WASTEWATER TREATMENT SYSTEM ENGINEER'S REPORT

for

New Harbour Village Housing Development
Old Harbour

Prepared
by

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Section 1
General project information

General Project Information

The proposed domestic sewage treatment plant is designed for New Harbour Village, a proposed housing development in the Old Harbour area of St. Catherine. The housing development will consist of approximately 950 2 bedroom houses. The systems capacity is designed for 0.361M gallons of sewage per day. The treatment plant is designed by Appropriate Technologies Ltd. utilizing Lakeside Electro/Mechanical Equipment. The characteristics of the wastewater influent and the expected effluent characteristics are outlined in the Basis of Design

Site Topography

The general character of the land in this rural area is generally uniform with less than 10% of the proposed site being on a slope. The predominant soil type on the project site is upland plateau soil with bedrock outcroppings. Based on a soils investigation report completed through
to a depth of 3m below existing ground elevation, the strata is dense cream brown limestone with sand and silt (see appendix for Bore hole logs) The project site is located in a coastal zone and situated above the 10 m contour line. There are no water wells adjacent to the site as well as there are no sink hole conditions.

Section 2

Sewage treatment System and Appurtenances

Sewage Treatment System and Appurtenances

Plant Site

The plant site will be located in a remote area 40m (130 feet) away from the subdivision boundary and more than 40m away from the Parochial road. The site will be fenced to ensure security from vandalism as well as ensuring that humans as well as animals do not accidentally just wander onto the site. The sewage released from each house in the subdivision will be pumped from lift stations to the main sewer line. This main sewer line will empty the sewage by gravity directly into the treatment plant.

The surrounding areas of the plant site are rural lands comprising generally of trees and shrubs. See Appendix for a plan of the plant site location.

Treatment Method Technical Description

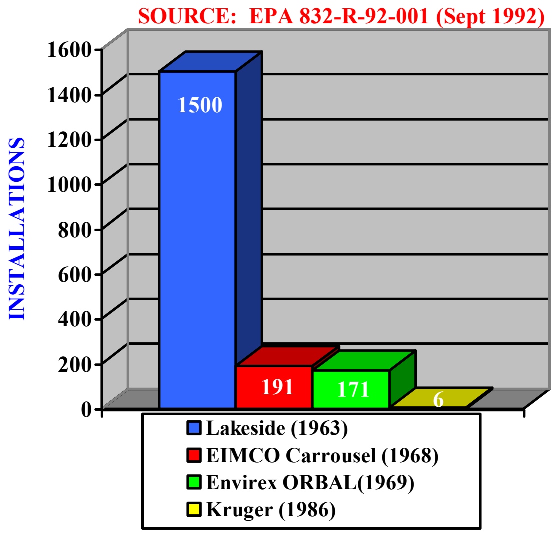
Combined biological nitrogen and phosphorous removal can be achieved with CLR Process with the addition of an anaerobic and anoxic stage ahead of the aeration basin. It combines BOD5 removal with de-nitrification and phosphorous removal. The plant will be designed to produce tertiary treated effluent that will meet NEPA Irrigation Standards. The proposed system includes an anaerobic inlet chamber with two anoxic chambers followed by two aeration basins and two clarifiers. A sludge digester and a bank of drying bed will also be included as part of the system, to allow for easier sludge management during the operation of the plant.

Our system will have eight basic components: -

- A Grit/Trash Chamber
- An Anaerobic Chamber
- Two (2) Anoxic Chambers
- Two (2) Closed Loop Reactors (Oxidation Ditches)
- Two (2) Spiraflo Clarifiers
- A Chlorine Contact Chamber
- A Digester
- Two (2) Drying Beds

EXPERIENCE

Lakeside first introduced the "oxidation ditch process" to the United States in 1964. Since that time this simple activated sludge process has evolved to what is now known as the state-of-the-art Lakeside Closed Loop Reactor (CLR) Process. To date Lakeside has installed more than 1,700 CLR Process installations worldwide.



The Lakeside "experience factor" is more than 5 times our nearest competitors which introduced their versions of the "oxidation ditch" process only 5 years later than Lakeside. Why has the Lakeside CLR Process been preferred by engineers and owners? Please consider the following advantages for both process simplicity, process flexibility, superior equipment design and ease of maintenance and low cost.

LAKESIDE ADVANTAGES

Lakeside offers the following benefits to the owner and engineer from project inception, through design, start-up and operation:

- **NO LICENSE FEES** - are charged by Lakeside to provide up-front profits for our equipment. Specifications and drawings along with process design assistance are offered as part of normal business practice.

- **FUTURE EXPANSION** - considerations are designed by the Lakeside professional staff into each CLR Process to allow not only additional treatment capability but also to respond to changing effluent limitations such as Biological Nutrient Removal (BNR) with our non-proprietary processes which do not require expensive license fees nor will additional reactors be required for future Total Nitrogen removal.

- **FLEXIBLE OXYGEN DELIVERY** - is provided by the Lakeside Magna Rotors. Each Magna Rotor with a simple 2-speed drive has an Oxygen Delivery Ratio (ODR) of 6.87 to 1 when operating at immersion ranges of 5 to 15 inches and rotational speeds of 48 to 72 rev/min. This means greater process control for BNR and associated energy savings, especially during the initial start-up year conditions.

- **MIXING UNDER ALL FLOW CONDITIONS** - is provided with our design to ensure a bulk liquid velocity of 1 ft/sec or greater, even at low power input. The power necessary to maintain a 1 ft/sec minimum bulk liquid velocity in each reactor is only 7.2 brake horsepower. Compare the power necessary to maintain a similar 1ft/sec minimum bulk liquid velocity with other types of aerators such as vertical turbines.

- **MADE IN THE U.S.A.** - defines the Lakeside CLR Process equipment. All our CLR Process equipment is fabricated at our shop in Chariton, Iowa. Buy-out items such as motors, speed reducers, bearings, etc. are standard stock, off-the-shelf components for overnight delivery should a replacement ever be needed. This is not possible with the drive used by vertical turbine aerators.

BASIS OF DESIGN

This design was selected based upon the following criteria (US units):

INFLUENT DESIGN PARAMETERS	
Average Day Flow, mgd	0.361
Peak Day Flow, mgd	0.542
Peak Hourly Flow, mgd	0.903
BOD_5 , mg/l	250
INFLUENT DESIGN PARAMETERS	
TSS, mg/l	250
TKN, mg/l	40
NH_3-N, mg/l	27
Total P, mg/l	23
Minimum Temperature, ^{o}C	10
Maximum Temperature, ^{o}C	25
Site Elevation, feet above MSL	**50**

PREDICTED PERFORMANCE

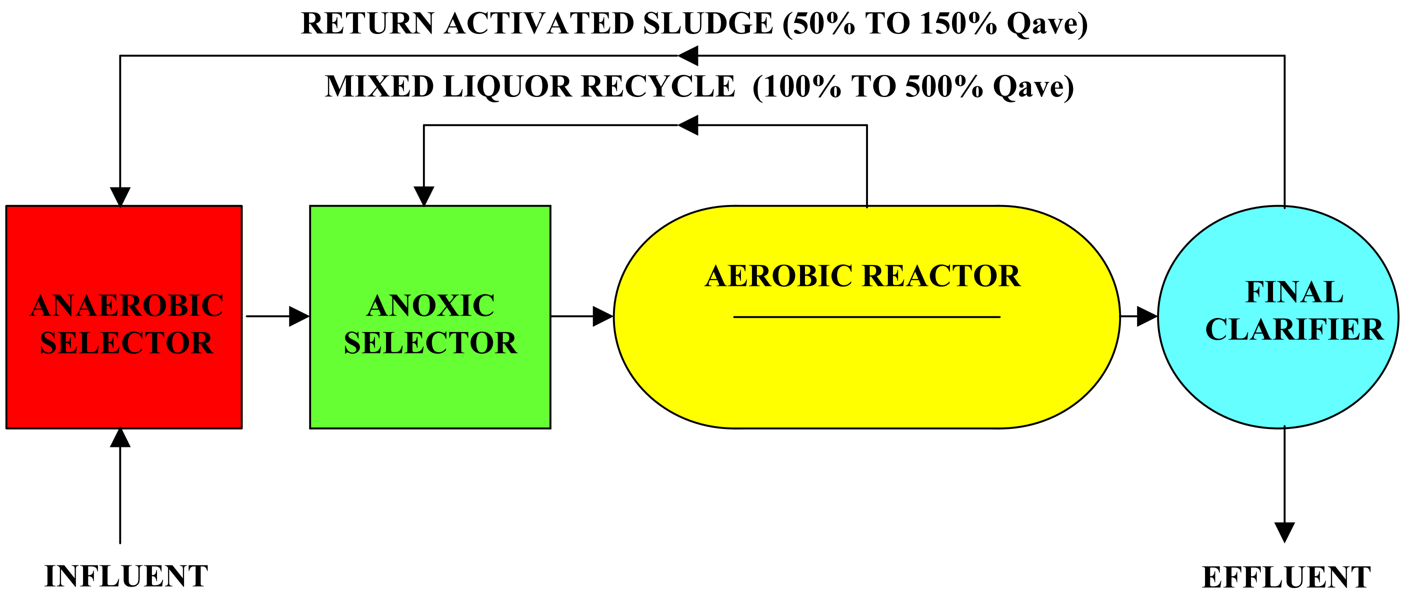
PREDICTED EFFLUENT CHARACTERISTICS	
$CBOD_5$, mg/l	20
TSS, mg/l	20
NH_3-N, mg/l	2.0
Total P, mg/l	4.0

CLR PROCESS BNR OPERATIONAL MODES

Most small facilities are designed with chemical addition since the time/education/experience of the operations staff is not conducive to their ability to controlling the process for biological phosphorus removal. Chemical addition to the final clarifiers for phosphorus precipitation has been successfully implemented on numerous applications. The Lakeside Spiraflo Clarifier is especially well-suited for chemical precipitation of phosphorus. Refer to Plant Performance Report 126 – Bemidji, MN.

The Phoredox configuration is the simplest design for strictly pass through operation. The Phoredox design variant does not require extensive instrumentation and control.

Lakeside has furnished equipment for similar facilities for Snow Hill, North Carolina, Becker, MN, Alberville, MN, Prescott Valley, AZ and many other projects. Refer also to Plant Performance Report Nos. PPR-131a and PPR-131b on our project for Prescott Valley, AZ and PPR-134 on our project for Becker, MN. Refer to the following figure.



CLR PROCESS STANDARD OPERATIONAL MODES

To provide maximum operator flexibility and ease of operation, we can design the aeration basins to be operated in parallel, series, or in a "peak flow" mode. Bulletin 1412, CLR Process Modifications Section, provides an excellent discussion of the various standard process options that are available. To provide maximum operator flexibility and ease of operation, we design the anaerobic, anoxic and aerobic reactors to be operated in parallel or series using common wall construction to save concrete and piping costs. This flexible control can be provided by a utilizing a series of gates and flexible piping arrangement to control the feedpoint of the raw wastewater, return activated sludge (r) recycle and mixed liquor (a) recycle.

- **Parallel Mode:** The raw wastewater and return activated sludge (r) recycle would be introduced to the anaerobic reactor (UAR-2) and then equally split via slide gates SG-1 and SG-2 to the anoxic reactors (UAR-1 and UAR-3). The flow would then be introduced to each Closed Loop Reactor (CLR-1 and CLR-2) via slide gates SG-3 and SG-4. Mixed liquor (a) recycle would be pumped from each closed loop reactor to each anoxic reactor. Each Closed Loop Reactor liquid level would be controlled by its own effluent weir EW-1 or EW-2. The following are the gate and effluent weir settings:

  SG-1 - Open
  SG-2 - Open
  SG-3 - Open
  SG-4 - Open
  SG-5 - Closed

EW-1 - Open
EW-2 - Open

- **<u>Series Mode (Option A)</u>:** The raw wastewater and return activated sludge (r) recycle would be introduced to the anaerobic reactor (UAR-1) and then via slide gate SG-1 would feed anoxic reactor UAR-2. The flow would then be introduced to only Closed Loop Reactor CLR-1 via slide gate SG-3. Mixed liquor (a) recycle would be pumped from each closed loop reactor to each anoxic reactor. Mixed liquor recycle from anoxic reactor UAR-3 would be returned to the anaerobic reactor UAR-1 via slide gate SG-2. Closed Loop Reactor CLR-1 would be operated with flow being introduced to CLR-2 via slide gate SG-5. Effluent weir EW-1 would be raised to its maximum position allowing EW-2 to provide for oxygen delivery control. The following gate and effluent weir settings would be provided:

  SG-1 - Open
  SG-2 - Open
  SG-3 - Open
  SG-4 - Closed
  SG-5 - Open
  EW-1 - Closed
  EW-2 - Open

- **<u>Series Mode (Option B)</u>:** The raw wastewater and return activated sludge (r) recycle would be introduced to the anaerobic reactor (UAR-3) and then via slide gate SG-2 would feed in series anoxic reactor UAR-1 and via slide gate SG-1 would feed anoxic reactor UAR-2. The flow would then be introduced to only Closed Loop Reactor CLR-1 via slide gate SG-3. Mixed liquor (a) recycle would be pumped from each closed loop reactor to anoxic reactor UAR-2 only. Closed Loop Reactor CLR-1 would be operated with flow being introduced to CLR-2 via slide gate SG-5. Effluent weir EW-1 would be raised to its maximum position allowing EW-2 to provide for oxygen delivery control. The following gate and effluent weir settings would be provided:

  SG-1 - Open
  SG-2 - Open
  SG-3 - Open
  SG-4 - Closed
  SG-5 - Open
  EW-1 - Closed
  EW-2 - Open

- **<u>Series Mode (Option C)</u>:** The raw wastewater and return activated sludge (r) recycle would be introduced to the anaerobic reactor (UAR-1) and then via slide gate SG-1 would feed anoxic reactor UAR-2. The flow would then be introduced to only Closed Loop Reactor CLR-1 via slide gate SG-3. Mixed liquor (a) recycle would be pumped from each closed loop reactor to each anoxic reactor. Each anoxic reactor is paired with its own Closed Loop Reactor (UAR-2 with CLR-1 and UAR-3 with CLR-2) for two-stage denitrification. The Closed Loop Reactors would be operated with flow being introduced from CLR-1 to CLR-2 via slide gate SG-5. Effluent weir EW-1 would be raised to its maximum position allowing EW-2 to provide for oxygen delivery control. The following gate and effluent weir settings would be provided:

  SG-1 - Open
  SG-2 - Closed

SG-3 - Open
SG-4 - Open
SG-5 - Open
EW-1 - Closed
EW-2 - Open

- **Storm Flow Mode:** The raw wastewater would be introduced to the anaerobic reactor (UAR-1) and then via slide gate SG-1 would feed anoxic reactor UAR-2. The flow would then be introduced to only Closed Loop Reactor CLR-1 via slide gate SG-3. Return activated sludge (r) recycle would be introduced into UAR-3 which would then feed Closed Loop Reactor CLR-2. One or more Magna Rotors would be turned off in Closed Loop Reactor CLR-2 to provide minimal mixing. This allows for the biomass to be temporarily stored "off line" eliminating loss out the final clarifier effluent during peak storm events.

  Mixed liquor (a) recycle would be pumped from each closed loop reactor to each anoxic reactor. Each anoxic reactor is paired with its own Closed Loop Reactor (UAR-2 with CLR-1 and UAR-3 with CLR-2) for two-stage denitrification. The Closed Loop Reactors would be operated with MLSS biomass that is being stored "off line to slowly flow from CLR-2 to CLR-1 via slide gate SG-5. Effluent weir EW-2 would be raised to its maximum position allowing EW-1 to provide for oxygen delivery control. The following gate and effluent weir settings would be provided:

  SG-1 - Open
  SG-2 - Closed
  SG-3 - Open
  SG-4 - Open
  SG-5 - Open
  EW-1 - Open
  EW-2 - Closed

ANAEROBIC SELECTOR DESIGN

The first phase in the CLR Process schematic is one (1) anaerobic selector reactor utilized for the release of soluble phosphorus from the biomass. The predictive model calculations indicate a desired hydraulic detention time of 2.5 hours. For this application the anaerobic reactor would be mixed only using a Lakeside-Landia POP-I submersible mixer. We suggest one (1) POP-I mixer with 2.4 hp motors designed to operate at 180 rev/min.

ANOXIC SELECTOR DESIGN

The second phase in the CLR Process is two (2) anoxic reactors utilized for the denitrification reaction to reduce the effluent nitrate-nitrite levels. The predictive model calculations indicate a desired hydraulic detention time of 5.0 hours. For this application the anoxic reactors would be mixed only via Lakeside-Landia POP-I submersible mixers. We suggest one (1) POP-I mixer with 2.4 hp motor designed to operate at 180 rev/min for each reactor.

ANAEROBIC-ANOXIC SELECTOR REACTOR DESIGN

Each of the anaerobic and anoxic reactors are suggested to have the same volume which will allow for three (3) identical tanks for construction cost savings. These tanks can be designed to be a separate structure from the aerobic reactors or can be designed as a common structure such as our recent Luke Air Force base and Prescott Valley projects in Arizona. These tanks will be mixed only.

MIXED LIQUOR RECYCLE PUMP DESIGN

Mixed liquor recycle (a) has been calculated for this project to range from 100% (240 gal/min) up to 400% (961 gal/min) for enhancement of denitrification. This recycle flow would be split equally between each anoxic-aerobic reactor. Pumping can be via any type of pump (wet pit - dry pit, submersible, etc.). The Lakeside-Landia submersible propeller pumps will save considerable costs as compared to a wet pit - dry pit design by eliminating the pump structure and piping.

CLR PROCESS REACTOR DESIGN

The two (2) closed loop reactors have been calculated based upon the following design parameters:

DESIGN PARAMETER	RANGE	DESIGN
Organic Loading (**O_L**), lb BOD_5 /1,000 cu ft	6 - 20	14.97
Hydraulic Detention Time (**D**), hours	15 - 30	25
Food-to-Microorganism Ratio (**F:m**)	0.03 - 0.12	0.072
Mean Cell Residence Time (**θ_c**), days	15 - 40	25
Growth Yield Coefficient (**Y**), lb VSS/lb BOD_5	0.4 - 0.8	0.65
Endogenous Decay Coefficient (**k_d**), day $^{-1}$	0.04 - 0.075	0.05
Mixed Liquor Suspended Solids (**X**), mg/L	1,500 - 5,000	3,338
Volatile Suspended Solids Fraction (**X_v**)	0.5 - 0.8	0.75
Decay Fraction (**f_d**)	0.78 - 0.82	0.8
Inert BOD_5 Fraction (**f_i**)	0.18 - 0.25	0.2

The two (2) closed loop reactors have been calculated based upon Ten States Standards of limiting the organic loading to 15 lb $CBOD_5$ or less per 1,000 cubic feet. This results in a total volume of approximately 376,042 gallons providing for a nominal hydraulic detention time of 25 hours for the CLR Process at the design year average day flow conditions. The reactors would be provided with the Lakeside Magna Rotors for mixing and oxygen delivery requirements.

ROTOR AERATOR SELECTION

To supply the oxygen requirements for the plant we have selected two (2) 9-ft long Magna Rotors, each with 9 ft of 304 stainless steel blades. This design allows us to maximize the installed horsepower and still operate over a 5 to 15 inch immersion range without overloading the drive. This selection was determined using an oxygen requirement for $CBOD_5$ removal of 1.5 lb O_2 per lb of $CBOD_5$ and 4.6 lb O_2 per lb. We assume complete hydrolysis of TKN to NH_3-N in the biological process.

The suggested Magna Rotor drives are 20 hp constant torque motors. If desired, additional operational flexibility can be obtained by using 2-speed motors or variable frequency drives.

OXYGEN REQUIREMENTS

Please note that the design parameters for determination of the Actual Oxygen Transfer Requirement (AOTR) of 1.5 lb O_2 per lb of $CBOD_5$ and 4.6 lb O_2 per lb should be the same for all manufacturers that you are considering. The conversion of the AOTR to Standard Oxygen Transfer Requirement (SOTR) should also use the same alpha, beta, theta, C_o, C_{st}, C_{se} and C_{sw} values to have an apples-to-apples comparison.

For this application we have assumed an alpha (α) value of 0.90, a beta (β) value of 0.97, a theta (θ) value of 1.024, operating dissolved oxygen concentration (C_o) in the anoxic reactor of 0 mg/l, operating dissolved oxygen concentration (C_o) in the aerobic reactor of 2 mg/l, saturation dissolved oxygen (C_{st}) at worst case summer conditions at 25^oC of 8.26 mg/l, saturation dissolved oxygen (C_{se}) of 9.08 mg/l at a site elevation assumed to be 50 ft above mean sea level, and a saturation dissolved oxygen (C_{sw}) of 9.09 mg/l.

For normal “parallel” operation the design Actual Oxygen Transfer Requirement (AOTR) is 1,683 lb oxygen per day assuming a denitrification credit of -262 lb oxygen per day for an adjusted AOTR of 1,421 lb oxygen per day. The adjusted design year average day AOTR is then converted to Standard Oxygen Transfer Requirement (SOTR) of 1,816 lb oxygen per day.

At design year average day conditions taking into account denitrification in “parallel” operation, the rotors would each operate at approximately 9.5 inches immersion with two (2) Magna Rotors operating at 48 rev/min in each reactor. Under these conditions the Magna Rotors would provide 1,761 lb O_2 per day. The power draw would be 23.0 brake horsepower-hour or 3.33 lb of oxygen per brake horsepower hour. The power cost for this application would be approximately $16,906 per year per reactor . Refer to pages 11 through 14 in the "CALCULATIONS" section for the Magna Rotor oxygen delivery performance with a denitrification credit.

We checked the sizing of the Magna Rotors at average day loading conditions whereby no denitrification takes places thereby presenting a worst-case scenario in the "parallel" mode of operation. The actual oxygen requirement of 1,682 lb O_2 per day was converted to standard conditions or 2,516 lb O_2 per day. At these conditions, the rotors would operate at approximately 12.1 inches immersion with one (1) Magna Rotor operating at 72 rev/min and one (1) Magna Rotor operating at 48 rev/min in each reactor. Under these conditions the Magna Rotors would provide 2,419 lb O_2 per day. The power draw would be 29.9 brake horsepower-hour or 3.40 lb of oxygen per brake horsepower hour. The power cost for this application would be approximately $22,912 per year per reactor. Refer to pages 13 through 15 in the "CALCULATIONS" section for the Magna Rotor oxygen delivery performance without a denitrification credit.

Should one Magna Rotor be out of service for any reason or an entire reactor be out of service, the remaining one () Magna Rotor in a reactor can handle the necessary mixing and aeration requirements by operating at 72 rev/min and 12.1 inches immersion. Refer to pages 10 through 11 in the "CALCULATIONS" section for the Magna Rotor oxygen delivery performance with one Magna Rotor out of service.

MIXING REQUIREMENTS

To provide the necessary complete mix conditions (1 ft/sec velocity), this system will require approximately 8.95 ft of blades and only 7.2 brake horsepower per reactor. Refer to page 8 in the "CALCULATIONS" section for the Magna Rotor length requirement for mixing. This analysis means that one (1) Magna Rotor could be turned off and still maintain adequate mixing (1 ft/sec velocity as mandated by Ten States Standards) with one (1) Magna Rotor in service at immersions of approximately 5.9 inches or greater for operation at 72 rev/min. If other combinations of Magna Rotor speeds are to be used, the average channel velocity could drop below 1 ft/sec. In real world conditions, an average channel velocity of 0.7 ft/sec will maintain adequate mixing conditions without affecting performance.

SLUDGE PRODUCTION

Net sludge production at the design average day conditions would be approximately 489 lb/day or 0.65 lb solids/lb $CBOD_5$. Refer to pages 7 and 8 in the "CALCULATIONS" section for the sludge production.

ROTOR MAINTENANCE

The Lakeside Magna Rotors require very little maintenance. The two (2) bearings on each rotor are normally grease via a grease gun every two (2) weeks to four (4) weeks. The speed reducer oil is changed 2 times per year with a conventional petroleum-based oil or on an as-needed basis when using a synthetic oil.

VELOCITY CONTROL BAFFLES

The Lakeside Magna Rotor is the most efficient mixer there is for a closed loop reactor. Therefore, bulk liquid velocities can reach over 3 ft/sec in some cases. Velocity control baffles are used to convert excess bulk liquid velocity to more turbulent mixing. The velocity control baffles are adjustable allowing the pitch on the baffle to be changed from 15 to 60 degrees from horizontal.

SPRAY AND COLD WEATHER PROTECTION

We recommend either our Type “B” or our Type "E" Rotor Cover to eliminate spray in the Rotor area. This cover minimizes misting and spray from the Rotor operation and provides a clean working environment for the operator.

EFFLUENT WEIR ASSEMBLY

Each Rotor is designed to operate with an approximate 1.5-inch allowance for diurnal aeration basin variations without overloading the motor. To provide adjustment of Magna Rotor immersion we are recommending the use of one (1) 9-ft long effluent assembly per reactor. Refer to pages 18 through 21 in the "CALCULATIONS" section for the weir sizing.

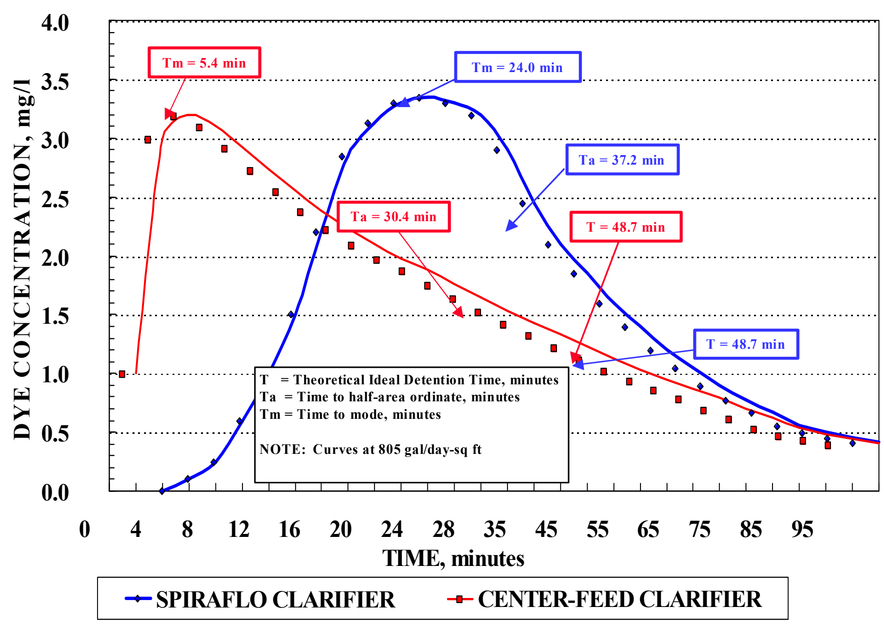
FINAL CLARIFICATION

We have sized the final clarifiers with a hydraulic loading rate at a design average flow of less than 293 gallons per square foot per day and not to exceed 733 gallons per square foot per day at the peak hydraulic loading rate.

We used a maximum solids loading of 35 lb/day-sq ft as recommended by Ten States Standards, a maximum reactor mixed liquor suspended solids (MLSS) concentration of 4,750 mg/l, a peak day flow of 0.542 mgd and a maximum RAS pumping rate of 150 percent of the 0.361 mgd design average flow.

We recommend two (2) 28-ft diameter by 12-ft sidewater depth Spiraflo Clarifiers. Refer to calculation worksheet pages 1 through 7 in the "CALCULATIONS" section for the final clarifier sizing.

As shown in Bulletin 1219 the Lakeside Spiraflo Clarifier has a hydraulic efficiency of 2 to 4 times that of a centerfeed clarifier. This hydraulic superiority has been the key to the operating success of more than 1,700 Lakeside CLR plants worldwide.



Where two or more clarifiers are used, an "upstream" flow control splitter box must be considered to ensure proper distribution between units. Flow and solids cannot be equally split under the assumption that the clarifier effluent launder weirs will provide an equal "downstream" flow split. Likewise, flow and solids cannot be equally split using piping and valves with the "calibrated eyeball" technique. The splitter box should be designed using rectangular weirs to each clarifier with an flow isolation slide gate.

When compared to conventional centerfeed clarifiers, the Lakeside Spiraflo Clarifier installation costs are typically lower. This is primarily due to the fact that the Lakeside Spiraflo Clarifier, although slightly more costly based on equipment only, can be easily installed in a circular tank and does not require cantilevered concrete or steel launders as typically utilized with a centerfeed design. The Spiraflo Clarifiers do not need Stamford baffles, mid-radius baffles, energy dissipation feedwells or flocculation wells to perform properly. Our pricing for the Lakeside Spiraflo Clarifiers also includes the launders, weirs, and baffles which typically must be added to the price of a centerfeed clarifier.

SCREENING

For preliminary treatment, we recommend our RAPTOR Micro Strainer Screen Model 12MS with 7 mm (1/4 inch) openings which is rated for a clean water capacity of 1.14 mgd. All Lakeside Screens can be channel-mounted for gravity flow applications or tank-mounted for a force main application.

The RAPTOR Micro Strainer Screen combines four (4) unit processes in an all stainless steel design with only one motorized moving part. The RAPTOR Micro Strainer Screen:

- **Screens** material with a unique basket design for higher solids removal efficiency.

- **<u>Washes organics</u>** from the screenings using 5 to 15 gal/min of washwater only when the screen is in operation.

- **<u>Transports screenings</u>** to a receptacle or conveyor system.

- **<u>Compacts and dewaters the screenings</u>** to 40 percent solids which reduces the volume by 50 % and the weight by 67%.

CONCLUSIONS

In summary, the Lakeside Closed Loop Reactor (CLR) provides enhanced treatment performance with less construction cost, less energy cost, less operation cost and less maintenance than competing systems. We trust this information meets your requirements. Should you desire additional information or have any questions, please do not hesitate contact me.

Best personal regards,

LAKESIDE EQUIPMENT CORPORATION

Steve Eckstein

Additional treatment system designs

In addition to the design done by Lakeside, Appropriate Technologies Ltd. has also included the following designs to complete the wastewater treatment process. These additional equipment include:

- Sludge management system
- Chlorine contact Chamber
- Soak Away Trench
- V-notch weir

Sludge management system:

The RAPTOR, as suggested by LAKESIDE Equipment, will not be used as the preliminary treatment. Instead, preliminary treatment of the wastewater will be done using a grit/trash chamber. The grit/trash chamber consists of an inlet screen, surface skimmer, and eductor (airlift pump). The inlet screen will remove the very large solid (for example rags) inorganic wastes from the waste stream, which will be incinerated onsite. The surface skimmer will skim the surface of the wastewater, removing grease and scum. Settleable solids (for example sand and grit) will settle from the wastewater stream and fall to the bottom of the grit/trash chamber. The grit is then removed from the bottom of the tank with an eductor, which is an airlift pump that will pump the grit to the sludge digester.
The excess sludge as well as the grease and scum that accumulates in the sewage treatment process will be stored, and thickened in the sludge digester. The thickened sludge will be dried in drying beds and eventually composted with yard waste from around the plant to kill the bacteria that was active in the wastewater treatment process. The composted yard waste and sludge can now be safely removed and used for gardening soil conditioner.

Chlorine contact Chamber:

The Chlorine Contact Chamber (CCC) retains the chlorinated effluent for 45 minutes to allow the pathogens to be killed prior to releasing the effluent to the Soak Away Trench. Pumping should happen several times a day, and a control panel using a set of float switches operates a pair of submersible pumps automatically. The pumps can also be operated manually, by using the manual (Hand) switch inside the control panel.

V-notch weir:

This weir will be placed at the end of the Chlorine Contact Chamber to measure as well as control the flow of water leaving the CCC. The weir will be marked at different heights so a visual inspection of the water level by the plant operator can determine if the effluent flow is at the prescribed rate.

Effluent Discharge:

Effluent from the treatment plant will be discharged by gravity into the proposed storm drain that will connect to the Frasier's gully.

Treatment plant bypass:

No bypass of the treatment plant will be installed. Even though each clarifier will be equipped with bypass gates between influent and effluent chambers of the clarifier, these bypass gates will only be used as a last resort. Since It will be possible to do Maintenance on one clarifier at a time, by diverting the flow to the other clarifier, the need to use the bypass gates is virtually eliminated.

Anticipated Effluent Quality

The table below shows the expected influent quality, and the anticipated effluent quality for the completed waste water treatment process compared with the NRCA sewage effluent regulations for discharge to gullies.

	Influent(mg/l)	Effluent (mg/l)	NRCA Standard	%Reduction
BOD5	250	20	20	92%
COD	1500	100	100	93%
TSS	250	20	20	92%
Nitrates	27	2	10	92%
Phosphates	5	4	4	80%
Feacal Colifor	1,000,000	<1 (MPN/100ml)	<1	99%

Section 3
Design Calculations

LAKESIDE CLR PROCESS

DATE: 6-Mar-06

PROJECT: New Harbor Village WWTP

I. DESIGN SUMMARY — VALUE

A. ANAEROBIC REACTOR DESIGN

1. Number of Anaerobic Reactors Provided	-	1
2. Anaerobic Reactor Unit Volume, gallons	-	36,000
3. Anaerobic Reactor Total Volume, gallons	-	36,000
4. Total Hydraulic Detention Time, hours	-	2.39
5. Reactor Width, feet	-	18.67
6. Reactor Length to Aerobic Reactor End Centerline, feet	-	44.00
7. Number of Mixers per Reactor	-	1
8. Total Number of Mixers	-	1
9. Mixer Type	-	POP-I
10. Mixer Rotational Speed, rev/min	-	180
11. Mixer Drive Size, hp	-	2.4
12. Total Installed Horsepower, hp	-	2.4

B. UNAERATED REACTOR DESIGN

1. Number of Unaerated Reactors Provided	-	2
2. Unaerated Reactor Unit Volume, gallons	-	36,000
3. Unaerated Reactor Total Volume, gallons		72,000
4. Total Hydraulic Detention Time, hours	-	4.79
5. Reactor Width, feet	-	18.67
6. Number of Mixers per Reactor	-	1
7. Total Number of Mixers	-	2
8. Mixer Type	-	POP-I
9. Mixer Rotational Speed, rev/min	-	180
10. Mixer Drive Size, hp	-	2.4
11. Total Installed Horsepower, hp	-	4.8

C. AEROBIC REACTOR DESIGN

1. Number of Reactors Provided	-	2
2. Organic Loading, lb $CBOD_5$ per 1,000 cubic feet	-	14.97
3. Aeration Volume, gallons	-	376,042
4. Aeration Volume Per Reactor, gallons		188,021

5. Hydraulic Detention Time, hours	-	25.00
6. Minimum Mixed Liquor Suspended Solids (MLSS) Required, mg/L	-	3,338
7. Minimum Mixed Liquor Volatile Suspended Solids (MLVSS) Required, mg/L	-	2,503
8. Food-to-Microorganism Ratio, F:m	-	0.072
9. Food-to-Volatile Microoranism Ratio, F:vm	-	0.096
10. Sludge Produced, lb TSS/day	-	489

D. ROTOR AERATOR DESIGN

1. Type of Rotor Utilized	-	Magna
2. Minimum Length of Rotor Blades for Mixing, feet/reactor	-	8.95
3. Total Number of Rotors Provided	-	4
4. Number of Rotors Provided Per Reactor	-	2
5. Single Rotor Blade Length, feet	-	9.00
6. Total Rotor Blade Length Provided Per Reactor, feet	-	18.00
7. Minimum Immersion, inches	-	5.0
8. Maximum Immersion, inches	-	15.0
9. Maximum Rotational Speed, rev/min	-	72
10. Minimum Rotational Speed, rev/min	-	48
11. Drive Size at High Speed, horsepower	-	20
12. Drive Size at Low Speed, horsepower	-	13
13. Maximum Brake Horsepower Draw Per Rotor, bhp/hr	-	19.00

E. MIXED LIQUOR RECIRCULATION PUMP DESIGN

1. Number of MLSS Recirculation Pumps per Reactor	-	1
2. Total Number of Mixers	-	2
3. Propeller Pump Type	-	AXD-I 300
4. Pumping Rate (maximum), gal/min	-	1,000
5. Pumping Heat, feet	-	2.00
6. Propeller Pump Drive Size, hp	-	2.4
7. Total Installed Horsepower, hp	-	4.8

F. OXYGEN DELIVERY REQUIREMENTS

1. **Average Day Design Year Without Denitrification Credit**

a. Actual Oxygen Transfer Required, lb O_2/day	-	1,683
b. Standard Oxygen Transfer Required, lb O_2/day	-	2,516
c. Standard Oxygen Transfer Required, lb O_2/hour	-	104.8
d. Rotor Immersion, inches	-	8.4
e. No. Rotors at 72 rev/min	-	1
f. No. Rotors at 48 rev/min	-	1
g. Standard Oxygen Transfer Provided, lb O_2/hour	-	106.2
h. Power Draw, brake horsepower/hour	-	0.0

i. Oxygen Transfer Efficiency, lb O_2/bhp	-	3.41
j. Design Year Annual Average Power Cost, $	-	22,912

2. Average Day Design Year With Denitrification Credit

a. Actual Oxygen Transfer Required, lb O_2/day	-	1,683
b. Actual Oxygen Transfer Recovered Via Denitrification, -lb O_2/day	-	-262
c. Adjusted Actual Oxygen Transfer Required, lb O_2/day	-	1,421
d. Standard Oxygen Transfer Required, lb O_2/day	-	1,816
e. Standard Oxygen Transfer Required, lb O_2/hour	-	75.7
f. Rotor Immersion, inches	-	9.5
g. No. Rotors at 72 rev/min	-	0
h. No. Rotors at 48 rev/min	-	2
i. Standard Oxygen Transfer Provided, lb O_2/hour	-	76.6
j. Power Draw, brake horsepower/hour	-	23.0
k. Oxygen Transfer Efficiency, lb O_2/bhp	-	3.33
l. Design Year Annual Average Power Cost, $	-	16,906
m. Design Year Annual Average Power Cost Savings Via Denitrification, $	-	(6,006)
n. Power Savings Present Worth at 4 % for 20 years, $	-	-81,621

3. Operation With One Rotor Out of Service at Average Day Conditions

a. Actual Oxygen Transfer Required, lb O_2/day	-	1,683
b. Standard Oxygen Transfer Required, lb O_2/day	-	2,516
c. Standard Oxygen Transfer Required, lb O_2/hour	-	104.8
d. Rotor Immersion, inches	-	12.1
e. No. Rotors at 72 rev/min	-	1
f. No. Rotors at 48 rev/min	-	0
g. Standard Oxygen Transfer Provided, lb O_2/hour	-	105.0
h. Power Draw, brake horsepower/hour	-	29.9

G. AEROBIC REACTOR DIMENSIONS

1. Sidewater Depth, feet	-	8.00
2. Reactor Width, feet	-	14.00
3. Reactor Cross Sectional Area, square feet	-	112.00
4. Center Wall Thickness, feet	-	1.00
5. Single Reactor Curved End Section Volume, gallons	-	39,526
6. Single Reactor Straight Section Volume, gallons	-	140,744
7. Single Reactor Total Volume, gallons	-	180,269
8. CLR Process Total Volume, gallons	-	360,538
9. Reactor Straight Wall Length, feet	-	84.00
10. Overall Reactor Width, feet	-	29.00
11. Overall Reactor Length, feet	-	113.00

H. ADJUSTABLE EFFLUENT WEIR DESIGN

1. Number of Adjustable Weirs Per Reactor	-	**1**
2. Length of Adjustable Weir, feet	-	**9.00**

II. INFLUENT FLOW DATA

				VALUE
Minimum Day (Q_{min}) Flow, mgd - assumed to be	**50**	% of Average Day (Q_{ave})	-	**0.181**
Average Day (Q_{ave}) Flow, mgd			-	**0.361**
Maximum Month (Q_{aww}) Flow, mgd - assumed to be	**125**	% of Average Day (Q_{ave})	-	**0.451**
Maximum Day (Q_{mww}) Flow, mgd - assumed to be	**200**	% of Average Day (Q_{ave})	-	**0.722**
Peak Hourly (Q_{phww}) Flow, mgd - assumed to be	**250**	% of Average Day (Q_{ave})	-	**0.903**

III. INFLUENT LOADING DATA

				VALUE
Average Day $CBOD_5$, mg/L			-	**250**
Average Day $CBOD_5$, lb/day			-	**753**
Maximum $CBOD_5$, lb/day - assumed to be	**125**	% of Average Day	-	**941**
Average Day TSS, mg/L			-	**250**
Average Day TSS, lb/day			-	**753**
Maximum TSS, lb/day - assumed to be	**125**	% of Average Day	-	**941**
Average Day TKN, mg/L			-	**40**
Average Day TKN, lb/day			-	**120**
Maximum TKN, lb/day - assumed to be	**125**	% of Average Day	-	**151**
Average Day NH_3-N, mg/L			-	**27**
Average Day NH_3-N, lb/day			-	**81**
Maximum NH_3-N, lb/day - assumed to be	**125**	% of Average Day	-	**102**
Average Day Total Phosphorus, mg/L			-	**23**
Average Day Total Phosphorus, lb/day			-	**69**
Maximum Total Phosphorus, lb/day - assumed to be	**125**	% of Average Day	-	**87**

IV. PREDICTED EFFLUENT

PARAMETER		30-DAY AVERAGE	7-DAY AVERAGE
$CBOD_5$, mg/l	-	**20.0**	**20.0**
TSS, mg/l	-	**20.0**	**20.0**
Total Nitrogen, mg/l (TKN + NO_2 + NO_3)	-	**10.0**	**10.0**
TKN, mg/l	-	**NR**	**NR**
NH_3-N, mg/l	-	**2.0**	**2.0**
Total Phosphorus	-	**4.0**	**4.0**

Lakeside recommends chemical backup be included for Phosphorus removal

V. AERATION BASIN DESIGN REQUIREMENTS

The design presented in these calculation worksheets is based upon the requirements of the 2004 Edition of *Recommended Standards for Wastewater Facilities* which is often called 10 States Standards.

The reactor volume can be calculated by knowing the design year average flow (Q_{ave}) rate times the desired hydraulic detention time (θ_{hyd}).

Enter the desired number of reactors for this application: - **2**
Enter the desired hydraulic detention time (θ_{hyd}) in hours: - **25.00**

$$V_T = Q_{ave} \times (\theta_{hyd}/24)$$

$$V_T = \frac{0.361 \text{ mil gal} \times 25.00 \text{ hours}}{24 \text{ hr} \times (1 \times 10^{-6} \text{ mil gal/gal})}$$

V_T =

376,042	gallons
50,273	cubic feet

V_R =

188,021	gallons/reactor
25,136	cubic feet/reactor

10 States Standards in Section 92.31 limits the organic loading to less than 15 lb BOD_5 per 1,000 cubic feet when sizing an extended aeration process. Organic loadings of up to 40 lb $CBOD_5$ per 1,000 cubic feet can be used for conventional activated sludge processes or industrial applications.

Enter the desired maximum organic loading (O_L), lb BOD_5/1,000 cu ft - **15.00**

$$O_L = \frac{CBOD_{5ave}\text{, lb/day} \times 1{,}000 \text{ cu ft}}{V\text{, cu ft}}$$

$$O_L = \frac{753 \text{ lb/day x 1,000 cu ft x 7.48 cu ft/gal}}{376{,}042 \text{ gallons}}$$

O_L = 14.97 lb $CBOD_5$/1,000 cu ft for aeration tanks only

The following formula utilizes a biological kinetic design to calculate the relationship of mixed liquor suspended solids (X) and aeration basin volume (V). The formula assumes that a portion of the influent contains inert and non-biodegradable components. By inputting the values of Y, Q, P_r, Se, θc, V, Kd, fd and f_i, the designer can determine the operating mixed liquor suspended solids (X) concentration. The mixed liquor suspended solids concentration also affects the solids loading in the final clarifier design.

$$X = \left[\frac{Qave \times \theta c}{V}\right] \times \left[\left[\frac{Y \times (So - S)}{(Kd \times \theta c) + 1}\right] \times \left[(1 + (1 - f_d) \times K_d \times \theta c)\right] + [f_i \times To]\right]$$

The above formula is from *Biological Kinetic Design of the Activated Sludge Process with Application to the Oxidation Ditch* , a master's thesis by Wayne Langeland at the University of Illinois.

REACTOR DESIGN		**VALUE**
Design Average Day Flow (Q_{ave}), mgd	-	**0.361**
Aeration Basin Volume (V), mil gal	-	**0.376**
Growth Yield Coefficient (Y), lb/lb	-	**0.65**
Mean Cell Residence Time (θ_c), days	-	**25**
Endogenous Decay Coeffiecient (K_d), day^{-1}	-	**0.05**
Volatile Suspended Solids Fraction (X_v), %	-	**0.75**
Decay Fraction (f_d), %	-	**0.80**
Inert Fraction (f_i), %	-	**0.20**
Influent Average Day $CBOD_5$ (S_o), mg/L	-	**250**
Influent Average Day TSS (T_o), mg/L	-	**250**
Predicted effluent $CBOD_5$ (S_e), mg/L	-	**20.0**

Calculate the effluent Soluble $CBOD_5$ (**S**), mg/l:

S = Se - [Se x Xv x 1.42 x (1 - e[-0.2 x 5])]

S = 20.0 mg/L - [20.0 mg/L x 0.75 mg/L x 1.42 x (1 - 0.368)]

S = 6.54 mg/L and...

$$X = \underbrace{\left[\frac{Qave \times \theta c}{V}\right]}_{(1)} \times \left[\underbrace{\left[\frac{Y \times (So - S)}{(K_d \times \theta c) + 1}\right]}_{(2)} \times \underbrace{\left[(1 + (1 - f_d) \times K_d \times \theta c)\right]}_{(3)} + \underbrace{[f_i \times To]}_{(4)}\right]$$

Calculate the first part of the equation **(1)**:

$$\frac{Q_{ave} \times \theta c}{V} = \frac{0.361 \text{ mgd} \times 25 \text{ days}}{0.376 \text{ mil gal}}$$

$$\frac{Q_{ave} \times \theta c}{V} = \boxed{24.00}$$

Calculate the second part of the equation **(2)**:

$$\frac{Y \times (S_o - S)}{(K_d \times \theta c) + 1} = \frac{0.65 \text{ lb/lb} \times (250 \text{ mg/L} - 6.54 \text{ mg/L})}{0.05 \text{ day}^{-1} \times 25 \text{ days} + 1}$$

$$\frac{(Y \times S_o) - S}{(K_d \times \theta c) + 1} = \boxed{71.79} \text{ mg/L}$$

Calculate the third part of the equation **(3)**:

$$1 + (1 - f_d) \times K_d \times \theta c = 1 + (1 - 0.80) \times 0.05 \text{ day}^{-1} \times \# \text{ days}$$

$$1 + (1 - f_d) \times K_d \times \theta c = \boxed{1.2409}$$

Calculate the fourth part of the equation **(4)**:

$$f_i \times T_o = 0.20 \times 250 \text{ mg/L}$$

$$f_i \times T_o = \boxed{50.00} \text{ mg/L}$$

$$X = \left[\frac{Q_{ave} \times \theta c}{V}\right]_{(1)} \times \left[\left[\frac{Y \times (S_o - S)}{(K_d \times \theta c) + 1}\right]_{(2)} \times \left[(1 + (1 - f_d) \times K_d \times \theta c)\right]_{(3)} + [f_i \times T_o]_{(4)}\right]$$

$$X = 24.00 \times [(71.79 \text{ mg/L} \times 1.2409) + 50.00 \text{ mg/L}]$$

$$X = \boxed{3{,}338} \text{ mg/L}$$

Calculate the required mixed liquor volatile suspended solids concentration:

$$X_{vol} = X \times X_v$$

$$X_{vol} = 3{,}338 \text{ mg/L} \times 0.75$$

X_{vol} = **2,503** **mg/L**

Calculate the food-to-microorganism ratio (F:m):

$$\text{F:m} = \frac{\text{CBOD}_5\text{, lb/day}}{\text{X, mg/L} \times 8.34 \times \text{V, mil gal}}$$

$$\text{F:m} = \frac{753 \text{ lb/day}}{3{,}338 \text{ mg/L} \times 0.376 \text{ mil gal} \times 8.34}$$

F:m = **0.072**

Calculate the food-to-volatile microorganism ratio (F:vm):

$$\text{F:vm} = \frac{\text{CBOD}_5\text{, lb/day}}{X_v \times \text{X, mg/L} \times 8.34 \times \text{V, mil gal}}$$

$$\text{F:vm} = \frac{753 \text{ lb/day}}{0.75 \times 3{,}338 \text{ mg/L} \times 8.34 \times 0.376 \text{ mil gal}}$$

F:vm = **0.096**

The amount of sludge produced each day is a function of a variety of factors. The typical sludge production rate for the CLR Process is 0.65 lb TSS per lb $CBOD_5$ applied.

Enter the sludge production rate, lb TSS per lb $CBOD_5$ applied: - **0.65**

SP_{TSS} = **753 lb/day x 0.65 lb TSS/lb $CBOD_5$ applied**

SP_{TSS} = **489** **lb TSS produced per day**

VI. ROTOR LENGTH REQUIRED FOR MIXING

The bulk liquid velocity in a reactor varies with rotor type, rotor length, rotor speed, rotor immersion, reactor geometry, reactor depth, reactor material, velocity control baffles and their inclination (0 to 60 degrees from horizontal) and obstructions in the reactor. The minimum Magna Rotor length for mixing is based a maximum of 1 ft of rotor length per 21,000 gallons. For reactor volumes of less than 60,000 gallons, reduce the length to 1 ft per 16,000 gallons.

Calculate the minimum required rotor length for mixing based upon the calculated reactor volume:

MIN. ROTOR LENGTH = $\frac{\text{Reactor Volume, gallons}}{\text{gal/ft rotor x number of reactors}}$

MIN. ROTOR LENGTH = $\frac{376{,}042 \text{ gallons}}{21{,}000 \text{ gal/ft} \times 2 \text{ reactors}}$

MIN. ROTOR LENGTH = **8.95** **feet of rotor per reactor**

VII. AERATION REQUIREMENTS

Based upon a known quantity of influent CBOD5 and TKN, the actual oxygen transfer rate requirement (AOTR) can be calculated. The actual oxygen transfer rate (AOTR) can be converted to standard oxygen transfer rate (SOTR) knowing the elevation of the plant, operating D.O level, water temperature, alpha, beta, theta, and the saturation concentration at a given temperature.

10 States Standards requires that aeration equipment for extended aeration processes, such as the CLR Process, be designed based upon 1.5 lb oxygen per lb of $CBOD_5$ (includes endogenous respiration) and 4.6 lb oxygen per lb of TKN apllied to the reactors for peak loadings.

Conservative values have been developed for the alpha (α), beta (β) and theta (θ) factors for domestic wastewater. For domestic wastewater we use an alpha (α) factor of 0.90, beta (β) factor of 0.98, theta (θ) of 1.024, C*w for site conditions from *Standard Methods* , C*t from *Standard Methods* and mixed liquor temperture (T) during warm summer conditions.

$$SOTR = \frac{AOTR}{\alpha \left[\frac{(\beta \times C^*_w) - C_L}{C^*_t}\right] \times [\theta^{T-20}]}$$

AOTR = Actual field (on-site) oxygen transfer rate for wastewater, lb oxygen per day

SOTR = Standard (test) oxygen transfer rate to tap water at 0 mg/L D.O. and 20^oC, lb oxygen per day

PARAMETER			**VALUE**
O_{2bod} =	lb oxygen per lb $CBOD_5$ applied	-	1.5
O_{2tkn} =	lb oxygen per lb TKN applied	-	4.6
α =	Relative rate of oxygen transfer as compared to clean water	-	0.90
β =	Relative oxygen saturation value of wastewater as compared to saturation of tap water	-	0.97

θ =	Temperature correction constant equal to 1.024	-	**1.024**
C_L =	Operational D.O. level in the reactor mixed liquor, mg/L	-	**2.0**
T =	Mixed liquor temperature during the warmest ambient period, °C	-	**25**
EL =	Site elevation, feet above mean sea level	-	**50**
C^*_w =	Saturation value of oxygen in water at operating temperature (T) and site elevation, mg/L		

$$C^*_w = \frac{C_{SE} \times C^*}{C^*_t}$$

C_{SE} =	Saturation value of oxygen in water at 20°C at site elevation, mg/L	-	**9.08**
C^* =	Saturation value of oxygen in water at operating temperature, mg/L	-	**8.26**
C^*_t =	Saturation value of oxygen used at standard conditions, mg/L	-	**9.092**

$$C^*_w = \frac{9.08 \text{ mg/L} \times 8.26 \text{ mg/L}}{9.092 \text{ mg/L}}$$

C^*_w = **8.25** mg/L

θ^{T-20} = **1.024** ^ [**25** °C - **20** °C]

θ^{T-20} = **1.126**

$$\text{SOTR} = \frac{\text{AOTR}}{0.90 \left[\frac{[0.97 \times 8.25 \text{ mg/L}] - 2.0 \text{ mg/L}}{9.092 \text{ mg/L}} \right] \times 1.126}$$

SOTR = 1.50 x AOTR for normal operation with 2.0 mg/L mixed liquor D.O.

Calculate AOTR and SOTR for each design parameter:

AOTR = (lb $CBOD_5$ x 1.5) + (lb TKN x 4.6)

Enter the desired number rotor aerators **per reactor** for this project:	-	**2**
Enter the desired rotor length, feet:	-	**9**
Select the desired rotor **maximum** rotational speed, rev/min:	-	**72**

Select the desired rotor **minimum** rotational speed, rev/min: - **48**

Enter the cost of power, $/kilwatt-hour - **0.10**
Enter the motor efficiency, % - **0.936**

Average Day Oxygen Delivery With One (1) Rotor Out of Service

Enter the desired mixed liquor D.O. (C_{LP}) for operation with one rotor out of service, mg/L - **2.00**

SOTR = 1.50 x AOTR for operation with one rotor out of service

10 States Standards mandates that the design be based upon maintaining the maximum oxygen transfer rate with the largest aerator out of service in each reactor. Enter a "1" in the appropriate cell which will form the basis of design for one rotor out of service.

PARAMETER	BASIS OF DESIGN	AOTR				SOTR	
		$CBOD_5$ + (lb/day)	TKN (lb/day)	=	TOTAL (lb/day)	(lb/day)	(lb/hour)
Average Day	1	1,129	554	=	1,683	2,516	104.8
Maximum**		1,411	692	=	2,104	3,145	131.1

**See cell K661 for mixed liquor operating D.O. (C_o) at the maximum loading conditions.

Design will be the **Average Day** oxygen transfer rate for the CLR Process of **104.8** lb/hour. Each reactor will be designed for **52.4** lb/hour-reactor.

Select the desired immersion, inches: - **12.1**

Enter the number of rotors at each speed as well as immersion in the table on the next page:

DESIGN PARAMETERS WITH ONE ROTOR OUT OF SERVICE	MAXIMUM SPEED 72 (rev/min)	MINIMUM SPEED 48 (rev/min)	TOTAL
Number of Rotors/Reactor	1	0	1
Oxygen Transfer @ Immersion, lb/hr-ft	5.83	2.48	-
Oxygen Transfer, lb/hr-reactor	52.5	0.0	52.5
Power Draw @ Immersion, bhp/hr-ft	1.662	0.849	-
Power Draw, bhp/hr-reactor	14.96	0.00	15.0

Transfer Efficiency, lb O_2/bhp-hr	**3.51**	**2.92**	**3.51**

Enter the desired drive horsepower: **20**

Based upon a (an) **9.00** ft rotor operating at a maximum speed of **72** rev/min with a **20** horsepower drive, the maximum brake horsepower per foot of Magna Rotor is **2.111** bhp/ft. The maximum allowable immersion is **15.00** inches.

Average Day Oxygen Delivery With Denitrification Credit

The CLR Process can be operated in a denitrification mode, even though the NPDES Permit may not require Total Nitrogen removal. Denitrification offers energy savings and can recover 50% of the Total Alkalinity (as $CaCO_3$) that was destroyed during the nitrification process.

Enter the Operating D.O. (Co) for the nitrification reactor, mg/l: - **2.00**

Enter the Operating D.O. (Cdno) for the denitrification reactor, mg/l: - **0.00**

Enter the predicted total nitrogen (TN) in the effluent, mg/l: - **10.00**

The maximum percent oxygen recovery is, %: - **0.63**

Calculate the percent denitrification:

$$\text{Denit} = \frac{(\text{TKN, mgl} - \text{TN, mg/l})}{\text{TKN, mg/l}}$$

$$\text{Denit} = \frac{40 \text{ mg/l} - 10.00 \text{ mg/l}}{40 \text{ mg/l}}$$

Denit = **0.75**

Calculate the AOTR recovered via denitrification:

O_{2rec} = TKN, lb/day x lb O_2/lb TKN applied x Oxygen Recovery, % x Denitrification, %

O_{2rec} = 120 lb/day x 4.6 lb/lb x 0.63 x 0.75

O_{2rec} = **-262** **lb/day**

AOTR		-	AOTR CREDIT	=	AOTR
$CBOD_5$ (lb/day)	+ TKN (+lb/day)	-	DENITRIFICATION (-lb/day)	=	TOTAL (lb/day)

1,129	554	-	262	=	1,421

Design is based on the actual oxygen transfer rate (AOTR) for the CLR Process of 1,421 lb/day.

Enter the Process Oxygen (AOTR) split between the reactors:

Denitrification Reactors, %	-	57.00
Nitrification Reactors, %	-	43.00
Total AOTR, %	-	100.00

The SOTR split between the 2 reactors is as follows:

Calculate the SOTR for denitrification reactors with a mixed liquor operating D.O. (C_o) of
0.0 mg/l:

$$\textbf{SOTR} = \frac{\textbf{AOTR}}{0.90\left[\dfrac{\left[0.97 \times 8.25\ \text{mg/L}\right] - 0.0\ \text{mg/L}}{9.092\ \text{mg/L}}\right] \times 1.126}$$

SOTR = 1.12 AOTR x Denitrification reactor %

SOTR = 1.12 x 1,421 lb O_2/day x 0.57

SOTR = 908 lb O_2/day to denitrification reactor

SOTR = 37.8 lb O_2/hr to denitrification reactor

Calculate the SOTR for nitrification reactors with a mixed liquor operating D.O. (C_o) of
2.00 mg/l:

$$\textbf{SOTR} = \frac{\textbf{AOTR}}{0.90\left[\dfrac{\left[0.97 \times 8.25\ \text{mg/L}\right] - 2.0\ \text{mg/L}}{9.092\ \text{mg/L}}\right] \times 1.126}$$

SOTR = 1.50 AOTR x Nitrification reactor %

SOTR = 1.50 x 1,421 lb O_2/day x 0.43

SOTR = 914 lb O_2/day to nitrification reactors

SOTR = 38.1 lb O_2/hr to nitrification reactors

Select the desired immersion, inches: - 9.5

Enter the number of rotors at each speed as well as immersion in the table below:

AVERAGE DAY PARAMETERS WITH DENITRIFICATION CREDIT	MAXIMUM SPEED 72 (rev/min)	MINIMUM SPEED 48 (rev/min)	TOTAL
Number of Rotors/Reactor	0	2	2
Oxygen Transfer @ Immersion, lb/hr-ft	4.61	2.13	-
Oxygen Transfer, lb/hr-reactor	0.0	38.3	38.3
Power Draw @ Immersion, bhp/hr-ft	1.327	0.639	-
Power Draw, bhp/hr-reactor	0.00	11.50	11.5
Transfer Efficiency, lb O_2/bhp-hr	3.47	3.33	3.33
Total Energy Costs, $/year	$0	$16,906	$16,906

Average Day Oxygen Delivery Without Denitrification Credit

Calculate the required oxygen delivery for the average day requirements assuming a worst case scenario where there is no denitrification. This would typically represent the operating conditions for "parallel" operation of the reactors.

PARAMETER	AOTR SOTR RATIO	AOTR				SOTR	
		$CBOD_5$ + (lb/day)	TKN (lb/day)	=	TOTAL (lb/day)	(lb/day)	(lb/hour)
Average Day	1.50	1,129	554	=	1,683	2,516	104.8

Design will be the oxygen transfer rate for the CLR Process of 104.8 lb/hour.
Each reactor will be designed for 52.4 lb/hour-reactor.

\- 8.4

Enter the number of rotors at each speed as well as immersion in the table on the next page:

AVERAGE DAY PARAMETERS WITHOUT DENITRIFICATION CREDIT	MAXIMUM SPEED 72 (rev/min)	MINIMUM SPEED 48 (rev/min)	TOTAL
Number of Rotors/Reactor	1	1	2
Oxygen Transfer @ Immersion, lb/hr-ft	3.97	1.93	-
Oxygen Transfer, lb/hr-reactor	35.7	17.4	53.1
Power Draw @ Immersion, bhp/hr-ft	1.180	0.552	-
Power Draw, bhp/hr-reactor	10.62	4.97	15.6
Transfer Efficiency, lb O_2/bhp-hr	3.36	3.50	3.41
Total Energy Costs, $/year	$15,610	$7,302	$22,912

Maximum Oxygen Delivery

Enter the desired mixed liquor dissolved oxygen concentration allowed for the maximum day loadin - 2.0

Design will be based on the Maximum oxygen transfer rate for the CLR Process of 131.1 lb/hour. Each reactor will be designed for 65.5 lb/hour-reactor.

Select the desired immersion, inches: - 10.3

Enter the number of rotors at each speed as well as immersion in the table on the next page:

MAXIMUM PARAMETERS	MAXIMUM SPEED 72 (rev/min)	MINIMUM SPEED 48 (rev/min)	TOTAL
Number of Rotors	1	1	2
Oxygen Transfer @ Immersion, lb/hr-ft	5.04	2.26	-
Oxygen Transfer, lb/hr	45.4	20.3	65.7
Power Draw @ Immersion, bhp/hr-ft	1.432	0.702	-

Power Draw, bhp/hr	**12.89**	**6.32**	**19.21**
Transfer Efficiency, lb O_2/bhp-hr	**3.52**	**3.22**	**3.42**

VIII. UNAERATED REACTOR SIZING

Enter the number of anaerobic reactors	-	**1**
Enter the required anaerobic selector volume, gallons	-	**36,000**
Enter the number of anoxic reactors	-	**2**
Enter the required anoxic selector volume, gallons	-	**72,000**
Total anaerobic and anoxic reactor volume, gallons	-	**108,000**
Outer Wall Thickness, feet	-	**1.00**

For this application we are recommending a "common wall" construction to save space and to reduce the overall construction costs. The dimensions can be calculated for the anaerobic and anoxic selector reactor portion of the CLR Process:

Calculate the overall outside width of the CLR Process tankage:

Width = [Channel Width, ft x 4] + [Common Wall Thickness, ft x 2] + [Center Wall Thickness, ft x2]

Width = [14.00 ft x 4 Channels] + [1.00 ft x 2] + [1.00 ft x 2]

Width = 60.00 feet

Calculate the anaerobic and anoxic selector reactor widths assuming that they are equally divided into three (3) cells:

Width = [Overall Width, ft - (Common Wall Width, ft x 2) - (Outer Wall Width, ft)] / 3 Reactors

Width = 60.00 ft - (2.00) ft - (2.00 ft) / 3 Reactors

Width = 18.67 feet

Calculate the length of the anoxic selector reactor to the centerline of the aerobic reactor return ends:

Length = Anaerobic-Anoxic Reactor Volume, cu ft - CLR End Volume, cu ft / Liquid Depth, ft x [Reactor Width, ft - (Common Wall Thickness x 2)]

Length = 108,000 (gallons / 7.48) + 6,038 cu ft / 8.00 ft x [60.00 ft - (1.00 ft x 2)]

Length = 44.13 feet

Length = 44.00 feet

IX. CLOSED LOOP REACTOR SIZING

The total volume required for the CLR Process is 50,273 cubic feet.

Enter the desired liquid depth, feet: - 8.00
Enter the desired channel width, feet: - 14.00
Enter the center dividing wall thickness, feet - 1.00

Calculate the volume of the ends of each reactor:

$$\mathbf{Vend} = \frac{[(\text{Channel Width, ft} \times 2) + \text{Dividing Wall Thickness, ft}]^2 \times \pi \times \text{Liquid Depth, ft}}{4}$$

$$\mathbf{Vend} = \frac{[[\ 14.00\ \text{ft} \times 2\ ] + 1.00\ \text{ft}]^2 \times \pi \times 8.00\ \text{feet}}{4}$$

Vend =

5,284	**cubic feet**
39,526	**gallons**

Calculate the straight section length required:

$$\mathbf{Lstr} = \frac{(\text{Total Required Reactor Volume, cu ft / Number of Reactors}) - \text{End Section Volume, cu ft}}{\text{Liquid Depth, feet} \times \text{Channel Width, feet} \times 2\ \text{Channels}}$$

$$\mathbf{Lstr} = \frac{[\ 50{,}273\ \text{cu ft} / 2\ \text{reactors}\ ] - 5{,}284\ \text{cu ft}}{8.00\ \text{feet} \times 14.00\ \text{feet} \times 2\ \text{channels}}$$

Lstr = 88.63 **feet**

Round up to the nearest foot and enter the value of the staight wall length, feet: - 84.00

Calculate the straight section volume:

Vstr = Straight Wall Length, feet x Liquid Depth, feet x 2 channels x Channel Width, feet

Vstr = 84.00 ft x 8.00 ft x 2 x 14.00 ft

Vstr =

18,816	**cubic feet**
140,744	**gallons**

Calculate the total reactor volume (V_R) as designed:

V_R = End Volume, cu ft + Straight Section Volume, cu ft

V_R = 5,284 cu ft + 18,816 cu ft

V_R =		
	24,100	**cubic feet**
	180,269	**gallons**

Calculate the total Closed Loop Reactor (CLR) volume (V_T) as designed:

V_T = Total Reactor Volume, cu ft x Number of Reactors

V_T = 24,100 cu ft x 2 reactors

V_T =		
	48,200	**cubic feet**
	360,538	**gallons**

X. AEROBIC REACTOR ADJUSTABLE WEIR DESIGN

A rectangular weir is often utilized for providing a controlled discharge into and out of a reactor unit. The most commonly utilized formula is based on the work conducted by Francis. Francis concluded that the formula of Q = 0.*L*H^3/2 was valid for contracted weirs provided that the ratio of the head does not exceed one-third of the crest length. The following computations are based on this premise using flows (Q) in mgd, weir lengths (L) in feet and weir head (H) in feet.

Lakeside offer three (3) types of level control weirs for the CLR Process. Enter a "1" for the type of level control weir desired in the table below:

WEIR TYPE	AVAILABLE LENGTH (feet)	BASIS OF DESIGN
Weir Gate	2 to 7	
Hinged Plate Weir	2 to 15	1
Rotating Plate Weir	6 to 30	

Under the heading "Number of Reactors" enter 50% of the number of reactors if the CLR Process will be operated in series where each reactor will see the full flow.

WEIR DESIGN		**VALUE**
Number of Reactors	-	**1**
Maximum RAS ratio to Average Day (Q_{max}) Flow, %	-	**150**

Average RAS ratio to Average Day (Q_{ave}) Flow, %	-	100
Minimum RAS ratio to Average Day (Q_{min}) Flow, %	-	50
Number of Weirs per Reactor	-	1
Weir Length, feet	-	9
Enter a "1" if this project is for a municipal application	-	1
Enter a "1" if this project is for an industrial application	-	

Calculate the maximum return activated sludge (R_{max}) pumping rate:

R_{max} = Q_{ave} x maximum RAS ratio

R_{max} = 0.361 mgd x 150 % / 100

R_{max} = 0.542 mgd

Calculate the average return activated sludge (R_{ave}) pumping rate:

R_{ave} = Q_{ave} x average RAS ratio

R_{ave} = 0.361 mgd x 100 % / 100

R_{ave} = 0.361 mgd

Calculate the minimum return activated sludge (R_{min}) pumping rate:

R_{min} = Q_{ave} x minimum RAS ratio

R_{min} = 0.361 mgd x 50 % / 100

R_{min} = 0.181 mgd

Calculate the peak flow over the weir which includes the Q_{piww} + R_{max}:

Q_{peak} = [0.903 mgd + 0.542 mgd] / 1 reactor(s)

Q_{peak} = 1.444 mgd

Calculate the average flow over the weir which includes the Q_{ave} + RAS_{ave}:

Q_{ave} = [0.361 mgd + 0.361 mgd] / 1 reactor(s)

Q_{ave} = 0.722 mgd

Calculate the minimum flow over the weir which includes the Q_{min} + RAS_{min}:

$$Q_{min} = [\ 0.181 \text{ mgd} + 0.181 \text{ mgd}\ ] \ / \ 1 \text{ reactor(s)}$$

$$Q_{min} = \boxed{0.361} \text{ mgd}$$

Calculate the maximum weir head (H_{max}) over the weir at the peak flow rate (Q_{peak}):

$$H_{max} = \left[\frac{Q_{peak}, \text{mgd}}{2.152 \times L, \text{feet} \times \text{Number of Reactors}} \right]^{2/3}$$

$$H_{max} = \left[\frac{1.444 \text{ mgd}}{2.152 \times 9.00 \text{ feet} \times 1} \right]^{2/3}$$

$$H_{max} = \boxed{0.177} \text{ feet}$$

$$H_{max} = \boxed{2.13} \text{ inches}$$

Calculate the average weir head (H_{ave}) over the weir at the average flow rate (Q_{ave}):

$$H_{ave} = \left[\frac{Q_{ave}, \text{mgd}}{2.152 \times L, \text{feet} \times \text{Number of Reactors}} \right]^{2/3}$$

$$H_{ave} = \left[\frac{0.722 \text{ mgd}}{2.152 \times 9.00 \text{ feet} \times 1} \right]^{2/3}$$

$$H_{ave} = \boxed{0.112} \text{ feet}$$

$$H_{ave} = \boxed{1.34} \text{ inches}$$

Calculate the minimum weir head (H_{min}) over the weir at the minimum flow rate (Q_{ave}):

$$H_{min} = \left[\frac{Q_{min}, \text{mgd}}{2.152 \times L, \text{feet} \times \text{Number of Reactors}} \right]^{2/3}$$

$$H_{min} = \left[\frac{0.361 \text{ mgd}}{2.152 \times 9.00 \text{ feet} \times 1} \right]^{2/3}$$

$$H_{min} = \boxed{0.070} \text{ feet}$$

$$H_{min} = \boxed{0.84} \text{ inches}$$

The maximum head differential (ΔH) should be less than 1.5 to 2 inches for domestic wastewaters and less than 2 to 3 inches for industrial applications. Calculate the ΔH over the weir between the peak flow rate (Q_{peak}) versus the average flow rate (Qave):

ΔH = H_{peak} inches - H_{min} inches

ΔH = 0.177 inches - 0.070 inches

ΔH =	**0.107**	**feet**
ΔH =	**1.28**	**inches**

LAKESIDE SPIRAFLO CLARIFIER

DATE: **6-Mar-06**

PROJECT: **New Harbor Village WWTP**

I. FINAL CLARIFIER DESIGN

The final clarifier is the "heart" of any biological process. Lakeside uses our state-of-the-art Spiraflo Clarifier for biological processes because it has been proven to be from 2 to 4 times more hydraulically efficient than a center-feed clarifier.

Clarifier sizing is based upon both hydraulic loading rate and solids loading rate according to Ten States Standards. For the CLR Process the peak hourly hydraulic loading rate should be limited to 1,000 gal/day-sq ft. For conventional activated sludge processes the hydraulic loading should be limited to 1,200 gal/day-sq ft. The solids loading should be limited to no more than 35 lb/sq ft-day based upon the maximum RAS flow rate (RASmax) and the peak day flow (Qmww) rate to the clarifiers. The maximum MLSS to the final clarifiers should be either 3,500 mg/l or the maximum calculated MLSS value (X).

For plants with industrial contributions such as dairies or where chemical addition is being added for phosphorus removal, we suggest decreasing the hydraulic loading to 800 gal/day-sq ft.

I. INFLUENT FLOW DATA

				VALUE
Average Day (Qave) Flow, mgd			-	**0.361**
Maximum Day (Qmww) Flow, mgd assumed to be	**150**	% of Average Day (Q_{ave})	-	**0.542**
Peak Hourly (Qphww) Flow, mgd assumed to be	**250**	% of Average Day (Q_{ave})	-	**0.903**

II. DESIGN DATA

		VALUE
Number of Final Clarifiers	-	**2**
Maximum Hydraulic Loading Rate, gal/day-sq ft	-	**1,000**
Maximum Solids Loading, lb/sq ft-day	-	**35**
Maximum Mixed Liquor Suspended Solids (X), mg/l	-	**4,750**
Maximum Return Activated Sludge (RAS) Flow, % of Q_{ave}	-	**150**

III. DESIGN CALCULATIONS

Calculate the clarifier diameter based upon the hydraulic loading rate:

$$D = \left[\frac{\text{Qphww, gal/day} \times 4}{\text{Number of Final Clarifiers} \times \text{Hydraulic Loading Rate, gal/day-sq ft} \times \pi} \right]^{1/2}$$

$$D = \left[\frac{0.9025 \text{ mgd} \times 1{,}000{,}000 \text{ gal/mgd} \times 4}{2 \text{ units} \times 1{,}000 \text{ gal/day-sq ft} \times \pi} \right]^{1/2}$$

D = 23.97 feet

Calculate the minimum clarifier diameter based upon the solids loading rate:

$$D = \left[\frac{(\text{Qmww, mgd} + \text{RASmax, mgd}) \times \text{MLSS, mg/l} \times 8.34 \times 4}{\text{Number of Final Clarifiers} \times \text{Solids Loading Rate, lb/day-sq ft} \times \pi} \right]^{1/2}$$

$$D = \left[\frac{0.54 \text{ mgd} + 0.54 \text{ mgd} \times 4{,}750 \text{ mg/l} \times 8.34 \times 4}{2 \text{ units} \times 35 \text{ lb/day-sq ft} \times \pi} \right]^{1/2}$$

D = 27.94 **feet**

The clarifier design for this project is based upon solids loading, not hydraulic loading.

The minimum final clarifier diameter required for this project is: - 27.94 **feet**

Round up the final clarifier diameter to the nearest foot: - 28 **feet**

Calculate the final clarifier surface area:

$$\text{Area} = \frac{(\text{Diameter, feet})^2 \times \pi}{4}$$

$$\text{Area} = \frac{[28 \text{ feet}]^2 \times \pi}{4}$$

Area = 616 **sq ft**

Calculate the hydraulic loading (Q_{hyd}) for the final clarifiers based upon the selected diameter:

$$Q_{hyd} = \frac{\text{Q, mgd} \times 1{,}000{,}000 \text{ gal/mgd}}{\text{Area, sq ft} \times \text{Number of Units}}$$

INFLUENT FLOW PARAMETER	FLOW (mgd)	HYDRAULIC LOADING (gal/day-sq ft)
Average Day (Qave) Flow, mgd	0.36	293
Maximum Day (Qmww) Flow, mgd	0.54	440
Peak Hourly (Qphww) Flow, mgd	0.90	733

The sidewater depth for the final clarifiers is very important since the CLR Process is operated in the extended aeration mode with a relatively high Mixed Liquor Suspended Solids (MLSS) concentration. The table below represents the suggested minimum final clarifier sidewater depths for the following final clarifier diameters. For plants with industrial contributions that tend to promote a high Sludge Volume Index (SVI) such as dairy waste or where chemical addition is being added for phosphorus removal, we suggest increasing the sidewater depth by 2 ft.

FINAL CLARIFIER DIAMETER (feet)	MINIMUM SIDEWATER DEPTH (feet)
$D \leq 40$	12
$40 < D \leq 75$	14
$75 < D \leq 125$	16
$D > 125$	18

Based upon the final clarifier diameter for this project, the suggest minimum sidewater depth should be not less than 12 feet.

Enter the desired final clarifier sidewater depth: - 12 feet

Calculate the final clarifier volume:

V = Surface Area, sq ft x Sidewater Depth, feet

V = 616 sq ft x 12 feet

V = 7,389 cu ft

Calculate the hydraulic detention time (DT) for the final clarifiers based upon the selected diameter and sidewater depth:

$$DT = \frac{\text{Volume, cu ft x 7.48 gal/cu ft x 24 hr/day x Number of Units}}{\text{Flow, mgd x 1,000,000 gal/mgd}}$$

INFLUENT FLOW PARAMETER	FLOW (mgd)	DETENTION TIME (hours)
Average Day (Qave) Flow, mgd	0.361	7.35
Maximum Day (Qmww) Flow, mgd	0.542	4.90
Peak Hourly (Qphww) Flow, mgd	0.903	2.94

Ten States Standards requires that the final clarifier weir loading rate be less than 20,000 gal/day-ft for plants with an average flow of less than 1.0 mgd and less than 30,000 gal/day-ft for plants with an average flow of greater than 1.0 mgd. The final clarifier maximum weir loading rate calculation is based upon the peak hourly flow rate which is **0.90** mgd for this application. Based upon an average flow of **0.36** mgd, the maximum weir loading is not to exceed **20,000** gallons per day per linear feet of weir.

Based upon a final clarifier diameter of **28** feet selected for this project, the minimum total weir length is **82** feet. Weir configuration for this size clarifier is **round** . This weir configuration has a **13.00** foot **diameter** dimension. Calculate the peak weir loading rate for the final clarifiers based upon the selected diameter:

$$\textbf{WL} = \frac{\textbf{Peak Hourly (Qphww) Flow, mgd} \times 1{,}000{,}000}{\textbf{Weir Length, feet} \times \textbf{Number of units}}$$

$$\textbf{WL} = \frac{0.9025 \text{ mgd} \times 1{,}000{,}000 \text{ gal/mgd}}{82 \text{ feet} \times 2 \text{ units}}$$

WL = **5,503** **gal/day-ft**

Additional Treatment system designs

Grit/Trash Chamber Design

1. Assume the Peak hour flowrate = Pf

$Pf := 903000$ gallons per day (gpd)

2. Determine the volume of the grit chamber. Assume that the detention time at the peak hour flow rate is 10 minutes

$$Volume := \frac{(Pf*10)}{24*60*7.48}$$

$Volume = 838.347\ ft^3$

3. Determine the dimensions of grit chamber. Using a width to depth ratio of 2.5:1 and assume that the depth of settling zone is 4 ft

$Depth := 4$ ft

$Width := 2.5 * Depth$

$Width = 10$ ft

$$Length := \frac{Volume}{(Depth * Width)}$$

$Length = 20.959$ ft

Actual Length of chamber: $L := 20ft$

4. Determine the average quantity of grit that must be handled. Assume a value of 7 ft^3 of grit for every 1gallon of influent to the grit/trash chamber (refer to page 297, Crites and Tchobanoglous

$$Grit\_volume := 7.\frac{Pf}{1*10^6}$$

$Grit\_volume = 6.321\ ft^3/day$

5. Determine Hopper volume for storing daily grit\trash accummulated

Using the cone shaped volume below the settling zone to collect the grit, the collection volume would be

$$Hopper\_volume := \left(\frac{1}{3}*2 L*Depth*10 - \frac{1*2*1.05*0.475}{3}\right)$$

$Hopper\_volume = 266.334\ ft^3$ of grit storage capacity

Sludge Digester Design

Based on the design parameters, approximately 489 pounds of sludge will be produced daily. Sludge will be wasted from the digester periodically to the sludge drying beds to ensure the sludge is always fresh.about 75% of the sludge will be recycled, leaving about 25% to be sent to the digesters

Amount of wasted sludge (WS) is therefore:

$$WS := 489 - 0.75 \cdot (469)$$

$$WS = 137.25 \quad \text{lbs}$$

limiting the solids loading to the sludge digester to 0.1lb solids/ft^3.day, the volume of tank needed is:

$$VS := \frac{WS}{0.1}$$

$$VS = 1.373 \cdot 10^3 \quad ft^3$$ of digester space needed per day

Using a detention time of 4 days the digester volume now becomes:

$$:= \; VD = VS*4$$

$$VD = 5.49 \cdot 10^3 \, ft^3$$

Actual volume of digester is 4742 ft^3 with a depth of 10 ft, width of 20 ft and length of 23.7 ft

NB* the sludge digester will be used primarily as a holding tank for the waste sludge before being discharged to the sludge drying bed. the sludge digester will also help with the sludge thickening process prior to the discharge to the sludge drying bed

Chlorine Contact Chamber (CCC) Design

The chlorine contact chamber will be designed using the average flow of effluent with a detention time of about 45 minutes to ensure complete disinfection of the effluent.

1. Assume the average flow rate = avgf

$$avgf := 361000$$ gallons per day (gpd)

2. Determine the volume of the CCC. Assume that the detention time at the peak hour flow rate is 45 minutes

$$Volume := \frac{(avgf * 45)}{24*60*7.48} \qquad 0$$

$$Volume = 1.508*10^{3} ft^{3}$$

3. Determine the dimensions of CCC. Using a width of 11 feet and assume that the depth of CCC is 4 ft

$$Depth := 4 \quad ft$$

$$Width := 11 \quad ft$$

$$Length := \frac{Volume}{Width * Depth}$$

$$Length = 34.277$$

Actual length of CCC is 40 ft

V-notch weir calculations

c=Discharge coefficient

The angle of a V-notch weir, (**ang)** is 90º

$$ang := 90^{o}$$

$$c := 0.607165052 - (0.000874466963 * ang) + (0.00000610393334 * ang^{2})$$

$$c = 0.578$$

let h be the water head at the weir crest

Let: $h := 0.79$ ft

K=Head correction factor

$$K := 0.0144902648 - 0.00033955535 * ang + 0.00000329819003 * ang^{2} - 0.0000000106215442 * ang^{3}$$

$$K = 2.903 * 10^{-3}$$

Therefore the flow rate, Q at the head, h is given by:

$$Q := 4.28 * c \tan(45)\,(h + K)^{\frac{5}{2}}$$

$Q = 2.243$ ft^{3}/s

Alternate equation

Using : $Cv := 2.5$ (v notch weir coefficient used when v notch angle = 90º)

$$Q2 := Cv \tan\left(\frac{90}{2}\right) h^{\frac{5}{2}}$$

$Q2 = 2.246$ ft^{3}/s

let g = acceleration due to gravity $g := 32.25$ ft^{2}/s

$$Q3 := \sqrt{2\,g} \cos\left(\frac{ang}{2}\right) h^{\frac{5}{2}}$$

$Q3 = 2.34$ ft^{3}/s

Both approaches to the weir calculation give approximately the same resultant flow rate (Q) at the weir head (h). this flow rate is approximately twice the peak hourly flow rate. the height of the weir will therefore be made 1 foot high for design safety. This way the weir may never be overloaded under varying daily flow conditions. the weir length will be 2 feet

Section 4
Operations and Maintenance Manual

GENERAL MAINTENANCE PROCEDURES:

a. Cleanliness of plant components should be our number one priority. Residual scum and accumulated sludge will accelerate wear of moving parts. Plant components must be hosed down daily.

b. A stiff broom is to be used while hosing down to remove algal growth, which tends to proliferate at the waterline.

c. The trough of the clarifier must be kept clean to avoid algae being discharger with the effluent.

d. Disinfection of the effluent will be accomplished by the use of gaseous chlorine, which is extremely hazardous if improperly handled. READ THE MANUAL ACCOMPANYING THE CHLORINATOR WITH DUE DILEGENCE AND FOLLOW INSTRUCTIONS !!!. The following are standard practices which will apply:

    1. The chlorine room must be properly vented, especially near the floor-line. The gas being heavier than air will accumulate at floor level if there is a leak, and could result in serious consequences.
    2. Do not reuse lead washers. Filled cylinders should be delivered with new washers, which should be used when making the connection.
    3. Open the valve of the chlorine cylinder fully so as not to encourage a leak at the valve stem.
    4. Always keep one extra cylinder on hand so as to be in a position to always discharge a chlorinated effluent.
    5. The chlorine contact chamber must always be kept free of sludge. Times for cleaning the chlorine contact chamber will be a function of the rate at which the sludge accumulates.

e. Mechanical components with moving parts will all have lubrication points. The manuals, which accompany these mechanical components, are to be studied and the lubrication schedule adhered to (typically every 1-2 weeks).

f. The management of sludge in the system is vital to the efficiency of the plant. 25% of the return sludge should be isolated in the digester for further treatment and ultimately removal through the drying beds. The proper management of the sludge is one of the most important functions of the plant operator.

PERSONNEL REQUIREMENTS

A. Trained Plant operator (w/associates degree – strengths or experience in electro-mechanical engineering and wastewater treatment). To work with and supervise staff, to document maintenance activities in daily logs and to generate monthly reports.

B. All round technician (to assist the plant operater with maintenance tasks and also keep plant clean).

C. Labourer (to assist technician to keep both the plant and the grounds clean).

MONTHLY MAINTENANCE COST

Maintenance crew		
A. Plant operator	$3,000/day =	$ 60,000/month
B. Technician	$1,500/day =	$ 30,000/month
C. Labourer	$1,000/day =	$ 20,000/month
	Sub - Total	$110,000/month
Consumables (grease, oil, petrol, contact cleaner, belts)		
A. Monthly budget		$ 15,000/month
Monthly sampling and lab work		
A. Lab Cost		$ 15,000/month
Monthly Estimated Energy Consumption		
A. Anaerobic, Anoxic, Digester, & Mixed liquor Return (22.5 Hp)		$ 175,500/month
B. Reactors (23Hp x 2 = 46Hp)		$ 358,800/month
C. RAS system & Clarifier (10 HP)		$ 78,000/month
D. Misc….light etc. (1.5Hp)		$ 11,700/month
	Sub - Total	$ 624,000/month
	Total	$ 764,000/month

Note: Cost was estimated using an exchange rate of JA $65.00 for U.S.$1.00. Energy supplied by Jamaica Public Service Company was estimated at US$4.00 for 1 Hp of energy per day. Supply and installation of chlorine Cylinders for Chlorination system Are not included in cost, and need to be added to attain grand total.

LAB EQUIPMENT AND ANALYSIS CAPABILITIES

Onsite testing will be done by the plant operators to ensure that the plant is running efficiently and meeting effluent targets. The Lab will have the following equipment to complete the tests as suggested in the “General Observations and Testing” section in the operations manual:

- Dissolved oxygen probe
- BOD_5 test kit
- Residual chlorine test kit
- ImHoff cone
- PH meter
- Graduated measuring cylinder
- Microscope - to check the health of the sludge being used.

Appropriate Technologies will be responsible for training the operators for both running the plant and completing the lab analysis. In addition, lab samples will be sent to an outside laboratory to compare with the plant laboratory results.

Emergency Power Generation

A 134 Hp (100 Kw) standby generator will be installed. This standby generator will provide power to the plant in the event of the unavailability of electricity from Jamaica Public Service Company.

Specific maintenance documents included in manual:

OPERATING INSTRUCTIONS FOR THE OXIDATION DITCH

GENERAL ROTOR INSTALLATION INSTRUCTIONS

START-UP/SHUT-DOWN PROCEDURES FOR ROTOR AERATORS

TROUBLE SHOOTING GUIDE FOR ROTOR AERATORS

INSTALLATION AND MAINTENANCE OF V-Belt Drives

SPIRAFLO CLARIFIER OPERATING INSTRUCTIONS

TROUBLE SHOOTING GUIDE FOR SPIRAFLO CLARIFIER

CARE AND LUBRICATION OF SPIRAFLO CLARIFIER

INSTRUCTION MANUAL FOR PILLOW BLOCKS

RECOMMENDATIONS FOR LONG TERM STORAGE OF MOUNTED BEARINGS

REGAL GAS CHLORINATOR SPECIFICATIONS

Lakeside Equipment Corporation

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OPERATING INSTRUCTIONS

FOR THE

OXIDATION DITCH WASTEWATER TREATMENT PLANT

Your oxidation ditch wastewater treatment plant is one of the most efficient methods yet developed to economically treat domestic and many industrial wastewaters.

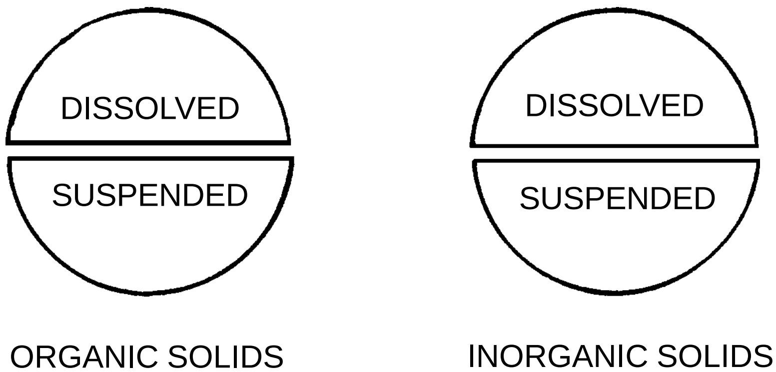
Careful reading of these instructions will help insure efficient operation of your oxidation ditch. If you operate it properly, your plant will give you as clear and clean an effluent as any plant in your area.

TABLE OF CONTENTS

I. THEORY OF OPERATION

Your Oxidation Ditch plant uses naturally occurring bacteria and specially designed equipment to remove pollution from the treated waters it discharges. The Oxidation Ditch system is known to engineers as a modified form of the activated sludge process and is classified as "complete mix extended aeration".

Wastewater coming to your Oxidation Ditch brings with it four types of solids as shown below:



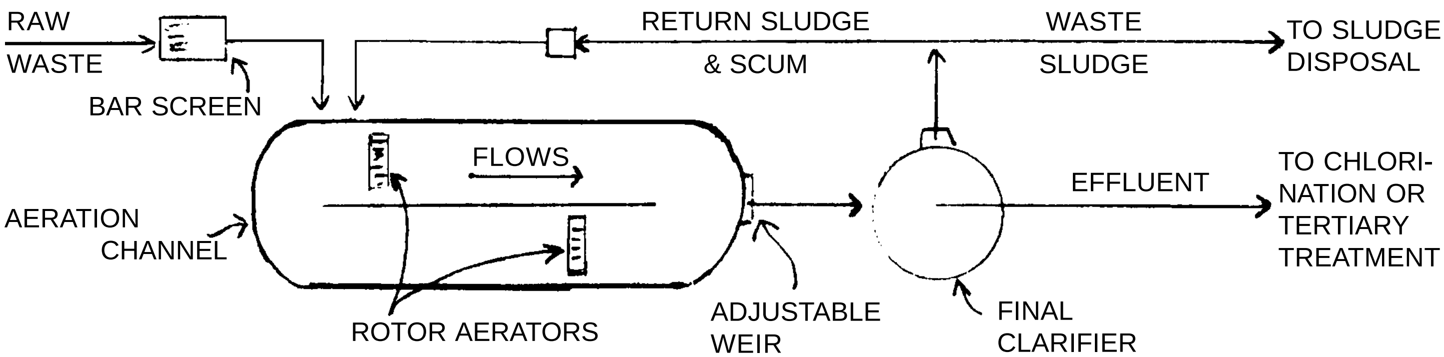
Organic solids, both suspended and dissolved, are mostly human wastes and food wastes which are principal causes of water pollution. Removal of organic solids is done in the Oxidation Ditch with bacteria and other microorganisms. Bacteria uses these organic solids as food and with oxygen will turn them into harmless water, gases, minerals and new bacteria.

Suspended inorganic solids, such as sand, silt and cinders also can cause water pollution. These are captured in the Oxidation Ditch plant and removed during sludge wasting or cleaning operations.

Dissolved inorganic solids, such as salts and similar chemicals typical to domestic wastewaters are normally not considered serious pollutants, although many dissolved industrial inorganic chemical solids can be serious water pollution threats. Your Oxidation Ditch plant is not designed to remove these materials and they will pass through the process untouched.

II. HOW THE OXIDATION DITCH WORKS

The "flow diagram" below shows the flow of waste through the Oxidation Ditch plant. Follow this flow diagram through as you read the following explanation and walk around your plant to find all of the parts shown. This will help you to better understand how your plant works.



The untreated "raw" wastewater passes through a bar screen and/or comminutor where large objects such as cans, rags and wood are kept from entering the aeration channel. The bar screen is necessary to protect the mechanical equipment such as the rotor aerators and pumps from damage. As the wastewater enters the aeration channel it is mixed with the bacteria and other microorganisms known as "mixed liquor" or "activated sludge". In the aeration channel, the rotor aerator (the paddle wheel) has two jobs:

1) It continuously puts oxygen from the air into the mixed liquor, oxygen which is necessary for the bacteria to live; and

2) Keeps the contents of the channel mixed and moving.

While the wastewater flows into the aeration channel, mixed liquor flows over the adjustable weir and out of the channel to the "final clarifier". The clarifier is a specially designed tank which lets the mixed liquor solids (bacteria and inert inorganic material) settle to the bottom. When the solids settle, they leave a clarified liquid, (supernatant) which then passes over the clarifier effluent weir. The supernatant is either discharged directly to the receiving stream as "effluent", or goes to additional "tertiary" treatment or a disinfecting chlorine contact chamber before discharging to the stream.

The solids which have settled to the bottom of the clarifier are continuously removed from the clarifier by pump, air lift or telescoping valve for return to the aeration channel to mix with new incoming wastewater. Normally, all sludge formed by the process and settled in the clarifier is returned to the aeration channel. Scum which is captured by the final clarifier is also removed from the clarifier and returned to the Oxidation Ditch.

As the mixed liquor suspended solids accumulate in the aeration basin, it will be necessary from time to time to take excess activated sludge out of the process. This is knows as wasting. The waste activated sludge may be removed, depending upon the particular plant design, by pumping to a tank truck, to a sludge holding tank, to sludge drying beds or to sludge lagoons. We will discuss later when you should waste sludge.

III. OPERATING REQUIREMENTS

Your Engineer has designed your Oxidation Ditch plant to require a minimum amount of maintenance and operation, but the word "minimum" does not mean that no maintenance or operation is required. Generally, only a couple of hours per day will keep most Oxidation Ditch plants operating at peak efficiency with some additional time required for laboratory testing. You will find that if you make a little extra effort each day to improve something about your plant, you can turn your treatment plant into a show case water pollution control plant that your community or company can take pride in.

Except under very special circumstances, you should make sure your plant is inspected each day. A little thing which may go wrong at your plant, if not noticed and corrected, in a short period of time may cause much larger problems. Think of it this way. If your car or truck radiator springs a leak, do you neglect it? No, you fix it right away before you ruin your engine. The mechanical equipment at your plant deserves the same attention. Your Oxidation Ditch cost many thousands of dollars. It is an excellent investment for your town or company and it should not be neglected. Further, the condition of your plant reflects upon you.

There are three basic areas of your responsibility for operating the Oxidation Ditch plant. These are basic plant control and testing, equipment maintenance and general housekeeping.

III. A. GENERAL HOUSEKEEPING

A general cleanup each workday at the plant is important. This not only gives you a more pleasant place to work but also helps your plant work better.

Daily cleanup normally includes removal and burying of debris that may have accumulated on the bar screen; removal of grease and scum from the surface of the clarifier and once weekly washing or brushing down the channel and clarifier weirs and walls. Figure out ways to save time and still get the job done well. Some lab tests can be done during your daily plant cleanup which can save you time. For one example, the settleable tests which takes roughly 30 minutes can be done while you grease the rotors and clean the Oxidation Ditch.

Of course, from time to time you will also have to do very general tasks such as cutting the grass and removing leaves from the plant site. Incidentally, leaves can become very troublesome in clogging pumps and pipes.

III. B. EQUIPMENT MAINTENANCE

Regularly scheduled equipment maintenance must be done. As boring as equipment manufacturer's instruction books are (including this one) , read them! Learn what they say! You should check each piece of equipment daily to see that it is functioning properly. You have very few mechanical devices in your Oxidation Ditch plant but they are all important. The rotor aerators and pumps should be inspected to see that they are operating. If pumps are clogged, the obstruction should be removed. Listen for unusual noises. Check for loose bolts. Uncovering a mechanical problem in its early stages could prevent a costly repair or replacement at a later date.

LUBRICATION SHOULD ALSO BE PERFORMED WITH A FIXED OPERATING SCHEDULE AND SUITABLY RECORDED. FOLLOW LUBRICATION AND MAINTENANCE INSTRUCTIONS FURNISHED WITH EACH PIECE OF EQUIPMENT. IF YOU CAN'T FIND THE INSTRUCTIONS, WRITE TO THE MANUFACTURER FOR A NEW SET. Make sure that the proper oils and greases are used. Over lubrication is wasteful and reduces the effectiveness of lubricant seals and may cause overheating of bearings or reducers. The rotor aerator support bearings are the exception. ROTOR AERATOR SUPPORT BEARINGS CANNOT BE OVER-LUBRICATED. THE MANUFACTURER EVEN RECOMMENDS IT.

Painting should be done periodically. In addition to beautifying your plant, it gives a good protective coating on all "ferrous" (iron, steel) parts and will prolong the life of the metal. Never paint over identification tags on machinery! You will regret it if you do.

Incidentally, you should make it your business to know the manufacturer of every piece of equipment in your plant. Knowing the manufacturer and how to reach him may save important time (and money) when equipment breaks down.

III. C. PLANT CONTROL

You have three basic ways to change or correct the operating of the Oxidation Ditch plant:

1) Control of dissolved oxygen concentrations in the mixed liquor
2) Control of return sludge recirculation rates, and
3) Control of mixed liquor suspended solids concentrations through sludge wasting.

1) Dissolved Oxygen Concentration

Oxygen concentration in the mixed liquor can be varied by changing the oxygen input to the aeration channel by the rotor aerator. This is done by changing the depth the rotor extends into the water. When the rotor immersion is increased, more oxygen is put in. Similarly, the less the rotor immersion, the less oxygen is put in. The immersion of the rotor is controlled by varying the liquid level of the aeration channel by cranking the adjustable effluent weir in the aeration channel up or down.

Under normal operation, the dissolved oxygen concentration in the aeration channel should be between 0.5 and 2.0 mg/l. This should be as measured approximately 15' upstream from the rotor. If your dissolved oxygen concentration is higher than 2.0 mg/l, you are wasting power. If it is lower than 0.5 mg/l, you may reduce the quality of treatment. You should not decrease the immersion of the rotor so much that the velocity of the mixed liquor in the aeration channel is reduced to where your mixed liquor solids settle to the bottom of the ditch. Also, you should not increase your rotor aerator immersion to the point where the motor is overloaded. The approximate maximum allowable rotor immersion is shown on your rotor installation drawings. This figure can be checked by actually measuring motor power draw.

2) Activated Sludge Recirculation

The required rate of activated sludge recirculation can be estimated by two methods. The first is a common sense method, the second is by calculation. The common sense method is the best method and is based on the idea that if the sludge blanket in the final clarifier rises so close to the effluent weirs that it threatens to spill over into the effluent, not enough sludge is being removed from the bottom of the clarifier.

To make this common sense method work, initially set the rate of sludge return at 75% plant flow. Watch the final clarifier water surface during peak flow times like during high flows in the morning hours or after a heavy rain or snow melt. If the sludge blanket in the clarifier rises and threatens to spill over the clarifier weirs, increase the rate of return sludge pumping. If your return sludge pumps are already working at full capacity and still can’t keep the sludge blanket below the effluent weirs or if the clarifier becomes too turbulent and solids no longer settle well, then too much sludge is being carried in the Oxidation Ditch and sludge must be wasted.

The second method of approximating return sludge pumping requirements is by calculation with the following formula:

$$q = (Q + q) \times (SVF)$$

Where: Q = Plant Flow (gpm)
q = Return Sludge Flow (gpm)

SVF = Return Volume Fraction

SVF (Sludge Volume Fraction) is the fraction of volume occupied by sludge solids following a 30 minute sludge settleability test. For example, if sludge solids occupy 600 ml of a 1000 ml beaker following 30 minutes of settling, the SVF is:

$$\frac{600 \text{ ml}}{1000 \text{ ml}} = 0.6$$

The operator should note that as the SVF increases, the required return sludge pumping rate also increases.

The calculation method for approximating return sludge pumping requirements should be used for estimating purposes only, with the common sense method and the operator's judgment being more important.

In some treatment plants, very heavy rains or snow melts cause flows to the treatment plant to exceed three to four times design flow. These hydraulic overloads may exceed the capacity of the final clarifier to settle sludge solids. When this occurs, extremely high BOD and suspended solids concentrations will be discharged to the stream and possible process upsets can occur if corrective action is not taken.

To prevent hydraulic overloads from causing this discharge of high BOD and suspended solids concentrations, shut down one or more rotor aerators in the Oxidation Ditch. This will allow the Oxidation Ditch to act as a large settling tank, keeping the mixed liquor suspended solids from flowing into the final clarifier where they could be washed out. When the plant flow decreases to more normal levels, all rotors can then be restarted to resume normal operation. The Oxidation Ditch can stand without aeration for many days without harm done to the microorganisms which treat the sewage.

NOTE: In cold winter climates, the operator should not stop the rotor during periods when ice may form on the blades.

3) Sludge Wasting

The need to waste excess sludge is governed by the actual plant loadings and the quality of final effluent required for a particular permit. The Oxidation Ditch can be operated in a balanced state with no excess sludge buildup but the ability to remove BOD and suspended solids will be lowered due to the loss of suspended solids and some BOD over the effluent weirs. Most operators believe that water pollution control plants are for water pollution control and should be operated to obtain the most highly polished effluent possible. When an Oxidation Ditch plant is fully loaded and highly polished effluent is required, there will be excess sludge buildup in the aeration channel requiring wasting.

The rate at which the mixed liquor suspended solids buildup in the aeration channel is determined by the quantities of inert solids in the raw waste, the BOD removed daily and the rate of sludge wasting Normally, solids should be wasted when the 30 minute settleable solids test shows over 75% sludge volume, and/or the dissolved oxygen concentration in the aeration basin is reduced to lower than 0.5 mg/l (when the rotor is operating a maximum immersion). See the section on Return Sludge Pumping in the instructions for additional information.

Depending upon your plant design, excess sludge is discharged to sand drying beds, a tank truck, sludge lagoons or a holding tank. When you do have to waste sludge the preferred operation is to reduce the mixed liquor suspended solids concentration as much as 35-50% over a period of several days.

Experience has indicated that excess sludge must normally be discharged at intervals of one to four weeks with a fully loaded plant.

If your sludge holding tanks or drying beds are overloaded, try concentrating the sludge in the final clarifier first before wasting by turning off your return sludge pump and letting the sludge bed rise in the clarifier. Do not let it come close enough to the clarifier effluent weirs to go over! When the sludge blanket is high, draw off your waste activated sludge from the clarifier bottom. This procedure will give you a more concentrated sludge and you will not need to waste as much.

III. D. GENERAL OBSERVATIONS AND TESTING

Operation of your Oxidation Ditch plant can be controlled and adjusted with the help of a few simple tests and some general observations. The testing and observations prescribed in this section are directed to helping you run your plant more efficiently. Other tests such as those sometimes required by Federal, State or local authorities are normally done to measure plant performance, such as effluent BOD, effluent suspended solids, etc. will not be covered in this manual because they are available from many other sources.

General observations of the plant are important to help you determine whether or not your Oxidation Ditch is operating as intended. These observations include color of the liquid in the aeration chamber, odor on the plant site and clarity of the aeration tank and final clarifier surface. Lab tests important to helping the plant run well include settleable solids test for both the aeration chamber and final clarifier effluent, dissolved oxygenation concentration in the aeration basin, mixed liquor suspended solids concentration in the aeration basin, pH and residual chlorine. A brief discussion of each test is included below:

1) <u>Color</u>

You should note the color of the mixed liquor in the aeration basin daily. A properly running Oxidation Ditch plant mixed liquor should have a medium to rich dark brown color. If the plant, following proper startup, changes color from a dark brown to a light brown and the solids appear to be thinner than before, the sludge wasting rate may be too high which may cause the plant to lose efficiency in removing polluting materials. By decreasing or halting sludge wasting before the color lightens too much, you can insure that the plant effluent quality will not deteriorate.

During plant startup a dark gray color of the aeration basin contents may be seen. A dark gray color normally indicates a lack of bacterial build up in the mixed liquor. If this condition persists for more than several days, check your sludge recirculation system to see that it is working properly.

If the mixed liquor becomes black, the aeration basin is not receiving enough oxygen and has gone “anaerobic”. The oxygen output of the rotors must be increased to eliminate the black color and return the process to normal aerobic operation. This is done by increasing the immersion of the rotor by raising the aeration basin water level. See the section on “Plant Control — Dissolved Oxygen” in Section III.C.1 for further information.

2) Odor

When the Oxidation Ditch plant is operating properly, there will be little or no odor. Odor, if detected, should have an earthy smell. If an odor other than this is present, you should check and determine the cause. Odor similar to rotten eggs indicates that the aeration basin may have gone anaerobic, requiring more oxygen. The color of the aeration basin mixed liquor would be black if this were the case.

Odor may also be a sign of poor housekeeping. Grease and solids buildup on the edge of the aeration basin or final settling tank will go anaerobic and cause foul odors. With an Oxidation Ditch, odors are much more often caused by poor housekeeping than poor operation.

3) Clarity

Freedom of the surface of the Oxidation Ditch from foam buildup and the clarity of the clarifier water surface are two good indications of a properly operating Oxidation Ditch.

Foam buildup on the Oxidation Ditch, (normally not enough to be a nuisance) is caused by an insufficient mixed liquor solids concentration in the aeration basin. Most frequently foam buildup is only seen during plant startup and will gradually disappear.

Foam buildup can also occur if peak hydraulic loads such as after heavy rain storms or snow melts cause “wash out of the Oxidation Ditch contents. Solids should never be allowed to wash out of an Oxidation Ditch. See the section “Plant Control — Return Sludge Pumping” for a discussion of controlling Oxidation Ditch solids wash out during peak wet weather flow. Control of solids washout will prevent this cause of foam buildup.

Excessive sludge wasting is also a possible cause of foam buildup. Sludge wasting should occur only when needed. For further discussion, refer to section “Plant Control — Sludge Wasting”.

Clarity of the effluent from the final clarifier discharged over the clarifier weirs is the best indication of excellent plant performance. A very clear effluent shows the plant is achieving excellent pollution removals. A cloudy effluent often indicates a problem with the plant. The lab tests discussed in section "Laboratory Testing — Settleable Solids Test" will frequently help you locate the problem if one exists.

4) Settleable Solids Tests

The most important of your laboratory tests are the two settleable solids tests. The mixed liquor settleable solids test tells the volume of activated sludge solids in the Oxidation Ditch and also tells how well it settles. The clarifier effluent settleable solids test shows how well your final clarifier is operating.

The equipment required for the mixed liquor settleable solids test is a 1000 ml graduated cylinder. Fill the graduate to the 1000 ml mark with a sample taken from the mixed liquor in the aeration channel (sample from the same spot every day). Let the graduate stand without mixing or handling for 30 minutes. After 30 minutes, measure the percent sludge volume by reading the scale on the graduate. For example, if the top of the settled sludge is at the 550 ml mark, then the sludge volume is 550 ml/l (milliliters per liter). Also note the clarity of the liquid above the sludge, (supernatant) as well as the density and general appearance of the settled sludge. Write down the sludge volume and appearance on your operating record.

The clarifier effluent settleable solids test requires an Imhoff cone. Take your sample from the effluent of the final clarifier and allow it to stand quietly for 30 minutes. After 30 minutes, see how much (if any) sludge has settled in the bottom of the cone. Record this also, as well as the clarity of the liquid above.

When the plant is operating as it was designed to function, the mixed liquor sample in the graduated cylinder will have a dense sludge and a clear supernatant. The effluent sample in the Imhoff cone will show a slight dusting of sludge settling on the bottom with some light suspended floc in the liquid above.

Clarity in the effluent sample is an excellent indicator that your plant is operating well. If the plant is operating poorly and the liquid in the graduated cylinder above the settled sludge is cloudy, the cause may be too much waste coming to the plant (overload) insufficient nutrients, improper dissolved oxygen concentrations in the aeration channel, very low or very high pH, or possibly industrial chemicals in your raw sewage "poisoning" the microorganisms in the mixed liquor. First check to make sure you have the, right amount of dissolved oxygen in the aeration basin. If you do not, adjust the immersion of the rotor according to Section III.C-1 to get the oxygen needed. If conditions do not improve after a couple of weeks, more extensive tests will be needed to check other possible causes.

The clarifier effluent suspended solids sample in the Imhoff cone may also be quite cloudy if the plant is not operating well. If the supernatant in the graduated cylinder is clear and the supernatant in the Imhoff cone is cloudy, the problem is probably in the final settling tank. The problem may be a clogged return sludge line or sludge pockets hanging on the walls and/or baffle skirts of the final clarifier. Check the return sludge system for clogging and clean the final clarifier. This will in most cases cure the problem.

If the supernatant in the Imhoff cone is clear and more than a dusting of solids appears in the bottom of the cone, the final clarifier may be hydraulically overloaded or your return sludge rate may either be too low or much too high. See Section III.C.2 "Activated Sludge Recirculation" for methods of correcting this problem.

5) Mixed Liquor Suspended Solids Test

While not as essential to plant operation as the settleable solids test, the mixed liquor suspended solids test provides the operator with an excellent means of determining proper sludge wasting times and rates. The test will also help identify a bulked sludge condition.

There are two methods by which the actual concentration of suspended solids in the mixed liquor can be determined, one is known as a gravimetric test, which uses laboratory equipment including filters, drying ovens and very sensitive scales, the other uses wither a hand operated or motor driven centrifuge. The centrifuge method is quickly done and provides an approximation of mixed liquor suspended solids concentration. The gravimetric test achieves a high degree of accuracy but is time consuming.

With the centrifuge test, the volume of centrifuged solids is proportioned to the mixed liquor or return sludge solids concentration. By occasionally comparing the volume of the centrifuge solids in the mixed liquor sample to measurements of the suspended solids concentration using the gravimetric test you can accurately determine the relation between solids concentration and centrifuged sludge volume.

The great advantage of the centrifuge method is the very small amount of time required to perform the test. Thus it can be used from day to day to easily approximate the mixed liquor and suspended solids concentration. The centrifuge used can either be one which is hand operated or a laboratory type centrifuge operated by an electric motor.

6) Dissolved Oxygen Test

Testing the aeration basin mixed liquor for dissolved oxygen is another test which can be easily done and is important to the efficient operation of the Oxidation Ditch plant. Insufficient dissolved oxygen (less than 0.5 mg/l D.O. 15' upstream from the rotor aerator) may cause a decrease in effluent quality. Excessive dissolved oxygen concentrations (greater than 2.0 mg/l) means that your rotor aerator is putting too much oxygen into the aeration basin. Too much oxygen may cause a decrease in effluent quality and it will waste electricity.

While dissolved oxygen can be measured chemically by using test kits obtained from several manufacturers, or according to instructions found in Standard Methods for the Examination of Water and Wastewater, the easiest way to monitor D.O. is by using a dissolved oxygen meter. These are available from many sources. Remember when using the dissolved oxygen meter that it must be properly calibrated to obtain accurate readings.

7) pH Test

Checking the pH is another of the simple tests. pH can be measured by chemical methods, a pH meter or simple inexpensive litmus paper. Chemical analysis takes more time but is less expensive initially than the pH meter. The pH meter gives excellent accuracy and is easiest to do. Litmus paper is the cheapest and easiest of all and can give satisfactory accuracy.

The pH test should be made on the raw waste, the aeration tank contents and the final effluent. Most microorganisms which are used in the Oxidation Ditch to treat sewage cannot tolerate pH levels above 9.5 or below 6.5 and 7.5. pH levels outside of this range can cause deterioration in treatment plant performance most frequently resulting in a cloudy effluent or sludge bulking.

The pH of the influent should be near 7.0 if the raw waste is normal domestic sewage. Substantial variation (pHs of less than 6 or greater than 8) would normally indicate an industrial discharge of acid or alkalis. Any rapid change in pH is a good indicator of potential problems and should be investigated.

8) Residual Chlorine Test

In some locations it is necessary to chlorinate the effluent from the Oxidation Ditch plant for disinfection purposes. This test is required only at the plants where chlorination is being practiced. There are three reasons for the test. First, too little chlorine in the plant effluent will not properly disinfect the effluent. Secondly, too much chlorine may harm aquatic life in the receiving waters. Finally, too much chlorine is wasteful and costly. Residual chlorine test kits are available from many sources. The chlorinator should be set so that the residual chlorine in the effluent is not less than 0.5 mg/l and no more than 1.0 mg/l.

9) Records

A daily log sheet should be kept with notations made on all plant operations. This can be a very simple form. The operator should record settleable solids tests, D.O. tests, pH, residual chlorine, color, odor, when and how much sludge was wasted, any unusual conditions and the results of any outside laboratory analyses.

These records are helpful for determining operating procedures and in evaluating plant performance. Many times the cause of operation difficulties may be determined and corrected from information in the log.

IV. POTENTIAL OPERATING PROBLEMS

1) Foaming

During startup, when the MLSS are low or after excessive sludge wasting, the aeration channel may experience foaming. Foaming is believed to occur because of the presence of synthetic detergents and other surfactants in conjunction with high aeration rates and low aeration MLSS. The foam, containing sludge solids, grease and bacteria is normally brought under control without action by the operator as MLSS builds and the process approaches stability.

For a more complete discussion of causes of Oxidation Ditch foaming and its correction, refer to Section III.D-3 “Clarity.”

2) Cloudy Effluent

There may be several reasons why the Oxidation Ditch process effluent from the final clarifier may be cloudy. Section III.D-4 “Settleable Solids Test” discusses these in detail.

3) Rising Sludge

Rising sludge occurs as a result of too long a detention time in the clarifier. The sludge undergoes denitrification with the release of nitrogen gas that becomes entrapped in the sludge causing it to rise to the surface. The sludge rises in chunks from the size of a pea to as large as a basketball, usually forming a brownish black fine scum or froth on the surface of the settling tank.

By increasing the rate of return of activated sludge pumping, the problem of rising sludge should be corrected. Rising sludge should not be confused with sludge bulking. In a rising sludge, the settling characteristics and compaction are good. Bulked sludge will not settle well in the mixed liquor settleable solids test. (Section III.D.4)

4) Sludge Bulking

Sludge bulking is characterized by a poorly settling sludge which compacts very little in the settleable solids test. The filamentous type organisms which cause “sludge bulking” bind themselves together as slime growths so that they cannot compact as normal floc. The Oxidation Ditch with its low food to microorganism ratio normally does not allow the development of the filamentous organisms which cause “sludge bulking.”

Occasionally, undersized final clarifiers and/or insufficient sludge return rates cause loss of solids over the final clarifier weir during peak overflow periods. Frequently, this problem is incorrectly identified as a “bulked sludge” condition. If sludge bulking seems only to be a problem during periods of high flow, the operator should check to make sure his return sludge pumping rate and final clarifier size are sufficient to handle actual (not design) flows. (Section III.C.2)

True sludge bulking has usually been associated with conditions that favor the growth of filamentous organisms such as low pH, low dissolved oxygen concentrations in the aeration basins, insufficient nutrient concentrations (phosphorus, nitrogen) in the waste, and high food to microorganism ratios. Sludge bulking has also been associated with wastes containing high grease concentrations. The following is a brief discussion of each factor as it relates to the Oxidation Ditch:

Low pH — This condition would be caused by an industrial discharge into the sewer system of acid or low alkaline wastewaters and can be monitored by a pH test of the plant influent. Because the Oxidation Ditch has such a large aeration chamber volume, only a major discharge of acids or low alkalis will appreciably affect treatment in the Oxidation Ditch.)

Low Nutrients — Normal domestic sewage has more than sufficient nutrient concentrations to prevent sludge bulking due to this cause. In a treatment plant handling industrial wastes containing high BODs but low nutrient concentrations, insufficient nutrients may permit the onset of sludge bulking. Your plant chemist or consulting engineer should be able to provide this analysis.

High Food to Microorganism Ratio — The Oxidation Ditch operates with the lowest food to microorganism ratio of any suspended growth activated sludge system. Hence, in the absence of heavy overloads to the Oxidation Ditch plant, this cause for sludge bulking is highly unlikely. Plant expansion, limiting the quantities of waste coming into the plant, or greatly increasing sludge wasting rates are possible solutions to this problem.

Heavily Grease Laden Wastes — While not caused by filamentous organisms, this infrequently seen condition is caused by an industrial discharger such as a meat or poultry packing house putting sufficient quantities of grease into the sewer system to prevent the floc in the mixed liquor from settling in the final settling tank. Minimizing grease discharge by the industrial user should control this condition.

Low Dissolved Oxygen Concentrations — In some instances low dissolved oxygen concentrations in the aeration basin can cause sludge bulking. Normal dissolved oxygen in the Oxidation Ditch 15' upstream from the rotor aerator is between 0.5 and 2.0 mg/l. Should low D.O. concentrations be suspected as a cause of sludge bulking, the rotor aerator immersion should be increased so that more D.O. is put into the aeration basin.

V. OXIDATION DITCH PLANT STARTUP

1) General

There are two primary objectives of startup. One is to make certain all mechanical equipment is operating properly. The second is to develop a proper microbial floc (activated sludge) in the Oxidation Ditch. This floc development is essential for the plant to succeed in reducing the quantities of polluting materials in the plant effluent.

The startup procedures presented should be used along with the manufacturer’s startup procedure for all major components of the plant. The treatment plant operator together with the contractor, engineer and equipment manufacturer’s representative should be present at the startup of each major component.

During startup of the treatment plant, some construction may still be in progress. Special care should be taken to insure that all safety procedures are adhered to.

2) Preparation for Startup — Bar Screen and Headworks

The headworks structure should be checked for debris and all debris cleaned from the structure prior to startup.

The channel structure should be cleaned of all debris prior to startup. Check the walkway to insure there is no debris that can later fall into the channel. Check the outlet and inlet lines to insure they are free of debris. Refer to the rotor aerator manufacturer's installation drawings appearing in the O & M manuals for complete rotor startup information. The rotor should be checked for proper installation and direction of rotation. Lubricant levels should be checked on the rotor drive unit and bearings. The belt tension on the rotor drives should be checked. Check for any loose bolts.

Start the rotors with the rotors out of the water. The incoming voltage and amperage should be checked on each phase. Check the rotation of the rotor and run the unit for at least one hour. Recheck the rotor support bearing and drive alignment and realign if necessary per manufacturer's installation drawings. Tighten all nuts and set screws to prepare the unit for regular operation.

If you have an adjustable weir make sure it operates freely and does not bind. Set the overflow weir at the proper elevation for the design conditions.

The clarifier structure and piping should be cleared of all debris. All control gates and valves should be checked for smooth operation and proper seating and the sludge collector mechanism checked for proper alignments, correct rotation, clearances and lubrication. The drive mechanism should be inspected for tight mountings, drive alignment, clearances, safety devices and proper lubrication; the weirs should be inspected for level. The manufacturer's literature should be reviewed to see that the mechanism has been installed, lubricated and is operating according to their instructions.

The raking mechanism should be run for three to four hours without liquid in the tank. The rake arms should be checked for proper clearance and smoothness of operation and the drive motor inspected for any undue noise, vibration and overheating and an amperage reading taken and recorded. Initial observations in the dry run are particularly important since this is a most important part of the treatment process and many of its mechanical parts are submerged during normal operation.

The sludge return system should be checked for leakage and all valves should be operated one complete cycle and set for normal operation. If the return sludge pump pit has a sump pump, this unit should be manually operated and the sump filled with liquid to check its operation.

3) Startup

With all the components of the aeration channel ready for startup, allow the raw sewage to enter the aeration basin. This may take one or two days before startup rotor immersion of 3" to 5" is reached. After the liquid level in the channel reaches the startup immersion level for the rotor aerator, the rotor can be started for continuous operation.

The wastewater should then be allowed to gradually fill the clarifier structure with the clarifier motor turned on. As the unit is rotating, note the position of the scrapers to insure that they are scraping the settling sludge to the sludge hopper. When the unit is filled, note the liquid level on the overflow weirs. All the weirs should be producing a similar discharge rate if the weir unit is level. Check the final clarifier scum skimmer to make sure that scum and other floatables are sent back to the Oxidation Ditch.

Return sludge pumps should be primed (if necessary) for operation. For testing purposes, the pumps should be placed on manual operation. One pump should be operated and checked for vibrations, excess noise, overheating and the amperage reading recorded. The same procedure should then be repeated for the second pump with the first pump manually shut off.

If your plant has waste sludge facilities (e.g. holding tanks, lagoons or drying beds) , operate the necessary valves to allow pumping to this part of the plant. Operate each pump manually and note the discharge. Shut both pumps off and return the valves to the normal flow position for returning the settled sludge back to the aeration channel.

During startup an unstable effluent will probably result due to the inadequate biological treatment. Chlorination is often used to reduce health hazards on the receiving water during this time. State regulatory agencies should be contacted to insure that the receiving water will not be harmed as a result of heavily chlorinating the plant effluent.

4) Post Startup

During this period of startup, wastewater testing procedures should be initiated as soon as possible. The actual flow rate should be recorded and also the incoming BOD concentration.

Building of mixed liquor suspended solids concentration is the most important activity during the startup process. In the event. the actual mixed liquor suspended solids concentration cannot be determined daily, as a minimum the operation should record daily the results of the 30 minute sludge settleability tests.

Dissolved oxygen (DO) residual should be taken at a sampling point approximately 15' upstream from the rotor aerator. During the first two months following the buildup of mixed liquor suspended solids to a 30 minute sludge settleability volume of 200 mg/l, a minimum dissolved oxygen concentration of 2.0 mg/l should be kept in the aeration channel. Following this period, a minimum dissolved oxygen concentration of 0.5 mg/l should be maintained 15' upstream from the rotor aerator.

Following startup, when the plant has stabilized, the solids should settle rapidly leaving a clear, odorless and stable effluent. The solids should look like particles, golden to rich dark brown in color, with sharply defined edges.

The operator should not expect immediate results from the startup procedures. Plant startup takes time, sometimes over a month. Also, there are some conditions that may occur during startup that would under normal conditions, indicate a poorly operating process such as light foaming in the aeration basin or cloudy supernatant in the settleable solids tests. These conditions should only be temporary.

CONCLUSION

We at Lakeside Equipment Corporation have worked hard to provide your plant with the finest equipment and process design available in the water pollution control field. We hope that the enthusiasm and pride with which you operate your new Lakeside plant and equipment will equal the enthusiasm and pride which we at Lakeside have used in its design and manufacture.

Good luck with your new plant! We look forward to hearing from you about your operating experience.

APM/jr
R-RAD-7
1/76

LAKESIDE

Water Purification Since 1928

Lakeside Equipment Corporation

1022 E. Devon Avenue ● Bartlett, IL 60103-8448 ● 630-837-5640 ● FAX: 630-837-5647 ● E-mail: sales @lakeside-equipment.com

GENERAL ROTOR INSTALLATION INSTRUCTIONS

PRELIMINARY: Read instructions, study service book and all drawings to be thoroughly familiar with equipment before actual assembly is started.

We try to ship the correct quantity of items listed on the assembly drawings. If we are in error, we will make corrections immediately at our expense. We should be advised of this error within five (5) days after receipt of shipment and allowed a reasonable period of time to correct the error. If the contractor, subcontractor of other person authorizes changes or corrections, payment of this alteration must be made by other than Lakeside, unless written authorization was issued by Lakeside Equipment Corporation.

FOUNDATION MATERIALS

Usually Lakeside furnishes foundation bolts or foundation material for the equipment and normally ships these ahead of the main shipment for placing in the concrete. The proper installation or assembly drawings should be checked for proper location of parts in concrete. Use care in placing these embedded items in the prescribed location with the correct projection. We recommend the use of accurate templates. Improper installation of parts in concrete will create problems during the erection of the equipment, and could cause problems in aligning the equipment.

SHIPMENT

Parts are shop assembled as required to determine the equipment will operate as intended. They will be shipped in as large assemblies as are practical. The drive assemblies and miscellaneous parts are shipped separately and are boxed or crated. Where special situations require components be matched or erected in a special manner, they will be marked as called for on the assembly and installation drawings.

VARIATION FROM PROCEDURE

These instructions represent one method of installation and are presented as a workable method for proper installation by Lakeside. Due to equipment, manpower, etc., you may wish to make deviations in sequence or method. This is satisfactory as long as equivalent results are obtained.

DRIVE AND ROTOR INSTALLATION

Drive types vary as well as Rotor types and the manner in which they are used. Separate instructions for the drive and Rotor are enclosed. Refer to them for the proper information for erection and maintenance.

Installation Drawing
Drive Assembly Drawing
Rotor Assembly Drawing
Lubrication Instruction Drawing
Installation Instruction Drawing

LUBRICATION

Lubrication plays a distinct role in determining the life of the equipment. Lakeside includes a drawing showing the points to be lubricated with oil and grease recommendations. For each motor, reducer, bearing, coupling, etc. a manufacturer's instruction sheet has been provided. In the case of discrepancies, the manufacturer's recommendations govern unless we specifically say otherwise or as listed below:

1) Some reducer manufacturers' instructions do not extend the recommended lubricants over as large a range of temperatures as may be necessary. In these cases, Lakeside has conferred with the reducer manufacturer in making the list for the extended range for you.

2) The bearings are to be packed 100% full of grease, and require much more frequent greasing than the bearing manufacturer recommends.

MAINTENANCE AND OPERATION

One of the most essential items for good operation and long life of the equipment as well as the plant is good housekeeping. Weekly hosing of the unit is recommended to remove possible accumulation of material that can become obnoxious in appearance, cause odors or deterioration of coatings and materials. Maintain proper lubrication of the moving parts for trouble free continuous operation. Mineral spirits may be used to clean off gummy grease and dirt from the electric motor. Inflammable liquid should never be used.

While performing the routine lubrication and housekeeping operations, keep looking for evidence of other problems: loose belts, worn parts, evidence of wear, movement of any part with respect to another at a connection, foundation movement, periodic check of bolts and nuts for tightness, excessive vibration, unusual noises, oil leaks, overheated motor, reducer or bearings. Most of these can be quickly checked during a daily inspection. When something of this nature is discovered, the unit should be checked more closely, and the trouble spot located and corrected. Correction in the early stages will prevent a more expensive major breakdown of the equipment. The Rotors are designed for 24-hour continuous operation. Observing proper lubrication and maintenance procedures will assure they provide trouble free service.

LAKESIDE EQUIPMENT CORPORATION

RP/sp
3/29/99
R-RAD-277

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START-UP/SHUT-DOWN PROCEDURES

ROTOR AERATORS

The Rotor Aerators may be started and shut-down by simply operating the local control on/off switch. Under normal operating conditions, no further operator attention is required.

In the event maintenance or other work is to be performed on the motor, V-belt drive, reducer, or rotor aerator, the local disconnect switch must be locked out to prevent inadvertent start-up.

After shut-down of a rotor, if extended storage is expected, follow the instructions given on GSI-27 and GSI-41 under the General Instructions given in the front of this manual.

EMERGENCY OPERATIONS

The operation of the rotor aerators is intended to be through the electric drive motors provided. In the event of power outage, the rotors, therefore, cannot be operated.

In the event the rotor aerators are taken out of operation for an extended period of time, the dissolved oxygen in the aeration basins may drop to 0. This could lead to anoxic or anaerobic conditions. Should this occur after an extended operation, and the color of the mixed liquor turns very dark brown or grayish, operate all the rotors at the maximum immersion until the normal color returns to the ditch.

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RAD-678

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TROUBLE SHOOTING GUIDE

FOR ROTOR AERATORS

Common symptoms, possible causes and their cures are listed in the following table:

SYMPTOM	POSSIBLE CAUSES	POSSIBLE CURES
Equipment won't start.	Electrical.	Check wiring motor overloads.
Motor hums.	Drive belts too tight.	Adjust belts. Refer to "V" belt instruction manual.
Motor labors, runs slow, etc.	Not wired correctly for plant voltage.	Correct wiring at motor.
	One fuse out.	Check fuses.
Rotor starts slow.	Loose belts.	Adjust belts. Refer to "V" belt instruction manual.
Noisy reducer.	Low on oil.	Check and fill if necessary. If not low on oil, check with factory or Lakeside.
Noisy motor.	Bad bearing(s).	Call Lakeside.
Clunking or thumping sound.	Allowed to run with loose bearing set screws.	Tighten set screws. Repair shaft and/or bearing.

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RWJ/bm 5/87
R/RAD-558

LAKESIDE
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RAD-688

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RECOMMENDED SPARE PARTS FOR HORIZONTAL ROTOR AERATORS

All Lakeside rotor support bearings are designed to provide a minimum AFBMA L-10 life of 100,000 hours.

V-Belt drives that have the tension properly maintained to prevent slippage can provide a minimum service life in the 4 to 5 year range.

Motors and reducers, and couplings on multiple length rotors, have been designed with service factors to provide several years of expected service life.

These expected service lives can normally be obtained and frequently exceeded by following the maintenance and lubrication instructions included within this service book.

Lakeside does not normally recommend spare parts for rotors beyond a spare set of belts which is included with the original shipment in case some belts are damaged during installation. The reason for this is that sometimes, despite the best efforts, the **parts deteriorate in storage** and, when put into service, they may not perform properly and warranties have lapsed. Many parts are standard commercially available products. They can be obtained in relatively short times, will be new units in good shape and **full warranties will be in force.**

If some parts are desired, the following are possibilities:

Parts more likely to need replacing:

V-Belts
Split J Seals

Parts less likely to need replacing:

Blades
Rotor Bearings
Motor
Reducer

RWJ/bm
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LAKESIDE

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RAD-920

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LUBRICATION SHEET FOR LAKESIDE ROTOR AERATOR

Gear Reducers

Shaft Mounted:

Size ________________ Mfg. ______________________ Approx. Oil Capacity_________ Qts.

Bearings:

Inboard Brg. ________________________ Mfg. __________________ Approx. ________ lb.
Outboard Brg. ________________________ Grease Capacity _______ lb.

LUBRICATION SCHEDULE:

Shaft Mounted & Motorized Reducers

Fill to level plug (do not overfill) with oil as specified in the manufacturer's instructions or Lakeside Lubrication Instructions drawings or equal. Change oil after 2 week break in period, then every 4 months. Check oil level weekly and add if necessary.

Bearings

Pack bearings full until grease shows at bearings seals. Grease at least once every two weeks. Note: (Rotate by hand while greasing. Overgreasing will not harm these bearings.)

Reducer Motor

Motor bearings are greased at factory and ready for operation. Relubricate yearly or every 6 months at most. (Do not overgrease). Manufacturer's recommendations for motors supplied are included in Lakeside's service book. Relubrication grease can be same as used for shaft bearings

For more information on Rotor lubrications, see Lakeside dwg. __________________________ .

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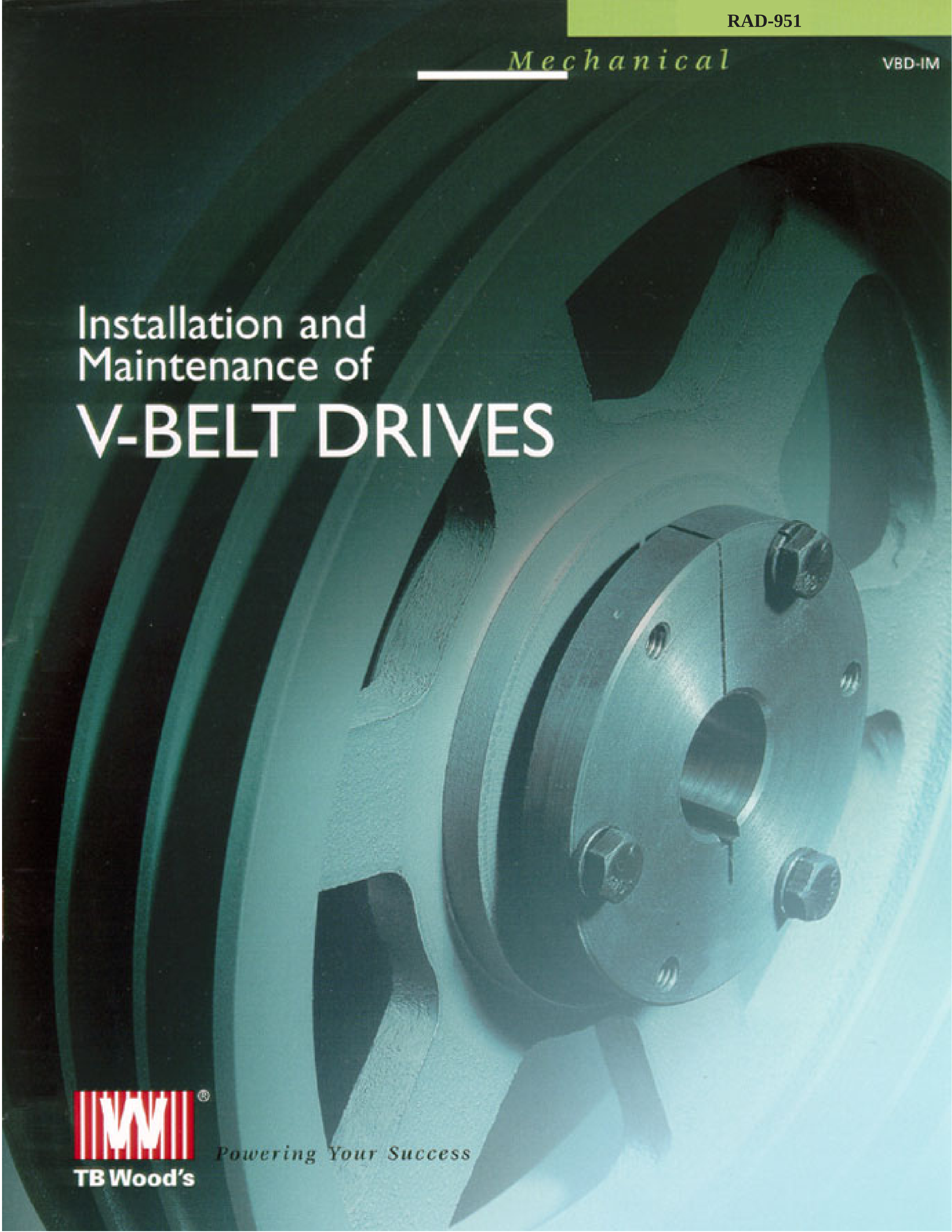
Mechanical

VBD-IM

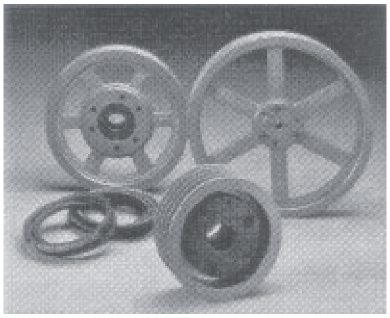
Installation and Maintenance of
V-BELT DRIVES



TB Wood's

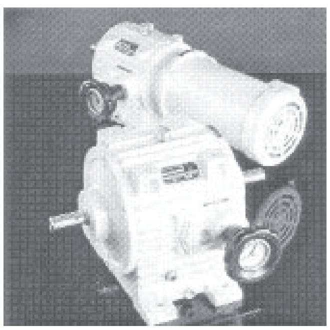
Powering Your Success

Quality Products and the Support to Back Them Up – Wood’s



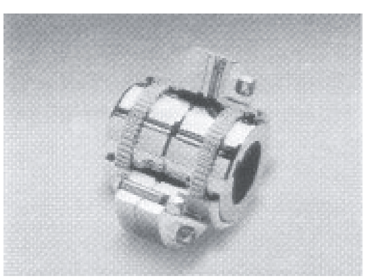
V-Belt sheaves of close grain, high-tensile cast iron are machined to provide safe, vibration-free operation at speeds up to 6500 FPM. Made to order sheaves of ductile iron material can be provided for speeds up to 10,000 FPM. V-Belt drives are only the beginning of what Wood’s can do.

Wood’s offers a complete line of high capacity synchronous drives. The RPP-Plus system offers a higher horsepower capacity drive at the cost of the competitions standard rated product. Wood’s also offers the aramid fiber QT Powerchain drive in 8M and 14M pitch. The QT drive is capable of high horsepower capacity in a smaller package. Both QT and RPP sprockets offer metric/inch drilling for applications which require a totally metric drive system.



Wood’s has many different ways of offering variable speed for customer applications. The most basic way is through the use of one of our many belted variable speed systems. Wood’s also offers many different options in the line of electronic inverters and electronic speed controls. One of the most unique ways of varying speed, however, is our HSV/HSVA hydrostatic systems. The HSV system is ideal for harsh, dirty, or explosive proof environments.

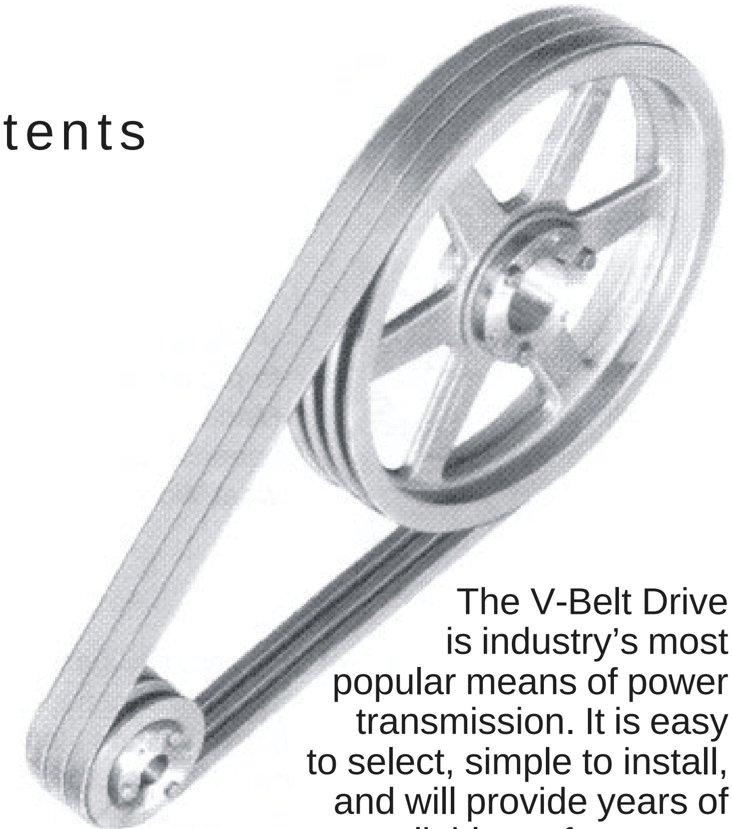
Wood’s Elastomeric coupling line offers something for every application. Wood’s Jaw couplings offer a full compliment of spider materials and bore option. Our Sure-Flex line offers the 4-way flexing action, and many different flange and sleeve options to meet your needs. The Dura-Flex coupling is designed and patented with improvements over other similar type coupling that provide for the maximum possible service life.



Wood’s line of Steel couplings offers both gear and disc coupling options. Wood’s Form-Flex disc couplings offer zero-backlash and eliminate the need for lubrication. Our gear couplings are available in all the standard, spacer, and special options common to the industry. In both disc and gear lines we welcome the challenge of the “special” coupling.

TB Wood's

Contents



The V-Belt Drive is industry's most popular means of power transmission. It is easy to select, simple to install, and will provide years of reliable performance.

Even when misapplied, improperly installed or completely ignored, the V-Belt Drive will usually deliver some kind of performance. However, with proper installation and maintenance, many years of operating efficiency can be added to the life span of the V-Belt Drive.

It is hoped that the information contained herein will help you receive the greatest possible value from your V-belts and sheaves, will help you receive a full measure of performance from industry's dominant drive.

V-Drive Inspection and Maintenance Procedures

Well designed and properly installed V-belt drives are without question the most reliable, trouble-free means of power transmission available. In general, except for an occasional retensioning, they will run year in and year out without maintenance.

However, some do require periodic inspection and maintenance, both while the drive is running and while it is stationary.

Inspection while running

A noisy V-belt drive is like a person with a fever. Both need attention.

V-drive noise can be caused by the slapping of belts against the drive guard or other obstruction. Check for an improperly installed guard, loose belts or excessive vibration. Squealing of belts as a drive is started or while it is running is usually caused by a poorly tensioned drive and/or by a build-up of foreign material in the sheave grooves. But it can also be caused by oil or grease between the belt and the sheave groove.

If necessary, remove the belt guard and watch the drive while it is running under load. **(Caution: Observe only; stand clear of the running drive!)** Much can be learned by watching the action of the slack side of the drive. Each variation in the driven load causes a corresponding change in the tension of the slack side of the belt. During across-the-line starts or suddenly applied loads while running, the sag on the slack side of the drive will increase, if the sag under these conditions is excessive, tension should be increased.

Any vibration in a system will cause the slack side of the belts to dance up and down. Excessive vibration will also induce a vibration in the tight side of the drive. The cause of the vibration should be determined and corrected.

If a set of belts is perfectly matched, all belts will have the same amount of sag. However, perfection is a rare thing and there will usually exist some difference in sag from belt to belt. It is more important to look at the tight side of a drive to be sure that all of the belts are running tight. If one or more belts are running loose, the drive needs to be retensioned, or the belts replaced with a matched set.

The above conditions could also be caused by uneven wear of the grooves in the sheave. These should be checked with sheave groove gages.

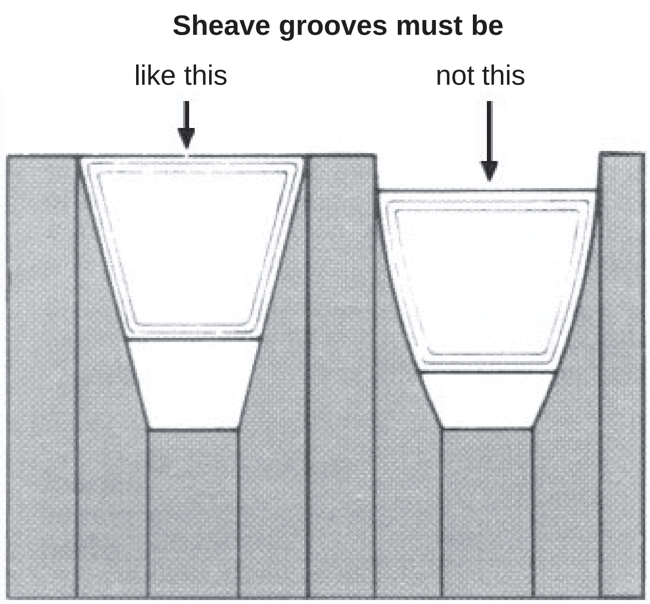
Inspect sheaves often

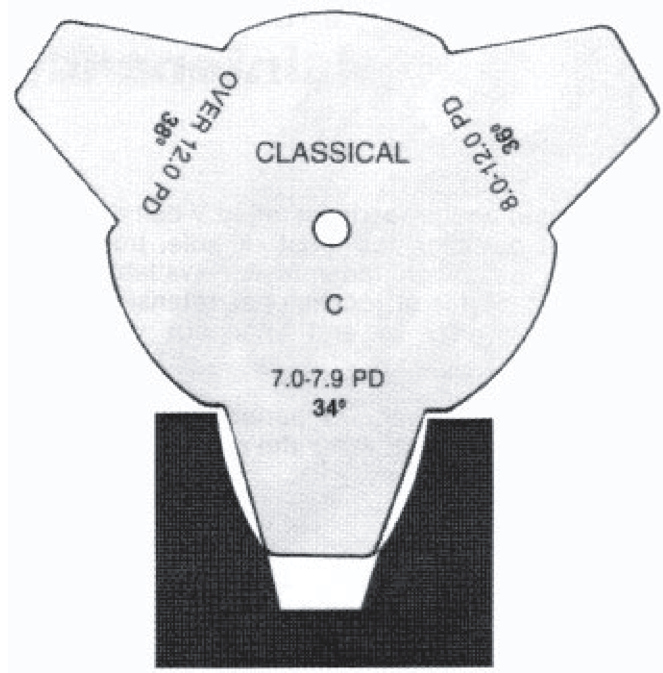
Keep all sheave grooves smooth and uniform. Burrs and rough spots along the sheave rim can damage belts. Dust, oil and other foreign matter can lead to pitting and rust and should be avoided as much as possible. If sheave sidewalls are permitted to “dish out,” as shown in the picture on page 5, the bottom “shoulder” ruins belts quickly by chewing off their bottom corners. Also, the belt’s wedging action is reduced and it loses its gripping power.

A shiny groove bottom indicates that either the sheave, the belt or both are badly worn and the belt is bottoming in the groove.

Badly worn grooves cause one or more belts to ride lower than the rest of the belts, and the effect is the same as with mismatched belts. This is called “differential driving.” The belts riding high in the grooves travel faster than the belts riding low. In a drive under proper tension, a sure sign of differential driving is when one or several belts on the tight side are slack.

Check alignment of drive. Sheaves that are not aligned properly cause excessive belt and sheave wear. When the shafts are not parallel, belts on one side are drawn tighter and pull more than their share of the load. These overloaded belts wear out faster, reducing the service life of the entire set. If the misalignment is between the sheaves themselves, belts will enter and leave the grooves at an angle, causing excessive cover and sheave wear and premature failure. See page 13 for complete information on drive alignment.



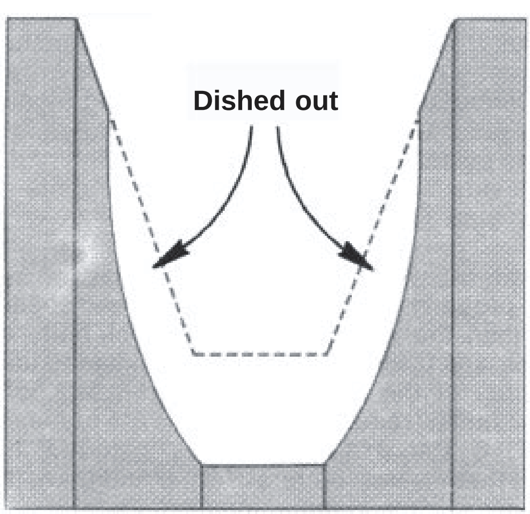


Groove gage.

Belt and sheave gages

Belt and sheave groove gage sets are available from your Wood's distributor.

You can use them to determine the proper belt section by trying the old belt in the various gages until a proper fit is obtained. The cross section of the Classical or Narrow belt can be read from the gage.



To check sheave grooves for wear, simply select the proper gage and template for the sheave diameter; then insert the gage in the groove until the rim of the gage butts against the outside diameter of the sheave flange. Worn grooves will show up as illustrated below. If more than $^{1}/_{32}$ inch of wear can be seen, poor V-belt life may be expected.

Check belt fit

Classical V-belts should ride in standard sheave grooves so that the top surface of the belt is just above the highest point of the sheave. In A-B combination grooves, an A section belt will ride slightly low in the groove, while a B belt will be in the normal position. In special deep groove sheaves, belts will ride below the top of the sheave.

Narrow belts are purposely designed so that the top of the belt will ride above the O.D. of the sheave. The tensile cords are located in the belt so that they ride almost at the O.D. of the sheave. This simplifies sheave identification and drive calculations.

No matter which V-belt section the sheave is grooved for, the belts should never be allowed to bottom in the groove. This will cause the belt to lose its wedging action, to slip and/or burn. Sheaves worn to the point where they allow a belt to bottom should be replaced immediately.

Keep belts clean

Dirt and grease reduce belt life. Belts should be wiped with a dry cloth occasionally to remove any build-up of foreign material. If the belts have been splattered with grease and/or oil, clean them with methyl chloroform or soap and water. Inflammable cleaners such as gasoline are to be avoided as a matter of safety.

Although all Wood's V-belts are of oil resistant construction, an occasional cleaning will help to prolong their life.

Under no circumstances is the use of belt dressing recommended on a V-belt. The remedial effect is only temporary. It is much better to keep the belts and grooves of the drive clean.

Use belt guards

Belt guards protect personnel and the drive itself. They should be definitely used in abrasive atmospheres to protect the drive from sand, metal chips and other foreign matter. But they should be ventilated to avoid excessive heat.

Check them periodically for damage and for loose or missing mounting bolts. These could cause the belts to come in contact with the guard and cause failure.

Guards alone will generally protect belts from abrasion. But where abrasive materials are common — in rock processing machinery, grinders, foundries, etc. — drives should be inspected frequently for excessive belt and groove wear.

Check for hot bearings

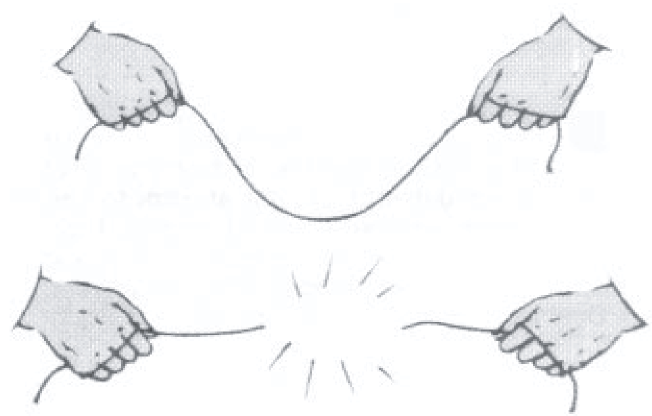
When the drive has been stopped for inspection, check the bearings to make sure they are not running hot. If they are, it could be due to improper lubrication or improper drive tension. Hot bearings can be caused by belts that are either too tight or too loose. Check the tension carefully using the instructions furnished.

If the belts are slipping on your drive, retension the drive. Never use belt dressing to correct slipping belts.

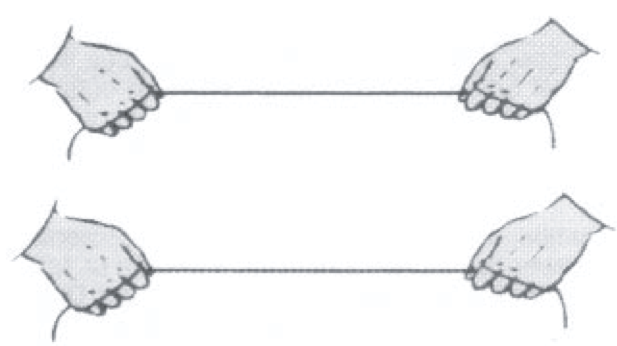
Maintain proper belt tension

Maintaining correct tension is the most important rule of V-belt care. It will give the belts 50% to 100% longer life.

Belts that are too loose will slip, causing excessive belt and sheave wear. V-belts that sag too much are snapped tight suddenly when the motor starts or when peak loads occur. That snapping action can actually break the belts, because the added stress is more than the belt was designed to take. This can be clearly demonstrated with a piece of string, as illustrated.



Loosely-held string snaps easily,
Taut string can stand stron pull.



TB Wood's

Belt Selection

Selecting the correct belts

All the work and experience that goes into designing a V-belt drive is wasted if the specified belts are not used or the number of belts is changed. Over-belting is wasteful. Under-belting is even more expensive in the long run, because overloaded belts wear out faster.

V-belts are identified for size according to industry standards. A combination of letters and numbers indicates the width across the top of the belt (often referred to as “cross section”) and the belt length. Classical belts come in five widths: A, B, C, D, and E; while Narrow belts are made in three widths: 3V, 5V, and 8V. In addition, there are the Light Duty 2L, 3L, 4L, and 5L belts. If you are not sure which to use, measure the top width of the old belts carefully, or use Wood’s gages described previously.

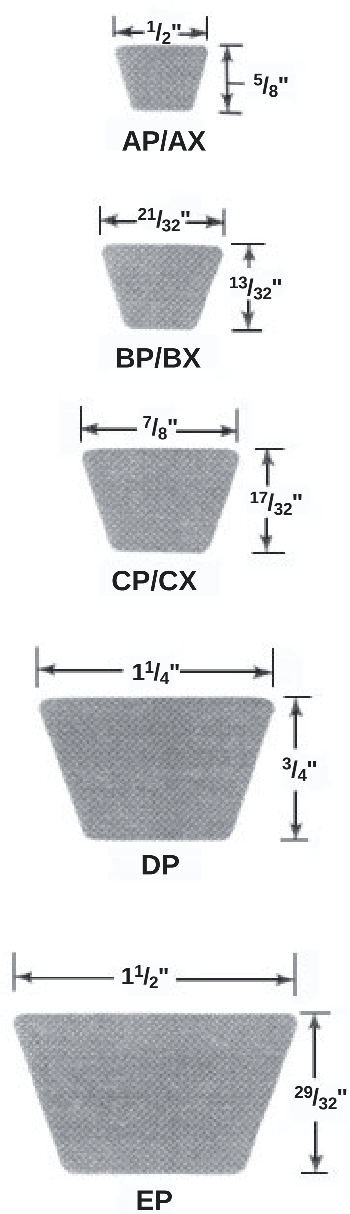
Be careful in measuring V-belts. The top widths of the B and 5V belts are very close; however, the 5V is considerably thicker, and the groove angles of the sheaves are different. Do not attempt to use these belts interchangeably. The 4L and 5L Light Duty belts are also very close in size to the A and B belts. But again, groove angles may be different. Light Duty belts should not be used on heavy-duty drives.

The belt number C270 indicates a belt with a nominal 7/8" top width and a nominal length of 270". Its pitch length is 270.9". These should be ordered as: CP270 Classical belts. (The “P” is for Wood’s Premium construction.)

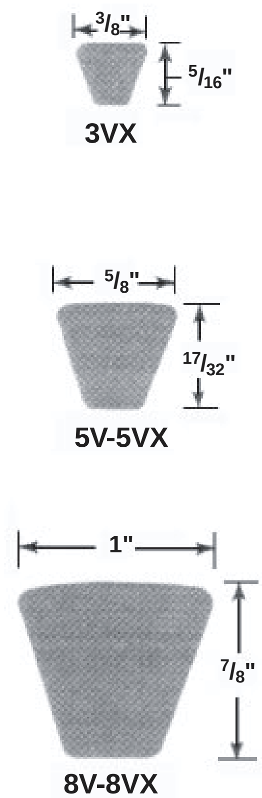
The number 5VX1250 indicates a narrow belt with a nominal 5/8" top width and an effective outside length of 125". These belts should be ordered as follows: 5VX1250 Narrow belts. (The “X” identifies cogged construction belts.)

The number 4L550 indicates a Light Duty fractional horsepower belt having a nominal top width of 1/2" and a nominal outside length of 55". Light Duty belts are available for general purpose applications; specify 4L550 Light Duty. It is designed to have little or no stretch and will require few takeups during its life.

Classical Belts



Narrow Belts



To assure maximum V-belt life, follow the minimum recommended pitch and sheave diameters for belts established by Mechanical Power Transmission Association and Rubber Manufacturers Association standards.

Classical Belt Section	Minimum* Pitch Diameter
A	3.0"
AX	2.2"
B	5.4"
BX	4.0"
C	9.0"
CX	6.8"
D	13.0"

Not applicable to Light Duty Belts

Narrow Belt Section	Minimum Sheave Diameter
3V	2.65"
3VX	2.2"
5V	7.1"
5VX	4.4"
8V	12.5"

All belts “ORS”

At one time it was necessary to order special belts for various types of environments. All Wood’s belts are of “ORS” construction, meaning they are heat resistant, oil resistant and static conducting.

By heat resistant, we mean these belts will operate well in ambient temperatures up to 140° F. They may be operated at higher temperatures, but there would be a reduction in service life. In general, short belts develop higher internal temperatures than tong belts. They are usually subjected to more flexures per minute and are frequently found on totally-enclosed drives where there is little or no air circulation.

Oil resistance is a matter of degree. It varies with the amount of contact with oil, whether it is continuous or intermittent immersion, exposure to an atmospheric mist or an occasional spattering. A great many chemicals, particularly petroleum derivatives, can cause deterioration. All Narrow, Classical and Light Duty belts will withstand nominal exposure to oil and grease, but they are not 100% oilproof.

For maximum performance from belts in oily atmospheres, they should be guarded as much as practical against excessive amounts of oil and should be periodically cleaned with methyl chloroform. Oil and grease on belts and sheaves will tend to lubricate the drive and reduce the traction of the belt, even though they may not actually harm the belts themselves. However, since the friction factor is reduced, belts must be operated at abnormal tensions, and their life is shortened.

Belt failure caused by oil is obvious and easy to detect. The most apparent sign is the build-up of a black, soft substance that can be wiped off when the belt is rubbed. Another sign is a softening and swelling of the belt to the point where it no longer fits the sheave groove properly.

Like oil resistance, resistance to ozone is a matter of degree. Narrow, Classical and Light Duty belts are resistant to normal amounts of ozone in the atmosphere. However, high concentrations such as found around arc welding equipment can cause rubber to harden and crack. It is because of ozone that belts should never be stored in direct sunlight.

Belts intended for operation in potentially dangerous atmospheres are constructed with a relatively low electrical resistance characteristic and referred to as “static conducting.” All Narrow, Classical and Light Duty belts meet the following requirements.

In the standard method of measuring a belt’s electrical resistivity, two $^5/_8$"-diameter flat contacts are placed $8^1/_2$" apart on centers, moistened with water and pressed against the belt with a force of $12^1/_2$ lbs. The resistance “conductivity” between the contacts is measured with an ohmmeter operating at a potential of 500 volts and having an accuracy range from 0 to 10 megohms. Experience has demonstrated that the dissipation provided by belts having a resistance at 6 megohms or less “when new and measured as above” is satisfactory for operation in hazardous atmospheres.

Explosive atmospheres

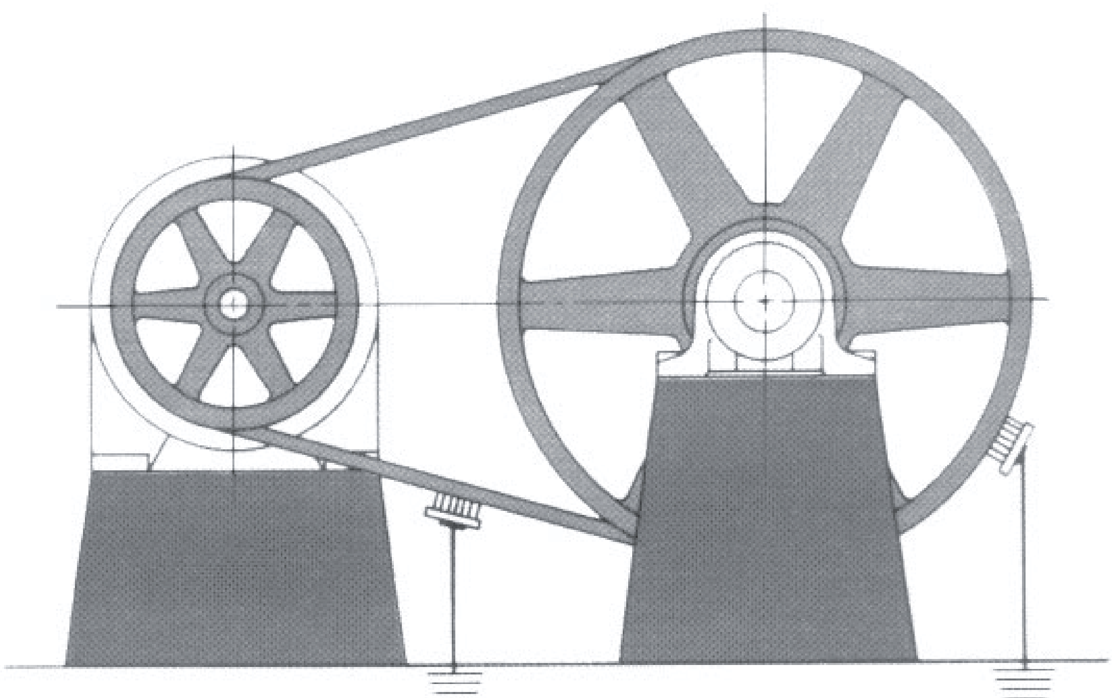
Belts on drives in hazardous atmospheres should be kept reasonably free of encrusted accumulations of non-conducting materials. In addition, all elements of the drive must be interconnected and grounded to earth as illustrated here.

Although we know of no explosion caused by static generated by a V-belt drive, we cannot accept responsibility beyond that of furnishing belts within the above described limits.

Store belts properly

V-belts should be stored in a cool, dry place out of direct sunlight. They should be kept away from ozone-producing equipment such as arc welders and high voltage apparatus. Temperature should be below 85°F, relative humidity below 70%. If belts are stored in piles, the piles should be kept small to avoid excessive weight which could distort the bottom belts. When belts are stored in boxes, the box size should be limited. Ideally, belts should be hung on saddle type pegs. With proper storage, belt quality will not change significantly within eight years.

Assuming good storage practices, a decrease in service life of approximately 10% per year of storage beyond eight years can be expected. From a norm of eight years storage life at 85°, it is estimated that the storage limit should be reduced by half for each 15° increase in temperature. A significant increase in humidity may cause a fungus to form on belts, but any effect on the performance of the belt would be very slight.



Proper V-drive installation in explosive atmospheres

Safety Tips

No matter where rotating machines are located or by what means they are driven, there is always a chance of personal injury unless they are installed and operated under safe conditions. It is with this thought uppermost in our minds that this manual is written.

Guard all drives properly

All regulating agencies such as OSHA, State Departments of Labor and Industry, insurance firms and other safety authorities either recommend or insist on drive guards. We, also, strongly recommend that every V-belt drive be completely guarded. Do not be lulled into a sense of security by a temporary or makeshift guard.

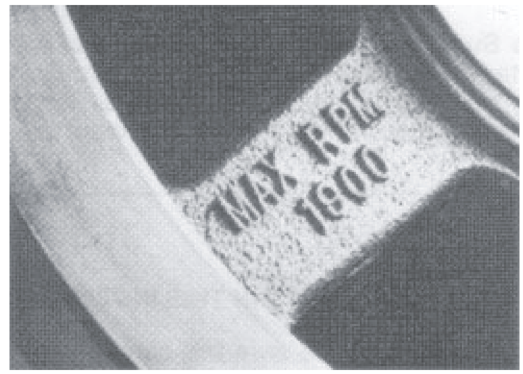
Of course, provision can and should be made for proper ventilation and inspection by the use of grills, inspection doors and removable panels. But the guard should have no gap where workers can reach inside and become caught in the drive. Besides being a safety asset, a good guard helps make maintenance easier by protecting the drive from weather and foreign objects.

Check safe speed limits

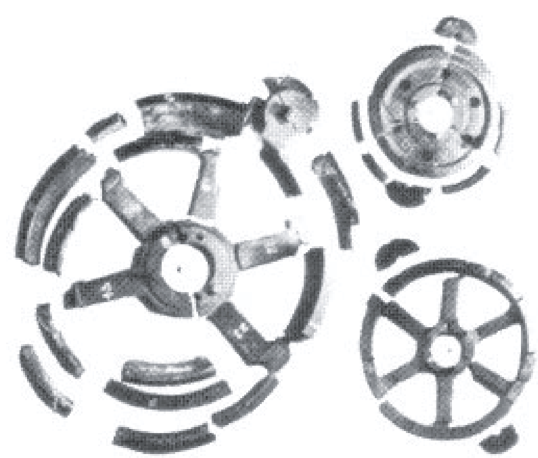
Safe speed limits for sheaves manufactured by TB Wood's Incorporated have been established by a rigorous burst testing program. The limit for cast iron sheaves has been established at 6500 fpm; the maximum speed in rpm corresponding to 6500 fpm is either cast or stamped on each sheave.

Before installing the drive, this safe speed limit should be checked against the speed of the shaft on which it is being installed. Operating sheaves above recommended speeds could result in serious damage to equipment and/ or serious personal injury.

Safe speed is cast into the arm of Wood's sheaves.



Burst testing. Results of centrifugal force are clearly shown in these broken "D"-groove sheaves. The pattern of breakage is typical. The rim breaks away from the arms, arms break from hub and the hub shatters through its bolt holes. With the force in several hundred thousand pounds, it all happens in a split second.



Drive Installation

Sure-Grip® Sheave and Bushing Installation Instructions

Wood's Sure-Grip bushings are the most widely used, tapered, OD-type and have exceptional holding power that eliminates wobble. Standard and reverse mounting features provide greater adaptability. Sure-Grip bushings can be used interchangeably in many of Wood's products as well as those of other manufacturers.

To Install:

IMPORTANT:
DO NOT USE LUBRICANTS IN THIS INSTALLATION

Before beginning, make sure the correct size and quantity of parts are available for the installation. The bushing has been manufactured to accept a setscrew over the key and its use is optional. It is packaged with the hardware on sizes SH to M and loosely installed in the bushing on sizes N to S.

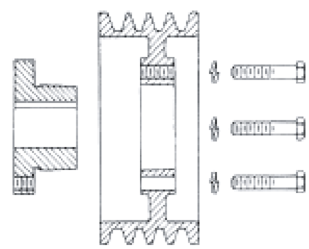


FIG. 1 **Standard Mounting**

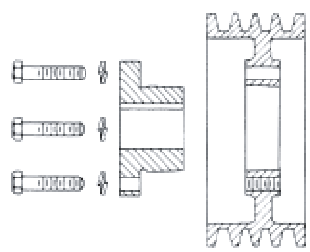


FIG. 2 **Reverse Mounting**

1. Inspect the tapered bore of the sheave and the tapered surface of the bushing. Any paint, dirt, oil, or grease MUST be removed.
2. Select the type of mounting (See Fig. 1 or 2) that best suits your application.
3. **STANDARD MOUNTING:** Install shaft key. (Note: If key was furnished with bushing, you must use that key.) Install bushing on clean shaft, flange end first. If bushing will not freely slide on the shaft, insert a screwdriver or similar object into the flange sawcut to act as a wedge to open the bushing's bore. **Caution: Excessive wedging will split the bushing.** If using the setscrew, tighten it just enough to prevent the bushing from sliding on the shaft. **Caution: Do not over tighten setscrew!** Slide sheave into position on bushing aligning the drilled holes in the sheave with the tapped holes in the bushing flange. (Note: Install M thru S bushings so that the two tapped holes in the sheave are located as far away as possible from the bushing's saw-cut.) Loosely thread the capscrews with lock-washers into the assembly. **DO NOT USE LUBRICANT ON THE CAPSCREWS!**
4. **REVERSE MOUNTING:** With large end of the taper out, slide sheave onto shaft as far as possible. Install shaft key. (See shaft key note in #3 above.) Install bushing onto shaft so tapered end will mate with sheave. (See wedging note in #3 above.) If using the setscrew, tighten it enough to prevent the bushing from sliding on the shaft. **Caution: Do not over tighten setscrew!** Pull the sheave up on the bushing, aligning the drilled holes in the bushing flange with the tapped holes in the sheave. Loosely thread the capscrews with lockwashers into the assembly. **DO NOT USE LUBRICANT ON THE CAPSCREWS!**
5. Using a torque wrench, tighten all capscrews evenly and progressively in rotation to the torque value in Table. There must be a gap between the bushing flange and sheave hub when installation is complete. **DO NOT OVER TORQUE! DO NOT ATTEMPT TO CLOSE GAP BETWEEN BUSHING FLANGE AND SHEAVE HUB!**

To Remove:

1. Relieve drive tension by shortening the center distance between driver and driven sheaves.
2. Lift off belts.
3. Loosen and remove cap screws. If the bushings have keyway setscrews, loosen them.
4. As shown below, insert cap screws (three in JA through J bushings, two in QT and M thru W bushings and four in S bushing) in tapped removal holes and progressively tighten each one until mating part is loose on bushing. (Exception: If mating part is installed with cap screw heads next to motor, with insufficient room to insert screws in tapped holes, loosen cap screws and use wedge between bushing flange and mating part.)
5. Remove mating part from bushing, and if necessary, bushing from shaft.

Sure-Grip Bushing Screw Tightening Information

Tapered Bushing	Size & Thread of Cap Screw	Ft.-Lbs. To Apply With Torque Wrench
QT	$^{1}/_{4}$ — 20	9
JA	No. 10 — 24	5
SH-SDS-SD	$^{1}/_{4}$ — 20	9
SK	$^{5}/_{16}$ — 18	15
SF	$^{3}/_{8}$ — 16	30
E	$^{1}/_{2}$ — 13	60
F	$^{9}/_{16}$ — 12	110
J	$^{5}/_{8}$ — 11	135
M	$^{3}/_{4}$ — 10	225
N	$^{7}/_{8}$ — 9	300
P	1 — 8	450
W	$1^{1}/_{8}$ — 7	600
S	$1^{1}/_{4}$ — 7	750

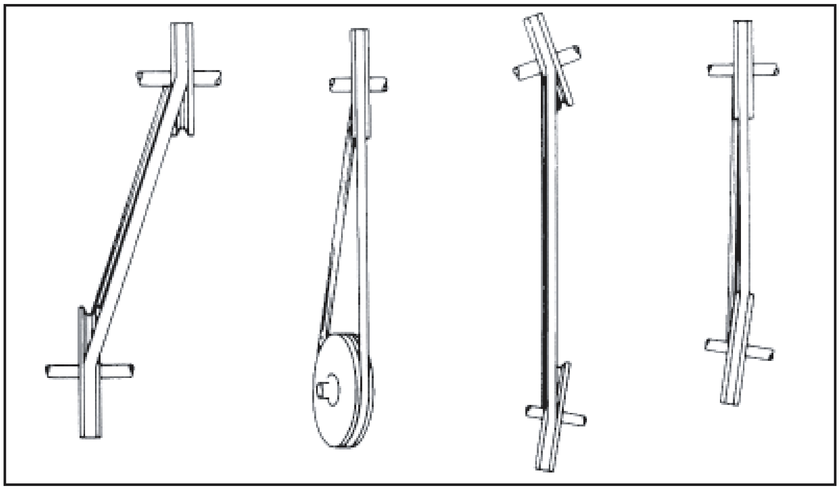
CAUTION: The tightening force on the screws is multiplied many times by the wedging action of the tapered surface. If extreme tightening force is applied, or if a lubricant is used, bursting pressures will be created in the hub of the mating part.

Check alignment

Although alignment is not as critical in V-belt drives as in others, proper alignment is essential to long belt and sheave life.

First, make sure that drive shafts are parallel. The most common causes of misalignment are nonparallel shafts and improperly located sheaves.

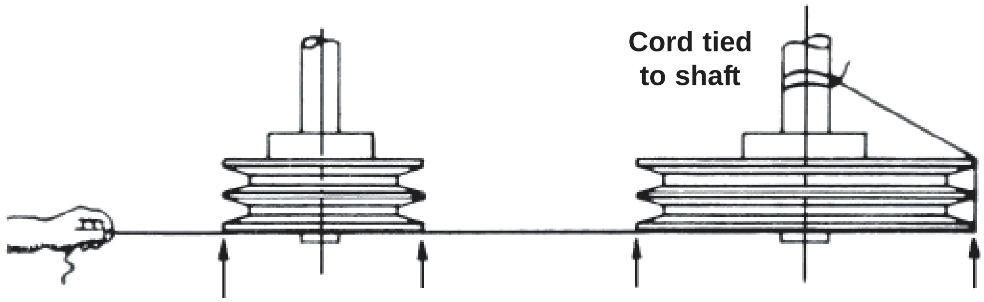
Where shafts are not parallel, belts on one side are drawn tighter and pull more than their share of the load. As a result, these belts wear out faster, requiring the entire set to be replaced before it has given maximum service. If misalignment is in the sheave, belts will enter and leave the grooves at an angle, causing excessive belt cover and sheave wear.



Shaft alignment can be checked by measuring the distance between the shafts at three or more locations. If the distances are equal, then the shafts will be parallel.

To check the location of the sheaves on the shafts, a straightedge or a piece of string can be used. If the sheaves are properly lined up, the string will touch them at the points indicated by the arrows in the accompanying sketch. Rotating each sheave a half revolution will determine whether the sheave is wobbly or the drive shaft is bent. Correct any misalignment.

With sheaves aligned, tighten cap screws evenly and progressively. Apply the recommended torque to cap screws as listed in table on page 12. NOTE: There should be $^{1}/_{8}$" to $^{1}/_{4}$" gap between the mating part hub and the bushing flange. If gap is closed, the shaft is seriously undersize.



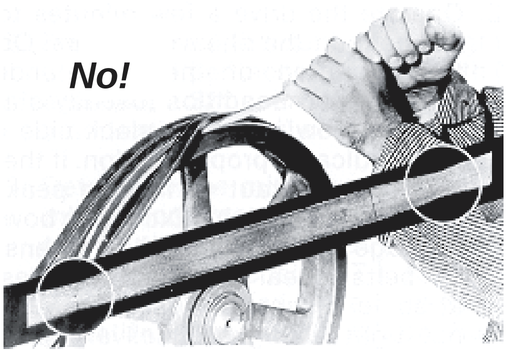
Install belts

Shorten the center distance between the driven and driver sheave so the belts can be put on without the use of force.

While the belts are still loose on the drive, rotate the drive until all the slack is on one side. Then increase the center distance until the belts are snug. The drive is now ready for tensioning.

NOTE: Never “roll” or “pry” the belts into the sheave grooves. This can damage the belt cords and lead to belt turnover, short life or actual breakage. Moreover, it is both difficult and unsafe to install belts this way.

Keep take-up rails, motor base or other means of center distance adjustment free of dirt, rust and grit. Lubricate adjusting screws and slide rails from time to time.



When belts are forced into the sheave with a screwdriver or other wedge, the outer fabric is often ruptured and cords broken.

It is well worth the time to move the driver unit forward so V-belts can be slipped easily into the sheave groove without damage.

Center Distance Allowance for Installation and Take-Up (Inches)

Narrow Belts

Belt Length	For Installation (Subtract)						For take-up (Add)
	3VX & 3V	3V Banded	5VX & 5V	5V Banded	8VX & 8V	8V Banded	All Cross Sections
250 thru 475	0.5	1.2	–	–	–	–	1.0
500 thru 710	0.8	1.4	1.0	2.1	–	–	1.2
750 thru 1060	0.8	1.4	1.0	2.1	1.5	3.4	1.5
1120 thru 1250	0.8	1.4	1.0	2.1	1.5	3.4	1.8
1320 thru 1700	0.8	1.4	1.0	2.1	1.5	3.4	2.2
1800 thru 2000	–	–	1.0	2.1	1.8	3.6	2.5
2120 thru 2360	–	–	1.2	2.4	1.8	3.6	3.0
2500 thru 2650	–	–	1.2	2.4	1.8	3.6	3.2
2800 thru 3000	–		1.2	2.4	1.8	3.6	3.5
3150 thru 3550	–	–	1.2	2.4	2.0	4.0	4.0
3750	–	–	–	–	2.0	4.0	4.5
4000 thru 5000	–	–	–	–	2.0	4.0	5.5

Classical Belts

Belt Length Designation	For Installation (Subtract)							For take-up (Add)
	AX & AP	BX & BP	BX & BP Banded	CX & CP	CX & CP Banded	DX & DP	DX & DP Banded	All Cross Sections
21 thru 35	0.8	1.0	1.5	–	–	–	–	1.0
36 thru 55	0.8	1.0	1.5	1.5	2.0	–	–	1.5
56 thru 85	0.8	12	1.6	1.5	2.0	–	–	2.0
86 thru 112	1.0	12	1.6	1.5	2.0	–	–	2.5
116 thru 144	1.0	1.3	1.8	1.5	2.1	2.0	3.0	
148 thru 180	–	1.3	1.8	2.0	2.2	2.0	3.0	3.5
191 thru 210	–	1.5	1.9	2.0	2.3	2.0	3.2	4.0
225 thru 240	–	1.5	2.0	2.0	2.5	2.5	3.2	4.5
255 thru 300	–	1.5	2.2	2.0	2.5	2.5	3.5	5.0
315 thru 390	–	–	–	2.0	2.7	2.5	3.6	6.0
420 and Over	–	–	–	2.5	2.9	3.0	4.1	1.5% of belt length.

All dimensions in inches.

Tensioning V-Belt Drives

Without exception, the most important factor in the successful operation of a V-belt drive is proper belt-tensioning. To achieve the long, trouble-free service associated with V-belt drives, belt tension must be sufficient to overcome slipping under maximum peak load. This could be either at start or during the work cycle. The amount of peak load will vary depending upon the character of the driven machine or drive system. To increase total tension, merely increase the center distance. Before attempting to tension any drive it is imperative that the sheaves be properly installed and aligned. If a V-belt slips it is too loose. Add to the tension by increasing the center distance. Never apply belt dressing as this will damage the belt and cause early failure.

General method

The general method for tensioning V-belts should satisfy most drive requirements.

Step 1: Reduce the center distance so that the belts may be placed over the sheaves and in the grooves without forcing them over the sides of the grooves. Arrange the belts so that both the top and bottom spans have about the same sag. Apply tension to the belts by increasing the center distance until the belts are snug. See figure 1.

Step 2: Operate the drive a few minutes to seat the belts in the sheave grooves. Observe the operation of the drive under its highest load condition (usually starting). A slight bowing of the slack side of the drive indicates proper tension. If the slack side remains taut during the peak load, the drive is too tight. Excessive bowing or slippage indicates insufficient tension. If the belts squeal as the motor comes on or at some subsequent peak load, they are not tight enough to deliver the torque demanded by the drive machine. The drive should be stopped and the belts tightened.

Step 3: Check the tension on a new drive frequently during the first day by observing the slack side span. After a few days' operation the belts will seat themselves in the sheave grooves and it may become necessary to readjust so that the drive again shows a slight bow in the slack side.

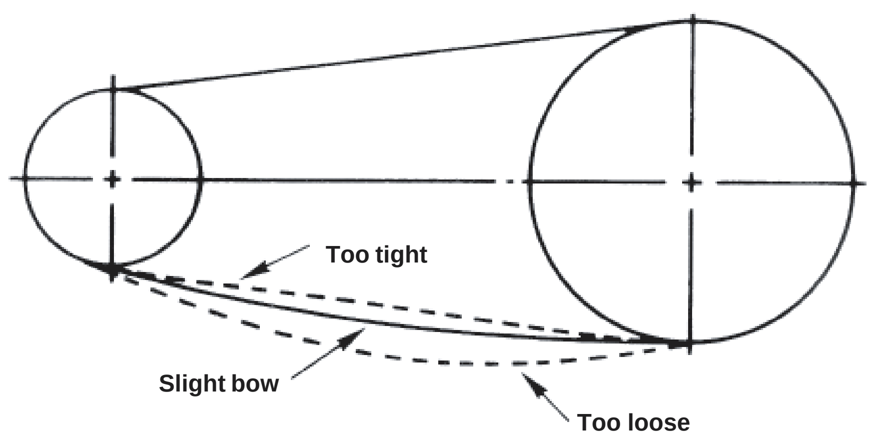


Figure 1

Force deflection method

This method should be used only for tensioning drives on which the grade of belt, rated belt capacity, service factor, design horsepower, etc. are known.

Step 1: Install belts per Step 1 of General Method. Measure span length (t) in inches as shown in figure 2, or calculate using formula.

Step 2: From figure 2 the deflection height (h) is always $^{1}/_{64}$" per inch of span length (t). For example, a 32" span length would require a deflection of $^{32}/_{64}$" or $^{1}/_{2}$".

Step 3: Determine the minimum, maximum, and initial recommended pounds force using table 1 or calculate based on the required Static Strand Tension (Is). Note: The initial recommended force is used only for installing new belts which have not seated themselves into the sheave grooves and where initial belt stretch has not taken place.

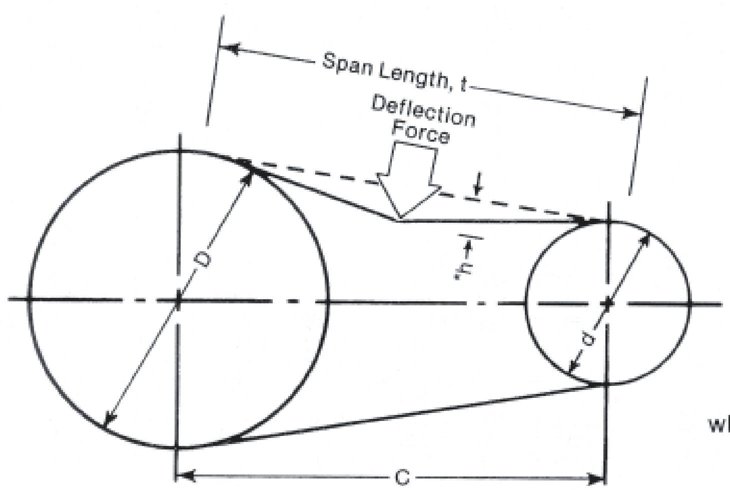
Step 4: Using a spring scale, apply a perpendicular force to any ONE of the belts at the mid point of the span as shown in figure 2. Compare this deflection force with the values found in Step 3.

a. If the deflection force is below the minimum, the belts are too loose and the tension should be increased by increasing the center distance.

b. If the deflection force is higher than the maximum, the belts are too tight and the tension should be decreased.

When new V-belts are installed on a drive the INITIAL tension will drop rapidly during the first few hours. Check tension frequently during the first 24 hours of operation. Subsequent retensioning should fall between the minimum and maximum force.

To determine the deflection distance from normal position, use a straightedge or stretch a cord from sheave to sheave to use as a reference line. On multiple-belt drives an adjacent undeflected belt can be used as a reference.



$$t = \sqrt{C^2 - \left(\frac{D-d}{2}\right)^2}$$

$$h = \frac{t}{64}$$

where t = Span length, inches
C = Center distance, inches
D = Larger sheave diameter, inches
d = Smaller sheave diameter, inches

Figure 2

Table 1
Recommended Minimum Force Per Belt

Belt Section	Small Sheave: Speed Range	Small Sheave: Dia.	Drive Ratio: 1.0	Drive Ratio: 1.5	Drive Ratio: 2.0	Drive Ratio: 4.0 & over
3V	1200-3600	2.65	2.0	2.4	2.6	3.0
	1200-3600	3.65	2.8	3.6	3.8	4.2
	1200-3600	4.75	3.8	4.2	4.4	4.8
	1200-3600	5.60	4.2	4.6	4.8	5.4
	1200-3600	6.90	4.6	5.0	5.2	5.6
5V	900-1800	7.1	8.5	9.5	10	11
	900-1800	9.0	10	11	12	13
	900-1800	14.0	12	13	14	15
	700-1200	21.2	14	15	16	17
8V	900-1800	12.5	18	21	23	25
	900-1800	14.0	21	23	24	28
	700-1500	17.0	24	26	28	30
	700-1200	21.2	28	30	32	34
	400-1000	24.8	31	32	34	36
3VX	1200-3600	2.20	2.2	2.5	2.7	3.0
	1200-3600	2.50	2.6	2.9	3.1	3.6
	1200-3600	3.00	3.1	3.5	3.7	4.2
	1200-3600	4.12	3.9	4.3	4.5	5.1
	1200-3600	5.30	4.6	4.9	5.1	5.7
	1200-3600	6.9	5.0	5.4	5.6	6.2
5VX	1200-3600	4.4	6.5	7.6	8.0	9.0
	1200-3600	5.2	8.0	9.0	9.5	10
	1200-3600	6.3	9.5	10	11	12
	1200-3600	7.1	10	11	12	13
	900-1800	9.0	12	13	14	15
	900-1800	14.0	14	15	16	17
AP	1800-3600	3.0	2.0	2.3	2.4	2.6
	1800-3600	4.0	2.6	2.8	3.0	3.3
	1800-3600	5.0	3.0	3.3	3.4	3.7
	1800-3600	7.0	3.5	3.7	3.8	4.3
BP	1200-1800	4.6	3.7	4.3	4.5	5.0
	1200-1800	5.0	4.1	4.6	4.8	5.6
	1200-1800	6.0	4.8	5.3	5.5	6.3
	1200-1800	8.0	5.7	6.2	6.4	7.2
CP	900-1800	7.0	6.5	7.0	8.0	9.0
	900-1800	9.0	8.0	9.0	10	11
	900-1800	12.0	10	11	12	13
	700-1500	16.0	12	13	13	14
DP	900-1500	12.0	13	15	16	17
	900-1500	15.0	16	18	19	21
	700-1200	18.0	19	21	22	24
	700-1200	22.0	22	23	24	26
AX	1800-3600	3.0	2.5	2.8	3.0	3.3
	1800-3600	4.0	3.3	3.6	3.8	4.2
	1800-3600	5.0	3.7	4.1	4.3	4.6
	1800-3600	7.0	4.3	4.6	4.8	5.3
BX	1200-1800	4.6	5.2	5.8	6.0	6.9
	1200-1800	5.0	5.4	6.0	6.3	7.1
	1200-1800	6.0	6.0	6.4	6.7	7.7
	1200-1800	8.0	6.6	7.1	7.5	8.2
CX	900-1800	7.0	10	11	12	13
	900-1800	9.0	11	12	13	14
	900-1800	12.0	12	13	13	14
	700-1500	16.0	13	14	14	15
DX	900-1500	12.0	16	18	19	20
	9001500	15.0	19	21	22	24
	700-1200	18.0	22	24	25	27
	700-1200	22.0	25	27	28	30

MAXIMUM Deflection Force = Minimum times 1.5

INITIAL Deflection Force = Minimum times 2.0

Minimum deflection force values shown in table 1 are based on assumed average static tensions for drives having multiple belts or more than one V-band, thus eliminating calculations. (For drives using only one belt or one V-band, deflection force must be determined by use of engineering formulas.)

Find the minimum recommended deflection force for the belt section and type based upon the small sheave diameter, speed and drive ratio. For intermediate sheave diameters and/or drive ratio combinations the minimum deflection force may be Interpolated.

For Narrow Band, Classical Band and Classical Cog Band belts multiply the minimum deflection force from table 1 by the number of belts in the band. Where larger values make use of the Force Deflection Method impractical, use the Elongation Method to tension V-bands.

Table 2
K Factors and Arc of contact

$\frac{D-d}{C}$	Arc Contact Degree	Factor Ac	Factor K
0.000	180	1.000	24.750
0.025	179	0.997	24.883
0.050	177	0.994	25.019
0.075	176	0.990	25.158
0.100	174	0.987	25.300
0.125	173	0.983	25.444
0.150	171	0.980	25.591
0.175	170	0.977	25.742
0.200	169	0.973	25.896
0.225	167	0.969	26.053
0.250	166	0.966	26.213
0.275	164	0.962	26.377
0.300	163	0.958	26.545
0.325	161	0.954	26.717
0.350	160	0.951	26.892
0.375	158	0.947	27.072
0.400	157	0.943	27.257
0.425	155	0.939	27.445
0.450	154	0.935	27.639
0.475	153	0.930	27.837
0.500	151	0.926	28.040
0.525	150	0.922	28.249
0.550	148	0.917	28.463
0.575	147	0.913	28.684
0.600	145	0.908	28.910
0.625	144	0.904	29.142
0.650	142	0.899	29.381
0.675	141	0.894	29.627
0.700	139	0.889	29.881
0.725	137	0.884	30.142
0.750	136	0.879	30.411
0.775	134	0.874	30.688
0.800	133	0.869	30.975
0.825	131	0.864	31.270
0.850	130	0.858	31.576
0.875	128	0.852	31.892
0.900	127	0.847	32.219
0.925	125	0.841	32.558
0.950	123	0.835	32.909
0.975	122	0.829	33.273
1.000	120	0.823	33.652
1.025	118	0.816	34.045
1.050	117	0.810	34.454
1.075	115	0.803	34.879
1.100	113	0.796	35.323
1.125	112	0.789	35.786
1.150	110	0.782	36.270
1.175	108	0.774	36.777
1.200	106	0.767	37.307
1.225	104	0.759	37.864
1.250	103	0.751	38.448
1275	101	0.742	39.064
1.300	99	0.734	39.713
1.325	97	0.725	40.398
1.350	95	0.716	41.123
1.375	93	0.706	41.892
1.400	91	0.697	42.709
1.425	89	0.687	43.580

Force deflection engineering formulas

For a more precise method, or where a V-drive combination is not within specified limits, table 1, use the following engineering formulas to determine force deflection values.

Step 1: Determine Span Length (t) and Deflection Height (h). Reference figure 2.

Step 2: Calculate the Static Strand Tension (Ts).

$$TS = \frac{K \times DHP}{N \times S} + \frac{MS^2}{2}$$

Step 3: Calculate the recommended Deflection Forces (P) for drives using multiple belts or more than one V-band.

$$P_{Minimum} = \frac{Ts + Y}{16}$$

$$P_{Maximum} = \frac{1.5(Ts) + Y}{16}$$

$$P_{Initial} = 1.33 \text{ times } P_{Maximum}$$

Explanation of Symbols

- Ac = Arc of contact – smaller sheave, degrees
- C = Center distance, inches
- D = Larger sheave pitch diameter, inches
- d = Smaller sheave pitch diameter, inches
- DHP = Design horsepower based upon the recommended application service factor
- h = Deflection height, inches (Refer. figure 2)
- K = Value from table 2 depending on $\frac{D-d}{C}$ or $K = 16.5 \frac{2.5\text{-}Ac}{Ac}$
- L = Belt length, inches
- M = Centrifugal constant table 3
- N = Number of belts or V-band ribs
- P = Deflection force, pounds
- S = Belt speed, FPM/1000
- t = Span length, inches (Refer. figure 2)
- Y = Belt constant table 3

Note: For drives using only one belt or one V-band, and at least one shaft free to rotate use the following to determine the recommended Deflection Forces (P).

$$P_{Minimum} = \frac{Ts + Y\left(\frac{t}{L}\right)}{16} \qquad P_{Maximum} = \frac{1.5(Ts) + Y\left(\frac{t}{L}\right)}{16} \qquad P_{Initial} = 1.33 \text{ times } P_{Maximum}$$

Table 3
Belt Constants M and Y

Factors	Narrow			Narrow Cog		Classical					Classical Cog			
	3V	4V	8V	3VX	5VX	AP	BP	CP	DP	EP	AX	BX	CX	DX
M Single Belts	.46	1.23	3.28	.39	1.08	.66	1.08	1.98	3.74	5.85	.61	1.00	1.78	3.97
M V-Band	.51	1.32	3.80	–	–	–	1.40	2.33	4.29	6.26	–	1.28	2.10	4.56
Y	4.0	12.00	22.00	7.0	20.0	6.0	9.0	16.0	30.00	45.00	7.0	10.00	28.00	82.00

Belt elongation method

This method is recommended for V-band drives where larger deflecting forces make the use of previously described methods impractical.

Elongation is related to the tension causing it; thus, tape measured V-band lengths, both slack and tight, can be used to obtain proper V-band tension.

Step 1: Decrease the center distance until the V-band(s) can be easily slipped into the sheave grooves. Forcing the belts on can damage the load-carrying cords and cause premature belt failure.

Step 2: With the V-band(s) still on the drive at NO tension, measure the outside circumference (slack O.C.) of the bands. Note: If retensioning a used drive, decrease the center distance until there is no tension on the band(s), then measure the outside circumference (slack O.C.) of the band(s).

Step 3: Determine the required Static Tension (Ts) per individual rib strand using the following formula.

$$Ts = \frac{K \times DHP}{N \times S} + \frac{MS^2}{2}$$

Step 4: Find a range of recommended tensions.

Lower Tension = Ts
Upper Tension = 1.5 times Ts

Step 5: Calculate minimum and maximum elongated band lengths for use in tensioning the drive.

a. From table 4, find length multipliers corresponding to the lower and upper Ts values in Step 4 above.

b. Multiply the slack O.C. found in Step 2 by the length multipliers to find the minimum and maximum elongated band lengths.

Step 6: Increase the drive center distance until a tape measurement of the band(s) O.C. is between the two values calculated for elongated band length Step 5b.

Step 7: Retension as required. New V-bands may lose tension rapidly during the run-in period and will probably require retensioning. V-bands that have been on a drive for some time may also require retensioning due to tension decay from normal use and wear.

Table 4 Belt length multipliers for tensioning banded belts

Ts Per Strand (lbs.)	NARROW BAND					CLASSICAL BAND					CLASSICAL COG BAND		
	CROSS SECTION												
	3V	5V		8V		BP		CP		DP	BX	CX	DX
		5V1700 & under	5V1800 & over	8V1700 & under	8V1800 & over	BP144 & under	Over BP144	CP144 & under	Over CP144		All Sizes	All Sizes	All Sizes
10	1.00186	1.00056	1.00001	1.00013	1.00010	1.00113	1.00141	1.00029	1.00052	1.00013	1.00082	1.00027	1.00013
12	1.00220	1.00068	1.00097	1.00016	1.00012	1.00135	1.00168	1.00035	1.00062	1.00016	1.00098	1.00032	1.00016
14	1.00254	1.00079	1.00113	1.00019	1.00014	1.00157	1.00194	1.00041	1.00072	1.00019	1.00114	1.00038	1.00019
16	1.00288	1.00090	1.00129	1.00021	1.00016	1.00178	1.00220	1.00046	1.00082	1.00021	1.00129	1.00043	1.00021
18	1.00320	1.00101	1.00144	1.00024	1.00018	1.00199	1.00246	1.00052	1.00092	1.00024	1.00145	1.00048	1.00024
20	1.00352	1.00112	1.00159	1.00027	1.00020	1.00220	1.00271	1.00058	1.00102	1.00027	1.00160	1.00054	1.00027
24	1.00414	1.00133	1.00190	1.00032	1.00024	1.00261	1.00320	1.00069	1.00122	1.00033	1.00191	1.00065	1.00032
28	1.00472	1.00155	1.00219	1.00037	1.00029	1.00301	1.00368	1.00081	1.00141	1.00038	1.00220	1.00075	1.00038
32	1.00520	1.00176	1.00249	1.00043	1.00033	1.00339	1.00414	1.00092	1.00161	1.00044	1.00250	1.00086	1.00043
36	1.00556	1.00197	1.00277	1.00048	1.00037	1.00377	1.00458	1.00104	1.00180	1.00050	1.00278	1.00097	1.00049
40	1.00588	1.00217	1.00305	1.00054	1.00042	1.00413	1.00500	1.00115	1.00199	1.00056	1.00306	1.00107	1.00054
45	1.00625	1.00243	1.00340	1.00060	1.00047	1.00458	1.00529	1.00129	1.00222	1.00063	1.00341	1.00121	1.00061
50	1.00659	1.00268	1.00374	1.00067	1.00053	1.00500	1.00553	1.00144	1.00246	1.00071	1.00374	1.00134	1.00068
55	1.00691	1.00293	1.00406	1.00074	1.00058	1.00528	1.00574	1.00158	1.00268	1.00078	1.00407	1.00147	1.00075
60	1.00722	1.00317	1.00438	1.00081	1.00064	1.00553	1.00591	1.00172	1.00291	1.00086	1.00439	1.00161	1.00081
65	1.00754	1.00341	1.00470	1.00088	1.00070	1.00576	1.00606	1.00186	1.00313	1.00094	1.00470	1.00174	1.00088
70	1.00787	1.00365	1.00500	1.00095	1.00076	1.00596	1.00620	1.00200	1.00335	1.00102	1.00500	1.00187	1.00095
75	1.00822	1.00389	1.00523	1.00101	1.00082	1.00614	1.00632	1.00214	1.00357	1.00110	1.00522	1.00200	1.00102
80	1.00861	1.00412	1.00545	1.00108	1.00088	1.00631	1.00644	1.00228	1.00378	1.00118	1.00543	1.00213	1.00109
85	1.00903	1.00434	1.00566	1.00115	1.00094	1.00646	1.00656	1.00242	1.00399	1.00127	1.00563	1.00227	1.00116
90	1.00949	1.00456	1.00586	1.00122	1.00100	1.00659	1.00668	1.00256	1.00420	1.00135	1.00581	1.00240	1.00123
95	1.01000	1.00478	1.00606	1.00129	1.00106	1.00672	1.00682	1.00270	1.00441	1.00144	1.00599	1.00253	1.00130
100	1.01056	1.00500	1.00625	1.00136	1.00113	1.00684	1.00697	1.00284	1.00461	1.00152	1.00616	1.00266	1.00137
120	1.01333	1.00561	1.00696	1.00164	1.00139	1.00727	1.00780	1.00339	1.00528	1.00188	1.00679	1.00319	1.00166
140	1.01692	1.00617	1.00765	1.00192	1.00166	1.00771	1.00912	1.00393	1.00579	1.00226	1.00736	1.00371	1.00195
160	1.02081	1.00672	1.00836	1.00220	1.00194	1.00827	1.01104	1.00447	1.00627	1.00265	1.00793	1.00423	1.00224
180	1.02385	1.00728	1.00913	1.00249	1.00223	1.00902	1.01357	1.00500	1.00675	1.00306	1.00854	1.00474	1.00253
200	1.02655	1.00707	1.01000	1.00277	1.00254	1.01000	1.01718	1.00534	1.00724	1.00349	1.00922	1.00525	1.00283
240	1.03118	1.00921	1.01213	1.00335	1.00319	1.01279	1.02268	1.00607	1.00832	1.00440	1.01090	1.00625	1.00343
280	1.03579	1.01088	1.01524	1.00395	1.00389	1.01663	1.02737	1.00692	1.00963	1.00542	1.01313	1.00724	1.00405
320	1.04070	1.01292	1.01834	1.00454	1.00461	1.02088	1.03275	1.00797	1.01124	1.00656	1.01590	1.00824	1.00468
360	1.04671	1.01562	1.02162	1.00515	1.00543	1.02423	1.03853	1.00926	1.01317	1.00771	1.01925	1.00924	1.00532
400	1.05308	1.01826	1.02526	1.00575	1.00631	1.02708	1.04393	1.01081	1.01580	1.00886	1.02229	1.01026	1.00598
450		1.02179	1.03056	1.00652	1.00744	1.03072	1.05000	1.01311	1.01877	1.01028	1.02625	1.01156	1.00683
500		1.02558	1.03643	1.00732	1.00859	1.03425		1.01610	1.02186	1.01164	1.03000	1.01292	1.00768
550		1.02927	1.04200	1.00813	1.00976	1.03781		1.01888	1.02500	1.01293	1.03354	1.01435	1.00856
600		1.03286	1.04642	1.00896	1.01094	1.04158		1.02169	1.02813	1.01413	1.03685	1.01557	1.00946
650		1.03632	1.05000	1.00982	1.01213	1.04567		1.02449	1.03123	1.01524	1.04000	1.01729	1.01037
700		1.03967		1.01071	1.01331	1.05000		1.02718	1.03426	1.01625	1.04333	1.01919	1.01130
750		1.04310		1.01163	1.01449			1.03000	1.03719	1.01718	1.04667	1.02126	1.01224
800		1.04655		1.01257	1.01571			1.03282	1.04000	1.01802	1.05000	1.02372	1.01320
850		1.05000		1.01354	1.01689			1.03563	1.04268	1.01833		1.02607	1.01418
900				1.01454	1.01887			1.03838	1.04524	1.01936		1.02840	1.01518
950				1.01561	1.01927			1.04101	1.04768	1.02044		1.03068	1.01619
1000				1.01667	1.02049			1.04345	1.05000	1.02156		1.03209	1.01717

TB Wood's

Trouble Shooting V-Belts

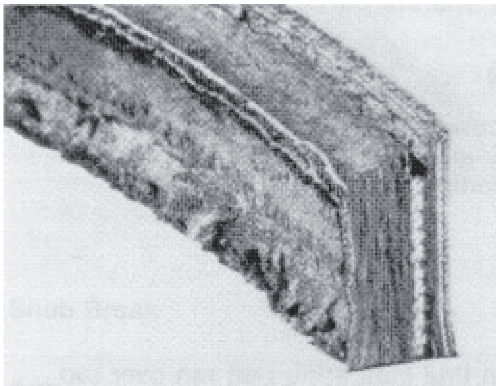
How to spot V-belt trouble

Trouble	Cause	To correct
Belt slip (sidewalls glazed)	Not enough tension.	Replace belts; apply proper tension.
Drive squeals	Shock load.	Apply proper tension.
	Not enough arc of contact.	Increase center distance.
	Heavy starting load.	Increase tension.
Belt turned over.	Broken cord caused by prying on sheave.	Replace set of belts correctly.
	Overloaded drive.	Redesign drive.
	Impulse loads.	Apply proper tension.
	Misalignment of sheave and shaft.	Realign drive.
	Worn sheave grooves.	Replace sheaves.
	Flat idler sheave.	Align idler. Re-position on slack side of drive close to drive sheave.
	Excessive belt vibration.	Check drive design. Check equipment for solid mounting. Consider use of banded belts.
Mismatched belts.	New belts installed with old belts.	Replace belts in matched set only.
	Sheave grooves worn unevenly; improper groove angle. Give appearance of mismatched belts.	Replace sheaves.
	Sheave shafts not parallel. Give appearance of mismatched belts.	Align drive.
Belt breaks.	Shock loads.	Apply proper tension; Recheck drive.
	Heavy starting loads.	Apply proper tension; Recheck drive. Use compensator starting.
	Belt pried over sheaves.	Replace set of belts correctly.
	Foreign objects in drive.	Provide drive shroud.
Belt wears rapidly.	Sheave grooves worn.	Replace sheaves.
	Sheave diameter too small.	Redesign drive.
	Mismatched belts.	Replace with matched belts.
	Drive overloaded.	Redesign drive.
	Belt slips.	Increase tension.
	Sheaves misaligned.	Align sheaves.
	Oil or heat condition.	Eliminate oil. Ventilate drive.

How to diagnose V-belt failure

V-Belt Troubleshooting Checklist

BELT CONDITION



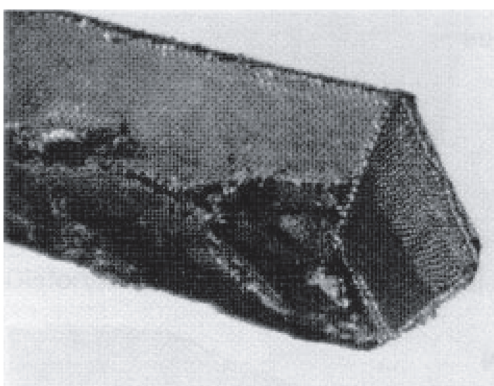
Oil Deterioration

CAUSE

Oil-softened rubber.

PREVENTION

Splash guards will protect drives against oil. Although Classical belts are oil resisting, excessive oil can cause some deterioration.



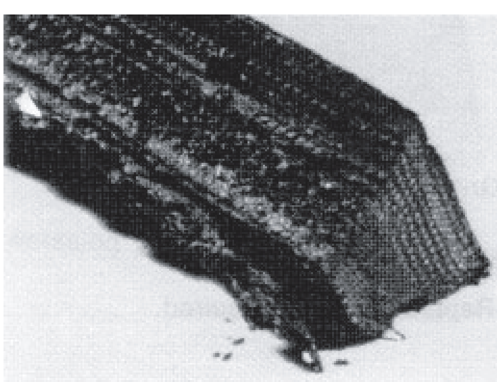
Cover Fabric Rupture

CAUSE

Cover fabric ruptured when belt was pried over sheave during installation.

PREVENTION

Proper installation of belts by moving motor so belts do not have to be pried into the grooves.



Slip Burn

CAUSE

Belt too loose. Belt didn't move, friction against sheave burned rubber. When belt finally grabbed, it snapped.

PREVENTION

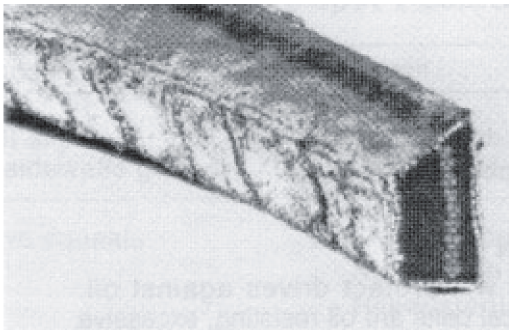
Maintain proper tension on the drive.

TB Wood's

How to diagnose V-belt failure

V-Belt Troubleshooting Checklist

BELT CONDITION



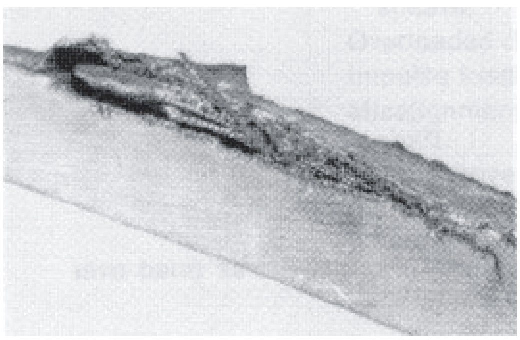
Base Cracking

CAUSE

Severe back-bend idlers. Improper storage. Excessive ambient operating temperature.

PREVENTION

Check storage conditions. If back-bend idler cannot be avoided, install idler of larger diameter. Avoid ambient temperature over 140°.



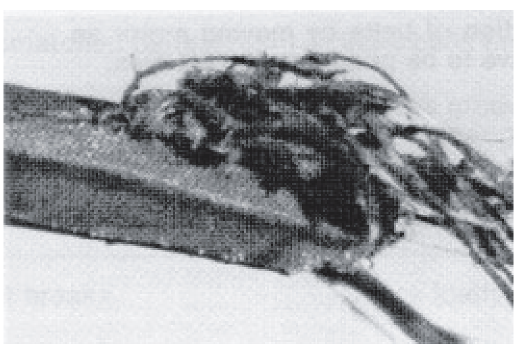
Ply Separation

CAUSE

Split along pitch line indicating belt ran over too small a sheave.

PREVENTION

Redesign drive using sheaves of proper size.



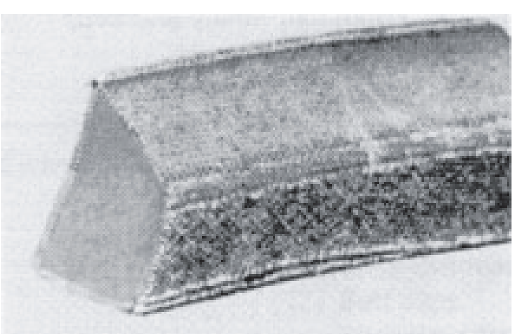
Ruptured

CAUSE

Ruptured cords in the plies.

PREVENTION

Check for rocks or tools falling into sheave grooves. Check tension. Belts loose enough to twist in groove can rupture cords.



Worn Belt Sides

CAUSE

Misalignment. Grit or dirt. Normal wear.

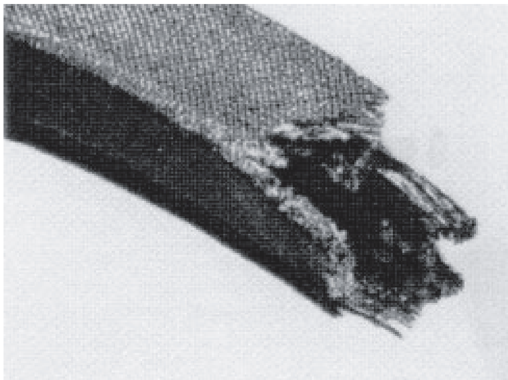
PREVENTION

Align sheaves. Replace belts as required.

How to diagnose V-belt failure

V-Belt Troubleshooting Checklist

BELT CONDITION

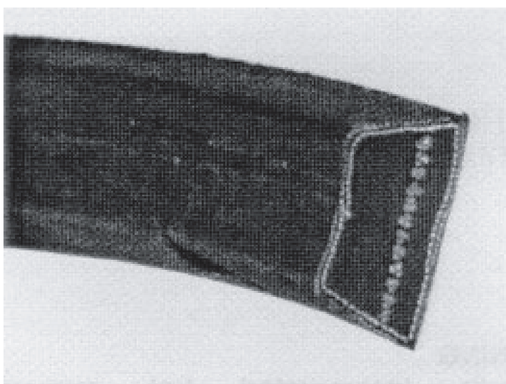

Snub Break

CAUSE

Cover wear indicates slip. Clean break reveals sudden snap.

PREVENTION

Maintain proper tension on the drive.

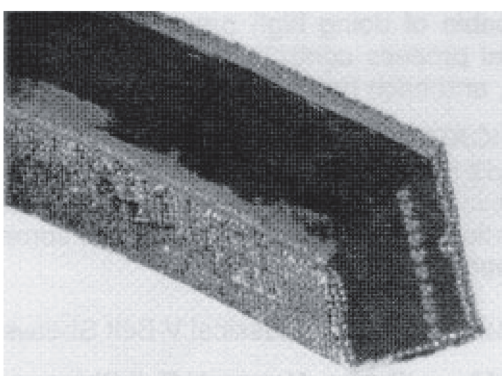

Distorted Belt

CAUSE

Breakdown of adhesion or broken cords.

PREVENTION

Do not pry belts on drives. Check sheaves for recommended diameters.


Abrasion

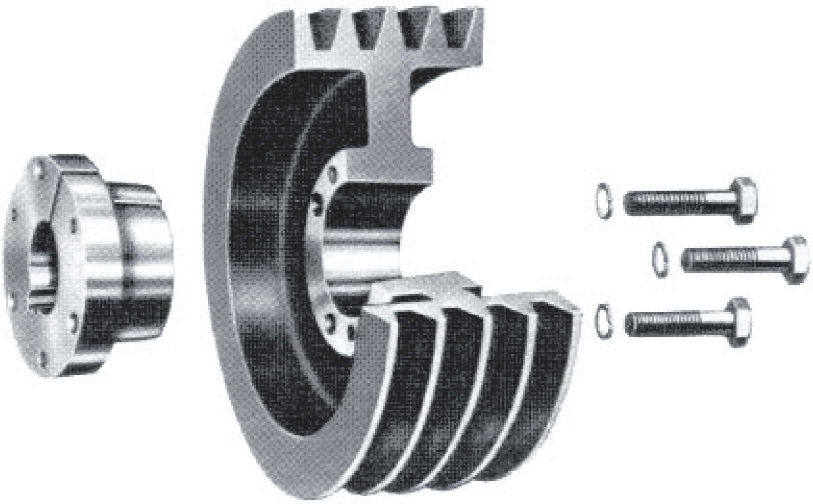
CAUSE

Foreign material and rust in sheaves wore away sidewalls, letting belt drop to bottom of groove.

PREVENTION

Dust guards help protect against abrasion. Tension must be maintained in dusty atmospheres.

SURE-GRIP® SHEAVE FEATURES



Wood's sheaves are constructed of fine grain, high tensile cast iron, and have been carefully engineered to assure maximum performance over a long life span. Behind each sheave is one of the most extensive engineering design and testing programs in the industry.

DESIGN INTEGRITY

TB Wood's incorporated has been a leading supplier of cast iron pulleys, v-belt sheaves, synchronous belt sprockets and Sure-Grip mounting bushings since the inception of these products. We are committed to the continual improvement of our standard products and special or MTO products through design, materials and quality enhancements. For example, new product designs are typically computer generated and then verified using finite element analysis before CAD drawings are made. This enables Wood's to quickly and accurately quote on any special needs, and to relay the tool paths for new designs quickly from engineering to the shop floor.

FOUNDRY PROCESSES

TB Wood's Incorporated has a modern state-of-the-art foundry in Chambersburg, PA where cast iron and ductile iron castings are produced. This captive foundry operation not only gives Wood's the control needed to obtain standard high quality castings as they are required, but also enables them to produce any special requirements in a minimal amount of time.

MACHINING

TB Wood's Incorporated has numerous machining facilities throughout North America. Each is equipped with modern CNC equipment and capable of doing high precision machining. Statistical process controls are in place in each location, and each has been ISO-9000 certified.

SPECIFICATIONS

TB Wood's products are manufactured to conform to or exceed recognized industry standard specifications. The following is a listing of some of these specs.

ANSI/RMA	IP-20	Classical V-Belt Sheaves
ANSI/RMA	IP-22	Narrow V-Belt Sheaves
ANSI/RMA	IP-24	Synchronous Sprockets
MPTA	QD-1	QD Bushing Guideline
MPTA	SPB	Pulley Balance
MPTA	SAS	V-Belt Sheave Arm Stress
MPTA	SF	Pulley Surface Finish

TB Wood's

Powering Your Success

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Authorized Distributors Worldwide

VBD-IM 10/01-15M

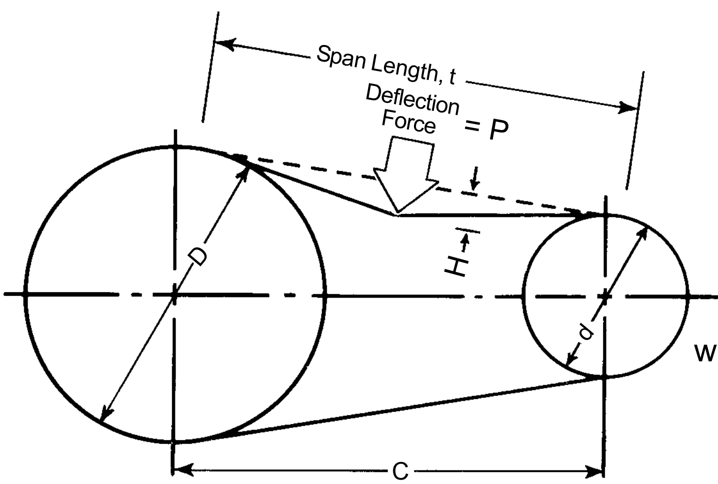
LAKESIDE

Water Purification Since 1928

Lakeside Equipment Corporation

1022 E. Devon Avenue ● Bartlett, IL 60103-8448 ● 630-837-5640 ● FAX: 630-837-5647 ● E-mail: sales @lakeside-equipment.com

V-BELT TIGHTENING INFORMATION



Deflection height
h = 1/64" per inch of span

$$t = \sqrt{C^2 - \left(\frac{D-d}{2}\right)^2}$$

$$H = \frac{t}{64}$$

where t = Span length, inches
C = Center distance, inches
D = Larger sheave diameter, inches
d = Smaller sheave diameter, inches

Figure 2

LAKESIDE EQUIPMENT CORPORATION
RWJ:bm 4-12-85

LAKESIDE
Water Purification Since 1928

SCI-218

Lakeside Equipment Corporation

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SPIRAFLO CLARIFIER

OPERATING INSTRUCTIONS

GENERAL

The purpose of the Spiraflo is to remove sludge from the waste. The operator can help by:

1. Seeing that the weirs are kept level.
2. Adjusting the pumps for even flow to and from the tank.
3. Remove sludge from the bottom at a constant rate and keep it from building up and spilling over the effluent weir.

SCRAPER MECHANISM

The scrapers should run continuously. Once each day the operator should verify that the scraper is rotating. This can be done visually by observing the movement of the drive shaft.

SLUDGE REMOVAL — PRIMARY CLARIFIER

The sludge from a primary Spiraflo should be pumped to the digester every hour for 1-1/2 to 2 minutes by means of a time clock controlled sludge pump. The sludge scraper squeegees should clear the floor by approximately 1/4". The clarifier should be kept free of sludge for the best performance.

SLUDGE REMOVAL — FINAL CLARIFIER — TRICKLING FILTER PLANT

If this is a final tank on a trickling filter plant, the sludge should be returned to the primary clarifier for resettling, either constantly or every hour or two, by time clock control.

SLUDGE REMOVAL — FINAL CLARIFIER — ACTIVATED SLUDGE PROCESS

The sludge pumps should be adjusted to withdraw sludge continuously from the clarifier floor. The solids content of the withdrawn sludge should remain constant. The color and density of the sludge should remain uniform. The operator should observe the sludge daily to be aware of any changes.

SCUM REMOVAL

The skirt around the outer periphery of the tank serves as a baffle and forms a race to trap scum and prevent it from being discharged over the effluent weirs. A 10" slotted scum pipe is provided in the race for removal of this scum.

On larger diameter clarifiers one or two skimmers are provided to break up the scum should it build up enough to bridge across the width of the race.

Normally the scum pipe would be set for continuous automatic removal of scum. Sometimes it is possible to remove the scum on a periodic basis during the day. Once or twice each day, or as required, the operator should rotate the scum pipe to remove the scum on the downstream side of the pipe. Any accumulation of scum can be moved into the scum pipe at this time.

MAINTENANCE & HOUSEKEEPING

For maintenance of the mechanical portion of the clarifier see "Care and Lubrication of Mechanized Clarifiers" in the Lakeside service book.

For good housekeeping we recommend the skirt, concrete wall and weir trough be cleaned at least once a month. A high pressure hose is a good method of doing this but in some cases a good stiff long handled brush may do a better job. This brush should be narrow enough to fit in the weir trough.

SHEAR PIN

All Spiraflo Clarifiers are equipped with shear pins as protection against overloads that could damage the motor, gear reducer or sludge scraper arms. This usually occurs when a rock or some other object gets wedged under the scraper arm. At this time the thin neck of the shear pin breaks. The motor and gear reducer continue to operate but the larger gear and sludge scraper arms stop rotating.

The operator should check the drive shaft at water level daily to make sure it is rotation. A 2" projection welded on the shaft above the water level is provided to assist in making this visual inspection.

If a shear pin is broken, first determine the cause and make the correction. Then remove the broken shear pin and replace with one of the three supplied with the equipment. Additional shear pins can be purchased from Lakeside.

If it is necessary to empty the tank to remove an obstruction, etc. it is also a good time to inspect all submerged parts, not normally accessible, for any indication of wear or other problem.

PROBLEMS

Spiraflo clarifiers are designed to provide years of trouble free operator when properly operated and cared for as outlined in the service book. If a mechanical problem or process problem develops which is not covered in the service book, contact your local Lakeside representative or our Bartlett office. The addresses and telephone numbers are on the title sheet in the front of the service book.

LAKESIDE
Water Purification Since 1928

SCI -211

Lakeside Equipment Corporation

1022 E. Devon Avenue ● Bartlett, IL 60103-8448 ● 630-837-5640 ● FAX: 630-837-5647 ● E-mail: sales @lakeside-equipment.com

TROUBLESHOOTING GUIDE

FOR CLARIFIERS

PROBLEM	POSSIBLE CAUSES	REMEDY
Drive motor stopped.	Scrapers overloaded by some obstruction, excessive amount of settled solids, debris or some solid substance lodged under squeegee plates.	Drain tank. Remove obstruction. Arm may spring forward when wedged obstruction is loosened. BE CAREFUL!
	or	
	Inadequate clearance between floor and scrapers.	Check upper column bearing and scraper arms to column connection.
	Note: If equipped with an emergency trip bar, the shear has sheared and the motor has turned off automatically.	After clearing obstruction, etc., install new shear pin and reset trip mechanism and alarm circuit.
	Note: If equipped with torque control, the unit has reached its maximum overload condition and has turned the motor off automatically	No reset required after clearing obstruction, etc. Only to reset alarm circuit.
	Electrical.	Check starter, heater elements, wiring, etc.
	Defective motor.	Replace motor.

PROBLEM	**POSSIBLE CAUSES**	**REMEDY**
Center Column (scraper arms) not turning. Motor continues to run.	Shear pin has sheared from overloading by scrapers being held by some obstruction.	Drain tank. Remove obstruction. Arm may spring forward when obstruction is loosened. BE CAREFUL!
	or	
	Inadequate clearance between floor and scrapers.	Check upper column bearing and scraper arms to column connection.
	Note: If equipped with torque control, the shear pin shearing indicates that this unit has malfunctioned.	Notify Lakeside of this and receive special instructions.
Overload alarm or light actuates on and off intermittently.	Note: This condition possible only when equipped with torque control.	
	Scraper arms overloaded periodically by some obstruction.	Monitor operation for a time. The arms may clear themselves. If condition persists or worsens, check arms and remove obstruction.
	Inadequate sludge drawoff.	Increase amount or sequence of drawoff.
Noisy motor.	Bad motor bearing.	Replace motor.
	Cooling fan striking end cover.	Remove cover to straighten or reorient so fan clears.
Motor vibrates.	Improper shaft connection with reducer input shaft. Key may be in wedged position or oversize.	Remove motor, check connection, key, etc. When reinstalling, do not force back on. Shaft should have a medium to light push fit.

If problem persists, give Lakeside a call.

LAKESIDE EQUIPMENT CORPORATION
RJ/bm 6/29/87

LAKESIDE

Water Purification Since 1928

SCI-156

Lakeside Equipment Corporation

1022 E. Devon Avenue ● Bartlett, IL 60103-8448 ● 630-837-5640 ● FAX: 630-837-5647 ● E-mail: sales @lakeside-equipment.com

CARE & LUBRICATION OF MECHANIZED CLARIFIERS

The Lakeside Clarifier will give excellent service provided it is given a reasonable amount of care. We recommend that all painted surfaces above and below the waterline be inspected yearly and any spots showing rust be wire brushed and touched up or the whole unit repainted if necessary. Good paints are offered by the Tnemec or Kopper Companies.

The drive shaft should be checked daily to confirm the scraper is operating. On Clarifiers with the drive shaft and scraper supported by the bridge, an indicator is welded to the drive shaft for this purpose. Refer to "Clarifier Operating Instructions" for other items of care to check.

LUBRICATION

Gear Reducer

Winsmith Reducer: Size ____________________ Approx. Oil Capacity ______________ Qts.
(See below)

The reducer should be kept filled with the required lubricant. See the "Lubrication Instructions" drawing and the manufacturer's instructions for worm gear reducers. Fill to level plug(s). Note: Double reduction box has two level plugs and the triple reduction box has three level plugs.

Drive Motor

Some drive motors do not require lubrication, others only require infrequent lubrication. Refer to the tag or leaflet furnished with the motor or the bulletin included in the Lakeside service book. **DO NOT OVER-LUBRICATE** the electric motor.

Gears

The large spur gear under the walkway at the top of the main driving shaft and the pinion gear driving it should have Extra Heavy Gear Shield lubricant applied on the teeth every 3 months. A one pound spray can of this lubricant was sent along with the shipment of equipment.

Bearings

The large bearing at the top of the main shaft turns very slowly: 1/10 rpm of less depending on the drive. The pinion will be moving one rpm or less.

On most drives, grease fittings are provided in the reducer mounting plate for the pinion bearing and for the large bearing. On some drives the fitting for the large bearing rotates with the gear. The "Lubrication Instruction" drawing shows which type you have. These bearings should be greased once a month. Be sure they are full of grease by a visual inspection. Over greasing will not damage or shorten the life of these bearings.

On larger Clarifiers the main bearing and spur gear are made as one unit, called a turntable. This has several greasing points. The submerged Gatke bearing needs NO lubrication.

Shear Pin

All Lakeside Clarifiers are furnished with a shear pin. This pin should be removed once each year and cleaned of any foreign material or rust. It should be coated with a rust preventative such as Never-Seez or a light coat of Extra Heavy Gear Shield before replacing.

LUBRICATION CHART

LUBRICATION POINTS	LUBRICATION DATES	LUBRICANT
Bearings and/or Turntable	First working day each month.	NLGI No. 2 Lithium Base Grease
Gear Reducer Check Oil Level: Change Oil: Reducer Bearings: (when fittings are provided)	 Weekly March, July & Nov. 1st First working day of each month	See Lakeside Lubrication Instructions drawing and manufacturer's instructions. NLGI No. 2 Lithium Base Grease
Drive Motor	March & Nov. 1st	Check Manufacturer's Instructions
Gears	March, June, Sept. & Dec. 1st	Extra Heavy Gear Shield
Shear Pin	March 1st	Never-Seez

Refer to the "Lubrication Instructions" drawing which is included in the Lakeside service book and with the equipment drawings.

LAKESIDE EQUIPMENT CORPORATION
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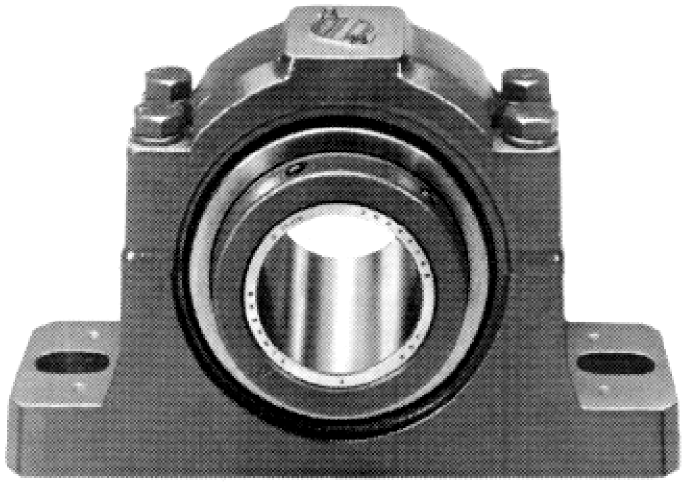
R-SCI-136

DODGE® INSTRUCTION MANUAL for

RAD-910

Type K and DOUBLE-INTERLOCK® Pillow Blocks & S-1 Units



FITTING OR REPLACING A UNIT IN A PILLOW BLOCK

WARNING

To ensure that drive is not unexpectedly started, turn off and lock out or tag power source before proceeding. Failure to observe these precautions could result in bodily injury.

1. Up to 5" bore, match marks have been stamped on the mating faces of the cap and base of each outer housing. Over 5" bore match mark cap and base of each outer housing before removing cap. When reassembling pillow block make sure match marks on cap and base match.
2. Lubricate bearing seat on the cap and on the base of the outer housing with an anti-seize compound.
3. Fit each unit to its outer housing before carrying out step 7. Place the unit in the pillow block base and install cap. Tighten cap bolts to specified torque in Table 1.

Table 1 — Cap Bolt Torque (Non-Expansion & Expansion)

Bore Size (In.)	2 Bolt Base		4 Bolt Base	
	Bolt Size	Torque Ft.-Lbs.	Bolt Size	Torque Ft.-Lbs.
1 3/16-1 11/16	3/8-16	24-30	—	—
1 15/16-2 3/16	7/16-14	40-50	—	—
2 7/16-2 1/2	1/2-13	60-75	1/2-13	60-75
2 15/16-3	5/8-11	120-150	5/8-11	120-150
3 7/16-3 1/2	3/4-10	208-260	3/4-10	208-260
3 15/16-4	—	—	3/4-10	208-260
4 7/16-4 1/2	—	—	7/8-9	344-430
4 15/16-5	—	—	1-8	512-640
5 7/16-6	—	—	1-8	250
6 7/16-7	—	—	1 1/8-7	350

4. Add or remove shims between cap and base as required to obtain “snug” fit of unit in outer housing with cap bolts tightened to specified torque in Table 1.

WARNING: Because of the possible danger to persons(s) or property from accidents which may result from the improper use of products, it is important that correct procedures be followed. Products must be used in accordance with the engineering information specified in the catalog. Proper installation, maintenance and operation procedures must be observed. The instructions in the instruction manuals must be followed. Inspections should be made as necessary to assure safe operation under prevailing conditions. Proper guards and other suitable safety devices or procedures as may be desirable or as may be specified in safety codes should be provided, and are neither provided by Rockwell Automation nor are the responsibility of Rockwell Automation. This unit and its associated equipment must be installed, adjusted and maintained by qualified personnel who are familiar with the construction and operation of all equipment in the system and the potential hazards involved, when risk to persons or property may be involved, a holding device must be an integral part of the driven equipment beyond the speed reducer output shaft.

DODGE / P.O. Box 499 / 6040 Ponders Court / Greenville, S.C. 29602-0499 / (864) 297-4800
Visit us on the Internet at http://www.industry.net/dodge.rockwell.automation
or contact us via E-Mail at adv@dodge.ra.rockwell.com.

Rockwell Automation Dodge

Printed in U.S.A. Instruction Manual 499798 497 2M-K

5. Check fit by prying against lubrication stud in unit through the lubrication hole in housing cap with a screwdriver or small pinch bar depending upon the size of the pillow blocks.
6. The “snug” fit becomes a matter of judgment. A “loose or sloppy” fit may allow a unit mount to move in its outer housing thus wearing the mating surfaces. Too “tight” a fit will not allow the unit to move and compensate for misalignment and for shaft deflection caused by belt pull and dead weight.
7. Install bearings per installation instruction on following pages.

TABLE 2

Set Screw Torque	
Size	**In.-Lbs.**
5/16	165
3/8	290
1/2	620
5/8	1325
3/4	2150
7/8	5130

INSTALLATION INSTRUCTIONS (Medium Speed, Normal & Heavy Load)*

WARNING
To ensure that drive is not unexpectedly started, turn off and lock out or tag power source before proceeding. Failure to observe these precautions could result in bodily injury.

1. Clean shaft and bore of bearing. Lubricate with light oil.
2. Slip bearing in position noting step 3.
3. **Expansion Bearing**: Loosen cap bolts in outer housing a little so inner unit is free to align in outer housing. Outer housing shims provide a proper fit and must not be removed. Bolt outer housing to support. For heavy loads, use grade 8 base bolts.* Expansion type outer housings should be located so inner unit can move freely in either direction.

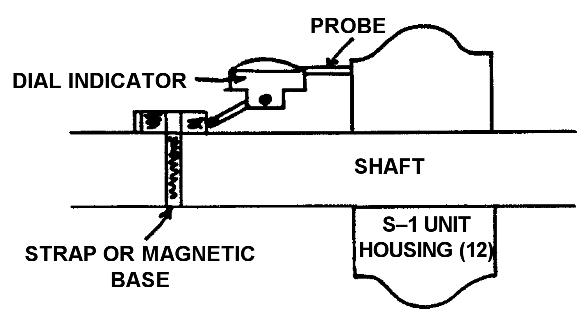
   Non-Expansion Bearings: Loosen cap bolts in outer housing a little so inner unit is free to align in outer housing. The hold-down bolts should be loose in the bolt holes. If the bolts are tight in bolt holes, the unit should be moved slightly on the shaft to provide looseness. This will help prevent preloading or inducing an initial thrust on bearings. Tighten nuts on hold-down bolts. For heavy loads, use grade 8 base bolts.*
4. Tighten set screws to the torque values shown on Table 2.
5. Turn shaft several revolutions, or run shaft, if feasible and safe, to allow alignment of inserts in their respective housings. Retighten cap bolts of both the expansion and the non-expansion outer housing to recommended torque in Table 1. Outer housing shims provide a proper fit and must not be removed.
6. **The effort required to turn the shaft should be the same before and after bolting bearings to the support.**

INSTALLATION INSTRUCTIONS (High Speed and/or Light Load)

Use this procedure for mounting pillow block bearings on horizontal or vertical applications, operating at high speed (above 75% of rated speed) or under light load (less than 2% of Dynamic Capacity).

WARNING
To ensure that drive is not unexpectedly started, turn off and lock out or tag power source before proceeding. Failure to observe these precautions could result in bodily injury.

1. Shaft must be clean, free of burrs and lubricated. File nicks from housing bases.
2. Loosen setscrews (52) in collar (50) and slide bearings on shaft. If force is necessary, tap inner race **only** with a light drift. For vertical applications, locate adjusting nut (24) on bearing so nut faces upward.
3. Loosen housing cap bolt nuts one (1) turn.
4. Position expansion (floating) pillow block on mounting surface and tighten base hold-down bolts.
5. Position non-expansion (fixed) pillow block in correct relation to shaft and mounting surface. Tighten base holddown bolts, then torque setscrews (52) in collar per Table 2.
6. Mount a dial indicator on the shaft near the non-expansion (fixed) bearing. Place the indicator probe so that it contacts the machined surface of the S-1 Unit Housing (12) perpendicular to that surface. See sketch below. Only one face of the S-1 Unit is a machined face.



7. Zero the indicator and sweep the machined face 3600, noting the total indicator turnout (TIR).
8. If the TIR is less than or equal to the value shown on Table 3, tighten the housing cap bolts per Table 1.
9. If the TIR is greater than shown on Table 3, gently tap the machined face of the 5-1 housing until the TIR is less than or equal to the value shown on Table 3. Then torque the housing cap bolts per Table 1. Sweep machined faces again to verify that the TIR is still less than or equal to the value shown on Table 3.
10. The non-expansion (fixed) bearing is now installed. Move to the expansion (floating) bearing.
11. Locate expansion unit in center of its axial travel or at extreme if maximum expansion is required (do not

* Defined in the DODGE Engineering Catalog

preload stop pin) and torque collar setscrews (52) per Table 2.

12. Do not install external grease fittings until completion of final steps below.
13. Torque setscrews of expansion unit (Table 2).
14. Repeat Steps *6,* 7, 8 and 9 for the expansion bearing.
15. The expansion (floating) bearing is now installed.

TABLE 3

Total Indicator Run-out (TIR)	
Shaft Size (Inches)	**TIR (Inches)**
1 3/16 — 1 7/16	.0030
1 1/2 — 1 11/16	.0035
1 3/4 — 2	.0040
2 3/16	.0040
2 1/4 — 2 1/2	.0045
2 11/16 — 3	.0055
3 3/16 — 3 1/2	.0065
3 15/16 — 4	.0070
4 7/16 — 4 1/2	.0080
4 15/16 — 5	.0085

LUBRICATION INSTRUCTIONS

Storage or Special Shutdown — If exposed to wet or dusty conditions or to corrosive vapors, extra protection is necessary. Add grease until it shows at the seals; rotate the bearing to distribute grease; cover the bearing. After storage or idle period, add a little fresh grease before running. During long idle periods, rotate shaft at least once a month.

High Speed Operation — In the higher speed ranges too much grease will cause overheating. The amount of grease that the bearing will take for a particular high speed application can only be determined by experience — see “Operating Temperature” below. If excess grease in the bearing causes overheating, it will be necessary to remove grease fitting (also drain plug when furnished) to permit excess grease to escape. The bearing has been greased at the factory and is ready to run. When establishing a relubrication schedule, note that a small amount of grease at frequent intervals is preferable to a large amount at infrequent intervals.

Operation in Presence of Dust, Water or Corrosive Vapors — Under these conditions the bearing should contain as much grease as speed will permit, since a full bearing with consequent slight leakage is the best protection against entrance of foreign material. In the higher speed ranges too much grease will cause overheating — see “High Speed Operation” above. In the lower speed ranges it is advisable to add extra grease to a new bearing before putting into operation. Bearings should be greased as often as necessary (daily if required) to maintain a slight leakage at the seals.

Average Operation — This bearing has been greased at the factory and is ready to run. The following table is a general guide for relubrication. However, certain conditions may require a change of lubricating periods as dictated by experience. See “High Speed Operation” and “Operation in Presence of Dust, Water or Corrosive Vapors” above.

Operating Temperature — Abnormal bearing temperature may indicate faulty lubrication. Normal temperature may range from “cool to warm to the touch” up to a point “too hot to touch for more than a few seconds,” depending on bearing size and speed, and surrounding conditions. Unusually high temperature accompanied by excessive leakage of grease indicates too much grease. High temperature with no grease showing at the seals, particularly if the bearing seems noisy, usually indicates too little grease. Normal temperature and slight showing of grease at the seals indicate proper lubrication.

Lubrication Guide
Read Preceding Paragraphs Before Establishing Lubrication Schedule.

Hours Run per Day	Suggested Lubrication Period In Weeks				
	1 to 250 RPM	**251 to 500 RPM**	**501 to 750 RPM**	**751 to 1000 RPM**	**1001 to 1500 RPM**
8	12	12	10	7	5
16	12	7	5	4	2
24	10	5	3	2	1

Kind of Grease — Many ordinary cup greases will disintegrate at speeds far below those at which DODGE bearings will operate successfully if proper grease is used. DODGE bearings have been lubricated at the factory with No. 2 consistency lithium-base grease which is suitable for normal operating conditions. Relubricate with lithium-base grease or a grease which is compatible with original lubricant and suitable for roller bearing service. In unusual or doubtful cases the recommendation of a reputable grease manufacturer should be secured.

Special Operating Conditions — Refer acid, chemical, extreme or other special operating conditions to DODGE, Greenville, SC 29602.

Replacement Parts (Type K and DOUBLE-INTERLOCK) Bearings

Refer-ence	Name of Part	Req'd. for One Ass'y. N.E. Pil. Blk.	Exp. Pil. Blk.	S-1 Unit	Part Numbers for Various Shaft Sizes 1 3/16, 1 1/4	1 3/8, 1 7/8	1 1/2, 1 5/8, 1 11/16	1 3/4, 1 7/8, 1 15/16, 2	2 3/16	2 1/4, 2 7/16, 2 1/2	2 11/16, 2 3/4, 2 15/16, 3
2	Pillow Block Housing										
	2 bolt Non-Expansion (K/DI) *	1	—	—	056130	056132	056134	056136	056138	056140	056142
	2 bolt Expansion (K/DI) *	—	1	—	056100	056102	0561041	056106	056108	056110	056112
	4 bolt Non-Expansion (K/DI) *	1	—	—	—	—	—	—	—	060745	060747
	4 bolt Expansion (K/DI)*	—	1	—	—	—	—	—	—	060746	060748
4	Lubrication cover/Nameplate										
	K/DI Expansion	—	—	—	405942	405942	405942	405942	405942	405942	405942
	K/DI Non-Expansion	1	—	—	405941	405941	405941	405941	405941	405941	405941
6	Lubrication cover Screw	2	2	—	405943	405943	405943	405943	405943	405943	405943
†	Housing Shim										
	.005" Thick	2	2	—	427890	427893	427896	427899	427902	427905	427908
	.007" Thick	2	2	—	427891	427894	427897	427900	427903	427906	427909
12	S-1 Unit Housing (only)	1	1	1	056120	060430	060431	060432	060433	060434	060435
14	Cup	2	2	2	390748	390751	390755	390760	390762	390766	390771
16	Lubrication Fitting	1	1	1	405015	405015	405015	405015	405015	405015	405015
18	Lubrication Stud	1	1	1	—	405010	405010	405010	405010	405010	405010
22	Adjustment Shim Pack	1	1	1	391101	391102	391103	391104	391105	391106	391107
	Snap Ring	1	1	1	401002	401004	401008	401012	401016	401020	401024
	Seal, Single Lip	2	2	2	061355	061356	061357	061358	061359	061360	061361
50	Drive Collar (65° Set										
	Screw Angle) ●	+	+	+	060944	040050	040051	040052	040053	040054	040055
52	Drive collar Screw ▲	‡	‡	‡	400054	400058	400058	400094	400094	400094	400150

Refer-ence	Name of Part	Req'd. for One Ass'y. N.E. Pil. Blk.	Exp. Pil. Blk.	S-1 Unit	Part Numbers for Various Shaft Sizes 3 3/16, 3 1/4 3 7/16, 3 1/2	3 15/16, 4	4 7/16, 41/2	4 15/16, 5	5 7/16	5 15/16, 6	6 7/16, 6 1/2	6 15/16, 7
2	Pillow Block Housing											
	2 bolt Non-Expansion (K/DI) *	1	—	—	056144	—	—	—	—	—	—	—
	2 bolt Expansion (K/DI)*	—	1	—	056114	—	—	—	—	—	—	—
	4 bolt Non-Expansion (K/DI) *	1	—	—	060749	060751	060753	060755	060579	060579	060583	060583
	4 bolt Expansion (K/DI) *	—	1	—	060750	060752	060754	060756	060578	060578	060582	060582
4	Lubrication Cover/Nameplate											
	K/DI - Exp.	—	—	—	405942	405942	405942	405942	405043	405043	405043	405043
	K/DI - Non-Exp.	1	1	—	405941	405941	405941	405941	405043	405043	405043	405043
6	Lubrication Cover Screw	2	2	—	405943	405943	405943	405943	—	—	—	—
†	Housing Shim											
	.005" Thick	2	2	—	427991	427914	427917	427920	—	—	—	—
	.007" Thick	2	2	—	427912	427915	427918	427921	427176	427176	427177	427177
12	S-1 Unit Housing (only)	1	1	1	060436	060437	060438	060439	000440	000440	000441	000441
14	Cup	2	2	2	390776	390779	390782	390785	391826	391826	391829	391829
16	Lubrication Fitting	1	1	1	405015	405015	405015	405015	405015	405015	405015	405015
18	Lubrication Stud	1	1	1	405010	405018	405018	405018	405018	405018	405018	405018
24	Adjustment Nut	1	1	1	060490	060491	060492	060493	—	—	—	
25	Adjustment Nut Screw	1	1	1	400530	400530	400530	400530	—	—	—	—
30	End Plate	1	1	1	—	—	—	—	060046	060046	060047	060047
32	End Plate Shim Pack											
	.002" Thick	2	2	2	—	—	—	—	427065	427065	427068	427068
	.005" Thick	2	2	2	—	—	—	—	427064	427064	427067	427067
	.010" Thick	2	2	2	—	—	—	—	427063	427063	427066	427066
	.020" Thick	2	2	2	—	—	—	—	427061	427061	427062	427062
34	End Plate Screw	8	8	8	—	—	—	—	411576	411576	411577	411577
36	Lockwasher	8	8	8	—	—	—	—	419010	419010	419011	419011
40	Seal, Single Lip	2	2	2	061362	061363	061364	061365	061366	061366	061367	061367
50	Drive Collar (65° Set											
	Screw Angle) ●	2	2	2	060945	060946	060947	040059	043384	043384	043385	043385
52	Drive Collar Screw ▲	4	4	4	400154	400186	400186	400190	400238	400234	400252	400251

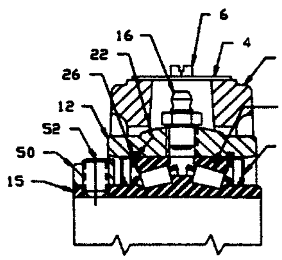
Refer-ence	BRG. Type	Name of Part	Req'd.	Part Numbers for Various Shaft Sizes 1 3/16	1 1/4	1 3/8	1 7/16	1 1/2	1 5/8	1 11/16	1 3/4	1 7/8
	Type K		1	389760	389761	389762	389763	389764	389765	389766	389767	—
15	DI	Cone	1	389782	389783	389784	389785	389786	389787	389788	389789	389790
		Shaft Size →		1 15/16	2	2 3/16	2 1/4	2 7/16	2 1/2	2 11/16	2 3/4	2 15/16
	Type K		1	389768	389769	389770	389771	389772	389773	389774	389775	389776
15	DI	Cone	1	389791	389792	389793	389794	389795	389796	389797	389798	389799
		Shaft Size →		3	3 3/16	3 1/4	3 7/16	3 1/2	3 15/16	4	4 7/16	4 1/2
	Type K		1	389777	389778	389779	389780	389781	—	—	—	
15	DI	Cone	1	389800	389801	389802	389803	389804	389805	389806	389807	389808
		Shaft Size →		4 15/16	5	5 7/16	5 15/16	6	6 7/16	6 1/2	6 15/16	7
15	DI	Cone	¶	389809	389810	391826	391826	391826	391828	391828	391828	391828
20	DI	—	—	—	—	059960	059961	059962	059963	059964	059965	059966

Shaft Tolerances:
Up to 1 1/2" + .0000 — .0005   4 7/16" to 6" + .0000 — .0015
1 5/8" to 4" + .0000 — .0010   6 7/16" to 7" + .0000 — .0020

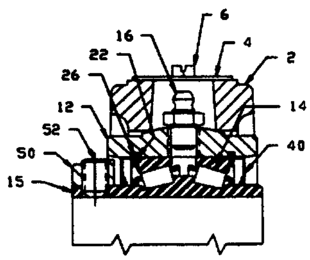
† Not shown on drawing
* K - Type K; DI - DOUBLE-INTERLOCK
+ 2 required on DOUBLE-INTERLOCK; 1 required on Type K
‡ 4 required on DOUBLE-INTERLOCK; 2 required on Type K
¶ 1 required on sizes 415/16 & 5; 2 required on size 5 7/16 and larger
● Includes part listed below marked ▲

Replacement Parts for Type K and DOUBLE-INTERLOCK Bearings

1 3/16" & 1 1/4" Type K

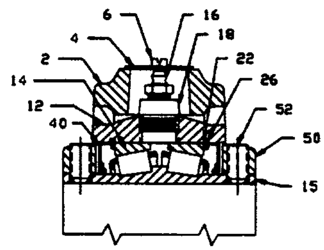


EXPANSION TYPE



NON-EXPANSION TYPE

1 3/16" thru 3" DOUBLE-INTERLOCK



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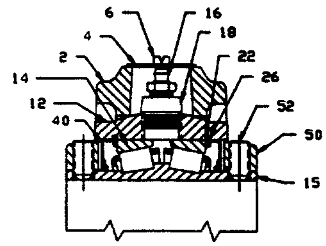
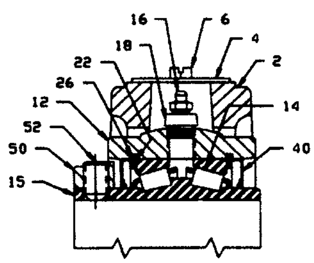


NON-EXPANSION TYPE

1 3/8" thru 3" Type K



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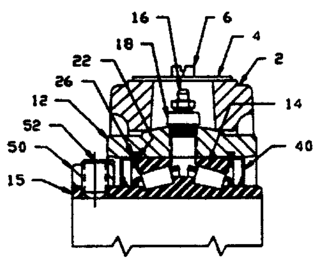
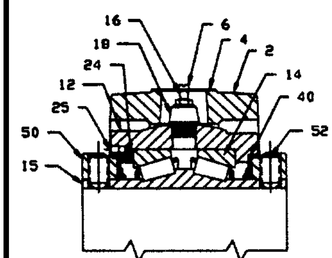


NON-EXPANSION TYPE

3 3/16" thru 5" DOUBLE-INTERLOCK



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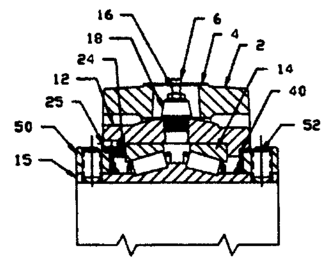

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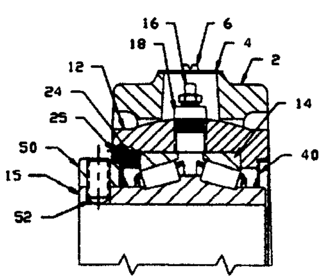
3 3/16" thru 3 15/16" Type K



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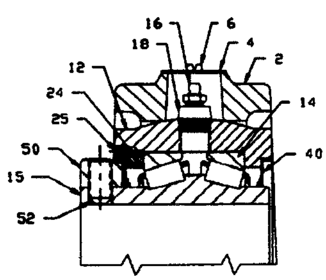
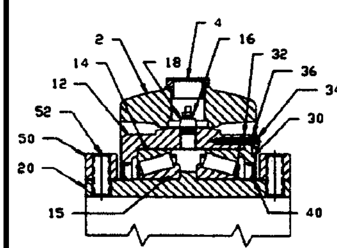


NON-EXPANSION TYPE

5 7/16" thru 7" DOUBLE-INTERLOCK



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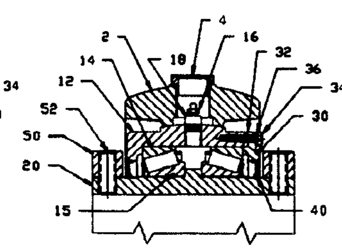


NON-EXPANSION TYPE

DODGE
DIVISION OF RELIANCE ELECTRIC

RECOMMENDATIONS FOR LONG TERM STORAGE OF MOUNTED BEARINGS

GENERAL

1. These suggestions are submitted for guidance in securing satisfactory and trouble free operation following extended storage and are not to be regarded as extension of standard warranty coverage.

2. Store in heated and dry area. Temperature during storage should not exceed 150°F maximum or 50°F minimum and a maximum relative humidity of 60%.

3. Periodic inspection (3 month intervals or less) should be made of all unpainted exposed parts for corrosion from humidity or atmospheric contaminants.

4. Keep bearings covered with plastic cover but do not seal, as this traps moisture.

5. Store bearings off the floor to reduce moisture pick up.

ANTI-FRICTION BEARINGS

1. Bearings are to be filled with grease until it purges at the seals.

2. Ball and roller (anti-friction) bearings are to be rotated manually every six months and greased in accordance with the Instruction Manual.

START-UP

1. Purge excess lubricant installed at beginning of storage.

2. Inspect for corrosion and remove, if necessary.

3. Lubricate according to instructions in the manual supplied with the bearings.

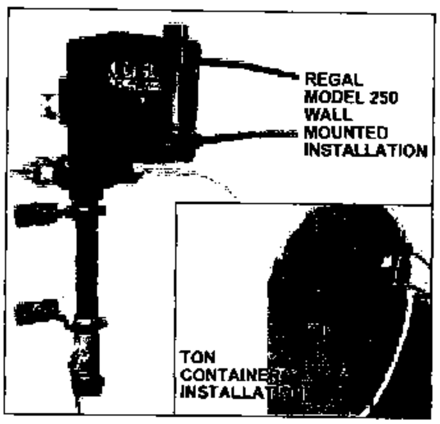
4. After start-up, check bearing temperatures for indications of excessive heating indicating lubricant contamination or oxidation.

5. For detailed handling, installation and maintenance, see manuals or information furnished for individual units.

MISHAWAKA, INDIANA 46544, / AREA CODE 219-256-1551 / CABLE ADDRESS DODMANCOR

REGAL GAS CHLORINATOR

The REGAL Model 250 Chlorinator is a vacuum-operated solution feed type, designed for mounting on wall manifold or ton container when continuous chlorine feed rates up to 500 lbs. per 24 hours (10 kg/hr) is needed. The Model 250 may also be mounted directly on the valve of a 100 or 150 lb. chlorine cylinder and operated up to 500 lbs./24 hrs. for very short periods. The chlorine flow rate is manually adjusted. The chlorinator clamps directly to a chlorine header valve on the chlorine supply manifold or directly onto the REGAL TAY-200 ton container adaptor by means of a positive, heavy-duty yoke clamp. A highly efficient, water operated, vacuum-producing ejector is close coupled with the chlorine solution diffuser. The assembly contains a back flow check valve. Chlorine gas flow rate is regulated by a spring opposed diaphragm regulator which is also the safety shut-off valve.



FEATURES

The REGAL Model 250 incorporates the very best available materials with the latest technology in design and construction, to reduce maintenance, simplify construction, and improve operation.

APPLICATION

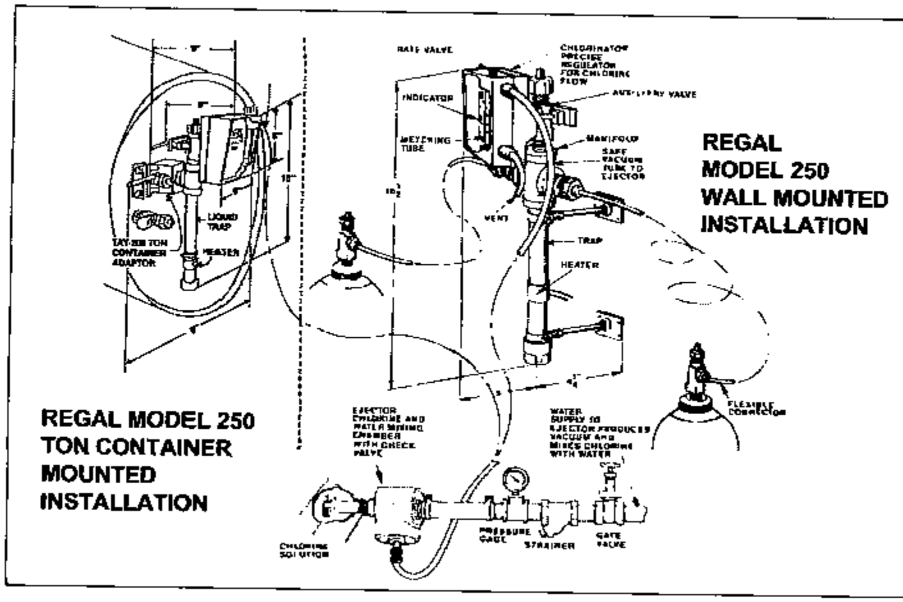
The Model 250 is designed to handle the vast majority of water treatment requirements.

CAPACITIES

Dual scale metering tube with maximum capacity of 500 pounds per 24 hrs. of chlorine gas with corresponding metric scales of 10 kg per hr. Minimum feed rate is 1/20th of maximum.

FLOW RATE ADJUSTMENT

Manually adjustable by means of a flow rate control valve located at the top of the flow meter. Flow rate is then regulated by a special spring-opposed diaphragm operated valve. The system is automatic. It will go off and on as the ejector water is turned off and on and will always return to the pre-set flow rate.



EJECTOR REQUIREMENTS

The standard ejector is designed to withstand static back pressures in excess of 200 psig (14.1 kg/cm²). However, due to the potential for "water hammer" in high pressure on-off systems and special booster pump considerations, it is recommended that a factory representative, or Chlorinators Incorporated be consulted regarding installation details on systems over 100 psig (7 kg/cm²).

The amount of water required to operate the ejector depends upon the chlorine feed rate, water back pressure and water supply pressure available. Generally, the higher the chlorine flow and higher back pressure the greater the water flow is needed.

OPERATION

The chlorinator is clamped on the chlorine cylinder valve. The ejector assembly is normally attached to the solution diffuser at the point of injection (it may be wall mounted, but this is not recommended). A vacuum line connects these two units.

Water, under pressure, is forced through the ejector nozzle which creates a strong vacuum in the ejector body. This pulls gas into the ejector through a special back-flow check valve and then into the nozzle outlet. The gas mixes with the ejector water and is discharged through the diffuser into the water being treated.

The ejector vacuum is transmitted back to the chlorinator through the vacuum line, then through the rate valve and the flow meter and to the back of the diaphragm. With sufficient vacuum, the diaphragm moves backward, opening the spring loaded inlet regulating valve to allow chlorine to enter from the cylinder.

The chlorine passes through the flow rate indicating meter, flow rate adjusting valve and to the ejector.

SPECIFICATIONS

The chlorinator shall be a REGAL Model 250 manufactured by Chlorinators Incorporated, Stuart, Florida, with a maximum capacity of 500 lbs./24 hrs (10kg/hr). It will be a vacuum operated solution feed type and mount directly on the chlorine header valve or directly onto the Regal TAY-200 ton container adaptor by means of a positive yoke type clamp having an integral tightening screw with slide-bar handle.

All regulating, metering, flow adjusting and safety functions shall be incorporated in the cylinder mounted unit.

The inlet safety shut-off/vacuum regulating valve shall be of capsulated construction, easily removable as a unit from the outlet side of the yoke for ease of inspection, cleaning or maintenance.

Vacuum shall be created by an ejector assembly connected directly to the chlorine solution diffuser. The assembly shall consist of a single piece venturi-recovery throat to prevent mis-alignment; also, a back flow check valve to prevent water from entering the gas system. The check valve shall be of positive, tight shut-off, unitized design not requiring springs or diaphragms for tight closing.

SERVICE

Most service problems can be handled by the user, with no special tools. If that is not possible, or desirable, the chlorinator and ejector assembly can be shipped to the factory for overhaul and retest to like-new condition for a reasonable single service charge. If the unit cannot be taken out of service, we will send an "exchange" unit.

The REGAL Model 256 Automatic Switchover Gas Chlorinator is a totally vacuum-operated system which is designed to automatically switch the chlorine feed from an empty chlorine supply to a full chlorine supply. It is also designed to provide system-backup. Should a problem develop with either vacuum regulator, chlorination can be continued. The chlorinators are of the vacuum-operated solution-feed type, designed for mounting directly on a chlorine cylinder valve of a wall manifold or ton container adaptor, Regal Model TAY-200. The switchovers are self-actuating, eliminating the need for a separate switchover module. A separate gas flow meter and rate control valve panel may be located wherever it is most convenient for the operator and connected between the vacuum regulator junction at the pressure relief (vent) valve, and the ejector, by means of safe vacuum tubing. The ejector assembly contains a back flow check valve. Chlorine gas flow rate is regulated by a spring-opposed diaphragm regulator which is also the automatic safety shut-off valve. Should vacuum be interrupted for any reason anywhere in the system the safety shut-off/inlet valve immediately closes, shutting off the chlorine supply from the cylinder. A pressure relief valve designed to "vent" the system also provides a central interconnection point for the vacuum tubing.

OTHER IMPORTANT FEATURES

- System Back-up — Each cylinder's chlorinator has its own vacuum regulating diaphragm and safety/inlet valve insuring that chlorination can be continued if service should be required on either chlorinator.

  Corrosion-resistant, Factory-adjusted Detent Mechanism — Detent does not require any field adjustment assuring that cylinder switchover will occur at the proper time, and that all available gas in supply cylinder will be used.

- In-Use/Stand-by Indication — Prominent indicator on face quickly tells which is the stand-by cylinder and which cylinder is in use. Optional flowmeter panels are available for applications where the feed rate must be known at the chlorinator and the flow meter/rate valve panel cannot be seen.

CAPACITIES

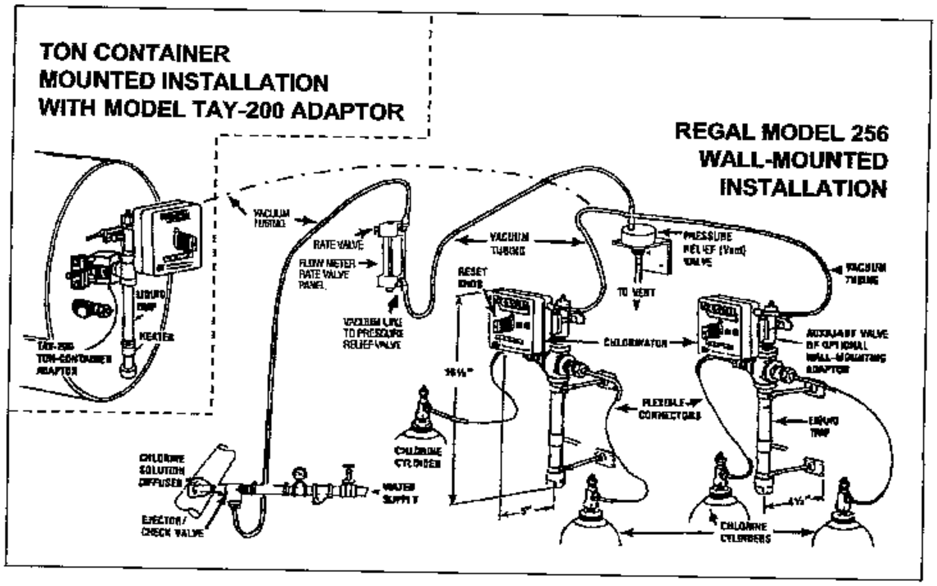
Dual scale metering tube with maximum capacity of 500 pounds per 24 hrs. of chlorine gas with corresponding metric scale of 10kg/hr.

FLOW RATE ADJUSTMENT

Manually adjustable by means of a flow rate control valve located at the top of the flow meter. Flow rate is then regulated by a special spring-opposed diaphragm operated valve. The system is automatic. It will go off and on as the ejector water is turned off and on and will always return to the pre-set flow rate.

MATERIALS OF CONSTRUCTION

All materials used in REGAL gas chlorinators have been carefully chosen for their excellent corrosion-resistant, ultra-violet-resistant properties plus their ability to withstand stresses far greater than will be encountered in actual use.



OPERATION

The chlorinators are clamped onto the chlorine cylinder valves. The ejector assembly is normally attached to the solution diffuser at the point of injection. A vacuum line is connected from each cylinder unit to the wall-mounted, pressure-relief (vent) valve, and a single vacuum line connects the outlet of the connector to a wall-mounted, flow-meter/rate valve panel. The ejector is connected to the rate valve panel with a single vacuum line.

Water, under pressure, is forced through the ejector nozzle which creates a strong vacuum in the ejector body. This pulls gas into the ejector through a special back-flow check valve and then into the nozzle outlet. The gas mixes with the ejector water and is discharged through the diffuser into the water being treated. The ejector vacuum is transmitted through the vacuum line to the rate valve and the flow meter; then through the connector on the pressure-relief (vent) valve and on to the back of the operating chlorinator diaphragm. With sufficient vacuum, the diaphragm moves backward, opening the spring-loaded inlet regulating valve to allow chlorine to enter from the cylinder. The chlorine passes through the chlorinator, the pressure-relief (vent) valve connector and the flow rate indicating meter/flow rate adjusting valve to the ejector.

When the operating cylinder starts to run out, the vacuum starts to build up in the system causing the diaphragm of the chlorinator on "stand-by" to be drawn back, overcoming a detent mechanism and opening the safety/inlet valve. This allows chlorine gas to be withdrawn from the "stand-by" cylinder to satisfy the increased system vacuum and the vacuum falls back to the operating level.

The original supply cylinder also continues to feed until it is empty, virtually assuring that there will be no interruption of chlorination and that full use will be made of all available chlorine. This also reduces the possibility and risk of returning cylinders with some remaining gas to the supplier.

SPECIFICATIONS

The chlorinator system shall be a vacuum-operated, solution-feed type and shall automatically switch the chlorine supply from an empty chlorine source to a full chlorine source. It shall be REGAL Model 256 manufactured by Chlorinators Incorporated, Stuart, Florida, and shall have a maximum capacity of 500 lbs./24 hrs (10kg/hr).

The Model 256 Vacuum-Operated Automatic Switchover Chlorinator shall consist of the following components: Two (2) automatic switchover vacuum regulators for mounting directly on chlorine gas cylinder valves, one (1) pressure-relief (vent) valve, one (1) chlorine gas flow meter panel with rate valve, & one (1) ejector/check valve assembly.

The vacuum regulators shall mount directly onto the cylinder header valve or directly onto the Regal TAY-200 ton container adaptor by means of a positive yoke type clamp having an integral tightening screw with slide bar handle. The main vacuum-regulating diaphragm of each chlorinator shall have a minimum operating area of 13 sq. inches in order to achieve required accuracy and repeatability of the set chlorine flow rate. All metallic bolts shall mate with metallic threaded nuts or inserts. Plastic mating threads for metallic bolts shall not be acceptable.

Each chlorinator vacuum regulator shall have its own diaphragm, safety-shutoff/inlet valve and switchover detent mechanism, thereby allowing chlorination to continue should it become necessary to remove either vacuum regulator from service for cleaning or servicing. Switchover detent mechanism shall be made of corrosion-resistant materials and shall not require any field adjustment.

SEE CONTENTS GUIDE 250 OR 256 FOR STANDARD ACCESSORIES AND SHIPPING WEIGHTS.

chlorinators incorporated
1044 SE Dixie Cutoff Road, Stuart, FL 34994 USA • Tel: 772-288-4854 • Fax: 772-287-3238 • www.regalchlorinators.com • E-mail: chlorinc@aol.com

REGAL SERIES 7000 SMARTVALVE™

GENERAL

The REGAL Series 7000 SMARTVALVE™ shall be a modular system component capable of automatically varying the gas chemical flow rate from a REGAL Gas Feed System using standard 4-20 milliamp DC analog input signals from field mounted transmitting devices such as water flowmeter transmitters or contact closures from pump motor starter auxiliary contacts.

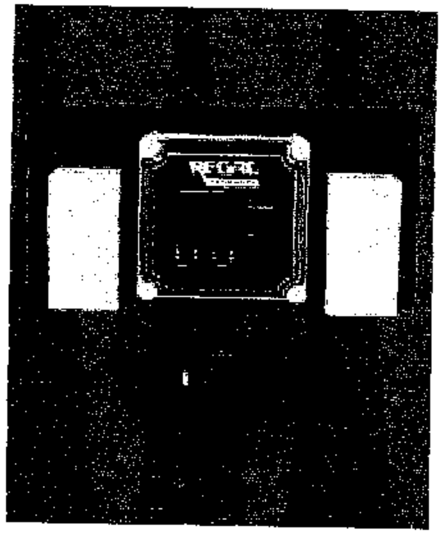
The REGAL SMARTVALVE™ shall offer the user a choice of two (2) automatic control schemes; "Flow Proportional Control (FPC)" or, "Step Rate Control (SRC)".

Model 7001 — FPC (10 to 500 PPD)
Model 7002 — SRC (10 to 500 PPD)
Model 7006 — FPC (1,000/2,000 PPD)
Model 7007 — SRC (1,000/2,000 PPD)

Each control scheme is briefly defined as follows:

A.Flow Proportional Control (FPC)
This control scheme is needed whenever the water flow rate to be treated varies and will work well as long as the quality of the water remains constant. In this control scheme, the SMARTVALVE™ automatically regulates the magnitude of gas flow rate through a REGAL Gas Feed System proportionally to the varying water flow rates. The required ratio "dosage" of chemical to the water flow rate is easily set by the operator to maintain the desired residual using the keypad on the SMARTVALVE™ enclosure.

B.Step Rate Control (SRC)
This control scheme can be used whenever fixed speed pumps (up to four) are used to move the water to be treated through a common line. The SMARTVALVE™ responds to on/off signals supplied by the pump circuits and automatically positions the valve plug so that the correct amount of chemical is added to the system regardless of which or how many pumps are running at any given time.



SPECIFICATIONS

The REGAL SMARTVALVE™ shall be available in eight (8) maximum capacities: 10, 25, 50, 100, 250, 500, 1,000, and 2,000 PPD (200, 500, 900, 2,000, and 5,000 gms/hr and, 10, 20, and 40 kg/hr) using only four (4) different valve plugs.

The REGAL SMARTVALVE shall include a four phase linear, heavy duty stepper motor, feedback potentiometer and modulating gas flow control valve. The circuitry shall produce a series of pulses such that the motor position is a function of the number of pulses generated. Shaft direction shall be a function of phase sequence, and speed shall be a function of the pulse ratio. The rotary motion of the motor shall be converted to a linear motion driving a precision machined valve plug in an orifice via a lead screw.

The valve plug shall move linearly a maximum of 1" for all capacities through 2,000 PPD based on a maximum of sixteen revolutions of the stepper motor with two hundred precise motor positioning points per revolution. The lead screw and valve plug shall move linearly a maximum of 0.0003125" per motor pulse.

For maximum system accuracy, and to compensate for manufacturing tolerance differences in the various parts making up the complete gas feed system, the SMARTVALVE™ shall include a program by which the factory and/or the end user can easily "linearize" the valve's digital display to precisely match the gas feed systems metering tube reading in PPD at 25%, 50%, 75%, and 100% of capacity.

The SMARTVALVE™ must contain a program whereby the operator can easily reset "typical electrical linear values" by simply pressing two (2) keypad buttons at the same time.

The SMARTVALVE™ shall include a program by which the factory and/or the end user can easily decrease or increase the speed of response of the stepper motor from one motor revolution every ten (10) seconds to one motor revolution every one (1) second.

All REGAL SMARTVALVES™ shall include a manual feed rate adjustment knob with indicator pin and plate for use during times when electrical power to the SMARTVALVE™ is lost. This feature shall give the operator four (4) ways to operate the SMARTVALVE™; fully automatic, electric/manual and two (2) forms of manual (manual via the adjustment knob on the SMARTVALVE™, and manual via the rate adjustment valve furnished as part of the gas feed system).

Should an electrical surge, etc. upset or scramble the programmed "engineering" or "configuration" parameter settings, the operator must be able to re-load "TYPICAL" values into the microprocessor by pressing and holding one keypad button while reapplying AC electrical power to the SMARTVALVE™.

The digital display of the REGAL SMARTVALVE™ shall indicate the following conditions without the need of meters or test equipment: an analog input signal is not being received; signal wires are reversed; analog signal is too high.

The REGAL SMARTVALVE™ shall also include an "averaging" parameter in the "configuration mode" that can be used to smooth out fluctuations caused by the flowmeter and/or the flowmeter transmitter.

Operator interface in all program modes shall be via a four button keypad. The left two buttons shall enable the operator to scroll up or down through the active program parameters. The remaining two keypad buttons shall allow the operator to view the value of, and/or change the value of, the active parameter. Scrolling to the next parameter shall automatically enter into the microcontroller, the value selected in the previous parameter. There shall be no need for a separate "enter" key.

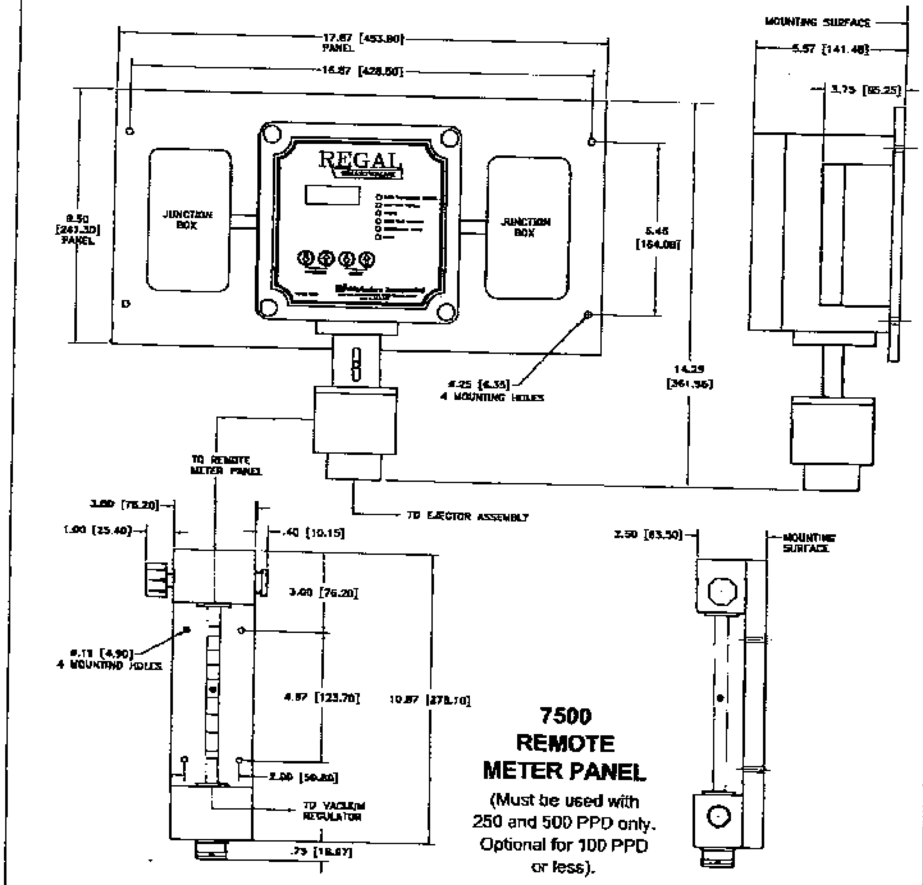
The SMARTVALVE™ shall include a serial communications output. A 20 milliamp digital current loop shall be provided as standard and shall be accessed (turned on or off) through the "Engineering" mode. Two (2) choices of communications shall be available. Selection of a "continuous" output will provide a digital output of valve plug position in PPD of instantaneous gas feed rate. Selection of a "full duplex" output will allow serial data to flow both ways simultaneously and will provide the user with full control of the SMARTVALVE™ from a remote site.

If the serial communications interface to field mounted devices requires analog rather than digital inputs, the optional REGAL Serial to Analog Converter can be used to convert the "continuous" digital output to a 4-20 milliamp analog output representing instantaneous gas feed rate in PPD.

The REGAL SMARTVALVE™ shall include the following easy to read digital displays and annunciator LEDs to indicate the following conditions:

A. Water flow rate being treated in actual numbers or as a percent of flow.
B. Current dosage setting.
C. Valve plug position in PPD.
D. Automatic or manual operation.
E. Low flow rate alarm condition.
F. Parameter and parameter value.

SERIES 7000 SMARTVALVE™ DIMENSIONS



ADDITIONAL SPECIFICATIONS

Power Requirements: Field selectable 115/230 VAC ± 15%, single phase. Operating frequency is 50 or 60 Hertz.

Fusing: 1/4A @ 230V, 1/2A @ 115V (Time Delay, 250V).

Power Consumption: 45 Watts.

Input Signal: 0-10 Volts, d.c., 4-20 mA, d.c.

Input Impedance: 60.4 Ohms for current inputs. 100K Ohms for voltage inputs.

Output Signals: Switch Contacts rated at 3 amps @ 240 VAC or 28 VDC, resistive load.

Environmental Limits: 32 to 120° F (0-50° C).

Calibration Accuracy: ±1/4% from zero.

Speed of Response: Variable and field selectable.

Operating Range: 10:1.

Operator Interface: Four (4) button keypad.

Display: 4 digit, red, .43" numeric LED and six (6) annunciators.

Control Mode: Automatic - Manual.

Dosage Ratio: 4:1, via keypad.

Serial Communications: Bi dir. 20 mA Current Loop. RX is opto-coupled.

Analog to Digital Converter: 12 bit, Unipolar, Successive Approximation.

Reliability & Protection: Watchdog for microprocessor, MOV & fuse for power supply. Transorb for digital power supply and analog input.

EEPROM: 128 Byte of EEPROM. Stores configuration and engineering parameters.

Memory: 8K RAM. 32K ROM.

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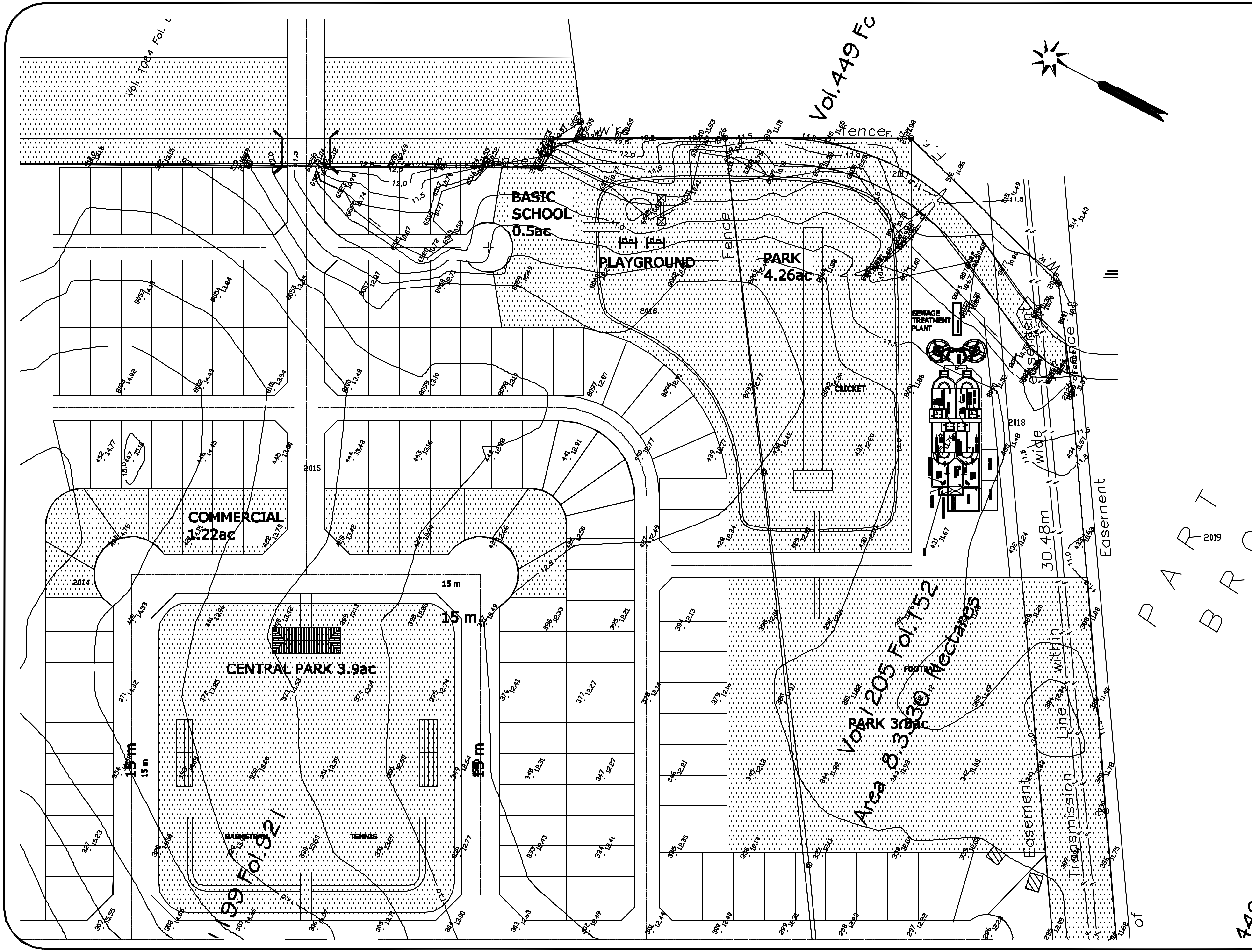


GENERAL NOTES

NO.	DESCRIPTION/REVISION	DATE

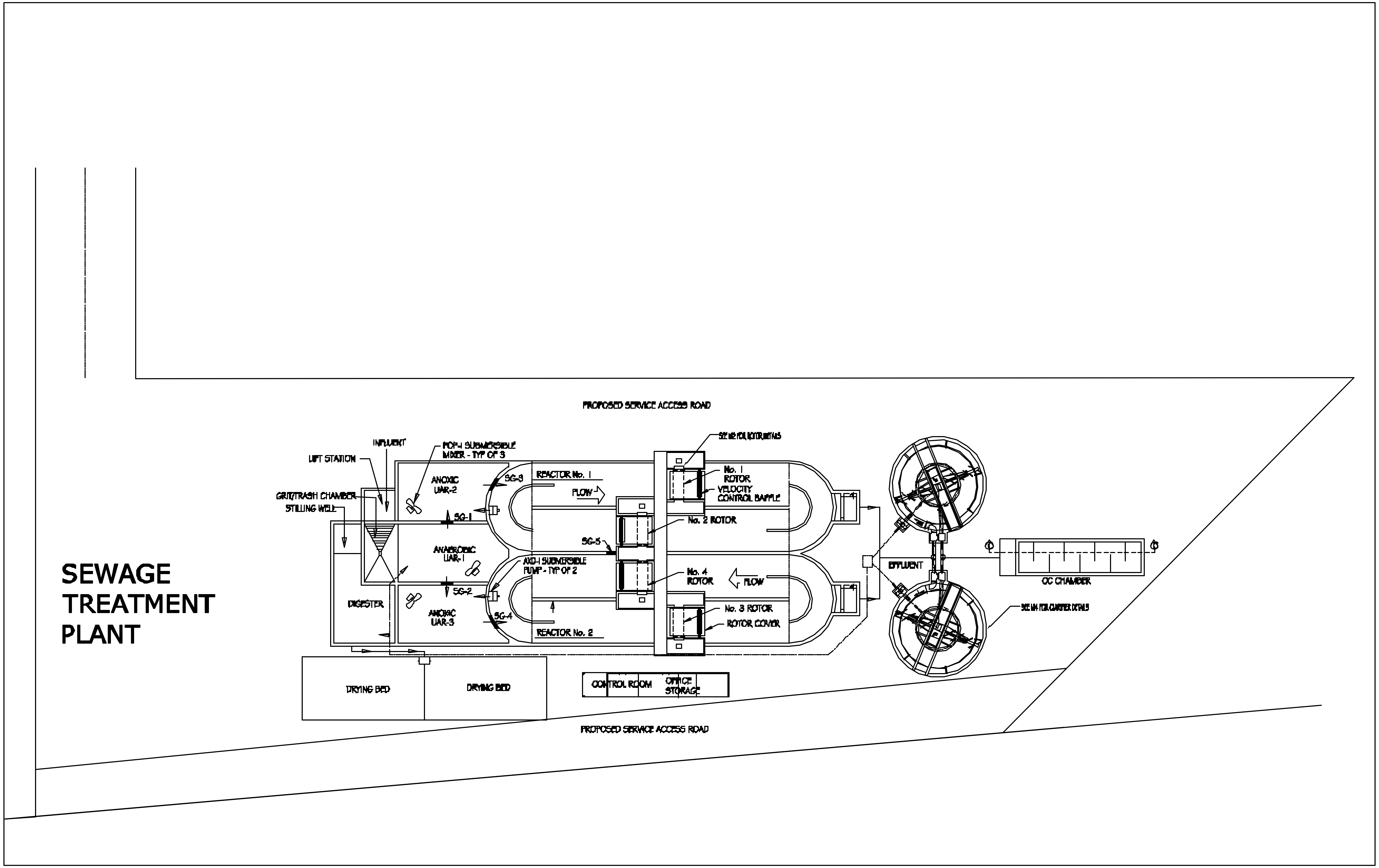
APPROPRIATE TECHNOLOGIES LTD.
ELECTRICAL/ENVIRONMENTAL ENGINEERS
34 K OLD HOPE ROAD KINGSTON 6
JAMAICA, W.I.
TEL. (876) 978-1334/9743
FAX. (876) 978-5026

CLIENT
CORE DEVELOPMENTS LTD.
2c Braemar Ave.,
KINGSTON 10, JAMAICA, W.I.
TEL: (876) 927-5323

LOCATION
NEW HARBOUR VILLAGE, OLD HARBOUR

DESCRIPTION
LOCATION OF WASTE WATER TREATMENT PLANT

SCALE	FILED AS 1038-01	DATE 11/01/06
DRAWN BY	I. W.	SHEET
CHECKED BY	J. E.	C1
DWG. NO.	D-1038-01-01-05-0001	



GENERAL NOTES

NO.	DESCRIPTION/REVISION	DATE

APPROPRIATE TECHNOLOGIES LTD.
ELECTRICAL/ENVIRONMENTAL ENGINEERS
94 K OLD HOPE ROAD KINGSTON 6
JAMAICA, W.I.
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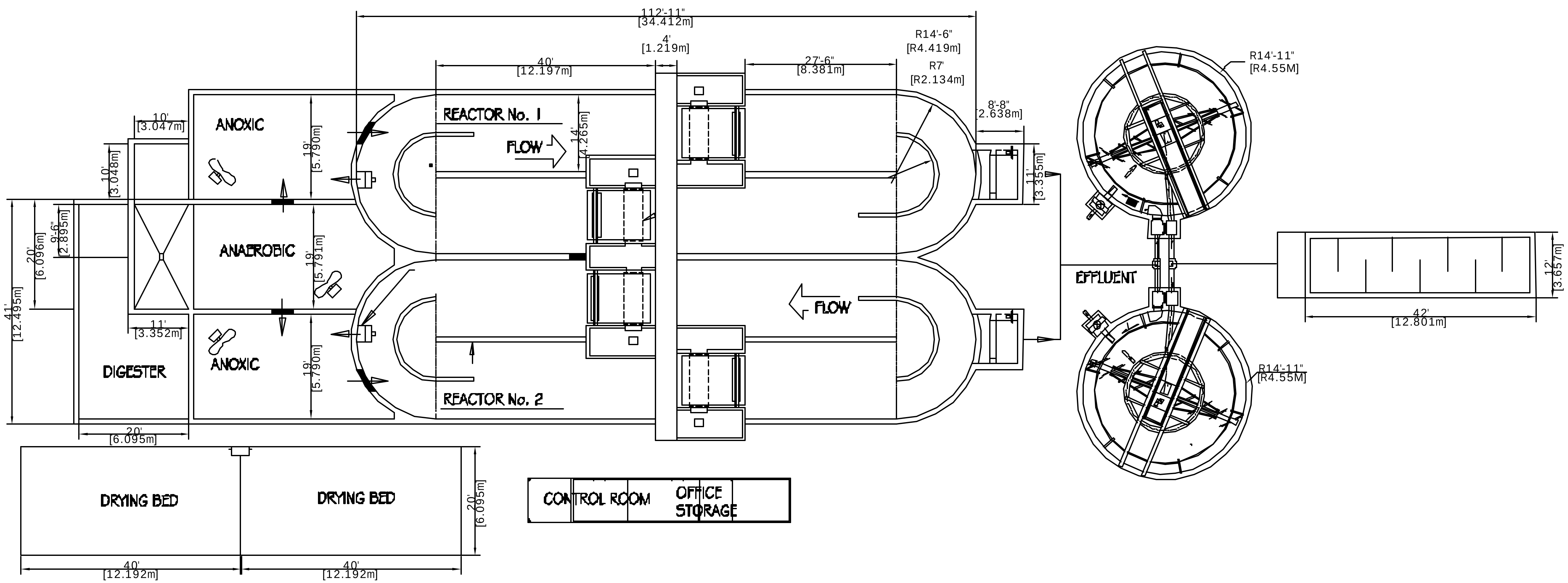
FAX. (876) 978-5028

CLIENT
GORE DEVELOPMENTS LTD.
2c Braemar Ave.,
KINGSTON 10, JAMAICA, W.I.
TEL: (876) 927-5323

LOCATION
NEW HARBOUR VILLAGE, OLD HARBOUR

DESCRIPTION
SITE PLAN

SCALE	FILED AS 1038-01	DATE 11/01/05
DRAWN BY I. W.		SHEET
CHECKED BY J. E.		C2
DWG. NO. D-1038-01-01-05-0001		



GENERAL NOTES

NO.	DESCRIPTION/REVISION	DATE

APPROPRIATE TECHNOLOGIES LTD.
ELECTRICAL/ENVIRONMENTAL ENGINEERS
94 K OLD HOPE ROAD KINGSTON 6
JAMAICA, W.I.
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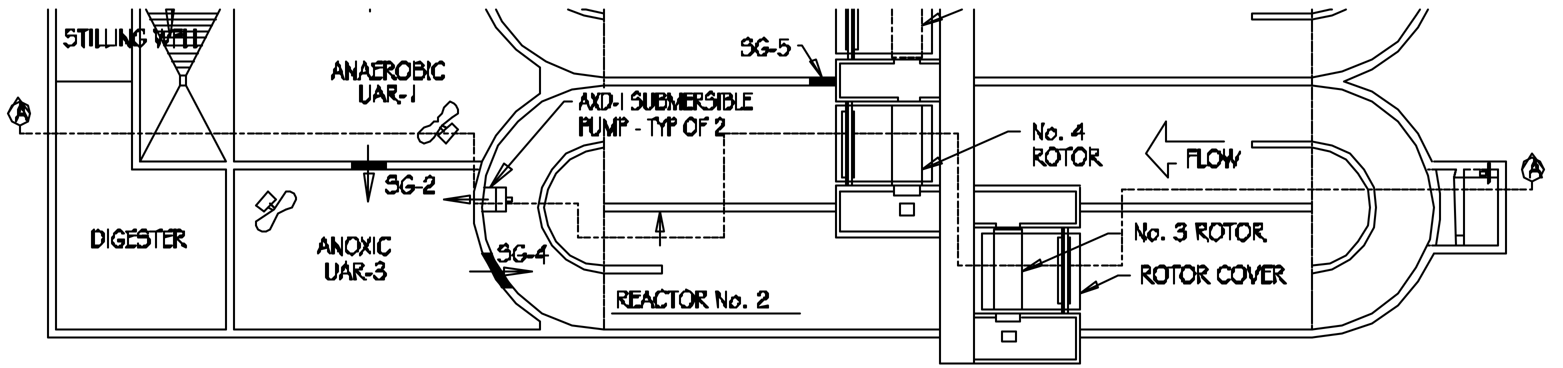
FAX. (876) 978-5028

CLIENT
CORE DEVELOPMENTS LTD.
2c Braemar Ave.,
KINGSTON 10, JAMAICA, W.I.
TEL: (876) 927-5323

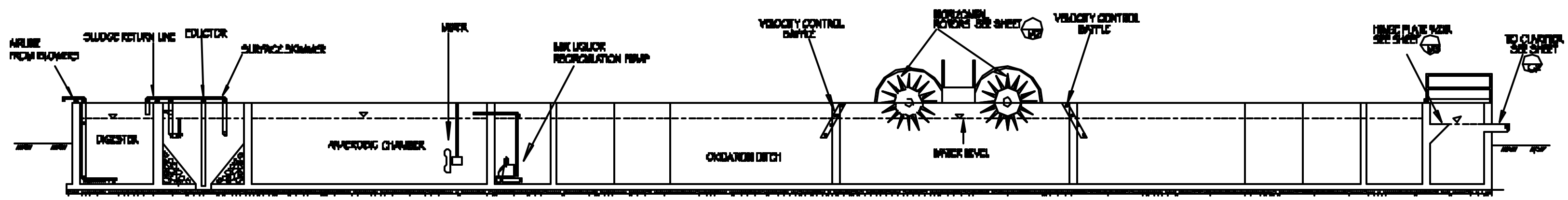
LOCATION
NEW HARBOUR VILLAGE, OLD HARBOUR

DESCRIPTION
PLAN TREATMENT PLANT

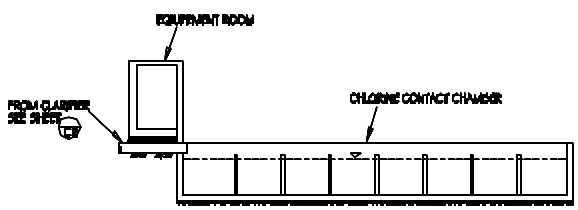
SCALE	FILED AS 1036-01	DATE 11/01/06
DRAWN BY I. W.		SHEET C3
CHECKED BY J. E.		
DWG. NO. D-1038-01-01-05-0001		



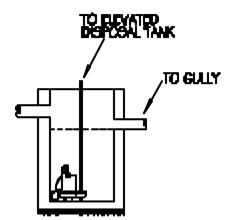
SECTION THRU TREATMENT PLANT



SECTIONAL ELEVATION OF DIGESTER, GRIT/TRASH, ANAEROBIC & OXIDATION DITCH



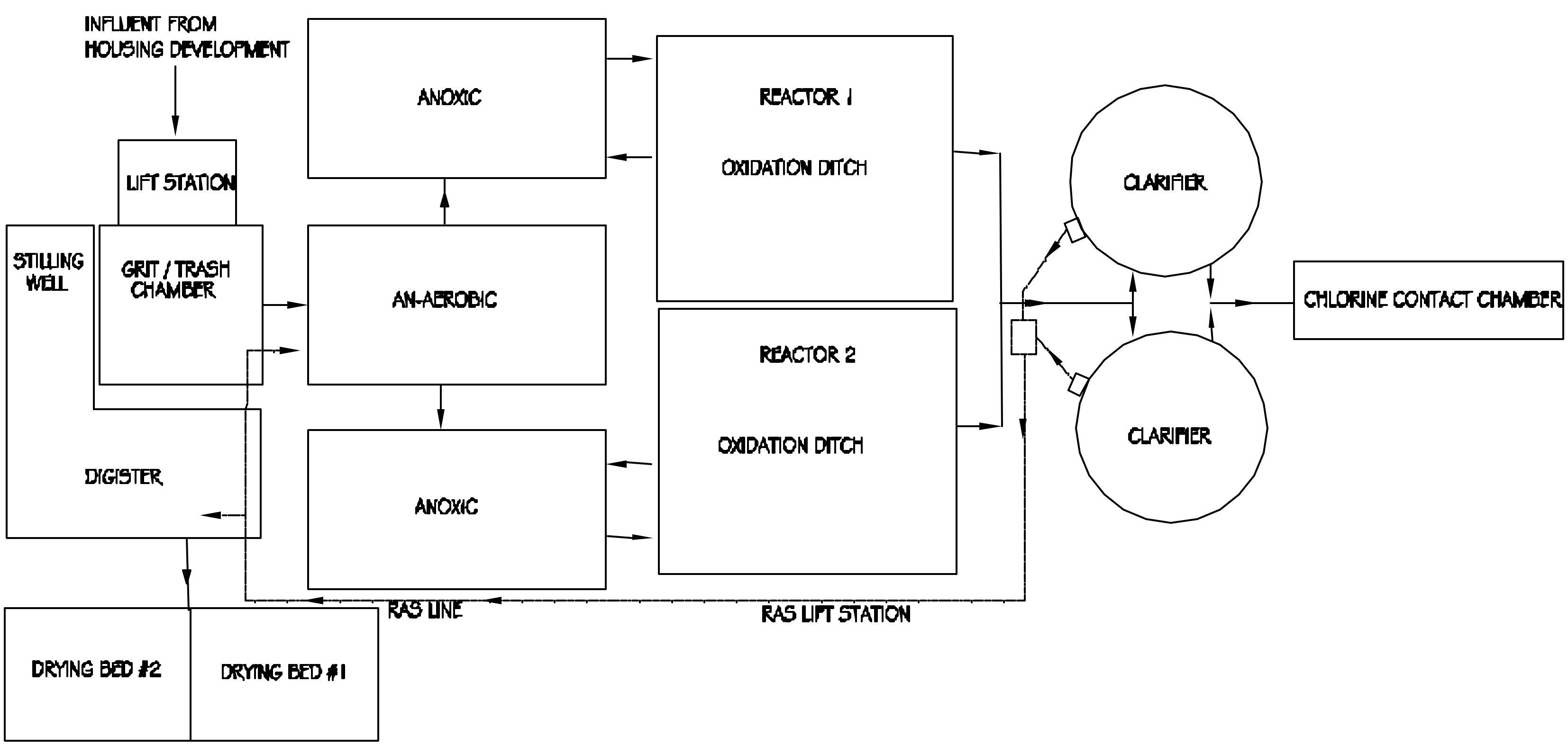
SECTIONAL ELEVATION OF CHLORINE CONTACT CHAMBER



EFFLUENT LIFT STATION

SECTION & ELEVATIONS

C4



NO. | DESCRIPTION/REVISION | DATE

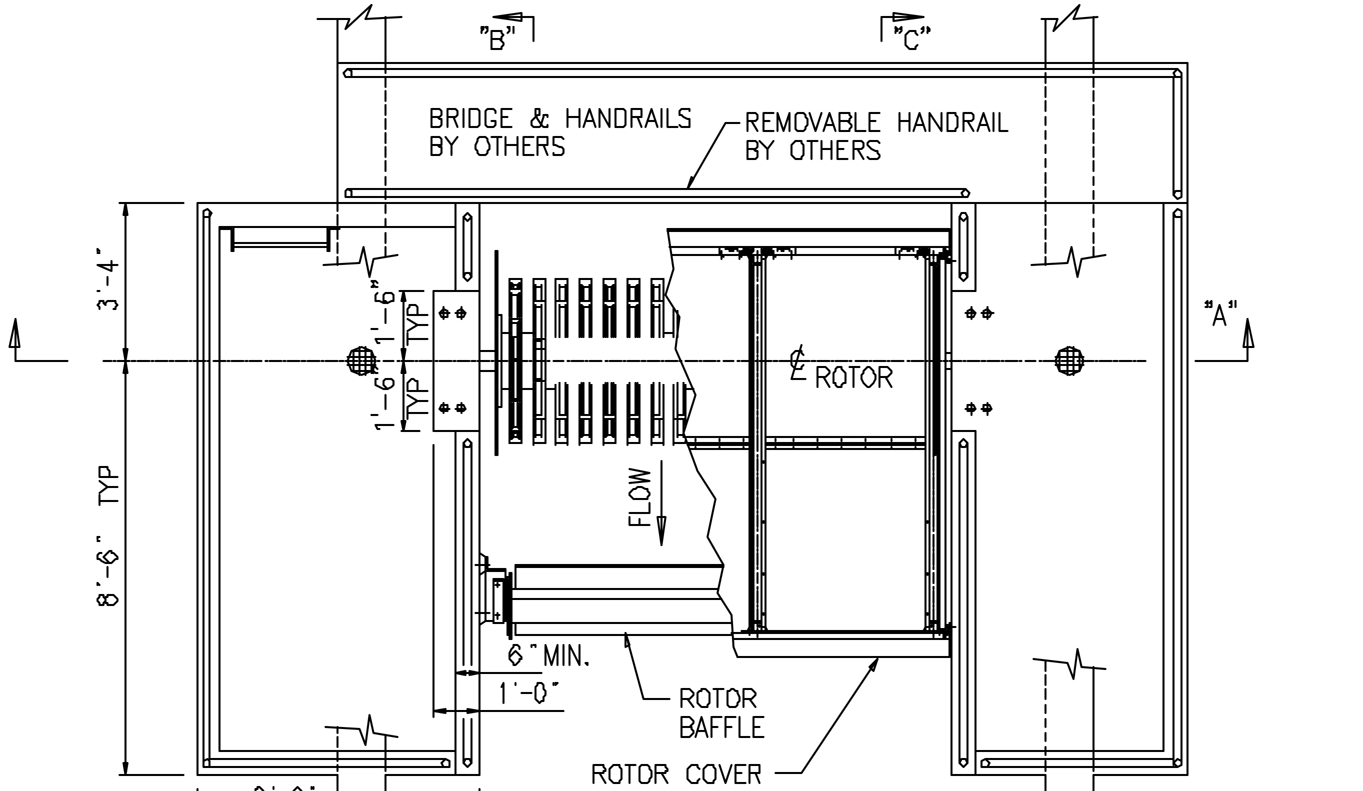
APPROPRIATE TECHNOLOGIES LTD.
ELECTRICAL/ENVIRONMENTAL ENGINEERS

CLIENT
CORE DEVELOPMENTS LTD.
2c Braemar Ave.,
KINGSTON 10, JAMAICA, W.I.
TEL: (876) 927-3323

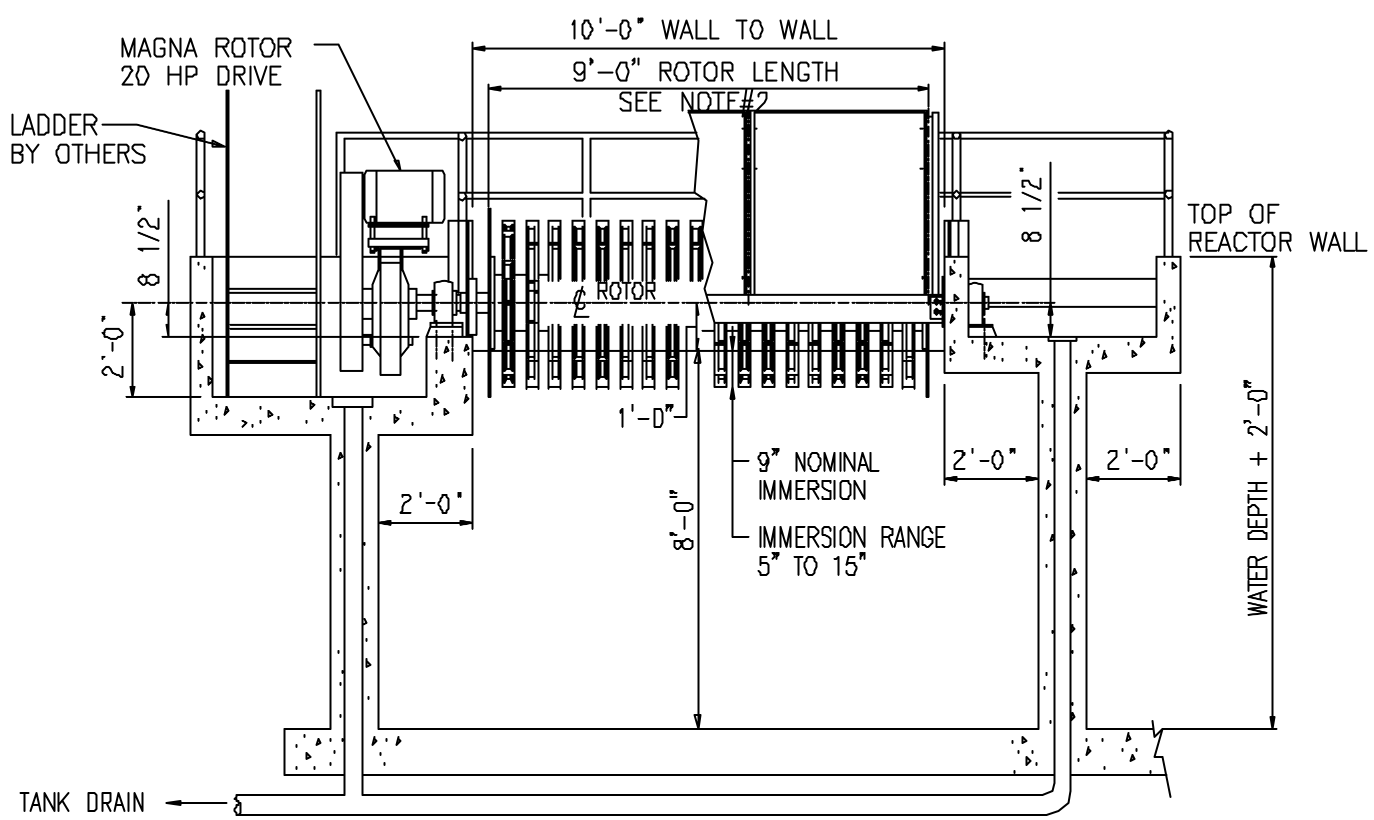
LOCATION
NEW HARBOUR VILLAGE, OLD HARBOUR

DESCRIPTION
TREATMENT PLANT PROCESS FLOW

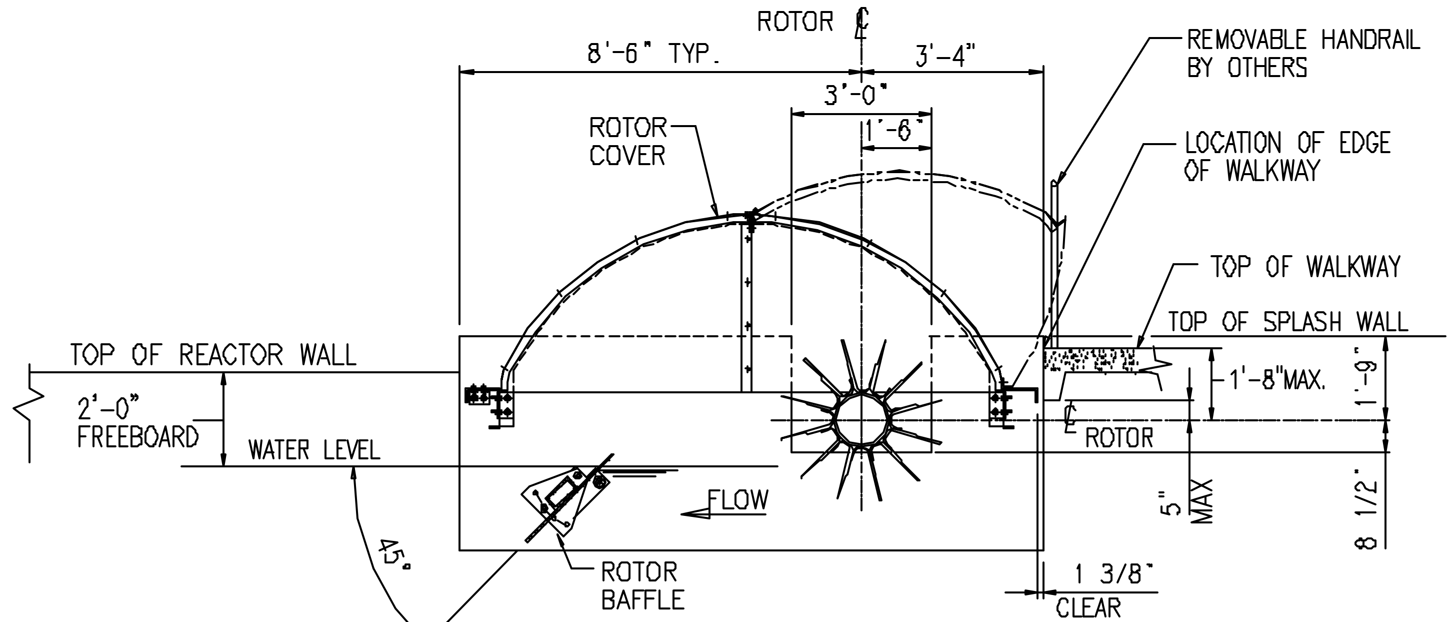
SCALE	FILED AS	DATE
DRAWN BY L. W.		SHEET
CHECKED BY J. E.		M1
DWG. NO. D-1038-01-01-05-0001		



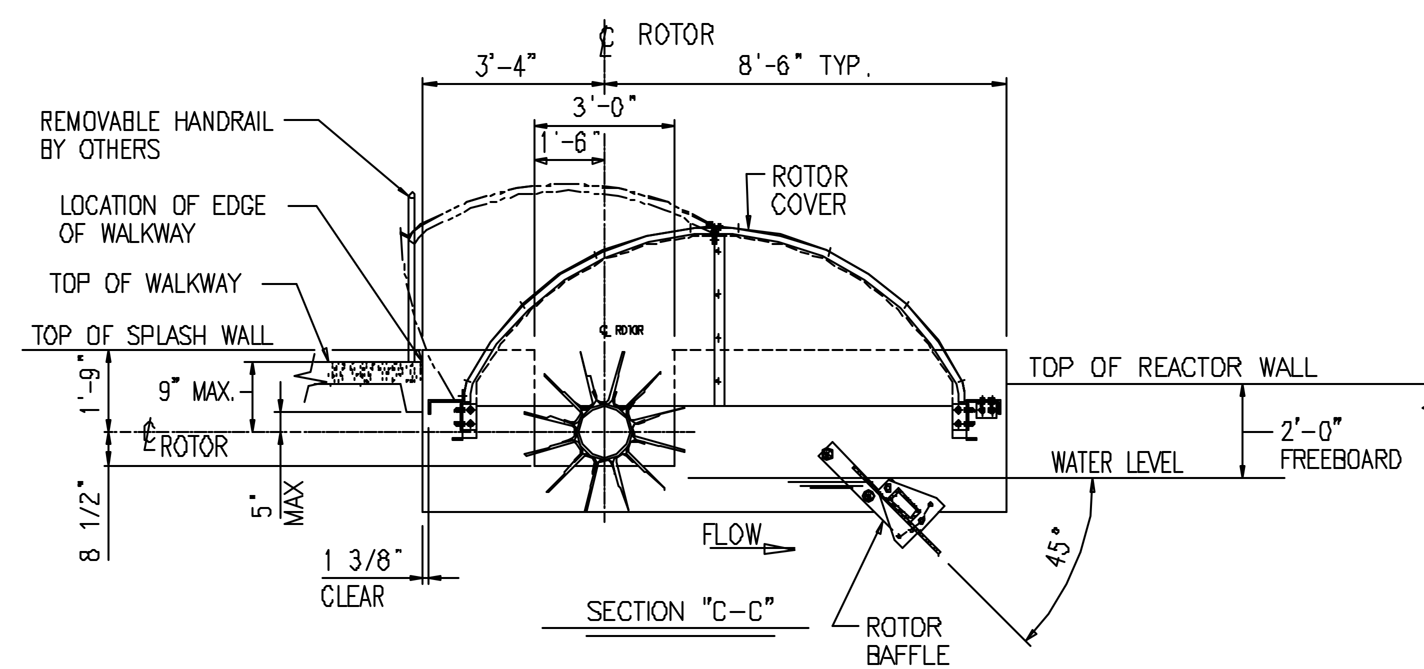
PLAN



SECTION "A-A"



SECTION "B-B"



SECTION "C-C"

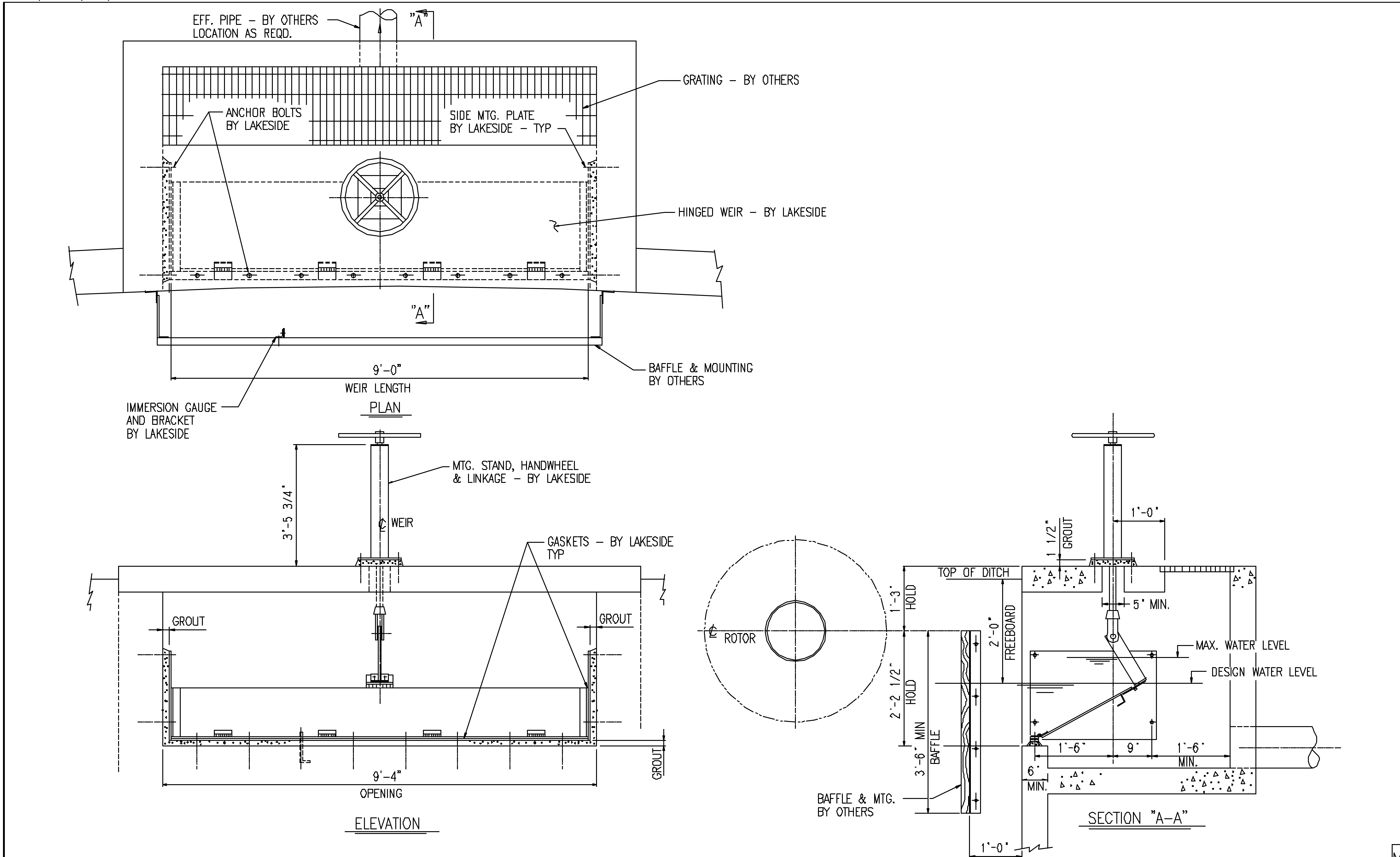
NOTES:

1) IF GROUND ELEVATION IS ABOVE DRAIN OUTLET, DRAIN PIT SHOULD BE PROVIDED.
2) 2 RINGS OF BLADES PER FOOT OF ROTOR.
3) WHEN A ROTOR COVER IS NOT SUPPLIED SEE DWG D-54871-S & D-56540-S.
4) MIRROR IMAGE OF EQUIPMENT MAY BE REQUIRED DEPENDING ON DIRECTION OF FLOW IN BASIN.
5) MINIMUM ONE DRAIN VALVE PER BASIN.

REVISIONS	DATE	DR.	CHKD.	REVISIONS	DATE	DR.	CHKD.	REVISIONS	DATE	DR.	CHKD.	REVISIONS	DATE	DR.	CHKD.

LAKESIDE EQUIPMENT CORPORATION	DR. STORCH/GS CHKD. Y.C. 11-11-03	DATE 12-22-06 NEW HARBOUR FILE NO GENPROJ	TYPE D ROTOR SUPPORT w/Type "E" Rotor Cover & ADJUSTABLE BAFFLE	NEW HARBOUR, JAMAICA	DWG. NO. D-68254-S	REV. M2

1:05p 12/22/105 DXF



REVISIONS	DATE	DR.	CHKD.
A REVISED	8-5-96	YC	JOHN J. 9-9-98
A REVISED	7-16-90	SNYDER	CT

LAKESIDE EQUIPMENT CORPORATION

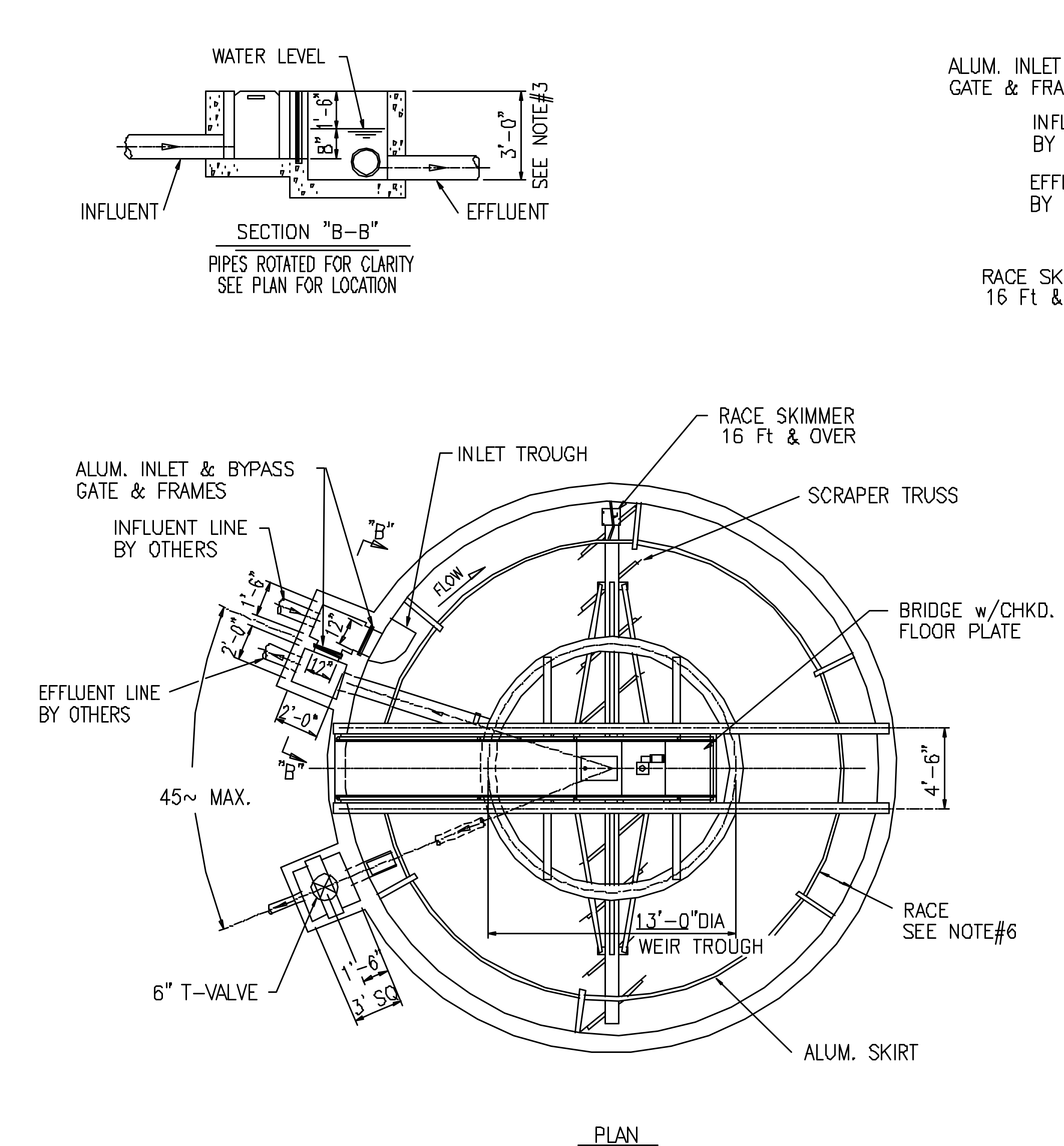
DR. SNYDER/GS DATE 12-22-05 CHKD. TODD 8-13-86 NEW HARBOUR FILE NO. GENPROJ

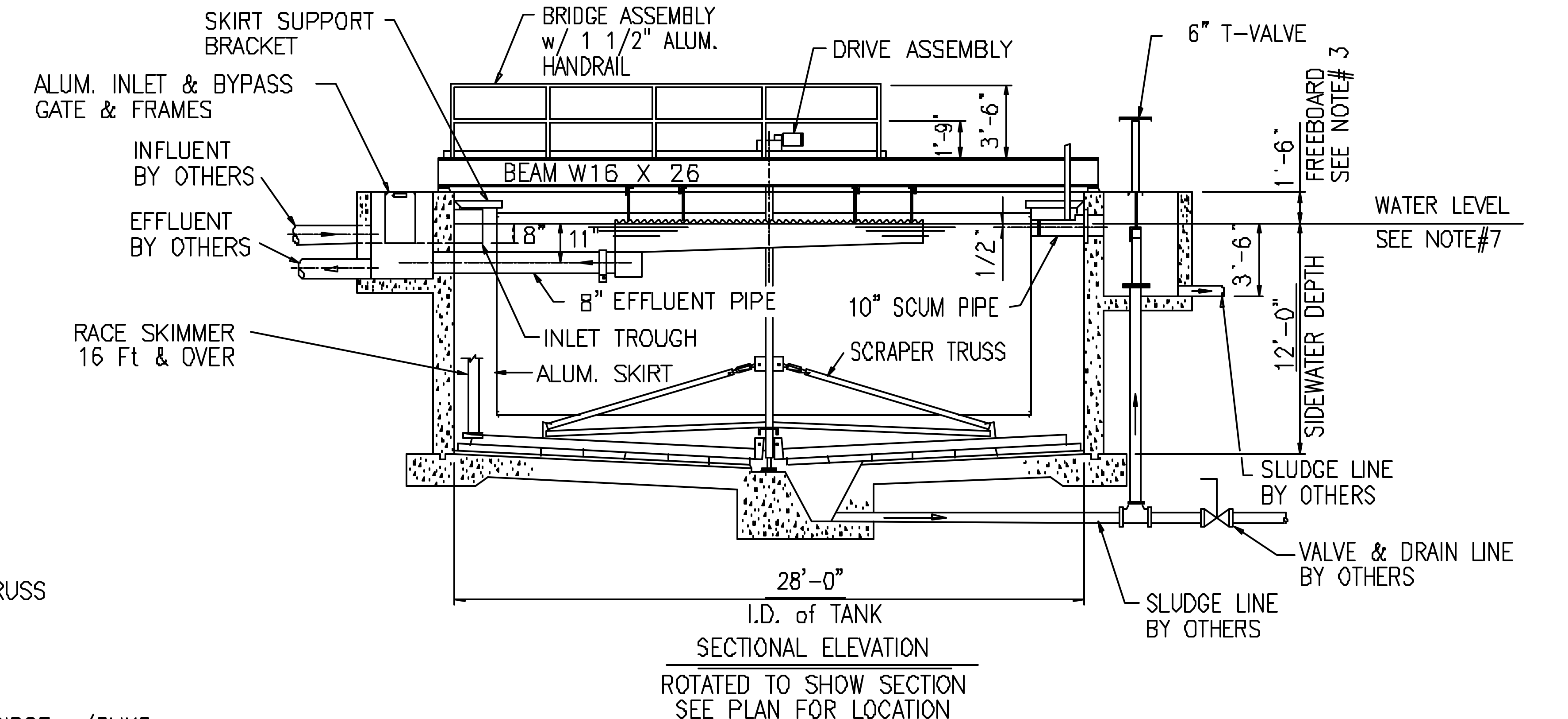
HINGED PLATE WEIR
STRAIGHT WALL

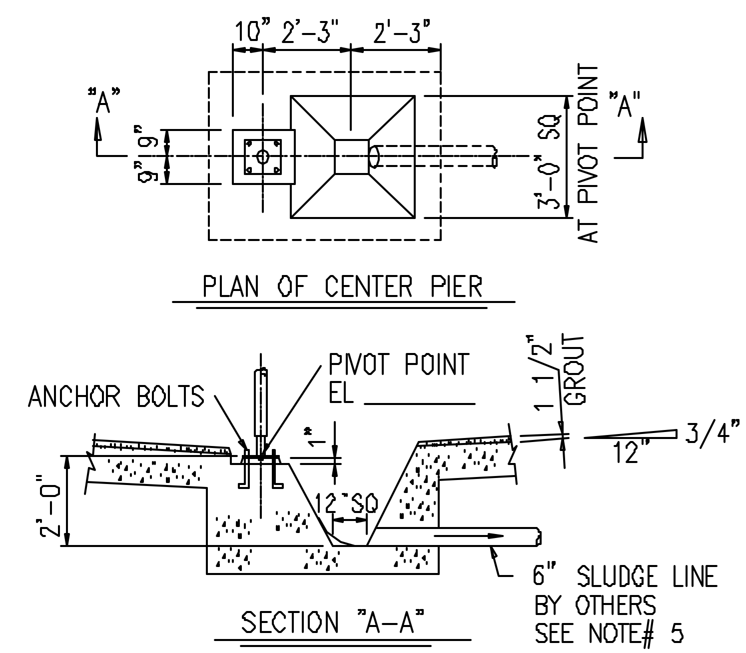
NEW HARBOUR, JAMAICA

DWG. NO. D-37708-S REV. B

1:07p 12/22/105 DXF







NOTES:

1) ALL EQUIPMENT SHOWN IS BY LAKESIDE UNLESS OTHERWISE SPECIFIED.
2) ALL CONCRETE & GROUT BY OTHERS.
3) ALL BOX DEPTHS BASED ON 1'-6" FREEBOARD. ANY VARIATION IN FREEBOARD AFFECTS DIMENSIONS ACCORDINGLY.
4) CLOCKWISE FLOW IS SHOWN. DIRECTION OF FLOW IS OPTIONAL. BOXES WOULD BE MIRROR IMAGE OF BOXES IN PLAN VIEW.
5) SLUDGE LINE SIZES ARE APPROXIMATE. ACTUAL SIZES TO BE BASED ON FLOW AND AVAILABLE HEADLOSS.
6) RACE DESIGN AND QUANTITY OF SUPPORTS BY LAKESIDE.
7) WATER LEVEL SHOWN IS BOTTOM OF V-NOTCH IN WEIR TROUGH.

REVISIONS	DATE	DR.	CHKD.	REVISIONS	DATE	DR.	CHKD.	REVISIONS	DATE	DR.	CHKD.	REVISIONS	DATE	DR.	CHKD.
												△ REVISED	10-18-99	ERT	

LAKESIDE EQUIPMENT CORPORATION	DR. GS CHKD. NEW HARBOUR	DATE 12-22-05 FILE NO. GENPROJ	28'-0" DIA SPIRAFLO CLARIFIER	NEW HARBOUR,JAMAICA	DWG. NO. D-19729-S	M4 REV. E

Reference

Crites, R., and Tchobanoglous, G., 1998. *Small and Decentralized Wastewater Management Systems.* McGraw-Hill.

http://www.lmnoeng.com/Weirs/vweir.htm

http://www.usbr.gov/pmts/hydraulics_lab/pubs/wmm/chap07_07.html

http://www.wsus.com/

Appendix
Bore Hole Logs

SOIL INVESTIGATION

PROPOSED HOUSING DEVELOPMENT
NEW MARKET PEN
OLD HARBOUR

JAMAICA W.I.

Prepared by

Rudolph G. Titus, (Civ. Eng), P.E.

March 2006

1. Introduction

The following report presents the results of a Soil Investigation carried out at the proposed site for housing development in the parish of Clarendon.

2. Authorization

Authorization to proceed with the work was obtained from Gore Brothers Ltd on approval of our financial proposal in February of 2006.

3. Location

The site is located approximately 0.8 km South for the town of Old Harbour along the Old Harbour Bay main road, with an area of approximately 52.44 hectares.

4. Topography/Flora

The area is flat, supporting mainly shrub and grassland with occasional large trees.

5. Borehole Location

The borehole locations are shown on the site plan attached in Appendix 3 of this report totaled seventeen boreholes.

6. Field Work

i. *Drilling*

Drilling consisted of advancing seventeen six-inch diameter boreholes to a depth of six metres with a CME 45 truck-mounted drill rig.

The holes were advanced using hollow stem augurs, with samples being retrieved at regular intervals (maximum 1.5 m) using a standard penetration split spoon sampler.

ii. *Sampling*

The samples were obtained downhole the boreholes with the split spoon at 0.75 metre intervals up to 3 metres and then 1.5 metre to their maximum depth of 6 metres.

iii.*Standard Penetration Testing*

Standard penetration testing was carried out with the standard one hundred and forty pound hammer, with the standard thirty-inch free-fall for each blow count. This was repeated for each sample retrieved during the total penetration of eighteen inches of the standard two-inch diameter split spoon.

The total sum of the number of blows over the last two (2) 6-inch (6") penetrated by the spit spoon is taken as the "N" value.

The "N" values are shown in the borehole logs attached in Appendix 2 of this report.

7. Laboratory Testing

All soil samples were removed to our laboratory for visual inspection and selection for those required for laboratory testing.

From the testing the materials were classified as described in the borehole logs and laboratory test results attached in Appendix 4 (1) to 4 (17).

8. Drainage and Ground Water Conditions

Several areas, particularly at the southern and eastern boundary of the property show ponding with occasional bogs in shallow depressions, from rainfall.

Ground Water

Ground water was observed in boreholes located along the southern and eastern peripheral boreholes to the property and are shown on the borehole logs.

The ground water we interpret to be a saturation zone generated by the ponded rainfall water.

No general static ground water table was encountered within the depths drilled across the proposed site.

9. Percolation Testing

Four percolation tests were carried out across the site. The tests gave an average rate of approximately eight (8) centimeters per hour.

10. Design Strategy

From the foregoing, the following were determined.

1. Bearing capacity
2. Presumptive subsoil stratigraphy across the sites
3. Recommended undrained shear strength (Cu)
4. Recommended vertical modulus of subgrade reaction (Kv1)

11. Subsoil Stratigraphy

The presumptive soil profiles generated appear in Appendix 1 inclusive as follows:

1. Boreholes 16 to 17

   Boreholes 13 to 15
2. Boreholes 10 to 13

3. Borehole No 5
4. Boreholes 6 to 9
5. Boreholes 1 to 4

12. Design Parameters/Geotechnical Recommendations

Recommended bearing capacity and design parameters are given below in Tables 1 to 17 for each borehole as follows:

In general the materials predominantly consist of a mixture of varying percentages of sand, silt and clay as shown by the grading curves.

The parameters would therefore vary depending on which percentage of each grain size is predominant between the granular and cohesive materials.

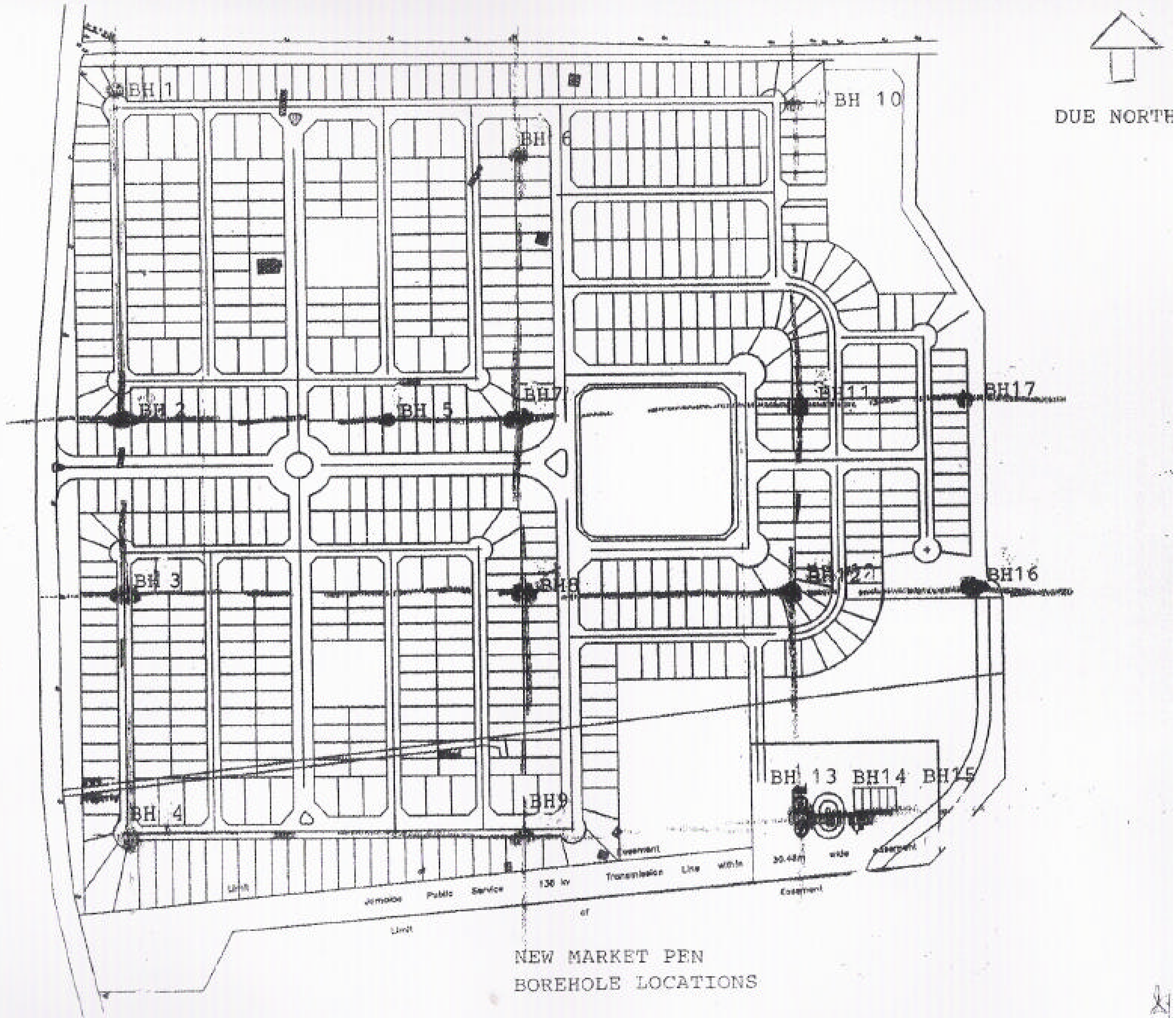
From the laboratory tests the grain sizes whose percentage are predominant across the site are in the cohesive range.

Plasticity indices range from essentially non plastic to low plasticity.

Generally such materials would exhibit relatively low compressibility for the recommended bearing values.

Hence for ease of manipulation both parameters were reduced to a single parameter to represent a combination of both (c) cohesion and ø friction to a single undrained shear strength cu, as the shear strength parameter for bearing capacity design.

The recommended bearing capacities are summarized in the following tables for use in the design of the foundations of the structures.



NEW MARKET PEN
BOREHOLE LOCATIONS

OFFICE BOREHOLE LOG

HB

BORE HOLE 13 SHEET 1 OF

PROJECT New Market Pen

LOCATION Old Harbour, St. Catherine

DATE March 2005 SURFACE ELEVATION

TYPE OF BORING: HOLLOW STEM AUGER [x] ROTARY DRILLING; CONE PENETRATION [ ] WASH BORING; TEST PIT [ ]

DIA. OF BORING

● unc. compr. str. (T/ft.²) 1 2 3 4 5 6; W_P — W — W_L; —X— CONE PENETRATION [ ]; N – VALUE [ ] 10 20 30 40 50 60

DEPTH (METERS)	SAMPLE NO.	SAMPLE TYPE	SAMPLE CONDITION	% RECOVERY	STANDARD PENETRATION TEST 1st 0.15m	2nd 0.15m	3rd 0.15m	DESCRIPTION OF STRATA	LABORA TESTS PERFOR
0									
.75	1	SS	D	66	10	15	19	Stiff sandy silt and clay	W A
1.5	2	SS	D	77	12	16	18		
2.3	3	SS	D	100	14	19	20		
3	4	SS	D	100	16	20	24		W A
								LWL	
4.5	5	SS	D	100	19	20	20	Stiff silty clay	
6	6	SS	D	66	10	10	9		
								End of borehole No. 13	
7.5									

SOIL SYMBOLS: SHATTERED BEDROCK, FILL, PEAT OR ORGANICS, CLAY, SILT, SAND, GRAVEL, BOULDER, SEA SHELLS, SOUND BEDROCK

SAMPLE CONDITION
D – DISTURBED
L – LOST
F – FAIR
G – GOOD (UNDISTURBED)

SAMPLE TYPE
SS – SPLIT SPOON
TW – THIN WALL SHELBY
BS – BAG SAMPLE
WS – WASH SAMPLE
RC – ROCK CORE

LABORATORY TEST SYMBOLS
A – ATTERBERG LIMITS
C – CONSOLIDATION
D – DENSITY
H – HYDROMETER
M – MECH. ANALYSIS
S – SHEAR
T – TRIAXIAL

OTHER SYMBOLS
WATER LEVEL

HILL-BETTY (ENGINEERS) LTD
37 BURLINGTON AVENUE
KINGSTON, JAMAICA.

HB

BORE HOLE 14 SHEET 1 OF

PROJECT New Market Pen

LOCATION Old Harbour, St. Catherine

DATE March 2005 SURFACE ELEVATION

TYPE OF BORING

HOLLOW STEM AUGER [x] ROTARY DRILLING [ ]

CONE PENETRATION [ ] WASH BORING [ ]

TEST PIT [ ]

DIA. OF BORING

DEPTH (METERS)	SAMPLE NO.	SAMPLE TYPE	SAMPLE CONDITION	% RECOVERY	STANDARD PENETRATION TEST 1st 0.15M	2nd 0.15M	3rd 0.15M	unc. compr. str. (T/ft.²) 1 2 3 4 5 6; Wp — W — WL; CONE PENETRATION; N – VALUE 10 20 30 40 50 60	SOIL LEGEND	DESCRIPTION OF STRATA	LABORATORY TESTS PERFORMED
0											
.75	1	SS	D	100	18	19	20			Hard silt and clay	W A M
1.5	2	SS	D	100	20	20	19				
2.3	3	SS	D	100	20	25	20			LWL	
3	4	SS	D	77	19	20	23				W A M
4.5	5	SS	D	72	10	10	13			Stiff sandy silty clay	
6	6	SS	D	66	9	9	10				
										End of borehole No. 14	
7.5											

SOIL SYMBOLS: SHATTERED BEDROCK, FILL, PEAT OR ORGANICS, CLAY, SILT, SAND, GRAVEL, BOULDER, SEA SHELLS, SOUND BEDROCK

SAMPLE CONDITION
D – DISTURBED
L – LOST
F – FAIR
G – GOOD (UNDISTURBED)

SAMPLE TYPE
SS – SPLIT SPOON
TW – THIN WALL SHELBY
BS – BAG SAMPLE
WS – WASH SAMPLE
RC – ROCK CORE

LABORATORY TEST SYMBOLS
A – ATTERBERG LIMITS
C – CONSOLIDATION
D – DENSITY
H – HYDROMETER
M – MECH. ANALYSIS
S – SHEAR
T – TRIAXIAL

OTHER SYMBOLS
WATER LEVEL

HILL-BETTY (ENGINEERS) LTD.,
37 BURLINGTON AVENUE
KINGSTON, JAMAICA.

HB

OFFICE BOREHOLE LOG

PROJECT: New Market Pen

LOCATION: Old Harbour, St. Catherine

DATE: March 2005 SURFACE ELEVATION:

BORE HOLE: 15 SHEET: 1 OF: 1

TYPE OF BORING: HOLLOW STEM AUGER [x] ROTARY DRILLING [ ] CONE PENETRATION [ ] WASH BORING [ ] TEST PIT [ ]

DIA. OF BORING:

DEPTH (METERS)	SAMPLE NO.	SAMPLE TYPE	SAMPLE CONDITION	% RECOVERY	SPT 1st 0.15M	SPT 2nd 0.15M	SPT 3rd 0.15M	SOIL LEGEND	DESCRIPTION OF STRATA	LABORATORY TESTS PERFORMED
0										
.75	1	SS	D	100	16	16	18		Stiff silty clay	W A M
1.5	2	SS	D	100	17	17	18			
2.3	3	SS	D	100	20	21	23		LWL	W M
3	4	SS	D	100	21	24	28			
4.5	5	SS	D	72	12	16	17		Stiff silty clay	
6	6	SS	D	66	10	10	11			
									End of borehole No. 15	
7.5										

unc. compr. str. (T/ft.2) 1 2 3 4 5 6 — W_P W W_L — CONE PENETRATION [ ] N – VALUE [ ] 10 20 30 40 50 60

SOIL SYMBOLS: SHATTERED BEDROCK, FILL, PEAT OR ORGANICS, CLAY, SILT, SAND, GRAVEL, BOULDER, SEA SHELLS, SOUND BEDROCK

SAMPLE CONDITION
D – DISTURBED
L – LOST
F – FAIR

SAMPLE TYPE
SS – SPLIT SPOON
TW – THIN WALL SHELBY
BS – BAG SAMPLE
WS – WASH SAMPLE

LABORATORY TEST SYMBOLS
A – ATTERBERG LIMITS
C – CONSOLIDATION
D – DENSITY
M – MECH. ANALYSIS
S – SHEAR
T – TRIAXIAL

OTHER SYMBOLS
WATER LEVEL

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