



# GRANULATOR OPERATING MANUAL

## *WO Series Machines*

**Rotogran International Inc.**

4 Simpson Road  
Bolton, Ontario, L7E 1G9  
CANADA  
Phone: (905)-738-0101  
Fax: (905)-738-5750  
E-mail: [sales@rotogran.com](mailto:sales@rotogran.com)  
[www.rotogran.com](http://www.rotogran.com)

# Table of Contents.

<b>1.</b>	Introduction	Pages 2-3
<b>2.</b>	Technical specifications	Pages 4-8
<b>3.</b>	Transporting and Lifting	Page 9
<b>4.</b>	Installation and Start-up	Pages 10-15
<b>5.</b>	Safety System	Pages 16
<b>6.</b>	Safety Instructions	Pages 17-18
<b>7.</b>	General Maintenance	Pages 19-22
<b>8.</b>	Open and close for service	Pages 23-28
<b>9.</b>	Remove, Sharpen, Set, and Install Blades	Pages 29-35
<b>10.</b>	Remove, Install, and Tension Drive Belts	Pages 36-37
<b>11.</b>	Spare parts	Page 38
<b>12.</b>	Troubleshooting	Pages 39-40
<b>13.</b>	Torque specifications	Pages 41-42
	<b>NTN</b> Lubrication Instructions	Pages 43-50
	<b>US Motors</b> Instructions	Pages 51-52
	<b>Warranty</b>	Page 53

# 1. Introduction.

Congratulations! Thank you for purchasing this new granulator, manufactured by **Rotogran International Inc.**, leader in design and manufacturing of quality plastics size reduction products.

**This Operating and Maintenance Manual** contains important information for installation, start-up and maintenance, of your granulator.

**You must read and understand this Operating and Maintenance Manual** thoroughly, and follow all the operating instructions.

**All** procedures contained herein should be followed before attempting to use your new Rotogran granulator. Failure to do so can result in serious personal injury, property damage, or void the warranty.

**Reasonable care and simple preventive maintenance**, will maintain efficiency, longer life and minimum down time. Maximize the performance of your granulator, by using it properly, and giving it the proper care.

**IF YOU HAVE ANY QUESTIONS REGARDING THE SAFE OPERATION OF YOUR NEW ROTOGRAN GRANULATOR,**

**STOP!**

**DO NOT ATTEMPT TO OPERATE.**

**CALL YOUR LOCAL REPRESENTATIVE,**

**OR:**

**Rotogran International Inc.**

4 Simpson Road  
Bolton, Ontario, L7E 1G9  
CANADA

Phone: (905)-738-0101

Fax: (905)-738-5750

E-mail: [sales@rotogran.com](mailto:sales@rotogran.com)

[www.rotogran.com](http://www.rotogran.com)

**Rotogran** granulators are designed to granulate plastic scrap resulting from the production of injection molded, blow molded, extruded, thermoformed, and other processed parts.

The size, configuration, horsepower and throughput of the machine is designed and adapted to suit the type and configuration of the plastic scrap the customer specified on ordering.

Introduction of any materials or products other than which the granulator was designed for, may void the warranty.

Please contact **Rotogran International Inc.** for approval, before introducing these parts into the machine.

The plastic scrap must be free from contaminants such as, any kind of metal, sand, stone, glass, flammable or explosive substances, etc.

Introducing any contaminants into the granulator can result in serious personal injury, property damage, damage to the machine, or poor performance of the machine.

With the objective of preventing personal injury, property damage or poor performance, and for the warranty to remain valid, any modifications, changes, additions, or conversions on any part of the granulator, is subject to the written approval of Rotogran International Inc.

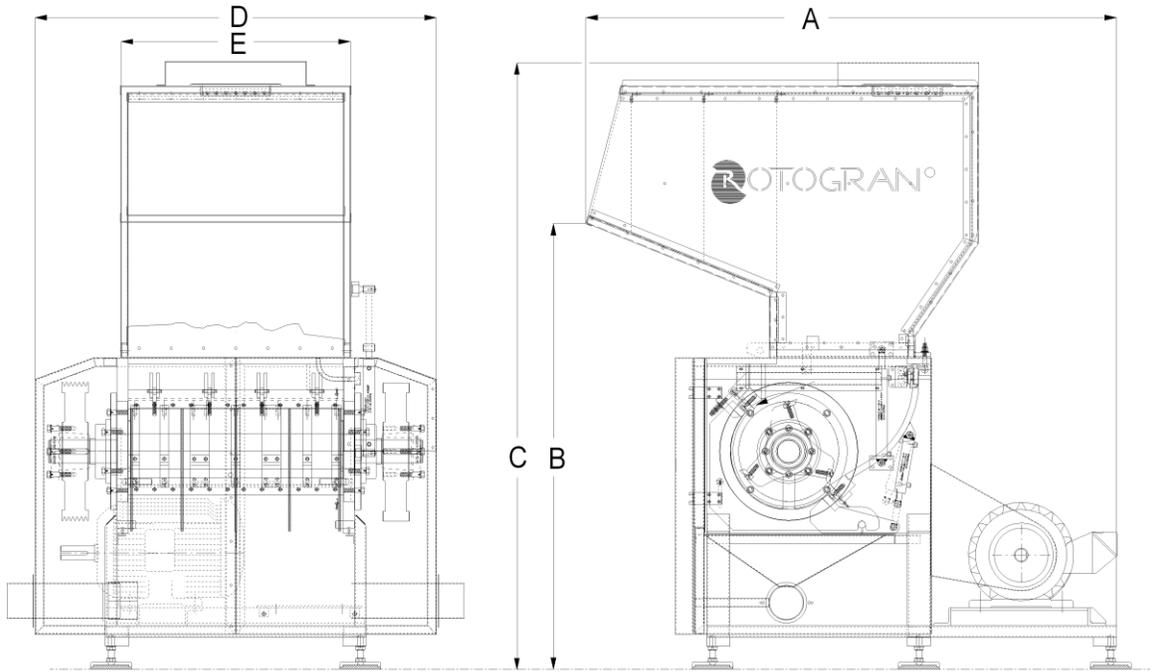
All installation work, electrical interconnections, startup of the machine, and other servicing work should be carried out by persons with relevant technical training or corresponding professional experience.

## **2. Technical Specifications.**

Dimensions .....**2.1**

Specifications..... **2.2**

## 2.1 - Dimensions:



Machine	WO-1418	WO-1424	WO-1430	WO-1442	WO-1456
A	62"	62"	61"	63"	69"
B	61"	61"	61"	58"	41"
C	76"	76"	76"	73"	41"
D	38"	44"	46"	66"	108"
E	20"	26"	26"	43"	56"

Dimensions to chamber top \* = No Hopper

Machine	WB-1460	WO-2224	WO-2236	WO-2248	WO-3036	WO-3052	WO-3065
A	68"	85"	93"	93"	112"	112"	112"
B	40 *	76"	78"	78"	102"	102"	102"
C	40 *	103"	104"	104"	132"	132"	132"
D	84"	46"	59"	71"	77"	94"	109"
E	62"	27"	40"	51"	40"	56"	69"

Please note that all dimensions are based on standard machine configurations and are subject to change without notice.

## 2.2 - Specifications:

<b>Motor: 60Hz</b>	WO-1418	284T	25hp	1750 rpm	575-480/3/60
		286T	30hp	1750 rpm	575-480/3/60
	WO-1424	284T	25hp	1750 rpm	575-480/3/60
		286T	30hp	1750 rpm	575-480/3/60
	WO-1430	286T	30hp	1750 rpm	575-480/3/60
		324T	40 hp	1750 rpm	575-480/3/60
	WO-1442	324T	40 hp	1750 rpm	575-480/3/60
		326T	50 hp	1750 rpm	575-480/3/60
	WO-1456	364T	60 hp	1750 rpm	575-480/3/60
		365T	75 hp	1750 rpm	575-480/3/60
	WB-1460	365T	75 hp	1750 rpm	575-480/3/60
		405T	100 hp	1750 rpm	575-480/3/60
	WO-2224	324T	40 hp	1750 rpm	575-480/3/60
		326T	50 hp	1750 rpm	575-480/3/60
	WO-2236	364T	60 hp	1750 rpm	575-480/3/60
		365T	75 hp	1750 rpm	575-480/3/60
	WO-2248	365T	75 hp	1750 rpm	575-480/3/60
		405T	100 hp	1750 rpm	575-480/3/60
	WO-3036	405T	100 hp	1750 rpm	575-480/3/60
		444T	125 hp	1750 rpm	575-480/3/60
		447T	150 hp	1750 rpm	575-480/3/60
	WO-3052	444T	125 hp	1750 rpm	575-480/3/60
		445T	150 hp	1750 rpm	575-480/3/60
		447T	200 hp	1750 rpm	575-480/3/60
	WO-3065	447T	200 hp	1750 rpm	575-480/3/60
		449	250 hp	1750 rpm	575-480/3/60

## Specifications (continued):

<b>Throat size</b>	WO-1418	14" deep,	18" wide
	WO-1424	14" deep,	24" wide
	WO-1430	14" deep,	30" wide
	WO-1442	14" deep,	42" wide
	WO-1456	14" deep,	56" wide
	WB-1460	16" deep,	60" wide
	WO-2224	22" deep,	24" wide
	WO-2236	22" deep,	36" wide
	WO-2248	22" deep,	48" wide
	WO-3036	30" deep,	36" wide
	WO-3052	30" deep,	52" wide
WO-3065	30" deep,	65" wide	

<b>Rotor Speed:</b>	WO-1418	689 rpm
	WO-1424	689 rpm
	WO-1430	743 rpm
	WO-1442	653 rpm
	WO-1456	653 rpm
	WB-1460	650 rpm
	WO-2224	674 rpm
	WO-2236	674 rpm
	WO-2248	674 rpm
	WO-3036	467 rpm
	WO-3052	467 rpm
WO-3065	467 rpm	

### Number of Blades:

WO-1418	(3-Blade rotor)	Rotor 3	Bed 2
WO-1424	(3-Blade rotor)	Rotor 6	Bed 2
WO-1430	(3-Blade rotor)	Rotor 9	Bed 4
WO-1442	(3-Blade rotor)	Rotor 9	Bed 6
WO-1456	(5-Blade rotor)	Rotor 20	Bed 8
WB-1460	(5-Blade rotor)	Rotor 25	Bed 10
WO-2224	(3-Blade rotor)	Rotor 6	Bed 2
	(5-Blade rotor)	Rotor 10	Bed 2
WO-2236	(3-Blade rotor)	Rotor 9	Bed 4
	(5-Blade rotor)	Rotor 15	Bed 4
WO-2248	(3 Blade rotor)	Rotor 12	Bed 4
	(5 Blade rotor)	Rotor 20	Bed 4

## Specifications (continued):

WO-3036	(5-Blade rotor)	Rotor 15	Bed 4
WO-3052	(5-Blade rotor)	Rotor 20	Bed 4
WO-3052	(5-Blade rotor)	Rotor 20	Bed 4
WO-3065	(5-Blade rotor)	Rotor 25	Bed 6

<b>Throughput:</b>	WO-1418	600 to 1100 lbs/hr
	WO-1424	800 to 1500 lbs/hr
	WO-1430	900 to 1500 lbs/hr
	WO-1442	1100 to 1800 lbs/hr
	WO-1456	1400 to 2000 lbs/hr
	WB-1460	1000 to 2000 lbs/hr
	WO-2224	1200 to 2400 lbs/hr
	WO-2236	1800 to 3200 lbs/hr
	WO-2248	2000 to 3400 lbs/hr
	WO-3036	2800 to 3800 lbs/hr
	WO-3052	3200 to 4800 lbs/hr
	WO-3065	3600 to 5500 lbs/hr

Please note that throughput varies and depends on screen hole size, feeding method, plastic type and size, and evacuation system.

<b>Weight:</b>	WO-1418	2500 lbs
	WO-1424	3200 lbs
	WO-1430	4500 lbs
	WO-1442	5000 lbs
	WO-1456	6000 lbs
	WB-1460	7000 lbs
	WO-2224	5200 lbs (5800 lbs with double flywheel)
	WO-2236	6500 lbs (7500 lbs with double flywheel)
	WO-2248	7800 lbs (8800 lbs with double flywheel)
	WO-3036	18000 lbs
	WO-3052	20000 lbs
	WO-3065	22000 lbs

### 3. Receiving, Transporting and Lifting.

**Be aware! This granulator is heavy and the weight point is unequal!**

**See specifications section for the weight of your machine.**

The machine should be lifted and handled by an appropriate fork-lift truck, and the work should be carried out by persons with relevant technical training or corresponding professional experience only.

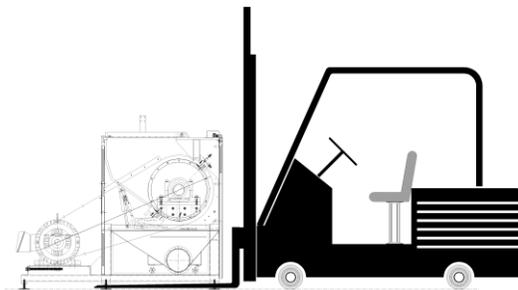
**Failure to do so can result in serious personal injury, and or property damage.**

Any apparent or suspected damage to the equipment during transportation should be immediately reported to both, the carrier and Rotogran International Inc. Digital photos should be taken if digital camera is available.

Upon delivery, all equipment furnished should be carefully inventoried against shipping documents. Any shortages must be reported immediately to both, the carrier and Rotogran International Inc.

The front side of the machine is normally heavier than the rear side due to the location of the rotor in the cutting chamber.

**Drive the fork-lift truck forks under the machine frame from the front (see illustration #1)**



**Illustration #1**

## **4. Installation & Start Up**

Locate & Level.....	4.1
Electrical connection .....	4.2
Clean-up .....	4-3
Start-up .....	4-4
Feeding the granulator .....	4.5

## 4.1 - Locate and Level

Prior to locating the machine check and make sure that the floor is sufficiently strong for the granulator and reasonably straight.

Lift the machine with care, and carefully transport and locate it to the place of use.

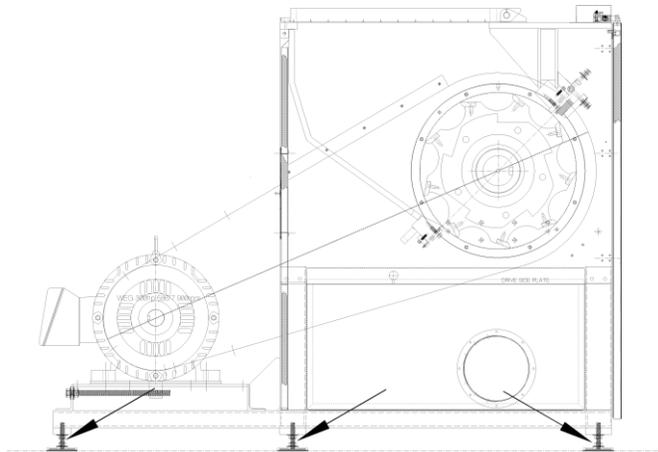
Place the machine in the desired location, and level it (both plains) by raising or lowering the vibration/leveling pads (See **Illustration #2**). All pads should be adjusted to take up load.

Machines equipped with casters and do not need leveling.

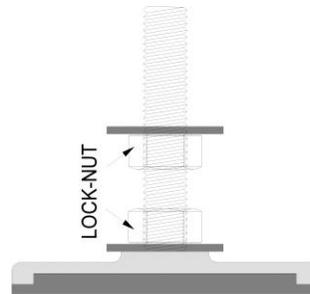
After leveling the machine make sure all the lock-nuts on the vibration/leveling pads are properly tightened.

**Be aware! This granulator is heavy and the weight point is unequal!**

**Before you attempt to lift the machine, see “specifications” section for the weight of your machine.**



**Illustration #2**



**Enlarged view of pad**

## 4.2 - Electrical connection.

**All required electrical work must be done by a qualified electrician.**

Consult electrical schematic.

Connect the machine to an approved disconnect switch which will supply power to the machine (size to be matched to the machine requirements)

Disconnect must be fused type, three (3) pole.

Ensure machine has good ground connection.

Close hopper and lock.

In order to activate safety limit switches, front doors must be closed tight.

Turn power ON, and start machine.

Check for proper rotation of all motors. Turn main power “OFF” and switch supply wiring if any motor is rotating to the wrong direction.

(See **Illustration #3**)

Motor overload has been set to ensure proper motor protection.

**DO NOT ADJUST OVERLOAD SETTINGS**

**If motor stops, do not attempt to restart.**

Check if motor overload is tripped.

Check for loose connections.

Check power supply.

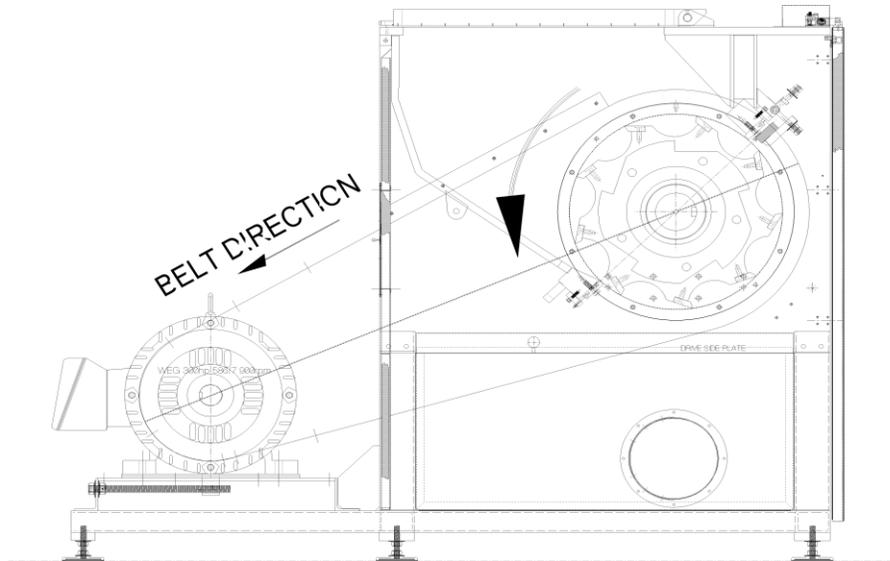
Check fuses.

Check motor connection diagram.

If fault is not found, call an electrician.

**All required electrical work must be done by a qualified electrician.**

**Always operate the machine in a safe manner.**



**DRIVE SIDE THIS SIDE**

**Illustration #3**  
(motor rotation)

### **4.3 - Inspection and Clean-up.**

**Only qualified and competent personnel should be carried out any procedures on this machine.**

Ensure all Limit Switches are engaged.

Ensure all motors are rotating to the right direction.  
(See **Illustration #3**)

Open the front doors (See instructions).

Remove material collection bin and clean it thoroughly  
(See **instructions**).

Unlock and drop the Screen Cradle (See **instructions**).

Disconnect main electrical power and **lock power out.**

### 4.3 - Inspection and Clean-up (continued).

Ensure that the Cutting Chamber of the machine is completely clean and free from any foreign items

Remove any foreign items and blow air through rotor and Cutting Chamber using shop compressed air.

#### **REMEMBER!!!**

**Blades are extremely sharp!!! Great care should be taken to prevent contact with the cutting edge of the blades. Proper gloves should be worn anytime the blades are torqued or handled.**

### 4.4 - Start-up.

Reinstall material collection bin.

Raise and lock Screen Cradle (See instructions).

Close the frond doors tightly.

Make sure all limit switches are properly engaged

Unlock, and switch “ON” electrical power.

Start the granulator.

**Rotogran recommends that ear and eye protection should be used during granulation, by all operators, and personnel working near the machine.**

Allow machine to idle for a half hour, and observe for unusual noises, or excessive vibrations.

If unusual noises occur, investigate to find the source of the noise, by ensuring the belts are properly tensioned, the motor is properly tighten on its base, and all guards are properly fastened..

If excessive vibration occurs, ensure that all Vibration Pads are properly adjusted to carry out load, and locked.

Check the evacuation system, make sure the evacuation route is clear, and the blower is rotating to the right direction.

Your granulator is now ready to go into production.

All personnel associated with the operation, maintenance or service of this machine should be thoroughly trained on the correct use, and the dangers associated with this granulator. Only persons with relevant technical training or corresponding professional experience should be assigned to work on the granulator

#### **4.5 - Feeding material into the granulator..**

Over-feeding your granulator may result in motor overload, jamming of the rotor, or melting of the plastic scrap into the cutting chamber.

Using a variable speed belt conveyor will enable you to control the feeding of the plastic scrap into the granulator. It could also be automated to slow down or stop feeding when the AMPS of the motor reach a preset zone.

In order to prevent blade damage, do not introduce any contaminants into the cutting chamber of the granulator. A metal detection system will prevent any metals from going into the machine.

Confirm that the blower system is properly evacuating the granules from the granule collection bin.

## 5. Safety System.

All Rotogran International Inc. granulators are equipped with safety features to cut-off power if attempt is made to open the doors or the hopper while the machine is operating.

Limit Switch “A” is activated by the drive side door, by an (adjustable) screw after door is firmly closed.

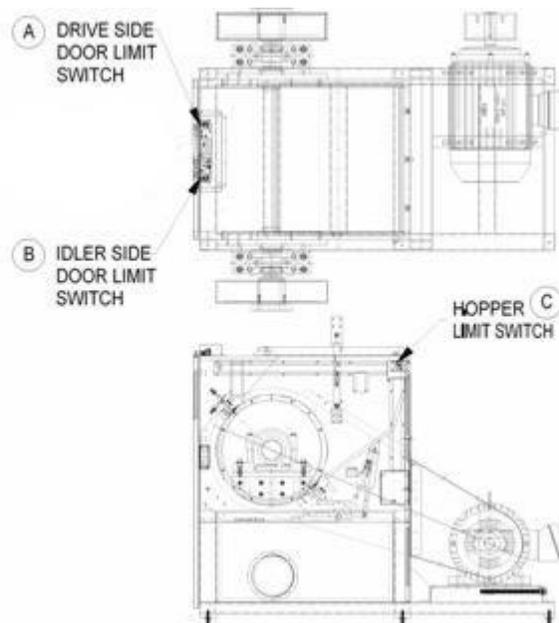
Limit Switch “B” is activated by the idler side door, by an (adjustable) screw after door is firmly closed.

Limit Switch “C” is activated by the hopper, by an (adjustable) screw after hopper is firmly closed and bolted down.

The limit switch adjusting screws are pre adjusted at the factory.

**Never attempt to override the limit switches, or any other safety feature of the granulator.**

**After switching power off, wait for one minute, for the rotor to stop, before opening doors or hopper.**



## **6. Safety Instructions.**

**The following safety instructions should be strictly followed when operating, servicing, or maintaining the granulator.**

- At least one Emergency Stop shall always be at sight and within the operator's reach.
- All electrical connection and wiring to be done by a qualified electrician and according to the local codes.
- Never attempt to bypass the Safety limit switches or any other safety feature or device of the granulator.
- In order to prevent the risk of an explosion, never introduce into the granulator flammable material, or material contaminated with flammable substances or liquids.
- Never allow anyone to enter the cutting chamber, even if power is locked. The rotor will rotate if stepped on, and the blades will pinch body parts, resulting in very serious personal injury.
- Never leave the granulator without proper supervision while the doors are open and the screen cradle lowered. Unauthorized or curious personnel could suffer serious injury if they insert fingers or arms into the cutting chamber.
- All personnel operating, servicing or maintaining the granulator, and all personnel working near the machine. must use eye and ear protection.
- Always use protective gloves when handling the blades. Blades are extremely sharp and could cause serious personal injury if handled improperly..
- Never attempt to stop the rotor by hand when is moving, even when is moving very slowly. The rotor, belts, and flywheels
- are generating great inertia. Failing to observe this safety precaution could result in serious injury.

## 6. Safety Instructions (continued).

In order to avoid serious personal injury, only one person should be allowed to handle the rotation of the rotor during blade change, cleaning the cutting chamber, or inspecting the blades.

- **Blades are extremely hard, and could break if dropped. Always handle blades carefully and always use proper gloves.**
- There is a pinch risk of fingers, between the drive belt and the motor sheave or flywheel, at the inspection and/or tensioning of the drive belts.
- To minimize the risk of slipping maintain the floors around the granulator clean and free from granules.

### **If your machine is equipped with a blower,**

- Never start the blower with out the inlet and outlet pipes installed. **WARNING!** Due to the very high suction power, objects and clothing can easily be sucked into the blower inlet, causing serious injury. Granules and/or other objects which have been sucked into the blower will be thrown out from the outlet port at an extremely high speed, resulting in serious personal injury.

All personnel associated with the operation, maintenance or service of this machine should be thoroughly trained on the correct use, and the dangers associated with this granulator. Only persons with relevant technical training or corresponding professional experience should be assigned to work on the granulator.

## **7. General Maintenance.**

- 1. Daily Inspection .....7.1**
- 2. Monthly Inspection .....7.2**
- 3. Three months inspection. ....7.3**
- 4. Six months or 2000 hours inspection.....7.4**

## 7.1 - Daily inspection

Your machine should be inspected daily for loose external fasteners. **Tighten any loose bolts.**

Your machine should be inspected daily for unusual noises. **Locate the noise source and repair accordingly.**

Your machine should be inspected daily for unusual vibrations. **Inspect Vibration Pads, adjust and tighten accordingly.**  
(See Illustration #2)

Your machine should be inspected daily for excessive heat on the cutting chamber sides and bearings. **Locate source and repair accordingly.**

Check for oil leaks from the hydraulic system. **If oil is leaking, repair accordingly**

Make sure the area around the machine is always clean and the floor is free from granules. Granules make the floors very slippery.

Wipe/Blow clean all external surfaces of the granulator.

**Rotogran recommends that ear and eye protection should be used during granulation, by all operators, and personnel working near the machine.**

Reasonable care and simple preventive maintenance, will maintain efficiency, longer life and minimum down time. Maximize the performance of your granulator, by using it properly, and giving it the proper care.

## 7.2 - Monthly inspection.

Visually inspect the sharpness of your blades every month, or every 250 hours of operation.. **Remember!** Sharp blades set to the proper gap will cut the material, instead of tearing it, resulting in cleaner granules and less fines.  
Re-sharpen blades as necessary (See section # 9-3)

Visually inspect the screen and clean any holes that have been plugged with plastic. The holes must be round. If the holes are elongated it is time to replace the screen.

Inspect the drive belts for tension and condition, and adjust or replace them if necessary (See section # 10)

### **7.3 - Three month inspection.**

Grease the bearings (See instructions and grease properties)  
**Never over grease the bearings. Over greased bearings will over heat, resulting in seal breakage, leak of the liquefied grease, and seizing of the bearings.**

Visually inspect the condition of the motor.

Listen for unusual noises.

Make sure the air intake grill is clean and unobstructed.

Grease the bearings following the manufacturer's instructions.

Ensure all fastening hardware is properly tightened.

Ensure motor adjusting screws are tightened.

### **7.4 - Six months or 2000 hour inspection.**

Visually inspect the whole granulator externally.

Look for any loose items and tighten as necessary.

Stop the machine, disconnect, and lock-out power.

**Open the doors (See instructions Section # 8.1 ).**

Remove material collection bin.

**Unlock and lower screen cradle (See instructions section #8.2).**

Visually inspect cutting chamber and rotor for unusual wear.

Check condition, and torque all blade bolts.  
(See chart #13 for torque values).

Ensure all blade adjusting screws are properly tightened  
(See Instructions # 15 section#9).

**REMEMBER!!!**

**Blades are extremely sharp!!! Great care should be taken to prevent contact with the cutting edge of the blades. Proper gloves should be worn anytime the blades are torqued or handled.**

Clean-up cutting chamber and rotor by blowing through, shop compressed air.

Raise screen cradle (See instructions section # 9.4).

Insert lock pins and tighten all bolts  
(See Illustration #5 section #8).

Insert material collection bin.

Close doors firmly making sure the limit switches are activated.

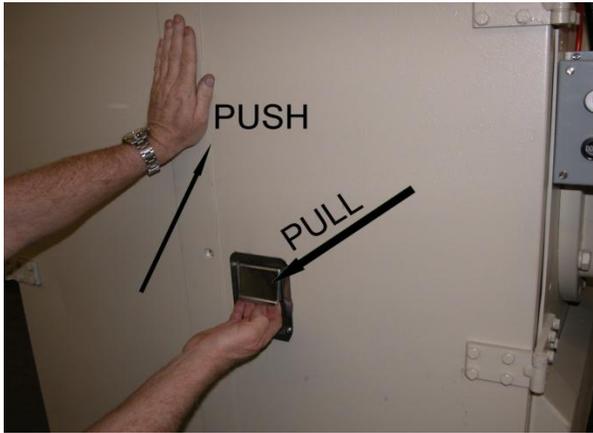
Unlock power and start the machine.

## **8. Service.**

<b>Opening procedure .....</b>	<b>8.1</b>
<b>Removing the Cradle .....</b>	<b>8.2</b>
<b>Closing procedure .....</b>	<b>8.3</b>
<b>Removing the Rotor Blade .....</b>	<b>8.4</b>
<b>Removing the Bed Blades.....</b>	<b>8.5</b>

## 8.1 - Opening procedure.

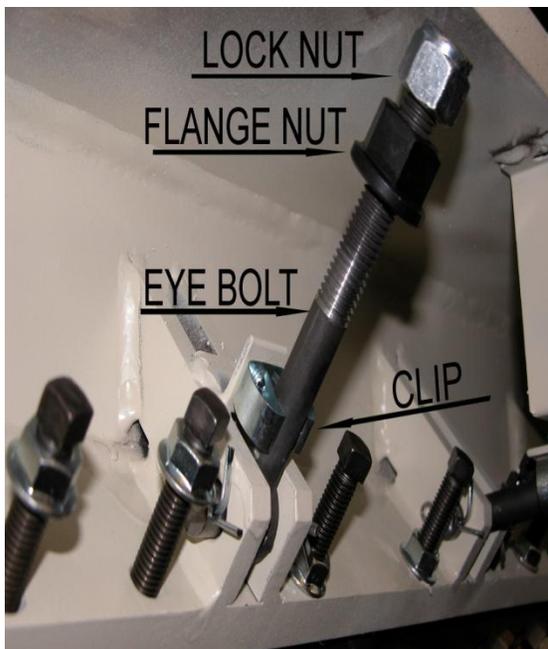
- Stop granulator. **Disconnect and lock-out power.**
- Wait for the rotor to stop (approximately one minute).
- Push doors in with one hand, and pull the latch with the other (**See Illustration # 4**).
- Open both doors all the way.
- Clean plastic off the screen and cradle.
- Remove material collection bin.
- Lift up and pull inwards both cradle lock pins (**See Illustration # 5**).
- Remove all lock nuts, loosen all flange nuts, and push all eyebolts into their corresponding spring clips (**See Illustration # 6**).
- Go to the hydraulic control box (**Illustration # 7**), and push the “**DOWN**” Button until **screen cradle** is all the way to the down. position (**Illustration # 8**).  
**Only if your machine is equipped with hydraulics.**
- If your machine is not equipped with hydraulics, carefully lower screen cradle all the way to the down position and pull it out by following the instructions in section **8.2**
- The machine is now open, and ready for service.



**Illustration # 4**



**Illustration # 5**



**Illustration # 6**



**Illustration # 7**



**Illustration # 8**



**Illustration # 8A**



**Illustration # 9**



**Illustration # 10**

## **8.2 - Removing Screen and Cradle.**

- **Lift Screen out of the Cradle and place it safely away from the granulator (See Illustration #8A).**
- **Remove Access cover from the back panel of the machine, and remove the (2) pins that hold the hydraulic cylinders onto the Cradle (only if your machine is equipped with hydraulics) (See Illustration # 9).**
- **Remove the Cradle by unhooking it from the Cradle hinges, and pull it out of the machine. (See Illustration #10).**

### 8.3 - Closing procedure.

- Make sure the cutting chamber and all other areas inside the granulator are cleared from granules and/or any other matters.
- Install the Cradle on the Cradle hinges, and insert cylinder pins through the rear access opening. **(only if your machine is equipped with hydraulics)**
- Install access cover in the back panel of the machine. **(only if your machine is equipped with hydraulics)**
- Unlock and connect electrical power.  
Go to the hydraulic control box and push the “UP” button until cradle is all the way up **(only if your machine is equipped with hydraulics)**  
**(See Illustration # 11).**
- **If your machine is not equipped with hydraulics, do not connect electrical power, until you carefully lift screen cradle all the way up and lock it.**  
**(See Illustration # 12).**
- **Push down all eyebolts into their corresponding slots and start gradually tightening the nuts, switching from one to another, until the cradle locating pins can easily be hand pushed into their corresponding holes.**  
**(See Illustration # 12).**
- **Push locating pins all the way into the hole and push the pin handle downwards into the slot.**  
**(See Illustration #12).**
- **Insert material collection bin.**
- **Close drive side door first.**
- **Close idler side door tightly.**
- **Start machine.**
- **The machine is now closed and ready for production.**

All installation work, electrical interconnections, startup of the machine, and other servicing work should be carried out by persons with relevant technical training or corresponding professional experience.



**Illustration # 11**



**Illustration # 12**

## **9. Remove, Set, and Install Blades.**

### **9.1 - Removing the Rotor Blades.**

#### **REMEMBER!!!**

**Always remove Rotor Blades first.**

**Blades are extremely sharp!!! Great care should be taken to prevent contact with the cutting edge of the blades.**

**Proper gloves should be worn anytime the blades are torqued or handled.**

#### **CAUTION!!!**

**Extreme caution must be taken when Rotor Blades are removed or installed.**

**Adding or subtracting Blades is changing the balance of the Rotor, and the Rotor will rotate with the DANGER of causing extreme personal injury.**

- **Open granulator by following the instructions in section 8.2 of this Manual.**
- **Turn rotor to the position most comfortable and safe to use a socket.**
- **Using wood blocks to prevent Rotor from turning during un tightening of the bolts, block the Rotor as shown (See Illustration # 13).**
- **Break loose all bolts in the front row. Hold each blade from the bottom, (opposite the sharp edge), remove the bolts one at the time, and place the blade in a safe place. (See Illustration # 13A and 14).**
- **Repeat the above procedure for the remaining rows of blades, by removing the wood, repositioning the rotor to gain access to the next row of Blades, and blocking it with the same wood blocks to prevent it from rotating.**

**CAUTION!!!**

**Extreme caution must be taken when Rotor Blades are removed or installed. Adding or subtracting Blades is changing the balance of the Rotor, and the Rotor will rotate with the DANGER of causing extreme personal injury.**



**Illustration # 13**

**Illustration # 13A**



**Illustration # 14**

**9.2 - Removing the Bed Blades.**

**REMEMBER!!!**

**Always remove all Rotor Blades first.**

**Blades are extremely sharp!!! Great care should be taken to prevent contact with the cutting edge of the blades.**

**Proper gloves should be worn anytime the blades are torqued or handled.**

- After removing all Rotor Blades, turn rotor to the position most comfortable and safe to use a socket.
- Remove all Blade adjusting screws situated over the top Blade Block, and break loose all bolts holding the Blades. (See **Illustration #15**). Hold each blade from the bottom, (opposite the sharp edge), remove the bolts one at the time, and place the blade in a safe place.
- Remove screen cradle (see instructions section 8.2)
- Repeat the above procedure for the bottom Blade Block (See **Illustration #16**).



**Illustration #15**



**Illustration #16**

### **9.3 - Sharpening the Blades.**

- All Rotogran International Inc. Blades are made from **D2** tool steel, are totally hardened to 58/59 Rc., double drawn, Cryogenically treated, and precision ground.
- Re-sharpening the Blades should be done by an experienced Blade sharpening company.
- Heat is developed during the sharpening process. If the Blades are not properly cooled the heat will burn and soften the cutting edges. A soft edge will result in dull Blades within minutes of operation.

## Sharpening the Blades (continued).

- A proper Blanchard grinding machine, with the proper grinding stones, is required to properly sharpen the granulator Blades.
- Grind only the marked surfaces, and observe the minimum dimensions the Blades could be ground to.  
**Illustration #17, and chart Section #13-3**

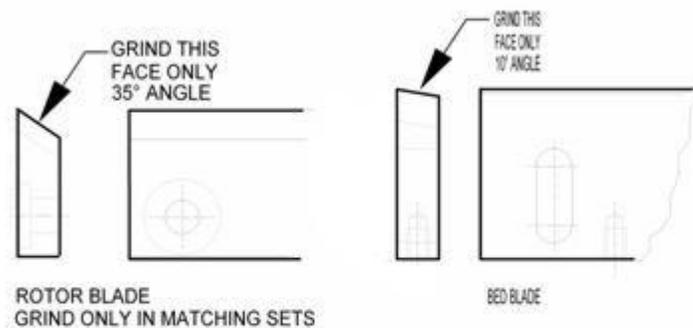


Illustration #17

- In order to maintain accuracy, all Rotor Blades should be ground together, as a set, and in one set-up. If the width of all Rotor Blades is not exactly the same, it will be impossible to set the proper gap ( $\pm 0.008$  to  $0.010$ ) between the Rotor and Bed Blades.
- **In order to minimize down time always have a spare set of Blades (Rotor and Bed) sharpen and stored.**
- While stored, always protect the cutting edge of the sharpen blades by applying tape on it. Also a rust inhibitor agent should be applied on all Blade surfaces.

## 9.4 - Installing and Setting all Blades.

### **REMEMBER!!!**

**Always install bed Blades first.**

**Blades are extremely sharp!!! Great care should be taken to prevent contact with the cutting edge of the blades.**

**Proper gloves should be worn anytime the blades are torqued or handled.**

Each Rotogran International Inc. granulator is equipped with two sets of Blades. One set of Stationary (**Bed Blades**), and one set of Rotating (**Rotor Blades**).

### **CAUTION!!!**

**Extreme caution must be taken when Rotor Blades are removed or installed. Adding or subtracting Blades is changing the balance of the Rotor, and the Rotor will rotate with the DANGER of causing extreme personal injury.**

- **Wipe clean all Blades and bring them close to the granulator.**
- **Inspect and clean all Blade seats, tapped holes, and bolts.**
- **Place the Bed Blades, one at the time, in their respective position and install all the bolts, finger tight.**
- **Install all the Bed Blade set screws, finger tight, pushing the Blades as far back as the slot allows..**
- **Turn rotor to a position most comfortable and safe to use a socket.**
- **Using wood blocks to prevent Rotor from turning during tightening of the bolts block the Rotor as shown (See **Illustration #13**).**
- **Hold each Rotor Blade from the bottom (See **Illustration #14**), place it in position, and insert the mounting bolts finger tight.**
- **ALL ROTOR BLADES HAVE A FIXED SEAT POSITION AND CAN NOT BE ADJUSTED.**

**Blades are extremely sharp!!! Great care should be taken to prevent contact with the cutting edge of the blades. Proper gloves should be worn anytime the blades are torqued or handled.**

- Tight all bolts lightly and then tap each Blade with a lead mallet to ensure proper seating against the Rotor,
- Using a properly calibrated torque wrench, torque all the bolts to the specified torque (**See Torque Specifications**).
- Remove all blocks of wood used to prevent Rotor from Turning.
- Move the Bed Blades within 1/16" from the Rotor Blades and tight all the bolts lightly.
- Tightening or loosening the set screws to push or pull the Blades, adjust the clearance between the Bed, and the Rotor Blades to 0.008" to 0.010", using a filler gage to confirm the gap (**See Illustration #15 and 15A**).

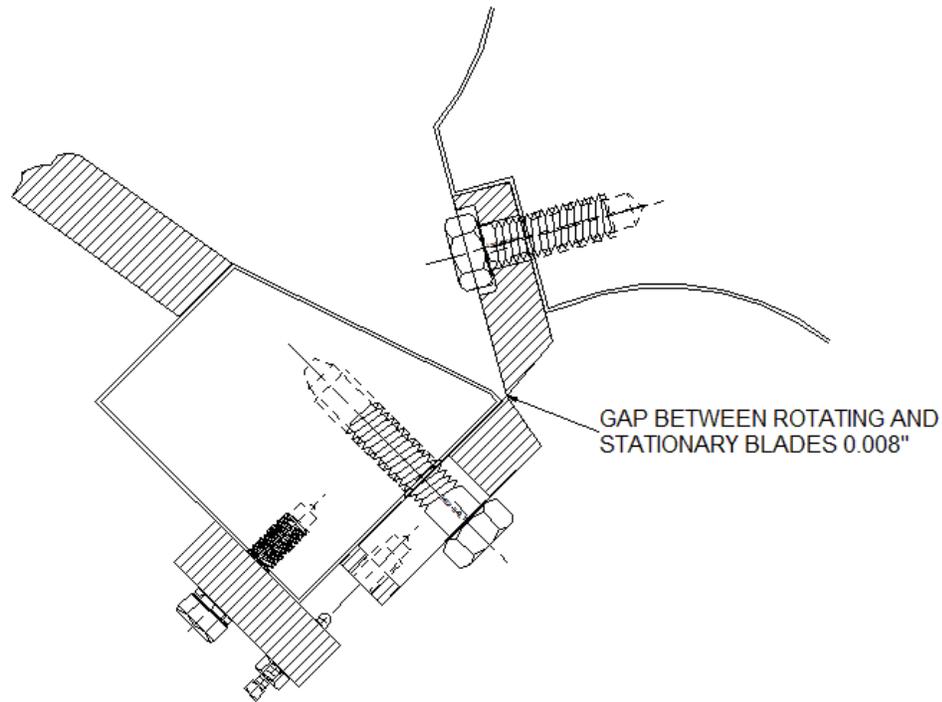


**Illustration #15**

- Using a properly calibrated torque wrench, torque all the bolts to the specified torque (**See Torque Specifications**).

To avoid chipping the Blades during the gap adjusting process, rotate the Rotor only backwards (Counter-clockwise looking at the Rotor from the driven flywheel).

**NOTE:** Every time there is a Blade change, replace any bolts that are damaged. Replace all bolts every third (3<sup>rd</sup>) Blade change.



**Illustration 15A**

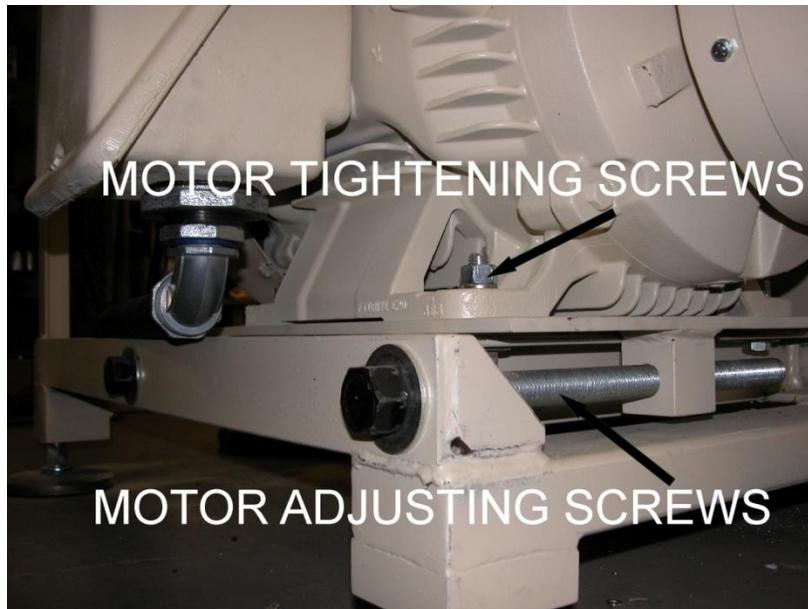
**VERY IMPORTANT!!!**

**All bolts must be tightened to the recommended torque. (See Torque Specifications below). A properly calibrated Torque Wrench MUST be used to tighten all Blade holding bolts.**

**If a torque wrench is not used to tighten the bolts, or if bolts are not tightened to the specified torque, they might become loose during granulation and damage the blades and/or the machine.**

**Use only certified grade 9 high strength bolts for mounting the Blades. The use of uncertified or inferior bolts will result in false torque readings and/or damage to the Rotor's tapped holes.**

## 10. Removing, Installing and Tensioning Drive Belts.



**Illustration 16**

- **Disconnect, and lock-out electrical power.**
- **Remove the belt guard.**
- **Loosen all (4) Motor tightening Screws (See Illustration #16).**
- **Turn the Motor Adjusting Screws, evenly, counter clock wise, pushing the motor as far as the slots on the motor base will allow (See Illustration #16).**
- **Remove the old belts carefully, keeping hands away from the flywheel or the motor sheave. CAUTION!!! PINCH RISK.**
- **Install new belts keeping hands away from the flywheel or the motor sheave. CAUTION!!! PINCH RISK.**

## Removing, Installing, and Tensioning drive belts, continued

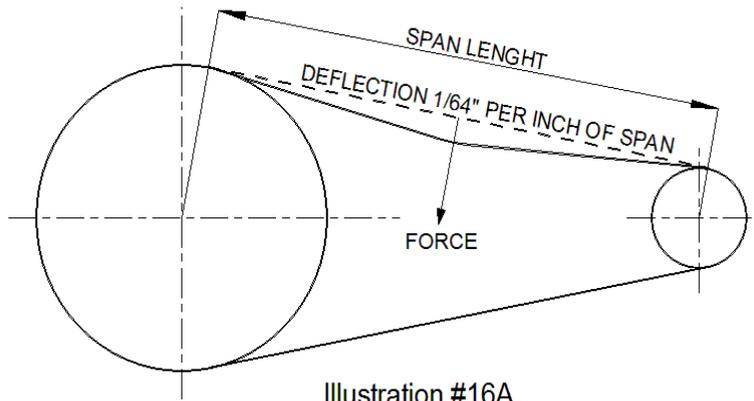


Illustration #16A

- Turn the Motor Adjusting Screws clock wise, pulling the motor evenly until the drive Belts are tighten (See **Illustration #16 and 16A**).
- Load each belt midway between flywheel and motor sheave as noted on **load chart page 13.4**).
- All guards **MUST** be installed before electrical power is connected to the machine.
- **NEVER** operate the granulator with the guards removed.

The key to long, efficient trouble free belt operation is proper tension. If belts are too loose the result is slippage, rapid belt and sheave wear. Conversely, too much tension imposes excessive strain on belts, bearings and adjacent drive components, resulting in premature wear of one, or all of the drive parts. The proper tension is the lowest tension at which the belts won't slip or "squeal" under peak load.

**Run machine for ten (10) minutes to seat the belts and then re-check the tension as per chart page 13.4.**

## **11. Spare parts (recommended).**

**In order to minimize down time, the following spare parts are recommended to be purchased with the Granulator. Use only genuine parts from Rotogran International Inc. Call (905) 738-0101 or e-mail to [info@rotogran.com](mailto:info@rotogran.com)**

**When ordering please have the following information ready:**

- **Machine Model.**
  - **Machine Serial number.**
- 
- **Door Limit switch –Drive side.**
  - **Door Limit Switch – Idler side.**
  - **Door Limit Switch – Hopper.**
  - **Drive Belts**
  - **Rotor Blade bolts.**
  - **Bed Blade bolts.**
  - **Complete set of Blades.**
  - **Screen**

## 12. Troubleshooting

### ➤ **If granulator does not start:**

- ✓ **Make sure both front doors are shut tight.**
- ✓ **Make sure limit switch activating screws (front doors and hopper) are properly adjusted.**
- ✓ **Make sure there is electrical power supply to the machine.**
- ✓ **Make sure the Emergency Stop is de-activated.**
- ✓ **Have a qualified electrician to check electrical panel for loose wires or burned fuses.**

### ➤ **Excessive vibrations during granulation:**

- ✓ **Make sure all vibration pads are properly tighten and all of them carry load.**
- ✓ **Inspect the condition of all Blades. If are dull, it is time to re-sharpen them.**
- ✓ **Check the gap between the rotor and bed blades and adjust as per chart 13.1**
- ✓ **Ensure all blades are tightened to the proper torque. Bed blades and rotor blades should be tightened as per specs on chart 13.1**
- ✓ **By using of a torque wrench, ensure all flywheel fastening bolts are tight. Torques values as per bushing manufacturer's spec.**
- ✓ **Ensure motor sheave is properly tightened.**
- ✓ **Ensure motor fastening and adjusting bolts are properly tightened.**

### ➤ **Hearing unusual noises during granulation:**

- ✓ **Stop granulator immediately, lock-out power and open, (see instructions section # 8).**

## Troubleshooting continued

- ✓ Inspect cutting chamber for contaminants.
- ✓ Inspect the condition of the Blades. If Blades are heavily chipped, may be foreign items have been introduced into the cutting chamber.
- ✓ Completely clean the cutting chamber, and replace blades if necessary.
- ✓ Ensure all drive belts are in good condition and properly tensioned (see Illustration #16A). Replace if necessary.
- ✓ Inspect the bearings for excessive heat. If bearings are not properly greased they may dry and seized. (See instructions for bearing lubrication).

All personnel associated with the operation, maintenance or service of this machine should be thoroughly trained on the correct use, and the dangers associated with this granulator. Only persons with relevant technical training or corresponding professional experience should be assigned to work on the granulator.

Reasonable care and simple preventive maintenance, will maintain efficiency, longer life and minimum down time. Maximize the performance of your granulator, by using it properly, and giving it the proper care.

# 13. Torque Specifications

ALL TORQUES ARE IN FT-LBS

## 13.1 Torque specifications, and clearance (gap) for stationary and rotor blades.

Granulator model #	Stationary blade bolt	Rotating (rotor) blade	Blade Gap
WO-1418	160	165	0.006"
WO-1424	160	165	0.006"
WO-1430	160	165	0.006"
WO-1442	160	165	0.006"
WO-1456	160	165	0.006"
WB-1460	160	165	0.006"
WO-2224	165	175	0.006"
WO-2236	165	175	0.006"
WO-2248	165	175	0.006"
WO-3036	175	270	0.008"
WO-3052	175	270	0.008"
WO-3065	175	270	0.008"

## 13.2 Minimum width for blade grinding.

Granulator model #	Stationary blade		Rotating (rotor)		
	NEW	MIN	NEW	MIN	
WO-1418	2.625"	2.187"	3.000"	2.562"	
WO-1424	2.562"	2.312"	3.000"	2.562"	
WO-1430	2.562"	2.312"	3.000"	2.562"	
WO-1442	2.562"	2.312"	3.000"	2.562"	
WO-1456	2.562"	2.312"	3.000"	2.562"	
WB-1460	2.562"	2.312"	3.000"	2.562"	
WO-2224	3.000"	2.625"	2.500"	2.062"	
WO-2236	3.000"	2.625"	2.500"	2.062"	
WO-2248	3.000"	2.625"	2.500"	2.062"	
WO-3036	4.000"	3.625"	3.500"	3.062"	
WO-3052	4.000"	3.625"	3.500"	3.062"	
WO-3065	4.000"	3.625"	3.500"	3.062"	

## 13.3 Torque specifications flywheel bolts.

Granulator model #	Bushing style	Bolt size	Torque Ft/lbs
WO-1418	"F"	9/16"	75
WO-1424	"F"	9/16"	75
WO-1430	"J"	5/8"	135
WO-1442	"J"	5/8"	135
WO-1456	"J"	5/8"	135
WB-1460	"J"	5/8"	135
WO-2224	"M"	3/4"	225
WO-2236	"M"	3/4"	225
WO-2248	"M"	3/4"	225

WO-3036	“P”	1”	450
WO-3052	“P”	1”	450
WO-3065	“P”	1”	450

13.4 Belt Tensioning load chart.		Recommended deflection and force (Lbs)			
Granulator	Span	Initial Installation		Retensioning	
Model #	Length	Deflection		Maximum	Minimum
WO-1418	30"	0.468"	16.5 Lbs	14.3 Lbs	11.0 Lbs
WO-1424	30"	0.468"	16.5 Lbs	14.3 Lbs	11.0 Lbs
WO-1430	30"	0.468"	16.5 Lbs	14.3 Lbs	11.0 Lbs
WO-1442	32"	0.468"	16.5 Lbs	14.3 Lbs	11.0 Lbs
WO-1456	34"	0.468"	16.5 Lbs	14.3 Lbs	11.0 Lbs
WB-1460	34"	0.680	16.5 Lbs	14.3 Lbs	11.0 Lbs
WO-2224	39-1/2"	0.616"	16.5 Lbs	14.3 Lbs	11.0 Lbs
WO-2236	43-5/8"	0.680"	16.5 Lbs	14.3 Lbs	11.0 Lbs
WO-2248	43-5/8"	0.680"	16.5 Lbs	14.3 Lbs	11.0 Lbs
WO-3036	54"	0.842"	16.5 Lbs	14.3 Lbs	11.0 Lbs
WO-3052	54"	0.842"	16.5 Lbs	14.3 Lbs	11.0 Lbs
WO-3065	54"	0.842"	16.5 Lbs	14.3 Lbs	11.0 Lbs

## 11. Lubrication

### 11.1 Lubrication of rolling bearings

The purpose of bearing lubrication is to prevent direct metallic contact between the various rolling and sliding elements. This is accomplished through the formation of a thin oil (or grease) film on the contact surfaces. However, for rolling bearings, lubrication has the following advantages:

- (1) **Friction and wear reduction**
- (2) **Friction heat dissipation**
- (3) **Prolonged bearing life**
- (4) **Prevention of rust**
- (5) **Protection against harmful elements**

In order to achieve the above effects, the most effective lubrication method for the operating conditions must be selected. Also, a good quality, reliable lubricant must be selected. In addition, an effectively designed sealing system that prevents the intrusion of damaging elements

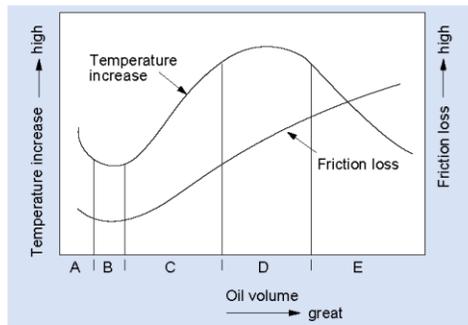


Fig. 11.1

Table 11.1 Oil volume, friction loss, bearing temperature (See Fig. 11.1)

Range	Characteristics	Lubrication method
A	When oil volume is extremely low, direct metallic contact occurs in places between the rolling elements and raceway surfaces. Bearing abrasion and seizing occur.	—
B	A thin oil film develops over all surfaces, friction is minimal and bearing temperature is low.	Grease lubrication, oil mist, air-oil lubrication
C	As oil volume increases, heat buildup is balanced by cooling.	Circulating lubrication
D	Regardless of oil volume, temperature increases at a fixed rate.	Circulating lubrication
E	As oil volume increases, cooling predominates and bearing temperature decreases.	Forced circulation lubrication, Oil jet lubrication

(dust, water, etc.) into the bearing interior, removes dust and other impurities from the lubricant, and prevents the lubricant from leaking to the outside, is also a requirement.

Almost all rolling bearings use either grease or oil lubrication methods, but in some special applications, a solid lubricant such as molybdenum disulfide or graphite may be used.

Fig. 11.1 shows the relationship between oil volume, friction loss, and bearing temperature. Table 11.1 details the characteristics of this relationship.

### 11.2 Lubrication methods and characteristics

The lubrication methods come in **two general methods**: you must be care for select of that from using condition.

The characteristic are show in table 11.2.

Table 11.2 Comparison of grease lubrication and oil lubrication characteristics

Method	Grease lubrication	Oil lubrication
Concern		
Handling	◎	△
Reliability	○	◎ (Circulation necessary)
Cooling effect	×	○ (Circulation necessary)
Seal structure	○	△
Power loss	○	○
Environment contamination	○	△
High speed rotation	×	○

◎ : Very good ○ : Good △ : Fair × : Poor

### 11.3 Grease lubrication

Grease type lubricants are relatively easy to handle and require only the simplest sealing devices-for these reasons, grease is the most widely used lubricant for rolling bearings.

#### 11.3.1 Types and characteristics of grease

Lubricating grease are composed of either a mineral oil base or a synthetic oil base. To this base a thickener and other additives are added. The properties of all greases are mainly determined by the kind of base oil used and by the combination of thickening agent and various additives.

Standard greases and their characteristics are listed in Table 11.3. As performance characteristics of even the same type of grease will vary widely from brand to brand, **it is best to check the manufacturers' data when selecting a grease.**

Table 11.3 Grease varieties and characteristics

Grease name	Lithium grease			Sodium grease (Fiber grease)	Calcium compound base grease
Thickener	Li soap			Na soap	Ca+Na soap Ca+Li soap
Base oil	Mineral oil	Diester oil	Silicone oil	Mineral oil	Mineral oil
Dropping point °C	170 ~ 190	170 ~ 190	200 ~ 250	150 ~ 180	150 ~ 180
Operating temperature range °C	-30 ~ +130	-50 ~ +130	-50 ~ +160	-20 ~ +130	-20 ~ +120
Mechanical stability	Excellent	Good	Good	Excellent ~ Good	Excellent ~ Good
Pressure resistance	Good	Good	poor	Good	Excellent ~ Good
Water resistance	Good	Good	Good	Good ~ poor	Good ~ poor
Applications	Widest range of applications. Grease used in all types of rolling bearings.	Excellent low temperature and wear characteristics. Suitable for small sized and miniature bearings.	Suitable for high and low temperatures. Unsuitable for heavy load applications due to low oil film strength.	Some emulsification when water is introduced. Excellent characteristics at relatively high temperatures.	Excellent pressure resistance and mechanical stability. Suitable for bearings receiving shock loads.

Grease name	Aluminum grease	Non-soap base grease Thickener	
Thickener	Al soap	Bentone, silica gel, urea, carbon black, fluorine compounds, etc.	
Base oil	Mineral oil	Mineral oil	Synthetic oil
Dropping point °C	70 ~ 90	250 or above	250 or above
Operating temperature range °C	-10 ~ +80	-10 ~ +130	-50 ~ +200
Mechanical stability	Good ~ poor	Good	Good
Pressure resistance	Good	Good	Good
Water resistance	Good	Good	Good
Applications	Excellent viscosity characteristics. Suitable for bearings subjected to vibrations.	Can be used in a wide range of low to high temperatures. Shows excellent heat resistance, cold resistance, chemical resistance, and other characteristics when matched with a suitable base oil and thickener. Grease used in all types of rolling bearings.	

**(1) Base oil**

Natural mineral oil or synthetic oils such as diester oil, silicone oil and fluorocarbon oil are used as grease base oils.

Mainly, the properties of any grease is determined by the properties of the base oil. Generally, greases with a low viscosity base oil are best suited for low temperatures and high speeds; while greases made from high viscosity base oils are best suited for heavy loads.

**(2) Thickening agents**

Thickening agents are compounded with base oils to maintain the semi-solid state of the grease. Thickening agents consist of two types of bases, metallic soaps and non-soaps. Metallic soap thickeners include: lithium, sodium, calcium, etc.

Non-soap base thickeners are divided into two groups; inorganic (silica gel, bentonite, etc.) and organic (poly-urea, fluorocarbon, etc.).

The various special characteristics of a grease, such as limiting temperature range, mechanical stability, water resistance, etc. depend largely on the type of thickening agent used. For example, a sodium based grease is generally poor in water resistance properties, while greases with bentone, poly-urea and other non-metallic soaps as the thickening agent are generally superior in high temperature properties.

**(3) Additives**

Various additives are added to greases to improve various properties and efficiency. For example, there are anti-oxidents, high-pressure additives (EP additives), rust preventives, and anti-corrosives.

For bearings subject to heavy loads and/or shock loads, a grease containing high-pressure additives should be used. For comparatively high operating temperatures or in applications where the grease cannot be replenished for long periods, a grease with an oxidation stabilizer is best to use.

**(4) Consistency**

The consistency of a grease, i.e. the stiffness and liquidity, is expressed by a numerical index.

The NLGI values for this index indicate the relative softness of the grease; the larger the number, the stiffer the grease. The consistency of a grease is determined by the amount of thickening agent used and the viscosity of the base oil. For the lubrication of rolling bearings, greases with the NLGI consistency numbers of 1, 2, and 3 are used.

General relationships between consistency and application of grease are shown in **Table 11.4**.

**Table 11.4 Consistency of grease**

NLGI Consistency No.	JIS (ASTM) Worked penetration	Applications
0	355~385	For centralized greasing use
1	310~340	For centralized greasing use
2	265~295	For general use and sealed bearing use
3	220~250	For general and high temperature use
4	175~205	For special use

**(5) Mixing of greases**

When greases of different kinds are mixed together, the consistency of the greases will change (usually softer), the operating temperature range will be lowered, and other changes in characteristics will occur. As a general rule, greases with different bases oil, and greases with different thickener agents should never be mixed.

Also, greases of different brands should not be mixed because of the different additives they contain.

However, if different greases must be mixed, at least greases with the same base oil and thickening agent should be selected. But even when greases of the same base oil and thickening agent are mixed, the quality of the grease may still change due to the difference in additives. For this reason, changes in consistency and other qualities should be checked before being applied.

**11.3.2 Amount of grease**

The amount of grease used in any given situation will depend on many factors relating to the size and shape of the housing, space limitations, bearing's rotating speed and type of grease used.

As a general rule, housings and bearings should be only filled from 30% to 60% of their capacities.

Where speeds are high and temperature rises need to be kept to a minimum, a reduced amount of grease should be used. Excessive amount of grease cause temperature rise which in turn causes the grease to soften and may allow leakage. With excessive grease fills oxidation and deterioration may cause lubricating efficiency to be lowered.

Moreover, the standard bearing space can be found by formula (11.1)

$$V = K \cdot W \dots\dots\dots (11.1)$$

where,

V: Quantity of bearing space open type (approx.) cm<sup>3</sup>

K: Bearing space factor (**Table 11.5**)

W: Mass of bearing kg

Table 11.5 Bearings space ratio  $K$

Bearing type	Retainer type	$K$
Ball bearings ❶	Pressed retainer	61
NU-type cylindrical roller bearings ❷	Pressed retainer	50
	Machined retainer	36
N-type cylindrical roller bearings ❸	Pressed retainer	55
	Machined retainer	37
Tapered roller bearings	Pressed retainer	46
Spherical roller bearings	Pressed retainer	35
	Machined retainer	28

- ❶ Remove 160 series
- ❷ Remove NU4 series
- ❸ Remove N4 series

11.3.3 Replenishment

As the lubricating efficiency of grease declines with the passage of time, fresh grease must be re-supplied at proper intervals. The replenishment time interval depends on the type of bearing, dimensions, bearing's rotating speed, bearing temperature, and type of grease.

An easy reference chart for calculating grease replenishment intervals is shown in Fig. 11.2.

This chart indicates the replenishment interval for standard rolling bearing grease when used under normal operating conditions.

As operating temperatures increase, the grease re-

supply interval should be shortened accordingly.

Generally, for every 10°C increase in bearing temperature above 80°C, the relubrication period is reduced by exponent "1/1.5".

(Example)

Find the grease relubrication time limit for deep groove ball bearing 6206, with a radial load of 2.0 kN operating at 3,600 r/min.

$C_1 I P_r = 19.5/2.0 \text{ kN} = 9.8$ , from Fig. 9.1 the adjusted load,  $f_{Li}$ , is 0.96.

From the bearing tables, the allowable speed for bearing 6206 is 11,000 r/min and the numbers of revolutions permissible at a radial load of 2.0 kN are

$$n_o = 0.96 \times 11,000 = 10,560 \text{ r/min}$$

therefore,  $\frac{n_o}{n} = \frac{10,560}{3,600} = 2.93$

Using the chart in Fig. 11.2, find the point corresponding to bore diameter  $d = 30$  (from bearing table) on the vertical line for radial ball bearings. Draw a straight horizontal line to vertical line I. Then, draw a straight line from that point (A in example) to the point on line II which corresponds to the  $n_o / n$  value (2.93 in example). The point, C, where this line intersects vertical line III indicates the relubrication interval  $h$ . In this case the life of the grease is approximately 5,500 hours.

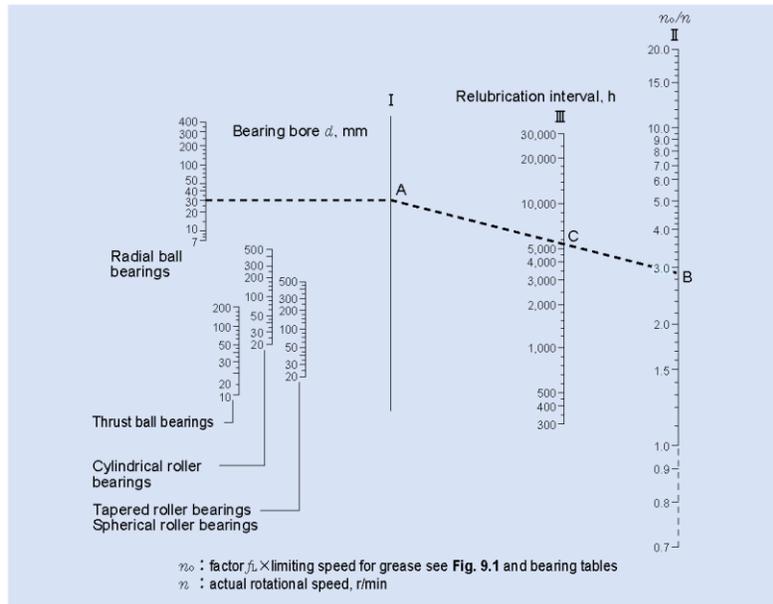


Fig. 11.2 Diagram for relubrication interval of greasing

**11.4 Solid grease (For bearings with solid grease)**

"Solid grease" is a lubricant composed mainly of lubricating grease and ultra-high polymer polyethylene. Solid grease has the same viscosity as grease at normal temperature, but by applying a special heat treatment process, this special grease solidifies retaining a large proportion of the lubricant within the bearing. The result of this solidification is that the grease does not easily leak from the bearing, even when the bearing is subjected to strong vibrations or centrifugal force.

Bearings with solid grease are available in two types: the spot-pack type in which solid grease is injected into the retainer, and the full-pack type in which all empty space around the rolling elements is filled with solid grease.

Spot-pack solid grease is standard for deep groove ball bearings, small diameter ball bearings, and bearing units. Full-pack solid grease is standard for self-aligning ball bearings, spherical roller bearings, and needle roller bearings.

Primary advantages:

- (1) Clean working environment with minimal grease leakage
- (2) Low bearing torque with spot-pack type solid grease

For more details, please refer to NTN special catalog of **Solid grease bearings**.

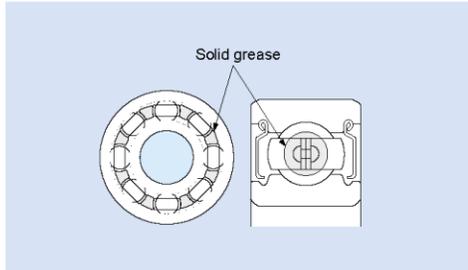


Fig. 11.3 Deep groove ball bearing with spot-pack solid grease (Z shield) (Standard for deep groove ball bearings)

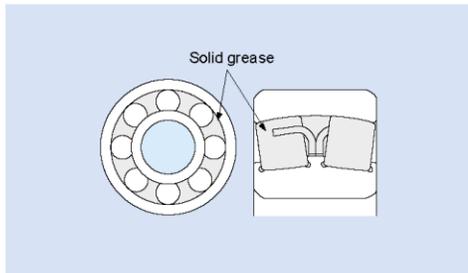


Fig. 11.4 Spherical roller bearing with full-pack solid grease (Standard for spherical roller bearings)

**11.5 Oil lubrication**

Oil lubrication is suitable for applications requiring that bearing-generated heat or heat applied to the bearing from other sources be carried away from the bearing and dissipated to the outside. **Table 11.6** shows the main methods of oil lubrication.

**11.5.1 Selection of lubricating oil**

Under normal operating conditions, **spindle oil, machine oil, turbine oil**, and other mineral oils are widely used for the lubrication of rolling bearings. However, for temperatures **above 150°C or below -30°C**, synthetic oils such as **diester oil, silicone oil, and fluorocarbon oil** are used.

For lubricating oils, viscosity is one of the most important properties and determines an oil's lubricating efficiency. If viscosity is too low, formation of the oil film will be insufficient, and damage will occur to the load carrying surfaces of the bearing. If viscosity is too high, viscous resistance will also be great and result in temperature increases and friction loss. In general, for higher speed applications a lower viscosity oil should be used; for heavier load applications, a higher viscosity oil should be used.

In regard to operating temperature and lubrication, **Table 11.7** lists the required oil viscosity for different types of rolling bearings. **Fig. 11.5** is an oil viscosity - operating temperature comparison chart for the purpose of selecting a lubrication oil with viscosity characteristics appropriate to an application.

**Table 11.8** lists the selection standards for lubricating oil viscosity with reference to bearing operating conditions.

**Table 11.7 Required lubricating oil viscosity for bearings**

Bearing type	Dynamic viscosity mm <sup>2</sup> /s
Ball bearings, Cylindrical roller bearings, Needle roller bearings	13
Spherical roller bearings, Tapered roller bearings, Needle roller thrust bearings	20
Self-aligning roller thrust bearings	30

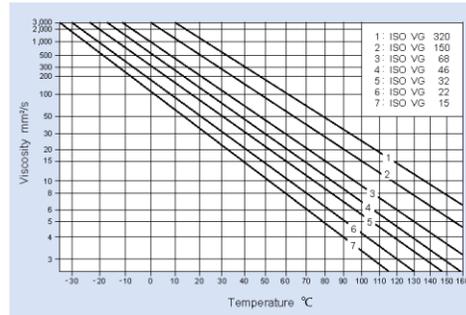


Fig. 11.5 Relation between lubricating oil viscosity and temperature

Table 11.6 Oil lubrication methods

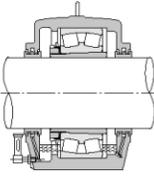
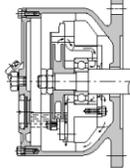
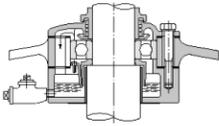
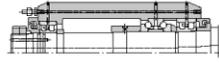
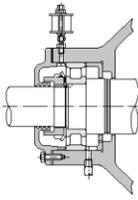
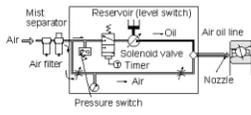
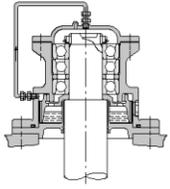
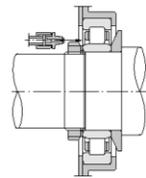
Lubrication method	Example	Lubrication method	Example
<p><b>(Oil bath lubrication)</b></p> <ul style="list-style-type: none"> <li>Oil bath lubrication is the most generally used method of lubrication and is widely used for low to moderate rotation speed applications.</li> <li>For horizontal shaft applications, oil level should be maintained at approximately the center of the lowest rolling element, according to the oil gauge, when the bearing is at rest. For vertical shafts at low speeds, oil level should be maintained at 50 - 80% submergence of the rolling elements.</li> </ul>		<p><b>(Disc lubrication)</b></p> <ul style="list-style-type: none"> <li>In this method, a partially submerged disc rotates and pulls oil up into a reservoir from which it then drains down through the bearing, lubricating it.</li> </ul>	
<p><b>(Oil spray lubrication)</b></p> <ul style="list-style-type: none"> <li>In this method, an impeller or similar device mounted on the shaft draws up oil and sprays it onto the bearing. This method can be used at considerably high speeds.</li> </ul>		<p><b>(Oil mist lubrication)</b></p> <ul style="list-style-type: none"> <li>Using pressurized air, lubricating oil is atomized before passing through the bearing.</li> <li>Due to the low lubricant resistance, this method is well suited to high speed applications.</li> </ul>	
<p><b>(Drip lubrication)</b></p> <ul style="list-style-type: none"> <li>In this method, oil is collected above the bearing and allowed to drip down into the housing where it becomes a lubricating mist as it strikes the rolling elements. Another version allows only slight amounts of oil to pass through the bearing.</li> <li>Used at relatively high speeds for light to moderate load applications.</li> <li>In most cases, oil volume is a few drops per minute.</li> </ul>		<p><b>(Air-oil lubrication)</b></p> <ul style="list-style-type: none"> <li>In this method, the required minimum amount of lubricating oil is measured and fed to each bearing at ideal intervals using compressed air.</li> <li>With fresh lubricating oil constantly being fed to the bearing, and with the cooling effect of the compressed air, bearing temperature rise can be minimized.</li> <li>Because the required oil quantity is infinitesimal, the working environment can be kept clean. Air-oil lubrication units are available from NTN.</li> </ul>	
<p><b>(Circulating lubrication)</b></p> <ul style="list-style-type: none"> <li>Used for bearing cooling applications or for automatic oil supply systems in which the oil supply is centrally located.</li> <li>One of the advantages of this method is that oil cooling devices and filters to maintain oil purity can be installed within the system.</li> <li>In order for oil to thoroughly lubricate the bearing, oil inlets and outlets must be provided on opposite sides of the bearing.</li> </ul>		<p><b>(Oil jet lubrication)</b></p> <ul style="list-style-type: none"> <li>This method lubricates by injecting oil under high pressure directly into the side of the bearing. This is a reliable system for high speed, high temperature or otherwise severe conditions.</li> <li>Used for lubricating the bearings in jet engines, gas turbines, and other high speed equipment.</li> <li>Under-race lubrication for machine tools is one example of this type of lubrication.</li> </ul>	

Table 11.8 Selection standards for lubricating oils (Reference)

Bearing operating temperature C	dn-value	Lubricating oil ISO viscosity grade (VG)		Suitable bearing
		Normal load	Heavy load or shock load	
-30~ 0	Up to allowable revolutions	22, 32	46	All types
0~ 60	15,000 Up to	46, 68	100	All types
	15,000 ~80,000	32, 46	68	All types
	80,000 ~150,000	22, 32	32	All types but thrust ball bearings
	150,000~500,000	10	22, 32	Single row radial ball bearings, cylindrical roller bearings
60~100	15,000 Up to	150	220	All types
	15,000 ~80,000	100	150	All types
	80,000 ~150,000	68	100, 150	All types but thrust ball bearings
	150,000~500,000	32	68	Single row radial ball bearings, cylindrical roller bearings
100 ~150	Up to allowable revolutions	320		All types
0~ 60	Up to allowable revolutions	46, 68		Self-aligning roller bearings
60~100	Up to allowable revolutions	150		

Note 1: Applied when lubrication method is either oil bath or circulating lubrication.  
 2: Please consult NTN Engineering in cases where operating conditions fall outside the range covered by this table.

11.5.2 Oil quantity

In forced oil lubrication systems, the heat radiated away by the housing and surrounding parts plus the heat carried away by the lubricating oil is approximately equal to the amount of heat generated by the bearing and other sources.

For standard housing applications, the quantity of oil required can be found by formula (11.2).

$$Q = \frac{W \cdot \Delta T}{\rho \cdot (T_o - T_s)} \quad (11.2)$$

where,

- Q: Quantity of oil for one bearing cm<sup>3</sup>/min.
- W: Allowable oil temperature rise factor (Table 11.9)
- ρ: Minimum oil quantity cm<sup>3</sup>/min. (Fig. 11.6)

Because the amount of heat radiated will vary according to the type of housing, for actual operation it is advisable that the quantity of oil calculated by formula (11.2) be multiplied by a factor of 1.5 or 2.0. Then, the amount of oil can be adjusted to correspond to actual operating conditions.

Furthermore, if it is assumed for calculation purposes that no heat is radiated by the housing, and that all bearing heat is removed by the oil, then the value in Fig. 11.3 for shaft diameter,  $d = 0$ , regardless of actual shaft diameter.

**(Example)** For tapered roller bearing 30220U mounted on a flywheel shaft with a radial load of 9.5 kN (969 kgf), operating at 1,800 r/min, what is the amount of lubricating oil required to keep the bearing temperature rise below 15 C.

$$d = 100 \text{ mm,}$$

$$n = 100 \times 1,800 = 18 \times 10^4$$

From Fig. 11.6  $Q = 180 \text{ cm}^3 / \text{min}$

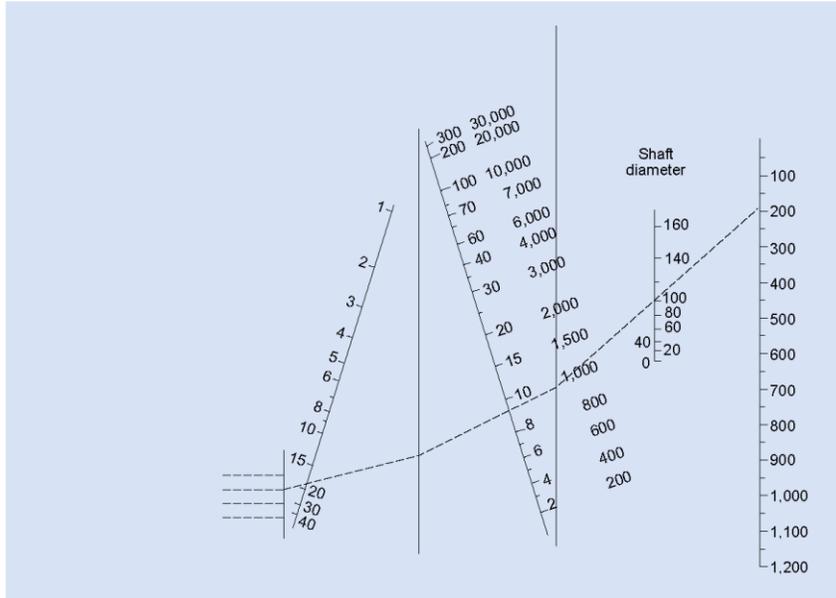
Assume the bearing temperature is approximately equal to the expelled oil temperature, from Table 11.9, since  $W = 1$   
 $Q = 1 \times 180 = 180 \text{ cm}^3 / \text{min}$

Table 11.9 Factor

Expelled oil temp minus supplied oil temp C	Factor
10	1.5
15	1
20	0.75
25	0.6

11.5.3 Relubrication intervals

The intervals at which lubricating oil should be changed varies depending upon operating conditions, oil quantity, and type of oil used. In general, for oil bath lubrication where the operating temperature is 50 C or less, oil should be replaced once a year. When the operating temperature is between 80 C ~ 100 C, oil should be replaced at least every three months. For important equipment, it is advisable that lubricating efficiency and oil purity deterioration be checked regularly to determine when oil replacement is necessary.





# U.S. Electrical Motors Installation and Maintenance Manual

## SAFETY FIRST

High voltage and rotating parts can cause serious or fatal injury. Safe installation, operation, and maintenance must be performed by qualified personnel. Familiarization with and adherence to NEMA MG2, the National Electrical Code (NEC) and local codes is required. It is important to observe safety precautions to protect personnel from possible injury. Personnel should be instructed to:

1. Be familiar with the equipment and read all instructions thoroughly before installing or working on equipment.
2. Avoid contact with energized circuits or rotating parts.
3. Disconnect all power sources before initiating any maintenance or repair.
4. Act with care in accordance with prescribed procedures in handling and lifting this equipment.
5. Be sure unit is electrically grounded in accordance with code requirements.
6. Be sure equipment is properly enclosed or protected to prevent access by children or other unauthorized personnel in order to prevent possible accidents.
7. Be sure shaft key is fully captive before unit is energized.
8. Avoid contact with capacitors until safe discharge procedures have been completed.
9. Provide proper guarding for personnel against rotating parts and applications involving high inertia loads which can cause overspeed.
10. Avoid extended exposure to equipment with high noise levels.

## INSPECTION AND HANDLING

Inspect unit to make sure no damage has occurred during shipment. Check nameplate for correct speed, horsepower, voltage, Hertz, and phase for conformance with power supply and equipment. **WARNING:** Units should be lifted using all eyebolts or lugs if provided. These eyebolts or lugs are provided for lifting this unit only and must not be used to lift any additional weight. Lifting angle, from shank of eyebolt, must not exceed 30° for machines with single and 45° for machines with multiple lifting means. Replacement eyebolts must be per ASTM A489 or equivalent. All eyebolts must be securely tightened. Be careful not to touch overhead power lines with lifting equipment. Failure to observe this warning may result in serious personal injury.

## STORAGE

Units should be stored indoors, in a clean, dry location & winding should be protected from excessive moisture absorption. **NOTE:** If motors are to be stored for more than one year, refer to U.S. Electrical Motors. If gear and belt transmission units are to be stored for more than six months, refer to U.S. Electrical Motors.

## LOCATION

**WARNING:** Use only UL Listed Hazardous Location Motors for service in Hazardous Locations as defined in Article 500 of the NEC. Units should be located in a clean, well-ventilated area. **WARNING:** Units should be located in a suitable enclosure to prevent access by children or other unauthorized personnel to prevent possible accidents.

## INSTALLATION / MOUNTING

Mount units on a firm, flat surface sufficiently rigid to prevent vibration. Drive belts and chains should be tensioned in accordance with supplier recommendations. Couplings should be properly aligned and balanced. For belt, chain and gear drive selection refer to the drive or equipment manufacturer. For application of drive equipment refer to applicable information in NEMA MG1.

Motors have been dynamically balanced using a half key the same length as the full key shipped with the motor. If pulley keyway length is less than this length, rework long key by removing one-half of excess length between pulley and end of key to maintain balance.

Do not restrict motor ventilation. Unless otherwise specified on nameplate, motor is designed for operation in accordance with NEMA MG1 "Usual Service Conditions" which states an ambient temperature range of -15°C to 40°C (5°F to 104°F). Standard grease lubricated units are suitable for operation within this temperature range, special lubricants may be required for ambient temperatures outside of the range.

**NOTE:** Motors operating under rated load and allowable ambient conditions may feel hot when touched; this is normal and should not be cause for concern. When in doubt, measure frame surface temperature and confer with nearest office. Enclosed motors normally have condensation drain openings. Insure that drain openings are properly located and open (plugs removed) for the motor mounting position. Drain openings should be at the lowest point of end brackets, frame housing and terminal housing when the motor is installed. This may require modification of motor to accomplish. If unit appears wet, and/or has been stored in a damp location, dry out thoroughly and check for adequate insulation resistance to ground before operating.

**WARNING:** Guards should be provided for all exposed rotating parts to prevent possible personal injury. Keep fingers and foreign objects away from ventilation and other openings. Applications involving *high inertia loads* may damage equipment due to motor overspeed during coast shutdown. Such applications should be referred to U.S. Electrical Motors.

**CAUTION:** Do not force drive coupling or other equipment onto shaft, as bearing damage may result

## POWER SUPPLY AND CONNECTIONS

The power supply must agree with values on nameplate. Terminal voltage should not vary more than ±10% of nameplate voltage at rated frequency. Unbalanced line voltage, greater than one percent, can cause overheating. Do not exceed the continuous rated load amperes on the nameplate. Starting controls and overload protection should be properly sized in accordance with the NEC and the control manufacturer's recommendations.

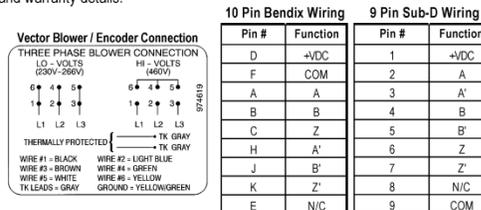
Motor connections should be made by following instructions on connection diagram. Determine direction of rotation before connecting driven equipment. If direction of rotation label is supplied, operate only in specified direction. Rotation may be reversed on three phase motors by interchanging any two line connections. On single phase motors, interchange leads per connection diagram on motor. Wiring of units, controls and grounding shall be in accordance with local and NEC requirements.

**WARNING:** Failure to properly ground unit may cause serious injury to personnel. Where unexpected starting could be hazardous to personnel, do not use automatic reset starting devices.

## USE OF VARIABLE FREQUENCY DRIVES

Electric motors can be detrimentally affected when applied with variable frequency drives (VFD's). The non-sinusoidal waveforms of VFD's have harmonic content which causes additional motor heating; and high voltage peaks and short rise times, which result in increased insulation stress, especially when long power cable lengths are used. Other effects of VFD's on motor performance include reduced efficiency, increased load current, vibration and noise. Standard motors utilized with VFD's must be limited to those application considerations defined in [NEMA MG-1 Part 30](#).

[NEMA MG-1 Part 31](#) defines performance and application considerations for Definite Purpose Inverter fed motors. To insure satisfactory performance and reliability, U.S. Electrical Motors offers and recommends nameplated inverter duty motor products which meet the requirements of NEMA MG-1 Part 31. The use of non-inverter duty motors may result in unsatisfactory performance or premature failure, which may not be warrantable under the Terms and Conditions of Sale. Contact your U.S. Electrical Motors Field Sales Engineer for technical assistance for motor selection, applications and warranty details.





# U.S. Electrical Motors Installation and Maintenance Manual

## OIL LUBRICATION

Most oil lubricated units are shipped without oil. Refer to instruction manual with unit for specific type and grade of oil to be used, change interval and level. If lubrication instructions specify synthetic oil, do not substitute. **WARNING:** For applications in the food and drug industry (including animal food), consult the petroleum supplier for lubricants that are acceptable to the Food & Drug Administration and other governing bodies.

## MAINTENANCE

Inspect units at regular intervals. Keep units clean and ventilation openings clear of dust, dirt or other debris. Lubricate units per this operating instruction sheet and instruction plate on unit. Excessive lubrication may damage the unit. Do not over-grease. **WARNING:** Disconnect all power sources to the unit and discharge all parts which may retain an electrical charge before attempting any maintenance or repair. Screen and covers must be maintained in place when unit is in operation. Failure to observe this warning may result in personal injury.

U.L. Listed Motors For Use in Hazardous Locations: Repair of these motors must be made by the manufacturer or manufacturer's authorized service station approved to repair U.L. Listed motors. The U.L. listing applies to the electric motor only and not to the belt or gear transmissions or other devices that may be connected to the motor.

## GREASE LUBRICATION INSTRUCTIONS

Units are prelubricated at the factory and do not require initial lubrication. Relubricating interval depends upon speed, type of bearing and service. Refer to Table 1 for suggested regreasing intervals. Operating conditions may dictate more frequent lubrications. Motor must be at rest and electrical controls should be locked open to prevent energizing while motor is being serviced. (refer to section on Safety). If motor is removed from storage, refer to storage procedures.

To relubricate bearings, remove the drain plug. Inspect grease drain and remove any blockage with a mechanical probe taking care not to damage bearing. **CAUTION:** Under no circumstances should a mechanical probe be used while the motor is in operation. Add new grease at the grease inlet, refer to Table 1 for replenishment quantities. New grease must be compatible with grease in the motor (See Caution Note). Run the motor for 15 to 30 minutes with the drain plug removed to allow purging of any excess grease. Shut off unit and replace the drain plug. Return motor to service. **CAUTION: Overgreasing can cause excessive bearing temperatures, premature lubricant breakdown and bearing failure. Care should be exercised against overgreasing.**

**TABLE 1**  
**Recommended Grease Replenishment Quantities & Intervals**  
(For Lubrication of Units in Service)

Bearing Number - Common		Bearing Number - AFBMAX		Grease Fl. Oz.	Lubrication Interval		
62XX	63XX	XXBC02	XXBC03		3600 RPM	1800 RPM	1200 RPM
6203 - 6207	6303 - 6306	17 - 35	17 - 30	0.2	2 years	3 years	3 years
6208 - 6212	6307 - 6309	40 - 60	35 - 45	0.4	1 year	2 years	2 years
6213 - 6215	6310 - 6311	65 - 75	50 - 55	0.6	1 year	2 years	2 years
6216 - 6220	6312 - 6315	80 - 100	60 - 75	1.0	6 months	1 year	2 years
6221 - 6228	6316 - 6320	105 - 140	80 - 100	1.8	6 months	1 year	1 year

For motors mounted vertically or in hostile environments, reduce intervals shown by 50 percent.

Refer to motor nameplate for bearings provided on a specific motor. For bearings not listed in the table above, the amount of grease required may be calculated by the formula:

$$G = 0.11 \times D \times B$$

where: G = Qty of grease in fluid ounces; D = Outside diameter of bearing (inches); B = Width of bearing (inches)

**TABLE 2**  
**Recommended Greases**

THE FOLLOWING GREASES ARE INTERCHANGEABLE WITH THE GREASE AS PROVIDED IN UNITS SUPPLIED FROM FACTORY (unless stated otherwise on a lubrication nameplate provided on motor).

Manufacturer	Grease (NLGI No. 2)
Exxon Mobil	Polyrex EM
Chevron USA Inc.	SRI No. 2

**CAUTION:** Greases of different bases (lithium, polyurea, clay, etc.) may not be compatible when mixed. Mixing such greases can result in reduced lubricant life and premature bearing failure. When necessary, prevent such intermixing by disassembling the motor, removing all old grease from bearings and housings (including all grease fill and drain holes). Inspect and replace damaged bearings. Fill bearing housings and bearings approximately 30% full of new grease. Remove any excess grease extending beyond the edges of the bearing races and retainers. Refer to Table 2 for recommended greases.

## RENEWAL PARTS & WARRANTY SERVICE

When inquiring for renewal parts, call the U.S. Electrical Motors **Parts Department** (Memphis, Tennessee) or a Parts Stocking Distributor. For warranty service call the nearest U.S. Motors Authorized Service Station. Give them complete nameplate data including ID number, etc. Request installation & maintenance manuals by product name.

REGIONAL OFFICES	PHONE	FAX	REGIONAL OFFICES	PHONE	FAX
DOMESTIC U.S. SALES	(888) 637-7333	(314) 553-1101	MONTERREY, MEXICO	(52) 8-389-1312	(52) 8-389-1310
INTERNATIONAL SALES	(314) 553-3185	(314) 553-2135	CARACAS, VENEZUELA	(58) 02-2377522	(58) 02-2329727
MONTRÉAL, QUÉBEC/CANADA	(800) 361-5509	(514) 332-5912	BOGOTÁ, COLOMBIA	(57) 1- 439-5420	(57) 1- 439-5417
TORONTO, ONTARIO/CANADA	(905) 475-4670	(905) 475-4672			

IN109-34K

11/00

©2000 U.S. Electrical Motors - Prices, specifications and ratings subject to change without notice.

Printed in the U.S.A.

## **WARRANTY AND DAMAGES**

**ROTOGRAN** warrants the equipment to be free from defects in material and workmanship under normal use, proper installation, and proper operating conditions. Except as to warranties of title, THIS LIMITED WARRANTY IS EXPRESSLY IN LIEU OF OTHER WARRANTIES AND REPRESENTATIONS, EXPRESSED OR IMPLIED, FROM THE COMPANY, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR USE. The company's liability under this limited warranty shall be limited to repairing or replacing any parts which prove defective at its factory in Concord, Ontario, if returned to the Company's said factory with shipping charges prepaid, within a period of one (1) year from the date of shipment. THERE SHALL BE NO LIABILITY FOR ANTICIPATED PROFITS, NOR CONSEQUENTIAL OR INCIDENTAL DAMAGES, DIRECT OR INDIRECT, FOR LOSS OF USE OF THE EQUIPMENT OR OF ANY INSTALLATION INTO WHICH THE EQUIPMENT MAY BE PUT UNDER THIS LIMITED WARRANTY. The Company's liability for warranty of component parts in the equipment which the company has purchased as a manufactured unit from a recognized manufacturer thereof, shall be no greater than the warrant liability assumed by the supplier or manufacturer of such component parts. In no event shall the Company be liable for CONSEQUENTIAL OR INCIDENTAL DAMAGES RESULTING DIRECTLY, OR INDIRECTLY, FROM THE FAILURE OF SUCH COMPONENT PARTS.

It is the Company's policy that it is the responsibility of the employer-owner of the equipment, and not the Company, to comply with the provisions and regulations under the Occupational Safety & Health Act of 1970 (hereinafter OSHA) as well as any other Federal, State or Local standards which might exist as to health and safety. Therefore, IN NO EVENT SHALL THE COMPANY BE LIABLE FOR ANY DIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, EITHER DIRECT OR INDIRECT, ARISING OUT OF OR RESULTING FROM THE OPERATION OF EQUIPMENT USED BY THE COMPANY AS SUCH OPERATION PERTAINS TO OSHA

OR ANY OTHER FEDERAL, STATE, OR LOCAL STANDARDS WHICH MIGHT EXIST REGARDING HEALTH AND SAFETY.

## **DELIVERY**

The shipping dates given by the Company are approximate, and the Company will use its best efforts to meet such dates.

The Company shall not be liable for delay or non-delivery due to causes beyond its reasonable control, by tardy approval drawings, and including but not limited to acts of God, casualty, act of civil or military supply difficulties or any interruption of its facilities due to extended power failures, lack of fuel, governmental laws, ordinances, rules and regulations whether valid or invalid.

## **TRANSPORTATION**

Unless the Buyer issues specific shipping instructions, the Company will choose the method of shipment. Claims for damages in shipment are to be by the Buyer direct to the carrier.

## **RETURNS**

Return of equipment or parts for credit will be permitted only after written authorization and shipping instructions have been obtained from an Officer or Division Sales Manager at the Company's headquarters in Concord, Ontario. All costs of handling and all transportation charges are for the Buyer's account. Unauthorized collect shipments will be rejected by our receiving facilities.

## **CANCELLATION**

The Buyer may cancel an order only with the written approval of an Officer of the Company as its headquarters in Concord, Ontario. The buyer shall pay to the Company the reasonable costs and expenses for any equipment manufactured, work in progress, engineering, and cancellation charges which may be incurred by the Company from its suppliers and subcontractors, plus the Company's usual rate of profit for similar work