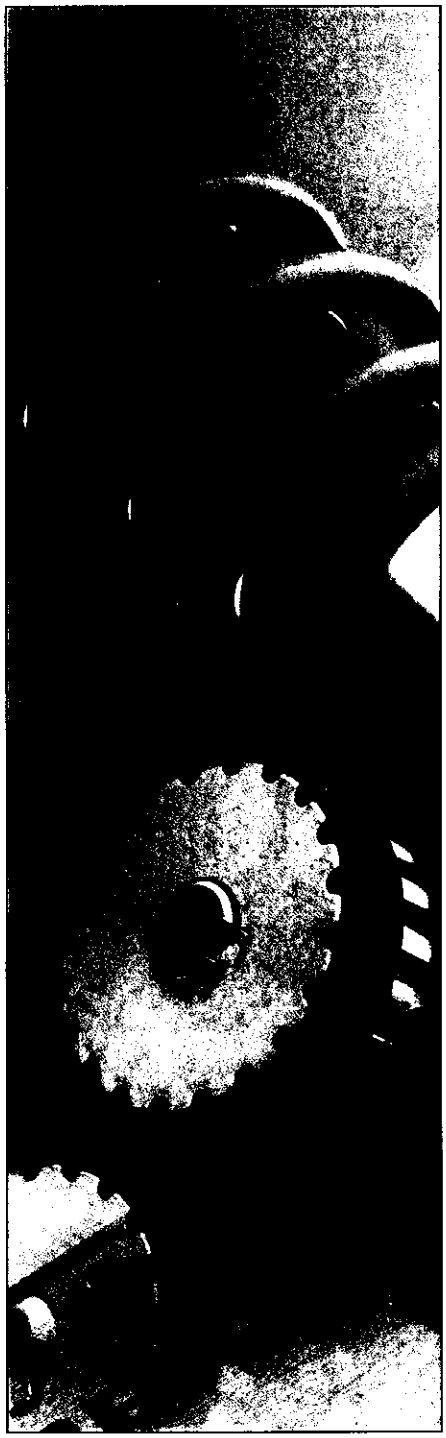
Operation and Maintenance Manual



ARPAC GROUP

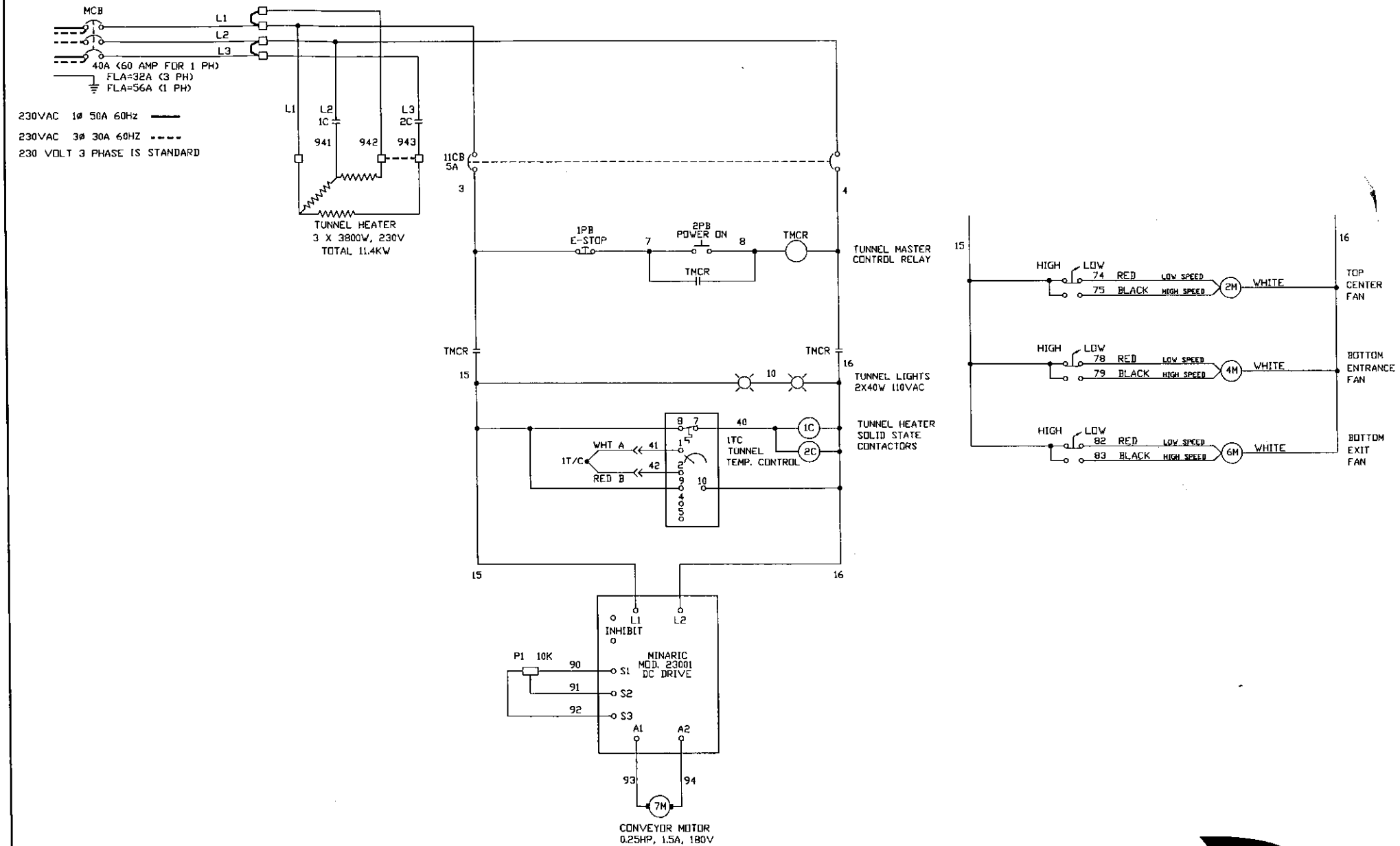
BFG Technologies

Model: VT122248

SN: 6817

August 2005

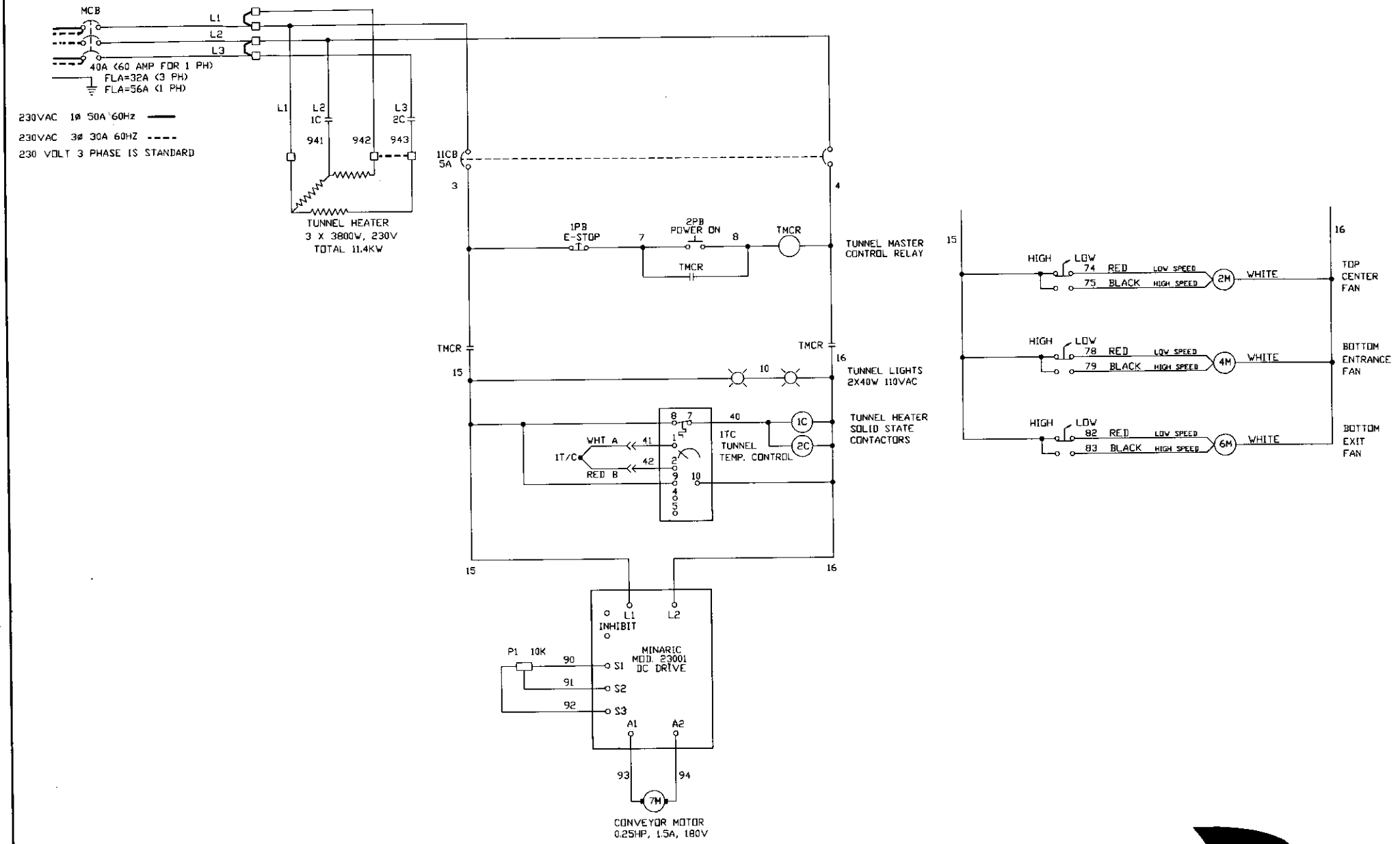
9511 River Street • Schiller Park, IL 60176 • 847 678-9034 • www.arpacgroup.com



6817-00

ARPAC GROUP

REV. A	ELECTRICAL SCHEMATIC	SIZE: A	
DESIGNER: HKS		DATE: 08-04-2005	
MODEL: VT122248		SHEET: 1 OF 2	
XPEDX		DRAWING NUMBER: 6817-99-01	



6817-00

ARPAC GROUP

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WARRANTY

ARPAC warrants the equipment of its manufacture to be free from defective material or workmanship for a period of one year from date of shipment from the factory, provided that:

1. Such equipment is given normal and proper usage.
2. It is still owned by the original purchaser.
3. The equipment has been operated in accordance with generally approved practice and in accordance with ARPAC's instructions.
4. No repairs, alterations, or replacements have been made by others without ARPAC's written approval.

The purchaser shall notify ARPAC immediately of any defective parts and ARPAC shall take corrective action. If such correction requires the replacement of a defective part or parts, ARPAC will supply them F.O.B. the factory.

ARPAC shall in no event be held liable for damage or delay caused by defective parts and will not accept any charges for work performed by purchaser in making adjustments or repairs to the equipment unless such work has been authorized in writing by ARPAC.

Any equipment or component not of ARPAC's own manufacture is sold under whatever warranty is provided by the maker, to the extent ARPAC is able to enforce such warranty. Such items are not warranted by ARPAC in any way.

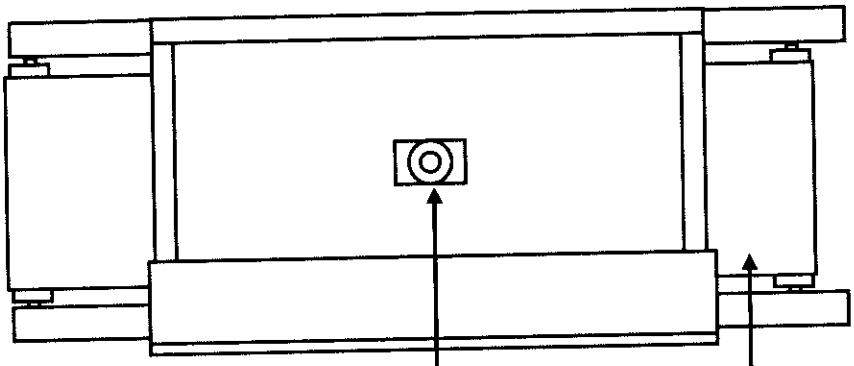
When components are sold to be assembled in combination of purchaser's design, the warranty shall be limited to each separate component and shall not apply to any combinations or components.

ARPAC's liability (except as to title) arising out of the supplying of the equipment shall in no case exceed the purchase price of the said equipment. ARPAC makes no guarantee or warranty, expressed or implied, other than as stated above.

ARPAC factory trained, qualified technical services personnel are available for start-up and instructional assistance. If the customer does not utilize ARPAC personnel for this function, ARPAC is only liable for replacement of defective parts, not for labor or expenses necessary to adjust any problems out in the field.

ARPAC personnel are available for ARPAC equipment training either on-site/hands on or in classroom environment, supported by visual aid and literature to be administered under a separate purchase order.

Machine Layout
Model: Vision Tunnel



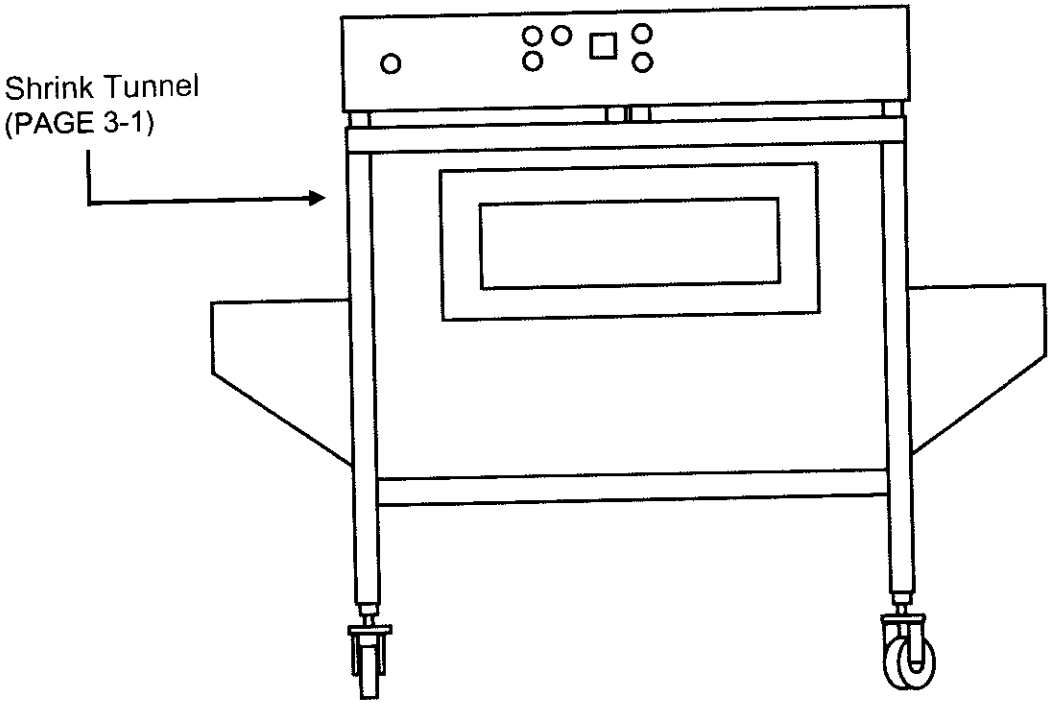


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Table of Contents

Table of Contents

SECTION 1

Introduction

1-1 Using This Manual

1-2 Manual Design

Introduction

This manual is an operations and maintenance manual for **THE ARPAC® GROUP** packaging equipment. Use this manual if you are responsible for using, operating and/or maintaining the equipment. It is organized in a manner that can be easily understood by personnel with reasonable experience. This manual is designed to provide clear and simple explanations of safety, daily operating procedures, troubleshooting guidelines and descriptions of machine parts and controls.

If operated and maintained correctly, this machine is designed to provide the user years of trouble-free service. It combines up-to-date, state-of-the art technology as well as ARPAC's enormous experience in the area of packaging systems.

Using this manual

The following features help make this manual simple to use:

Construction

The binder on this manual is attractive enough to sit on the shelf in the office, yet rugged enough to bring into the shop. Tabbed dividers separate the sections of this manual, providing quick access to a specific area of the text.

Text Notations

The titles at the top of every page provide a quick reference as to which section the manual is opened to.

Graphical Notations

Manuals for older equipment may contain some old style graphical notations as well as the following current graphical notations.

NOTE: Contain additional information to assist personnel in the operation of this machine.

DANGER: Warn the user of possible personnel and/or equipment hazards in the operation and maintenance of this machine.

Manual Design

This manual is organized into the following sections:

- **Warranty**	This is the standard ARPAC warranty provided with new equipment.
- **Machine Layout Drawing**	The layout drawing provides a visual index of this manual. Use the layout drawing to find information on individual assemblies.
- **Table of Contents**	The table of contents is a directory of this manual.
1 Introduction	This section explains how to use the manual.
2 Safety	Describes the safety precautions that should be followed when working with, on or around the equipment.
3 Mechanical Sub-Assemblies	Describes the features of the individual mechanical assemblies and their function. It also provides a brief overview of the interaction of these assemblies with other machine components.
4 Operator Controls	Explains the purpose and location of all the controls used to operate the machine.
5 Operating Procedures	This section is dedicated to the operator. It describes in detail step-by-step procedures for starting, stopping and operating the equipment including such operator functions as changeovers and correcting minor setup problems.
6 Troubleshooting	This section was designed to help the operator and the maintenance personnel understand and resolve any possible problems with the machine. Abnormal running conditions and error messages are covered in the troubleshooting section.

(Continued on the next page)

Manual Design

7 Maintenance	Explains the tasks the operator and the qualified maintenance person should do in order keep the machine in top running condition. It also gives some brief descriptions of how to repair minor problems.
8 Glossary of Terms	This section contains words that pertain to the equipment, which the operator may not be familiar with.
9 Service Information	This section contains an overview of ARPAC's service. Included are a field service policy, installation policy and parts ordering information with an order form.
10 Mechanical Assembly Drawings	The mechanical assembly drawings are the prints for all of the major assemblies on your machine with the complete mechanical bill of material.
11 Electrical Information	Detailed information on the machine's electrical engineering. Included are electrical schematics and complete electrical bill of material.
12 Vendor Information	Here you will find manufacturer's manuals for certain components.

SECTION 2

Safety

Safety Information

Every effort has been made by **ARPAC** to provide you with a safe machine. This section describes the safety precautions that should be taken when working with, on or around the equipment. It is essential that machine operators and maintenance personnel follow the safety information below.

Personnel Instructions

All personnel working around or coming into contact with the equipment must be instructed to keep their hands and other parts of their person and clothing clear of all moving parts.

Equipment must not be operated if any safety devices, including guards and doors are removed, disconnected or damaged.

Personnel shall not reach into the equipment for any reason, including maintenance, adjustment or clearing of jams, while the equipment is in the cycle mode. The cycle mode stops when the guard doors are opened or when the cycle stop button is pressed. This process may take a couple of seconds. Do not reach into the machine until the machine has stopped.

Before any person reaches into the equipment for maintenance or adjustment, air and electrical power shall be turned off using lockable shutoffs provided. The clearing of jams may be done while the machine is turned on, but not while in the cycle mode.

Anyone entering the machine for maintenance, troubleshooting or any procedure entailing the removal of guards or performing work at any point of operation, shall be required to observe all applicable lockout/tagout requirements.

NOTE: Because companies tend to tailor the lockout/tagout program to their specific needs, we advise all users to refer to their company's procedure manual.

Safety Information

Energy Hazards

Guard doors are equipped with electrical interlocks. When opened they interrupt the air supply and de-energize all outputs to the motion control devices on the wrapper. They do not shut off the main drive motor, the seal bar temperature controller or any of the tunnel functions.

Before any person reaches into the equipment for maintenance or adjustment, air and electrical power shall be turned off using lockable shutoffs provided. The clearing of jams may be done while the machine is turned on, but not while in the cycle mode.

Cycle stop buttons do not de-energize any circuits.

Emergency stop push buttons shut off power to the control circuit, the seal bar, all motors, the master air supply regulator and the tunnel. They do not shut off power to the programmable controller.

DANGER: Machine devices may move when the air is turned on or off, when the electrical power is turned on or off or when the guard doors are opened or closed.

Heat is used to seal and shrink the film and apply adhesives, including heat seal type labels and glue. After shutting off the power, seal bar components, the tunnel, label applicators and glue units may remain hot to the touch for an hour or more.

DANGER: <u>Do not clean a hot tunnel!!!</u> When cleaning the machine or any components, use only non-flammable cleaning materials. Flammable and/or aerosol cleaners may ignite or explode when coming into contact with the hot tunnel. This is extremely hazardous to your health.

Safety Information

Guarding and Doors

Equipment must not be operated if any safety devices, including guards and doors are removed, disconnected or damaged.

Guard doors are equipped with electrical interlocks. When opened they interrupt the air supply and de-energize all outputs to the motion control devices on the wrapper. They do not shut off the main drive motor, the seal bar temperature controller or any of the tunnel functions.

Personnel shall not reach into the equipment for any reason, including maintenance, adjustment or clearing of jams, while the equipment is in the cycle mode. The cycle mode stops when the guard doors are opened or when the cycle stop button is pressed. This process may take a couple of seconds. Do not reach into the machine until the machine has stopped.

Anyone entering the machine for maintenance, troubleshooting or any procedure entailing the removal of guards or performing work at any point of operation, shall be required to observe all applicable lockout requirements.

NOTE: Because companies tend to tailor the lockout/tagout program to their specific needs, we advise all users to refer to their company's procedure manual.

DANGER: Machine devices may move when the air is turned on or off, when the electrical power is turned on or off or when the guard doors are opened or closed.

Interfacing Equipment

Observe all applicable codes when interfacing this equipment to other equipment. Specific attention must be paid to any pinch points that may be created and the prevention of an unintended restart of the equipment when the electrical interlocks shut it down.

Warning Labels

This label indicates a pinching device (i.e., canopies or doors).

This label indicates a clamping pinch point (i.e., diverter).

This label indicates a spring-loaded pinch point (i.e., pinch rollers).

This label indicates high voltage.

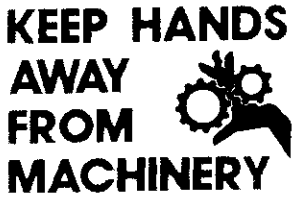
This label indicates a cutting device (i.e., knife).

(Continued on the next page)

Warning Labels

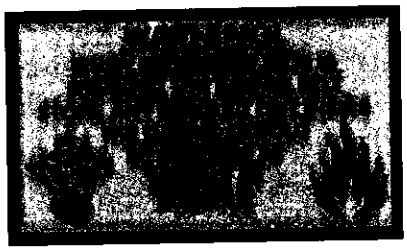
This label indicates unseen energy hazards (i.e., electrical or pneumatic).

This label indicates the necessity of re-installing guards and covers after cleaning or maintenance of the machine.



This label indicates a solid pinch point (i.e., gear or sprocket).

This label indicates mechanical moving parts (i.e., carriage, chains, sprockets and cylinders).



This label indicates that no product should be left in the tunnel. Any fallen products should be removed from the tunnel immediately.

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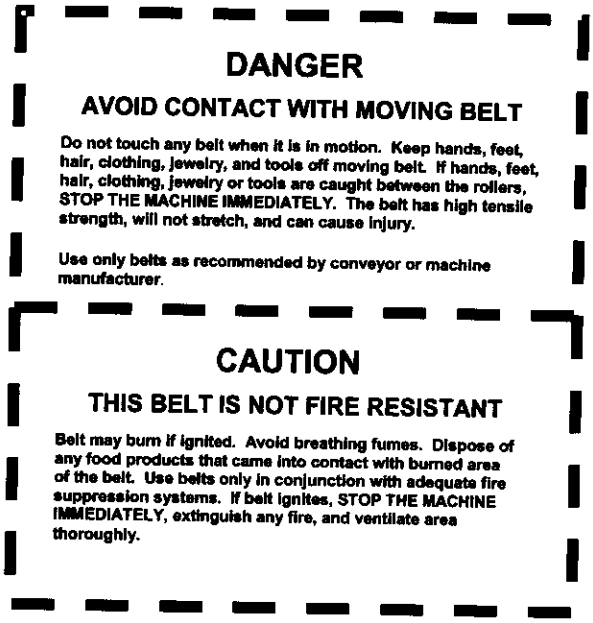
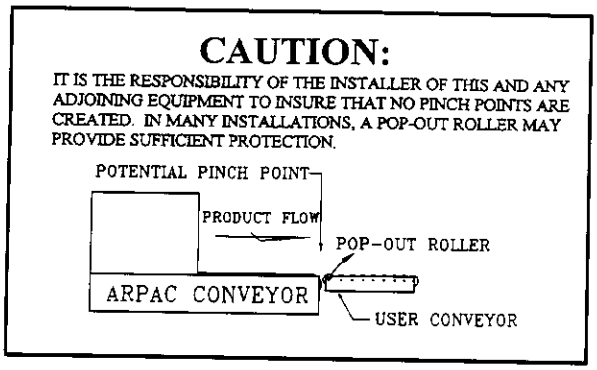
Warning Labels



This label indicates the presence of moving conveyor belts, which may be moving through the tunnel.



This label indicates a downstream pinch point (equipment connecting to the exit conveyor).

SECTION 3

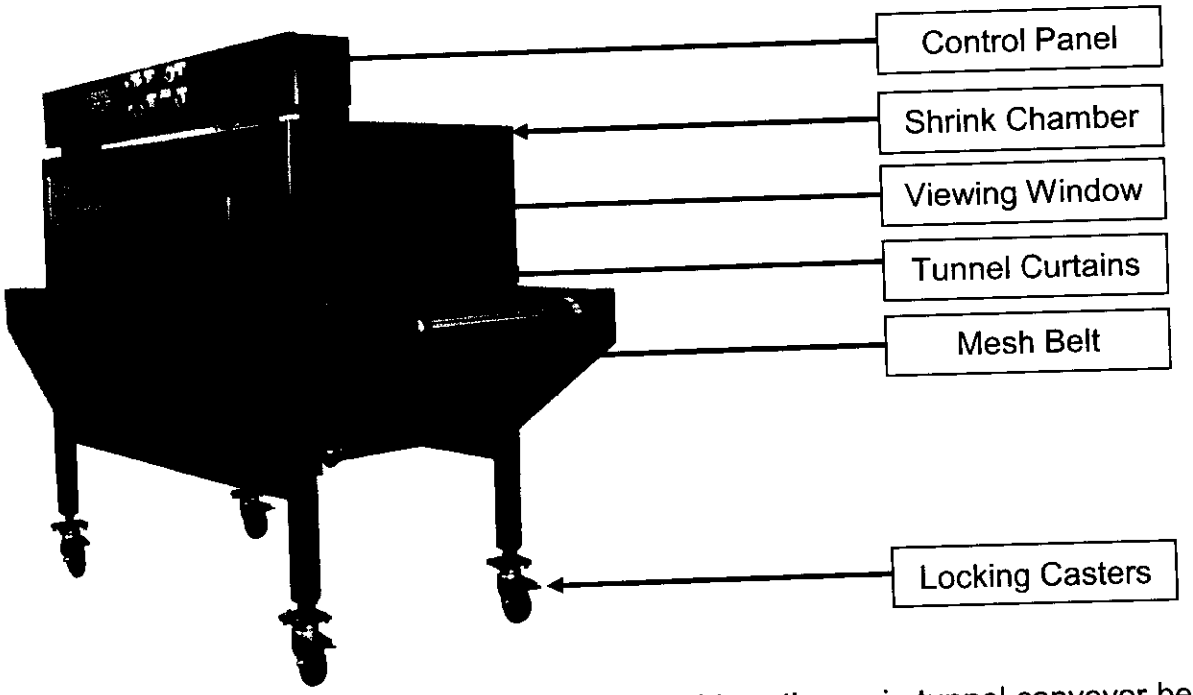
Mechanical Sub-Assemblies

Mechanical Sub-Assemblies

This section gives a brief overview of the equipment and its functions, under normal production conditions. See the machine layout in the front of this manual.

Shrink Tunnel

The tunnel has a mesh belted conveyor, multiple heater elements, a drive motor and blower motors. The tunnel shrinks the film around the product without adversely affecting the product in any way. The film must not only properly contain the product, but it must be aesthetically acceptable as well.



The tunnel drive motor, located under the tunnel, drives the main tunnel conveyor belt. It is important that the products are spaced properly going through the tunnel for proper airflow around the product and even shrinking of the film.

DANGER: The tunnel and some of its parts can become extremely hot. Do not allow anything, with the exception of the product, to enter the tunnel while it is turned on. This includes your body parts. **Do not clean a hot tunnel!!!** When cleaning the machine or any components, use only non-flammable cleaning materials. Flammable and/or aerosol cleaners may ignite or explode when coming into contact with the hot tunnel. This is extremely hazardous to your health.

(Continued on the next page)

Shrink Tunnel

It is also important that the products are spaced after the tunnel, as the film will be somewhat tacky and if the products touch the film wrapped around them may become damaged.

Use the tunnel belt speed dial to change the speed of the conveyor belt. The speed of this conveyor should be set slightly faster than the conveyor feeding it. This prevents shingling and/or tipping of the products as well as it keeps them spaced properly. When adjusting the speed of the tunnel conveyor the operator must also adjust the temperature of the tunnel. It is important to operate this conveyor at the slowest acceptable speed to get the job done, as the faster the conveyor runs the higher the tunnel temperature must be kept.

The main tunnel conveyor belt is a mesh belt. Adjustable shaft collars are used to adjust the belt tracking. The drive roller is knurled to decrease slipping and increase tracking ability. The belt take-up for this conveyor is located at the end of the tunnel.

This tunnel heats the product with forced air type heat. Upper and lower calrods supply the heat and upper and lower fans move the air around inside the shrink chamber. They do not circulate the air through any type of duct work. This controlled environment ensures a consistent uniform shrink on each package. Tunnel curtains are used to contain the heat within the shrink chamber.

A selector switch on the main control panel controls the power to each fan. This allows the operator to use any combination of the fans in order to adjust the shrink for each package.

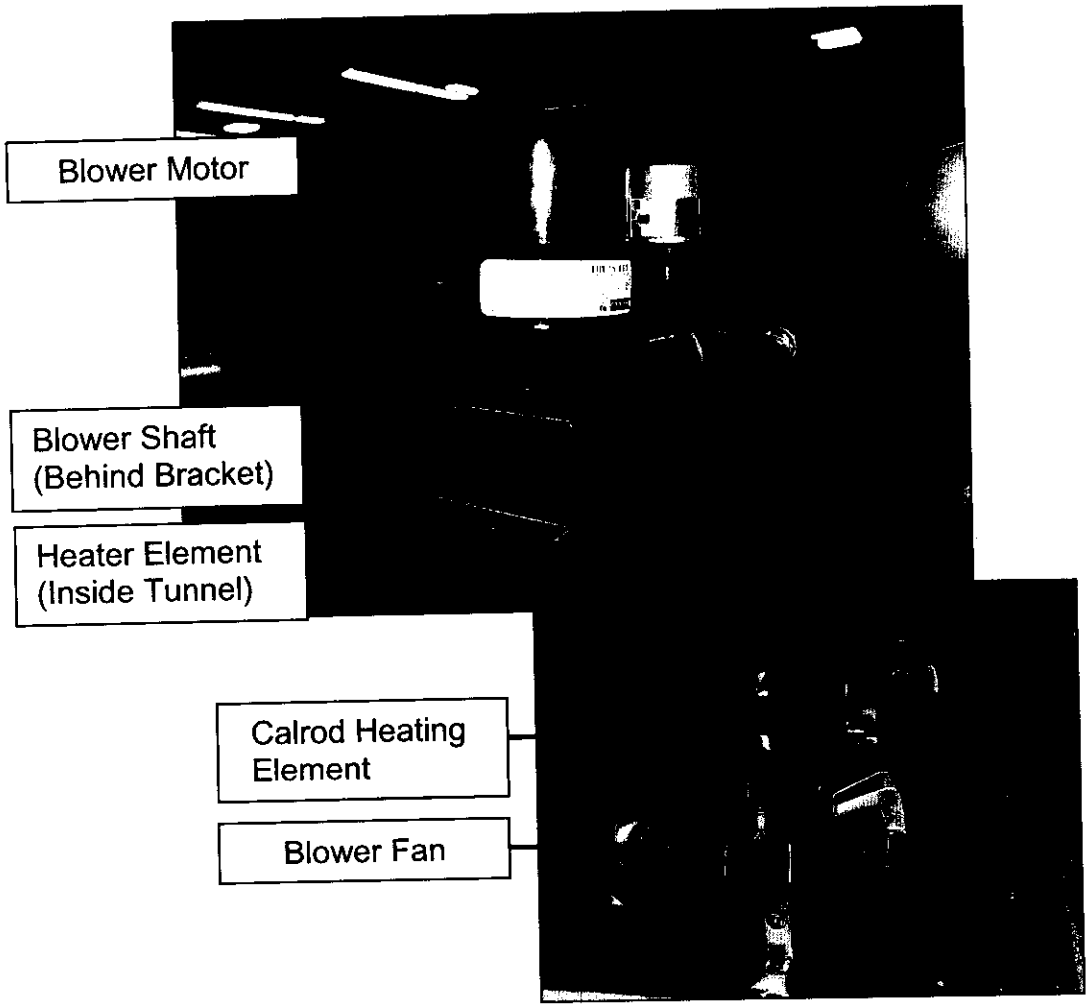
One thermocouple mounted inside the tunnel supplies the temperature feedback to the temperature controller. This thermocouple allows for accurate temperature control of the tunnel.

NOTE: It is important to clear any jams very quickly, as any product left in the tunnel could be melted or damaged. The tunnel temperature should never exceed 450° Fahrenheit.

Shrink Tunnel

Tunnel Blowers

The tunnel blower is an electrically controlled radial blower. There are multiple blowers, one located at the top of the tunnel and two underneath. The purpose of the blower is to circulate heated air around the film wrapped bundles as they travel through the tunnel.

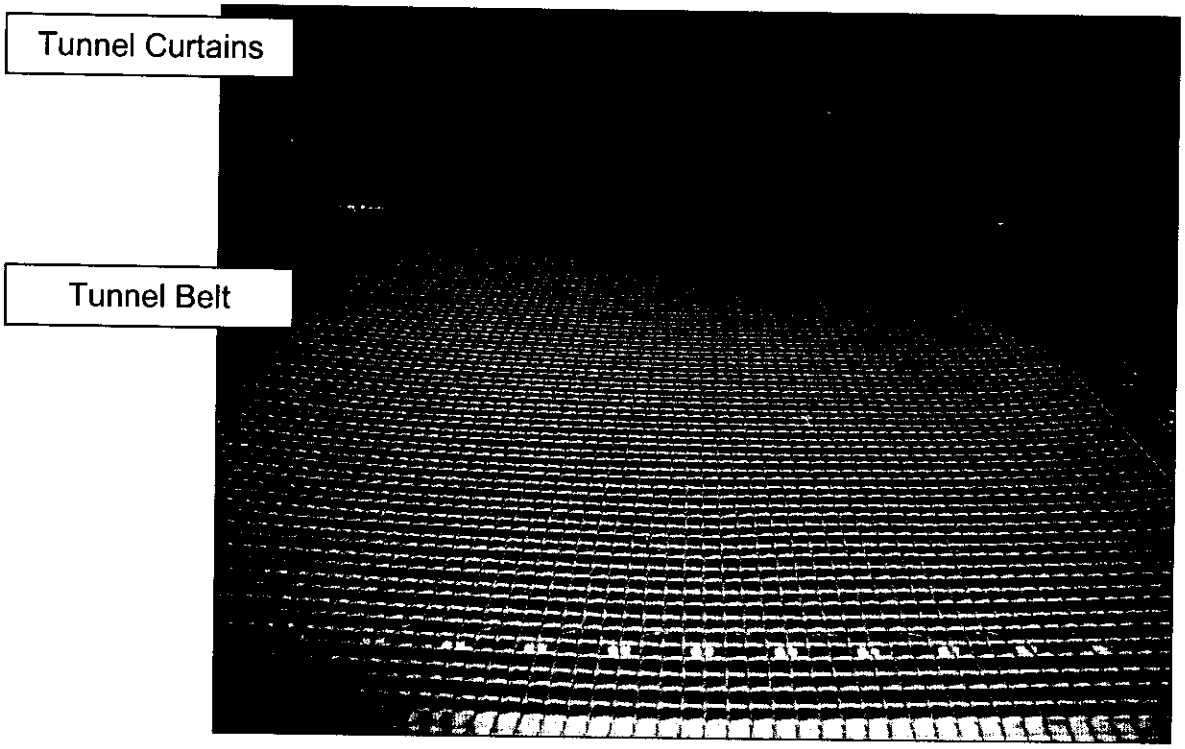


A thermocouple, mounted inside the tunnel for temperature, sends feedback to the temperature controller on the main control panel. This thermocouple allows for accurate temperature control of the tunnel.

Shrink Tunnel

Tunnel Conveyor Belt

The tunnel conveyor belt is a laced mesh belt designed to allow for the even shrinking of film around the product.



As the film-encased product passes through the shrink tunnel, the heat is circulated around them from the top and bottom fans. The heat causes seal seams to be pulled underneath or to the sides of the product.

The tunnel drive motor, located under the tunnel, drives the tunnel conveyor belt. A dial located on the main control panel is used to adjust the speed of the belt. When adjusting the speed of the conveyor the operator must also adjust the tunnel temperature to ensure a uniform shrink of the film around the product.

The speed of this conveyor should be set slightly faster than the conveyor feeding it. This prevents shingling and/or tipping of the products as well as it keeps them spaced properly. It is also important that the products are spaced after the tunnel, as the film will be somewhat tacky and if the products touch the film wrapped around them may become damaged.

SECTION 4

Operator Controls

Operator Controls

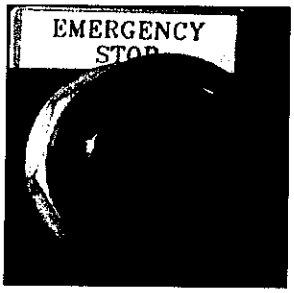
This section explains the purpose and location of all of the controls used to operate the machine.

Main Power Disconnect

The main power disconnect supplies the main high voltage (typically 240 or 480 volts) to the machine. It is typically mounted on the main control cabinet. It is extremely important that anyone coming in contact with the machine knows where this switch is and knows how to use it.

DANGER: This device controls electrical energy which is extremely hazardous and could cause serious injury or death.

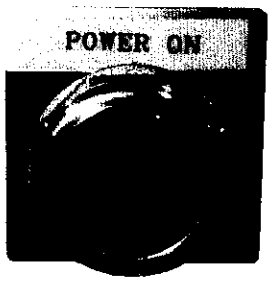
Emergency Stop Push-Pull Button



Each emergency stop button will shut down all electrical devices. There is sometimes more than one emergency stop button. One is located on the main control panel. Others if necessary are strategically placed on the machine.

DANGER: To avoid an explosion or fire hazard, remove any product left inside the tunnel when an emergency stop button is pressed.

Power On Push Button

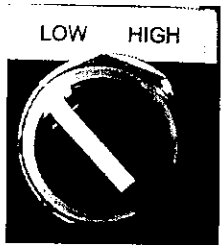


The power on button supplies power to the main drive motor, the control circuitry and the heater elements. It is located on the main control panel.

DANGER: To avoid personnel injury, always check around the machine before pressing this push button. Keep clothing and body parts clear of all machinery.

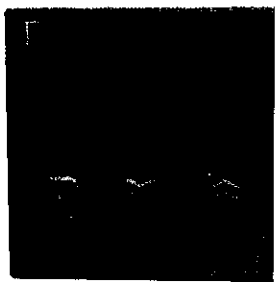
Operator Controls

Fan Selector Switch



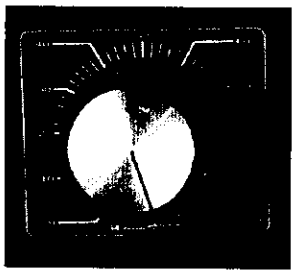
The fan selector switch controls the speed of the designated fans, located inside the tunnel. These switches are located on the main control panel.

Temperature Controller



The temperature controller controls and displays the temperature of the oven.

Tunnel Belt Speed Dial



The tunnel belt speed dial controls speed of the tunnel belt. When the speed of the tunnel belt is changed the oven temperature must also be changed. It is important to operate the tunnel at the slowest speed to adequately shrink the film.

SECTION 5

Operating Procedures

Operating Procedures

This section provides information on machine operating procedures. Operators as well as maintenance personnel should make themselves familiar with these operating procedures.

Startup and Shutdown Procedure Descriptions

Initial Startup

Applies to the first time the machine is run and the initial startup of each shift or day and after an emergency stop has been initiated.

Emergency Shutdown

Applies to times when the machine needs to be shut down immediately. This includes all times when personnel or the equipment are in danger of being damaged.

Long-Term Shutdown

Applies to times when the machine will be shut down completely, such as overnight, weekends, or to perform changeover procedures.

Initial Startup

Applies to the first time the machine is run and the initial startup of each shift or day and after an emergency stop has been initiated.

NOTE: If the wrapper is attached to a shrink tunnel, start the tunnel before starting the wrapper. Tunnels generally take longer to heat up.

Pre-Start Inspection

1. Make sure the machine and the area around the machine is clear of all products and any other items not directly related to the normal operation of the machine.
2. Inspect the tunnel's insides and belt for film and any other debris.
3. Ensure that the castors are locked in position.
4. Ensure any and all persons in the area of the machine are aware the machine is about to start.

Startup

1. Place the **main power disconnect switch** to the ON position.
2. Make sure the **emergency stop button** is pulled out.

DANGER: Be aware while working with the machine during this time. There are many possibly hazardous moving parts, including chains and sprockets.

3. Press the **power on button**. This will turn on the tunnel heating elements, as well as the tunnel blower motors and the tunnel drive motor.

Emergency Shutdown

Applies to times when the machine needs to be shut down immediately. This includes all times when personnel or the equipment are in danger of being damaged.

DANGER: When the **emergency stop** push-pull button is pressed the machine will stop immediately. In most cases product will stop in a hot tunnel. It is very important to remove the products from the tunnel as soon as possible. Products left in a hot tunnel for any length of time will be damaged and depending on the contents may explode.

1. Press any **emergency stop** push-pull button.
2. Take care of the emergency situation and remove product from the tunnel as soon as possible.

Long-Term Shutdown

Applies to times when the machine will be shut down completely, such as overnight, weekends, or to perform changeover procedures.

1. Make sure all products have exited the tunnel.
2. Press the **emergency stop** push-pull button to stop the conveyor belt.
3. Place the **main power disconnect** switch to the OFF position.

Product Setup Procedures

Product Setup Chart

The following information is used when changing the machine to run from one product to another.

Product Program #				
Product Number				
Product Description				
Product Width				
Product Length				
Product Height				
Top Center Fan				
Bottom Entrance Fan				
Bottom Exit Fan				
Tunnel Conveyor Speed				
Tunnel Temperature				

NOTE: The measurements on this chart are approximate. Adjustments may need to be made for actual set up of the machine.

Product Setup Procedures

Machine Temperatures

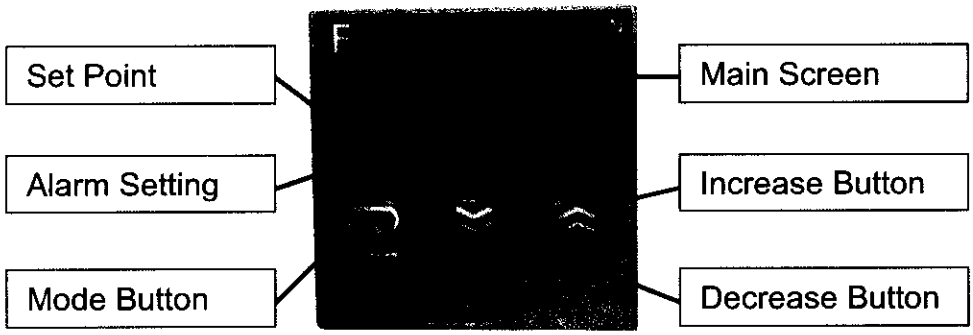
Temperature controllers typically control the temperature for the seal bars and tunnel heaters.

To change the preset temperature setting:

1. Press the **mode button** until the set point indicator light turns on.
2. Press the **increase** or **decrease button** until the desired temperature is reached.
3. Press the **mode button** twice to return to the actual temperature screen.

To change the alarm temperature setting:

1. Press the **mode button** until the alarm indicator light turns on.
2. Press the **increase** or **decrease button** until the desired temperature variance is reached.
3. Press the **mode button** once to return to the actual temperature screen.



Adjustments

Tunnel Belt Speed

The speed of the tunnel belt can be adjusted by using the belt speed dial on the operator control panel. It is important to run the tunnel at the slowest possible speed in order to achieve the best possible shrink around the product.

Tunnel Blower Fan Speed

The speed of the tunnel blower fans can be controlled using the selector switches on the main control panel. Typically, when running light product, it is suggested to run the fans at a low speed. If the film is not shrinking properly and the product is heavy enough try using the high speed.

SECTION 6

Troubleshooting

6-1 Abnormal Running Conditions

Troubleshooting

This section was designed to help the operator and the maintenance personnel understan and resolve any possible abnormalities with the machine.

Abnormal Running Conditions

The following section covers problems that may occur during the use of the machine.

Poor Shrink or No Shrink

The film does not shrink to the product as desired, or does not shrink at all.

POSSIBLE CAUSE	SOLUTION
Temperature too low.	Increase temperature using temperature controller.
Tunnel conveyor speed too fast.	Adjust the speed of the tunnel conveyor using the tunnel conveyor speed dial.
Tunnel fans set to low speed.	Adjust the speed of the tunnel fans using the speed selector switches.
Tunnel blower(s) not running.	Check for overload. Correct problem or reset as necessary. Check for loose connections. Replace as necessary. Inspect tunnel blower motor(s). Replace as necessary.
Cooling blower or other fan in plant blowing cooled air into tunnel.	Reposition blowers or fans.

Abnormal Running Conditions

Poor Shrink or Too Much Shrink

The film shrinks too much or burns the film.

POSSIBLE CAUSE	SOLUTION
Tunnel temperature too high.	Reduce the tunnel temperature using the temperature controller.
Tunnel conveyor speed too slow.	Adjust the speed of the tunnel conveyor using the tunnel conveyor speed dial.
Tunnel fans set to low speed.	Adjust the speed of the tunnel fans using the speed selector switches.
Tunnel blower(s) not running.	Check for overload. Correct problem or reset as necessary.
	Check for loose connections. Replace as necessary.
	Inspect tunnel blower motor(s). Replace as necessary.

Poor Temperature Uniformity

Poor temperature uniformity causes the film to shrink inconsistently on the package.

POSSIBLE CAUSE	SOLUTION
Incorrect temperature setting in tunnel.	Adjust temperature on temperature controller.
Loose connection.	Check connection between thermocouple and temperature controller. Correct as necessary.
Loose or open circuit on heater element tray.	Inspect the heater tubes and replace as necessary.
Incorrect air flow in tunnel.	Adjust the speed of the tunnel fans.

Abnormal Running Conditions

Tunnel Slow To Reach Temperature

Tunnel takes longer than usual to reach desired temperature.

POSSIBLE CAUSE	SOLUTION
Blown circuit breaker.	Inspect circuit breaker. Correct as necessary.
Loose connection.	Check connection between thermocouple and temperature controller. Correct as necessary.
Loose or open circuit on heater element tray.	Inspect the heater tubes and replace as necessary.
Tunnel blower not running.	Inspect circuit breakers and connections. Correct or replace as necessary.
	Inspect motor. Replace as necessary.
Cooling blower or other fan in plant blowing cooled air into tunnel.	Reposition blowers or fans.

SECTION 7

Maintenance

Maintenance

The most important for this or any other machinery is to keep the system clean. It is also essential to make periodic inspections to detect small problem before they become big problems. A clean, properly maintained machine enhances productivity. A little P.M. now goes a long way in future system operation and machine reliability.

Preventive Maintenance

DANGER: The following procedures should only be done after the machine has been turned off and allowed to cool down. Always follow Lockout/Tagout procedures. Always wear safety glasses.

Preventive Maintenance Schedule

Daily	Weekly	Monthly
❑ Clean machine and surrounding area ❑ Check emergency stop buttons for proper operations ❑ Inspect shrink tunnel ❑ Inspect tunnel belt for melted film and/or damage		❑ Lubricate bearings on tunnel belt conveyor ❑ Check for oil in gearboxes ❑ Inspect drive chains and drive chain take-ups ❑ Inspect bearing conditions ❑ Replace worn or damaged rollers ❑ Inspect tunnel timing belt and drive take ups ❑ Inspect tunnel curtains for damage

Preventive Maintenance

General Machine Maintenance

Time should be set aside daily for the cleaning of the machine and surrounding work area. All the paper dust should be wiped or blown from the machine. All excessive adhesives should be removed by wiping or scrapping.

DANGER: In some production and plant operations, machines and equipment are routinely cleaned with high pressure sprays and hoses. Care should be taken to prevent water from entering electrical enclosures, motors, etc...

Conveyor Belts and Rollers

These should be cleaned daily or weekly depending on the application and environment. For more information on cleaning conveyor belts, see the vendor information in section 12.

Tunnel Belt

The tunnel belt and the inside of the tunnel should be checked and cleaned daily.

Tunnel Curtains

The tunnel curtains should be checked a couple of times per year. If they become frayed or damaged, they should be replaced. Damaged tunnel curtains will cause the tunnel to run inefficiently, by allowing heat to escape and will affect the quality of wrap your product receives.

Corrective Maintenance

DANGER: Prior to performing any of the following procedures, shut down the machine and disconnect electrical power. Follow your company's lockout/tagout procedures.

Belt Tightening and Tracking

DANGER: Any adjustments made to the conveyor belt must be made with the conveyor running and the tunnel at operating temperature. Failure to comply with this situation may result in a false tracking and may cause severe damage to belt.

1. Make sure that the conveyor is level from side to side prior to making any adjustments on the belt.
2. Loosen the idle roller adjustment screws.
3. Using a ruler, measure from the back of the tunnel frame to the take up shaft on each side.

DANGER: Be very careful not to over tighten the belt, as this may cause the belt to wrinkle and eventually tear. Also, be careful with the placement of other conveyors. Do not allow them or any other metal components to rub against the belt.

4. Adjust the screws until both sides of the tunnel belt are equal.
5. Make any fine tune adjustments needed by very slowly turning the adjustment screw 1/16" at a time.
6. Observe the tracking of the belt before making more adjustments.

NOTE: The belt should be tightened only to the point at which it will pull the heaviest package through the tunnel without slipping.

7. Tighten the adjustment screws.

SECTION 8

Glossary of Terms

Glossary of Terms

Most every business field has its own language or terminology. The packaging industry is no exception. This section of the manual, Glossary of Terms, was designed to help the customer to become more familiar with this terminology. This in turn will help them to better understand their manual, as well as their machine. Because of the variety of equipment that ARPAC designs and manufacturers, not all of the following features or terms may be applicable to your machine.

45° Air Bar:

Film is fed around a nickel-plated steel bar used to redirect the film at a 90° angle. 45° air bars are required on machines with side film racks, because the film rack is positioned adjacent to the machine.

Acceleration Conveyor:

This conveyor runs a specific speed faster than the device immediately before it. Examples of the devices would be another conveyor or a mechanical pushing device. The function of this conveyor is to create a gap between products.

Accumulation Conveyor:

The conveyor on which products accumulate before entering the machine.

Belt Conveyor:

Flexible fiber or composite material such as silicone fiberglass, which is used as a conveyor belt material. The silicone fiberglass belt is standard on the ARPAC shrink tunnel conveyor.

Bottom Air Flow:

This refers to the airflow in a shrink tunnel that has been specially built to provide air to the bottom of the product. This is most often used with form/fill/seal and Brandpac® bottom lap seal applications. Bottom airflow tunnels must be equipped with a roller or a mesh tunnel conveyor.

Glossary of Terms

Bullseye:

A low density Polyethylene (LDPE) shrink film sleeve forms an oval area, void of film, as it shrinks. This is called the bullseye. The size of the bullseye is determined by the width of film used (i.e. The wider the film, the smaller the bullseye).

Collating/Collation:

The process of grouping products together in a pattern. A group of products assembled in a specific pattern.

Continuous Motion:

Refers to the Model 45, 50 and 60 families of wrappers. The seal carriage moves forward as the seal bars close on the sealing stroke and it moves backward to its home position while the seal bars open. This allows for a flying seal head operation, which is essential to increased speeds.

Control Panel:

The control panel is the enclosure, which houses the microprocessor and other electronics. It is either mounted on the right side or left side. The side the panel is mounted on is determined by looking at the system as if the product were flowing through it.

Conveyor Elevation:

This is the measurement from the floor to the top of the system conveyor. The ARPAC standard is 34 inches (+2, –0) on all systems except the continuous motion high-speed wrappers. These wrappers have a standard elevation of 36 inches (+2, –0).

Cooling Section:

The cooling section is mounted at the exit end of the tunnel. Its function is to cool the film wrapped around the product.

Glossary of Terms

Dancer Bars:

Part of the film-feed mechanism which provides a reservoir of film, the signal to activate the pinch roller film feed as needed and controls the film tension at the product.

Dead Plate:

A stationary metal plate that allows a group of products to collect. Applications where a dead plate is used include but not limited to, after the infeed conveyor and before a sliding plate (or grid), or allows products to collect in front of a pneumatically actuated ram pusher plate to move the products to the next station.

Discharge Conveyor:

See **Seal Conveyor**.

Escapement Fingers:

These are individual product detection fingers located in each lane in the lane divider area. The fingers sit on the product as it is moving through the lane divider assembly. If the photo eye connected to the assembly detects fallen, missing or jammed product, the lane divider assembly shuts down.

Film Former:

A device that forms the film in a Form/Fill/Seal application. Types of film formers include inverting heads and plows. Film formers can be fixed or adjustable.

Film Splice Bar:

A heat seal bar mounted on the film rack. It facilitates quick and easy film splicing from roll to roll. It is normally found on side-mounted film racks.

Flow Direction:

The direction a product travels through the wrapping system or on a conveyor.

Glossary of Terms

Form/Fill/Seal:

A method of wrapping in which a product travels through a web of film created by a film plow or a film former. The product is completely wrapped, the bottom is lapped upon itself and the ends are heat-sealed. The bottom lap seal is normally created by heat in the shrink tunnel but can also be formed by a drag wire heat-sealing device. The film can be shrink or non-shrink.

Heater Element Tray:

This is the shrink tunnel heater element tray on ARPAC wrappers. The heater element tray can be pulled out like a drawer, for replacement. This tray contains the heating elements for the tunnel.

Infeed Conveyor:

The infeed conveyor is the first conveyor on the machine, which receives the product from the customer's conveyor.

Interlocks:

Safety devices which interrupt normal machine cycle when a certain condition is met; can be guard door interlocks, product accumulation interlocks, etc.

Lane Divider:

This device can be as simple as a crowd-type lane set-up, where the product is forced into each lane by backpressure or it can be an air-operated or mechanical device that shunts the product into the proper lane. This device receives the products from one lane and places them into multiple lanes.

Leading Edge:

This is the front of the product in the direction of flow.

Glossary of Terms

Main Ram:

The mechanism that moves or transfers products through the seal frame. It is 90° to the product.

Magazine:

A device that stores and feeds stacks of corrugated carton blanks on a tray-packing machine.

Natural Closure:

Refers to the method of closing or sealing the open ends of the sleeve by oversizing the film width. This allows the top and bottom web of film to seal together in the shrink tunnel. The tunnel exit should be equipped with side-smoothing rollers in order to provide a better closure.

Operator Interface:

The external keypad and message display on the main control panel. The interface allows the operator to monitor and diagnose problems as well as set timing functions for conveyors and seal jaws. A security password can lock this feature, making it inaccessible for unauthorized users.

Overwrap:

Overwrap is a method of wrapping in which the film is wrapped completely around the product. Overwrap flight bars wrap the film around the product, leaving a portion of film overlapping under the product. The bottom airflow tunnel causes this overlap to fuse together.

Overwrap Flight Bar:

A mechanically driven device that wraps film completely around the product with the film overlaps on the bottom of the product.

Pacing Flight Bar:

A mechanically driven device that paces and advances the product.

Glossary of Terms

Pacing Gate:

The air-operated device which spaces the product at equal intervals, even though they may have been fed into the wrapper end to end. Normally a minimum four-inch gap is required between products to allow room for the seal bars.

Perforator:

A device which creates small holes along the width or length of the film. Holes are created for air escapement and/or to make the package easier to open.

Photoeye:

Photoeyes are photoelectric sensors are used to detect moving product or machine parts, and provide input to the PLC. They do this by transmitting a beam of light to a photo eye receiver. When the product or mechanical device blocks the beam, the product or device is detected.

PLC:

Programmable Logic Controller. The programmable microcomputer that reads the status of inputs, such as switches, photo-eyes and proximity switches. The PLC also performs programmed logic and controls outputs.

PLS:

Programmable Limit Switch. The device used to turn banks of switches on and off at different times depending on the position of a shaft.

Plow:

A type of film former used in Form/Fill/Seal application. A plow is not adjustable for different product sizes.

Glossary of Terms

Pop-Up Guides:

The air-operated guides that mounted below the machines deck. When activated the pop-up guides keep the products from going astray. When not activated they do not affect the products in any way.

Power Transition Rollers:

Powered rollers, which are small in diameter, are situated on each side of the seal gap to narrow the void and assist in the transition of the product across the gap.

Product Orientation:

The term's length, width and height determine product orientation. Width refers to the product as measured across the conveyor. Length as measured along the conveyor and height as the highest projection above the conveyor.

Proximity Sensors:

Typically, an inductive proximity sensor that detects the presence of metal used to provide input to the PLC, either for normal operation or to detect jam conditions. Also, known as a proximity switch.

Roller Flight Conveyor:

Free turning rollers that are mounted between two chains. When the chains move, the rollers are free to spin under the product thus providing low-pressure accumulation. There is typically one area of the conveyor that has a plate, which contacts the under side of the rollers. This causes the products to accelerate and therefore creates a gap between each product.

Seal:

The ARPAC method of sealing uses two narrow seal bars separated by an embedded hot knife. The hot knife separates the film and a seal remains on each side of the separation.

Glossary of Terms

Seal Bar:

There are two seal bars. One is called the hot bar and the other is called the cold bar. The seal bars are located on the seal frame. They are used to fuse and cut the film between products.

Seal Conveyor:

The conveyor that is located between the seal jaws and the shrink tunnel conveyor. This is where the product being wrapped sits while the film is being cut and sealed. The seal conveyor is sometimes replaced with a dead plate.

Seal Frame:

The assembly that holds and operates the seal bars.

Seal Gap:

The area where a space between the products on the conveyor allows the seal bars to come together, make the seal and cut the film.

Seal Gap Bridge:

An air-operated device that spans the gap so that unsupported products or multi-packs can span the gap without falling in or toppling over.

Servo Motor:

A servo motor is a digitally controlled "smart" motor. Servo motors have programming capability for achieving extremely high speeds, acceleration, deceleration, rapid and frequent starts and stops and precision positions.

Shrink Film:

Extruded plastic with properties that cause shrinkage when exposed to heat. Common shrink films include: Low density polyethylene (LDPE), Polypropylene (PP) and Polyvinyl Chloride (PVC). Shrink film is available in various thickness, called mil gauges (i.e., 0.002 inch = 2 mil.)

Glossary of Terms

Shrink Multi-packing:

The wrapping of a group of products which have been assembled or collated into a specific pattern with no supporting substrate.

Shrink Sleeve Wrapping/Shrink Bundle Wrapping:

This is the process of wrapping an open-ended sleeve of film around a product or group of products, then shrinking the sleeve to fit tightly.

Shrink Tunnel Zones:

This is the area that is heated and controlled by a single element drawer. This area has its own temperature controller and thermocouple feedback probe. Shrink tunnels can have multiple zones. All tunnels less than 83-inches long will have a single zone and 83-, 93-, 110- and 140-inch tunnels will have two zones.

Side Mounted Film Racks:

The film roll rack is mounted on the floor adjacent to the wrapper. The film is threaded around a 45-degree air bar and then through the pinch roller wrapper. The side-mounted film racks are designed for film roll loading with a 36-inch maximum lift.

Side Seal:

Is the closure of the open ends of the sleeve formed by a sealing device. ARPAC offers systems equipped with a U-Bar side seal, a side seal with and without trim, a side fold and tack and a side fold and multi-tack seal.

Solenoid Valve:

This electrically controlled mechanical device controls the airflow to the pneumatic cylinders on the machine. These are typically located together at the base of the wrapper, on the control side.

Glossary of Terms

Stacker:

Refers to the device that stacks the product. The stacker may either be a freestanding unit prior to the infeed of the system or an integral part of the machine located just prior to the seal bar.

Starwheel:

A star shaped device that reorients the position of the product. Star Wheels may also be used for product pacing purposes.

Static Seal:

A device that applies high voltage to the film overlap in bottom lap seal applications. This makes the film adhere to itself with static electricity.

Table Top Chain:

This is a plastic conveyor material that is available in a wide range of surface configurations. It is normally used in Multi-packing applications.

Telescoping Conveyor:

A special modification to a fabric belt conveyor that allows the conveyor to extend or retract without affecting belt length or tracking. This can be used on Models 45, 50 and 60 or as a transition bridge on some inline wrappers.

Torque Limiter:

A mechanical device that disengages the drive input from its driven output when a specific amount of torque is applied that is above starting and normal operating torque values. When its torque limit is reached or exceeded, the limiter will disengage and spin freely.

Thermocouple:

This is the device that detects the temperature of a specific area or device. These are typically located in the hot seal bar and in the heater bank chamber of the tunnel.

Glossary of Terms

Tray:

A corrugated or paperboard substrate with low sidewalls and end panels. Trays are required in order to sleeve wrap a product on an inline tray wrapper. They are also required for use of our tray loading systems.

Tunnel Blower:

The tunnel blower is mounted to the top of the tunnel directly over the heater elements. The number of blowers used depends on the application. The blower circulates the air through the tunnel, pulling the air from the tunnel up through the heater elements. The heated air then travels into the tunnel through an enclosed duct system. It enters the tunnel from the sides and the bottom. The air that is inside the tunnel is then pulled back up through the heater elements.

Tunnel Louver:

These are the mechanical controls located at the exit end of the tunnel and sometimes also located at the infeed end. These control the amount of force and the direction of the side airflow within the tunnel. Adjusting these will change the way the film shrinks around the product.

Venturi:

A short tube with a constricted passage used to lower the pressure of fluids that travel through it. Used to create a vacuum for suction cups.

Upender:

The upender reorients the product 90° by using a type of lift method.

Z Flow Wrapper:

Also known as an offset infeed system employs two rams. The first ram moves the product left or right and the second ram, the main ram, advances the multi-pack through the web of film. The Z Flow wrapper is normally used for collating applications or to facilitate an inline flow where the product must be advanced through the film with a ram.

SECTION 9

Service Information

Service Information

This section contains an overview of ARPAC's field service and form for ordering parts.

Field Service Policy

Objective

To furnish our customer with prompt, competent, and complete service so they can operate at optimum efficiency.

Service Personnel

ARPAC's field technicians are experienced in the servicing of ARPAC equipment, are qualified to instruct customer's personnel in correct operation and maintenance procedures of ARPAC equipment. ARPAC Field Service Technicians are fully supported by factory and all Engineering Departments.

Training

ARPAC personnel is available for ARPAC equipment training either on-site/hands on or in classroom environment, supported by visual aids and literature to be administered under separate purchase order.

ARPAC Commitment

- Be readily available to communicate with the customer(s).
- Service Technicians available for supervision and instruction of personnel at prevailing rates and expenses.
- Upon arrival of the ARPAC Service Technician, he should be able to commence immediately, minimize "downtime" of your production facilities and commence training of your personnel.

Scheduling Service

At least 10-days advance notice is required for scheduling personnel. Emergencies will be handled as quickly as possible. Contact the Technical Service Department via telephone at (847) 678-9034 or by fax (847) 678-2109 for immediate assistance.

Installation Policy

Objective

To furnish our customer with prompt, competent, and complete service so they can operate at optimum efficiency. Failure to use factory trained personnel for initial machine start-up may void the warranty.

Service Personnel

ARPAC's field technicians are experienced in the servicing of ARPAC equipment, and are qualified to instruct customer's personnel in the correct operation and maintenance procedures of ARPAC equipment. ARPAC Field Service Technicians are fully supported by factory and all Engineering Departments.

Training

ARPAC personnel are available for ARPAC equipment training, either on-site hands-on, or in a classroom environment supported by visual aids and literature to be administered under separate purchase order.

ARPAC Commitment

- To furnish equipment per quotation.
- Be readily available to communicate with the customer(s) to facilitate start-up.
- Service Technicians available for start-up supervision and instruction of personnel at prevailing rates and expenses.
- Upon arrival of the ARPAC Service Technician, he should be able to commence immediately, minimize "downtime" of your production facilities and commence training of your personnel.

(Continued on the next page)

Installation Policy

Customer On-Site Preparation

- Unload, unpack, and inspect the equipment for any freight damage (apparent or hidden). If there is any damage, the Bill of Lading will need to be signed, noting the damage. You will then need to file all the necessary freight claims with the appropriate carrier. All shipments are freight collect and you are responsible for any damages in transit.
- Remove all interfering equipment and clear area where equipment is to be installed.
- Assemble/erect subject equipment.
- Lag system to floor.
- Furnish all electrical wiring and connections per system requirements.
- Furnish any air and/or gas liners and connections if required.
- Integrate with any existing up and/or down stream equipment.
- Provide qualified technicians, operators, and maintenance personnel to start-up system.

Scheduling Service

At least 10-days advance notice is required for scheduling personnel. Contact the Technical Service Department via telephone at (847) 678-9034 or by fax (847) 678-2109 for immediate assistance.

Parts Order Form

In order for ARPAC to expedite your parts order, the following information is needed:

Model No.	Order No.	Buyer
Serial No.	**Request Date**	**Salesperson**

SOLD TO	SHIP TO
Company _____	Company _____
Address _____	Address _____
City / State _____ _____	City/State _____
Country ZIP _____ _____	Country ZIP _____ _____
ATTN: _____	ATTN: _____

Buyer	Telephone No.

Part Number	Qty.	Description

Complete the above form and contact ARPAC's Parts department to place your order.

ARPAC Parts Department Contact Information	
Phone	(847) 678-9034
Fax	(847) 678-2109
24-Hour Emergency Service	(800) 424-0545
e-mail	parts@arpac.com
Open for service Monday through Friday, 7:00 AM to 6:00 PM (Central Time)	

SECTION 10

Mechanical Assembly Drawings

Notice from ARPAC's Documentation Department

1. Please refer to your **serial specific** bill of material sheet (not the bill of material on the drawing) when ordering parts.
2. When multiple drawings are noted, only the drawings applicable are printed.

Table of Contents
Mechanical Assembly Drawings
Model: Vision Tunnel

BILL OF MATERIALS

Date printed 07/18/05

Parent Number 232032.000A
Model ..... N/A

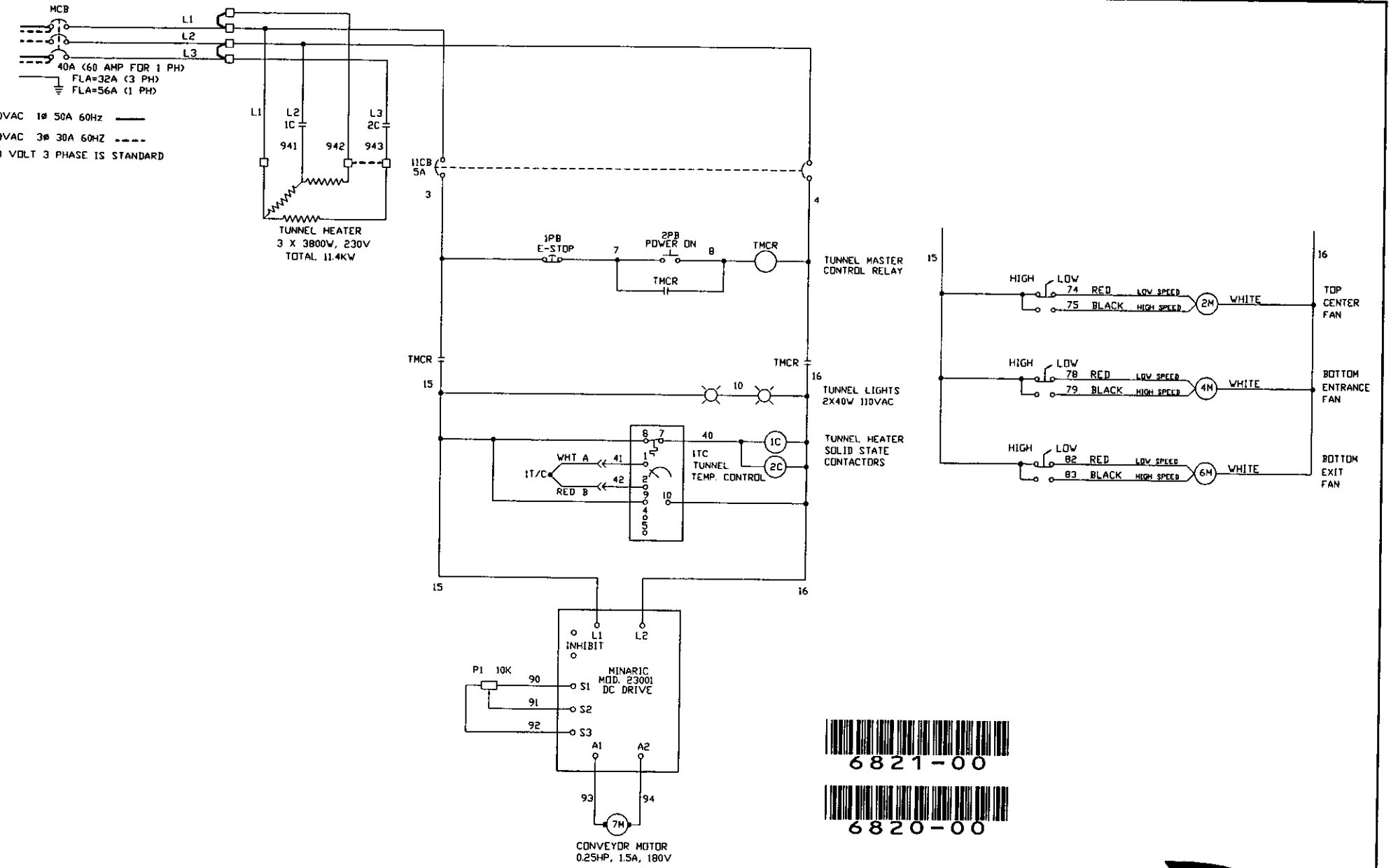
Assembly Part Number 232032.000A
Description ..... ASSY, TUNNEL, VT122248
Quantity 1

Item	Quantity	Arpac Part	Description	
1	2	228074.	BLK, MTG, RLR	
2	2	142136.742	RLR, IDL, AL, 1.500, 27-1/4 LG	"A"= 27
3	2	191350.017	PLT, NUT, 1/2 X 1/2 X 3, 1/4-20	
4	4	194467.017	INSULATION, 1.00 THK, K-FAC 19	A=26 3/4, B=2 1/2
5	4	228075.	PLT, INSULATION, PHENOLIC	
6	4	195400.	WLDMT, FOOT	
7	4	228077.	BAR, SPACER, TUNNEL	
8	3	199128.	NUT, BLADE, BLOWER	
9	2	232027.	PLT, EXIT, INFEED	
10	1	199736.	SHAFT, DRIVE, 3/4 DIA, 30 1/2 LONG	
11	1	199738.	ROLLER, DRIVE	
12	1	199739.	SHAFT, RISER, BELT	
13	1	199741.	RLR, IDL, STL, 3 1/2 DIA, 24" LG	
14	1	104643.028	SHAFT, 0.500, TAPPED, 1/4-20, 30.875 LG	
15	1	199747.002	SHAFT, IDLER	30 7/8 LG
16	1	232013.	CHAN, MTG, ELEMENT, LWR	
17	1	232014.	CHAN, MTG, ELEMENT, UPR	
18	6	201675.	BRACKET, MTG, ELEMENT	
19	2	204472.	PULLEY, TIMING, 15T, 3/8 P, 1 W,	3/4 BORE, WITH SET SCREW
20	2	232015.	PLT, TAKE-UP, LWR	
21	1	215508.001	SHAFT, TAKE-UP, RLR, IDL	VTXX22XX, "A" = 30 1/4
22	1	232022.	COVER, ELEMENT, UPR	
23	2	232023.	CURTAIN, TUNNEL	VT1222XX
24	1	232024.	FRAME, MTG, WINDOW	
25	1	232025.	FRAME, WINDOW, OUTER	
26	2	232026.	FRAME, CURTAIN	
27	1	232105.	BKT, MTG, MOTOR, TUNNEL	
28	1	232028.	COVER, ELEMENT, BTM	
29	1	225283.	BASE, COVER, MOTOR, FAN	
30	1	225284.	COVER, MOTOR, FAN	
31	2	232029.	BLK, TAKE-UP	
32	2	802744.	BRG, FLG, 3/4 ID, 2-BOLT	3.53 MTG HOLES
33	3	816958.	BLADE, BLOWER, AXIAL	
34	4	800588.	COLLAR, SHAFT, CLAMP, 2-PIECE, 1-1/2	
35	2	812723.	ADHESIVE SEALANT CLEAR 10.3 OZ CARTRIDGE	
36	4	800561.	COLLAR, SHAFT, SET SCREW, 1/2	
37	3	816959.	ELEMENT, HEATING, 3800 W, 230V	
38	1	821853.	MOTOR, GEAR, 1/4 HP, 180VDC, 104 RPM	
40	1	823265.	BELT, TIMING, 3/8 P, 1 W, 19.5 LG	
41	1	823263.	GLASS, TEMPERED, 8 X 27 X 1/8 THICK	
42	2	816980.	LAMPHOLDER, SNAP-IN, PORCELAIN	MEDIUM BASE
43	2	817013.	BULB, LIGHT, APPLIANCE, 40W, MEDIUM BASE	
44	3	816982.	MOTOR, 1/15 HP, 230V, 50/60 HZ	1750 AND 975 RPM
45	1	823266.	BELT, MESH, 22 X 156 TEFLON	SS 5/8 BULLNOSE ALIGATOR/FLAP
46	4	817006.	CASTERS, SWIVEL WITH BRAKE, 4" WHEEL	

ARPAC L.P., 9511 West River Street, Schiller Park, IL 60176
Phone: (847) 678-9034, Fax: (847) 678-2109

SECTION 11

Electrical Information



6821-00

6820-00

6818-00

6817-00

ARPAC GROUP

REV: A	ELECTRICAL SCHEMATIC	SIZE: A	
DESIGNER: HKS		DATE: 06-10-2005	
MODEL: VT122248		SHEET: 1 OF 2	
ARPAC STOCK		DRAWING NUMBER: 6817-99-01	

BILL OF MATERIALS

Date printed 07/12/05

Parent Number 6817
Model VT122248

Assembly Part Number 006817.099
Description ..... ASSY, ELECT, TUNNEL #6817
Quantity 1

Item	Quantity	Arpac Part	Description	
10	1	804000.140	CIRCUIT BREAKER, 3 POLE 40A 480VAC	SMALL FRAME SIZE
20	1	804000.148	CIRCUIT BREAKER, OPERATING HANDLE, BLACK	INCLUDES SHAFT - FOR USE WITH GD TYPE CB
30	2	804008.118	RELAY, SOLID STATE 63A, 480 VOLT	24-265VAC/DC COIL FOR VISION TUNNEL
40	1	804008.123	RELAY, 3 POLE, 10A, 240VAC, 3PDT	
50	1	804008.005	RELAY, SOCKET, 11 PIN FOR 3 POLE RELAY	
60	1	804023.002	TEMPERATURE CONTROL, CONTROLLER	
70	1	804012.009	DRIVE, DC, 0.25-2.000HP	
80	1	804030.020	RESISTOR, 10.0K POTENTIOMETER NO LOCKBL	MAKE: CLAROSTAT FOR A2Z
90	1	804000.017	CIRCUIT BREAKER, 2 POLE 5A 480VAC	
100	1	804004.175	PUSH BUTTON, E-STOP OPERATOR,22MM,RED	PUSH-PULL, 40MM HEAD,REQ804004.180+CONT
105	5	804004.180	PUSH BUTTON, METAL LATCH	FOR A-B 22MM OPERATORS
107	5	804004.177	PUSH BUTTON, N/O CONTACT BLOCK	FOR A-B 22MM OPERATORS
110	1	804004.168	PUSH BUTTON, 22MM NON-ILL, FLASH,GREEN	OPERATOR, METAL BODY
120	3	804021.033	SELECTOR SWITCH, 2 POS 22MM,MAINTAINED	METAL, KNOB LEVER REQ 804004.180+ CONTAC
130	2	804004.178	PUSH BUTTON, N/C CONTACT BLOCK	FOR A-B 22MM OPERATORS
140	1	804004.213	PUSH BUTTON, E-STOP LEGENTD PLATE	FOR 22.5MM P.B YELLOW 60MM ROUND
150	4	804004.214	PUSH BUTTON, LEGEND PLATE FRAME &SNAP IN	30X50 MM BLANK,FOR 22.5MM P.B QUANTITY10
160	4	804004.215	PUSH BUTTON, 30X50MM SNAP-IN PLATE ONLY	BLANK, FOR 22.5MM P.B QUANTITY 10
200	1	804023.025	TEMPERATURE CONTROL,OVERTEMP SWITCH	FOR HI-TECH TUNNEL

ARPAC L.P., 9511 West River Street, Schiller Park, IL 60176
Phone: (847) 678-9034, Fax: (847) 678-2109

SECTION 12

Vendor Information

USER'S MANUAL

MM23000 Series

SCR, Dual Voltage,
Adjustable Speed Drives
for DC Brush Motors

Minarik Automation & Control

Printed in the United States of America.

⚠ Safety Warnings

- Have a qualified electrical maintenance technician install, adjust, and service this equipment. Follow the National Electrical Code and all other applicable electrical and safety codes, including the provisions of the Occupational Safety and Health Act (OSHA) when installing equipment.

- Reduce the chance of an electrical fire, shock, or explosion by proper grounding, over current protection, thermal protection, and enclosure. Follow sound maintenance procedures.

- It is possible for a drive to run at full speed as a result of a component failure. Install a master switch in the AC line for stopping the drive in an emergency.

- This drive is not isolated from earth ground. Circuit potentials are at 115 VAC or 230 VAC above earth ground. Avoid direct contact with the printed circuit board or with circuit elements to prevent the risk of serious injury or fatality. Use a non-metallic screwdriver for adjusting the calibration trimpots.

Contents

Specifications

Model	Max. Armature Current (Amps DC)	HP Range with 115 VAC Applied	HP Range with 230 VAC Applied	Style
MM23011	1.5	1/20–1/8	1/10–1/4	Chassis
MM23111				NEMA 1
MM23211				NEMA 12
MM23411				NEMA 12
MM23072				Chassis
MM23001 †	5.0	1/8–1/2	1/4–1	Chassis
MM23101 ‡				NEMA 1
MM23201 ‡				NEMA 1
MM23071 †				Chassis
MM23401	10.0	1/8–1	1/4–2	NEMA 12
MM23501				NEMA 12

† Double maximum armature current and horsepower when drive is mounted on heat sink part number 223-0159.

‡ Double maximum armature current and horsepower when drive is mounted on heat sink part number 223-0174.

AC Line Voltage	115 VAC or 230 VAC ±10%, 50/60 Hz, single phase
Armature Voltage (115 VAC Input)	0–90 VDC
Armature Voltage (230 VAC Input)	0–180 VDC
Form Factor	1.37 at base speed
Field Voltage (115 VAC Input)	50 VDC (F1 to L1); 100 VDC (F1 to F2)
Field Voltage (230 VAC Input)	100 VDC (F1 to L1); 200 VDC (F1 to F2)
Max. Field Current	1 ADC
Accel. Time Range (for 0–90 VDC Armature Voltage)	0.5–11 seconds
(for 0–180 VDC Armature Voltage)	0.5–22 seconds
Decel. Time Range (for 0-90 VDC Armature Voltage)	coast to a stop–13 seconds
(for 0–180 VDC Armature Voltage)	coast to a stop–25 seconds
Analog Input Voltage Range (Isolated; S1 to S2)	
for 0–90 VDC Armature Voltage	0–1.4 VDC
for 0–180 VDC Armature Voltage	0–2.8 VDC
Input Impedance (S1 to S2)	100K ohms

Specifications *(Continued)*

Load Regulation	1% base speed or better
Vibration	0.5G max (0–50 Hz)
	0.1G max (>50 Hz)
Safety Certification	UL Recognized Component, file # E132235
	CSA Certified Component, file # LR41380
	CE Certificate of Compliance
Ambient Temp. Range (chassis drive)	10°C–55°C
Ambient Temp. Range (cased drive)	10°C–40°C

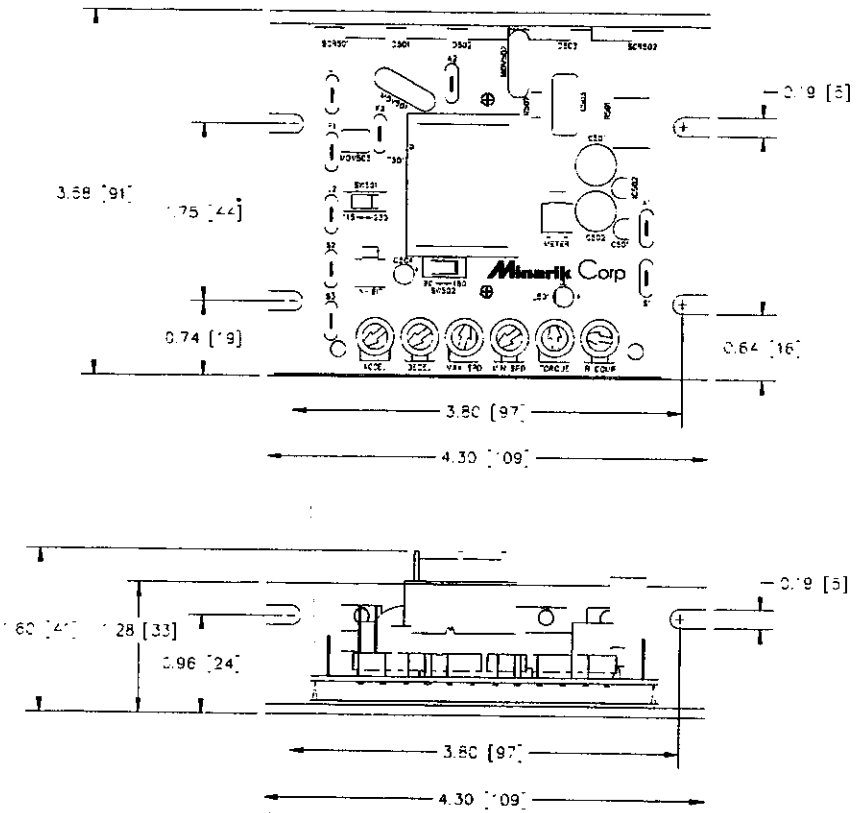
Suffix Definitions

A: Basic drive
C: Basic drive with current limit LED
C-H: Basic drive with current limit header block
C-Q: Basic drive with current limit LED, power LED, and quick-disconnect terminal block

Note:

- C suffix applies only to all models except MM23071 and MM23072.
- C-H and C-Q suffixes apply only to models MM23001 and MM23011.
- MM23071A and MM23072A drives include a current limit and power LED; trimmer potentiometers (trimpots) are perpendicular to the PC board.

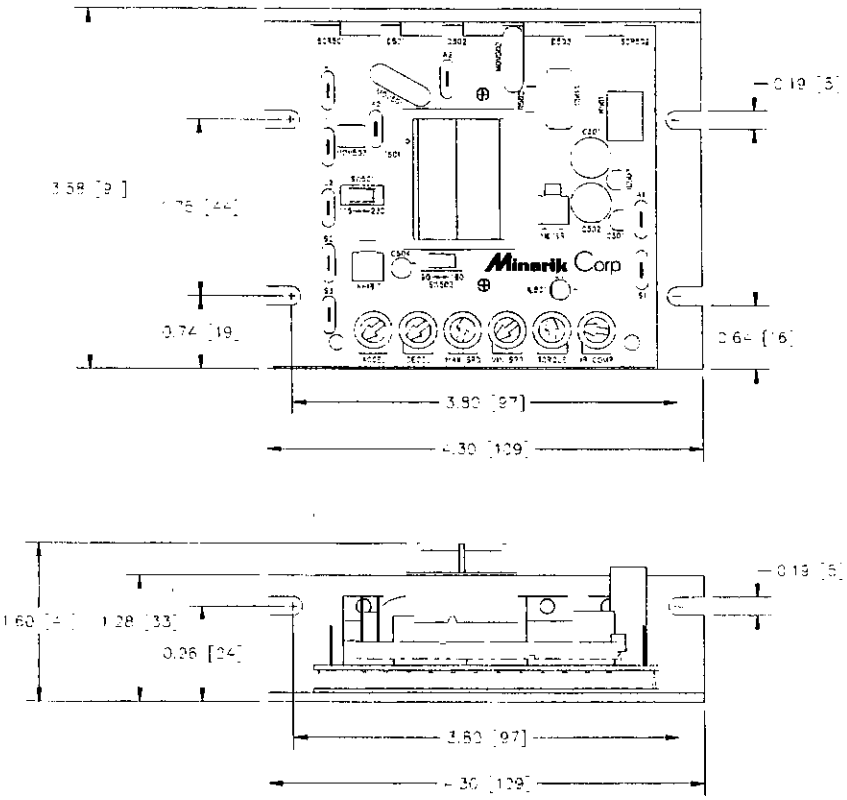
Dimensions



ALL DIMENSIONS IN INCHES [MILLIMETERS]

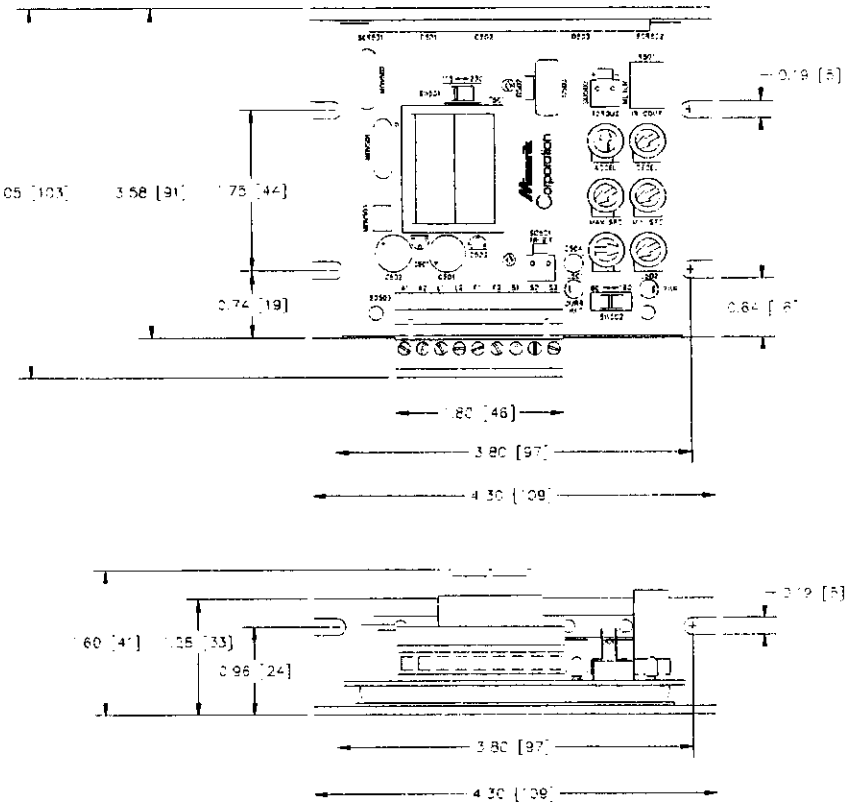
Figure 1. MM23001 and MM23011 Dimensions

Dimensions



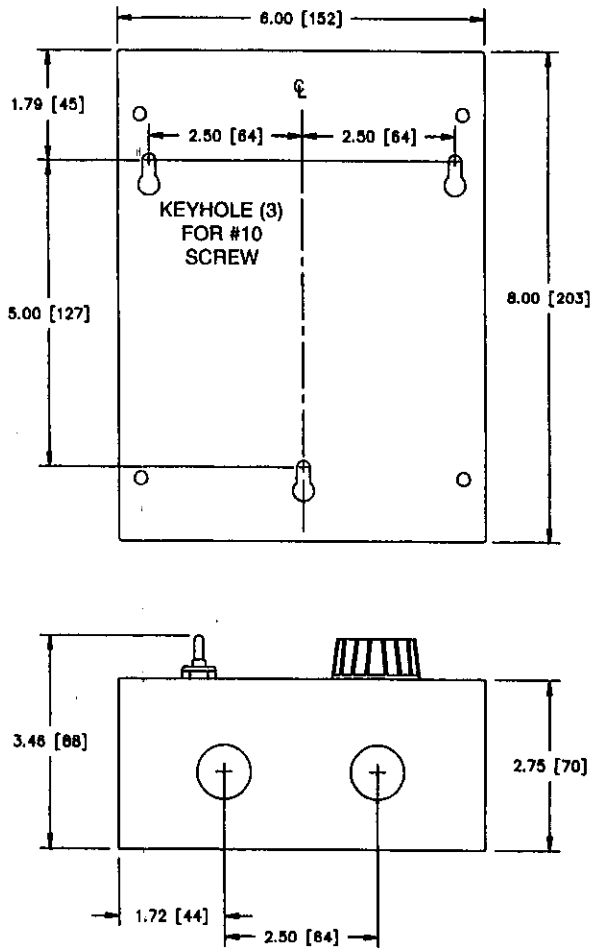
ALL DIMENSIONS IN INCHES [MILLIMETERS]

Figure 1. MM23001 and MM23011 Dimensions



ALL DIMENSIONS IN INCHES [MILLIMETERS]

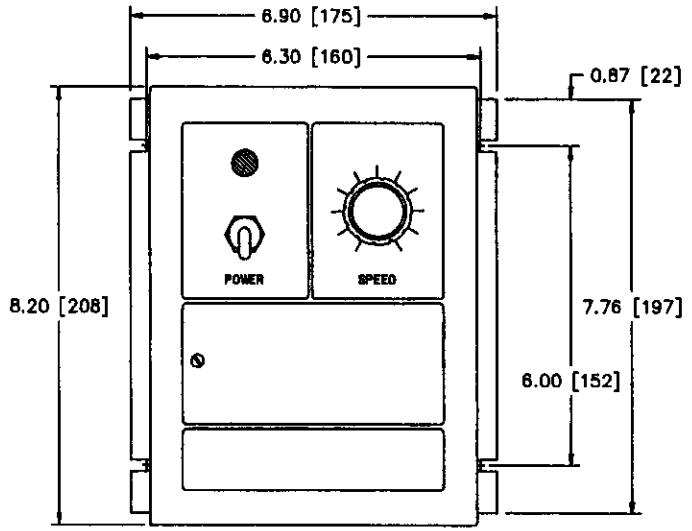
Figure 2. MM23001C-Q and MM23011C-Q Dimensions



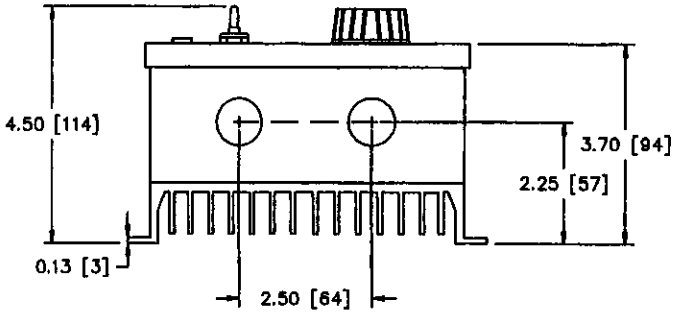
TWO 0.88 [22] CONDUIT HOLES

ALL DIMENSIONS IN INCHES [MILLIMETERS]

Figure 3. MM23101, MM23111, MM23201, and MM23211 Dimensions



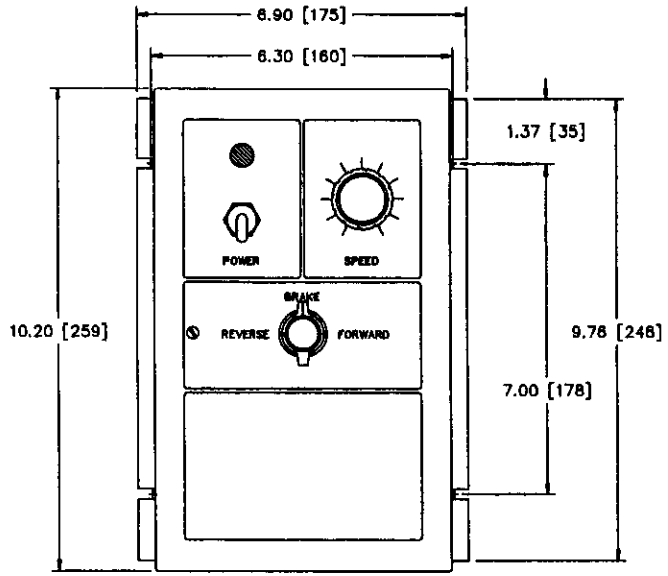
FOUR MOUNTING SLOTS 0.19 INCHES [5 MILLIMETERS] WIDE



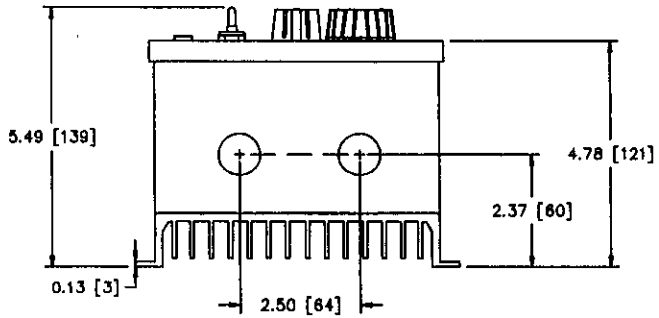
TWO 0.88 [22] KNOCKOUTS

ALL DIMENSIONS IN INCHES [MILLIMETERS]

Figure 4. MM23401 and MM23411 Dimensions



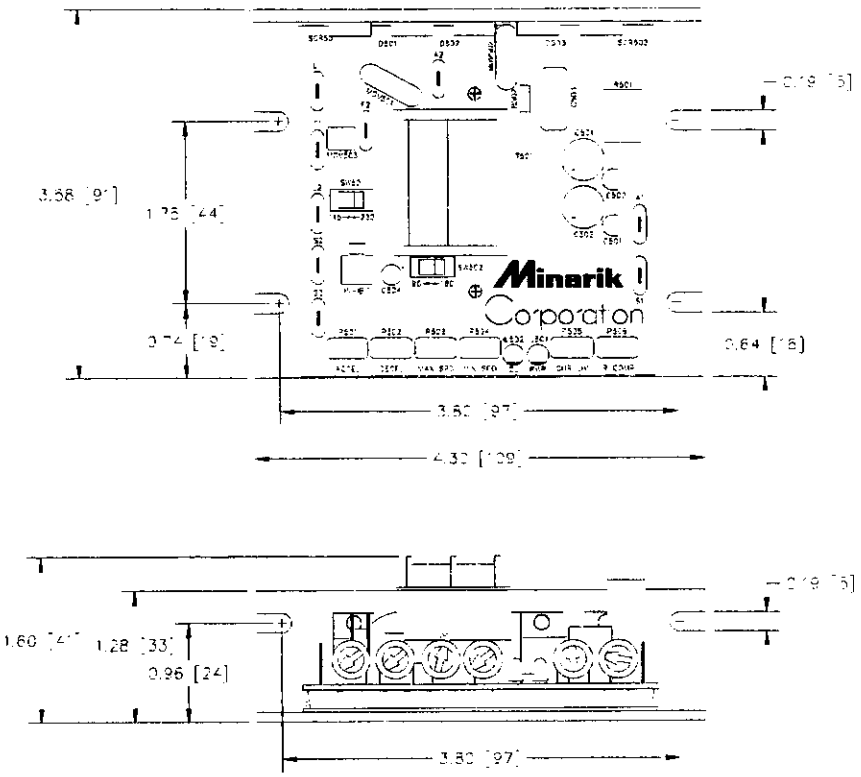
FOUR MOUNTING SLOTS 0.19 INCHES [5 MILLIMETERS] WIDE



TWO 0.88 [22] KNOCKOUTS

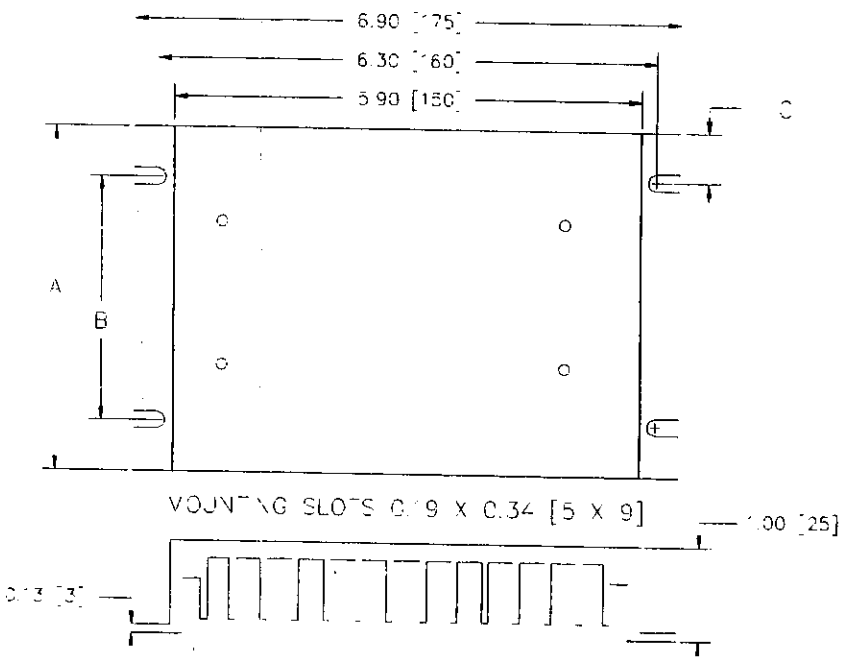
ALL DIMENSIONS IN INCHES [MILLIMETERS]

Figure 5. MM23501 Dimensions



ALL DIMENSIONS IN INCHES [MILLIMETERS]

Figure 6. MM23071 and MM23072 Dimensions



PART NO.	DIM "A"	DIM "B"	DIM "C"
223-0159	4.40 [112]	3.00 [76]	0.7 [18]
223-0174	7.78 [198]	6.00 [152]	0.89 [23]

Heat sinks sold separately.

ALL DIMENSIONS IN INCHES [MILLIMETERS]

Figure 7. Heat Sink Dimensions

Installation

Chassis drives

Mounting

- Drive components are sensitive to electrostatic fields. Avoid contact with the circuit board directly. Hold drive by the chassis only.
- Protect the drive from dirt, moisture, and accidental contact. Provide sufficient room for access to the terminal block and calibration trimpots.
- Mount the drive away from other heat sources. Operate the drive within the specified ambient operating temperature range.
- Prevent loose connections by avoiding excessive vibration of the drive.
- Mount drive with its board in either a horizontal or vertical plane. Six 0.19 inch (5 mm) wide slots in the chassis accept #8 pan head screws. Fasten either the large base or the narrow flange of the chassis to the subplate.
- The chassis must be earth grounded. To ground the chassis, use a star washer beneath the head of at least one of the mounting screws to penetrate the anodized chassis surface and to reach bare metal.

Heat sinking

Models MM23001 and MM23071 require an additional heat sink when the continuous armature current is above 5 ADC. Use Minarik® part number 223-0159. All other chassis drives have sufficient heat sinking in their basic configurations. Use a thermally conductive heat sink compound (such as Dow Corning® 340 Heat Sink Compound) between the drive chassis and heat sink surface for optimum heat transfer.

Connections

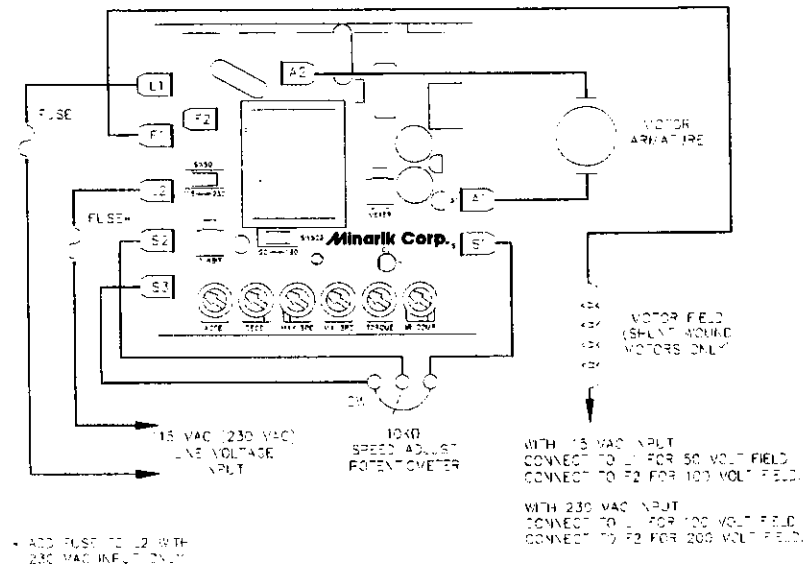


Figure 8. Chassis Drive Connections

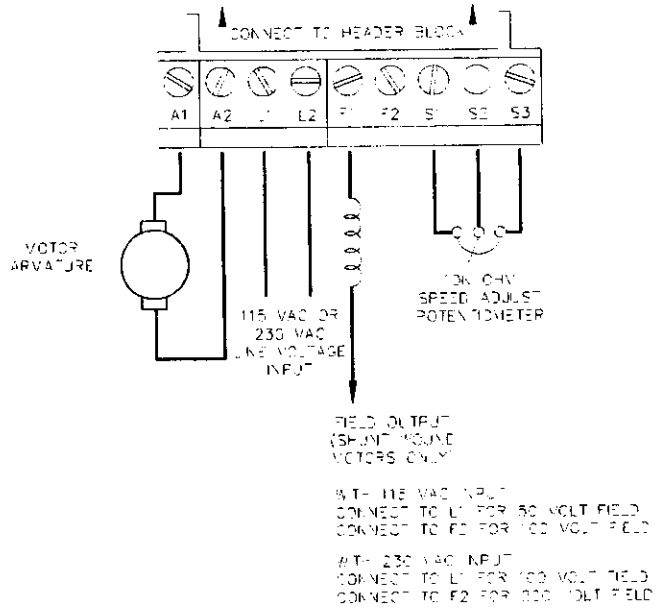


Figure 9. C-Q Connections

Quick-disconnect terminal block

The quick-disconnect terminal block, found only on C-Q drives, is composed of a 9-pin header block and 9-screw terminal plug (Figure 10). To use the quick-disconnect terminal block:

1. Carefully pull terminal plug from header block.
2. With a small flat-head screwdriver, turn terminal plug screw counterclockwise to open wire clamp.

3. Insert stripped wire into the large opening in front of the plug.
4. Turn the terminal plug screw clockwise to clamp the wire.
5. Repeat steps 2–4 for each terminal until all connections are made. Make no connections to F1 and F2 if using a permanent magnet motor.
6. Insert plug into header until securely fastened.

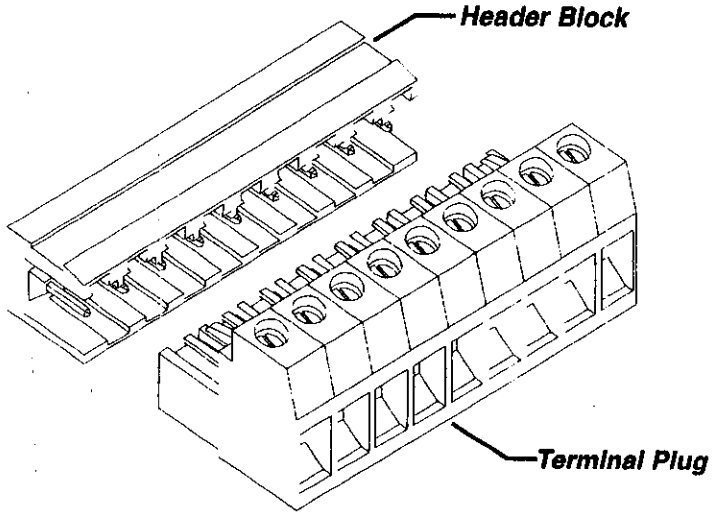


Figure 10. Quick-Disconnect Terminal Block

Field output

The field output is for shunt wound motors only. **Do not make any connections to F1 and F2 when using a permanent magnet motor.** See Table 1 for field output connections.

Table 1. Field Output Connections

Line Voltage (VAC)	Approximate Field Voltage (VDC)	Connect Motor Field To
115	50	F1 and L1
115	100	F1 and F2
230	100	F1 and L1
230	200	F1 and F2

Use 18 AWG wire to connect the field output to a shunt wound motor.

Speed adjust potentiometer

On chassis drives, install the circular insulating disk between the panel and the 10K ohm speed adjust potentiometer. Mount the speed adjust potentiometer through a 0.38 inch (10 mm) hole with the hardware provided (Figure 11). Twist the speed adjust potentiometer wire to avoid picking up unwanted electrical noise. If potentiometer leads are longer than 18 inch (457 mm), use shielded cable.

All cased controls come with the speed adjust potentiometer installed.

⚠ **Warning** Be sure that the potentiometer tabs do not make contact with the potentiometer enclosure. Grounding the input will cause damage to the drive.

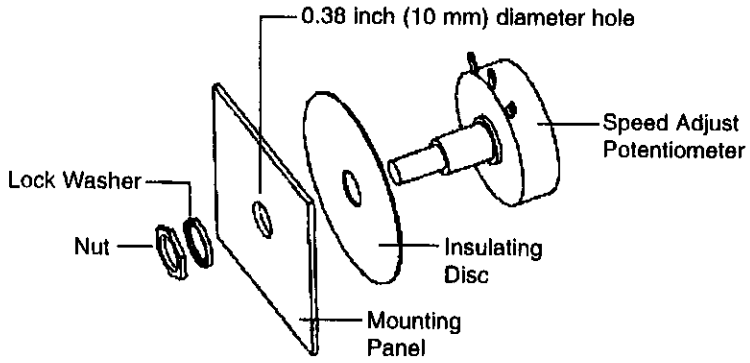


Figure 11. Speed Adjust Potentiometer

Shielded cable

Use shielded cable when logic lines (speed adjust potentiometer wires and inhibit wires) are longer than 18 in. (475 mm). Logic lines of this length act as an antenna and can pick up noise from the drive components, noise from other devices or other ground wires, or voltage from power lines that can cause erratic operation.

It may be necessary to earth ground the shielded cable. If noise is produced by devices other than the drive, ground the shield at the drive end. If noise is generated by a device on the drive, ground the shield at the end away from the drive. ***Do not ground both ends of the shield.***

If the drive continues to pick up noise after grounding the shield, it may be necessary to add AC line filtering devices, or to mount the drive in a less noisy environment.

Line fusing

Minarik drives require an external fuse for protection. Use fast acting fuses rated for 250 VAC or higher, and approximately 150% of the maximum armature current. Fuse only the hot leg of the AC line that connects to L1 and leave L2 unfused when the AC line voltage is 115 VAC. Fuse both L1 and L2 when the AC line voltage is 230 VAC. Fuse blocks are included on cased drives only. Table 2 lists the recommended line fuse sizes.

Table 2. Recommended Line Fuse Sizes

90 VDC Motor Horsepower	180 VDC Horsepower	Max. DC Armature Current (amps)	AC Line Fuse Size (amps)
1/20	1/10	0.5	1
1/15	1/8	0.8	1.5
1/8	1/4	1.5	3
1/6	1/3	1.7	3
1/4	1/2	2.6	5
1/3	3/4	3.5	8
1/2	1	5.0	10
3/4	1 1/2	7.6	15
1	2	10	15

Minarik Corporation offers two fuse kits: part number 050–0066 (1–5A Fuse Kit) and 050–0071 (5–15A Fuse Kit).

Voltage follower

Instead of using a speed adjust potentiometer, the drive may be wired to follow an analog input voltage signal that is isolated from earth ground (Figure 12). Connect the signal input (+) to S2. Connect the signal common (–) to S1. Make no connection to S3. A potentiometer can be used to scale the analog input voltage. An interface device, such as Minarik® model PCM4, may be used to scale and isolate an analog input voltage.

With either 115 VAC or 230 VAC line voltage, an analog input voltage range of approximately 0–1.4 VDC is required to produce an armature voltage range of 0–90 VDC. With 230 VAC line voltage, an analog input voltage range of approximately 0–2.8 VDC is required to produce an armature voltage range of 0–180 VDC.

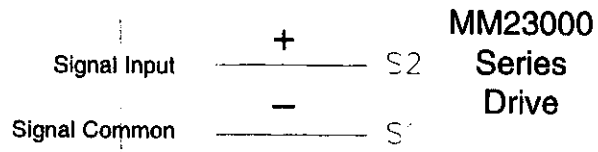


Figure 12. Voltage Follower Connections

Cased drives

Mounting (NEMA 1 enclosures)

NEMA 1 cased drives come with 0.88 inch (22 mm) conduit holes at the bottom of the case. The units may be vertically wall mounted or horizontally bench mounted using the three keyholes on the back of the case.

1. For access to the keyholes and the terminal strip, remove the two screws from the front of the case by turning them counterclockwise. Grasp the front cover and lift it straight out.
2. Install the mounting screws in the three keyholes.
3. Install conduit hardware through the conduit holes at the bottom of the case. Connect external wiring to the terminal block.
4. Reinstall the front cover. Avoid pinching any wires between the front cover and the case.
5. Replace the two screws to the front cover. Turn the screws clockwise to tighten.
6. Set the POWER switch to the OFF position before applying the AC line voltage.

Mounting (NEMA 12 enclosures)

NEMA 12 cased drives come with two 0.88 inch (22 mm) conduit knockout holes at the bottom of the case. The units may be vertically wall mounted using the four 0.19 inch (5 mm) slotted holes on the attached heat sink. For motor loads less than 5 ADC, the drive may be bench mounted horizontally, or operated without mounting.

1. Install the mounting screws.
2. For access to the terminal strip, turn the slotted screw on the front cover counterclockwise until it is free from the case. The right side of the cover is hinged to the case. Pull the slotted screw to open the case.
3. Carefully remove the conduit knockouts by tapping them into the case and twisting them off with pliers.
4. Install conduit hardware through the 0.88 inch (22 mm) knockout holes. Connect external wiring to the terminal block.
5. Grasp the slotted screw and tilt the front cover back into place. Avoid pinching any wires between the front cover and the case.
6. Turn the slotted screw clockwise until tight to secure the front cover.
7. Set the POWER switch to the OFF position before applying the AC line voltage.

Heat sinking

Models MM23101 and MM23201 require additional heat sinking when the continuous armature current is above 5 ADC. Use Minarik part number 223-0174. All other cased drives have sufficient heat sinking in their basic configurations. Use a thermally conductive heat sink compound (such as Dow Corning® 340 Heat Sink Compound) between the back of the drive case and heat sink surface for optimum heat transfer.

Connections

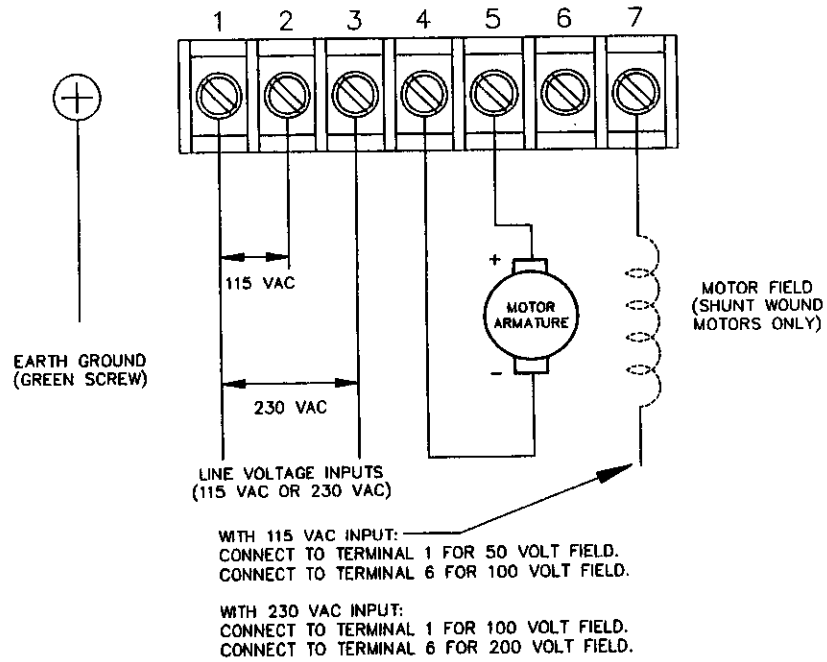


Figure 13. Cased Drive Connections

> ⚠ **Warning** The field output is for shunt wound motors only. Do not make any connections to terminals 6 and 7 when using a permanent magnet motor.

Line fusing

Fifteen amp line fuses are preinstalled on models MM23101, MM23201, MM23401, and MM23501. 3 amp line fuses are preinstalled on models MM23111, MM23211, and MM23411. If the horsepower rating of the motor being used is less than the maximum horsepower rating of the drive, the line fuse may have to be replaced with a lower rated one. Refer to the "Recommended Line Fuse Sizes" table on page 16 to install a lower rated fuse.

Operation

Before applying power

- Set the voltage switch SW501 to either 115V or 230V to match the AC line voltage. Set the voltage switch SW502 to either 90V or 180V to match the maximum armature voltage (see Figure 14).

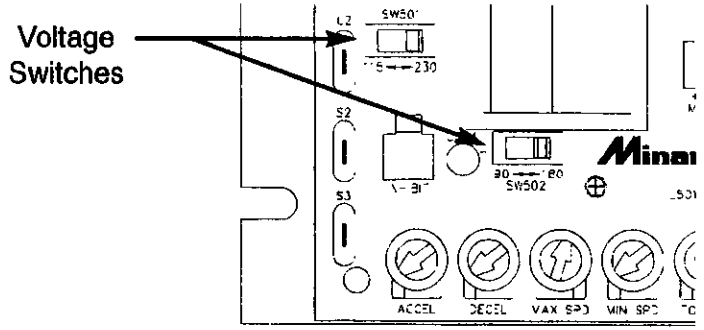


Figure 14. Voltage Switches

> ⚠ **Warning** Change voltage switch settings only when the drive is disconnected from AC line voltage. Make sure both switches are set to their correct position. If the switches are improperly set to a lower voltage position, the motor will not run at full voltage and may cause damage to the transformer. If the switches are improperly set to a higher voltage position, the motor will overspeed, which may cause motor damage.

- Verify that no conductive material is present on the printed circuit board.
- If using a 90 VDC or 130 VDC motor with 230 VAC line voltage, derate the nameplate motor speed and torque by at least 30%. Contact the factory for details.

Startup

MM23001, MM23011, MM23071, and MM23072

1. Turn the speed adjust potentiometer full counterclockwise (CCW).
2. Apply AC line voltage.
3. Slowly advance the speed adjust potentiometer clockwise (CW). The motor slowly accelerates as the potentiometer is turned CW. Continue until the desired speed is reached.
4. Remove AC line voltage from the drive to coast the motor to a stop.

MM23101, MM23111, MM23401, and MM23411

1. Set the speed adjust potentiometer to "0" (full CCW).
2. Apply AC line voltage.
3. Set the POWER switch to the ON position.
4. Slowly advance the speed adjust potentiometer clockwise (CW). The motor slowly accelerates as the potentiometer is turned CW. Continue until the desired speed is reached.
5. Set the POWER switch to the OFF position to coast the motor to a stop.

MM23201 and MM23211

1. Set the RUN/BRAKE switch to the BRAKE position.
2. Set the speed adjust potentiometer to "0" (full CCW).
3. Apply AC line voltage.
4. Set the POWER switch to the ON position.
5. Set the FORWARD/REVERSE switch to the desired direction of rotation.
6. Set the RUN/BRAKE switch to the RUN position.
7. Slowly advance the speed adjust potentiometer clockwise (CW). The motor slowly accelerates as the potentiometer is turned CW. Continue until the desired speed is reached.
8. To reverse direction:
   a. Set the RUN/BRAKE switch to the BRAKE position.
   b. Set the FORWARD/REVERSE switch to the desired direction of rotation.
   c. Set the RUN/BRAKE switch to the RUN position.
9. To brake the motor, set the RUN/BRAKE switch to the BRAKE position. To coast the motor to a stop, set the POWER switch to the OFF position.

> ⚠ **Warning** Do not change the FORWARD/REVERSE switch while the motor is running. The motor must come to a complete stop before reversing. Changing motor direction before allowing the motor to completely stop will cause excessively high current to flow in the armature circuit, and will damage the drive and/or motor.

MM23501

1. Set the FORWARD/BRAKE/REVERSE switch to the BRAKE position.
2. Set the speed adjust potentiometer to "0" (full CCW).
3. Apply AC line voltage.
4. Set the POWER switch to the ON position.
5. Set the FORWARD/BRAKE/REVERSE switch to the desired direction of rotation.
7. Slowly advance the speed adjust potentiometer clockwise (CW). The motor slowly accelerates as the potentiometer is turned CW. Continue until the desired speed is reached.
8. To reverse direction:
   a. Set the FORWARD/BRAKE/REVERSE switch to the BRAKE position.
   b. After the motor comes to a complete stop, set the FORWARD/BRAKE/REVERSE switch to the desired direction of rotation.
9. To brake the motor, set the FORWARD/BRAKE/REVERSE switch to the BRAKE position. To coast the motor to a stop, set the POWER switch to the OFF position.

All drives

If the motor or drive does not perform as described, disconnect the AC line voltage immediately. Refer to the Troubleshooting section, page 45, for further assistance.

Line starting and line stopping

Line starting and line stopping (applying and removing AC line voltage) is recommended for infrequent starting and stopping of a drive only. When AC line voltage is applied to the drive, the motor accelerates to the speed set by the speed adjust potentiometer. When AC line voltage is removed, the motor coasts to a stop.

Inhibit terminals

Short the INHIBIT terminals to coast the motor to minimum speed (see Figure 15 for INHIBIT terminal location). Reopen the INHIBIT terminals to accelerate the motor to set speed.

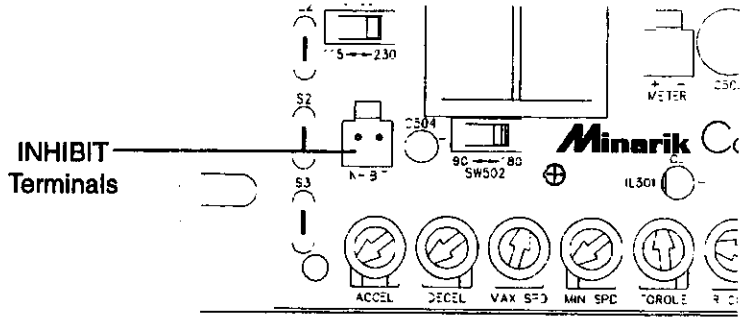


Figure 15. INHIBIT Terminals

Minarik Corporation offers two accessory plug harnesses for connecting to the INHIBIT terminals: part number 201-0024 [inhibit plug with 18 inches (46 cm) leads]; and part number 201-0079 [inhibit plug with 36 inches (91 cm) leads].

Twist inhibit wires and separate them from other power-carrying wires or sources of electrical noise. Use shielded cable if the inhibit wires are longer than 18 inches (46 cm). If shielded cable is used, ground only one end of the shield to earth ground. Do not ground both ends of the shield.

Decelerating to minimum speed

The switch shown in Figure 16 may be used to decelerate a motor to a minimum speed. Closing the switch between S1 and S2 decelerates the motor from set speed to a minimum speed determined by the MIN SPD trimpot setting. If the MIN SPD trimpot is set full CCW, the motor decelerates to zero speed when the switch between S1 and S2 is closed. The DECEL trimpot setting determines the rate at which the drive decelerates. By opening the switch, the motor accelerates to set speed at a rate determined by the ACCEL trimpot setting.

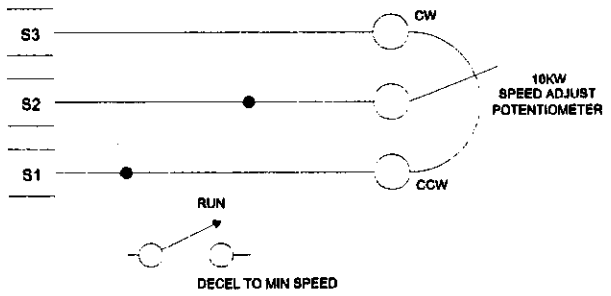


Figure 16. Run/Decelerate to Minimum Speed Switch

Dynamic braking

Dynamic braking may be used to rapidly stop a motor (Figure 17). For the RUN/BRAKE switch, use a two pole, two position switch rated for at least 125 VDC, 6 amps. For the dynamic brake resistor, use a 40 watt minimum, high power, wirewound resistor.

Sizing the dynamic brake resistor depends on load inertia, motor voltage, and braking time. Use a lower-value, higher-wattage dynamic brake resistor to stop a motor more rapidly.

Note: Models MM23201, MM23211, and MM23501 are equipped with dynamic braking.

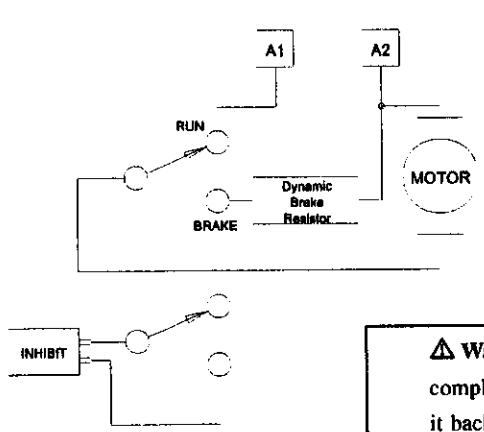


Figure 17. Dynamic Brake Connection

⚠ Warning

For frequent starts and stops, short the inhibit terminals, decelerate to a minimum speed, or apply a dynamic brake to the motor. Do not use any of these methods for emergency stopping. They may not stop a drive that is malfunctioning. **Removing AC line power (both L1 and L2) is the only acceptable method for emergency stopping.**

Frequent starting and stopping can produce high torque. This may cause damage to motors, especially gearmotors that are not properly sized for the application.

Current limit LED *(C models only)*

MM23000 series drives (C models) are equipped with a red current limit LED. The red current limit LED turns on whenever the drive reaches current limit and turns off whenever the drive is not in current limit (normal operation).

Current limit header block *(C-H models only)*

MM23000 series drives (C-H models) are equipped with a 2-pin current limit header block. The current limit header block outputs approximately a floating 5 VDC (5 mADC) signal whenever the drive reaches current limit. The signal may be input to an external device, such as an alarm or shut down circuit, that works when the drive reaches current limit.

Meter header block *(cased C models only)*

To supply power to external devices, the *Meter* header block can supply an unregulated +9 VDC (5 mA) signal when the motor and the power supply of the drive are fully loaded. More current is available with less motor loading. *Meter* can supply an unregulated +15V (10 mA) signal in typical applications.

MM23001C-Q, MM23071, and MM23072 diagnostic LEDs

Models MM23001C-Q, MM23071, and MM23072 are equipped with two diagnostic LEDs:

Power (PWR): Lights whenever the AC line voltage is applied to the drive.

Current Limit (CURR LIMIT or CL): Lights whenever the drive reaches current limit.

Calibration

MM23000 Series drives have six user adjustable trimpots: MIN SPD, MAX SPD, TORQUE, IR COMP, ACCEL, and DECEL. Each drive is factory calibrated to its maximum horsepower rating. Readjust the calibration trimpot settings to accommodate lower horsepower motors.

All trimpot settings increase with clockwise (CW) rotation, and decrease with counterclockwise (CCW) rotation. Use a non-metallic screwdriver for calibration. Each trimpot is identified on the printed circuit board.

MIN SPD

The MIN SPD setting determines the motor speed when the speed adjust potentiometer is turned full CCW. It is factory set to zero speed.

To calibrate, turn the speed adjust potentiometer full CCW. Adjust the MIN SPD trimpot until the motor has stopped (for zero speed setting), or is running at the desired minimum speed.

MAX SPD

The MAX SPD setting determines the motor speed when the speed adjust potentiometer is turned full CW. It is factory set for maximum rated speed.

To calibrate, set the MAX SPD trimpot full CCW. Turn the speed adjust potentiometer full CW. Adjust the MAX SPD trimpot until the desired maximum motor speed is reached.

Note: Check the MIN SPD and MAX SPD adjustments after recalibrating to verify that the motor runs at the desired minimum and maximum speed.

TORQUE

The TORQUE setting determines the maximum torque for accelerating and driving the motor. TORQUE is factory set at 120% of rated motor current.

To calibrate TORQUE:

1. With the power disconnected from the drive, connect a DC ammeter in series with the armature.
2. Set the TORQUE trimpot to minimum (full CCW).
3. Connect power to the drive.
4. Lock the motor shaft. Be sure that the motor is firmly mounted.
5. Set the speed adjust potentiometer to maximum reverse speed.
6. Adjust the TORQUE trimpot CW slowly until the armature current is 120% of motor rated armature current.
7. Set the speed adjust potentiometer to minimum and remove the stall from the motor.

See Figure 18, page 34, for recommended TORQUE settings.

IR COMP

The IR COMP trimpot setting determines the degree to which motor speed is held constant as the motor load changes. It is factory set for optimum motor regulation.

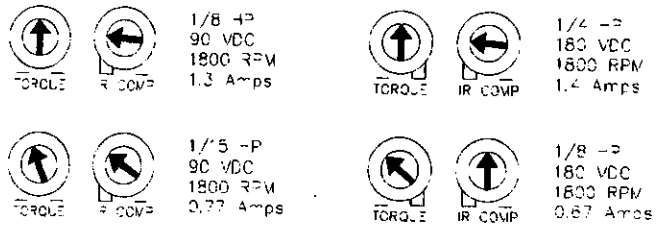
To calibrate IR COMP (exact calibration):

1. Turn the IR COMP trimpot full CCW.
2. Set the speed adjust potentiometer until the motor runs at midspeed without load (for example, 900 RPM for an 1800 RPM motor) A hand held tachometer may be used to measure motor speed.
3. Load the motor armature to its full load armature current rating. The motor should slow down.
4. While keeping the load on the motor, rotate the IR COMP trimpot until the motor runs at the speed measured in step 2.

Approximate calibration:
If the motor does not maintain set speed as the load changes, gradually rotate the IR COMP trimpot CW. If the motor oscillates (overcompensation), the IR COMP trimpot may be set too high (CW). Turn the IR COMP trimpot CCW to stabilize the motor speed.

See Figure 18, page 34, for recommended IR COMP settings.

Models MM23011, MM23111, MM23211, MM23072, and MM23411



Models MM230001, MM23071, MM23101, MM23201, MM23401, and MM23501

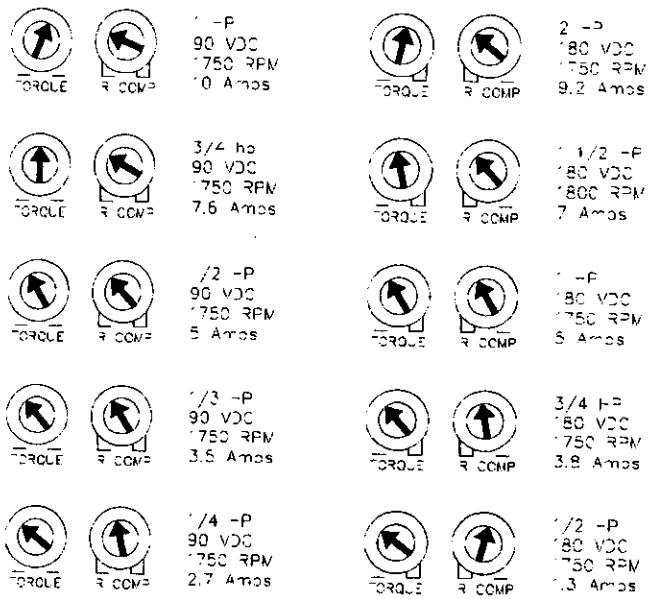


Figure 18. Recommended Torque and IR COMP Settings (actual settings may vary with each application)

ACCEL

The ACCEL setting determines the time the motor takes to ramp to a higher speed. See Specifications on page 1 for approximate acceleration times. ACCEL is factory set for the fastest acceleration time (full CCW).

To set the acceleration time:

1. Set the speed adjust potentiometer full CCW. The motor should run at minimum speed.
2. Turn the speed adjust potentiometer full CW and measure the time it takes the motor to go from minimum to maximum speed.
3. If the time measured in step 2 is not the desired acceleration time, turn the ACCEL trimpot CW for a slower acceleration time, or CCW for a faster acceleration time. Repeat steps 1 through 3 until the acceleration time is correct.

DECEL

The DECEL setting determines the time the motor takes to ramp to a lower speed. See Specifications on page 1 for approximate deceleration times. DECEL is factory set for the fastest deceleration time (full CCW).

To set the deceleration time:

1. Set the speed adjust potentiometer full CW. The motor should run at maximum speed.
2. Turn the speed adjust potentiometer full CCW and measure the time it takes the motor to go from maximum to minimum speed.
3. If the time measured in step 2 is not the desired deceleration time, turn the DECEL trimpot CW for a slower deceleration time, or CCW for a faster deceleration time. Repeat steps 1 through 3 until the deceleration time is correct.

Application Notes

Multiple fixed speeds

Replace the speed adjust potentiometer with series resistors with a total series resistance of 10K ohms (Figure 19). Add a single pole, multi-position switch with the correct number of positions for the desired number of fixed speeds.

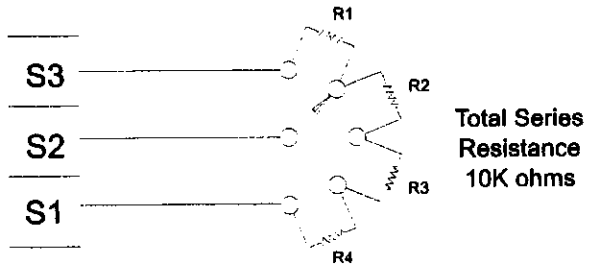


Figure 19. Multiple Fixed Speeds

Adjustable speeds using potentiometers in series

Replace the speed adjust potentiometer with a single pole, multi-position switch, and two or more potentiometers in series, with a total series resistance of 10K ohms. Figure 20 shows a connection for fixed high and low speed adjust potentiometers.

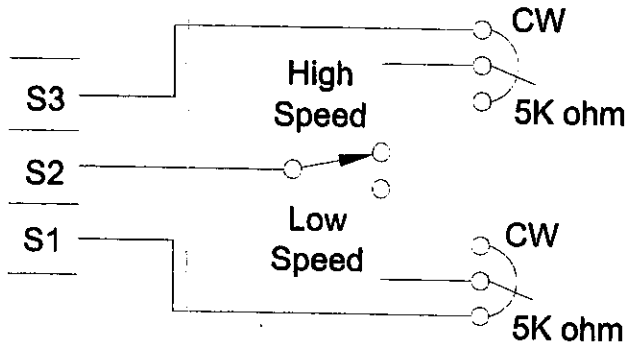


Figure 20. Adjustable Fixed Speeds Using Potentiometers in Series

Independent adjustable speeds

Replace the speed adjust potentiometer with a single pole, multi-position switch, and two or more potentiometers in parallel, with a total parallel resistance of 10K ohms. Figure 21 shows the connection of two independent speed adjust potentiometers that can be mounted at two separate operating stations.

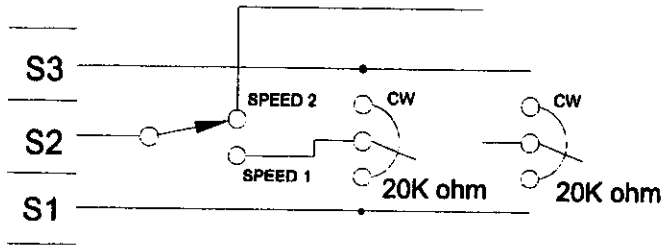


Figure 21. Independent Adjustable Speeds

RUN/JOG switch

Using a RUN/JOG switch is recommended in applications where quick stopping is not needed and frequent jogging is required. Use a single pole, two position switch for the RUN/JOG switch, and a single pole, normally closed, momentary operated pushbutton for the JOG pushbutton.

In the first wiring option, connect the RUN/JOG switch and JOG pushbutton to the inhibit plug as shown in Figure 22. The motor coasts to a stop when the RUN/JOG switch is set to JOG. Press the JOG pushbutton to jog the motor. Return the RUN/JOG switch to RUN for normal operation.

In the second wiring option, connect the RUN/JOG switch and the JOG pushbutton as shown in the Figure 23. When the RUN/JOG switch is set to JOG, the motor decelerates to minimum speed (minimum speed is determined by the MIN SPD trimpot setting). Press the JOG pushbutton to jog the motor. Return the RUN/JOG switch to RUN for normal operation.

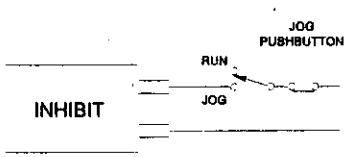


Figure 22. RUN/JOG Switch Connection to Inhibit Plug

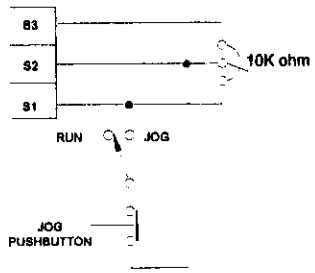


Figure 23. RUN/JOG Switch Connection to Speed Adjust Potentiometer

Leader-follower application

In this application, use a PCM4 to monitor the speed of the leader motor (Figure 24). The PCM4 isolates the leader motor from the follower drive, and outputs a voltage proportional to the leader motor armature voltage. The follower drive uses this voltage reference to set the speed of the follower motor. An optional ratio potentiometer may be used to scale the PCM4 output voltage.

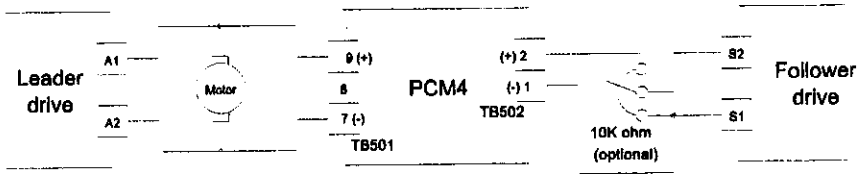


Figure 24. Leader-Follower Application

Single speed potentiometer control of multiple drives

Multiple drives can be controlled with a single speed adjust potentiometer using a PCM4 at the input of each drive to provide isolation (Figure 25). Optional ratio potentiometers can be used to scale the PCM4 output voltage, allowing independent control of each drive.

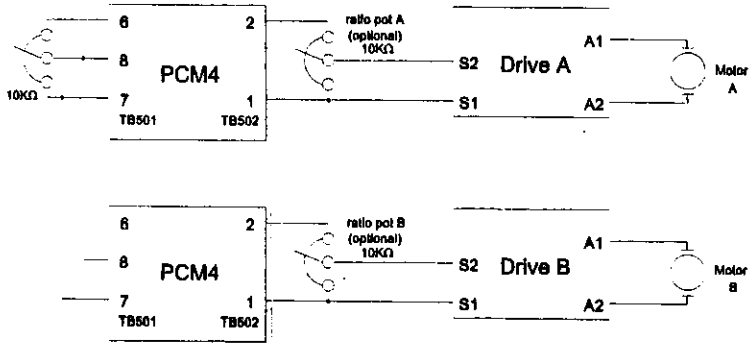


Figure 25. Single Speed Potentiometer Control of Multiple Drives

Reversing

A dynamic brake may be used when reversing the motor direction (Figure 26). Use a three pole, three position switch rated for at least the maximum DC armature voltage and maximum braking current. Wait for the motor to stop completely before switching it to either the forward or reverse direction. See the Dynamic braking section, page 28, for recommended dynamic brake resistor sizes

Note: Model MM23501 is equipped with this reversing feature.

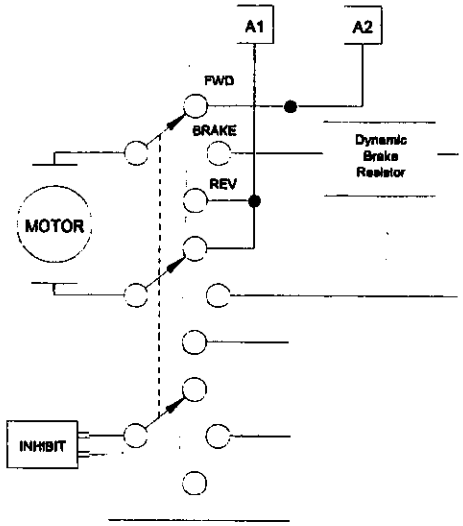


Figure 26. Reversing Circuit Connection

Reversing with a DIGI-LOK® controller

A DIGI-LOK® controller, model DLC100 (DLC200 for 230 VAC line voltage) or DLC300–SPEC.0404 (DLC400–SPEC.0404 for 230 VAC line voltage) can be used in a reversing application. The DIGI-LOK® must be inhibited while braking. Without the inhibit feature, the DIGI-LOK® will continue to regulate. This will cause overshoot when the DIGI-LOK® is switched back to the drive.

Figure 27 shows the connection of the reversing circuit to a MM23000 series drive and to a DLC100 (or DLC200).

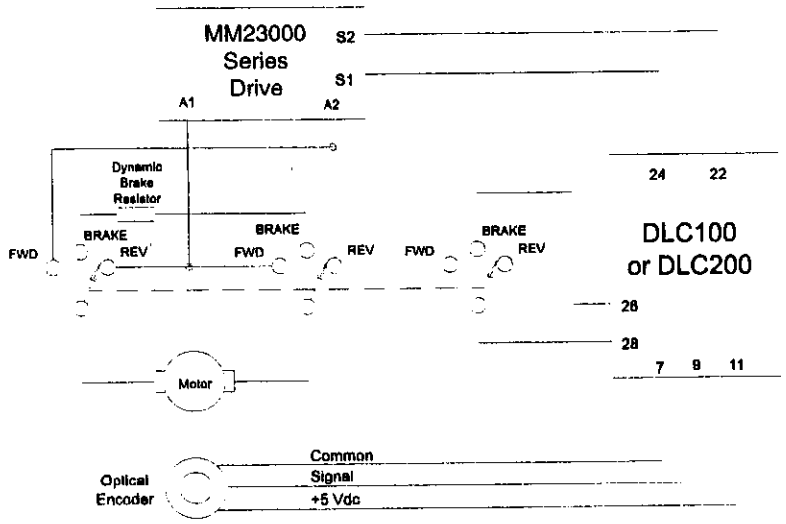


Figure 27. Reversing with a DLC100 (DLC200)

Figure 28 shows the connection of the reversing circuit to a MM23000 series drive and to a DLC300–SPEC.0404 (or DLC400–SPEC.0404).

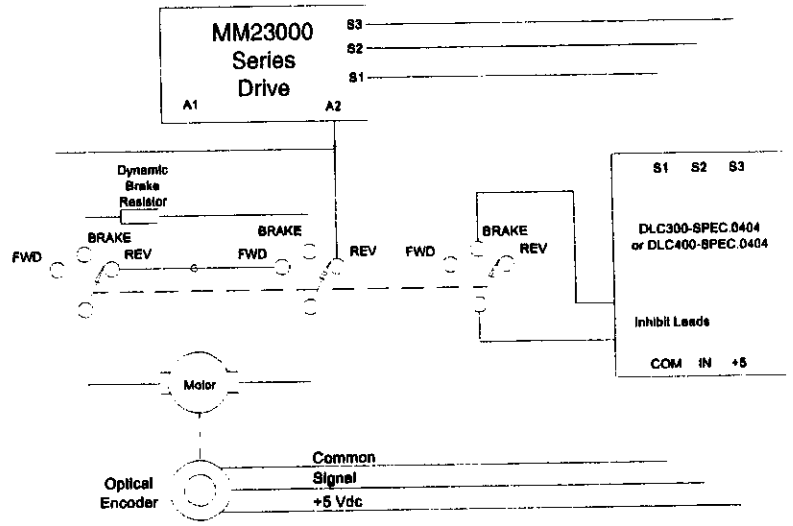


Figure 28. Reversing with a DLC300-SPEC.0404 (DLC400-SPEC.0404)

Troubleshooting

⚠ Warning

Dangerous voltages exist on the drive when it is powered. When possible, disconnect the AC line voltage from the drive while troubleshooting. Be alert. High voltages can cause serious or fatal injury.

Before troubleshooting

Perform the following steps before starting any procedure in this section:

- Disconnect AC line voltage from the drive.
- Check the drive closely for damaged components.
- Check that no conductive or other foreign material has become lodged on the printed circuit board.
- Verify that every connection is correct and in good condition.
- Verify that there are no short circuits or grounded connections.
- Check that the voltage selection switch settings match the AC line and output voltages.
- Check that the drive's rated armature and field outputs are consistent with the motor ratings.

Problem	Possible Causes	Suggested Solutions
Line fuse blows.	1. Line fuse is the wrong size.	1. Check that the line fuse is correct for the motor size.
	2. Motor cable or armature is shorted to ground.	2. Check motor cable and armature for shorts.
	3. Nuisance tripping caused by a combination of ambient conditions and high-current spikes (i.e. reversing).	3. Add a blower to cool the drive components; decrease TORQUE settings, or resize motor and drive for actual load demand, or check for incorrectly aligned mechanical components or "jams".

Problem	Possible Causes	Suggested Solutions
Line fuse does not blow, but the motor does not run.	1. Speed adjust potentiometer is set to zero speed.	1. Increase the speed adjust potentiometer setting.
	2. INHIBIT terminals are jumpered.	2. Remove jumper from the INHIBIT terminals.
	3. S2 is shorted to S1.	3. Remove short.
	4. Drive is in current limit.	4. Verify that motor is not jammed. Increase TORQUE setting if they are set too low.
	5. Drive is not receiving AC line voltage.	5. Apply AC line voltage to L1 and L2.
	6. Motor is not connected.	6. Connect motor to A1 and A2.
Motor does not stop when the speed adjust potentiometer is full CCW.	MIN SPD setting is too high.	Calibrate MIN SPD.
Motor runs in the opposite direction (non-reversing drives).	Motor connections to A1 and A2 are reversed.	Reverse connections to A1 and A2.

Problem	Possible Causes	Suggested Solutions
Motor runs too fast.	1. MAX SPD and MIN SPD are set too high.	1. Calibrate MAX SPD and MIN SPD.
	2. Motor field connections are loose (shunt wound motors only).	2. Check motor field connections.
Motor will not reach the desired speed.	1. MAX SPD setting is too low.	1. Increase MAX SPD setting.
	2. IR COMP setting is too low.	2. Increase IR COMP setting.
	3. TORQUE setting is too low.	3. Increase TORQUE setting.
	4. Motor is overloaded.	4. Check motor load. Resize the motor if necessary.
Motor pulsates or surges under load.	1. IR COMP is set too high.	1. Adjust the IR COMP setting slightly CCW until the motor speed stabilizes.
	2. Motor bouncing in and out of current limit.	2. Make sure motor is not undersized for load; adjust TORQUE trimpot CW.

For additional assistance, contact you local Minarik® Distributor, or the factory direct: phone (818)502-1528; fax (818)502-0716.

CE Compliance

Minarik Corporation hereby certifies that its MM23000 series drives have been approved to bear the "CE" mark provided the conditions of approval have been met by the end user.

The MM23000 series has been tested to the following test specifications:

EN55011:1991 (emissions), and
EN50082-1:1992 (immunity)

Compliance allows Minarik's MM23000 series to bear the CE mark.

The end user, as described herein, falls into one of two categories:

1. The Consumer will deploy a stand-alone unit as an integral, yet external, portion of the machine being operated.
2. The Original Equipment Manufacturer (OEM) will implement the product as a component of the machine being manufactured.

In addition to EMI/RFI safeguards inherent in the MM23000 series' design, external filtering is required.

Line filters

Minarik requires the Corcom® line filters listed below.

Corcom® Filters

Nameplate Current of Motor Wired to the Drive	Corcom® Filter Part Number
0 to 4 amps	6VV1
4.1 to 13 amps	20VV1

If the exact line filter is not available, the specifications are as follows:

L = (1.73 + 0.03) milliHenries.
C = (0.27 + 0.54) microFarads (X); 0.0055 microFarads (Y).
R = 330Kohms.
Rated current: 1.4 times maximum DC motor current.
Filter type: Balanced 2-section.

The line filters should be wired to the AC line within 0.25 meters of the drive. The ground connection from the line filter must be wired to solid earth ground (resistance less than 500 ohms); not machine ground. This is very important!

If the end-user is using a CE-approved motor, the correct line filter listed above is all that is necessary to meet the EMC directives listed herein.

Armature filters

If the end-user is not using a CE-approved motor, a second filter on the armature must be deployed. It is Minarik's CEXXMM. XX = rated current of the filter. Minarik® Filters are listed below.

Minarik® Filters

Nameplate Current of Motor Wired to the Drive	Minarik® Filter Part Number
0 to 4 amps	CE4MM
4.1 to 13 amps	CE20MM

The filters listed above are Real-Pole Balanced-Pi 3-pole filters. If the exact filter is not available, the specifications are as follows:

L & L1 = 2 * (0.8) milliHenries.
C & C1 = 2 * (0.1) microFarads @ 400W VDC.
Rin = 0.1 ohm; Rout = 1.2 ohm.

The filters listed above must be wired to the DC output of the drive, as close to the drive as possible.

The end user must use the filters listed in this section to comply with CE. The OEM may choose to provide alternative filtering that encompasses the Minarik drive and other electronics within the same panel.

The OEM has this liberty because CE is a machinery directive. Whether or not every component in the OEM's machinery meets CE, the OEM must still submit his machine for CE approval.

Thus, no component must necessarily meet CE within the machine, as long as the OEM takes the necessary steps to guarantee the machine does meet CE. By the same token, even if every component in the OEM's machine does meet CE, the machine will not necessarily meet CE as a machine.

Using CE-approved wiring practices (like proper shielding) and the filters listed in this section help the drive meet EN55011 (1991 emissions standard) and EN50082-1 (1992 immunity standard).

Functional Diagrams

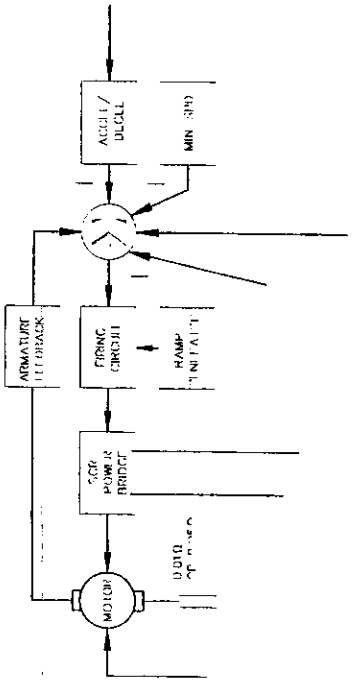


Figure 29. MM23000 Series Block Diagram

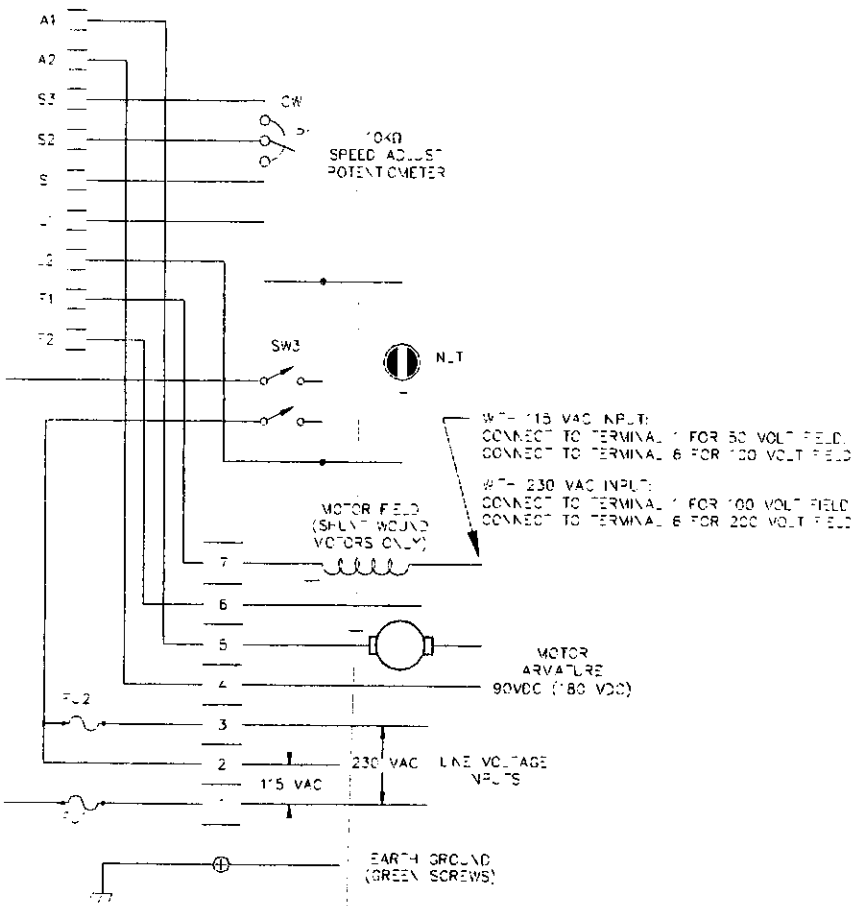


Figure 30. MM23101, MM23111, MM23401 and MM23411 Terminal Block Connections

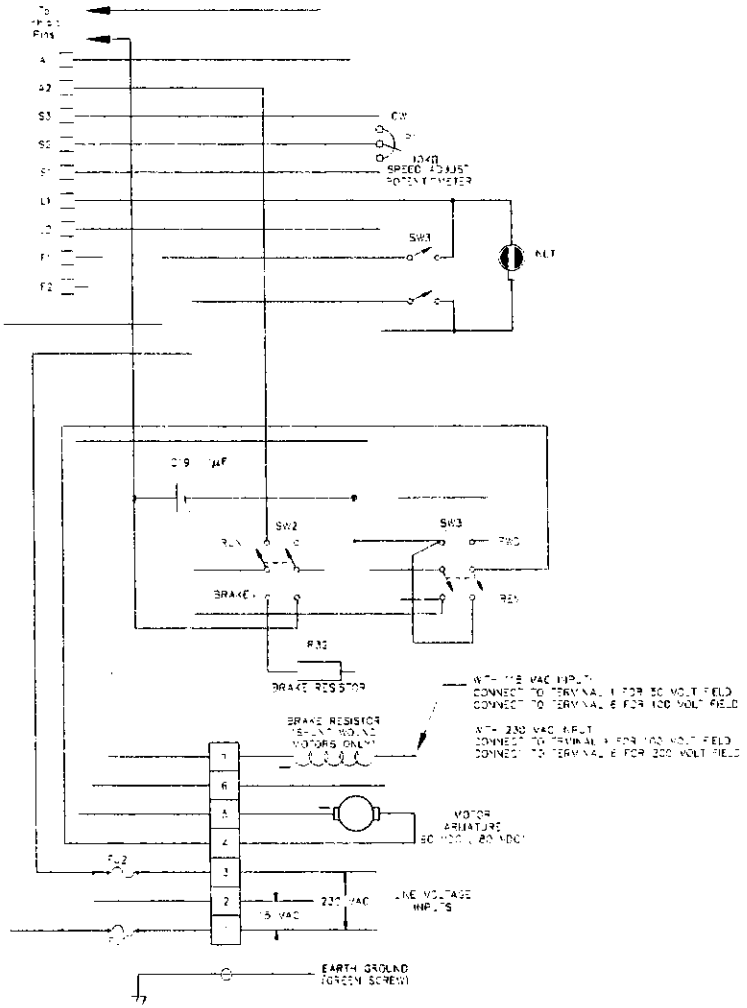


Figure 31. MM23201 and MM23211 Terminal Block Connections

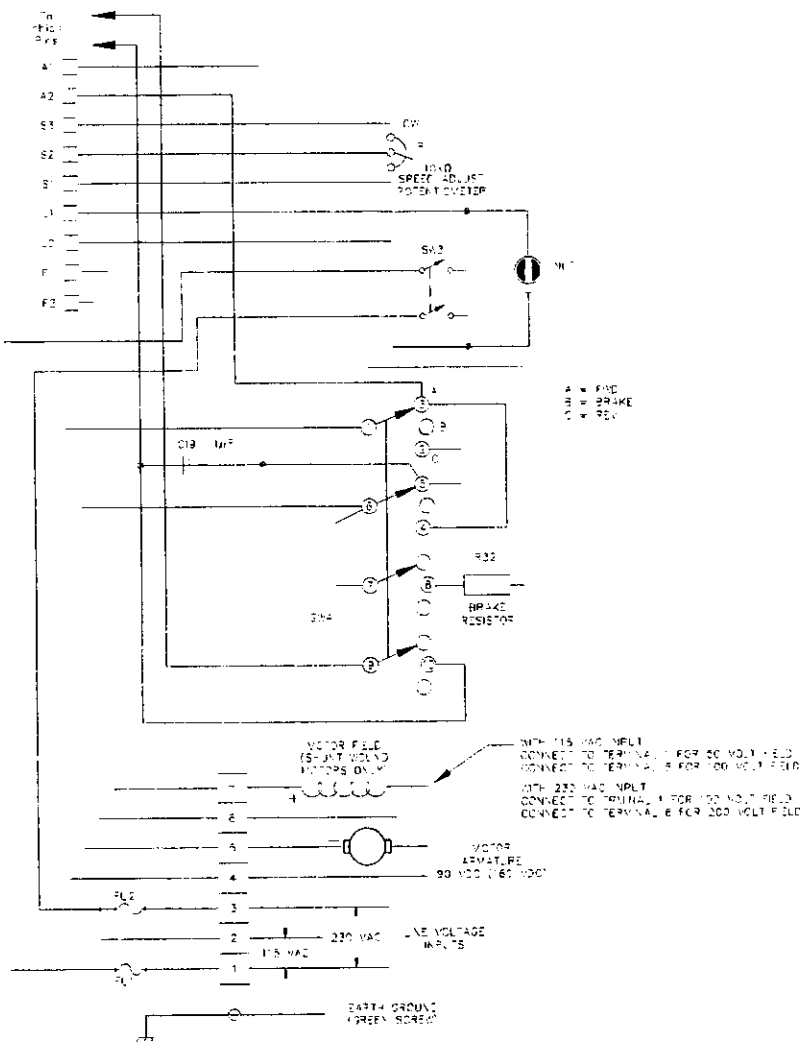


Figure 32. MM23501 Terminal Block Connections

Replacement Parts

Replacement parts are available from Minarik Corporation and its distributors for this drive series.

Table 3. Replacement Parts

Model No.	Symbol	Description	Minarik® P/N
MM23001 and MM23071	SCR501, 502	800 V, 20 A SCR	072-0043
	D501-503	800 V, 20 A Diode	071-0039
	R501	0.01Ω, 5 W Resistor	032-0129
	T501	3FD-224-001 Transformer	230-0083
		10KΩ potentiometer kit	202-0031
MM23011	Same as MM23001 except:		
	SCR501, 502	600 V, 8 A SCR	072-0024
	D501-503	600 V, 3 A Diode	071-0007
	R501	0.05Ω, 5W Resistor	032-0089
MM23101	Same as MM23001 except potentiometer kit, and including:		
		Case Bottom	223-0170
		Case Cover	223-0169
		240V Pilot Light	040-0043
		10KΩ, 1/2 W Potentiometer	120-0047
		Knob	140-0013
	SW3	DPST Power Switch	080-0030
		15 A, 3AB Fuse	050-0018
MM23111	Same as MM23011 except potentiometer kit. Same as MM23101 except fuse. Include:		
		3 A, 3AG Fuse	050-0021
MM23201	Same as MM23101 except case cover, and including:		
		Case Cover	223-0168
		40Ω, 40W Resistor	032-0076
	SW4	DPST Run/Brake Switch	080-0027
	SW5	DPST FWD/REV Switch	080-0027

Table 3. Replacement Parts (continued)

Model No.	Symbol	Description	Minarik® P/N
MM23211	Same as MM23011 except potentiometer kit. Same as MM23201 except fuse. Include:		
		3 A, 3AG Fuse	050-0021
MM23411	Same as MM23011 except potentiometer kit, and including:		
		Knob	140-0013
		240V Pilot Light	040-0043
		DPST Power Switch	080-0030
		Power Switch Boot	155-0050
		10KΩ, 1/2 W Potentiometer	120-0047
		3A 3AG Fuse	050-0021
		Heat Sink	223-0182
		Case	223-0104
MM23401	Same as MM23001 except pot kit. Same parts as MM23411 (knob,...,case) except fuse, and including:		
		15 A, 3AB Fuse	050-0018
MM23501	Same as MM23401 except heat sink and case, and including:		
		Heat Sink	223-0183
		Case	223-0106
		20Ω, 40 W Resistor	032-0062
		FWD/BRAKE/REV Switch	081-0010
		Rotary Switch Knob	140-0014
MM23072	Same as MM23071 except:		
	R501	0.05Ω, 5W Resistor	032-0089
MM23001C-Q	Same as MM23001 including:		
	SO503	Quick-Disconnect Header Block	164-0211
		Quick-Disconnect Plug	160-0095

Notes

Notes

Limited Warranty

A. Warranty - Minarik Corporation (referred to as "the Corporation") warrants that its products will be free from defects in workmanship and material for two (2) years from date of shipment thereof, or 6,000 hours, whichever comes first. Within this warranty period, the Corporation will repair or replace such products that are: (1) returned to Minarik Corporation, 901 East Thompson Avenue, Glendale, CA 91201-2011 USA; and, (2) determined by the Corporation to be defective.

This warranty shall not apply to any product that has been subject to misuse, negligence, or accident; or misapplied; or repaired by unauthorized persons; or improperly installed. The Corporation is not responsible for removal, installation, or any other incidental expenses incurred in shipping the product to and from the repair point.

B. Disclaimer - The provisions of Paragraph A are the Corporation's sole obligation and exclude all other warranties of merchantability for use, express or implied. The Corporation further disclaims any responsibility whatsoever to the customer or to any other person for injury to the person or damage or loss of property of value caused by any product that has been subject to misuse, negligence, or accident, or misapplied or modified by unauthorized persons or improperly installed.

C. Limitations of Liability - In the event of any claim for breech of any of the Corporation's obligations, whether express or implied, and particularly of any other claim or breech of warranty contained in Paragraph A, or of any other warranties, express or implied, or claim of liability that might, despite Paragraph B, be decided against the Corporation by lawful authority, the Corporation shall under no circumstances be liable for any consequential damages, losses, or expense arising in connection with the use of, or inability to use, the Corporation's product for any purpose whatsoever.

An adjustment made under warranty does not void the warranty, nor does it imply an extension of the original two (2) year or 6,000 hour warranty period. Products serviced and/or parts replaced on a no-charge basis during the warranty period carry the unexpired portion of the original warranty only.

If for any reason any of the foregoing provisions shall be ineffective, the Corporation's liability for damages arising out of its manufacture or sale of equipment, or use thereof, whether such liability is based on warranty, contract, negligence, strict liability in tort, or otherwise, shall not in any event exceed the full purchase price of such equipment.

Any action against the Corporation based upon any liability or obligation arising hereunder or under any law applicable to the sale of equipment or the use thereof, must be commenced within one year after the cause of such action arises.

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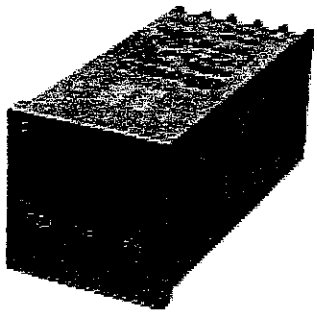
OMRON

Temperature Controller — E5CS-X

1/16 DIN Sized Multi-range Controller Offers Selectable Control Modes, Built-in Alarm



- Accurate to ±0.5% of full scale
- Multiple scale ranges allows flexibility to match application
- Field-selectable temperature ranges in °F and °C
- Selectable ON/OFF and PID control with auto-tuning of proportional band
- 8-function alarm, standard
- Tamper-proof setting, faulty sensor compensation and controller diagnostics
- Easy-to-read 11 mm high LED display
- Nonvolatile memory backup
- 3-year warranty

Ordering Information

■ TEMPERATURE CONTROLLERS

Control modes		PID or ON/OFF action		
Sensor intput type		Thermocouple	Platinum RTD(Pt: 100Ω, (DIN and JIS standard types)	Interchangeable thermistor (THE types)
Output	Contact	**E5CS-R1KJX-F**	**E5CS-R1PX-F**	**E5CS-R1GX-F**
	Voltage	**E5CS-Q1KJX-F**	**E5CS-Q1PX-F**	**E5CS-Q1GX-F**

■ TEMPERATURE RANGES

Thermocouple Input Type

Input type	Type K						Type J				
Switch setting	0	1	2	3	4	5	6	6	7	8	9
Temperature range	0 to 200	0 to 300	0 to 400	0 to 500	0 to 600	0 to 999	0 to 999	0 to 200	0 to 300	0 to 400	0 to 500
Scale indication	°C	°C	°C/°F	°C/°F	°C/°F	°C/°F	°F	°C	°C	°C/°F	°C/°F
Unit of measure	1° C or F										

Platinum RTD Input Type

Switch setting	0	1	2	3	4	5	6	7	8
Temperature range	-50 to 50	0.0 to 50.0	-20 to 80	0.0 to 99.9	0 to 200	0 to 300	0 to 400	0 to 600	0 to 800
Scale indication	°C	°C	°C	°C/°F	°C/°F	°C	°C/°F	°F	°F
Unit of measure	1° C or F								

Thermistor Input Type

Switch setting	0	1	2	3	4	5	6	7	8	9
Temperature range	-50 to 50	0 to 100	50 to 150	100 to 200	150 to 300	-50 to 100	0 to 200	100 to 300	200 to 400	300 to 600
Scale indication	°C					°F				
Unit of measure	1° C or F									

■ ACCESSORIES

Description		Part number
Protective cover	Hard plastic; protects front panel against dust, dirt and water drops	Y92A-48

■ REPLACEMENT PARTS

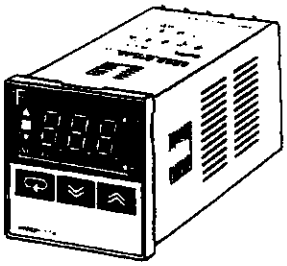
Description	Part number
Adapter for panel mounting (supplied with each unit)	Y92F-30

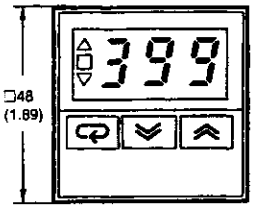
Specifications

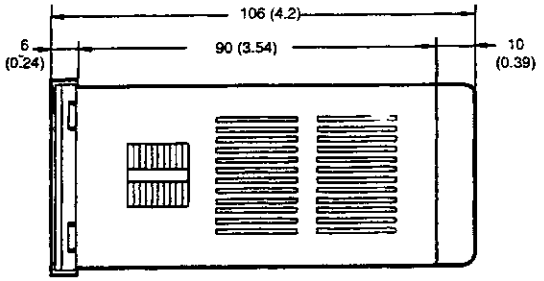
Part number			E5CS-□1KJX	E5CS-□1PX	E5CS-□1GX
Sensor input type			Thermocouple Type J (IC) and Type K (CA)	Platinum RTD (Pt: 100Ω) DIN or JIS standard	Thermistor (interchangeable type)
Supply voltage			100 to 240 VAC, 50/60 Hz; operates on 85 to 110% of rated volate		
Power consumption			Approx. 7 VA		
Control output	Contact	Type	SPDT relay		
		Max. load	3 A, 250 VAC (resistive load)		
	Voltage	Logic load	12 VDC, 20 mA with short-circuit protection		
	Hysteresis		0.2% of full scale during ON/OFF control action		
	Response time	Output	2 seconds for output to change		
		Display	2 seconds for displayed indication to change		
	Service life	Mechanical	10 million operations minimum with contact output		
		Electrical	100,000 operations minimum with contact output		
Alarm output		Type	SPST-NO relay		
		Max. load	1 A, 250 VAC (resistive load)		
		Setting range	Absolute value alarm: Same as control output setting range Others: 0 to full scale		
Setting accuracy			Set value coincides with indicated value, so no relative error exists		
Indication accuracy			±0.5% of full scale, ±1 digit max.		
Display Range			-999 to 999 (Limited to input type)		
Control modes	Type		ON/OFF and PID with automatic tuning of proportional band, switch selectable		
	Proportional band		3 to 20% (in PID mode) automatically adjusted according to the rise time of the controlled system		
	Reset time		4 minutes (in PID mode)		
	Rate time		0.4 minutes (in PID mode)		
	Proportional period		2 or 20 seconds, switch selectable		
	Sampling period		500 ms		
Materials			Plastic case		
Mounting			Fits 1/16 DIN panel cutout; includes panle mounting adapter		
Connections			Screw terminals		
Weight			170 g (6 oz.) without mounting adapter		
Enclosure ratings		Front panel	IP50, NEMA 4 with optional cover Y92A-48N		
		Rear panel	IP30		
		Terminals	IP00		
Approvals		UL	Recognized, File Number E68481		
		CSA	Certified, File Number LR59623		
Ambient temperature		Operating	-10° to 55°C (14° to 131°F)		
		Storage	-25° to 65°C (-13° to 149 °F)		
Humidity			35 to 85% RH		
Insulation resistance			20 MΩ minimum at 500 VDC		
Dielectric strength			2,000 VAC, 50/60 Hz for 1 minute between current-carrying terminals of different polarity		
Vibration	Mechanical durability		10 to 55 Hz, 0.75 mm (0.03 in) double amplitude in X, Y, and Z directions for 2 hours each		
	Malfunction durability		2 to 55 Hz, 2 G in X, Y, and Z directions for 10 minutes each		
Shock	Mechanical durability		30 m/s², in 6 directions, 3 times each		
	Malfunction durability		100 m/s², in 6 directions, 3 times each		

Dimensions

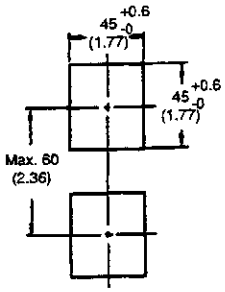
Unit: mm (inch)



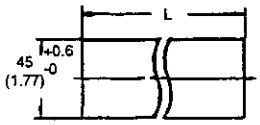




Panel Cutout



Side-by-side Mounting of Several Temperature Controllers

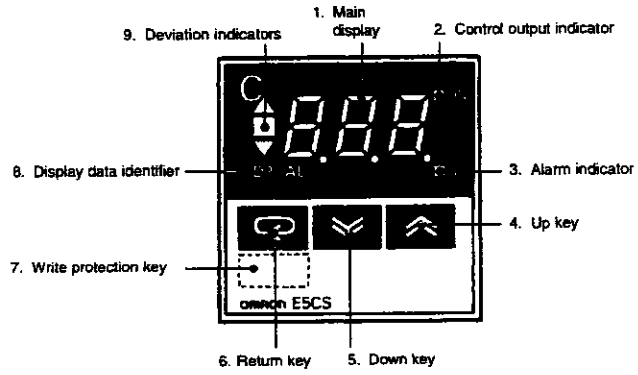


Controllers	2	3	4	5	6
L	93.5^{+1}_{-0}	141.5^{+1}_{-0}	189.5^{+1}_{-0}	237.5^{+1}_{-0}	285.5^{+1}_{-0}

$L=(48 \times \text{block} - 2.5)^{+1}_{-0}$
for tight side-by-side mounting

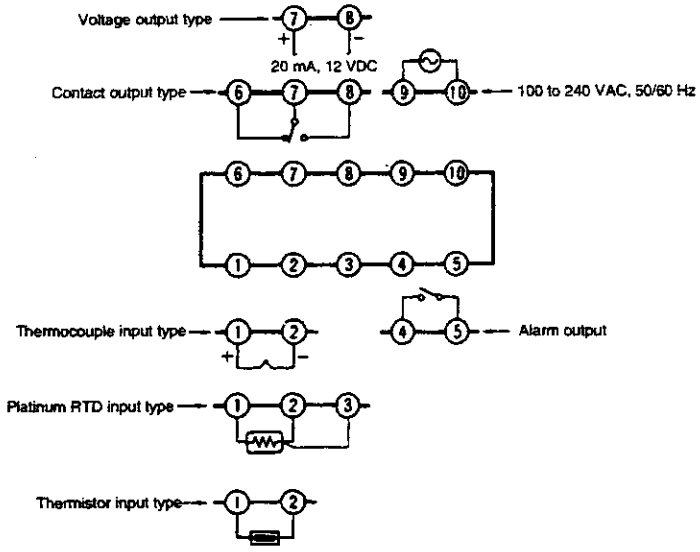
Note:
1. Recommended panel thickness is 1 to 8 mm (0.04 to 0.31 in).
2. Because mounting brackets are attached to the top and bottom of a temperature controller, tight side-by-side mounting is possible.

Nomenclature



Key	Description	Key	Description
1	Main display sequentially displays the present temperature, set temperature, and an alarm value each time the return key is pressed.	7	The hidden write protection key provides protection against unauthorized to set temperatures and is used in conjunction with the internal "protection" switch. If the internal protection switch is set to ON, then to obtain Up and Down operation, the hidden key must be pressed simultaneously with the Up and Down keys. If the internal protection switch is set to OFF, changes can be made simply by pressing the Up and Down keys.
2	Control output indicator lights when the output is ON.		
3	Alarm indicator lights when the alarm output is ON.		
4	Up key increases the set temperature or alarm value when pressed. Increases the value quickly when held down.		
5	Down key decreases the set temperature or alarm value when pressed. Decreases the value quickly when held down.	8	Display data identifier lights SP when the set temperature is displayed on the main display and AL when an alarm value is displayed.
6	Return key changes the value displayed on the main display each time pressed.	9	Red deviation indicators light an up arrow when the present temperature is higher than the set temperature and light a down arrow when the present value is lower than the set temperature. The green block indicates the temperature deviation is within ±1% of the full scale.

Connections



OMRON

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BALDOR
MOTORS AND DRIVES

Installation – Maintenance Instructions

Receiving

Inspect the motor for damage before accepting it. The Motor shaft should rotate freely with no rubs. Report any damage immediately to the commercial carrier that delivered your motor.

Safety Notice

Only qualified personnel trained in the safe installation and operation of this equipment should install this motor. When improperly installed or used, rotating equipment can cause serious or fatal injury. Equipment must be installed in accordance with the National Electrical Code (NEC), local codes and NEMA MG2 Safety Standards for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators. Observe the following guidelines:

1. When eyebolts are provided, they must be fully tightened and are intended to lift the motor and its included accessories only.
2. Ground the motor according to NEC and local codes.
3. Provide a permanent guard to prevent accidental contact of body parts or clothing with rotating or moving parts.
4. Shaft key must be secured before starting motor.
5. This motor must only be connected to the proper line voltage, line frequency and load size.
6. If a motor mounted brake is installed, provide proper safeguards for personnel in case of brake failure.
7. Disconnect all power services and allow motor to completely stop before servicing.
8. For single phase motors, discharge the start and/or run capacitors before servicing.
9. Do not by–pass or render inoperative any safety device.

Motor Enclosure

ODP, **Open drip proof** motors are intended for use in clean, dry locations with adequate supply of cooling air. These motors should not be used in the presence of flammable or combustible materials. Open motors can emit flame and/or molten metal in the event of insulation failure.

TEFC, **totally enclosed** motors are intended for use where moisture, dirt and/or corrosive materials are present in indoor and outdoor locations.

Explosion proof motors, as indicated by the Underwriters Laboratories, Inc. label are intended for use in hazardous areas as specified by the NEC.

Mounting

Foot mounted machines should be mounted to a rigid foundation to prevent excessive vibration. Shims may be used if location is uneven.

Flange mounted machines should be properly seated and aligned. Note: If improper rotation direction is detrimental to the load, check rotation direction prior to coupling the load to the motor shaft.

For **V–belt drive,** mount the sheave pulley close to the motor housing. Allow clearance for end to end movement of the motor shaft. Do not overtighten belts as this may cause premature bearing failure or shaft breakage.

Direct coupled machines should be carefully aligned and the shaft should rotate freely without binding.

Wiring

Connect the motor as shown in the connection diagram. The wiring, fusing and grounding must comply with the National Electrical Code and local codes. When the motor is connected to the load for proper direction of rotation and started, it should start quickly and run smoothly. If not, stop the motor immediately and determine the cause. Possible causes are: low voltage at the motor, motor connections are not correct or the load is too heavy. Check the motor current after a few minutes of operation and compare the measured current with the nameplate rating.

Lubrication

This is a ball bearing motor. The bearings have been lubricated at the factory. Motors that do not have regrease capability are factory lubricated for the normal life of the bearings.

Relubrication Intervals (For motors with regrease capability)

New motors that have been stored for a year or longer should be relubricated. Lubrication is also recommended at these intervals:

Relubrication Intervals

NEMA (IEC) Frame Size	Rated Speed (RPM)			
	3600	1800	1200	900
Up to 210 incl. (132)	5500Hrs.	12000Hrs.	18000Hrs.	22000Hrs.
Over 210 to 280 incl. (180)	3600Hrs.	9500Hrs.	15000Hrs.	18000Hrs.
Over 280 to 360 incl. (225)	*2200Hrs.	7400Hrs.	12000Hrs.	15000Hrs.
Over 360 to 5000 incl.(300)	*2200Hrs.	3500Hrs.	7400Hrs.	10500Hrs.

* Lubrication interval for 6313 or 6314 bearings that are used in 360 through 5000 frame, 2 pole motors. If roller bearings are used, bearings must be lubricated more frequently, divide the interval by 2.

Lubricant

Baldor motors are pregreased, normally with Chevron SRI#2. Equivalent and compatible greases are Texaco Polystar, Shell Dolium R and Amoco Rykon Premium #2.

Procedure

Clean the grease fitting (or area around grease hole, if equipped with slotted grease screws). If motor has a purge plug, remove it. Motors can be regreased while stopped (at less than 80°C) or running.

Apply grease gun to fitting (or grease hole). Too much grease or injecting grease to quickly can cause premature bearing failure. Slowly apply the recommended amount of grease, taking 1 minute or so to apply. Operate motor for 20 minutes, then reinstall purge plug if previously removed.

Caution: Keep grease clean. Mixing dissimilar grease is not recommended.

Amount of Grease to Add

Frame Size NEMA (IEC)	Weight of grease to add ounce (gram)	Volume of grease to add	
		inches^3	teaspoon
Up to 210 incl. (132)	0.30 (8.4)	0.6	2.0
Over 210 to 280 incl. (180)	0.61 (17.4)	1.2	3.9
Over 280 to 360 incl. (225)	0.81 (23.1)	1.5	5.2
Over 360 to 5000 incl.(300)	2.12 (60.0)	4.1	13.4

Additional copies of this instruction sheet may be obtained at no charge by writing to:

Baldor Electric Company
P.O. Box 2400
Fort Smith Arkansas 72902

BALDOR®
MOTORS AND DRIVES

BALDOR ELECTRIC COMPANY

Technical Handbook

Small Motors and Gear Motors

Gear Data

RATIO	MAX. TORQUE IN-LBS (MECH.)	GEAR STAGES	EFFICIENCY	OVERHUNG LOAD CAP. LBS.	GREASE CAPACITY OZ.	GREASE CAPACITY CM^3
STYLE FTA - .845 CENTER DISTANCE LUBRICANT NON FLUID OIL CORP # H260/MS						
5.0	15	1	0.80	1.3	0.3	8.88
7.4	15	1	0.75	1.3	0.3	8.88
8.0	15	1	0.75	1.3	0.3	8.88
10.0	15	1	0.75	1.3	0.3	8.88
12.0	15	1	0.70	1.3	0.3	8.88
15.0	15	1	0.65	1.3	0.3	8.88
20.0	15	1	0.50	1.3	0.3	8.88
24.0	15	1	0.45	1.3	0.3	8.88
30.0	15	1	0.45	1.3	0.3	8.88
40.0	15	1	0.45	1.3	0.3	8.88
50.0	10	1	0.40	1.3	0.3	8.88
STYLE GNA - DOUBLE REDUCTION LUBRICANT NON FLUID OIL CORP # H260/MS						
88.0	15	2	.41	1.3	0.8	23.66
120.0	15	2	.38	1.3	0.8	23.66
165.0	15	2	.35	1.3	0.8	23.66
225.0	15	2	.29	1.3	0.8	23.66
320.0	15	2	.26	1.3	0.8	23.66
480.0	15	2	.24	1.3	0.8	23.66
700.0	15	2	.22	1.3	0.8	23.66
1050.0	15	2	.13	1.3	0.8	23.66
1600.0	15	2	.13	1.3	0.8	23.66
STYLE B - 1.083 CENTER DISTANCE LUBRICANT MOBILITH # SHC100						
5.0	30	1	0.80	10	0.8	23.66
7.5	35	1	0.75	10	0.8	23.66
10.0	40	1	0.70	20	0.8	23.66
12.5	45	1	0.67	20	0.8	23.66
15.0	40	1	0.60	20	0.8	23.66
20.0	30	1	0.60	30	0.8	23.66
25.0	45	1	0.45	30	0.8	23.66
30.0	40	1	0.45	38	0.8	23.66
40.0	30	1	0.40	38	0.8	23.66
50.0	25	1	0.40	38	0.8	23.66
STYLE C - 1.750 CENTER DISTANCE LUBRICANT MOBILITH # SHC007						
8.0	75	1	0.76	40	1.9	56.18
11.0	75	1	0.74	40	1.9	56.18
15.0	75	1	0.72	65	1.9	56.18
22.5	75	1	0.70	65	1.9	56.18
33.0	75	1	0.60	65	1.9	56.18
45.0	75	1	0.60	65	1.9	56.18
58.0	75	1	0.50	65	1.9	56.18
72.0	60	1	0.45	65	1.9	56.18
90.0	40	1	0.40	65	1.9	56.18

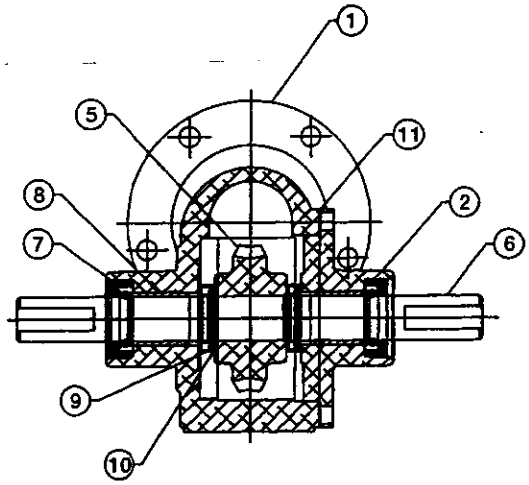
Gear Data

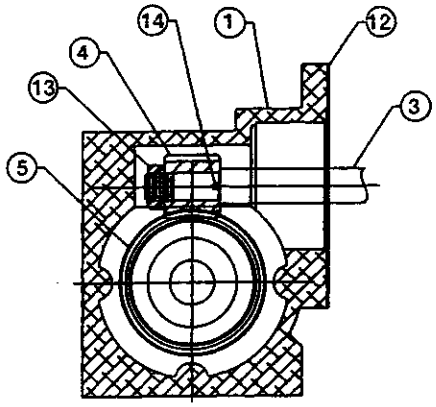
RATIO	MAX. TORQUE IN-LBS (MECH.)	GEAR STAGES	EFFICIENCY	OVERHUNG LOAD CAP. LBS.	GREASE CAPACITY OZ.	GREASE CAPACITY CM^3
STYLE D DOUBLE REDUCTION LUBRICANT NON FLUID OIL # H260/MS						
27.4	50	2	0.53	60	1.9	56.18
39.9	50	2	0.49	60	1.9	56.18
55.6	50	2	0.49	60	1.9	56.18
91.0	75	2	0.45	60	1.9	56.18
117.0	75	2	0.42	60	1.9	56.18
130.0	75	2	0.42	60	1.9	56.18
169.0	75	2	0.39	60	1.9	56.18
198.0	75	2	0.39	60	1.9	56.18
310.0	75	2	0.32	60	1.9	56.18
444.0	75	2	0.33	60	1.9	56.18
660.0	75	2	0.24	60	1.9	56.18
960.0	75	2	0.22	60	1.9	56.18
1500.0	50	2	0.14	60	1.9	56.18
2500.0	50	2	0.14	60	1.9	56.18
STYLE J - 1.750 CENTER DISTANCE LUBRICANT MOBILITH # SHC007						
8.0	125	1	0.76	100	1.9	56.18
11.0	125	1	0.74	100	1.9	56.18
15.0	125	1	0.72	100	1.9	56.18
22.5	125	1	0.70	125	1.9	56.18
33.0	150	1	0.60	125	1.9	56.18
45.0	125	1	0.60	125	1.9	56.18
58.0	75	1	0.50	125	1.9	56.18
72.0	60	1	0.45	125	1.9	56.18
90.0	40	1	0.40	125	1.9	56.18
STYLE E DOUBLE REDUCTION LUBRICANT NON FLUID OIL # H260/MS						
50.0	125	2	0.49	95	3.6	106.5
75.0	125	2	0.47	95	3.6	106.5
100.0	125	2	0.45	95	3.6	106.5
120.0	175	2	0.42	95	3.6	106.5
180.0	175	2	0.39	95	3.6	106.5
262.5	150	2	0.36	95	3.6	106.5
400.0	125	2	0.34	95	3.6	106.5
600.0	175	2	0.27	95	3.6	106.5
900.0	150	2	0.25	95	3.6	106.5
2000.0	125	2	0.20	95	3.6	106.5
STYLE PSLH LUBRICANT MOBILITH SHC007						
5.0	61	2	0.91	60	14.1	416
10.0	122	2	0.91	120	13.6	402
15.0	184	2	0.91	200	13.2	390
20.0	246	2	0.91	200	12.9	380
30.0	357	3	0.89	200	12.5	371

Gear Data

RATIO	MAX. TORQUE IN-LBS (MECH.)	GEAR STAGES	EFFICIENCY	OVERHUNG LOAD CAP. LBS.	GREASE CAPACITY OZ.	GREASE CAPACITY CM^3
			STYLE PSSH			
			LUBRICANT MOBILITH # SHC007			
5.0	19.7	2	0.88	10	4.2	125
10.0	38.8	2	0.88	40	3.4	100
15.0	57.5	2	0.88	40	3.0	90
20.0	77.4	2	0.88	40	2.7	80
30.0	115	3	0.79	40	2.7	80
40.0	119	3	0.79	100	2.6	77
50.0	119	3	0.79	100	2.6	77
60.0	120	3	0.79	100	2.5	75
90.0	120	4	0.72	100	2.4	70
120.0	120	4	0.72	100	2.0	60
180.0	120	4	0.72	100	2.0	60
300.0	94	4	0.72	100	2.0	60
450.0	94	5	0.70	100	1.9	57
900.0	94	5	0.70	100	1.9	57
			STYLE PSM			
			LUBRICANT MOBILITH # SHC007			
5.0	19.8	2	0.93	30	6.8	200
10.0	38.8	2	0.93	45	6.4	190
15.0	57.5	2	0.93	60	5.9	175
20.0	77.4	2	0.93	60	5.1	150
30.0	115	3	0.88	90	4.7	140
40.0	151	3	0.88	125	4.7	138
50.0	185	3	0.88	125	4.1	120
60.0	217	3	0.88	125	3.7	110
90.0	237	4	0.84	125	3.4	100
120.0	217	4	0.84	125	3.0	90
180.0	217	4	0.84	125	3.0	90
300.0	189	4	0.84	125	3.0	90
			STYLE PSL			
			LUBRICANT MOBILITH # SHC007			
5.0	31	2	0.91	60	14.8	438
10.0	61	2	0.91	120	14.3	423
15.0	106	2	0.91	200	13.9	410
20.0	122	2	0.91	200	13.5	400
30.0	182	3	0.89	200	13.2	390
40.0	244	3	0.89	200	13.0	385
50.0	250	3	0.89	200	12.9	380
60.0	280	3	0.89	200	12.9	380
90.0	305	4	0.87	200	12.5	370
120.0	315	4	0.87	200	12.2	360
180.0	340	4	0.87	200	11.8	350
240.0	330	4	0.87	200	11.5	340
300.0	330	4	0.87	200	11.2	330

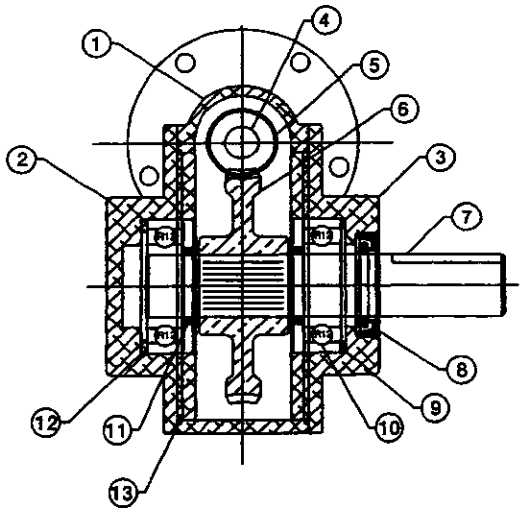
Parts List
Style BA, BP, BB, BC, BF, CB and CC Gear Units

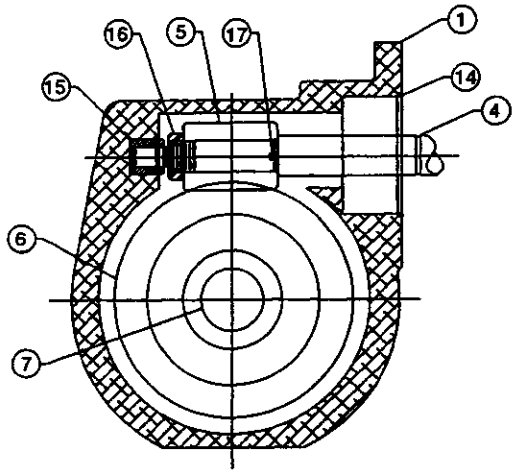




Item No.	Qty.	Description	Item No.	Qty.	Description
1	1	Gearhousing	8	2	Output Shaft Bushing
2	1	Gearcap	9	2	Output Shaft Thrust Brg Assy
3	1	Motor Shaft	10	1	Gear Spacer Pack
4	1	Worm	11	1	Gasket - Gearcap
5	1	Gear	12	1	Gasket - Gearhousing
6	1	Output Shaft	13	1	Worm Nut
7	2	Output shaft Oil Seal	14	1	Worm Pin

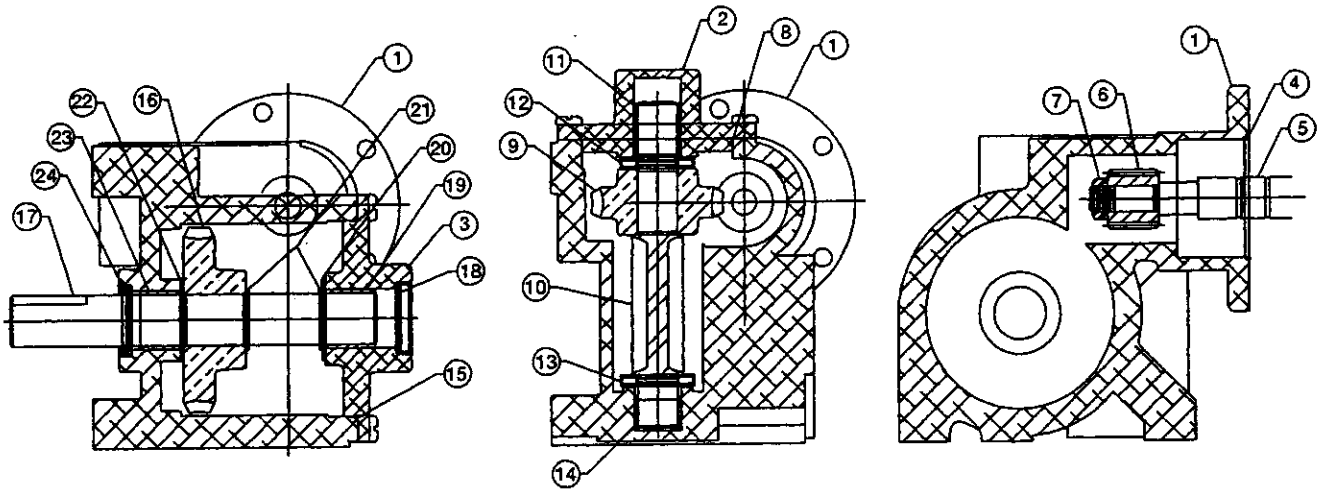
Style JC, JK, JP and JAF Gear Units





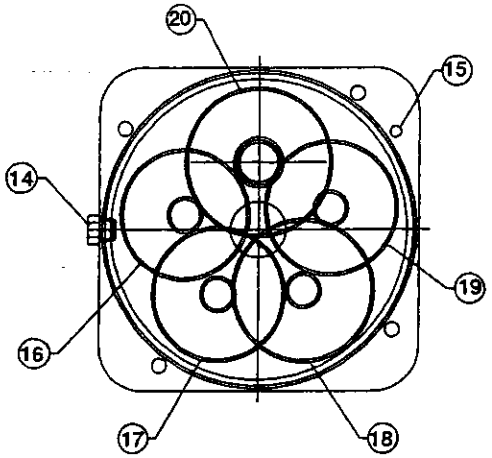
Item No.	Qty.	Description	Item No.	Qty.	Description
1	1	Gearhousing	10	2	Output Shaft Bearing
2	1	Gearcap - Closed	11	2	Gear Spacers
3	1	Gearcap - Open	12	1	Wavy Washer
4	1	Motor shaft	13	2	O-Ring Gasket - Gearcaps
5	1	Worm	14	1	O-Ring Gasket - Gearhousing
6	1	Gear	15	1	Bushing - Motor Shaft
7	1	Output Shaft	16	1	Worm Nut
8	1	Output shaft Oil Seal	17	1	Worm Pin
9	1	Bearing Spacer			

Parts List
Style DA, DB, DC, DF, EB and EC Gear Units

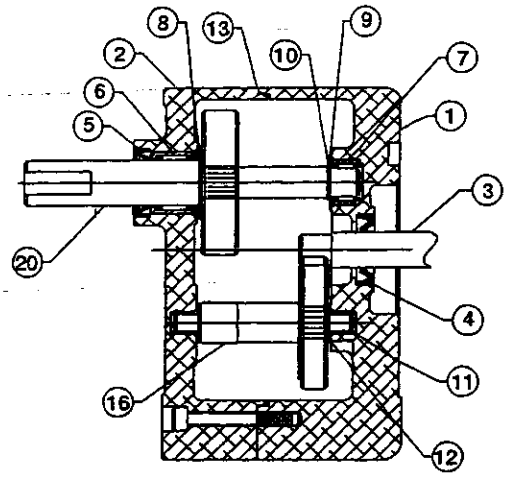


Item No.	Description	Item No.	Description
1	Gearhousing	13	Thrust Bearing Assy., Housing
2	Gearcap - 1st Reduction	14	Bushing, Housing
3	Gearcap - Output/2nd Reduction	15	O-ring, Output Cap
4	O-ring, Housing	16	Gear, 2nd Reduction
5	Motor Shaft	17	Shaft, Output
6	Worm - 1st Reduction	18	Seal, Output Cap
7	Worm Nut	19	Bushing, Output Cap
8	O-ring, Int. Cap	20	Spacer, Output Housing
9	Gear - 1st Reduction	21	Retaining Ring
10	Shaft - 2nd Reduction Worm	22	Spacer, Output Housing
11	Bushing, Cap	23	Bushing, Output Housing
12	Thrust Bearing Assy., Cap	24	Output Shaft Oil Seal

Parts List
Style PSSH Gear Units



5 STAGE BOX



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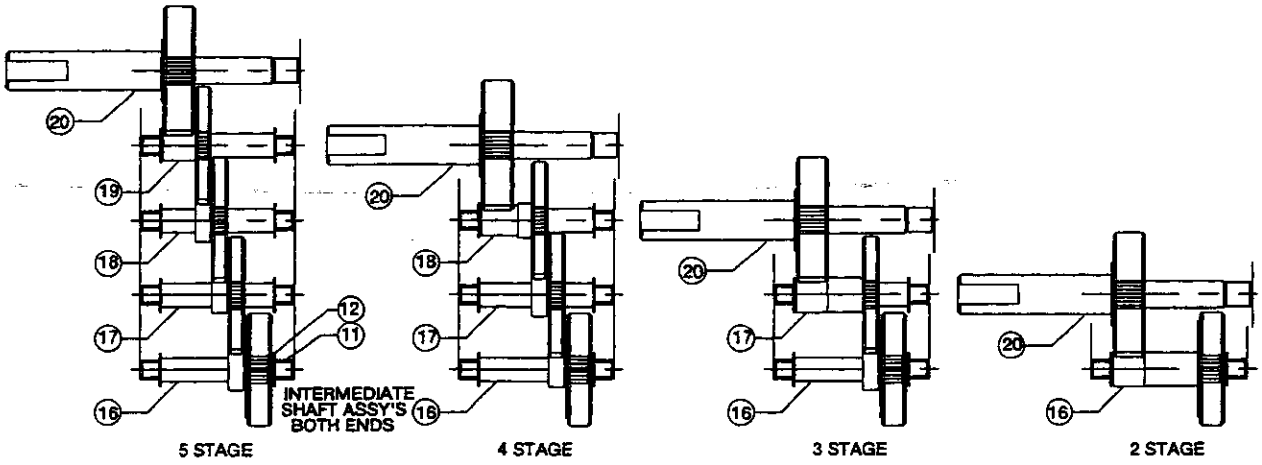
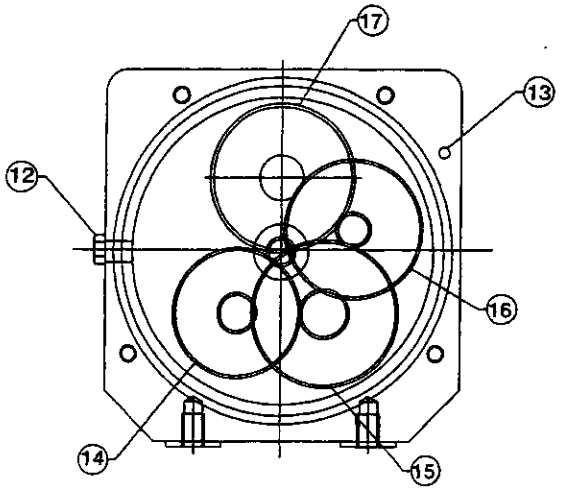


Item No.	Qty.	Description	Item No.	Qty.	Description
1	1	Gearhousing PSSH	11	2	Bushing
2	1	Gearcap PSSH	12	2	Washer Intermediate
3	1	Motor Shaft	13	1	O-Ring Gasket
4	1	Motor Shaft Oil Seal	14	1	Plug
5	1	Output shaft Oil Seal	15	1	Roll Pin
6	1	Needle Roller Bearing Front	16	1	!st Reduction Assy
7	1	Needle Roller Bearing Rear	17	1	2nd Reduction Assy
8	1	Washer Front	18	1	3rd Reduction Assy
9	1	Washer Rear	19	1	4th Reduction Assy
10	1	Retaining Ring	20	1	Output Shaft Assy

Parts List
Style PSM Gear Units



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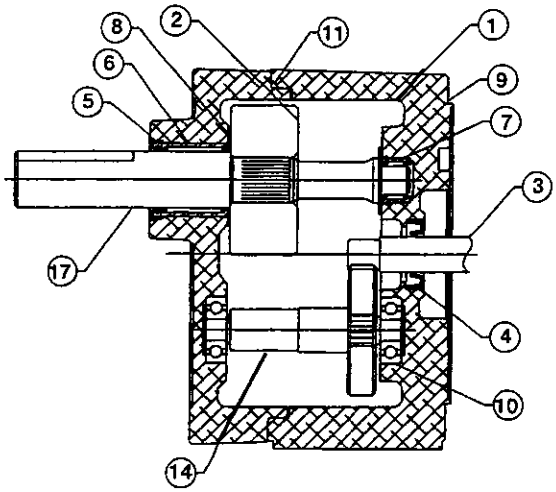

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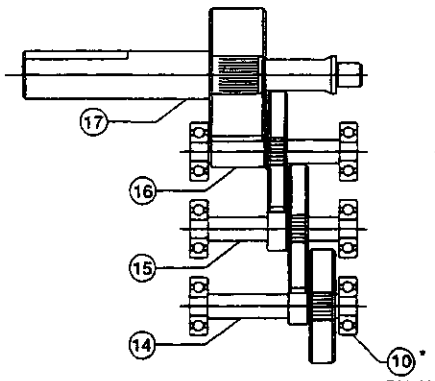
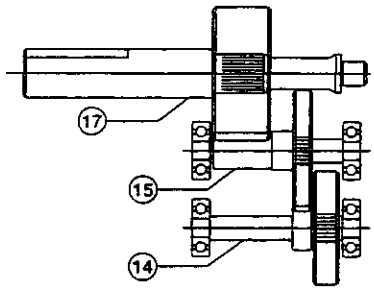


4 STAGE

*ON ALL INTERMEDIATE SHAFT ASSY'S BOTH ENDS



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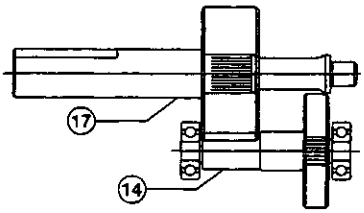
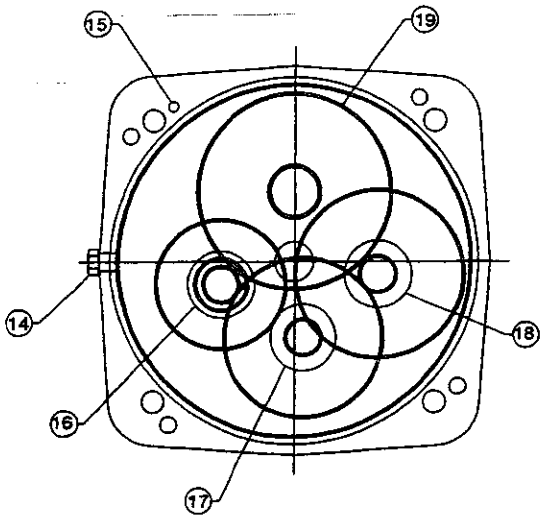


2 STAGE

Item No.	Qty.	Description	Item No.	Qty.	Description
1	1	Gearhousing PSM	10*	2	Ball Bearing
2	1	Gearcap PSM	11	1	O-Ring Gasket
3	1	Motor Shaft	12	1	Plug
4	1	Motor Shaft Oil Seal	13	1	Roll Pin
5	1	Output shaft Oil Seal	14	1	!st Reduction Assy
6	1	Needle Roller Bearing Front	15	1	2nd Reduction Assy
7	1	Needle Roller Bearing Rear	16	1	3rd Reduction Assy
8	1	Washer Front	17	1	Output Shaft Assy
9	1	Washer Rear			

Parts List
Style PSL and PSLH Gear Units



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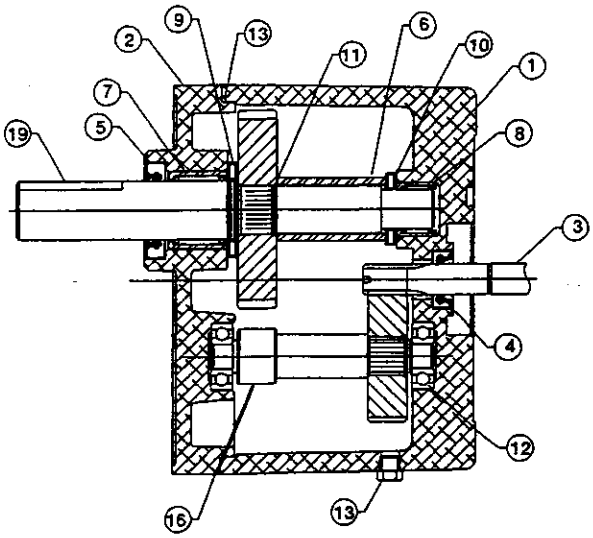

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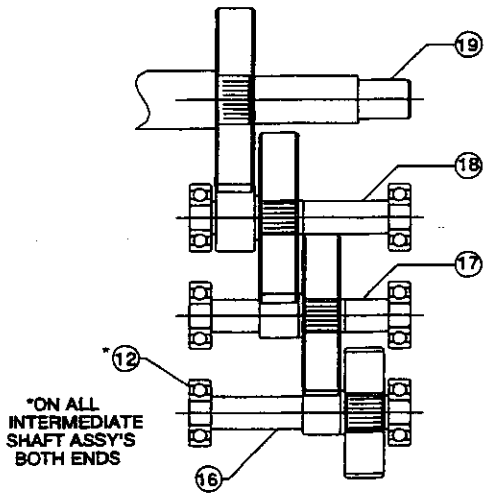
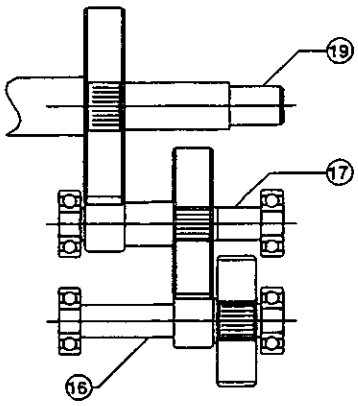


*ON ALL INTERMEDIATE SHAFT ASSY'S BOTH ENDS

4 STAGE



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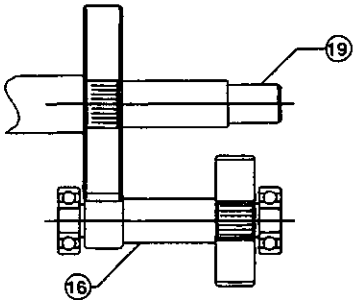

2 STAGE

Item No.	Qty.	Description	Item No.	Qty.	Description
1	1	Gearhousing PSL	11	1	Wavy Washer
2	1	Gearcap PSL	12*	2	608 Bearing
3	1	Motor Shaft	13	1	O-Ring Gasket
4	1	Motor Shaft Oil Seal	14	1	Plug
5	1	Output shaft Oil Seal	15	1	Roll Pin
6	1	Output Shaft Spacer	16	1	!st Reduction Assy
7	1	Needle Roller Bearing Front	17	1	2nd Reduction Assy
8	1	Needle Roller Bearing Rear	18	1	3rd Reduction Assy
9	1	Thrust Bearing Assy Front	19	1	Output Shaft Assy
10	1	Thrust Bearing Assy Rear			

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BALDOR
MOTORS AND DRIVES

Integral Horsepower
AC Induction Motors
ODP Enclosure
TEFC Enclosure
Explosion Proof

Installation & Operating Manual

12/98

MN400

Table of Contents

Section 1
General Information

Overview This manual contains general procedures that apply to Baldor Motor products. Be sure to read and understand the Safety Notice statements in this manual. For your protection, do not install, operate or attempt to perform maintenance procedures until you understand the Warning and Caution statements. A Warning statement indicates a possible unsafe condition that can cause harm to personnel. A Caution statement indicates a condition that can cause damage to equipment.

Important: **This instruction manual is not intended to include a comprehensive listing of all details for all procedures required for installation, operation and maintenance. This manual describes general guidelines that apply to most of the motor products shipped by Baldor. If you have a question about a procedure or are uncertain about any detail, Do Not Proceed. Please contact your Baldor distributor for more information or clarification.**

Before you install, operate or perform maintenance, become familiar with the following:

- NEMA Publication MG-2, Safety Standard for Construction and guide for Selection, Installation and Use of Electric Motors and Generators.
- The National Electrical Code
- Local codes and Practices

Limited Warranty

1. Baldor Electric motors are warranted for a period of one (1) year, from date of shipment from the factory or factory warehouse against defects in material and workmanship. To allow for stocking and/or fabrication period and to provide one year of actual service, the warranty period is extended for an additional period of six (6) months for a total of eighteen (18) months from the original date of shipment from the factory or factory warehouse stock. In no case will the warranty period be extended for a longer period. Baldor extends this limited warranty to each buyer of the electric motor for the purpose of resale and to the original purchaser for use.
2. Baldor will, at its option repair or replace a motor which fails due to defects in material or workmanship during the warranty period if:
   a. the purchaser presents the defective motor at or ships it prepaid to, the Baldor plant in Fort Smith, Arkansas or one of the Baldor Authorized Service Centers and
   b. the purchaser gives written notification concerning the motor and the claimed defect including the date purchased, the task performed by the Baldor motor and the problem encountered.
3. Baldor will not pay the cost of removal of any electric motor from any equipment, the cost of delivery to Fort Smith, Arkansas or a Baldor Authorized Service Center, or the cost of any incidental or consequential damages resulting from the claimed defects. (Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above exclusion may not apply to you.) Any implied warranty given by laws shall be limited to the duration of the warranty period hereunder. (Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you.)
4. Baldor Authorized Service Centers, when convinced to their satisfaction that a Baldor motor developed defects in material or workmanship within the warranty period, are authorized to proceed with the required repairs to fulfill Baldor's warranty when the cost of such repairs to be paid by Baldor does not exceed Baldor's warranty repair allowance. Baldor will not pay overtime premium repair charges without prior written authorization.
5. The cost of warranty repairs made by centers other than Baldor Authorized Service Centers **WILL NOT** be paid unless first authorized in writing by Baldor.
6. Claims by a purchaser that a motor is defective even when a failure results within one hour after being placed into service are not always justified. Therefore, Baldor Authorized Service Centers must determine from the condition of the motor as delivered to the center whether or not the motor is defective. If in the opinion of a Baldor Authorized Service Center, a motor did not fail as a result of defects in material or workmanship, the center is to proceed with repairs only if the purchaser agrees to pay for such repairs. If the decision is in dispute, the purchaser should still pay for the repairs and submit the paid invoice and the Authorized Service Center's signed service report to Baldor for further consideration.
7. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

   Note that **Baldor Super-E® Premium Efficiency** electric motors are warranted for a period of three (3) years. All other terms and conditions of the Limited Warranty statement apply.

Safety Notice:

This equipment contains high voltage! Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt installation, operation and maintenance of electrical equipment.

Be sure that you are completely familiar with NEMA publication MG-2, safety standards for construction and guide for selection, installation and use of electric motors and generators, the National Electrical Code and local codes and practices. Unsafe installation or use can cause conditions that lead to serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.

WARNING: **Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.**

WARNING: **Be sure the system is properly grounded before applying power. Do not apply AC power before you ensure that all grounding instructions have been followed. Electrical shock can cause serious or fatal injury. National Electrical Code and Local codes must be carefully followed.**

WARNING: **Avoid extended exposure to machinery with high noise levels. Be sure to wear ear protective devices to reduce harmful effects to your hearing.**

WARNING: **This equipment may be connected to other machinery that has rotating parts or parts that are driven by this equipment. Improper use can cause serious or fatal injury. Only qualified personnel should attempt to install operate or maintain this equipment.**

WARNING: **Do not by-pass or disable protective devices or safety guards. Safety features are designed to prevent damage to personnel or equipment. These devices can only provide protection if they remain operative.**

WARNING: **Avoid the use of automatic reset devices if the automatic restarting of equipment can be hazardous to personnel or equipment.**

WARNING: **Be sure the load is properly coupled to the motor shaft before applying power. The shaft key must be fully captive by the load device. Improper coupling can cause harm to personnel or equipment if the load decouples from the shaft during operation.**

WARNING: **Use proper care and procedures that are safe during handling, lifting, installing, operating and maintaining operations. Improper methods may cause muscle strain or other harm.**

WARNING: **Before performing any motor maintenance procedure, be sure that the equipment connected to the motor shaft cannot cause shaft rotation. If the load can cause shaft rotation, disconnect the load from the motor shaft before maintenance is performed. Unexpected mechanical rotation of the motor parts can cause injury or motor damage.**

WARNING: **Disconnect all electrical power from the motor windings and accessory devices before disassembly of the motor. Electrical shock can cause serious or fatal injury.**

WARNING: **Do not use these motors in the presence of flammable or combustible vapors or dust. These motors are not designed for atmospheric conditions that require explosion proof operation.**

WARNING: **Motors that are to be used in flammable and/or explosive atmospheres must display the UL label on the nameplate.**

Specific service conditions for these motors are defined in NEC 70-599.

WARNING: **UL rated motors must only be serviced by authorized Baldor Service Centers if these motors are to be returned to a flammable and/or explosive atmosphere.**

Caution: **To prevent premature equipment failure or damage, only qualified maintenance personnel should perform maintenance.**

Caution: **Do not lift the motor and its driven load by the motor lifting hardware. The motor lifting hardware is adequate for lifting only the motor. Disconnect the load from the motor shaft before moving the motor.**

Caution: **If eye bolts are used for lifting a motor, be sure they are securely tightened. The lifting direction should not exceed a 20° angle from the shank of the eye bolt or lifting lug. Excessive lifting angles can cause damage.**

Caution: **To prevent equipment damage, be sure that the electrical service is not capable of delivering more than the maximum motor rated amps listed on the rating plate.**

Caution: **If a HI POT test (High Potential Insulation test) must be performed, follow the precautions and procedure in NEMA MG-1 and MG-2 standards to avoid equipment damage.**

If you have any questions or are uncertain about any statement or procedure, or if you require additional information please contact your Baldor distributor or an Authorized Baldor Service Center.

Receiving

Each Baldor Electric Motor is thoroughly tested at the factory and carefully packaged for shipment. When you receive your motor, there are several things you should do immediately.

1. Observe the condition of the shipping container and report any damage immediately to the commercial carrier that delivered your motor.
2. Verify that the part number of the motor you received is the same as the part number listed on your purchase order.

Storage

If the motor is not put into service immediately, the motor must be stored in a clean, dry and warm location. Several precautionary steps must be performed to avoid motor damage during storage.

1. Use a "Megger" periodically to ensure that the integrity of the winding insulation has been maintained. Record the Megger readings. Immediately investigate any significant drop in insulation resistance.
2. Do not lubricate bearings during storage. Motor bearings are packed with grease at the factory. Excessive grease can damage insulation quality.
3. Rotate motor shaft at least 10 turns every two months during storage (more frequently if possible). This will prevent bearing damage due to storage.
4. If the storage location is damp or humid, the motor windings must be protected from moisture. This can be done by applying power to the motors' space heater (if available) while the motor is in storage.

Unpacking

Each Baldor motor is packaged for ease of handling and to prevent entry of contaminants.

1. To avoid condensation inside the motor, do not unpack until the motor has reached room temperature. (Room temperature is the temperature of the room in which it will be installed). The packing provides insulation from temperature changes during transportation.
2. When the motor has reached room temperature, remove all protective wrapping material from the motor.

Handling

The motor should be lifted using the lifting lugs or eye bolts provided.

1. Use the lugs or eye bolts provided to lift the motor. Never attempt to lift the motor and additional equipment connected to the motor by this method. The lugs or eye bolts provided are designed to lift only the motor. Never lift the motor by the motor shaft.
2. If the motor must be mounted to a plate with the driven equipment such as pump, compressor etc., it may not be possible to lift the motor alone. For this case, the assembly should be lifted by a sling around the mounting base. The entire assembly can be lifted as an assembly for installation. Do not lift using the motor lugs or eye bolts provided.

   If the load is unbalanced (as with couplings or additional attachments) additional slings or other means must be used to prevent tipping. In any event, the load must be secure before lifting.

Section 2
Installation & Operation

Overview

Installation should conform to the National Electrical Code as well as local codes and practices. When other devices are coupled to the motor shaft, be sure to install protective devices to prevent future accidents. Some protective devices include, coupling, belt guard, chain guard, shaft covers etc. These protect against accidental contact with moving parts. Machinery that is accessible to personnel should provide further protection in the form of guard rails, screening, warning signs etc.

Location

The motor should be installed in an area that is protected from direct sunlight, corrosives, harmful gases or liquids, dust, metallic particles, and vibration. Exposure to these can reduce the operating life and degrade performance. Be sure to allow clearance for ventilation and access for cleaning, repair, service and inspections. Ventilation is extremely important. Be sure the area for ventilation is not obstructed. Obstructions will limit the free passage of air. Motors get warm and the heat must be dissipated to prevent damage.

These motors are not designed for atmospheric conditions that require explosion proof operation. They must NOT be used in the presence of flammable or combustible vapors or dust.

1. ODP motors are suitable only for indoor applications.
2. TEFC motors are suitable for indoor or outdoor standard service applications.

Mounting

The motor must be securely installed to a rigid foundation or mounting surface to minimize vibration and maintain alignment between the motor and shaft load. Failure to provide a proper mounting surface may cause vibration, misalignment and bearing damage.

Foundation caps and sole plates are designed to act as spacers for the equipment they support. If these devices are used, be sure that they are evenly supported by the foundation or mounting surface.

After installation is complete and accurate alignment of the motor and load is accomplished, the base should be grouted to the foundation to maintain this alignment.

The standard motor base is designed for horizontal or vertical mounting. Adjustable or sliding rails are designed for horizontal mounting only. Consult your Baldor distributor or authorized Baldor Service Center for further information.

Alignment

Accurate alignment of the motor with the driven equipment is extremely important.

1. **Direct Coupling**
   For direct drive, use flexible couplings if possible. Consult the drive or equipment manufacturer for more information. Mechanical vibration and roughness during operation may indicate poor alignment. Use dial indicators to check alignment. The space between coupling hubs should be maintained as recommended by the coupling manufacturer.
2. **End-Play Adjustment**
   The axial position of the motor frame with respect to its load is also extremely important. The motor bearings are not designed for excessive external axial thrust loads. Improper adjustment will cause failure.
3. **Pulley Ratio**
   The pulley ratio should not exceed 8:1.
4. **Belt Drive**
   Align sheaves carefully to minimize belt wear and axial bearing loads (see End-Play Adjustment). Belt tension should be sufficient to prevent belt slippage at rated speed and load. However, belt slippage may occur during starting.

Caution: **Do not over tension belts.**

Doweling & Bolting

After proper alignment is verified, dowel pins should be inserted through the motor feet into the foundation. This will maintain the correct motor position should motor removal be required. (Baldor motors are designed for doweling.)

1. Drill dowel holes in diagonally opposite motor feet in the locations provided.
2. Drill corresponding holes in the foundation.
3. Ream all holes.
4. Install proper fitting dowels.
5. Mounting bolts must be carefully tightened to prevent changes in alignment. Use a flat washer and lock washer under each nut or bolt head to hold the motor feet secure. Flanged nuts or bolts may be used as an alternative to washers.

Power Connection

Motor and control wiring, overload protection, disconnects, accessories and grounding should conform to the National Electrical Code and local codes and practices.

Conduit Box

For ease of making connections, an oversize conduit box is provided. The box can be rotated 360° in 90° increments. Auxiliary conduit boxes are provided on some motors for accessories such as space heaters, RTD's etc.

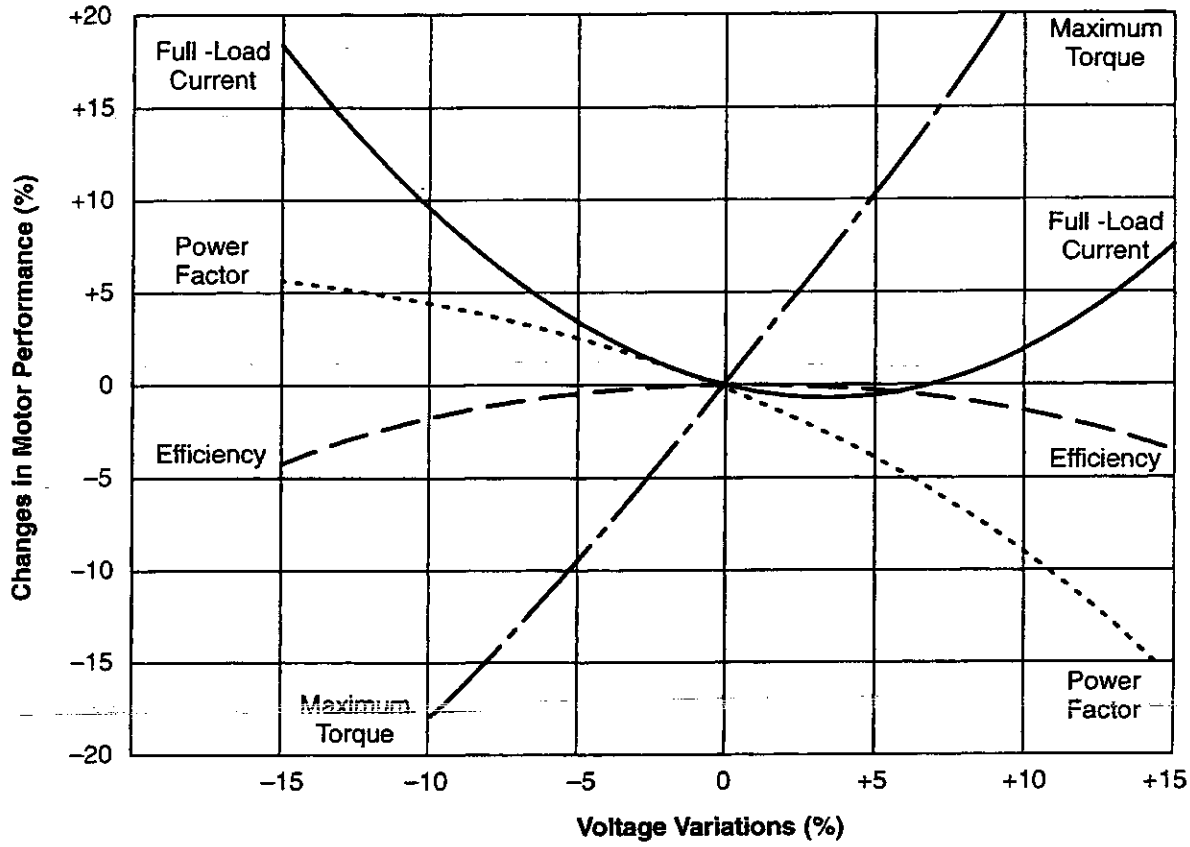
AC Power

Connect the motor leads as shown on the connection diagram located on the name plate or inside the cover on the conduit box. Be sure the following guidelines are met:

1. AC power is within ±10% of rated voltage with rated frequency. (See motor name plate for ratings).
   OR
2. AC power is within ±5% of rated frequency with rated voltage.
   OR
3. A combined variation in voltage and frequency of ±10% (sum of absolute values) of rated values, provided the frequency variation does not exceed ±5% of rated frequency.

Performance within these voltage and frequency variations are shown in Figure 2-1.

Figure 2-1 Motor Performance VS Voltage Variations



First Time Start Up

Be sure that all power to motor and accessories is off. Be sure the motor shaft is disconnected from the load and will not cause mechanical rotation of the motor shaft.

1. Make sure that the mechanical installation is secure. All bolts and nuts are tightened etc.
2. If motor has been in storage or idle for some time, check winding insulation integrity with a Megger.
3. Inspect all electrical connections for proper termination, clearance, mechanical strength and electrical continuity.
4. Be sure all shipping materials and braces (if used) are removed from motor shaft.
5. Manually rotate the motor shaft to ensure that it rotates freely.
6. Replace all panels and covers that were removed during installation.
7. Momentarily apply power and check the direction of rotation of the motor shaft.
8. If motor rotation is wrong, be sure power is off and change the motor lead connections. Verify rotation direction before you continue.
9. Start the motor and ensure operation is smooth without excessive vibration or noise. If so, run the motor for 1 hour with no load connected.
10. After 1 hour of operation, disconnect power and connect the to load to the motor shaft. Verify all coupling guards and protective devices are installed. Ensure motor is properly ventilated.

Coupled Start Up

This procedure assumes a coupled start up. Also, that the first time start up procedure was successful.

1. Check the coupling and ensure that all guards and protective devices are installed.
2. Check that the coupling is properly aligned and not binding.
3. The first coupled start up should be with no load. Apply power and verify that the load is not transmitting excessive vibration back to the motor though the coupling or the foundation. Vibration should be at an acceptable level.
4. Run for approximately 1 hour with the driven equipment in an unloaded condition.

The equipment can now be loaded and operated within specified limits. Do not exceed the name plate ratings for amperes for steady continuous loads.

Jogging and Repeated Starts Repeated starts and/or jogs of induction motors generally reduce the life of the motor winding insulation. A much greater amount of heat is produced by each acceleration or jog than than by the same motor under full load. If it is necessary to to repeatedly start or jog the motor, it is advisable to check the application with your local Baldor distributor or Baldor Service Center.

Heating - Duty rating and maximum ambient temperature are stated on the motor name plate. Do not exceed these values. If there is any question regarding safe operation, contact your local Baldor distributor or Baldor Service Center.

Section 3
Maintenance & Troubleshooting

WARNING: **UL rated motors must only be serviced by authorized Baldor Service Centers if these motors are to be returned to a flammable and/or explosive atmosphere.**

General Inspection

Inspect the motor at regular intervals, approximately every 500 hours of operation or every 3 months, whichever occurs first. Keep the motor clean and the ventilation openings clear. The following steps should be performed at each inspection:

WARNING: **Do not touch electrical connections before you first ensure that power has been disconnected. Electrical shock can cause serious or fatal injury. Only qualified personnel should attempt the installation, operation and maintenance of this equipment.**

1. Check that the motor is clean. Check that the interior and exterior of the motor is free of dirt, oil, grease, water, etc. Oily vapor, paper pulp, textile lint, etc. can accumulate and block motor ventilation. If the motor is not properly ventilated, overheating can occur and cause early motor failure.
2. Use a "Megger" periodically to ensure that the integrity of the winding insulation has been maintained. Record the Megger readings. Immediately investigate any significant drop in insulation resistance.
3. Check all electrical connectors to be sure that they are tight.

Lubrication & Bearings

Bearing grease will lose its lubricating ability over time, not suddenly. The lubricating ability of a grease (over time) depends primarily on the type of grease, the size of the bearing, the speed at which the bearing operates and the severity of the operating conditions. Good results can be obtained if the following recommendations are used in your maintenance program.

Type of Grease

A high grade ball or roller bearing grease should be used. Recommended greases for standard service conditions are:

Chevron SRI (Factory Installed) – Polyurea Base

Equivalent Greases

Name of Grease	Manufacturer	Type of Base
Rykon Premium #2	American Oil Co.	Polyurea
Shell Dolium R	Shell Oil Co.	Polyurea
Texaco Premium RB	Texaco	Lithium
Texaco Polystar	Texaco	Polyurea

Lubrication Intervals

Recommended lubrication intervals are shown in Table 3-1. It is important to realize that the recommended intervals of Table 3-1 are based on average use.

Refer to additional information contained in Tables 3-2 and 3-3.

Table 3-1 Lubrication Intervals *

NEMA / (IEC) Frame Size	Rated Speed - RPM					
	10000	6000	3600	1800	1200	900
Up to 210 incl. (132)	**	2700 Hrs.	5500 Hrs.	12000 Hrs.	18000 Hrs.	22000 Hrs.
Over 210 to 280 incl. (180)			3600 Hrs.	9500 Hrs.	15000 Hrs.	18000 Hrs.
Over 280 to 360 incl. (225)			* 2200 Hrs.	7400 Hrs.	12000 Hrs.	15000 Hrs.
Over 360 to 5800 incl. (300)			*2200 Hrs.	3500 Hrs.	7400 Hrs.	10500 Hrs.

* Lubrication intervals are for ball bearings. For roller bearings, divide the listed lubrication interval by 2.

** For 6205 and 6806 bearings. For 6807 bearings, consult oil mist lubrication (MN401).
Relubrication interval for 6205 bearing bearing is 1550Hrs. (using grease lubrication).
Relubrication interval for 6806 bearing bearing is 720Hrs. (using grease lubrication).

Table 3-2 Service Conditions

Severity of Service	Ambient Temperature Maximum	Atmospheric Contamination	Type of Bearing
Standard	40° C	Clean, Little Corrosion	Deep Groove Ball Bearing
Severe	50° C	Moderate dirt, Corrosion	Ball Thrust, Roller
Extreme	>50° C* or Class H Insulation	Severe dirt, Abrasive dust, Corrosion	All Bearings
Low Temperature	<-30° C **		

* Special high temperature grease is recommended (Darmex 707). Note that Darmex 707 grease does not mix with other grease types. Thoroughly clean bearing & cavity before adding grease.

** Special low temperature grease is recommended (Aeroshell 7).

Table 3-3 Lubrication Interval Multiplier

Severity of Service	Multiplier
Standard	1.0
Severe	0.5
Extreme	0.1
Low Temperature	1.0

Table 3-4 Bearings Sizes and Types

Frame Size NEMA (IEC)	Bearing Description (These are the "Large" bearings (Shaft End) in each frame size)					
	Bearing	OD D mm	Width B mm	Weight of Grease to add * oz (Grams)	Volume of grease to be added	
					in^3	tea-spoon
Up to 210 incl. (132)	6307	80	21	0.30 (8.4)	0.6	2.0
Over 210 to 280 incl. (180)	6311	120	29	0.61 (17)	1.2	3.9
Over 280 to 360 incl. (225)	6313	140	33	0.81 (23)	1.5	5.2
Over 360 to 449 incl. (280)	NU319	200	45	2.12 (60)	4.1	13.4
Over 5000 to 5800 incl. (355)	NU328	300	62	4.70 (130)	9.2	30.0
Spindle Motors						
76 Frame	6207	72	17	0.22 (6.1)	0.44	1.4
77 Frame	6210	90	20	0.32 (9.0)	0.64	2.1
80 Frame	6213	120	23	0.49 (14.0)	0.99	3.3

* Weight in grams = .005 DB

Lubrication Procedure

Be sure that the grease you are adding to the motor is compatible with the grease already in the motor. Consult your Baldor distributor or an authorized service center if a grease other than the recommended type is to be used.

Caution: To avoid damage to motor bearings, grease must be kept free of dirt. For an extremely dirty environment, contact your Baldor distributor or an authorized Baldor Service Center for additional information.

With Grease Outlet Plug

1. Clean all grease fittings.
2. Remove grease outlet plug.
3. If motor is stopped, add the recommended amount of grease.

   If motor is to be greased while running, a slightly greater quantity of grease will have to be added. Add grease slowly until new grease appears at shaft hole in the endplate or purge outlet plug.
4. Re-install grease outlet plug.

Without Grease Outlet Plug

1. Disassemble motor.
2. Add recommended amount of grease to bearing and bearing cavity. (Bearing should be about 1/3 full of grease and outboard bearing cavity should be about 1/2 full of grease.)

Note: Bearing is 1/3 full when only one side of bearing is completely full of grease.

3. Assemble motor.

Sample Lubrication Determination

Assume - NEMA 286T (IEC 180), 1750 RPM motor driving an exhaust fan in an ambient temperature of 43° C and the atmosphere is moderately corrosive.

1. Table 3-1 list 9500 hours for standard conditions.
2. Table 3-2 classifies severity of service as "Severe".
3. Table 3-3 lists a multiplier value of 0.5 for Severe conditions.
4. Table 3-4 shows that 1.2 in^3 or 3.9 teaspoon of grease is to be added.

Note: Smaller bearings in size category may require reduced amounts of grease.

Accessories

The following is a partial list of accessories available from Baldor.
Contact your Baldor distributor for availability and pricing information.

Note: Space heaters and RTD's are standard on some motors.

Bearing RTD
RTD (Resistance Temperature Detector) devices are used to measure or monitor the temperature of the motor bearing during operation.

Bearing Thermocouples
Used to measure or monitor bearing temperatures.

Bearing Thermostat
Temperature device that activates when bearing temperatures are excessive. Used with an external circuit to warn of excessive bearing temperature or to shut down a motor.

Conduit Boxes
Optional conduit boxes are available in various sizes to accommodate accessory devices.

Cord & Plug Assembly
Adds a line cord and plug for portable applications.

Drains and Breathers
Stainless steel drains with separate breathers are available.

Drip Covers
Designed for use when motor is mounted in a vertical position. Contact your Baldor distributor to confirm that the motor is designed for vertical mounting.

Fan Cover & Lint Screen
To prevent build-up of debris on the cooling fan.

Nameplate
Additional stainless steel nameplates are available.

Roller Bearings
Recommended for belt drive applications with a speed of 1800 RPM or less.

Rotation Arrow Labels
Rotation arrows are supplied on motors designed to operate in one direction only. Additional rotation arrows are available.

Space Heater
Added to prevent condensation of moisture within the motor enclosure during periods of shut down or storage.

Stainless Hardware
Stainless steel hardware is available. Standard hardware is corrosion resistant zinc plated steel.

Winding RTD
RTD (Resistance Temperature Detector) devices are used to measure or monitor the temperature of the motor winding during operation.

Winding Thermocouples
Used to measure or monitor winding temperatures.

Winding Thermostat
Temperature device that activates when winding temperatures are excessive. Used with an external circuit to warn of excessive winding temperature or to shut down a motor.

Note: On some motors, leads for accessory devices are brought out to a separate conduit box located on the side of the motor housing (unless otherwise specified).

Table 3-5 Troubleshooting Chart

Symptom	Possible Causes	Possible Solutions
Motor will not start	Usually caused by line trouble, such as, single phasing at the starter.	Check source of power. Check overloads, fuses, controls, etc.
Excessive humming	High Voltage.	Check input line connections.
	Eccentric air gap.	Have motor serviced at local Baldor service center.
Motor Over Heating	Overload. Compare actual amps (measured) with nameplate rating.	Locate and remove source of excessive friction in motor or load. Reduce load or replace with motor of greater capacity.
	Single Phasing.	Check current at all phases (should be approximately equal) to isolate and correct the problem.
	Improper ventilation.	Check external cooling fan to be sure air is moving properly across cooling fins. Excessive dirt build-up on motor. Clean motor.
	Unbalanced voltage.	Check voltage at all phases (should be approximately equal) to isolate and correct the problem.
	Rotor rubbing on stator.	Check air gap clearance and bearings.
		Tighten "Thru Bolts".
	Over voltage or under voltage.	Check input voltage at each phase to motor.
	Open stator winding.	Check stator resistance at all three phases for balance.
	Grounded winding.	Perform dielectric test and repair as required.
	Improper connections.	Inspect all electrical connections for proper termination, clearance, mechanical strength and electrical continuity. Refer to motor lead connection diagram.
Bearing Over Heating	Misalignment.	Check and align motor and driven equipment.
	Excessive belt tension.	Reduce belt tension to proper point for load.
	Excessive end thrust.	Reduce the end thrust from driven machine.
	Excessive grease in bearing.	Remove grease until cavity is approximately $^3/_4$ filled.
	Insufficient grease in bearing.	Add grease until cavity is approximately $^3/_4$ filled.
	Dirt in bearing.	Clean bearing cavity and bearing. Repack with correct grease until cavity is approximately $^3/_4$ filled.
Vibration	Misalignment.	Check and align motor and driven equipment.
	Rubbing between rotating parts and stationary parts.	Isolate and eliminate cause of rubbing.
	Rotor out of balance.	Have rotor balance checked are repaired at your Baldor Service Center.
	Resonance.	Tune system or contact your Baldor Service Center for assistance.
Noise	Foreign material in air gap or ventilation openings.	Remove rotor and foreign material. Reinstall rotor. Check insulation integrity. Clean ventilation openings.
Growling or whining	Bad bearing.	Replace bearing. Clean all grease from cavity and new bearing. Repack with correct grease until cavity is approximately $^3/_4$ filled.

BALDOR
MOTORS AND DRIVES

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TORRINGTON®
Lubrication Guide

INTRODUCTION

LUBRICATION INFORMATION

Lubricant Selection

The purpose of this guide is to help you to recognize the relationship of bearings and proper lubrication. Selection of the proper lubricant is an important design function in the use of bearings, since lubricant affects bearing life and operation. The major functions of lubrication in bearing application are:

- to minimize friction at points of contact within the bearing
- to protect the precision finishes on bearing surfaces from becoming corroded
- to dissipate heat generated within the bearing
- to remove or prevent the entry of foreign matter within the bearing

The Torrington Company hopes that this guide will help you to identify lubrication problems and take corrective and preventive measures to keep them from recurring.

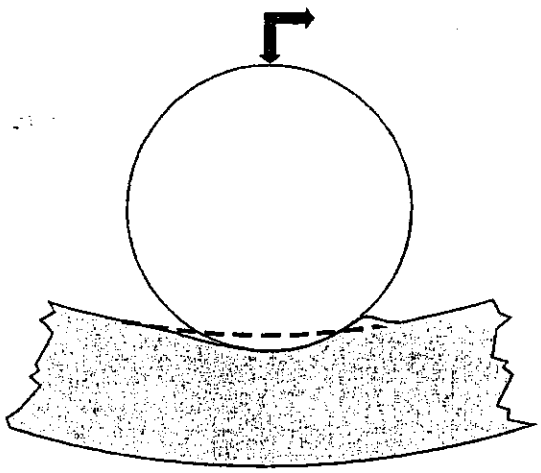
Mechanical Forces Within the Rolling Bearings

A major source of the frictional resistance in a ball bearing is sliding between the balls, the races, and the retainer. Additional frictional resistance occurs between the rotating parts and the lubricant.

A third factor contributing to frictional resistance is the deformation of the bearing parts under load. When a ball in a bearing is subjected to load, a deformation of both the ball and the race results. This deformation causes an elliptical area of contact between the ball and the race. The amount of deformation is a function of the elasticity of the materials used, the ball size, race geometry, and the magnitude and direction of the applied load.

Rolling Ball Under Vertical and Tangential Load

When a ball is motionless, the load is distributed symmetrically on the ball and the race within the contact area. When a tangential load is applied, causing the ball to roll, the material in the race bulges in front of the ball and flattens out behind the ball. The ball flattens out in the lower front quadrant and bulges in the lower rear quadrant.



Rolling Ball Under Vertical and Tangential Load

Contact Ellipse Formed by Ball and Race

One part of the resistance to rolling is accounted for by this elastic deformation of the rolling elements and the races. Another source of energy loss is the actual slippage within the contact areas of the ball and the races. As shown, all points in the contact area are at different distances from the axis of rotation of the ball and rotate at different velocities. However, two points, **A** and **B**, roll true and form a line parallel to the axis of rotation and perpendicular to the direction of rolling. All other points in the **contact ellipse** slide to varying degrees.

The retainer is another source of sliding friction. Depending upon the bearing design, the retainer may be ball or ring piloted. In both cases, sliding friction will occur between the balls and the ball pockets.

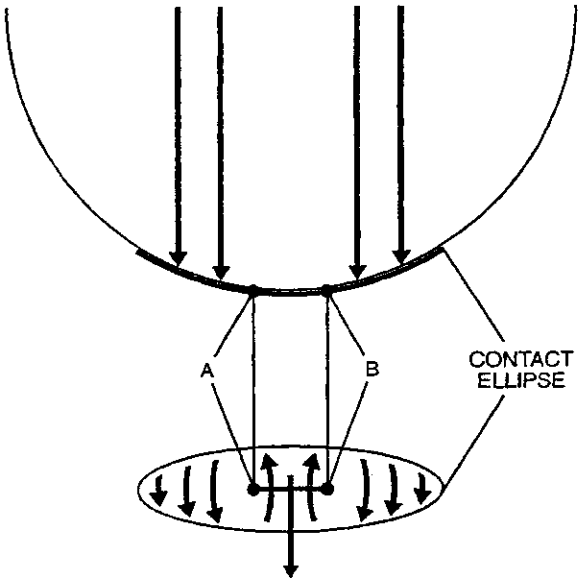
Sliding friction also occurs between the retainer and the controlling ring in the ring piloted retainer. The heat generated within the bearing is a consequence of the frictional resistance of the bearing as well as other effects enumerated above.

High pressures exist in the area of contact. In the absence of lubricant, metal to metal pick-up or welding between the balls and the races can occur. High temperatures due to sliding friction between the balls, races and retainer may also cause surface damage.

To prevent these actions from occurring, lubricants having adequate film strength are required. Insufficient film strength allows metal to metal contact within the contact areas. The hydrodynamics of the lubricant may reduce the stresses in the contact area. This is significant because the amount of deformation of the ball and the race bears a direct relationship to frictional resistance and the fatigue life of the bearing.

In both the ball to race contact area and the retainer rubbing areas, sufficient lubricant flow or movement must be maintained to prevent localized heat build-up in the bearing.

Fluid friction, friction within the lubricant itself, is a function of the chemical and physical composition of the lubricant. Friction between the lubricant and the bearing components is a function of the characteristics of the lubricant and the design of the bearing. All of these factors contribute significantly to the frictional resistance of the bearing and must be considered when selecting the proper lubricant. Of equal importance when selecting a lubricant for a specific application, are the actual operating conditions in addition to the bearing's characteristics.



Contact Ellipse Formed by Ball and Race

Lubricant Types

Two basic types of lubricants–oils and greases–are used with anti-friction bearings. Each has its advantages and limitations.

As a liquid, oil lubricates all the surfaces and is able to dissipate heat from these surfaces more readily. Oil retains its physical characteristics over a wide range of temperatures, making it ideal for high speed and high temperature applications. The quantity of oil supplied to the bearing may be controlled accurately allowing for better circulation, cleansing and cooling.

As a thicker substance, grease can seal a bearing better than oil, while allowing seal design simplification. It can be confined easily in the bearing housing, and permits prelubrication of sealed or shielded bearings.

Advantages of Oil and Grease

Oil

- Better for high speed operation. Easier dispersion over bearing surfaces. Diffuses heat quicker because of viscosity.
- Easier to handle and control amount of lubricant reaching the bearing.
- Variety of ways to deliver oil (drip, wick, circulation, batch, air-oil mist) make it easier to introduce into bearing.
- Easier to keep clean for recirculating systems.
- Easily controlled lubrication. Carries away moisture and particulate matter.

Grease

- Clings to surfaces better. Is squeezed out of roller path to lesser extent.
- Easier to retain in bearing. Lubricant loss is lower than oil loss. Generally requires less frequent lubrication.
- Lasts longer and protects better than oil.
- Acts as an efficient bearing sealant. Allows seal design simplification.
- Easily confined in housing, an important plus in food, textile and chemical industries.

Coatings and Surface Treatments

Coatings and surface treatments specifically developed to protect bearings from rusting, reduce wear, increase hardness and lubricity are available. Among them:

Electro-Plating

The coating of metal parts with another metal by means of ionic bonding, through the introduction of electric charges in the presence of a chemical agent.

Electroless-Plating

The coating of metal parts with another metal by means of ionic bonding, through the application of heat and chemical agents.

PVD (Physical Vapor Deposition)

The coating of metal surfaces with low temperature plasma coatings.

CVD (Chemical Vapor Deposition)

The coating of metal with alloys similar to electroless plating.

Solid Lubricants

Coatings and treatments at area of surface-to-surface interface which intentionally wear onto surfaces to ease interaction and contact.

Examples of these coatings are Fafnir TDC™ (Thin Dense Chrome) Electro-less Nickel, Cadmium Plating, Molybnium Disulfide, Titanium Nitride, gold/silver/brass flake and Teflon/Nomex.

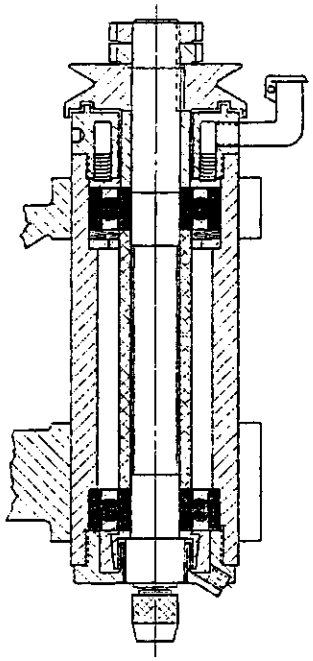
Lubrication Delivery Systems

Oil-Bath Lubrication

The conventional oil-bath system for lubricating bearings is satisfactory for low to moderately high speed applications. Because this type of system is non-circulating, the static oil-level should never be higher than the center of the lowest positioned rolling element in the bearing being lubricated. A greater amount of oil can cause churning, increase the fluid friction within the bearing and result in excessive operating temperatures.

Unless the running level of the oil is known, oil level should be checked only when equipment is shut down as the running level can drop considerably below the static level depending on the speed of the application.

Because speed, sealing effectiveness, temperature and type of oil are factors that influence the refilling cycle, regular inspection is necessary to determine the frequency of refilling. Applications of this type generally employ sight gages to facilitate inspection.



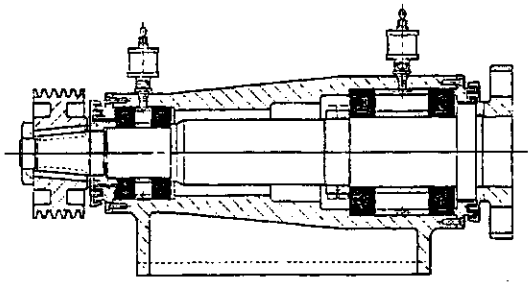
Wick-Feed Lubrication

Wick-Feed Lubrication

Wick-feed oilers, one of the older methods of applying oil to bearings, still enjoy a certain popularity. Properly designed, applied and maintained, then are effective and inexpensive.

Functioning as a filter and quantity regulator, the wick employs either capillary action, or gravity (see illustration) to transfer the oil from the reservoir to bearing.

Paraffinic lubricating oils may also be used with this type oiler although they have a tendency to deposit wax crystals on the wick fibers, destroying the effectiveness of the wick. Because napathetic and synthetic oils do not exhibit this tendency, they are preferred for wick oilers.



Drip-Feed Lubrication

Drip-Feed Lubrication

Another one of the older methods of lubrication of oiling bearings is the drip-feed system. This system has been applied successfully to applications where moderate loads and speeds are encountered. The oil introduced through a filter-type. sight feed oiler, has a controllable flow rate which is determined by the operating temperature of the particular application.

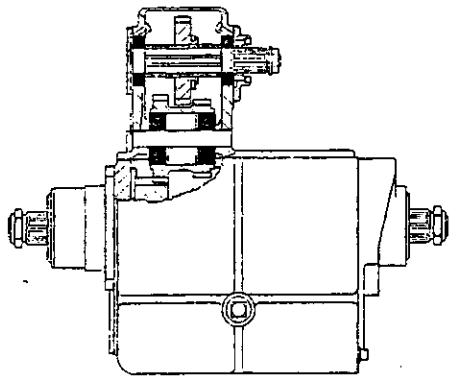
Oil -Splash Lubrication

This system of lubrication is used primarily in gear cases where the bearing and gear lubricant is common. The lubrication of bearings in a gearbox, other than one of slow speed, is usually not critical as the oil splash from gear teeth is sufficient to lubricate the bearings.

Because of the constant problem of the oil carrying wear debris, the use of filters and magnetic drain plugs is helpful in reducing the possibility of wear debris contaminating the bearings.

In applications where heavy oil flow or splash is encountered, bearings equipped with shields to reduce the quantity of oil reaching the bearings are sometimes necessary to prevent overheating caused by fluid friction where the bearing is flooded.

In systems where normal splash or washdown is expected to be marginal, oil feeder trails should be designed into the case to direct case washdown into the bearings.

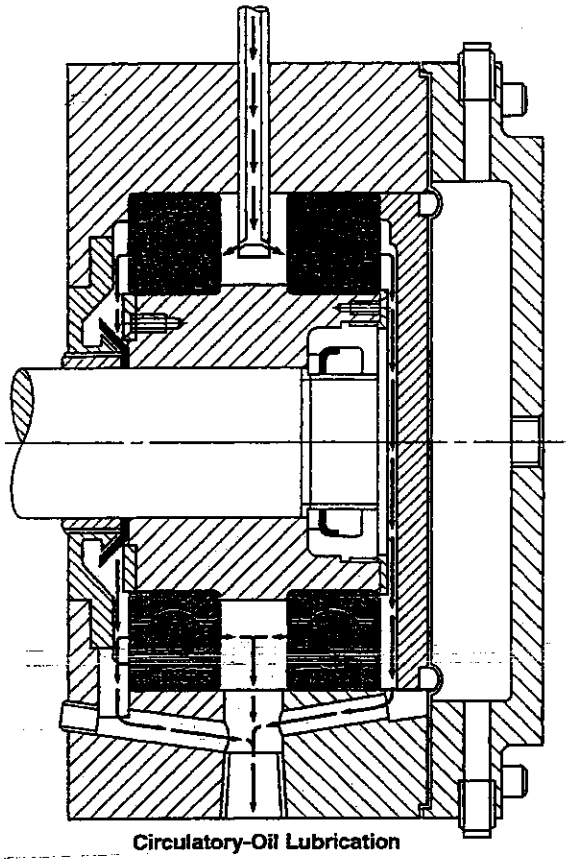


Oil-Splash Lubrication

Lubrication Delivery Systems

Circulating-Oil Lubrication

This type of system utilizes a circulating pump to assure a positive supply of lubricant to the bearing and can be used for low to moderately high speed and high temperature power transmission applications.The flow path of the oil in this system is important because bearing churning in a captive amount of oil can generate temperatures capable of causing lubricant breakdown and bearing damage. Due to the inherent possibility of contamination from wear debris in heavy duty applications, suitable oil filters and magnetic drain plugs are necessary to prevent damage to the bearings.



Circulatory-Oil Lubrication

Oil-Jet Lubrication

In applications where a bearing is heavily loaded and operating at high speed and temperatures, a sophisticated variation of circulating oil lubrication, called oil-jet lubrication, may be required. In such cases, it is necessary to lubricate each bearing location individually, under pressure, and to provide adequately large scavenging drains to prevent the accumulation of oil after passage through the bearing. In certain high speed applications where the bearing itself creates a pumping action, the flow of oil must be adjusted to assure passage through the bearing. This is extremely important where the flow of oil from the jet opposes the pumping action within the bearing.

Oil-Mist Lubrication

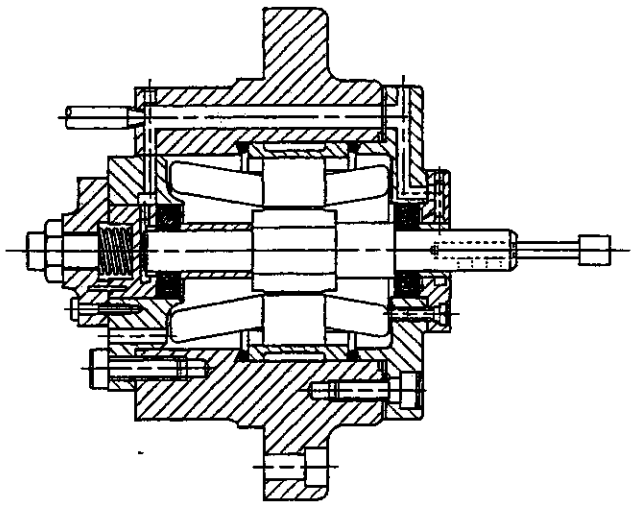
Oil-Mist Lubrication systems are used in high-speed, continuous operation applications. This system permits close control of the amount of lubricant reaching the bearing. The oil may be metered, atomized by compressed air and mixed with air, or it may be picked up from a reservoir using a venturi effect. In either case, the air is filtered and supplied under sufficient pressure to assure adequate lubrication of the bearings. Control of this type of lubricating system is accomplished by monitoring the operating temperatures of the bearings being lubricated.

The continuous passage of the pressurized air and oil through the labyrinth seals used in the system prevents the entrance of contaminants from the atmosphere into the system.

To insure "wetting" of the bearings and to prevent possible damage to the rolling elements and races, it is imperative that the oil-mist system be turned on for several minutes before the equipment is started. The importance of the "wetting" the bearings before starting cannot be overstressed and has particular significance for equipment that has been idle for extended periods of time.

The successful operation of this type of system is based upon the following factors:

- proper location of the lubricant entry ports in relation to the bearings being lubricated
- avoidance of excessive pressure drops across void systems within the system
- the proper air pressure and oil quantity ratios to suit the particular application
- the adequate exhaust of the air-oil mist after lubrication has been accomplished



Air-Oil-Mist

Lubrication Delivery Systems

Oil Quantity

Normally not more than a thin film of oil is required to lubricate a bearing. Experience has shown that when the oil quantity is increased to more than just enough to form a film on the bearings, fluid friction and friction torque will increase. In applications where generated heat is a critical factor, increased quantities of oil are used as a heat transfer medium.

Pre-Packed Bearings

Bearings which are utilized in moderately high speed applications are supplied with the proper amount and type of grease pre-packed in the bearing. Prelubricated Torrington Company bearings are prepacked with greases which have chemical and mechanical stability and that have demonstrated long-life characteristics in rotating bearings. Greases are filtered several times to remove all harmful material and accurately metered so that each bearing receives the proper amount of grease.

Prelubricated shielded and sealed bearings are extensively used with much success on applications where:

- Grease might be injurious to other parts of the mechanism
- Costs and space limitations preclude the use of a grease-filled housing
- Housings cannot be kept free of grit, water or other contaminants
- Relubrication is impossible or would be a hazard to satisfactory use

Housed Bearings

Applications utilizing grease lubrication should have a grease fitting and vent on opposite sides of the housing near the top. A drain plug should be located near the bottom of the housing to allow purging of the old grease from the bearing.

Relubricate at regular intervals to prevent damage to the bearing. Relubrication intervals are very difficult to determine. If plant practice or experience with other applications is not available, consult your lubricant supplier or a Torrington Company Sales Engineer located near you. (See listing on last page of this manual.)

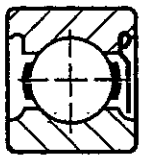
Grease Quantity

There is no set formula to determine the exact amount of grease necessary to lubricate a bearing because the quantity is directly dependent upon such factors as the application, the bearing and retainer design and the type of grease used. Certain bearings of the high precision types used in high speed applications may have as little as 20 percent of the bearing void filled with grease. Other bearings of the types used in low speed applications may have as much as 80 percent of the bearing void filled with grease. Aircraft bearings of the oscillating types may be 100 percent filled with grease. Even within the limits of a given application, the quantity of grease may be dependent upon the type of grease selected. For example, two different grades of grease, one a NLGI Grade #1 and the other a NLGI Grade #4, have proved to be suitable lubricants for machine tool spindle bearings. However, because the Grade #1 grease has a tendency to churn, a lesser amount must be used in a given bearing as compared to the amount of a Grade #4 grease is a channeling type which does not churn; consequently, the amount used in the bearing is less critical. Overgreasing may cause a rapid temperature rise in the bearing that can damage both the lubricant and the bearing.

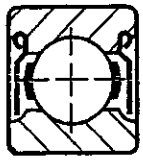
Shields

Shields, D-Type

Bearings are available with one shield (D-Type), or two shields (DD-Type). A shield on one side provides protection against the entrance of coarse dirt or chips and makes it possible to relubricate the bearing from the open side. Double shielded bearings are prelubricated with the correct amount of Torrington Company approved ball bearing grease and are designed for applications where relubrication is not required.



One Shield
D

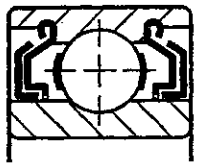


Two Shields
DD

Seals

Labyrinth or Mechani-Seals, L-Type

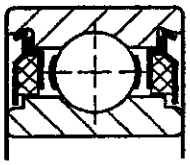
The Mechani-Seal was developed by the Torrington Company to provide a frictionless seal for effective grease retention and exclusion of foreign matter. Basically it consists of two "dished" steel plates. The inner member is fixed securely in the outer ring of the bearing and provides an ample grease chamber plus effective grease retention. The outer member is pressed on the outside diameter of the inner ring and rotates as a slinger to throw off contaminants. Close running clearance between the inner and outer members assures effective sealing under extremely severe operating conditions. This seal configuration is very effective at high speeds, because it is virtually frictionless and utilizes slinger action. Mechani-Seal bearings are very popular in high speed pneumatic tools, small electric motors, pumps, domestic appliances and similar high speed applications.



Mechani-Seals
LL

Felt Seals, T-Type

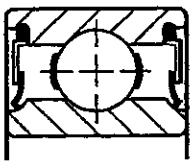
The felt seal consists of two metal plates fixed in the outer ring of the bearing which enclose a felt washer. This felt washer, which is saturated with oil before assembly in the bearing, contacts the ground outside of the inner ring to provide sealing with minimum friction drag.



Two Felt Seals
TT

Rubber Seals, P-Type

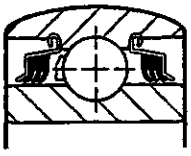
The P-Type design is a positive contact seal using a molded synthetic rubber. Firmly fixed to the outer ring, the seal flares outward and rides on the rabbet radius of the inner ring. The flareout of the seal against the inner rabbet radius assures constant positive contact to provide an effective barrier against the entrance of contamination or loss of lubricant.



Two Rubber Seals
PP

Tri-Ply Seals

Tri-Ply seals are designed for bearing applications involving exceptionally severe contamination or abrasive environment. Each Tri-Ply seal consists of a triple lip nitrile seal molded to a heavy metal shroud cap. All three seal lips have heavy flareout contact with the inner ring outside diameter and provide exceptionally effective protection against the loss of lubricant and the entrance of wet or abrasive contaminants. The shroud cap, which nests closely with the outside seal lip helps protect the rubber seal members from wrap and abrasion.



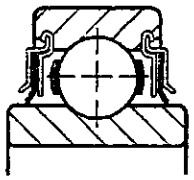
Tri-Ply Seal

Seals

Rubber Seals, R-Type

One of the most advanced sealing designs is the Fafnir R-Type rubber seal. This is a positive contact seal of three-piece construction utilizing a synthetic rubber seal retained by two steel caps. The seal flares outward and rides or wipes on the ground land of the inner ring. In this design, the rubber sealing element is completely protected by a loosely-fitting outer cap or shroud, which nests tightly against the seal member following its flared-out shape at the inner ring outside diameter. The innermost member is crimped into a groove in the outer ring and encapsulates the seal and outside shroud. Besides providing firm seal contact, the back-up plate of the seal assembly has a close clearance with the outside diameter of the inner ring thus preventing the seal from being pushed inward by external forces.

The "R" seal provides improved lubricant retention and greater protection against contaminants, the shroud design guards the rubber seal against abrasive damage by dirt and fiber wrap which may be prevalent in agriculture and textile applications.



R-Type Seal

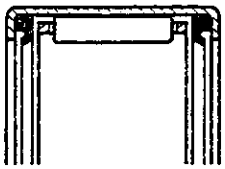
Sealed Bearings

Torrington drawn cup caged needle roller bearings are offered with integral seals. Lip contact seals limit the bearing operating temperature between –25°F and +225°F (–30°C and +110°C). The seal lip design achieves a light and constant contact with the shaft throughout the range of mounting bearing clearances thereby ensuring positive sealing and low frictional drag.

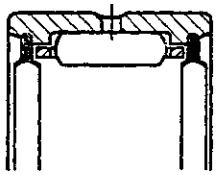
Sealed drawn cup bearings are intended to retain grease or non-pressurized oil within a bearing while also preventing contaminants entering the raceway area. These seals are not intended to withstand a pressure differential exceeding 2 psi (14kPa).

The standard lip contact seals are compatible with lubricating oils and petroleum based fuels, but they are adversely affected by certain fire-resistant hydraulic fluids and most common solvents.

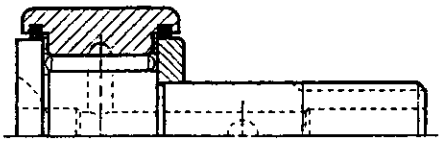
If the operating temperature must be outside of the above range or if the seals are exposed to unusual fluids please consult the Torrington Engineering Department.



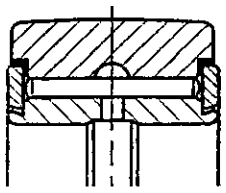
Drawn Cup
JTT



Heavy Duty
HJ-2RS



Track Roller/Cam Follower
CRS



Airframe
ATF

Compatibility of Seals and Lubricants

Buna N

Buna N is also known as Acrylonitrile which is often shortened to Nitrile. Buna N has greater resistance to petroleum oils, fuels and solvents at higher temperatures than Neoprene. Its compatibility with diester fluids and diester fluid greases made Buna N rubber an immediate success for bearing seals. The changeover from Neoprene to Buna N Ply-Seals began in early 1946. Because of its compatibility with fuels and lubricants, its excellent wear characteristics, easy moldability and low cost, Buna N has been and still is the most widely used seal material.

Buna N becomes stiff and brittle with extended exposure at 250°F so it is generally limited to service below that temperature.

Polyacrylic

Polyacrylic, also referred to as PA, is a copolymer of ethyl acrylate and chlorethylvinyl ether. Polyacrylic has excellent wear characteristics, petroleum oil and fuel compatibility and is capable of withstanding temperatures up to 320°F. Polyacrylic seals are not compatible with diester oils or greases.

Fluoro-Elastomer

The increased demand for equipment to operate at higher temperatures has led to the development of the Fluoro-Elastomer type seals. This group includes materials such as the fluorinated hydro-carbons which are copolymers of vinylidine fluoride and hexafluoropropylene (Viton) and also fluorinated silicone which, as the name implies, is a fluorine containing silicone elastomer. This family is noted for its exceptional heat resistance and compatibility with various fluids, especially petroleum products at higher temperatures than the other elastomers discussed.

This family of elastomers includes many trade names such as Viton, Teflon, Kel F, and Fluorothene. Although some of these are more correctly classified as plastics, they are used as sealing materials. Of this group only Viton and Teflon have been used in any quantity for bearing seals.

The cost of these materials is sufficiently higher than other elastomers so that very special applications are required to justify their use. Temperature range is –65°F to +450°F

Bonded Teflon Seals

Teflon or polytetrafluoroethylene (PTFE) is a relatively soft, white, waxy, inert non-toxic resin closely resembling a thermoplastic.

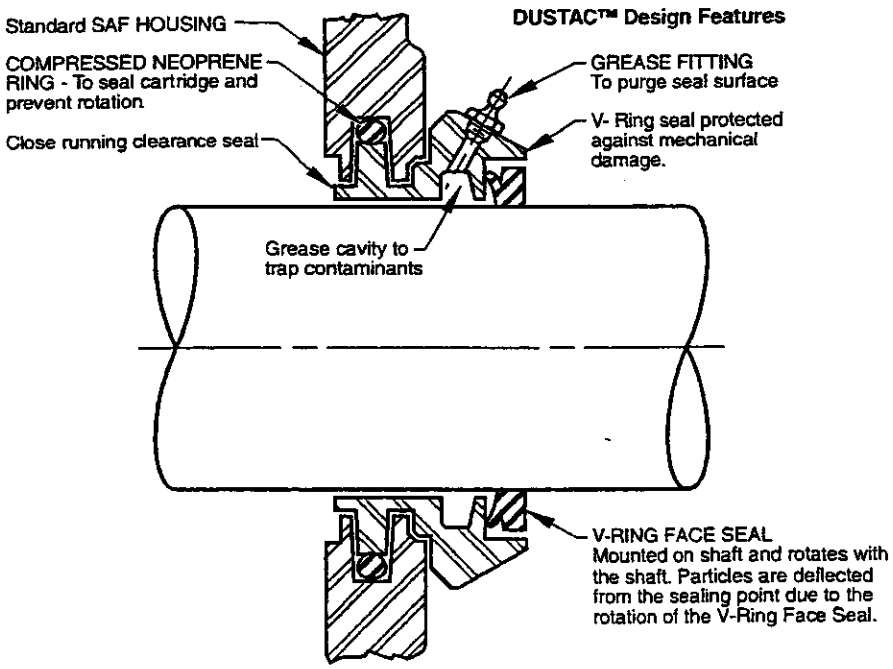
PTFE is used as bearing seal material because of its chemical inertness and wide thermal range (–125°F to +500°F). PTFE is a less effective seal material than elastomers primarily because it lacks wear or abrasion resistance.

Pillow Block Seal

The Dustac™ Shaft seal is for extremely contaminated environments, such as might be encountered by roller bearing pillow blocks located in taconite mines.

A Dustac seal shuts out residual and air-borne contaminants even better than the triple ring labyrinth shaft seal.

The Dustac shaft seal is a patented device utilizing a V-shaped nitrile ring which rotates with the shaft and applies pressure to the cartridge face to exclude contaminants. The geometry of this seal also enhances the excluding effect of centrifugal force.



Properties of Seal Materials

Property	Type of Material Base				
	Nitrile (Buna N)	Poly-acrylic	Viton	Teflon	Neoprene
Tear Resistance	Fair	Good	Good	Good	Good
Abrasion Resistance	Good	Good	Good	Poor	Excellent
Aging					
Sunlight	Poor	Good	Excellent	Excellent	Excellent
Oxidation	Fair	Excellent	Excellent	Excellent	Good
Heat (max. temp.)	250°F	350°F	400°F	500°F	225°F
Static (shelf)	Good	Good	Good	Excellent	Good
Flex Cracking Resistance	Good	Good	Good	Good	Excellent
Compression Set Resistance	Good	Good	Excellent	Poor	Excellent
Lubricant Resistance					
Low Aniline Mineral Oil	Excellent	Excellent	Excellent	Excellent	Fair
High Aniline Mineral Oil	Excellent	Excellent	Excellent	Excellent	Good
Silicones	Fair	Good	Excellent	Excellent	Fair
Diesters	Fair	Poor	Good	Excellent	Poor
Phosphate Esters	Poor	Poor	Good	Excellent	Poor
Silicate Esters	Fair	Poor	Good	Excellent	Poor
Solvent Resistance					
Aliphatic Hydrocarbon	Good	Excellent	Excellent	Excellent	Fair
Aromatic Hydrocarbon	Fair	Poor	Excellent	Excellent	Poor
Halogenated Solvent	Poor	Poor	Good	Excellent	Poor
Keytones	Poor	Poor	Poor	Excellent	Poor
Gasoline Resistance					
Aromatic	Good	Good	Excellent	Excellent	Poor
Non-Aromatic	Excellent	Good	Excellent	Excellent	Good
Acid Resistance					
Dilute (under 10%)	Good	Poor	Good	Excellent	Fair
Concentrated	Poor	Poor	Good	Excellent	Poor
Alkali Resistance					
Dilute (under 10%)	Good	Poor	Good	Excellent	Good
Concentrated	Fair	Poor	Poor	Excellent	Poor
Low Temperature Flexibility (max.)	–65°F	–55°F	–65°F	–125°F	–65°F
Resistance to Gas Permeation	Fair	Good	Good	Excellent	Good
Water Resistance	Good	Poor	Good	Excellent	Fair
Resilience	Fair	Fair	Good	Fair	Good

Lubricant Selection

The successful application of lubricating fluids in bearings depends on the physical and chemical properties of the lubricant as they pertain to the bearing, its application, installation and general environmental factors.

Viscosity

Generally, the most important single property of a lubricating fluid is its viscosity. Viscosity is the measure of the relative resistance of a fluid to flow.

The measurement of viscosity can be made by any of a number of different instruments called viscosimeters. A common unit of measure is the Saybolt Universal Second (SUS). This is the time, in seconds, required for 60 c.c. of a fluid to flow through a standardized orifice under a standard head, at a given temperature. The common temperatures for reporting viscosity are 100°F to 210°F. The higher the viscosity number, the greater the resistance to flow.

Experience indicates that a lubricating fluid with a viscosity of at least 100 SUS at the operating temperature of the application will be adequate for normal lubrication of bearings.

Viscosity Index

The ideal oil (as far as viscosity is concerned) would be the same viscosity at all temperatures. All oils become less viscous (thin-out) when heated and more viscous (thicken) when cooled.

However, all oils do not vary in viscosity to the same extent. Some thicken more rapidly or thin more rapidly than others.

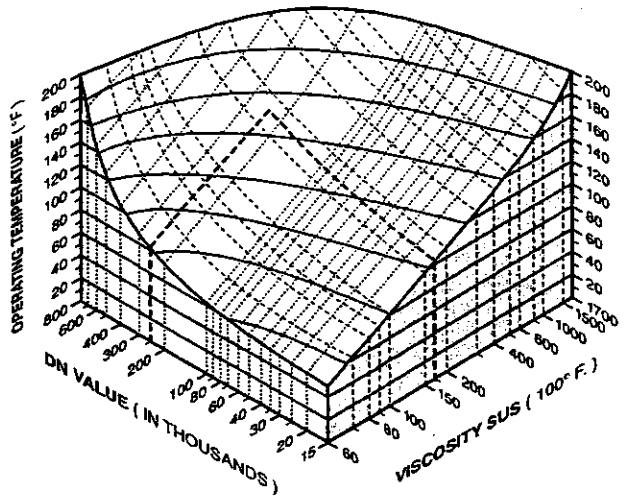
The term "viscosity index" or VI is used to rate oils according to their temperature-viscosity behavior.

Oils with the highest viscosity index are more resistant to changes in viscosity with changes in temperature than lower viscosity index oils. Obviously high viscosity index lubricants are most suitable for bearing applications experiencing wide temperature variations.

NLGI Grease Grades	Penetration Number
0	355-385
1	310-340
2	265-295
3	220-250
4	175-205
5	130-160
6	85-115

Pour Point

The pour point is the lowest temperature at which a fluid will flow or can be poured. It is important in applications exposed to low temperatures that the lubricating fluid selected has a pour point lower than the minimum ambient temperature.



The Oil Viscosity Selection Chart may be used to approximate the proper oil viscosity for all bearing applications.

To use the chart proceed as follows:

1. Determine the DN value – Multiply the bore diameter of the bearing, measured in millimeters, by the speed of the shaft, measured in revolutions per minute.
2. Select the proper temperature – The operating temperature of the bearing may run several degrees higher than the ambient temperature depending upon the application. The temperature scale of this chart reflects the operating temperature of the bearing.
3. Enter the DN value in the DN scale on the chart.
4. Follow or parallel the "DOTTED" line to the point where it intersects the selected "SOLID" temperature line.
5. At this point follow or parallel the nearest "DASHED" line downward and to the right to the viscosity scale.
6. Read off the approximate viscosity value – expressed in Saybolt Universal Seconds at 100°F

Lubricant Selection

Oxidation Resistance

The most important property of an oil, from a quality standpoint, is its chemical or oxidation stability.

All lubricating fluids are subject to a continual chemical combination with oxygen to form a multitude of compounds. The initial reaction generally results in the formation of unstable hydroperoxides which react to form such compounds as alcohols, aldehydes, keytones, acids and oxyacids. Subsequently, through polymerization and condensation reactions, oil in soluble gum, sludge and varnish will be formed. This can reduce bearing clearances, plug lines, increase operating temperature and further accelerate lubricant deterioration which will end with bearing failure.

Lubricating fluids vary in ability to resist oxidation effects. Oxidation stability is dependent upon the fluid type, refining methods and whether or not, oxidation inhibitors are present. In a circulating or splash system the oxidation rate is not only a function of the oil, but also of the operating conditions. Temperature, contaminants, water, metal surfaces and agitation all favor oxidation and all are present in lubrication systems.

Temperature Impact on Lubricant

Temperature is primarily an accelerator of oil oxidation. The rate of any chemical reaction including the oxidation of hydrocarbons will double for every 18°F increase in temperature. It is estimated that the life of an oil be decreased 50% for every 18°F temperature rise above 140°F and increased 50% for reductions in temperature of 18° below 140°F.

Metal Effect on Lubricant

Metal, particularly copper, and copper containing alloys are known catalysts for oil oxidation and their catalytic effect is greatly enhanced by water or water containing contaminants.

Additives to Lubricants

Present day lubricating fluids are formulated with chemical additives to increase the viscosity index, increase oxidation resistance, provide detergent properties, resist corrosion, provide extreme pressure properties and lower the pour point.

Grease Selection

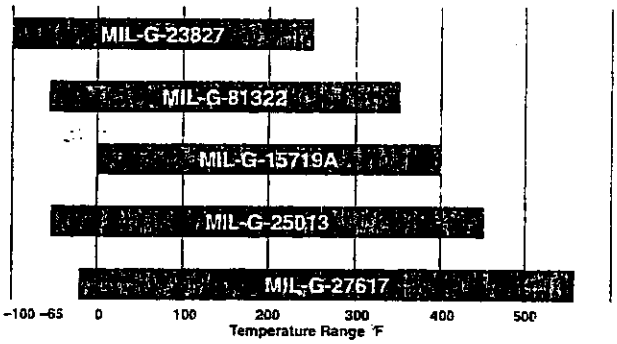
Sodium, lithium and polyurea base greases are normally preferred for general purpose bearing lubrication. Lime base greases are advantageous for high moisture applications but should not be operated above 150°F. Lithium complex greases have good water resistant characteristics and may be operated through the same temperature range as sodium base greases. Polyurea greases have excellent water resistance and can be used at higher temperatures.

The grease must be carefully selected with regard to its consistency at operating temperature. It should not exhibit thickening, separation of oil, acid formation or hardening to any marked degree. It should be smooth, non-fibrous and entirely free from chemically active ingredients. Its melting point should be considerably higher than the operating temperature of the bearing.

Frictional torque is influenced by the quantity and quality of lubricant present. Excessive quantities of grease causes churning. This results in excessive temperatures, separation of the grease components and break-down in lubricating valves. On normal speed applications the housings should be kept approximately one-third to one-half full.

Only on low speed applications may the housing be entirely filled with grease. This method of lubrication is a safeguard against the entry of foreign matter, where sealing provisions are inadequate for exclusion of contaminants or moisture.

During periods of non-operation, it is often wise to completely fill the housings with grease to protect the bearings surfaces. Prior to subsequent operation, the excess grease should be removed and the proper level restored.



Lubricating Grease Temperature Ranges

Thickener	Typical Dropping PT F	Typical Dropping PT C	Usable* Temp. F	Usable* Temp. C	Typical Water Resistance
Sodium Soap	500+	260+	250	121	Poor
Lithium Soap	360	193	220	104	Good
Polyurea	460	238	300	149	Excellent
Lithium Complex Soap	500+	260+	250	121	Good

* Continuous operation with no relubrication. Depending on the formulation, the service limits may vary. The usable limit can be extended significantly with relubrication.

Note: The properties of a grease may vary considerably depending on the particular oil, thickener and additives used in the formulation.

By expanding the formula:

Fluids + Thickening Agents + Special Ingredients = Lubricating Grease

it is possible to show the combinations possible for formulating greases to meet a wide range of operating conditions.

Fluids +	Thickening Agents +	Special Ingredients =	Lubricating Grease
Mineral Oils	Soaps	Oxidation Inhibitors	
Esters	Lithium, Sodium	Rust Inhibitors	
Organic Esters	Barium, Calcium	VI Improver	
Glycols	Strontium	Tackiness	
Silicones	Non-Soap (Inorganic)	Perfumes	
	Microgel (Clay)	Dyes	
	Carbon Black	Metal Deactivator	
	Silica-gel		
	Non-Soap (Organic)		
	Urea compounds		
	Terepthlamate		
	Organic Dyes		

Lubrication Terms

Additive	A chemical compound or compounds added to a lubricant for the purpose of imparting new properties or of enhancing those properties which the lubricant already has.
Channeling	The tendency of grease to form an unobstructed path or channel following the movement of the rolling elements in a bearing.
CVD – Chemical Vapor Deposition	A method of thin coating (3-5 microns) metal parts with metallic alloys through a gaseous medium. The coating adds to the hardness while reducing wear and increasing lubricity of base metal.
EP (Extreme Pressure) Lubricants	Lubricants which impart to rubbing surfaces the ability of carrying appreciably greater loads than would be possible with ordinary lubricants without excessive wear or damage.
Fiber Grease	Grease having a distinctly fibrous structure which is noticeable when a sample of the grease is pulled apart. Greases having this fibrous structure tend to resist being thrown off gears and out of bearings.
Flash Point (Cleveland Open Cup)	The temperature to which a combustible liquid must be heated to give off sufficient vapor to form momentarily a flammable mixture with air when a small flame is applied under conditions. (ASTM Designation D 92-57).
Grease	A lubricant composed of an oil or oils thickened with a soap, soaps or other thickener to a semi-solid or solid consistency.
Lime Base Grease	A grease prepared from a lubricating oil and a calcium soap.
Lithium Base Grease	A grease prepared from a lubricating oil and a lithium soap.
Lubricant	Any substance interposed between two surfaces in relative motion for the purpose of reducing the friction and/or wear between them.
NLGI	National Lubricating Grease Institute
Oil	A viscous unctuous liquid of vegetable, animal, mineral, or synthetic origin.
Penetration or Penetration Number	The depth, in tenths of a millimeter, that a standard cone penetrates a semi-solid sample under specified conditions (ASTM Designation D 217-60T.) (See Worked Penetration.)
Polyurea Base Grease	A grease prepared from a lubricating oil and a polyurea thickener.
Pour Point	The pour point is the lowest temperature at which a fluid will flow or can be poured.
PVD – Physical Vapor Deposition	A thin metal-plasma coating (2-5 microns) that is applied in a low heat temperature environment (350°F to 600°F) which can be applied to standard metal surfaces to help resist wear while increasing lubricity and hardness.
SAE Numbers – SAE Viscosity Classification.	Numbers applied to crankcase, transmission and rear axle lubricants to indicate their viscosity range.

Lubrication Terms

Saybolt Universal Viscosity , SUV (or Saybolt Universal Seconds, SUS)	The time in seconds required for 60 cubic centimeters of a fluid to flow through the orifice of the Standard Saybolt Universal Viscometer at a given temperature under specified conditions. (ASTM Designation D 88-56.)
Soda-Base Grease	A grease prepared from lubricating oil and sodium soap.
Thixotrophy	The characteristic of grease to soften under shear and return to original state when shearing force is removed.
Viscosity	That property of a fluid, semi-fluid or semi-solid substance which causes it to resist flow. It is defined as the shear stress on a fluid element divided by the rate of shear. The standard unit of viscosity in the English system is the dyne which has units of 16 sec/in^2. The standard unit of viscosity in the CGS. system is the poise which has the units of dyne sec/cm. 1 dyne = 6.895 x 10^4 poises.
Viscosity Index (VI)	A commonly used measure of a fluid's change of viscosity with temperature. The higher the viscosity index the smaller the relative change in viscosity temperature.
"Wetting" Bearings	The pre-lubrication of bearing surfaces prior to starting a machine that has been idle for an extended period of time. Prevention of possible brinel damage to bearing components upon sudden dry start of a machine.
Worked Penetration	The penetration of a sample of lubricating grease immediately after it has been brought to 77° F and then subjected to 60 strokes in a standard grease worker. (ASTM Designation D217-60T).

Newton's Law

$$\text{Force} = \text{dynamic viscosity} \times \text{area} \times \frac{\text{velocity}}{\text{film thickness}}$$

$$F = \eta \bullet A \bullet \frac{V}{h}$$

F = Force, Newton (N)

η = dynamic viscosity

A = area, square meters (m^2)

V = velocity, meters per second ($m \bullet s^{-1}$)

h = film thickness, meter (m)

Dynamic Viscosity

$$\eta = \frac{F}{A} \bullet \frac{h}{V}$$

$\frac{F}{A}$ = consists of units of pressure $\frac{N}{m^2}$ or pascal (Pa) -SI System.

$\frac{h}{V}$ = consists of units of time $\frac{m}{m \bullet s^{-1}}$ or seconds (s) -SI System.

therefore:

dynamic viscosity, η = pascal seconds, Pa · s.

or

cgs system unit of dynamic viscosity - poise (P)

for convenience both systems can be related as follows:

1 millipacal second = 1 centipoise

or

1 mPa • s = 1 cP

Kinematic Viscosity

$$\text{Kinematic viscosity} = \frac{\text{dynamic viscosity}}{\text{density}}$$

or

$$v = \frac{\eta}{p}$$

v = kinematic viscosity

η = dynamic viscosity, $Pa \cdot s = \frac{kg}{m \cdot s}$ (in base units)

p = density, $\frac{kg}{m^3}$

Conversion of Pa • s to $\frac{kg}{m \cdot s}$

$$Pa = \frac{N}{m^2} \quad \text{by definition}$$

$$N = \frac{kg \cdot m}{s^2} \quad \text{by definition}$$

therefore:

$$Pa \cdot s = \frac{N \cdot s}{m^2} = \frac{kg \cdot m \cdot s}{m^2 \cdot s^2} = \frac{kg}{m \cdot s}$$

therefore:

$$v = \frac{\eta}{p} = \frac{kg}{m \cdot s} \cdot \frac{m^3}{kg} = \frac{m^2}{s} \quad \text{(square meters per second)}$$

In the cgs system, v = stoke (st)

For most common uses units are related in lower common denominators:

1 millimeter squared per second = 1 centistoke

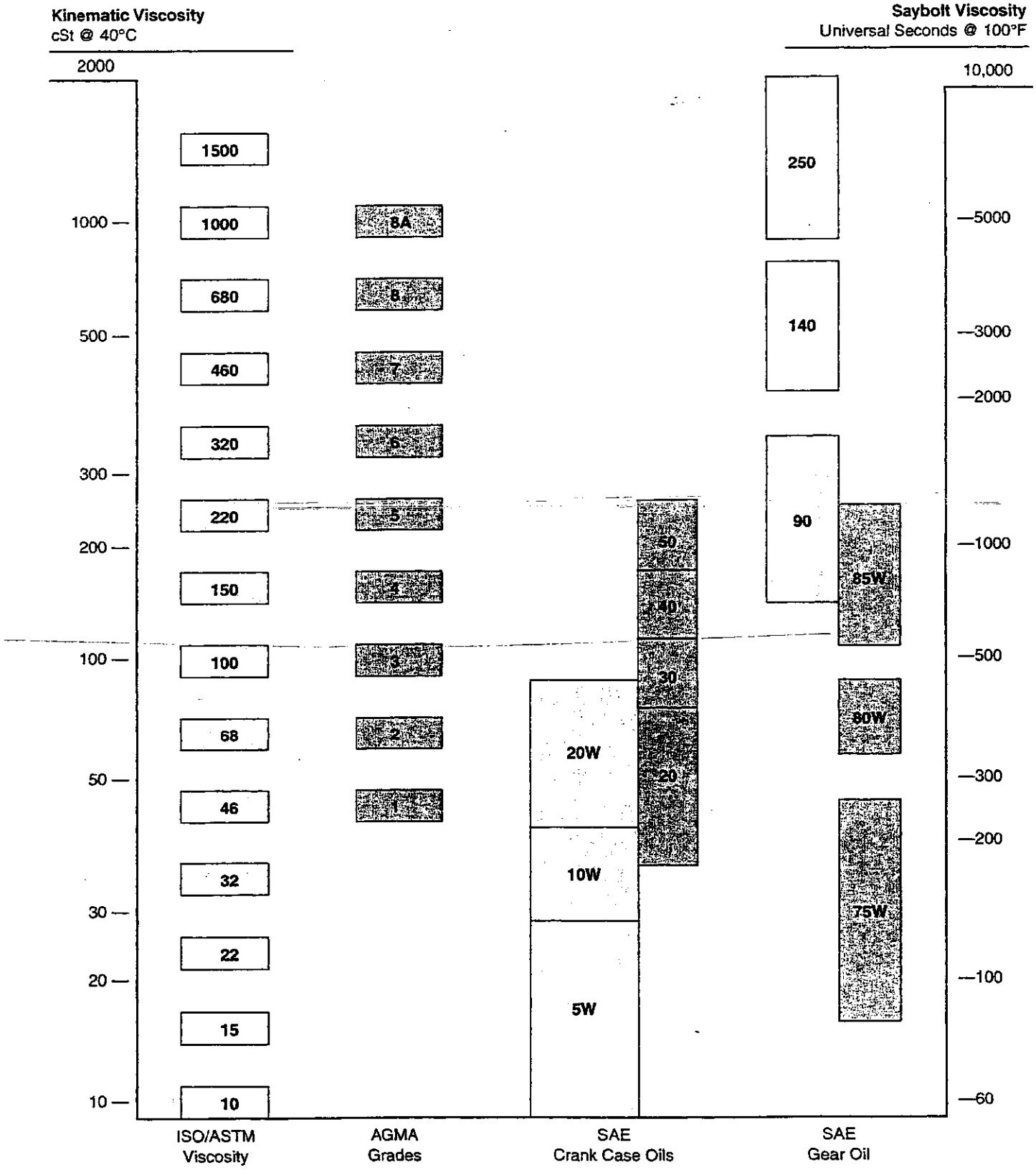
$$1 \ \frac{mm^2}{s} = 1 \text{ cSt}$$

Examples of Viscosity

Examples of the viscosities in the SI units of lubricating mineral oils are shown in the table.

Oil	Viscosity			
	Dynamic m Pa · s		Kinematic $mm^2 \cdot s^{-1}$	
	40°C	100°C	40°C	100°C
Light	7.9	2.1	9.2	2.5
Heavy	1065	50.8	1162	55.4

Viscosity Grade Comparisons



Conversion Tables

TO CONVERT FROM	TO		MULTIPLY BY
Acceleration			
foot/second^2	meter/second^2	m/s^2	0.3048
inch/second^2	meter/second^2	m/s^2	0.0254
Area			
foot^2	meter^2	m^2	0.09290304
inch^2	meter^2	m^2	0.00064516
inch^2	millimeter^2	mm^2	645.16
yard^2	meter^2	m^2	0.836127
mile^2 (U.S. statute)	meter^2	m^2	2589988
Bending Moment or Torque			
dyne-centimeter	newton-meter	N • m	0.0000001
kilogram-force-meter	newton-meter	N • m	9.806650
pound-force-inch	newton-meter	N • m	0.1129848
pound-force-foot	newton-meter	N • m	1.355818
Energy			
B.T.U. (International Table)	joule	J	1055.056
foot-pound-force	joule	J	1.355818
kilowatt-hour	megajoule	MJ	3.6
Force			
kilogram-force	newton	N	9.806650
kilopond-force	newton	N	9.806650
pound-force (lbf avoirdupois)	newton	N	4.448222
Length			
fathom	meter	m	1.8288
foot	meter	m	0.3048
inch	millimeter	mm	25.4
microinch	micrometer	um	0.0254
micron (µm)	millimeter	mm	0.0010
mile (U.S. statute)	meter	m	1609.344
yard	meter	m	0.9144
nautical mile (UK)	meter	m	1853.18
Mass			
kilogram-force-second^2/meter (mass)	kilogram	kg	9.806650
kilogram-mass	kilogram	kg	1.0
pound-mass (lbm avoirdupois)	kilogram	kg	0.4535924
ton (long, 2240 lbm)	kilogram	kg	1016.047
ton (short, 2000 lbm)	kilogram	kg	907.1847
tonne	kilogram	kg	1000.000
Power			
BTU (International Table)/hour	watt	W	0.293071
BTU (International Table)/minute	watt	W	17.58426
horsepower (550 ft lbf/s)	kilowatt	kW	0.745700
BTU (thermochemical)/minute	watt	W	17.57250
Pressure or Stress (Force/Area)			
newton/meter^2	pascal	Pa	1.0000
kilogram-force/centimeter^2	pascal	Pa	98066.50
kilogram-force/meter^2	pascal	Pa	9.806650
kilogram-force/millimeter^2	pascal	Pa	9806650
pound-force/foot^2	pascal	Pa	47.88026
pound-force/inch^2 (psi)	megapascal	MPa	0.006894757
Temperature			
degree Celsius	degree Kelvin	°K	$t_K = t_C + 273.15$
degree Fahrenheit	degree Kelvin	°K	$k = \frac{5}{9}(t_f + 459.67)$
degree Fahrenheit	degree Celsius	°C	$t_C = \frac{5}{9}(t_f - 32)$
Velocity			
foot/minute	meter/second	m/s	0.00508
foot/second	meter/second	m/s	0.3048
inch/second	meter/second	m/s	0.0254
kilometer/hour	meter/second	m/s	0.27778
mile/hour (U.S. statute)	meter/second	m/s	0.44704
mile/hour (U.S. statute)	kilometer/hour	km/h	1.609344
Volume			
foot^3	meter^3	m^3	0.02831685
gallon (U.S. liquid)	liter	l	3.785412
liter	meter^3	m^3	0.001
inch^3	meter^3	m^3	0.00001638706
inch^3	centimeter^3	cm^3	16.38706
inch^3	millimeter^3	mm^3	16387.06
ounce (U.S. fluid)	centimeter^3	cm^3	29.57353
yard^3	meter^3	m^3	0.7645549

VISCOSITY CONVERSION TABLE

SUS Saybolt (sec.)	R' Redwood (sec.)	E Engler (deg.)	cSt Centistokes
35	32.2	1.18	2.7
40	36.2	1.32	4.3
45	40.6	1.46	5.9
50	44.9	1.60	7.4
55	49.1	1.75	8.9
60	53.5	1.88	10.4
65	57.9	2.02	11.8
70	62.3	2.15	13.1
75	67.6	2.31	14.5
80	71.0	2.42	15.8
85	75.1	2.55	17.0
90	79.6	2.68	18.2
95	84.2	2.81	19.4
100	88.4	2.95	20.6
110	97.1	3.21	23.0
120	105.9	3.49	25.0
130	114.8	3.77	27.5
140	123.6	4.04	29.8
150	132.4	4.32	32.1
160	141.1	4.59	34.3
170	150.0	4.88	36.5
180	158.8	5.15	38.8
190	167.5	5.44	41.0
200	176.4	5.72	43.2
220	194.0	6.28	47.5
240	212	6.85	51.9
260	229	7.38	56.5
280	247	7.95	60.5
300	265	8.51	64.9
325	287	9.24	70.3
350	309	9.95	75.8
375	331	10.7	81.2
400	353	11.4	86.6
425	375	12.1	92.0
450	397	12.8	97.4
475	419	13.5	103
500	441	14.2	108
550	485	15.6	119
600	529	17.0	130
650	573	18.5	141
700	617	19.9	152
750	661	21.3	163
800	705	22.7	173
850	749	24.2	184
900	793	25.6	195
950	837	27.0	206
1000	882	28.4	217
1200	1058	34.1	260
1400	1234	39.8	302
1600	1411	45.5	347
1800	1587	51	390
2000	1763	57	433
2500	2204	71	542
3000	2646	85	650
3500	3087	99	758
4000	3526	114	867
4500	3967	128	974
5000	4408	142	1082
5500	4849	156	1150
6000	5290	170	1300
6500	5730	185	1400
7000	6171	199	1510
7500	6612	213	1630
8000	7053	227	1740
8500	7494	242	1850
9000	7934	256	1960
9500	8375	270	2070
10000	8816	284	2200

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THE TORRINGTON COMPANY

BEARING FAILURE PREVENTION GUIDE

Introduction

Identification, Cause and Preventive Measures

Torrington Catalogs, Sales Offices, Product

Life Expectancy

Bearing life expectancy based on material fatigue can be calculated if the operating loads and speeds are known. These calculations must assume that the bearing is correctly mounted, lubricated and otherwise properly handled. It cannot take into consideration the effect of adverse operating conditions.

Bearing failures not attributed to material fatigue are generally classified as premature. The majority of premature bearing failures are caused by:

- Faulty mounting
- Improper lubrication
- Contamination
- Improper handling
- Improper maintenance

Great savings in time, effort and expense can be effected if the bearing user can establish the reason for premature failure and undertake corrective action to prevent further failure.

With this in mind, The Torrington Company has published this guide to help maintenance and quality control personnel identify and correct some of the more commonly encountered failures. It is beyond the scope of this guide to discuss the complexities of metallurgical failure. There always will be situations that are ideally suited for our highly trained Field Service Engineers, Sales Engineers and Corporate Analytical Engineering Teams.

But the mechanical diagnosis of failure can be outlined and this publication should serve as a guide for the determination and correction of such failures.

There are many reasons for bearing failure, and usually each failure is due to a combination of causes, not just a single cause. In the following pages the major categories of failure will be covered, photographic examples will be shown, similar names for each cause will be listed, and identification, cause and preventive measures for each category will be discussed. Diagrams and line drawings are also included to support the written material.

It is The Torrington Company's hope that this guide will aid you in cutting needless expenditures of time and funds in the maintenance of machinery's most important single component – the bearing.

Safety Recommendations

- Store product in a dry and clean area.
- Do no open package until ready to use.
- Prior to installation, consult Torrington Company recommendations. Proper installation and maintenance must be adhered to for ultimate performance.
- Failure to adhere to recommendations may result in premature product failure, and/or in extreme cases, personal injury.

Service Damage Terminology

Abrasive Wear

Surface wear resulting from the lapping action of abrasive contaminants. The affected areas usually appear frosty gray; however, they may be highly polished if the abrasive particles are extremely small.

Brinelling

Permanent deformation of the bearing surfaces where the rollers (or balls) contact the races. Brinelling results from excessive load or impact on stationary bearings. It is a form of mechanical damage in which metal is displaced or upset without attrition.

Corrosion

Rust (corrosion) is the chemical attack of the bearing metal, almost always consisting of, or accompanied by, oxidation. It may cover a large or a small area, or be limited to a well-defined line, such as the line of contact between a roller and a race in a stationary bearing.

False Brinelling

False Brinelling of needle roller bearings is actually a fretting corrosion of their raceway surface. Although its appearance is similar to that of Brinelling, False Brinelling is characterized by attrition of the steel, and the load on the bearing is less than that required to produce the resulting impression. It is the result of a combination of mechanical and chemical action that is not completely understood, and occurs when a small relative motion or vibration is accompanied by some loading, in the presence of oxygen.

Flaking

See Spalling.

Fretting, Fretting Corrosion, Friction Oxidation

These terms all describe a type of service damage that occurs under the same conditions as False Brinelling. Red and black oxides of iron are usually evident. In bearings, fretting usually takes place at the I.D. or O.D., but it may occur anywhere there is a close fit with some movement.

Galling

See Scoring.

Heat Checks

Surface cracks resulting from heat generated by sliding contact with another part. Heat checks are oriented normal to the direction of motion. Depending on the stresses present in the component, the cracks may remain small or become nuclei for a complete fracture.

Indentations

The surface depressions caused by debris or foreign material.

Pickup

The welding and transfer of metal between rollers and raceways during bearing operation. Pickup results from inadequate lubrication.

Pitting

Small, roughly circular holes or craters resulting from corrosion, mechanical damage, or the passage of an electric current. Because these three types of pits have distinctly different causes, the word *pitting* should always be qualified.

Scoring, Scuffing, Seizing, Smearing

All terms referring to transfer of metal from one component of a bearing to another under sliding contact. This process, which is also called galling, is caused by lack of adequate lubrication under extreme unit pressure.

Spalling

A breaking away of metal from the raceway or rolling element in flakes or scale-like particles. Also called flaking.

Bearing Failure Terminology (Cross References)

Fatigue

- Flaking
- Spalling
- Pitting
- Peeling
- Surface Erosion
- Microcracking
- Inclusion Origin Fatigue
- Subsurface Fatigue
- Macro Spalling
- Rolling Contact Fatigue

Brinelling

- Denting
- Indentation
- Impact Denting
- True Brinelling

Misalignment

- Skewed
- Cocked
- Warped
- Tilted
- Shaft-deflection
- Non-Tangent
- Non-Square
- Out-of-Round
- Shaft-Slope

Electric Arcing

- Fluting
- Corduroying
- Electro-etching
- Electric Discharge Damage
- Electric Erosion
- Electric Arc Pitting
- Corrugation
- Electric Pitting

Contamination–Debris

- Pitting
- Bruising
- Denting
- Scoring
- Glazing
- Indentation
- Debris Damage
- Roughening
- Scratching
- Rollover of Debris
- Abrasion Failure

Thrust Failure

- Counterbore Failure
- Axial Failure

Lubrication Failure

General

- Peeling
- Smearing
- Fine Grain Spalling
- Microadhesion
- Surface Erosion
- Seizure
- Pitting

Inadequate Viscosity

- Glazing
- Fine Grain Spalling
- Surface Erosion
- Surface Peeling
- Point Surface Origin (PSO) Fatigue
- Frosting

Incorrect Amount of Lubrication

- Burn-Up
- Churning Failure
- Heat Failure
- Coking

False Brinelling

- Fretting Wear
- Friction Oxidation
- Vibration Damage
- Fretting Corrosion
- Vibration Brinnel
- Internal Fretting
- Fluting

Contamination–Moisture/Water

- Corrosion
- Water Etch
- Staining
- Black Acid Etch
- Rusting/Oxidation

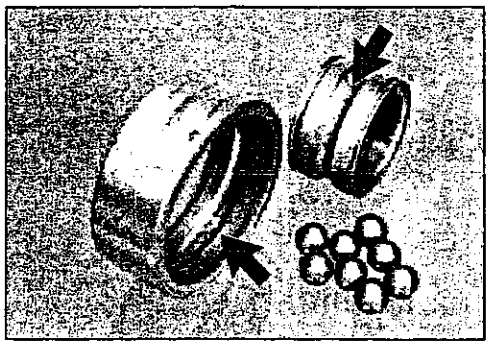
Identification

Flaking or Spalling of the normally smooth raceway

Spalling is caused by a granular weakening of the bearing steel. The failure begins as a small fracture of the steel's internal structure. This fracture progresses (propagates) to the surface of the bearing where particles of metal flake away.

Noisy Running of the Bearing

Because of the rough surface and the loosened metal chips there will be an increase in bearing vibration and noise.

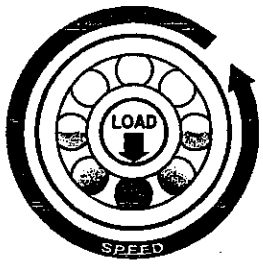


Flaking or Spalling of Raceway

Cause

Normal Duty

A bearing has a life expectancy which depends upon load and speed imposed on the bearing. Calculations, based upon laboratory testing and field experience, have been established to determine, as accurately as possible, the life span of a group of bearings of a given size. Fatigue failure is the result of a bearing living out its normal life span. The flaking of the races is the result of the combined effect of load and speed. In any rotating or oscillating bearing there is a constant flexing or deflection of the ring and the rolling element material under load. Speed determines how often the deflection occurs while load determines the actual amount of stress under which the bearing steel operates. Assuming good machine design, satisfactory lubrication and sound maintenance practices, it is load and speed that will, over a period of time, cause eventual failure.

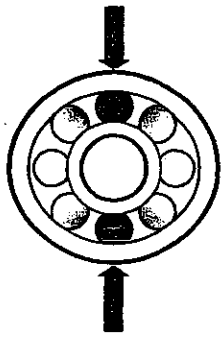


Normal Bearing Operation

Overload on the bearing

Premature failure of the bearings may result from the bearing being either radially or axially loaded beyond its normal capacity. Excessive operating load is not, however, the only reason for bearing overload. Overload may also occur due to abusive operating conditions. For example:

- If a bearing with insufficient internal clearance (space between rolling elements and races) is mounted on a shaft with an excessively heavy press fit, the bearing will operate with increased friction and torque — because with the outer ring held firmly, the inner ring has been expanded, "pinching" the rolling elements between the two rings.
- If the bearing housing is out-of-round, the outer ring will tend to conform to the shape of the housing. This will exert a localized pressure on the rolling element contact area, in addition to the normal pressure imposed by the operating work load.
- When a roller bearing is end loaded (due to misalignment, shaft slope, etc.) the load on the bearing is no longer uniformly distributed over the bearing's full width. This overloads a portion of the races and rolling elements resulting in localized fatigue.



Outer Ring Squeezed by Housing

Non-Bearing Quality Steel

Roller bearings often operate on raceways supplied by the customer. Occasionally a raceway is made from a non-bearing quality steel. The raceway will then fatigue spall sooner than another raceway made from a "cleaner" bearing quality steel.

Preventive Measures

Normal Duty

The bearing has lasted its normal life expectancy; simply replace the bearing.

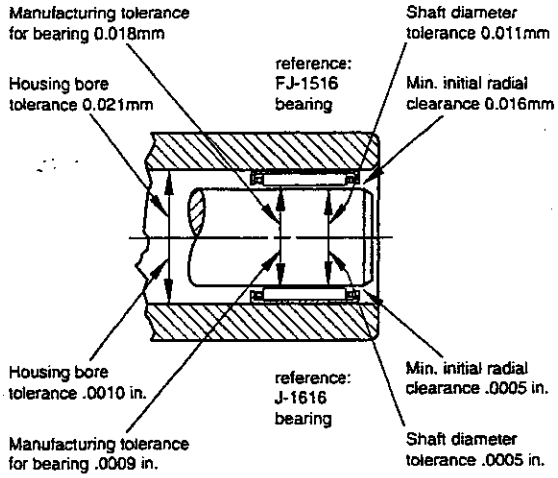
Overload Failure

Where overload is the cause of a premature fatigue failure, several alternatives are open:

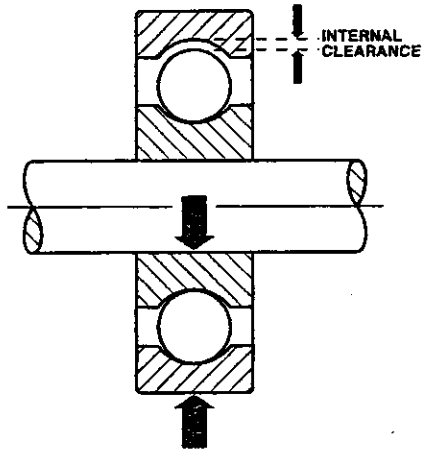
- Redesign to permit incorporating a bearing with greater capacity. Many types of standard Torrington bearings such as needle roller bearings, cylindrical roller bearings, spherical bearings, extra-light, light, medium and double row series are available to fit the same shaft size. The heavier series have thicker ring sections and larger rolling elements for greater capacity. Also available for higher radial capacity is the maximum capacity type of ball-bearing, cylindrical roller bearing and spherical roller bearing. These bearings have certain similar bore dimensions, but all can accept more radial load — either because there are more rolling elements, larger roller elements or larger envelope dimensions. Certain restrictions will apply. The Torrington Company has resources available to help in any design situation.
- The load may be decreased to prolong the life of the bearing.
- Housings should be gaged for out-of-roundness and machined for proper symmetry and size. This insures that the outer ring will not be "pinched" or "squeezed", resulting in an overload situation.
- If the failure is caused by an overload imposed by inner ring expansion, either the shaft fit may be made looser by regrinding it to the proper size or, in the event of thermal expansion, a bearing with a looser internal fit (more clearance between rolling elements and rings) may be recommended. Recommendations for shaft and housing fits are shown in the appropriate Torrington Company product catalogs.
- If the failure is caused by end loading, the cause of the end loading must be corrected. Recommendations on acceptable misalignment (shaft slope, etc.) is shown in the appropriate product catalog or can be easily supplied by a Torrington Company sales engineer.

Non-Bearing Quality Steel

Use steel that is listed as bearing quality for this particular application. Particularly avoid leaded and high sulfur content steels.



Manufacturing Tolerances and Built-In Clearances



Bearing with a Looser Internal Fit May Be Recommended

Identification

Debris - Scoring, Pitting, Scratching

A failure caused by the entrance of foreign objects into the bearing may show a number of identifying marks. Where large particles of dirt or dust are present there will be scratches and pits around the periphery of the race with corresponding scoring of the rolling elements.

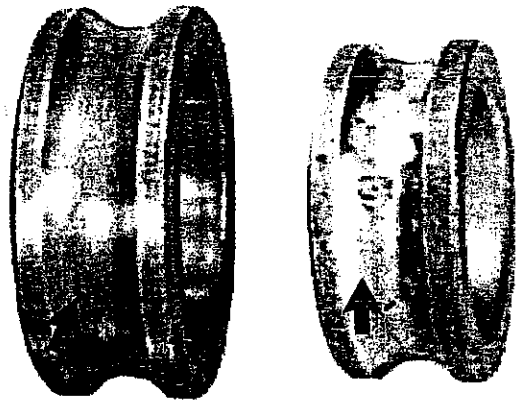
Where the contamination is in the form of very fine abrasives such as glass powder, graphite or dust impregnated lubricants, the impurities will act as a lapping agent, altering the appearance of rolling elements and raceway. This type of failure may be characterized by intermittent noise in the bearing. The actual presence of dirt in the bearing is the indication of this type of failure.

Rust

Where rust forms on the O.D. of the outer ring, it will not usually interfere with the bearing's performance in standard application, but rust in the bore is more serious because of the importance of inner ring-to-shaft fit. Rust in the raceways or on the roller elements precludes any further use of the bearings.

Moisture - Etching, Staining

If moisture is allowed to enter a bearing it can damage the bearing in several different ways. The internal surfaces may become corroded or etched. A stationary bearing exposed to moisture will probably show individual staining on the race in locations of contact between rolling elements and raceway; or random spots of corrosion on exposed surfaces. Either pattern of corrosion deters proper bearing performance and results in excessive noise, clearance, or the corroded zones may fatigue prematurely.



Examples of Scoring, Pitting and Scratching

Cause

Debris or Dirty Surroundings

Most bearing failures may be traced to some sort of contamination. Dirty working conditions are one of the bearing user's greatest problems. Thousands of dollars each year may be saved simply by taking certain precautions against the entrance of impurities into the bearings. Internal clearance in precision bearings is measured in the ten-thousandths (.0001) of an inch. Most dirt and particles are larger than one-thousandth (.001) of an inch, so hard particles will indent the race and the roller element surfaces when the bearing rotates.

Abrasive Waste Materials

In most applications such as; paper making, metal working, food processing, steel making etc., there will be an abrasive waste or by-product which infringes on the effective operation of bearings. This would also apply where coolants, washing solutions, acids or other liquids are used around a bearing application.

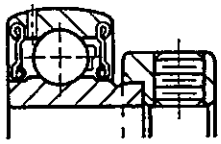
Moisture, Water

When water enters a bearing it can react with the lubricant or its additives (particularly EP additives) and form acids and other corrosive chemical compounds which attack the bearing surfaces.The most significant moisture damage occurs when the bearing is stationary because of the minimal lube film in the roller element's contact zones which leads to etching at point of contact. The water which entered the bearing could come from direct compromise of bearing or housing seals or from condensation due to environmental conditions.

Preventative Measures

Avoid Damage from Abrasive Waste Product

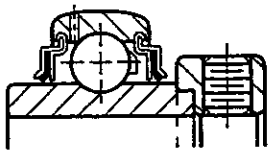
Where a manufacturing process involves an abrasive by-product, it is essential that the bearing be properly sealed. Where failures of this kind prevail, a more efficient seal is required. In applications where extreme contamination exists, a sealed housing or shroud may be incorporated into the design to protect the bearing. The Torrington Company also offers several coatings: TDC, TiN and MoS_2 which will protect as well as lubricate.



PLYA Seal

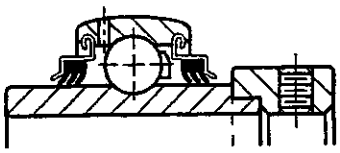
Clean Work Surroundings

The Torrington Company takes great care to provide bearings in as near pristine condition as possible: class 10,000 clean room assembly and inspection, pre-packed greases and oil-coatings, wrappings which prevent moisture seepage and superior boxing. Careful control of your area, tools, and clean dry hands are extremely important to prevent bearing failure. The following is a list of procedures outlined by the American Bearing Manufacturers Association (ABMA) for the control of cleanliness in handling bearings:



"R" Seal

- Work with clean tools in clean surroundings.
- Remove all outside dirt from housing before exposing bearings.
- Handle with clean, dry hands.
- Treat a used bearing as carefully as a new one.
- Use clean solvents and flushing oils.
- Lay bearing out on clean paper and cover.
- Protect disassembled bearings from dirt and moisture.
- Use clean, lint-free rags if wiping bearings.
- Keep bearings wrapped in oil-proof paper when not in use.
- Clean inside of housing before replacing bearings.
- Install new bearings as removed from packages.
- Keep bearing lubricants clean when applying and cover containers when not in use.

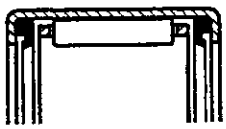


Tri-Ply Seal

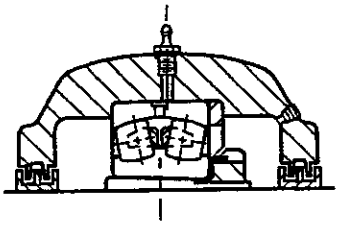
Moisture Entry

Consult your Torrington Sales Engineers for the optimum seal configuration for your application. External seals may be required on a specific case basis.

When the entry of moisture cannot be prevented, regular relubrication is necessary to purge the contaminated grease from the bearing and replace it with fresh grease.



Needle Bearing Seal



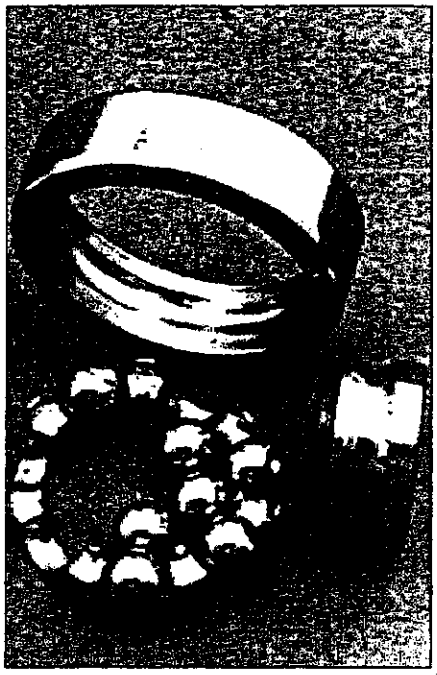
Sealed Pillow Block Housed Roller Bearing

Identification

Mounting indentations (thrust force) - Ball Bearings

This failure will appear as tiny indentations (sometimes barely discernable to the naked eye) high on the shoulder of the race. The dents will be angularly spaced in correspondence to the rolling element spacing. There will be a corresponding indentation of lesser magnitude on each rolling element.

When the bearing is radially loaded the brinells on the race shoulder may not interfere with the roller tracks. In this event, the dent on the rolling element will cause the failure. In the later stages of failure, spalling or chipping may result. The race shoulders can be inspected (with a microscope if available) to see if a spalling pattern may have resulted from initial brinelling. The term brinell comes from the mark on the bearing looking like the mark left from a brinell hardness testing machine.



Example of Mounting Indentation

Radial Indentations (radial force) - Ball Bearings

The indentations have the same general appearance as mounting indentations except that they appear in the center of the race instead of on the shoulder. This type of brinell is less common than the mounting brinell because, under the sharp impact of radial shock load, the rings may fracture beneath the force.

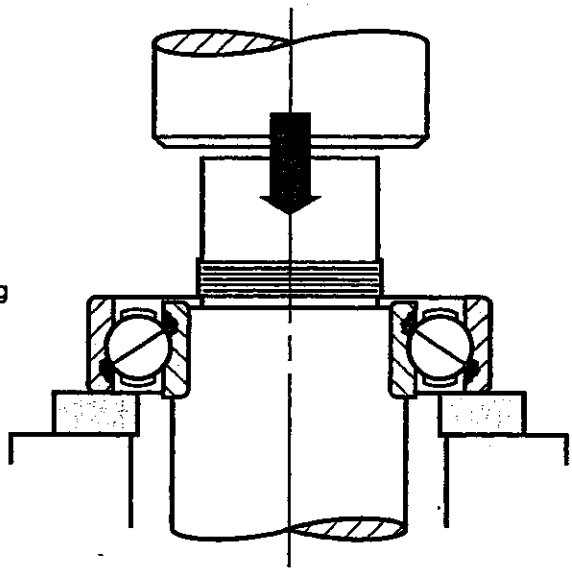
Radial Indentations (radial force) - Roller Bearings

In a uniformly loaded (no shaft slope or end load) roller bearing indentations appear as even, full contact lines the length and shape of roller. When an end load is present the marks will deepen at the end and the mark may not extend for the full length of the roller. As with all true brinell marks the surface manufacturing marks are visible in the indentations.

Cause

Force incorrectly exerted - Ball Bearings

Indentations high on the race shoulder are caused in mounting (or dismounting) where force is applied against the unmounted ring. When mounting a bearing on a shaft with a very close fit, pushing of the outer ring will exert an excessive thrust load bringing the rolling elements into sharp contact with the race shoulder, causing brinell.



Incorrect Arbor Press Dismounting

Radial shock load - Ball and Roller Bearings

Radial indentations are caused by a shock load or static overload imposed radially on a non-rotating bearing. This may be imposed by hitting the bearing with a hammer or by an operating shock load exerted on a static shaft.

Preventative Measures

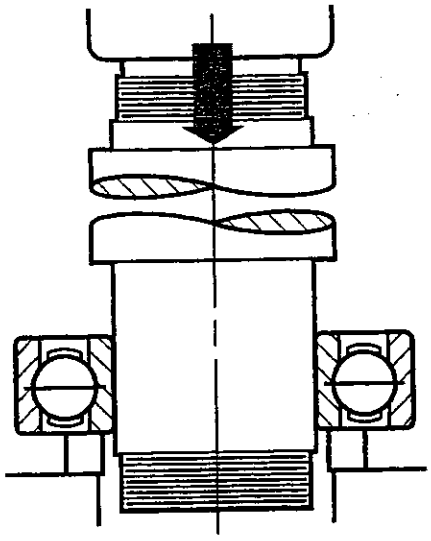
Proper Mounting Procedure

In mounting a bearing, force should always be exerted against the ring being mounted. In other words, when mounting the bearing on a shaft, the pressure should be applied against the inner ring. When mounting in a housing, press against the outer ring. The ring having the tighter fit (usually the ring which will rotate in application) should be pressed.

Be sure when mounting a bearing to apply the mounting pressure slowly and evenly.

Operation

Identify source of overload on bearings and eliminate. It must be determined first if it is shock loading (dynamic loading) or static overload.



Proper Mounting Procedure

Identification

Axial Indentations – Ball Bearings

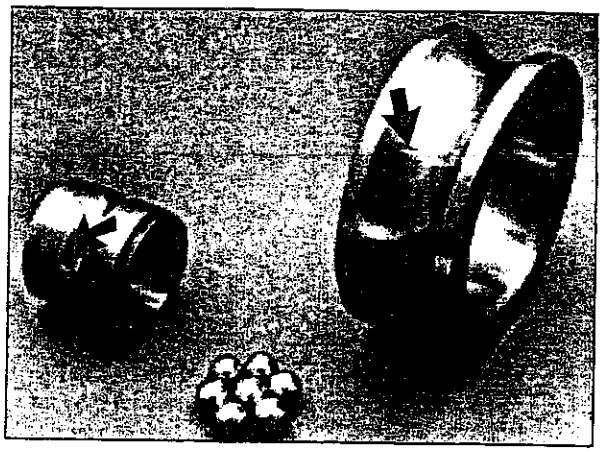
This type of brinelling will appear as elliptical impressions which run axially across the races. There will be a build-up of reddish lubricant around each brinell. Also, the brinells will be spaced with the corresponding roller element.

Circumferential Indentations – Ball Bearings

This will appear exactly as the brinelling above, except that the impression will be wider in a circumferential direction.

Roller Indentations – Roller Bearings

In a roller bearing, false brinell impressions look similar to the 'true' brinells produced by overload or shock load. They appear as roller shaped indentations in the raceway. However, careful examination will reveal the original surface manufacturing marks have been worn away in the false brinell indentation. This indicates the impression was formed through attrition.



Examples of Axial Indentations

Cause

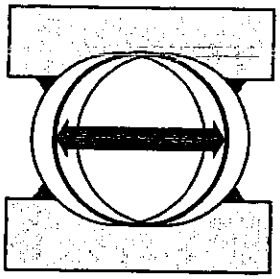
Vibration in a Static Bearing

False Brinelling is caused by the vibration of the rolling elements between the races (or themselves in a full complement bearing) in a stationary bearing. This vibration may be axial or circumferential. The appearance of the brinells will tell you which. As the roller element vibrates between the races, the lubricant is forced out of the contact area between roller and race. The failure is the result of a breakdown of the lubricant causing metal-to-metal contact and localized wear of rollers and races. The wearing action causes the formation of a fine reddish-brown powder (iron oxide). The oxide impregnates the lubricant and provides an abrasive compound that will polish (lap) the rollers and races if the bearing is put into operation. The indentations themselves will result in a rough and noisy operating bearing. Vibrations in a bearing may be caused by a number of factors which result in false brinelling. Two common causes of this failure occur:

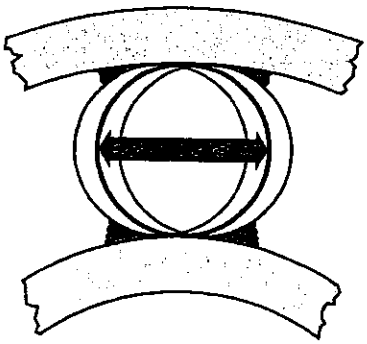
- when mounted, but unlocked bearings are transported.
- when the bearings in a non-operating machine are subjected to the static vibration by other machinery operating in the area.

Small Angular Oscillation

When a bearing does not rotate through a large enough angle, so one rolling element can reach the previous resting point of the adjacent rolling element. Over time, this results in a depletion of lubricant from the contact zone, and failure proceeds as outlined above in: "Vibration in a Static Bearing."



Axial Vibration



Oscillatory Vibration

Causes of False Brinelling

Preventative Measures

Vibration:

Correct the Source of Vibration

The source of agitation-loose parts, non-precision machinery, rough transportation, should be corrected so that vibration is avoided.

Locking the Bearing

When transporting bearings, apply a light thrust load (imposed by springs or rubber pads) to bring all of the rolling elements into contact with the races.

All Surfaces Adequately Lubricated

Where bearings are oil lubricated and employed in units that may not be in service for extended periods of time, the equipment should be set in motion periodically to spread the lubricant over all bearing surfaces. Intervals of one to three months should suffice.

Tighten Internal Fits

Sometimes a bearing with line-to-line contact between rings and roller elements will alleviate a false brinell failure. Great care should be taken, however, that a tight internal fit is satisfactory from an operations point of view.

Low Viscosity Lubricant

False brinelling is more common when stiffer lubricants are used. This failure is less apt to occur where oil or a light viscosity grease is used, because the liquid characteristics make it difficult for the lubrication to be forced out of the control area.

Oscillation:

Increase the Angle of Rotation

When possible, the application should be altered to increase the angle of bearing rotation, thus redirecting forces causing oscillation.

All Surfaces Adequately Lubricated

Bearings which are oil lubricated need a sufficient flow of oil to force wear debris away from the roller contact zone.

When grease is used - regular relubrication is required to purge contaminated grease from bearing.

Select Different Bearing Type

Depending on application, machinery, and environment, a different type bearing may be less susceptible to false brinelling. Please contact a Torrington Company Sales Engineer in your area for selections suited to your situation.

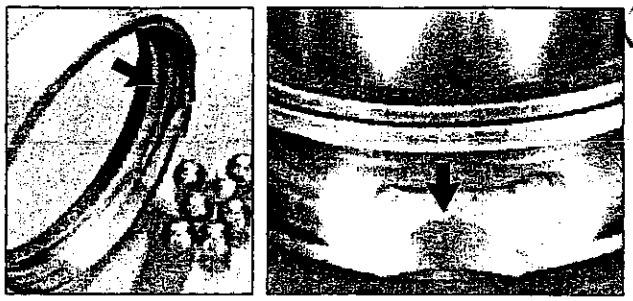
Identification

Maximum Capacity

Bearings with filling slots are not recommended for heavy thrust loading because, as the balls pass over the inner ring and outer ring notches, they may become nicked or dented. This in turn may cause spalling of the races (probably in the vicinity of the loading slot).

Counterbored Bearing

There will be a breakdown of the counterbored shoulder of the bearing which may result in the fracture of the ring. The balls will be banded from riding up against the shallow shoulder. Also the bearing may become disassembled during service.



Examples of Thrust Failure

Cause

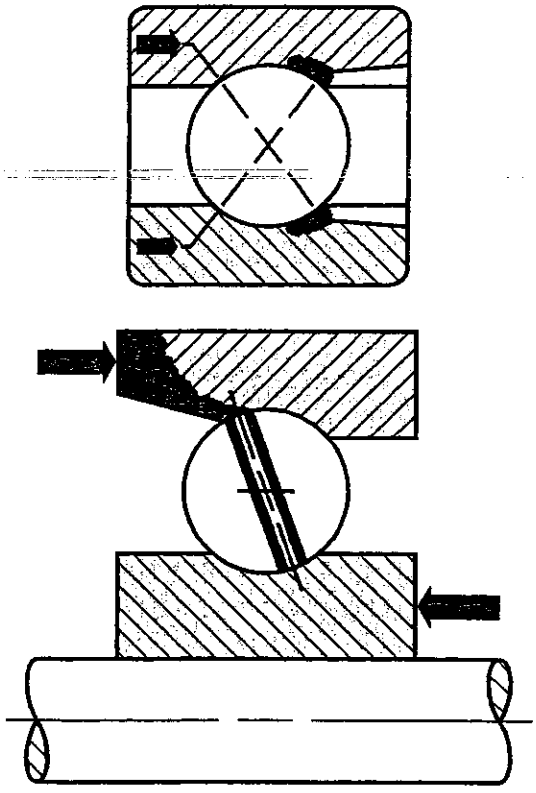
Improper Mounting or Misapplication as Indicated

Maximum Capacity Failure

This failure results from excessive thrust loads on a bearing not primarily intended for heavy thrust loads. The arrows in the diagram indicate that too much thrust load from either direction will cause interference between the rolling elements, and one of the loading slots which are ground in both the inner and outer rings.

Counterbore Failure

A thrust failure is caused either by mounting the bearing backwards (so that the load is carried against the shallow shoulder) or by putting a counterbored bring into a bi-directional thrust application.



Incorrect Thrust Direction

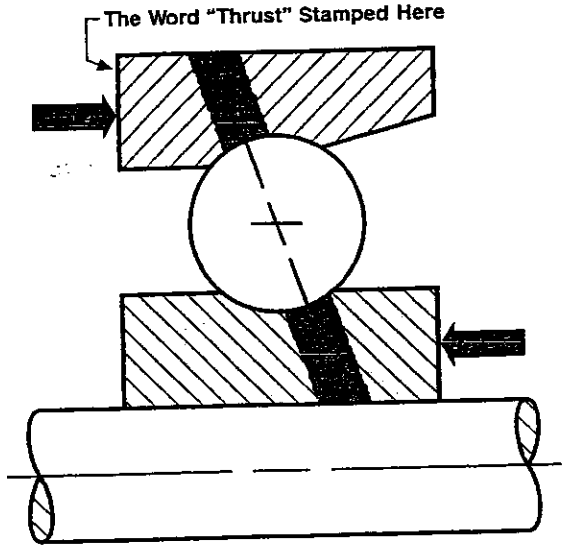
Preventative Measures

Maximum Capacity Failure

A more suitable Conrad or angular contact type bearing must be selected if high or predominate thrust capacity is required. Obviously, the maximum capacity failure was caused by using a bearing using a bearing designed for heavy radial, or combined radial thrust loads; not for pure thrust loading. It is recommended that no more than 60 percent of the accompanying radial load on the bearing be applied in thrust.

Counterbore Failure

The remedy here is to mount the bearing correctly so that the balls have full shoulder support on both the inner and outer rings. Remember that the outer ring counterbore bearing will take thrust against the inner ring on the counterbored side of the bearing, and the outer ring on the side opposite the counterbore. The word THRUST will be stamped on the outer ring face showing the proper thrust surface.



Proper Thrust Direction

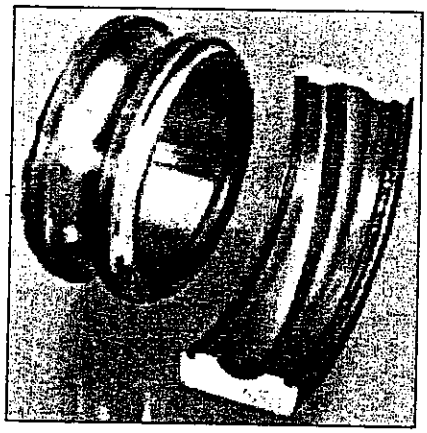
Identification

Ball or Roller Path

In a bearing with one side misaligned in relation to the other, the ball or roller path will run from one side of the race to the other around one-half of the circumference on the non-rotating ring. The rotating ring will have a wide roller path. Because of the extra pressure imposed on the bearing due to misaligned conditions, an excessively high temperature may develop which will discolor the raceways and the rolling elements while destroying the lubricant.

Retainer

The purpose of the retainer is to space the rolling elements and to guide them in a true path around the raceway. Where a ring is misaligned, the rollers are driven up against the race shoulder and a stress point is established between the roller and its retainer pocket. The pocket will flex, increasing the possibility of retainer fracture in the advanced stages of stress.



Examples of Bearings with Misaligned Rings

Cause

Shaft Misalignment

Misalignment of the shaft in relationship to the housing causes an overload of the balls or rollers which will result in the failure described.

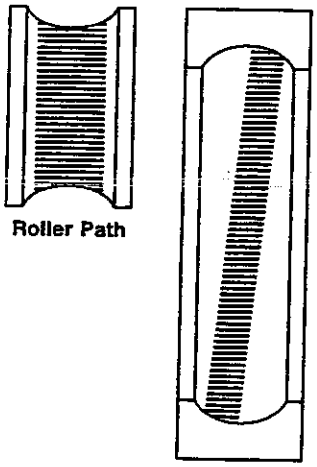
Housing Misalignment

Housing misalignment may be caused either by the housing being cocked in relation to the plane of the shaft or the housing shoulder being ground out-of-square so that it forces the outer ring to cock in relation to the inner. It may also be caused by the settling of housing frames or foundations.

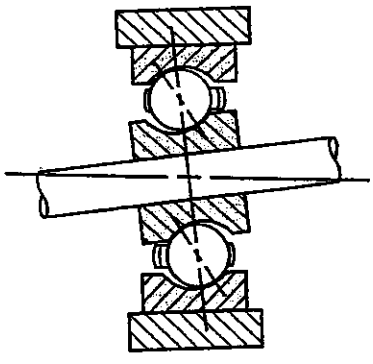
Shaft Bowing

Shaft bowing may be caused by the following:

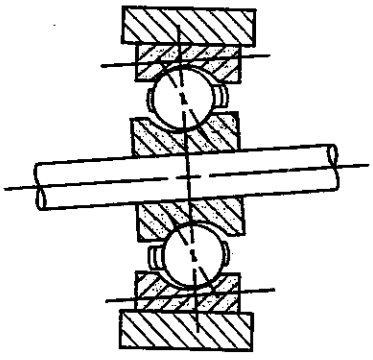
- As a result of improper handling
- Overhung load exceeding shaft capacity.
- Initial shaft bowing due to grinding inaccuracies.
- Shaft shoulders ground out-of-square with the shaft centerline which will, by cocking the inner ring, force a bowing of the shaft.



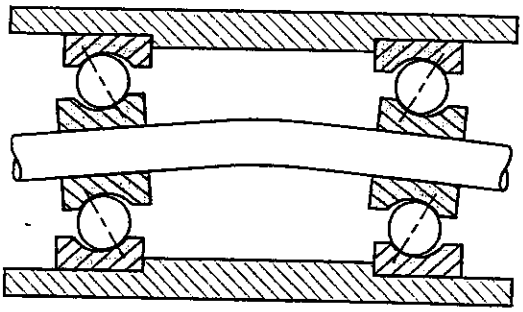
Examples of Ball Path Running from One Side of the Race to the Other Side



Shaft Misalignment



Housing Misalignment



Shaft Bowing

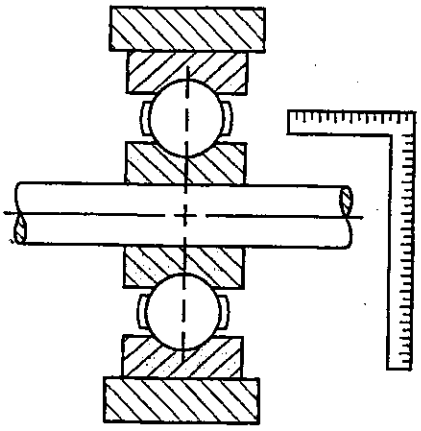
Preventative Measures

Housing

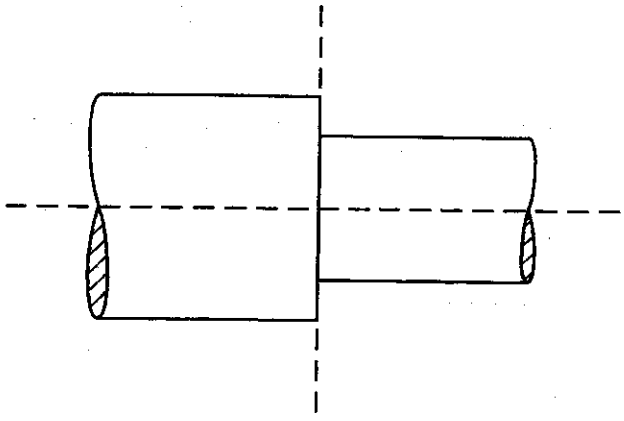
The remedy is to dimensionally check and insure that both the housing bores are true to each other.

Shaft

The shaft should be gauged to make sure that is concentric and straight. Heavy overhang loads should be lightened or moved closer to the bearing. If the shoulders are out-of-square; they should be reground and gauged so that they are perpendicular to both the bearing seat and the shaft centerline.



Both Housing Bores Must Be True to Each Other



Squaring-Up Shaft Shoulders

Identification

Electric Arc Erosion

Arcing, which produces high temperatures at localized points, results when an electric current passing through a bearing is broken at the contact surfaces between races and rolling elements. Each time the current is broken in its passage between the ball or roller and race, a pit is produced on both parts. Eventually the phenomenon known as fluting develops, (see photograph). As it becomes deeper, noise and vibration result.

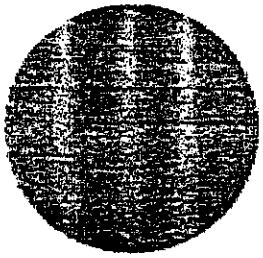
Electro-etching on Both Inner and Outer Ring

Granular Race Surfaces

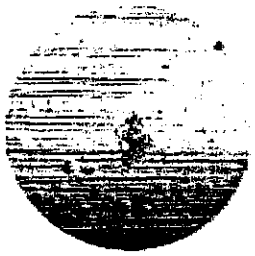
If the current is of higher amperage intensity such as a partial short circuit, the next phase of the failure will show up as a rough granular appearance in the ball track.

Pitting or Cratering

Heavy jolts of high amperage charges will cause a more severe failure resulting in the welding of metal from the race to the ball or roller. These protrusions of metal on the roller will, in turn, cause a cratering effect in the race. This phenomenon will result in noise and vibration in the bearing.



Magnification of Granular Race Surface



Magnification of Electric Pitting

Cause

Static Electricity

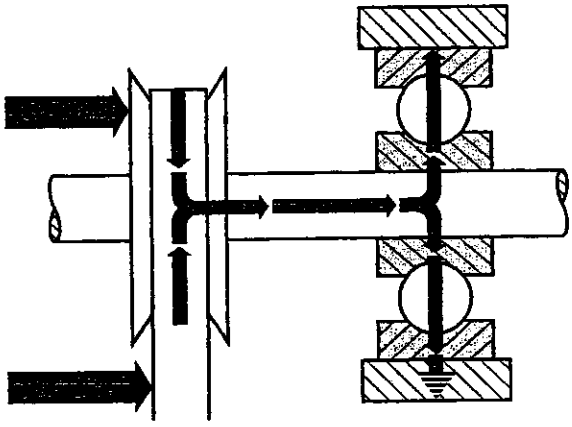
Static electricity usually emanates from charged belts or from manufacturing processes using calendar rolls (leather, rubber, cloth, paper). The current is carried from the belt to the pulley or sheave — from the sheave to the shaft — through the shaft to the bearing — and from the bearing to the ground.

Electric Leakage

Faulty wiring, inadequate or defective insulation, or loose rotor windings on an electric motor are all possible sources of current leakage. Either AC or DC currents will damage bearings.

Short Circuit

Wires which are crossed or contacted by a common conductor will cause a short circuit and may result in a passage of current through the bearing.



The Current Path

Preventative Measures

Shunts and Slip Rings

Where there is a passage of current through a bearing and the source of the current cannot be corrected, a shunt in the form of a slip ring assembly may be incorporated to by-pass the current around the bearing.

Corrective Maintenance

Be sure wiring, insulation, or rotor windings are sound and all connections are properly made. In arc welding, great care should be taken that the welding apparatus is not grounded on something that will circulate the current through the bearings.

Grounding Belts

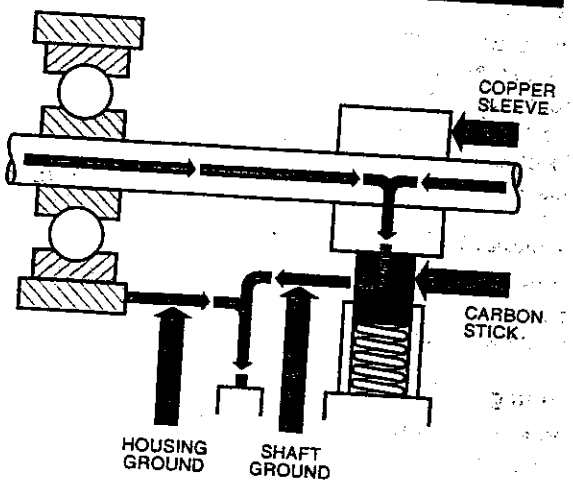
To eliminate static charges, ground the belt, or change the belting to a less generative material.

Insulating Bearings

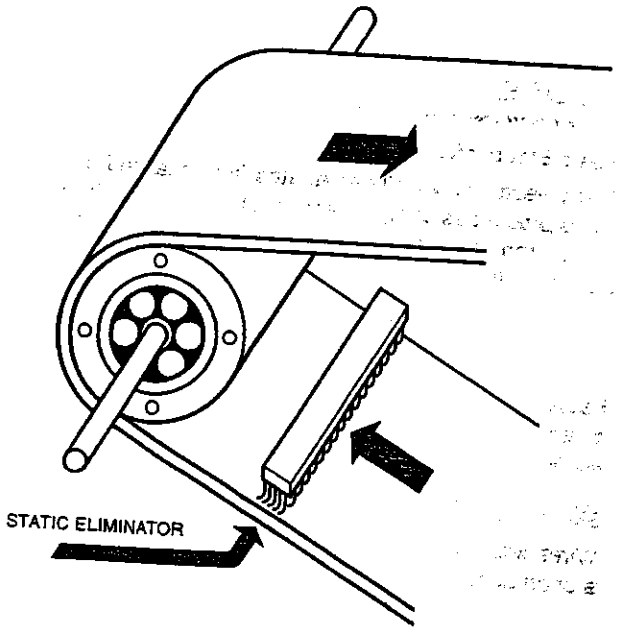
Sleeves of nonconductive material may be used either between the outer ring and housing or between inner ring and shaft, depending upon the source of current.

Conductive Grease

Utilizing an electrically conductive grease will provide a path for the current to minimize or cease damage to your bearings. Consult your lubricant supplier for availability.



Use Sleeves of Non-Conductive Material Either Between the Outer Ring and Housing, or Inner Ring and Shaft



Ground Belts to Eliminate Static Charges

Identification

Grease Appearance

If the grease is stiff or caked and changed in color, it indicates lubrication failure. The original color will usually turn to a dark shade or jet black. The grease will have an odor of burnt petroleum oil. Lubricity will be lost as a result of lack of oil. In cases of Lithium base greases, the residue appears like a glossy, brittle varnish which will shatter when probed with a sharp instrument.

Abnormal Temperature Rise

Probably the first indication of lubricant failure is a rapid rise from the normal operating temperature. Test by hand is not necessarily conclusive since normal operating temperature may exceed the bearable limit of roughly 120°F.

Noise

Lack of lubrication is soon accompanied by a whistling noise coupled with the rise in temperature. If not corrected, the bearing temperature will continue to rise and the intense heating will reduce the bearing hardness.

Bearing Discoloration

A brownish or bluish discoloration of the races and rolling elements indicates that the bearing operating temperature was excessively high to the extent that the bearing lost its physical properties and was no longer operable.

The bearing part that first indicates distress in lubrication failures is usually the retainer where the greatest amount of rubbing action takes place.

Inadequate Viscosity of Lubricant

The surface of the bearing has lost its as-manufactured appearance and now has a frosted appearance. When examined under a microscope you will see that the surface has roughened and appears granular. Under some conditions the granular appearance is visible even without using a microscope. Occasionally some areas of the bearing will be highly polished.

Cause

Dirty Lubricants

Contaminants found in lubricants often act as an abrasive compound which will lap or polish roller and race surfaces, increasing the probability of early failure. The Torrington Company filters bearing lubricants as many as five times to insure their purity.

Too Much Lubricant

A very common error in the maintenance of machinery is the tendency to over-lubricate. If the bearing reservoir is kept constantly full of grease, the friction heat developed within the lubricant will cause its own rapid deterioration.

Inadequate Lubrication

Heat will result from under-lubrication, also. Where there is inadequate lubricant to cover all metal surfaces, friction will result in heat-up of the bearing.

Wrong Kind of Lubricant

Selection of the correct lubricant is very important in achieving maximum efficiency and endurance from the bearing application.

After experimentation with many types of lubricants, the equipment manufacturer recommends those which he feels will provide ideal lubrication life under given operation conditions. Insofar as availability allows, you should use the same lubricant or its equal. Thus you are assured of using the correct lubricant, in addition to avoiding the problems associated with mixing two types of grease.

Many greases are incompatible and, although completely adequate when used individually, may prove unsatisfactory when mixed.

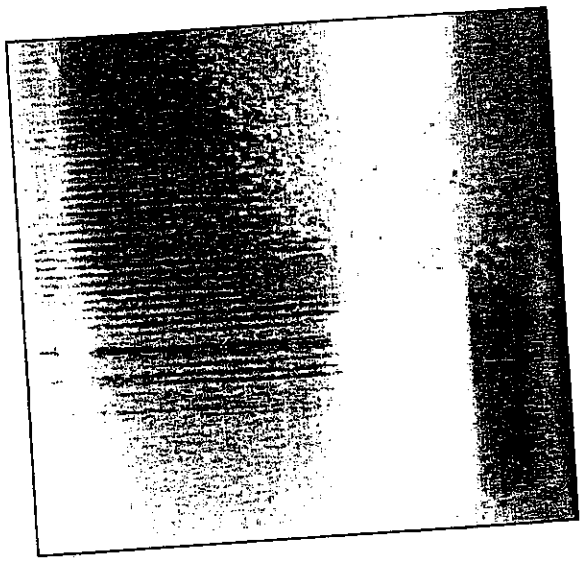
Other Failure Modes

The primary cause of lubricant failure is from the high temperatures developed when excessive loads overpower the lubricant film.

In many instances lubricant failure will accompany the bearing failures described in this manual. Lubricant changes might reduce the failure rate but the proper cause of action is to eliminate the primary cause for the lubricant breakdown.

Inadequate Viscosity of Lubricant

The viscosity of the lubricant was inadequate to properly separate the bearing surfaces.



Preventative Measures

Avoiding Dirty Lubricant

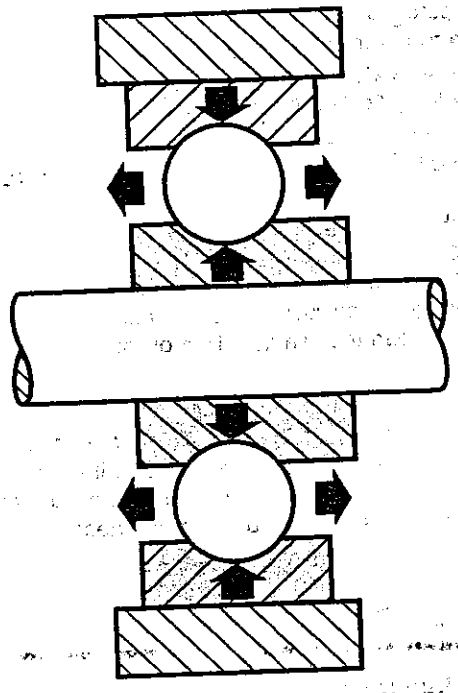
Always keep grease containers covered. Dust particles in the air can contaminate the lubricant. Use a clean, rust-resistant spatula for relubricating open bearings. When relubricating bearings through a grease fitting, always wipe off both the fitting and nozzle of the grease gun. Any steps which you can take to keep lubricants clean will pay off in longer bearing life.

Amount of Lubricant

The Torrington Company Engineering Department should be contacted when you are unsure of the amount of grease or oil for proper lubrication. In standard applications, it is generally recommended that the bearing should be greased one-third to one half full.

Inadequate Viscosity of Lubricant

Select a lubricant with sufficient viscosity to properly separate the rolling contact surfaces. Typically, we recommend a lubricant with a viscosity of at least 100 SUS (20 cSt) at the bearing operating temperature. If an application's lubricant does not meet the bearing's viscosity requirements and a lubricant with a greater viscosity cannot be substituted, improved cooling of the current lubricant may lower its operating temperature (and thus increase its viscosity) enough to obtain acceptable bearing life. Similarly, improving the surface finish on customer supplied races may allow the current lubricant to separate the rolling contact surfaces.



Lubrication Failures in Ball Bearings Are Usually Accompanied by a Thermal Expansion of the Components

The Torrington Company Catalogs

The Torrington Company offers the following publications to provide you with additional information about its bearing product line.

While these publications are not to be considered as containing sufficient data for all bearing selections, they can provide valuable assistance in your initial considerations of the type and characteristics of the bearing which may be most suitable tor your particular needs.

Torrington's highly trained sales engineers are available to work with you to make sure you have selected the best Torrington bearing for your application. See the last page of this manual for the phone number and address of the Torrington Engineering Sales Office nearest you.

Catalogs

The Torrington Company Service Catalog

An overall view of Torrington®, Fafnir® and Kilian® bearing products ..... **No. 100**

The following product catalogs present additional in-depth information on each product line:

Torrington® Needle Roller Bearings ..... **No. 101**

Fafnir® Superprecision Ball Bearings ..... **No. 102**

Fafnir® Wide Inner Ring Bearings and Housed Units ..... **No. 104**

Fafnir® Radial and Angular Contact Ball Bearings ..... **No. 105**

Torrington® Large Bearings, Roller, Ball and Pillow Blocks ..... **No. 106**

To Order These Catalogs

Contact your nearest Torrington Company Engineering sales office. **See listing** on page 24.