of housing, the back of the upper housing has swing opening doors to access internal components through another opening in the back of the upper housing. The center door support and baffle can be completely removed for even more access clearance. Smaller access doors are located in the front and back of the lower housing to gain access to the crusher below center line of rotor.

Power Unit Specification:
Pump/Motor/Reservoir Assembly with Directional Valve, Pressure Relief Valve, Pressure Gauge, 100 mesh Strainer, Hose Assemblies with Quick Disconnect Fittings, Off/On Switch and Power Cord. Counterbalance Valve piped into Hydraulic Cylinders with Hose Assemblies, tubing and fittings all connected to a common point at the back center of crusher.

Power Unit Specification - 115 VAC, 1 PH, 1 HP, 0.5 GPM, 1500 Operating Pressure
Oil capacity – 1.5 Gallon Reservoir
Hydraulic Oil ISO VG 22 (-5^0 F to $+140^0$ F)
ISO VG 32 ($+5^0$ F to $+170^0$ F)
Chevron EP, Mobil DTE

Installation:

⚠ WARNING

Never operate the Power Unit without having the reservoir half filled with oil (before extending the cylinders). Erratic operation can occur, causing serious injury and damage to the Power Unit.

All air must be evacuated from all hydraulic components. Bleed air from system at the cylinder port connections. Exercise hydraulic cylinder disconnected from upper front housing. If air remains in system serious injury will occur.

⚠ WARNING

Do not change any of the relief valve, flow control or counterbalance valve settings from the factory settings. Erratic operation can occur, causing serious injury.

Pressure relief valve on pump/motor is factory set @ 1500 PSI.

Flow control valves are located on the extend line of cylinders and have been factory set and permanently locked.

Counterbalance valves are incorporated into system to prevent the upper front housing, when opening from over speeding as the upper front housing travels through center of gravity and acts as a throttle to maintain constant speed. The counterbalance valves are factory set and require no adjustment.

Operation:

⚠ WARNING

Before operating the Power Unit, the bolted fasteners attaching the movable portion of the housing must be removed.

While operating the Power Unit, make sure that all personnel are clear of the Tilting Chute and Upper Covers during their movement.

The Power Unit as supplied by TerraSource does not include any limit switches for restricting the movement of the hinged housing. The operator must be aware of all personnel and possible obstructions while moving the hinged housing.

⚠ WARNING

When lowering the hinged housing into the maintenance position, always lower the housing onto a wood block or other sturdy support. Never leave the housing hanging in mid-air unsupported, and never allow personnel to move around or work on the Crusher while the hinged housing is in this position. Stored energy in the form of pressurized hydraulic fluid is present in the hydraulic lines, as well as potential energy in the raised masses of the hinged housing.

Once the hinged housing has been moved to the maintenance position and properly supported, Lock-Out and remove electrical power from the hydraulic power unit.

The area in front of the crusher is called the lay down area. The lay down area for upper front housing must be free and clear of any all obstructions and have at least 3 foot of access clearance on both sides of crusher. Electrically Lockout / Tag out motor before opening upper front housing. Before opening the housing into the open position, cribbing or support should be added under the housing, for added support. Maximum load that can be placed on housing in the open position is 500 lbs [227 kg]. Do not exceed the load limit or damage to Hydraulic System can occur.

When opening or closing upper front housing keep all body parts free and clear from all moving parts and pinch points on the of upper front housing. Operator of hydraulic directional valve must maintain good line of site to the movement of housing.

Before connecting hydraulic hoses to quick disconnect fittings, separate the bolt flanges to break caulk bond at split line. To break the caulk bond, remove all bolts from upper front housing and drive a steel wedge in between the bolt flanges at the center of housing in the width direction.

Then install hose assemblies to the back of housing at the location of the quick disconnects. Check oil level in power unit reservoir. Oil level should be approximately half full to allow the difference in oil volume of the retract and extend of cylinders. Power the Power Unit on, and open the hinged housing by moving directional control valve handle. Once upper front housing is fully open, turn off pump unit and disconnect power cord while working on crusher.

Before closing, make sure all body parts are free and clear from all moving parts and pinch points on the of upper front housing. Operator of hydraulic directional valve must maintain good line of site to the movement of housing. When closing upper front housing place a small bead of caulk on the bolt flange and allow to dry hard before closing or substitute a 1/8 thick x 1/2 wide self-adhering peel back close cell sponge rubber gasket to create the dust tight seal between bolt flanges.

Re-connect hydraulic hoses to quick disconnect fittings. Electrically connect the Power Unit, and close upper front housing by moving the directional control valve handle. When closing upper front housing, the last 3 inches of cylinder stroke should be eased closed by operator through proper control the directional valve. Do not allow the housing to slam closed.

⚠ WARNING

Under certain conditions, the hydraulic lines may contain stored energy in the form of pressurized hydraulic fluid. Before any maintenance is performed on the Power Unit:

1. **Remove electrical power from the Power Unit motor**
2. **Make sure that the hinged housing is fully supported and not hanging in mid-air, and….**
3. **Insure that all residual pressure is manually removed from the system. This is most easily accomplished by moving the directional valve handle in both directions to relieve the internal pressure.**

Before disconnecting pump unit hoses from back of housing, turn power unit off and unplug electrical cord. Move the directional valve handle in both directions to relief internal pressure in the hydraulic hoses / lines, then remove hoses / lines from quick disconnect fittings. Install and torque all bolts in the upper front housing bolt flange.

Rotation Sensing Appendix

Oil Lubrication Systems Appendix

Installing Circulating Oil and Hydraulic Systems (if furnished)

The optional Oil Lubrication System will be fully checked out, adjusted, and tested at the manufacturing shop before shipment. The customer normally supplies all piping between the Bearings and the manifolds on the oil lubrication system. Access for maintenance and protection from dirt, dust, and other physical damage is also required.

Cleanliness cannot be overemphasized during the installation, flushing, operation and maintenance of the oil lubrication system. Flexible connections at the crusher bearings are recommended.

The circulating oil system must be located so that the return line tank connection is a minimum of 24 inches (0.61m) below the bearing outlet, or such that the return lines will have a minimum of 10 degrees continuous slope to the tank, whichever gives the greater drop.

The location of the hydraulic system is not restricted as above, and may be located in any convenient place. Keeping it close to the crusher will eliminate long runs of connecting tubing, which could be damaged. The location for each system should provide protection from dust, dirt and physical damage. Access for inspection and maintenance is desirable.

The foundation load for the system is the total weight of the unit plus the required oil. Dynamic loading need not be considered. However, excessive vibration from adjacent equipment should be dampened or isolated to help prevent a malfunction of the system components, particularly the pressure switch.

All rigid or flexible connecting piping, tubing or hose must be clean and free of rust, scale, grit, dirt, chips, etc. and of the proper physical strength for the pressures involved. (See the Specific Instruction Manual for your model and type of crusher.)

After all interconnecting lines are in place, but before the connection to the bearings or cylinders is made, short-circuit the system by connecting the feed lines to the return lines or connect the two cylinder lines together and operate the system under pressure for a period of several hours. During this period, a hydraulic system with more than one circuit should have the directional control valves cycled a number of times so all lines will be cleaned of loose foreign materials.

After this test run procedure is complete, all filter cartridges should be replaced. If the filter element indicates a large amount of contaminants were present, an oil change may be required. Do not connect the bearings or cylinders to the system until this oil change, if necessary, has been completed.

All circulating oil systems are equipped with a heat exchanger for cooling the oil. The heat exchanger is a shell and tube type. Water is used as the heat exchange fluid. (On special orders, the heat exchanger can be oil to air type.) If the ambient temperature ever reaches freezing or lower (32F – 0C), protection for the exchanger and water lines must be provided by heating the water lines.

SECTION 2

Jeffrey Rader
DuraTip™ Replaceable Hammer Tips

(Catalog Number 331832)

Supplement Manual
116-21 e_2012-12

THE FOLLOWING WARNINGS APPLY SPECIFICALLY TO ALL CRUSHER, HAMMERMILL, PULVERIZER, & GRINDING EQUIPMENT MANUFACTURED AND SUPPLIED BY TERRASOURCE GLOBAL, AND ARE INTENDED TO HELP PROTECT BOTH PERSONNEL & EQUIPMENT. ALL PERSONNEL INVOLVED IN THE INSTALLATION, OPERATION & MAINTENANCE OF JEFFREY RADER EQUIPMENT MUST FOLLOW ALL GOVERNMENT & RECOGNIZED SAFETY CODES, SPECIFICALLY WITH ISO / OSHA / MSHA.

ALL PERSONNEL MUST READ AND UNDERSTAND THESE WARNINGS.

NEVER . . . . start the equipment unless the personnel in the immediate area are notified.

NEVER . . . . start or operate the equipment with any guards, doors or covers open, or open any guards, doors or covers while the equipment is operating. All rotating components must be covered.

NEVER . . . . perform any type of inspection or maintenance unless the equipment is stopped and all sources of energy are electrically locked out or blocked from operation. Equipment must be attempted to be restarted to verify that the power and other energy sources have been disconnected before any work is performed.

NEVER . . . . climb or stand on or over the equipment while it is operating. Never sit, stand on or perform any type of inspection or maintenance on or near any rotating component unless it is mechanically prevented from rotating and motor is electrically locked out.

NEVER . . . . feed material to the equipment unless the rotating components are running at operating speed. Always stop infeed before stopping equipment.

NEVER . . . . use the equipment for any purpose other than the original specified use, and do not make any modifications whatsoever unless approved by TerraSource.

NEVER . . . . attempt to make any adjustments to the equipment while feeding material.

NEVER . . . . attempt to clear a plugged feed or discharge chute by poking with a rod or similar device while the equipment is operating.

NEVER . . . . feed any explosives or combustibles into the equipment, or use explosives to free any plugging or build-up.

NEVER . . . . look or reach into the infeed/discharge to inspect or remove material while equipment is operating.

NEVER . . . . increase or decrease the speed of the equipment without written approval from TerraSource.

NEVER . . . . operate the equipment in the wrong direction of rotation. Never attempt to reverse the direction of the rotor unless it is stopped.

NEVER . . . . be in the vicinity of the crusher while it is operating without wearing hearing and eye protection, and any other required PPE (Personal Protective Equipment).

Always refer to the Jeffrey Rader equipment manual supplied with the equipment for additional safety information, instructions, and warnings. If you do not have an equipment manual, do not understand the above warnings, or have any safety questions concerning safe operating and maintenance procedures of this equipment, please feel free to contact a TerraSource representative at the following office locations. Additional contact information can be found on the Internet at WWW.TERRASOURCE.COM.

TerraSource Global
215 Parkway East, Suite A
Duncan, SC 29334
Tel. 864-476-7523
Fax. 864-476-7510

Jeffrey Rader AB
Domnarvsgatan 11, 163 53
Spånga, Sweden
Tel. +46 (0)8-56 47 57 47
Fax. +46 (0)8-56 47 57 48

Jeffrey Rader Canada
135 boul. Brunswick
Point-Claire, PQ H9R 5N2
Tel. 514-822-2660
Fax. 514-695-0060

Jeffrey Rader Canada
Unit 2, 63 Fawcett Road
Coquitlam, BC V3K 6V5
Tel. 604-299-0241
Fax. 604-299-1491

NOTICE

The information presented in this manual pertains specifically to the Jeffrey Rader DuraTip™ Replaceable Hammer Tips and Shanks. These instructions should be used as a supplement to the information found in the General Crusher Equipment Manual 116-2. Instructions for equipment and systems not of TerraSource manufacture will be supplied separate from this manual.

The sections of this manual are written to correspond to the sections of the Jeffrey Rader General Crusher Equipment Manual 116-2. This supplement manual contains only information that is specific to DuraTip™ Hammers. Always refer to the corresponding sections of the General Crusher Equipment Manual 116-2 to obtain complete information.

The contents are subject to change without notice. TerraSource reserves the right to make material substitutions and design changes without notice, and is under no obligation to revise equipment of previous manufacture.

Table of Contents

A. Overview and Safety

A.1. Preface

This manual is provided as a guide to personnel involved with the installation, operation, and maintenance of Jeffrey Rader equipment. Operators, Inspectors, and Maintenance personnel of Jeffrey Rader equipment should read and become familiar with the general procedures and information contained within this manual. In addition we recommend that this manual be kept readily available for reference before beginning any work associated with equipment.

Safety precautions and instructions for awareness and information on potential hazards are found throughout this manual. Due to the complexities of the systems in which this equipment is used and the environment in which it operates, situations may arise which are not directly discussed in detail in this manual. When such a situation arises, past experience, availability of equipment, intelligence and common sense play a large part in what steps are to be taken. In addition, a service representative is available to answer your questions, perform inspections and safety reviews, provide operator training, and supervise maintenance crews upon request.

Please feel free to contact a technical or service representative at the following office locations. Additional contact information can be found on the Internet at WWW.TERRASOURCE.COM.

TerraSource Global
215 Parkway East, Suite A
Duncan, SC 29334
Tel. 864-476-7523
Fax. 864-476-7510

Jeffrey Rader AB
Domnarvsgatan 11, 163 53
Spånga, Sweden
Tel. +46 (0)8-56 47 57 47
Fax. +46 (0)8-56 47 57 48

Jeffrey Rader Canada
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Jeffrey Rader Canada
Unit 2, 63 Fawcett Road
Coquitlam, BC V3K 6V5
Tel. 604-299-0241
Fax. 604-299-1491

A.2. General Safety

All parts of the equipment and the system into which it is placed must be installed, operated, and maintained in keeping with sound safety practices. This manual contains safety information designed to be used in two ways: first as a primary reference for operators and plant maintenance personnel, providing them with details and explanations of operational and maintenance safety procedures; and second as a training tool within your plant's safety program.

Safety begins with properly designed and manufactured equipment. To that end, TerraSource Global has designed this equipment with safety in mind. The following general safety standards have been used in the design and manufacture of the equipment; additional standards will be used in equipment that is sold into specific countries or areas of the world as required:

OSHA 29 CFR 1910	USA Code of Federal Reg., Occupational Health and Safety
ASME B15.1b	American Society Mech. Eng., Mech. Power Transmission Safety
ASME B20.1a	American Society Mech. Eng., Conveyor & related safety stds
NFPA 70e	USA National Fire Protection Assoc., National Electric Code Part 1, Electrical Safety in the Workplace
EN ISO 12100	European Community General Principles of Design

2A 2006/42/EC or EG	European Community Machinery Directive (complete machines with drives attached)
2B 2006/42/EC or EG	European Community Machinery Directive (partly completed machines without drives attached)
2006/95/EC	European Community Electrical Directive
EN 60204-1	European Community Safety of Machinery, Electrical Equipment

However, the use of the equipment is subject to certain hazards that cannot be met by mechanical means alone, but by the exercise of intelligence, care, and common sense in its use. Once the equipment is shipped, TerraSource Global has no direct control over its installation, operation, inspection, maintenance. For this reason, **safety in the field is the responsibility of the user**.

Any maintenance other than inspection, cleaning, or obvious repair due to wear should be discussed with your technical or service representative. Certain design parameters are utilized in the construction of this equipment, making allowances for moderate wear and normal environmental conditions that could affect corrosion, erosion, or impact. Severe wear, operating equipment at higher or lower speeds, increasing horsepower/kilowatt power, severely corrosive environments, material tramp and rocks, etc. can render the equipment un-safe or hazardous to operate and should be discussed with your TerraSource representative.

The following notes provide basic safety guidelines that should be incorporated into a comprehensive safety program at your plant. See manual 000-1 Safe Operating Procedures for additional safety information regarding the use of Jeffrey Rader equipment.

- Do not remove warning signs from the equipment. If warning signs become damaged, contact TerraSource for replacements.
- Make certain that all barriers, covers, and guards are in place before starting the equipment.
- Keep aisles around equipment clear of unnecessary or potentially hazardous articles.
- Wipe up spilled oil, grease, or water to minimize the risk of slips and falls.
- Keep loose clothing, long hair, jewelry and all parts of the body away from moving machinery parts.
- Keep away from belt and chain drives.
- Wear appropriate safety protection equipment as required by the job and environment. This includes hard hats, safety goggles, hearing and eye protection, dust masks, safety shoes, and any additional PPE (personal protective equipment) required by the plant.
- Read and understand all safety related information in this manual.

A.3. Warning Signs

Signs of various types are posted throughout this manual and on the equipment to warn the end user of potential hazards associated with the operation of this machinery. These signs aid in the safe and efficient operation of this equipment, and it is recommended that periodic inspection of all signs be included in the machines inspection program.

The following standards are used for warning signs on Jeffrey Rader equipment; additional standards may be used in equipment that is sold into specific countries or areas of the world as required:

ANSI Z535	American National Standards Institute, Safety Alerting Stds
ANSI A13.1	American National Standards Institute, Pipe Marking Stds

EN 61310	European Community, Safety of Equipment, Indication, Marking, and Actuation
ISO 3864-2	International Standards Organization, Stds for Safety Symbols

If signs are missing, damaged or illegible, they should be cleaned or replaced to ensure the safe operation of the equipment. Replacement warning signs are available for a nominal charge by contacting the TerraSource representatives at one of the addresses listed in Section A.1. Refer to Section B.5. for a complete listing of warning signs.

Signs used in this manual and on Jeffrey Rader equipment use the following signal words to emphasize important and critical instructions.

⚠ DANGER

Danger is used to indicate an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.

⚠ WARNING

Warning is used to indicate a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

Caution is used to indicate a potentially hazardous situation which, if not avoided, may result in minor or moderate injury or property damage.

NOTICE

Notice is used for special important instructions, but not hazard related.

A.4. Lockout/Tagout Procedures

When performing inspection or maintenance on Jeffrey Rader equipment, always follow Lockout/Tagout Procedures as required by the following standard organizations; additional standards may be used in equipment that is sold into specific countries or areas of the world as required:

OSHA 29 CFR 1910	USA Code of Federal Reg., Occupational Health and Safety, sub-sections .147, .269, .333
ANSI Z244.1	American National Standards Institute, Control of Hazardous Energy
NFPA 70e	USA National Fire Protection Assoc., National Electric Code Part 1, Electrical Safety in the Workplace
CSA Z460	Canadian Safety Assoc., Control of Hazardous Energy
EN ISO 12100	European Community General Principles of Design
EN ISO 11161	European Community Safety of Machinery, Integrated Manufacturing System

Refer to the maintenance section of your manual prior to performing any maintenance. If the specific topic is not covered, contact TerraSource before proceeding.

Lockout/Tagout Procedures are intended to protect personnel working on or around the equipment by preventing accidental start up and exposure to hazardous energy release such as electrical shocks and stored energy. The procedure requires that individual locks and tags are placed on controls, shutoff switches, valves, or other devices to prevent usage until the person who installed the lock removes it. Never attempt to operate any control device when it is in LockOut/TagOut while personnel are inspecting or working on the equipment.

Proper Lockout/Tagout Procedures must include:

1. A documented and established site policy on the steps to follow for lockout and tagout such as:
    a. Notify all affected people including supervisors before lockout or tagout is used.
    b. Shut off the affected machine, equipment, system or function.
    c. Disengage, isolate or release energy supply or source.
    d. Apply individual locks and tags on controls, or other devices to prevent usage.
    e. Try or test the equipment to check that the energy has been removed before service or maintenance.
    f. Entry allowed to equipment
2. Employee training on proper Lockout/Tagout Procedures for the facility.
3. Identification and location of shutoff switches and controls that isolate hazardous energy are predetermined at the facility.
4. After inspection or maintenance is complete all individuals must remove their Lockout/Tagout. After all LockOut/TagOuts are removed, notify the appropriate personnel that all inspection and maintenance has been completed and the energy or power can be restored.
5. A documented and established procedure must be in place to handle locks that must be forcibly removed, to ensure that all conditions are safe before removal.

A.5. Confined Spaces Procedures

Certain areas of this equipment may be considered a Confined Space, or a Permit Required Confined Space, per the following standards; additional standards may be used in equipment that is sold into specific countries or areas of the world as required:

OSHA 29 CFR 1910	USA Code of Federal Reg., Occupational Health and Safety, sub-section .146
ANSI Z117.1	American National Standards Institute, Safety Requirements for Confined Spaces
CSA Z1006	Canadian Safety Association, Management of Work in Confined Spaces

If the equipment is so designated, a warning sign will be posted, and a documented and established site policy must detail the steps to follow before any entry is allowed. These procedures, along with LockOut/TagOut, must be followed before any entry is attempted into a confined space or permit required confined space. In some cases, the equipment may not be able to be physically entered, but may contain a possibility of dangerous dust loadings, gasses, temperatures, or other conditions which may be identified and proper precautions taken before any work is performed.

A.6. Safety of Materials

A system of providing material safety for workers and workplaces has been created and adopted in most areas of the world. TerraSource will supply this information on customer request; all requests must include the equipment name, part name or part number, and project or serial number, and additional specific information that may also be required fulfill the request. Inquiries concerning material safety information can be addressed to the TerraSource Engineering Dept. at one of the locations listed in Section A.1.

MSDS	USA, Material Safety Data Sheet System
WHMIS	Canada, Workplace Hazardous Materials Information System
REACH	European Community, Registration, Evaluation, Authorization & Restriction of Chemicals System

A.7. Equipment in Explosive or Hazardous Atmospheres

If special ordered, most Jeffrey Rader equipment can be supplied to handle and operate in dust rated hazardous zones. In these cases, special design, risk assessments and manufacturing considerations will be taken to the equipment as supplied, and special installation, operation, inspection, and maintenance procedures will be required to operate the equipment safely.

NFPA 68	USA National Fire Protection Assoc., Explosion Protection by Deflagration Venting
NFPA 69	USA National Fire Protection Assoc., Explosion Prevention Systems
NFPA 70 Article 500	USA National Fire Protection Assoc., National Electric Code, Hazardous (Classified) Locations
NFPA 61	USA National Fire Protection Assoc., Prevention of Fires & Dust Explosions in Agricultural and Food Processing Facilities
NFPA 484	USA National Fire Protection Assoc., Standard for Combustible Metals
NFPA 664	USA National Fire Protection Assoc., Prevention of Fire and Explosions in Wood Processing and Woodworking Facilities
EN 1127-1	European Community, Explosive Atmospheres, Exp Prevention & Protection (also known as ATEX)
EN 60079-0	European Community, Explosive atmospheres
ISO/IEC 80079-34	European Community, Potentially Explosive Atmospheres-Application of Quality Systems

B. General Information

This manual provides information for receiving, installing, and maintaining Jeffrey Rader DuraTip™ Replaceable Tip Hammers. In order to have a thorough understanding of the equipment and its operation, it is important to read this manual carefully before installing your hammers and tips. Please contact your local TerraSource Representative at one of the locations listed in Section A.1. to answer any questions you may have or to provide any additional information that your particular application may require.

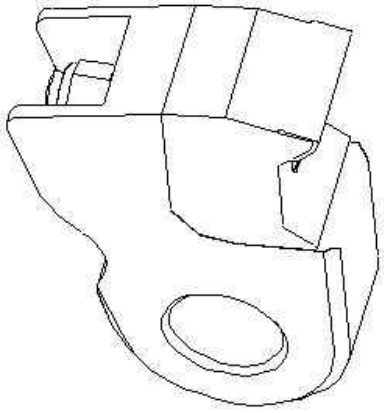

Figure #1

⚠ CAUTION

Failure to follow the instructions and procedures in this manual could void your warranty.

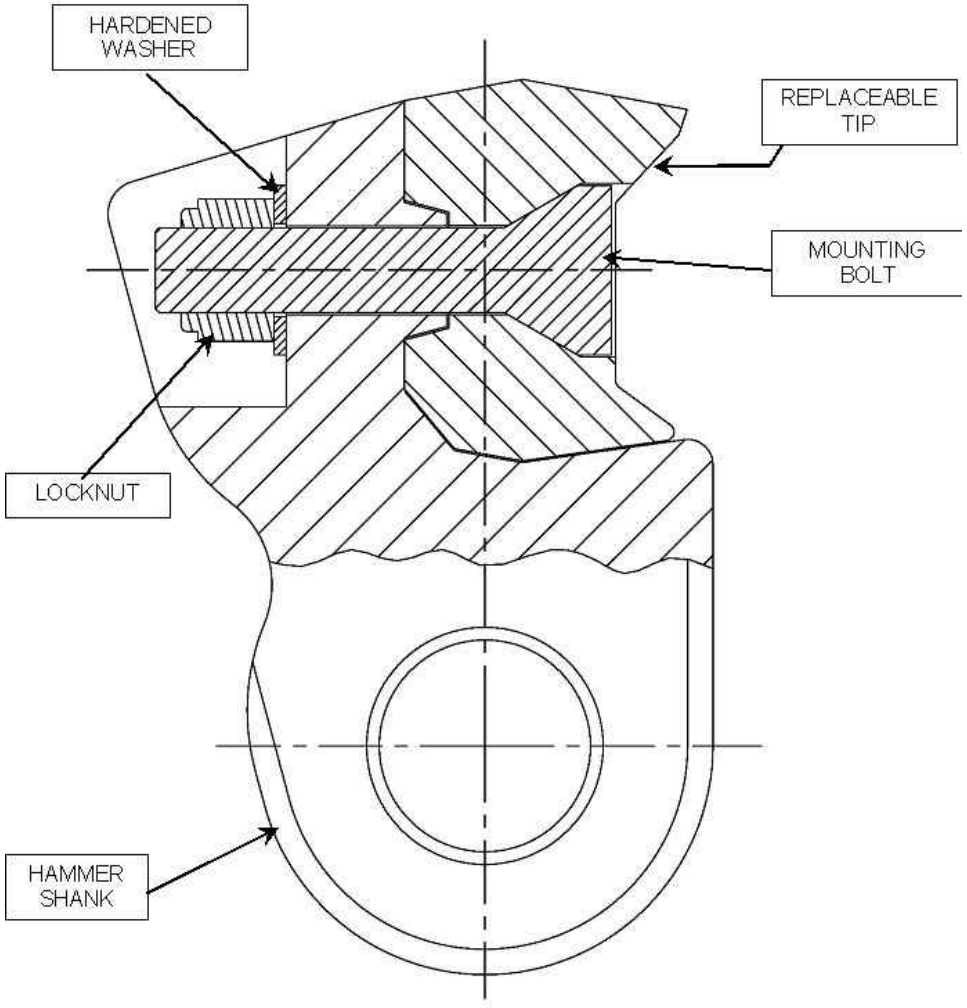

Figure #2

B.4. Component Description

The Jeffrey Rader DuraTip™ Replaceable Tip Hammer is a unique design that provides a hard, durable abrasion resistant replaceable hammer tip bolted to a tough abrasion resistant, ductile hammer shank. DuraTip™ replaceable tip hammers are shipped complete with a hammer shank, replaceable tip, high strength mounting bolt, special washer, and a lock nut. Once the replaceable tip hammers are installed, the tips can be easily replace as they become worn without having to remove the hammer shank from the machine. Replacement tips may NOT be rebuilt using hard surface welding. Become familiar with the replaceable tip hammer terms and the proper assembly by referring to Figure #2.

C. Installation

⚠ WARNING

Be sure to read all information contained in the General Crusher Equipment Manual 116-2. This equipment can cause serious injury or death if proper safety precautions are not observed.

C.1. Shipping, Handling and Storage

When purchasing DuraTip™ replaceable tip hammers, they are shipped completely assembled. Otherwise, when purchasing replaceable tip and hardware only, your maintenance personnel must remove the worn tip assembly from the shank prior to installing the new ones. Replaceable tip assemblies consist of the tip, bolt, hardened washer, and lock nut. Inspect your shipment immediately upon receipt. Check to see that all items have been received and note any damaged or missing items on the freight bill of lading. Report any damaged or missing items to the carrier and also contact TerraSource at one of our locations given in Section A.1. for information on repairs or replacements.

D. Startup Information

⚠ WARNING

Be sure to read all information contained in the General Crusher Equipment Manual 116-2. This equipment can cause serious injury or death if proper safety precautions are not observed.

.

E. Operation

⚠ WARNING

Be sure to read all safety instructions and information contained in the General Crusher Equipment Manual 116-2. This equipment can cause serious injury or death if proper safety precautions are not observed.

F. Maintenance

⚠ WARNING

Be sure to read all safety instructions and information contained in the General Crusher Equipment Manual 116-2. This equipment can cause serious injury or death if proper safety precautions are not observed.

⚠ DANGER

This equipment can cause death or severe personal injury if all safety precautions are not taken. LockOut/TagOut this equipment anytime inspection or maintenance is to be performed. This includes all clean-out procedures where the Crusher and/or it's infeed/discharge is plugged or bridged over with material.

In addition, equipment adjacent to the Crusher may require LockOut/TagOut during Crusher inspection and maintenance. Determine all necessary Lockout requirements before any work is performed.

⚠ DANGER

All procedures listed in this section require LockOut/TagOut before proceeding, unless otherwise noted.

F.1. Preventive Maintenance Schedule

Weekly, inspect hammer tips for looseness, damage or wear. Do not allow the hammer tips to wear to the point of exposing the hammer shank face for the bolt head to wear. New tips will not fit properly on worn shanks.

F.5. Hammer Balancing, Installation, & Replacement

⚠ WARNING

All hammer shanks are weighed and marked before shipment. A balanced arrangement sheet should accompany your order to aid in proper installation positions. If the balanced arrangement sheet is missing, please contact TerraSource to obtain one. Unbalanced hammer assemblies installed in a Crusher will cause severe vibration and could damage Crusher components.

The procedure to properly balance shanks and install hammer tips is as follows:

a. Weigh all hammer shanks with the tips removed separately using a calibrated scale to within 0.1 pound. Mark each hammer shank with its weight or a code number representing its weight.

b. Arrange the hammer shanks in a balanced pattern according to the number of rows and spaces for your particular Crusher rotor. Refer to Figures #3, #4, and #5, for typical hammer arrangements for various rotors. Once the hammer shanks have been arranged in a balanced arrangement, the hammer tips can be assembled onto the shanks before installing the in the Crusher if desired.

NOTICE

It is important that the hammer shanks are put in a balanced arrangement independent of the tip so the tips can be changed in the crusher without having to reweigh the shanks.

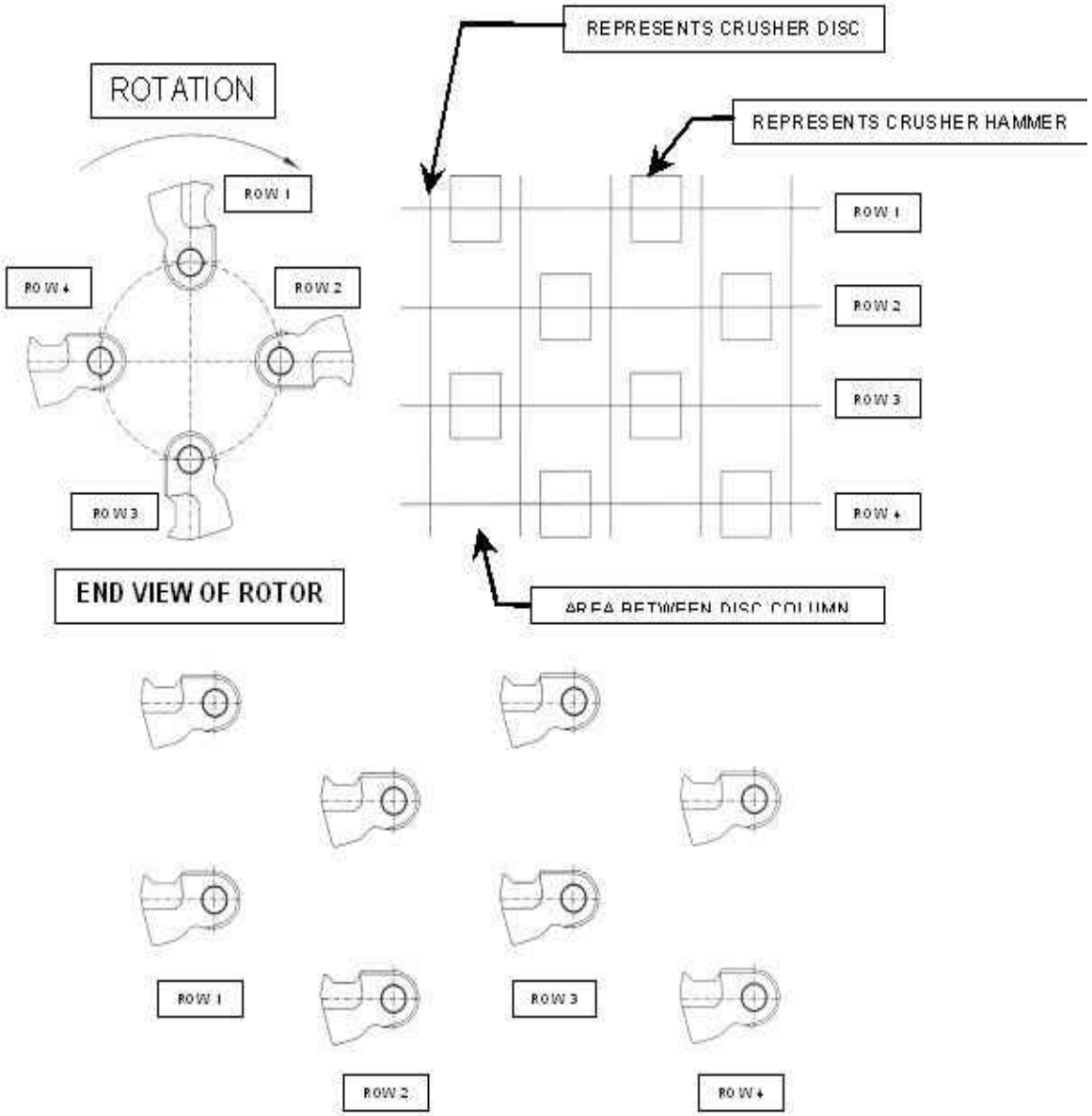

Figure #3- Hammer Arrangement 4 Staggered Rows

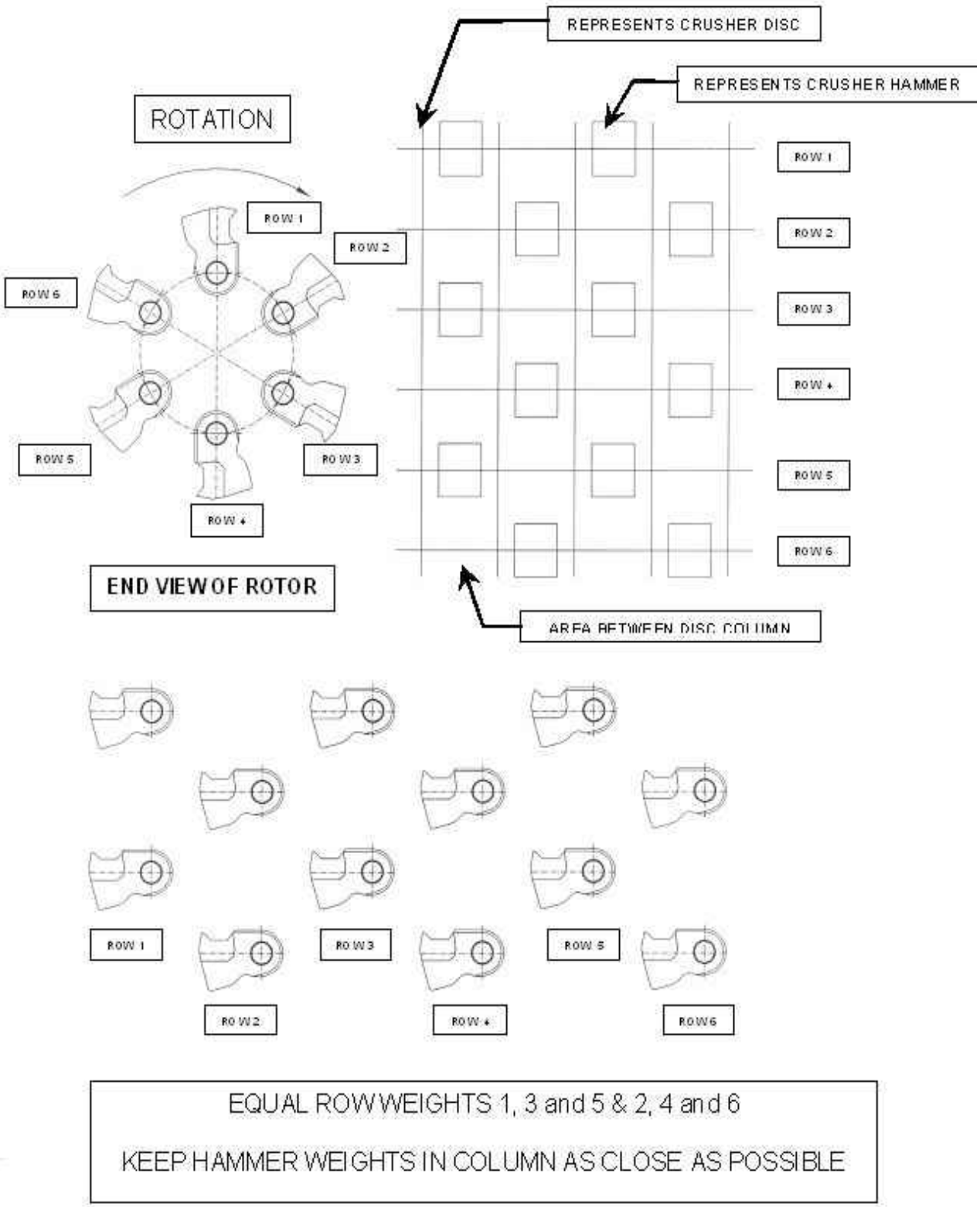

Figure #4- Hammer Arrangement 6 Staggered Rows

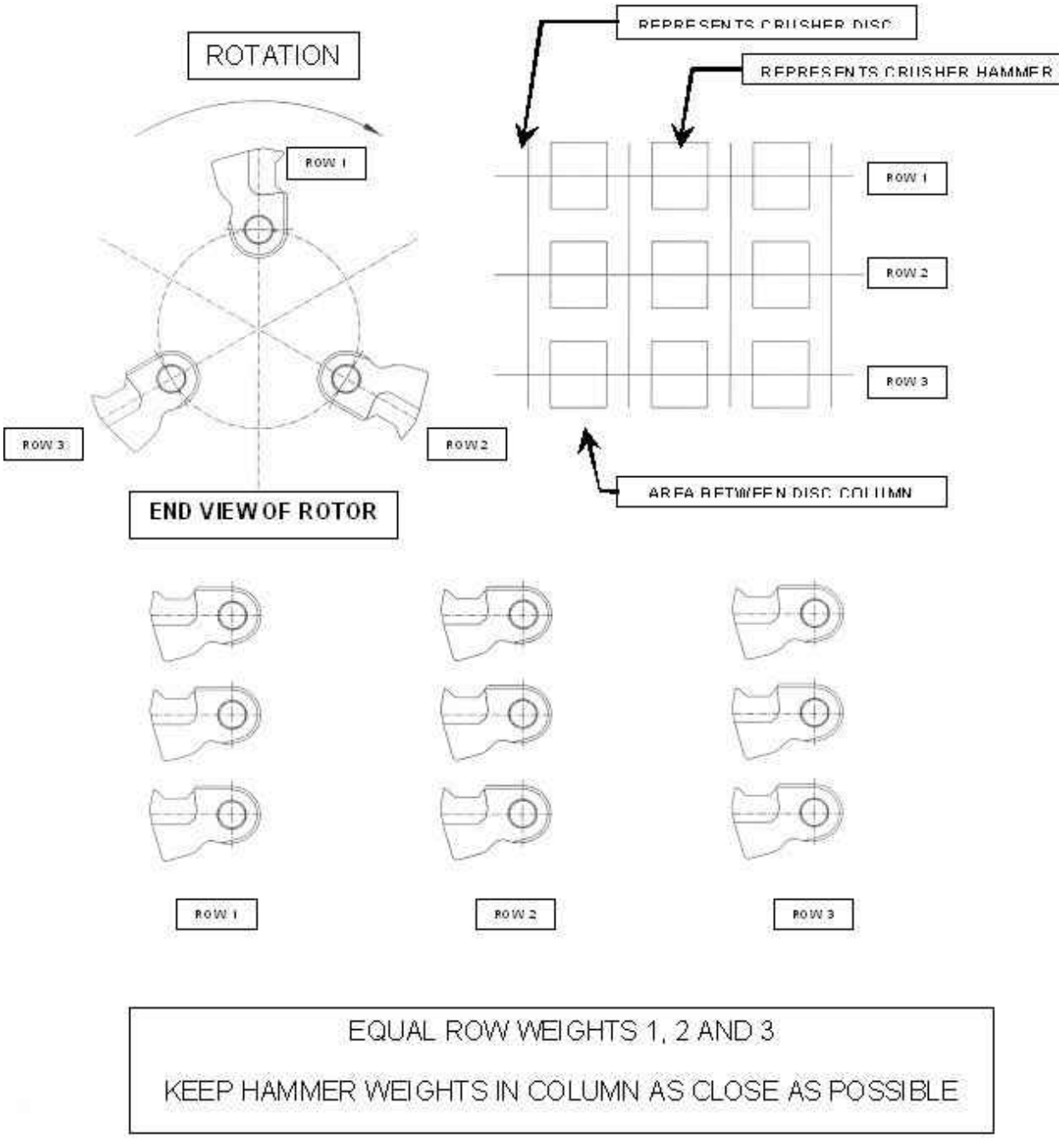

Figure #5 – Hammer Arrangement 3 Solid Rows

NOTICE

Start your hammer arrangement using your two heaviest hammer shanks in the first disc space (column) making sure they are in opposite rows; i.e., For a four row rotor, rows 1 and 3 or 2 and 4. For the next disk space (column), choose the lightest two hammer shanks, again arranging them in opposite rows. If the heaviest and lightest hammer shanks are far from each other across the rotor, significant shaft imbalance could occur, causing excessive vibration.

c. Ensure that the tip and shank mounting surfaces are clean and free of all dirt and other foreign material.

d. Assemble the hammer tips to the hammer shanks using the high strength bolts, hardened washer and lock nuts supplied with your hammer tips. Hand tighten the lock nuts.

e. Using a calibrated torque wrench, tighten the lock nut to the torque value specified in Section F.7 of this manual. Ensure that each hammer tip is firmly seated against the hammer shank face during final tightening by rapping with a hammer and rechecking torque.

Worn or damaged hammer tips are replaced using the same procedure outlined in the installation section of this manual, with the following exceptions and additions:

f. Since the hammer shanks were installed in a balanced pattern at initial installation, they will not have to be removed when replacing hammer tips only.

g. Remove the old hammer tips by loosening the lock nut and removing the hardware and tip from the hammer shank.

h. If a damaged or worn tip is replaced, a replacement tip must also be installed 180° from the first tip in order to maintain rotor balance.

i. Inspect and clean the hammer shank face before installing a new hammer tip. If the hammer shank face is damaged or worn the hammer shank must be replaced.

j. New mounting fasteners are provided with your new hammer tips and must replace old fasteners.

⚠ WARNING

Used fasteners must never be used to attach new hammer tips. Installation of new tips with used hardware could result in the hammer tip coming loose and causing damage to your equipment.

k. Assemble the hammer tips to the hammer shanks using the high strength bolts, hardened washer and lock nuts supplied with your hammer tips. Hand tighten the lock nuts.

l. Using a calibrated torque wrench, tighten the lock nut to the torque value specified in this manual. Ensure that each hammer tip is firmly seated against the hammer shank face during final tightening by rapping with a hammer and rechecking torque.

F.7. Bolt Torque Specifications

The bolts used to attach the DuraTip replaceable tip to the shank are a special design bolt that is made of special materials. Do not substitute off-the-shelf bolts for this connection. The bolt uses fine thread, and must include the hardened washer and locknut as shown in Figure #2.

Used fasteners must never be used to attach new hammer tips. Installation of new tips with used hardware could result in the hammer tip coming loose and causing damage to your equipment.

Crusher Model	Tightening Torque (Dry)** (Ft-Lbs)
44-45 WB SERIES	625-675
50 WB SERIES	800-900
50 SERIES WB-SS	800-900
60 SERIES WB	800-900

** Do not exceed maximum torque limit on bolts while installing tips. Always use a calibrated torque wrench when tightening bolts. If bolt is over torqued, premature bolt fatigue may occur while the hammer is in operation. Do not under torque the bolts while installing tips. Torque levels below the minimum tightening torque can result in the tips coming loose. This may result in damage to the crusher

G. Recommended Spare Parts

The following items are recommended spare parts that should be kept on hand at all times. The complete callout for the following items can be found in the General Arrangement and Parts List drawings for this job, and are included as part of this manual. This includes necessary ordering information, including drawing numbers (part numbers) that are required to fill orders. When ordering spares, it is helpful to have the original TerraSource / Jeffrey Rader / Jeffrey Job Number and Model Number from the metal nameplate located on the Hammermill frame.

Many parts of the Crusher are made special for TerraSource, using special tolerances and materials. Contact your TerraSource product representative for all replacement parts. It is suggested that wear items, such as hammer tips and mounting hardware, be ordered well in advance. While most items are stocked, these parts are subject to prior sale and may be unavailable when you require them. A regular review of your maintenance log will suggest parts that you should have on hand in the event of an unexpected failure.

It is also recommended that you have a serviceable set of shanks on hand when replacing tips, as inspection may reveal an unserviceable part that should be replaced at once.

Crusher Model	DuraTip™ Hammer Assy Part No.	Hammer Shank Part No.	Hammer Tip Complete with Hardware*
44-45 WB SERIES	331416	331413	331415
50 WB SERIES	330628	328781	330627
50 SERIES WB-SS	330719	330721	330722
60 SERIES WB	330727	330725	330726

* Hammer tip catalog number listed is for standard applications. For special applications requiring special alloys, consult the factory. The tip complete will include a new tip, bolt, washer and lock nut.

SECTION 3

Jeffrey Rader
Machinery Lubricants

Reference Manual
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