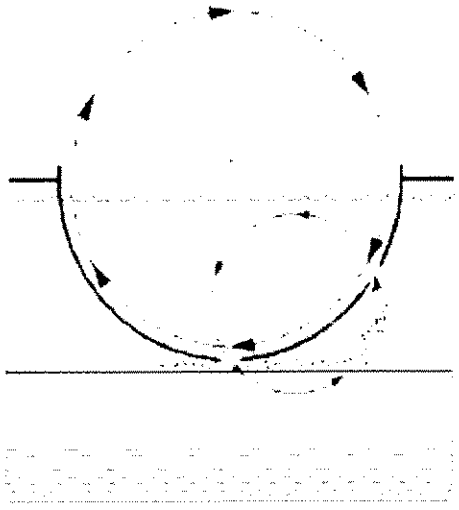


Figure c-Unit operating with excess sludge accumulated to base of Rotorzone. Both influent flows and re-circulation flows will disturb and carry sludge solids. Increase in BOD and solids loads entering Rotorzone will be substantially above design treatment levels, increase accumulated masses on rotating assembly, produce potential for damage to structure and drive unit.

3.6 - PUMPOUT PROCEDURES FOR ROTORDISK® TREATMENT SYSTEMS (summary)

Using suction hose, floating or surface scum should be removed first.
Place the suction hose directly to the bottom of the tank and withdraw sludge only, while taking as little as possible of the volume of waste liquid above the sludge blanket (supernatant).
Move the hose at multiple number of points along the bottom of the settlement tanks.
Do not wash off biological growth (biomass) on the disks. The exception to this is excess accumulated biomass on the disks due to an overdue sludge pump-out. Excess accumulated biomass is when a disk bank is 100% fully covered with biomass and the colour is grey with a slight odour.

Keep a record of all pump-outs to arrive at an actual normal operating interval for sludge pump-outs. For systems with several flow meters, it is also beneficial to note the total flow generated between pump-outs.

3.7 - START-UP PROCEDURES OF ROTORDISK®

The ROTORDISK® sewage treatment plant is based on a fixed film treatment process referred to as the Rotating Biological Contactor (RBC). In this process, microorganisms or bugs are attached and grown on the surface of a media, the quantity of bugs being directly proportional to the amount of food in the wastewater. When starting up a new system, it will normally take about two weeks to get organic removal from the wastewater and three to four weeks to establish the nitrification process at normal domestic sewage temperatures. The method of and effluent discharge during system start-up should be discussed and thoroughly communicated with the environmental authority. The primary sedimentation tank and RBC of the system should, preferably, be filled with fresh water before admitting wastewater to the system. A flow less than design is not a problem. The biomass will develop themselves on the media. If there is a small flow only a portion of the disk will have biomass. As the flow increases the amount of biomass will increase.

Seeding a ROTORDISK® with activated sludge, although not required, can be accomplished. The activated sludge should be at the same temperature as the influent. Sudden changes in wastewater temperature had caused biomass sloughing. In most cases the use of domestic waste as a seed culture has provided the required biomass for continuos operation. When seeding the ROTORDISK® with activated sludge is decided, the primary sedimentation tank and RBC of the system should first be filled with fresh water (preferably) and the activated sludge added to the RBC. The RBC should be rotating at all times. The wastewater introduced to the tank needs to have only 20% of the disks covered with waste. This can already provide the needed wetting and still provide some times to reach normal operating levels when source flow is introduced. The final clarifier does not need to be filled with anything.

The preferred start up is the introduction of source wastewater at design or less than design loading. The disks need to be rotating at all times. When the disks are rotating and wastewater is introduced the biomass will develop and the pollutants will be removed.

The practice of starting up a sewage plant with a charge of septage or activated sludge may be appropriate for suspended growth systems where sludge return is an essential and necessary part of the process. However, start-up with septage is <u>not</u> an appropriate practice for fixed film systems such as the Rotating Biological Contactor process and is <u>not</u> recommended. This is especially true of the ROTORDISK® process and its static, internal storage of sludge.

Studies have shown that the natural start-up time for a ROTORDISK® is 2 1/2 – 3 weeks (normal temperatures and BOD reduction only), and that it has already developed sufficient biomass for 50% removals in only 1 week. These are time frames significantly shorter than respective ones for suspended growth systems. Thus there is little rationale for "pre-starting" a ROTORDISK® unit with septage.

Further, septage contains solids that are already well digested, and therefore not subject to further digestion-compaction in the storage zones. This contrasts to the fresh solids, which will undergo considerable digestion-compaction in the 6 – 9 months after initial

settlement. Therefore, a charge of septage would contribute disproportionately to the accumulation of sludge levels, and necessitate a shorter interval to the first pump-out of the unit.

The ROTORDISK® concept of static sludge storage contributes greatly to its overall operation and maintenance simplicity. Following the above guidelines and recommendations will help ensure that the trouble-free simplicity of ROTORDISK® is maintained.

4.0 - STORAGE OF **ROTORDISK®** SEWAGE TREATMENT EQUIPMENT

If the unit is not to be operated for an extended period, then the motor-reducer assembly (drive unit) should be removed from its mound and stored at room temperature in a reasonably dry area (unless the whole unit is being stored in such an area).

Additionally:

1. Reducer: The input shaft should be given several turns once a month to re-lubricate the upper bearings.

NOTE: Some reducers are shipped to site filled with synthetic lubrication. Otherwise, fill the reducer with the lubricant (see reducer section of installation & maintenance instructions).

2. Motor: The motor has a tendency to take on moisture when not in operation. It requires no attention during storage, but before it goes into operation the insulation should be measured using a Meger. It should be at least 1.0 mega-ohm. If below 1.0 mega-ohm, it has taken on excessive condensation, and must be dried out before being operated. (Note: any electrical contractor or repair shop commonly understands these terms and procedures).

3. Support bearings on main ROTORDISK® shaft(s) should be re-lubricated prior to start-up.

4. The system should not be installed and operated in water. In the absence of sewage inputs and normal biological activity, freezing and consequent mechanical damage would be a distinct possibility. Water level in the primary settlement tank to be dropped to below the bottom of the Rotorzone tank level, if freezing of the tank contents is possible.

6.0 - ROUTINE MECHANICAL MAINTENANCE OF **ROTORDISK®** SEWAGE TREATMENT PLANTS

6.1 - MOTOR:

If motor is equipped with grease fittings and relief plugs, it should be re-lubricated using a low-pressure gun once a year with Shell Alvenia R2" grease (DO NOT OVER-LUBRICATE). There is no lubrication required for motors without grease fittings and relief plugs

6.2 - REDUCER:

Reduction gear on ROTORDISK® units is filled with synthetic long life lubricant. No inspection or maintenance outside of periodic visual inspection is normally required. If there are no evidence of oil leaks on the seals, the synthetic lubricant must be changed every five (5) years for ROTORDISK® units running 24 hours a day.
Reduction Gear on medium and large ROTORDISK® size units are filled with Shell Tivela 75 oil and does not require oil changes (permanent lubrication). Periodic visual inspection is required. Check oil level and top up to required level with same oil, if necessary.

6.3 - BEARINGS:

Bearings are lubricated with NLGI Grade 2 Molyslip Multipurpose grease or SKF LGEP2 lithium grease. Lubricant will deteriorate in time and rate of deterioration is a function of the operating conditions encountered. Lubrication cycle can be determined by analysing the samples taken near the bearing. It is usually sufficient to apply grease once a month or at least every three- (3) months.

6.4 - SPROCKETS AND CHAIN:

(Applicable to non-direct drive ROTORDISK® units)
Chain drive should be inspected every six- (6) months for following points:
- If Chain is covered with grit or chips, it should be cleaned in kerosene and re-lubricated.
- Inspect oil for contamination, such as chips, dirt or grit. Replace oil if necessary (Oil with viscosity of SAE30 at ambient temperature 40° to 100° F is recommended).
- Milky white colour of the oil is indicative of flooding. Replace oil and determine the cause of the flood.
-Check Chain tension and adjust if required.

6.5 - COUPLING:

(Applicable for direct drive ROTORDISK® units and 'L' models)
Coupling should be checked for lubricant level. Lubricant is to be added if required. Re-lubrication with NLGI#2 or LTG Grease once a year is usually adequate.

7.0 - TROUBLE SHOOTING

7.1 - MECHANICAL HARDWARE

TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
Noisy chain	1. Loose chain 2. Faulty lubrication 3. Misalignment 4. Worn Parts 5. Moving parts rubbing stationary parts	1. Tighten chain 2. Lubricate properly 3. Correct sprocket alignment 4. Replace worn chain 5. Align & tighten chain to clear oil bath
Rapid wear on chain	1. Faulty lubrication 2. Loose or misalign parts	1. Lubricate properly 2. Align & tighten entire drive
Chain climbing sprockets	1. Worn out chain and sprockets 2. Loose chain	1. Replace worn out parts 2. Tighten chain
Stiff chain	1. Misalignment 2. Worn out chain or sprockets 3. Faulty lubrication 4. Rust corrosion	1. Correct alignment 2. Replace worn out parts 3. Lubricate properly 4. Clean and lubricate
Noisy Bearing	Rollers or bearings damaged	Replace bearing cartridge
Bearing grease discoloured or mixed with water	Insufficient grease in the bearings	Purge bearing with grease and increase lubrication interval
Hot bearing	1. Improper lubrication 2. Rollers or bearing race damaged	1. Purge bearing with grease and decrease lubrication interval 2. Replace bearing cartridge
Reducer temperature rises above 200 degrees Fahrenheit.	Oil level too high or too low	Maintain proper oil level
Oil leakage from reducer	1. Oil seals need to be replaced 2. Ventilators/breather plugged causing pressure build-up inside the reducer. 3. Oil level too high	1. Replace oil seals 2. Clean Ventilators 3. Correct oil level
Noisy reducer	1. Bearing failure 2. Misalignment in worm gear inside 3. Coupling between motor and reducer worn out and misalign	1. Check bearings and replace if necessary 2. Align worm gear shafts. 3. Replace coupling between motor and reducer. Align coupling hub vertically
Noisy Motor	Bearing damage	Replace damaged bearings
Motor overheating	1. Reducer overheating 2. Cooling fins on motor are clogged 3. Overload 4. Rotor rubbing on stator 5. Over greasing or lubrication	1. Check reducer 2. Clean fins 3. Check for excess friction or imbalance 4. Replace bearings 5. Avoid packing grease too tightly
Motor won't start	1. Power trouble 2. Single phasing at station 3. Fuse blown	1. Check source of power supply 2. Do not try to make it go and "fry" motor. Check starter windings 3. Replace fuse
Knocking/rumbling on motor bearings	1. Bearing worn due to lack of lubrication or excessive mechanical overload 2. bearings slack in housing	1. Replace baring and put new grease of recommended grade. 2. Fir new end shields
Rotordisk® shaft	1. Power failure 2. Motor failure 3. Reducer failure 4. chain drive failure	1. Check power supply 2. Check and replace motor and bearings. 3. Check teeth worn gears and bearings. Replace necessary parts 4. Replace chain

7.2 - **ROTORDISK®** PROCESS

ROTORDISK® TROUBLESHOOTING GUIDE

Problem	Cause	Corrective Action
1. Slime on media appears shaggy with a brown colour	PROPER OPERATION	NO PROBLEM NORMAL CONDITION
2. Black slime growing on disks	Solids and/or BOD overloading	**a.** Pre-aerate RBC influent **b.** For severe organic overloads, increase recycle rate **c.** De-sludge unit **d.** Place another RBC unit in parallel
3. Rotten egg or other obnoxious odors	Solids or BOD overloading	See Problem 2, solutions a, b, c and d, above
4. Development of odors and white biomass over most of the media surface	1. Septic influent wastewater or high hydrogen sulfide or sulfate concentration	**e.** Determine the cause of the problem and correct it at source. For example, aerate equalization tank **f.** Pre-aerate influent wastewater **g.** Determine the cause of the problem, possibly with the addition of chlorine or hydrogen peroxide; potassium permanganate has also been used
	2. Overload first stage	**a.** Check dissolved oxygen levels to confirm overload problem **b.** Provide a larger amount of surface area for the first stage treatment by removing baffle **c.** Increase number of recycle buckets
5. White slime	1. Bacteria that feed on sulfur compounds. Also, industrial discharges containing sulfur compounds may cause an overload	▪ See Problem 2, solutions a, b, and c above
	2. Grease on the disks	**a.** Remove grease at source **b.** Install grease traps
6. Sloughing or loss of slime (biomass)	1. Toxic or inhibitory substances in influent, including abrupt pH changes	**a.** Eliminate source of toxic or inhibitory substances **b.** Reduce peaks of toxic or inhibitory substances by carefully regulating inflow to plant **c.** Dilute influent using plant effluent or any other source of water **d.** See Problem 7.4
	2. Variation in flow or organic loading	**a.** - During low flow or loading periods, pump from secondary clarifier or 4th stage RBC unit effluent to recycle water with food and dissolved oxygen through the RBC unit **b.** - During high flow or loading conditions, attempt to throttle plant inflow during peak periods **c.** - For severe organic overloads, remove bulkhead or baffle between stages 1 and 2

ROTORDISK® TROUBLESHOOTING GUIDE

Problem	Cause	Corrective Action
7. Decrease in process efficiency	1. Reduced wastewater temperature	**a.** Decrease air opening in RBC building **b.** Heat air inside RBC unit cover or building
	2. Unusual variations in flow or organic loading	▪ See Problem 6, cause 2, solutions a, b, and c above
	3. Sustained flows or loads above design levels	▪ Install additional treatment units
	4. High or low pH values	▪ Adjust pH to near neutral
	5. Improper rotation of media	▪ Inspect chain tension and adjust
8. Accumulation of solids and clogging in the RBC system	Solids removal in pre-treatment steps is not adequate	**a.** Improve pre-treatment efficiencies **b.** Provide supplemental aeration to help prevent solids from settling **c.** Move baffles to change flow patterns to reduce settling (if the problem is serious, the RBC wastewater tank may have to be pumped or cleaned out) **d.** De-sludge primary tank
9. Floating or rising sludge in the secondary clarifier	Removal of sludge from the clarifier is inadequate	**a.** Increase the duration of pumping sludge from the clarifier **b.** Remove sludge from the clarifier more often
10. Excess shaft weight or biomass thickness	1. Organic loading too high	▪ Decrease organic loading
	2. Stage loading too high	**a.** Remove baffles between units to increase size of treatment stages **b.** Increase number of recycle buckets
	3. Shaft speed too low	▪ Increase the shaft rotational speed by adjusting drive ratio
	4. Inorganic solids accumulation because of inadequate pre-treatment	▪ Check primary treatment and grit removal equipment for proper operation
	5. Accumulation of minerals	▪ Use chemical pre-treatment to eliminate minerals
	6. Digester supernatant adding excessive BOD or sulfides	▪ Modify supernatant pumping frequency
11. Shaft rotation non-uniform or "jerky"	1. Normal variations in balance	▪ Time rotation by quarters. A difference of less than 3 seconds in quarter rotation time is normal
	2. Uneven biomass weight due to power outage	**a.** If severe, shut unit down and wash down disks **b.** Turn off the unit temporarily and rotate manually to uniformly wet biomass growth before restarting **c.** Decrease or stop flow of wastewater to affected units **d.** contact manufacturer for assistance

ROTORDISK® TROUBLESHOOTING GUIDE

Problem	Cause	Corrective Action
12. Effluent quality apparently below requirements	1. Organic loading too high	**a.** Add additional operating RBCs **b.** Identify cause of additional loading and eliminate at source **c.** Add supplemental air to RBC trough
	2. Sampling or testing procedures inaccurate	**a.** In nitrification is occurring, analyze for carbon BOD only by using nitrification inhibitor **b.** Check for contaminated dilution water, sampler lines, or improper sampling storage
	3. Inadequate secondary clarifier operation	**a.** Clean and de-sludge clarifier **b.** Modify sludge removal procedures to eliminate BOD kickback **c.** Install **BUGS** filter after clarifier
	4. Anaerobic solids in the RBC tanks producing BOD kickback	▪ Flush or drain tanks
13. Snails or other nuisance organisms in RBC tanks	Nutritional and conducive environment for reproduction of hard-bodied shell snails ($^1/_8$" - $^1/_2$" in size)	**a.** Addition of controlled dosages of chlorine. Physical removal may be required with taking units out of service temporarily **b.** Contact manufacturer

8.0 - MAINTENANCE PROGRAM

Do's and Don'ts

DO'S

1. Do use biodegradable soap if at all possible. The system will however handle a certain amount of normal soap. When laundering clothes, please follow manufacturer's instructions regarding quantity of detergent. Excessive use of detergent can cause odour in the system.

2. Do put large amounts of grease in a container and dump in garbage. The system will handle a certain amount of fat and grease. If fats and grease get into the tile bed, they may plug the pores of the soil and seal up the bed. Never put large amounts of grease (i.e. old grease from deep fryer) into the sewer lines.

3. Have your system pumped out a minimum of once a year to remove sludge and scum to maintain top operating treatment in your system and filter bed.

4. Do keep service hatch above ground. Do not let run-off water enter system, as this will cause hydraulic overload.

5. Do keep traffic such as cars, snowmobiles, etc., from around the system bed areas as they will break pipes and seal the soil over the bed.

6. Do leave the raised filter in place without disturbing it. The filter is specifically designed to provide maximum dispersal of the water. Altering it by adding fill, covering it up or changing in any way may destroy its water dispersal characteristics and result in bed failure.

7. Do encourage a growth of ground cover over the filter bed as it helps disperse water by evaporation and transpiration.

DON'Ts

1. Do not put non-biodegradable materials downs the drain, put them in the garbage, these include any plastics, rubber, disposable diapers, sanitary napkins, rubber goods, cigarettes, children's toys, cellophane, etc. They will plug the system, and a pump out will be needed.

2. Do not put harsh chemicals down the drain. They will kill the bacteria necessary for efficient treatment. These include acid or caustic cleaners, gasoline, oil, turpentine, photographic chemicals, etc. Disinfectant and chlorine bleaches should be kept to domestic uses.

3. Do not leave taps running or faulty toilets. The excess water may overload the system and tile field causing breakout and poor treatment.

4. Do not attempt to fix the mechanical parts yourself. Your dealer is trained to repair your plant and work safely with electrical and mechanical components. Call him if you have a problem or concerns.

5. Do not connect any other electrical load to the fuse or breaker feeding the plant as it will cause damage to the controls.

6. Never put large amounts of grease (i.e. old grease from deep fryer) into the sewer lines.

YOUR CO-OPERATION WITH RESPECT TO THE ABOVE POINTS SHOULD ENSURE TROUBLE-FREE OPERATION OF YOUR TREATMENT PLANT AND WILL BE GREATLY APPRECIATED.

9.0 - INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS FOR VARIOUS MECHANICAL PARTS OF THE **ROTORDISK®** AND OTHER EQUIPMENT SUPPLIED

9.1 INSTALLATION & MAINTENANCE DETAILS FOR ROLLER CHAIN DRIVES

CHAIN TENSIONING:

The proper fit of a chain may be obtained by adjusting the sprocket centres. When a chain is correctly tensioned, the total mid-span movement (double amplitude) in the slack span should be 4-6% of the span length for normal drives.

Where there is no adjustment means, adjustment may be made by removing links to compensate for elongation due to wear (Drives with fixed centres). Proper lubrication and proper drive maintenance may minimize chain wear.

LUBRICATION:

Although many slow speed drives operate successfully with litter or no lubrication beyond the initial factory lubrication, proper lubrication will greatly extend the useful life of every chain drive.

A good grade of clean petroleum oil without additives, free from flowing at the prevailing temperatures should be used.

Chain drives should be protected from abrasive and corrosive conditions, and the oil supply kept free of contamination. Periodic oil change is desirable. The lubricant viscosity recommended for ambient temperature 40° - 100°F is SAE 30.

OIL BATH:

With bath lubrication the lower strand of chain runs through a sump of oil in the drive housing. The oil level should reach the pitch line of the chain at its lowest point while operating. Only a short length of chain should run through oil.

INSTALLATION RECOMMENDATIONS:

Shafting, bearings and foundations should be supported rigidly to maintain the initial alignment. Roller chain should be free of grit and dirt. Wash chain in kerosene when required. Re-lubricate!

Misalignment results in uneven loading across the width of the chain and may cause roller link-plate and sprocket tooth wear. Drive alignment involves two things:

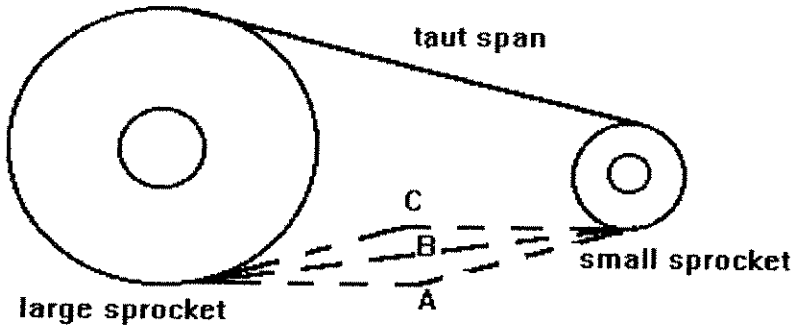
a) Parallel shaft alignment: Shafts should be parallel and level.
b) Axial sprocket alignment: Sprocket axial alignment can be checked with a straight edge, which will extend across the finished sides of the two sprockets.

Normally it is good practice to align sprockets as close to the shaft bearings as possible.

Installing the Chain: Recheck all preceding adjustments for alignment and make certain all setscrews, bolts and nuts are tight. Fit chain around both sprockets and bring free ends together one sprocket for connection.

Chain Tension: Check chain tension to be certain the slack span has 4-7% mid-span movement in horizontal drives.

Recommended Possible Mid-Span Movement AC									
Drive Center-Line	Tangent Length Between Sprockets								
	5"	10"	15"	20"	30"	40"	60"	80"	100"
Horizontal to 45	.25"	.5"	.75"	1"	1.5"	2"	3"	4"	5"
Vertical to 45	.12"	.25"	.38"	.5"	.75"	1"	1.5"	2"	2.5"



AC = Total Possible Mid-Span Movement
Depth of Free Sag = .866 AB, approximately

MAINTENANCE RECOMMENDATIONS:

Regular maintenance schedules should be followed for all chain drives. Each drive should be inspected every six months. At each inspection period the following points should be checked:

a) Check Lubrication: If chain is covered with grit or chips, it should be cleaned in kerosene and re-lubricated before reinstalling. With bath lubrication, oil should be maintained at the proper level, as shown in lubrication instructions. Add oil if necessary. At each inspection oil should be checked for contamination, such as chips, dirt or grit.

b) Check sprocket alignment: If the chain is properly aligned, no wear will show on the inner surfaces of the chain roller link-plates. If wear is apparent, this is evidence that sprockets are misalign and should be realigned as outlined in the installation instructions to prevent further chain and sprocket wear.

c) Check sprocket tooth wear: If sprocket shows evidence of wear high on the sprocket teeth, this is evidence of excessive wear in the chain, the chain should be replaced. If the sprocket teeth are severely worn, the sprocket should be replaced. Do not run new chain on worn sprockets.

d) Check chain tension: At each inspection period, the chain tension should be adjusted. If excessive slack has accumulated which cannot be removed by available shaft centre adjustment (i.e. by moving reducer away from large sprocket using chain tensioning bolts), two or more pitches of chain should be removed and chain reconnected.

PREPARATION OF PILLOW BLOCK HOUSING

Check to be sure all pillow block parts are free of burrs and are completely clean. Internal surfaces should be removed. Apply a thin coat of grease to the bearing seat in the base. Fit the bearing and seal inserts into the pillow block base, being careful not to damage to O-rings. For assembling larger sizes where hoists must be used, it may be convenient to seat both bearings into their housing bases simultaneously.

FIXING RINGS

On each shaft one bearing is generally "Held" and other bearings are "Free", to permit shaft expansion. For "Held" bearing housings, use two fixing rings. Place one on each side of bearing.

CAPPING THE PILLOW BLOCK

Place the cap on the base so that the dowel pins in the base align with the holes in the cap, being careful not to damage the O-rings. Caps and bases are not manufactured for interchangeable assembly. They must be kept together. Install cap-bolts with lock washers and tighten securely.

GREASE LUBRICATED BLOCKS

Lubrication Notes

Grease Lubrication

If grease is used as a lubricant, it should be smeared between the rolling elements and worked in. The lower half of the housing should be packaged $^{1}/_{2}$ to $^{3}/_{4}$ full.

Use NLGI Grade #2 Molyslip multi-purpose grease or LGEP2 lithium grease.

PROCEDURE FOR APPLYING LUBRICANT TO BEARINGS AND PILLOW BLOCKS

Pack each bearing as completely full of the specified grease as possible by swiveling the outer ring open and rotating it as necessary to inject the grease. Then, swivel the outer ring closed being careful not to use force in the event a roller end catch the corner of the outer ring sphere.

B) Before assembling the pillow block cap to the base, and after completing bearing and base assembly, fill $^{1}/_{2}$ to $^{3}/_{4}$ of the pillow block base with the same lubricant that was used to pack the bearing.

C) Before applying cap to base, spray or otherwise coat interior of cap with a rust preventative, such as Houghton Rust Veto 342.

LUBRICATION PROCEDURE TO BE USED AT START-UP

A) All pillow block assemblies that have not been prepared for stage are ready for use, assuming the installation procedures have been correctly followed.

B) While shaft is rotating, lubricate each seal through the outside lubricant fittings until grease is seen emerging from the labyrinth areas. Make sure the outside of the lubricant fitting is clean before applying grease.

RE LUBRICATION

Lubricants deteriorate in time, and the rate of deterioration is a function of the lubricant used at the operating conditions encountered. Determining the re-lubrication cycle depends on sampling the grease and analysis of the samples. Provisions must be made to adequately evaluate the contamination by solids. Samples for grease evaluation should be taken from near the bearing, and evaluation of the samples should dictate the re-lubrication cycle.

Remove caps once a year and re-apply new grease.

Each seal assembly should be lubricated once a month, while the bearing is rotating, with the same grease that is used in the bearing.

GREASE CLASSIFICATION

		Oil Viscosity Saybolt Second (approx. SSU)		
Class	Type of Base (1)	@ 100 F	@ 210 F	NLGI (2) Grade
A	Lithium or Equal	200 - 500	48 - 55	0
B	Lithium or Equal	400 - 600	58 - 68	1
C	Lithium or Equal	800 - 1,000	75 - 82	1
D	Lithium only	800 - 1,000	75 - 82	2

	Grease requirement from above			
Operating temperature of bearing (4)	Low (5)	Medium	High	Suggested Re-lube cycle
0 – 70	A or B			6 - 12 months
70 – 120	B or C			6 - 12 months
120 – 160	B or C	C or D (6)	D (7)	2 - 3 weeks
160 – 200	C	C or D (6)	D (7)	1 - 4 weeks

1) Calcium Complex Greases NOT recommended for spherical roller bearings.

2) National Lubricating Grease Institute Consistency Code.

3) Definition of speed categories:

Low: up to 1/4 of catalog speed limit for static oil lubrication.
Medium: 1/4 to 1/2 catalog speed limit for static oil lubrication.
High: 1/2 to full catalog speed limit for static oil lubrication.

4) Consult SKF Engineering if temperature is below 0° or above 200°F.

5) Extremely slow speed will require special consideration if loads are high.

* Under all conditions, application should be checked using the SKF lubricant film parameter found in the Engineer Data Catalog.

6) Use type "C" where load is heavy, 15,000 hours-rating life or less and/or speed are less than RPM.

7) Consult SKF Engineering - Grease lube not normally recommended under this combination of operating conditions.

8) Dry clean applications only. For moderate conditions of dirt and/or moisture, use cycle of 1 to 2 months. For extreme conditions of dirt and/or moisture, use cycle of 1 week. Vertical applications normally require shorter than normal re-lube cycle.

9) Never mix greases with unlike bases.

10) Remove old grease at least once a year.

Appendix B

Rotordisk Design Brief

(supplied by Seprotech Incorporated)

ROTORDISK DESIGN BRIEF

(for BOD and SS Removal in an RBC)

MACRO J

DATE: June 18 1997
PROJECT NAME: Echo Bay Mines

1. HYDRAULIC DESIGN: (AVERAGE DAILY FLOW)

50 units each at 227 l/d/unit = 11356 l/d = Q
design based o 24 hour day.
Peak H 1893 l/hr

2. INFLUENT PARAMETERS:

BOD (biochemical oxygen demand) = 250 mg/l
SS (suspended solids) = 250 mg/l

Designated Model? y y/n
What Model? S30
In concrete tank? n y/n

3. TREATED EFFLUENT QUALITY:

BOD (biochemical oxygen demand) = 25 mg/l
SS (suspended solids) = 25 mg/l

CLARIFIER LENGTHS		
	P.S.T.	F.S.T.
BASIC LGTH	8.17	3.75
REV. LGTH	8.17	3.75

4. R.B.C. SURFACE AREA REQUIRED (AO):

a) Removal in Primary Settling Tank (P.S.T.)

Primary BOD Removal = 30%
Primary Tank. Eff. BOD = 250 mg/l x 70%
to RBC = 175 mg/l

(Ref.1)

b) RBC BOD Loading.

Applied Load = 175 mg/l x 11,356 L/d
= 1.99 Kg/d BOD

c) Area required to reduce BOD to 25 mg/l. (AO)
Applied Load = 1.99 Kg/d BOD

For 25 mg/l use 1.57 kgm/day/100sq.m. (from Table #1)
= 127 sq.m.

Compare with Min. area req'd for First Stage Ldg 161 sq.m.
US 161 sq.m. 1736 sq. ft.

TABLE #1

BOD REMOVAL RATES	CMS Curve	
Req'd effluent	#/1000 s.f.	kgms/100 m2
10	1.25	0.61
15	2.00	0.98
20	2.50	1.22
25	3.21	1.57
30	3.75	1.83
35	4.34	2.12
40	4.90	2.39
50	6.03	2.93
60	7.15	3.52
70	8.28	4.05
80	9.40	4.59
90	10.53	5.13
	USE	1.57

No temperature correction required
Refs. 13,14,&15

Designated Model S30
Max Surface Area per Unit = 2200 sq.ft 204 sq.m. :::
Number of Units = 1 Surface Area per unit = 1736 sq.ft.
Use 1 Rotordisk Model S30

d) Check for First Stage Loading.(per RBC unit)

Allowable Loading =	3.1	kg. BOD / d / 100 sq.m.				(Ref. 4)
First Stage area per unit	40%	% of total media area				
=	65	sq.m.				
Applied First Stage Loading =	1.99	kg. / d BOD	on	65	sq.m.	
Actual Loading =	3.08	kg. BOD / 100 sq.m.				

there LOADING ACCEPTABLE

5. PRIMARY SETTLING TANK (P.S.T) (per RBC unit)

a) Primary Settling Tank Influent Flows: (per RBC unit)

Average Daily Flow =	11,356	l/d			
Recycle at	100	%	= 11356	l/d	
Total Average Flow =	22,712	l/d			
Peak Daily Flow @ 3 x A.D.F. =	34,069	l/d			
Peak Flow Including Recycle =	45,425	l/d	= 1893	l/hr	

b) Loading Rates.

Average Overflow Rate =	16,000	Litres/day/sq.m.	max from	(Ref.5)
Detention Time =	4	hours	use 4 hrs	(Ref.6)
Peak Overflow Rate =	100,000	Litres/day/sq.m. (rounded)	use 2500 usgpd/s.f.	(Ref.7)

c) Surface Area Required.

i) by Average Overflow Rate = Total Average Flow divided by Average Overflow Rate
= 1.42 sq.m.

ii) by Peak Flow Rate = Peak Flow divided by Peak Overflow Rate
= 0.45 sq.m.

Therefore, use 1.42 sq.m. to compare with actual area of P.S.T.

Actual P. S. T. Surface Area for Modal S30 7.5 ft. wide x 8.17 ft. long = 61
or 2.29 m. x 2.49 m. = 5.7

Safety factor of 4.01 times supplied.

there Surface Area Acceptable

d) Volume Required = Q x Detention Time / 1000 / 24 hrs / day
= 1.89 cu.m.

Primary Settling Tank Capacity for S30 is 3.17 cu.m. or 1.7
(after allowance for sludge)

therefore Volume Acceptable

e) Sludge Production:

60% of influent solids are retained in the Primary Settling Tank. [Ref. 8]

Influent S.S. =	250	mg/l x	60%			
	150	mg/l capture @ P.S.T.				
Primary Solids production is =	150	mg/l x	11356	litres/day		
	1.7	kgs. of sludge / day		(dry)		
Recycled Biomass =	0.26	kg/d (see section 6.d).				
Total Solids Production =	1.96	kg/d (dry)				
Thickened Solids Concentration =	100	kg / cu.m. =	10	% solids		(Ref. 9)
Wet Solids Production =	0.020	cu.m /d				
Sludge Storage Capacity in	S30	is	2.9	cu.m		
=	147	days				
Pump out Required every	4.9	months				
The P.S.T. Sludge Storage is	2.9	cu.m., which permits approximately			4.9	months of operation.

6- FINAL SETTLING TANK (F.S.T.):

a) Area Required.

a) Average Overflow Rate = 24000 Litres/day/sq.m [Ref. 10]
Peak Overflow Rate = 44822 Litres/day/sq.m [Ref. 10] - use 800 usgpd/sf rounded - avge of 1000 & 1200

i) by Average Overflow Rate
Surface Area Required = Q divided by Average Overflow Rate
= 0.47 sq.m.

ii) by Peak Overflow Rate
Surface Area Required = Peak Flow divided by peak loading rate
= 0.76 sq.m. 0

USE 0.76 sq.m. to compare with actual area of F.S.T.

Actual area F. S. T. Area for S30 7.5 ft. wide x 3.75 ft. long = 28 sq.ft.
or 2.29 m. x 1.14 m. = 2.61 sq.m.

Safety factor of 3.44 F.S.T. Area acceptable

b) Volume Required.

Detention Time = 3.0 hours
Volume Required. = Q times Detention Time
= 1.4 cu.m

Actual capacity of F. S. T. for S30 is 2.5 cu.m.
(after allowance for sludge)

Safety factor of 1.79 F.S.T. Volume acceptable

c) Sludge Production.

RBC Influent BOD = 175 mg/l
RBC Effluent BOD = 25 mg/l
BOD Removed = 150 mg/l
Net Biomass S.S. = 150 mg/l BOD x 0.3 mg S.S./ mg BOD removed [Ref.11]
= 45 mg/l S.S.
Net Biomass Production = 45 mg/l S.S.x 11 cu.m./d
0.51 kg/d

Recycle Rate = 50%
Biomass Recycled to P.S.T. = 0.51 kg/d x 50%
= 0.26 kg/d
Biomass to F.S.T. = 0.51 kg/d x 50%
0.26 kg/d (dry)
Biomass loss to effluent = 25 mg/l x 11.3662 cu.m./d

0.28 kg/d
Net S.S. Accumulation = 0.28 kg/d less 0.28 kg/d
= 0.00 kg/d
Thickened Solids Concentration = 50 kg solids / cu.m = 5% [Ref. 9]
Wet Solids Production = 0.00 kg. dry solids/solids concentration
0.000 cu.m./d (thickened sludge)
Sludge Storage Capacity of Model S30 is 0.57 cu.m

Sludge Storage Capacity = F.S.T. Sludge Cap.(cu.m.)/cu.m./d(thickened sludge)
= ACCEPTABLE

The F.S.T. Sludge Storage is 0.57 cu.m., which is sufficient for more than 6 months of operation.
The F.S.T. will be pumped out at the same time as the P.S.T.

It should be noted that the suspended solids in an R.B.C. effluent are made up entirely of sloughed biomass from a fixed growth system. These solids settle in about 15 minutes. The required capacity of the Final Settlement Tank is based on the settling rate of a suspended growth system, for which the settling time is much higher. The above parameters therefore add an additional safety factor to the ROTORDISK(tm) design

SUMMARY OF REFERENCES:

Ref.1 -
excerpt from "Design of Municipal Wastewater Treatment Plants Volume 1", Chapters 1-12, WEF Manual of Practice No. 8, ASCE Manual and Report on Engineering Practice No. 76, p. 475, which states, " Sedimentation with coagulation may remove 60 to 90% of the TSS, 40 to 70% of BOD5, 30 to 60% of COD, 70 to 90% of the Phosphorus, and 80 to 90% of the bacteria loadings. In comparison, sedimentation without coagulation, may remove only 40 to 70% of the TSS, 25 to 40% of the BOD5, 5 to 10% of the Phosphorus loadings, and 50 to 60% of the bacteria loadings."

Ref.3 -
excerpt from "Pilot Plant Studies of Rotating Biological Contactors treating municipal Wastewater", by: K.L. Murphy and R.W. Wilson, International Environmental Consultants Ltd., Toronto Ontario, prepared for Central Mortgage and Housing Corporation, Ottawa, Ontario.

Ref.4 -
excerpt from "Design of Municipal Wastewater Treatment Plants Volume 1", Chapters 1-12, WEF Manual of Practice No. 8, ASCE Manual and Report on Engineering Practice No. 76, p. 776, which states, "...whenever the first stage loading limit exceeded 3.1 kg BOD5/100 sq.m.day(6.4 lbs. BOD5/d/1000 sq.ft.), the system was associated with the presence of sulfur-oxidizing organisms".

Ref.5 -
excerpt from "EPA Process Design Manual, On-site Wastewater Treatment and Disposal Systems", Oct 1980, EPA 625/1-80-012, section 6.4.2.4.e., p.149, which states, "...average flow design values normally range from 200 to 400 gpd/sq.ft.(8 to 16 cu.m./d/sq.m.)".

Ref.6 -
excerpt from " O&M of Trickling Filters, RBC's, and Related Processes, Manual of Practice OM-10, 1988, Water Pollution Control Federation, p. 105, which states, " Weir overflow rates typically range from 125 to 250 cu.m./m.d (10,000 to 20,000 USgpd/ft.)...The wastewater detention time in a settling basin is normally between 1 to 3 hours, but has been as high as 10 hours with excellent results". [use 4 hours]

Ref.7 -
excerpt from "EPA Process Design Manual, Wastewater Treatment Facilities for Sewered Small Communities", Oct 1977, EPA-625/1-77-009, section 6.4.2., which states, " the peak overflow rate may be 2,500 to 3,000 USgpd/sq.ft. (100 to 120 cu.m./sq.m.d) for primary clarifiers followed by biological treatment processes".
" Clarifiers handling chemical flocs, such as aluminum or iron coagulants, should be designed for peak overflow rates no longer than 600 and 800 USgpd/sq.ft.(24 and 32 cu.m./sq.m.d)".

Ref.8 -
excerpt from "Design of Municipal Wastewater Treatment Plants Volume 1", Chapters 1-12, WEF Manual of Practice No. 8, ASCE Manual and Report on Engineering Practice No. 76, p. 484, which states, " TSS removal efficiencies in primary sedimentation tanks usually range between 50 and 65%. Many designers assume a removal efficiency of 60% for estimation purposes".

Ref.9 -
excerpt from "Wastewater Engineering Treatment, Disposal, and Reuse", 3rd ed., Metcalf and Eddy Inc., revised by George Tchobanoglous and Franklin L. Burton, p.808, table 12-14, which shows,"...typical concentrations of thickened sludge for a rotating biological contactor is 2 to 5%".

Ref.10 -
excerpt from "Design Information on Rotating Biological Contactors", by Richard C. Brenner, EPA-600/2-84-108, section 2.10, which states, " Murphy and Wilson recommend surface overflow rates less than 600 gpd/sq.ft. to maximize solids removal... DeCarlo recommends that peak hydraulic rates be limited to 1000 to 1200 gpd/sq.ft.".

Ref.11 -
excerpt from "EPA Process Design Manual, Wastewater Treatment Facilities for Sewered Small Communities", Oct 1977, EPA-625/1-77-009, section 9.2.4.6, p.9-43, which states, " Sludge produced by the RBC unit is similar to humus sludge from a trickling filter. The amount of sludge produced will depend on waste characteristics and loading rates. An RBC unit designed for 80% BOD5 removal would produce about 0.7 lb. of sludge per lb. of BOD5 removed; 95% percent removal would produce about 0.3 lb. of sludge."

Ref 12. -

Ref. 13
excerpt from Ministry of Environment and Energy - Ahlberg & Kwong Report - "Winter Operation"
No process or operating problems were experienced throughout the winter. The minimum temperature encountered in the unit, with a raw sewage feed rate of 320 gpd, was 4 oC. Process performance remained good during the winter even under conditions of intermittent operation.

Ref. 14

excerpt from the Forgie study

For the RBC unit and wastewater tested, the effect of temperature on removal efficiency over the 15 oC to 5 oC range was relatively low (theta = 1.001 to 1.02)

Ref. 15

excerpt from Trinh - Environment Canada "Exploration Camp Wastewater Characterization and Treatment Plant Assessment"

It [the RBC] also operated at a low liquid temperature of 4 oC during one week without the effluent quality deteriorating.