ROTATING BIOLOGICAL CONTACTORS
REVIEW

- SUSPENDED SOLIDS
- DISSOLVED SOLIDS
- SECONDARY TREATMENT
  - SETTLEABLE SOLIDS
SECONDARY TREATMENT

- WASTE TREATMENT PONDS
- TRICKLING FILTERS
- ROTATING BIOLOGICAL CONTACTORS (RBCs)
- ACTIVATED SLUDGE
RBCs ARE FAIRLY RECENT TECHNOLOGY- SINCE THE 1970's
OVER 6,000 ROTATING BIOLOGICAL CONTACTORS IN SERVICE

15,000 gpd to >30 MGD
TRICKLING FILTER vs RBC

WASTEWATER

TRICKLING FILTER
Wastewater is passed thru the media

RBC
Media is passed thru the wastewater
PRELIMINARY TREATMENT (SCREENS, GRIT REMOVAL) and PRIMARY TREATMENT SHOULD PRECEDE ROTATING BIOLOGICAL CONTACTORS TO PREVENT PROBLEMS WITH SOLIDS
DESCRIPTION OF AN RBC

• ROTATING SHAFT (UP TO 25 ft LONG)

• ROUND PLASTIC DISKS (USUALLY 12 ft DIAMETER)
MEDIA IS AVAILABLE AS STANDARD, MEDIUM OR HIGH DENSITY

A CONVENTIONAL RBC WITH STANDARD MEDIA, 25-ft LONG by 12-ft DIAMETER = >110,000 ft² of media surface area!

(high density >165,000 ft²)
COMBINATION OF SHAFT AND MEDIA IS CALLED A “DRUM”
40% of disk submerged

Wastewater

~1.5 rpm

AIR

SLIME GROWTH

USUALLY A “ONCE THRU” OPERATION—NO RECIRCULATION
DIRECTION OF FLOW

A. FLOW IS PARALLEL TO SHAFT

B. FLOW IS PERPENDICULAR TO THE SHAFT
BIOMASS THICKNESS RANGES FROM <1 to 3 mm
MAJOR PARTS OF AN RBC

CONCRETE OR STEEL TANK SHAPED TO CONFORM TO THE GENERAL SHAPE OF THE DISKS

This eliminates “DEAD SPOTS” where solids could settle and create odors
MAJOR PARTS OF AN RBC

Wastewater flow (1\textsuperscript{st} stage gets HIGHEST BOD load)

4 stages (separated by baffles)
MAJOR PARTS OF AN RBC

COVERED FOR PROTECTION
RBCs are covered to:

- Protect the slime from freezing
- Prevent the rain from washing off the slime
- Block sunlight to prevent algae growth and deterioration
- Protect the operator
SOME COVERS ARE COMPLETE BUILDINGS, OTHERS ARE SIMPLY FIBERGLASS COVERS SHAPED LIKE THE DRUMS
RBC DRIVE ASSEMBLIES

3 TYPES:

1. MOTOR & CHAIN DRIVE
RBC DRIVE ASSEMBLIES

3 TYPES:

1. MOTOR & CHAIN DRIVE
2. MOTOR W/ DIRECT SHAFT DRIVE
3. AIR DRIVE
AIR DRIVE

AIR FROM DIFFUSERS IS DIRECTED TO PLASTIC CUPS ON THE DRUMS CAUSING THEM TO TURN
RBC vs TRICKLING FILTERS

ADVANTAGES OF RBCs:

1. NO PROBLEMS WITH DISTRIBUTOR ARMS, SEALS, NOZZLES

2. NO PONDING

3. NO FILTER FLIES

4. COMPLETELY AEROBIC and BETTER DISTRIBUTION OF THE WASTEWATER OVER THE MEDIA
**RBC vs TRICKLING FILTERS**

**DISADVANTAGES OF RBCs:**

1. **RBCs ARE MORE SENSITIVE TO INDUSTRIAL WASTES**

2. **SOLIDS CAN SETTLE IN THE DRUM HOUSING CAUSING SEPTIC CONDITIONS, REDUCED TANK VOLUME, AND SCRAPE THE MEDIA (and possibly stall)**
RBCs and NITRIFICATION

In addition to removing the oxygen demand (BOD), RBCs are used to convert ammonia to nitrate.

\[
\text{NH}_3 + \text{O}_2 \xrightarrow{\text{Biomass}} \text{NO}_2 \xrightarrow{} \text{NO}_3
\]
RBC START-UP

PRE-START CHECKS:

- **TIGHTNESS** (ANCHOR BOLTS, MOUNTING STUDS, JACKING SCREWS, CHAINS, BELTS, MEDIA)

- **LUBRICATION** (MAINSHAFT BEARINGS, ROLLER CHAIN, SPEED REDUCER)
RBC START-UP

PRE-START CHECKS (con't)

• CLEARANCES: BETWEEN MEDIA and TANK WALL; BAFFLES; COVER; BETWEEN CHAIN CASING and MEDIA; SPROCKETS
START-UP PROCEDURE

✓ CHECK TEXT FOR DETAILS

1) START FOR 1/4 TURN, TURN OFF-LOCK OUT AND CHECK EVERYTHING

2) SWITCH ON POWER AND ROTATE FOR 15 min
START-UP PROCEDURE

✓ CHECK TEXT FOR DETAILS

3) SHUT OFF UNIT AND CHECK BEARING TEMPERATURES WITH A PYROMETER
WHAT'S A PYROMETER?

A SPECIAL THERMOMETER TO MEASURE HIGH TEMPERATURES
SOME PYROMETERS WORK ON OPTICS, OTHERS ON RADIATION and COLORS,
The temperature of the outer housing of the shaft bearing should not exceed 200°F.
BIOMASS DEVELOPMENT

1. REGULATE THE RATE AND STRENGTH OF THE WASTEWATER AND RECIRCULATE IF POSSIBLE

2. MAINTAIN TEMPERATURES AROUND 65°F (or higher). SLIME IS LESS ACTIVE IN COLD WEATHER SO TAKES LONGER TO DEVELOP
3. BEST ROTATION SPEED (rpm) WILL SHEAR OFF BIOMASS GROWTH AND PROVIDE A “HUNGRY AND REPRODUCTIVE” FILM

4. ALLOW 1 to 2 WEEKS FOR FULL DEVELOPMENT
BIOMASS DEVELOPMENT

- EXPECT EXCESSIVE SLOUGHING THE FIRST WEEK

BEST GROWTH IS:

- UNIFORM
- SHAGGY BROWN to GRAY
- FEW or NO BARE SPOTS
RBC OPERATION

INSPECTING EQUIPMENT

1. SHAFT BEARING TEMP (<200°F)

USE A PYROMETER
RBC OPERATION

INSPECTING EQUIPMENT

2. CHECK FOR PROPER LUBRICATION OF SHAFT BEARINGS
RBC OPERATION

INSPECTING EQUIPMENT

3. PROPER SHAFT ALIGNMENT and BELT TENSIONS
RBC OPERATION

INSPECTING EQUIPMENT

4. LISTEN FOR UNUSUAL NOISES
RBC OPERATION

INSPECTING EQUIPMENT

5. FEEL MOTORS TO DETERMINE IF THEY ARE RUNNING HOT!
RBC OPERATION

INSPECTING EQUIPMENT

6. LOOK FOR OIL SPILLS, CHECK OIL LEVELS IN SPEED REDUCERS, and INSPECT FOR WORN OUT GASKETS or SEALS
INSPECTING EQUIPMENT

7. CHECK PROTECTIVE GUARDS AND CLEAN UP SPILLS, MESSES OR DEBRIS
RBC OPERATION

SAMPLING & ANALYSIS

ROUTinely CHECK (as NPDES PERMIT REQUIRES):

• BOD and TOTAL SUSPENDED SOLIDS (24-hr COMPOSITE)

• DISSOLVED OXYGEN and pH (GRAB SAMPLES)
RBC OPERATION

DISSOLVED OXYGEN:

0.5 to 1.0 mg/L (1st stage)

1 to 3 mg/L (4th stage)

D.O. VARIES, DEPENDING ON TREATMENT OBJECTIVE: BOD REMOVAL OR NITRIFICATION
EFFLUENT QUALITY

BOD, TSS, AMMONIA (NH₃), AND NITRATE (NO₃) WILL INCREASE WITH:

• INCREASED FLOW
  (DECREASE IN CONTACT TIME WITH BIOMASS)

• INCREASED INFLUENT CONCENTRATIONS
REMOVAL EFFICIENCIES

BOD  80 to 95%
WHAT IF REMOVAL EFFICIENCY DECREASES?

✓ CHECK FOR:

• REDUCED WASTEWATER TEMPERATURE

• UNUSUAL VARIATIONS IN FLOW, ORGANIC LOADING (BOD), OR BOTH

• HIGH or LOW pH VALUES (<6.5 or >8.5)
RBC OPERATION

SAMPLING & ANALYSIS

WASTEWATER TEMPERATURE:

Less than 55°F → REDUCTION IN BIOLOGICAL ACTIVITY WITH CORRESPONDING REDUCTION IN BOD REMOVAL

NOT MUCH AN OPERATOR CAN DO
RBC OPERATION

INFLUENT VARIATIONS:

- LESS THAN 3 TIMES THE DAILY AVERAGE FLOW WILL HAVE LITTLE EFFECT

- FOR SEVER ORGANIC OVERLOAD, REMOVE THE BAFFLE BETWEEN FIRST TWO STAGES
RBC OPERATION

\(pH\) (optimum: 6.5 to 8.5)

Can adjust by pre-aeration or chemical addition.
TOO LOW? ADD SODIUM BICARBONATE or LIME

TOO HIGH? ADD ACETIC ACID

BE SURE TO WEAR SAFETY EQUIP.
RBC OPERATION

$pH$ DURING NITRIFICATION
(optimum: 8.4)

$pH$ and **ALKALINITY** CRITICAL FOR NITRIFICATION

RECALL: **ALKALINITY** IS A MEASURE OF THE WATER’S ABILITY TO NEUTRALIZE ACIDS (MEASURED AS $CaCO_3$)
**NITRIFICATION**

**CONVERTING AMMONIA (NH₃) TO NITRATE (NO₃)**

- pH as close to 8.4 as possible
- ALKALINITY SHOULD BE AT LEAST 7.1 TIMES THE AMMONIA CONCENTRATION
- SODIUM BICARBONATE IS USED TO INCREASE THE ALKALINITY and THE pH
NITRIFICATION EXAMPLE

THE INFLUENT TO THE RBC HAS AN AMMONIA CONCENTRATION OF 12 mg/L and an ALKALINITY OF 137 mg/L. WILL YOU HAVE TO ADD ADDITIONAL ALKALINITY FOR NITRIFICATION?
WHAT ABOUT DIGESTER SUPERNATANT?
DIGESTER SUPERNATANT

Can cause problems from high suspended solids and low pH.

- **High solids**: return during low flows (more contact time)
- **Low pH**: return during during high flows (for dilution and neutralization)
WATCH THE MEDIA!

GOOD OPERATION:
BIOMASS IS **SHAGGY** WITH UNIFORM COVERAGE; **BROWN**-to-GRAY COLOR; NO ALGAE PRESENT; NON-OFFENSIVE ODOR
WATCH THE MEDIA!

BLACK APPEARANCE (WITH ODORS)

• PROBABLY A BOD OR SOLIDS OVERLOAD

• LIKELY WILL HAVE LOW DISSOLVED OXYGEN IN THE EFFLUENT
WATCH THE MEDIA!

BLACK APPEARANCE (WITH ODORS)

CORRECTIVE ACTIONS

• PLACE ANOTHER RBC IN SERVICE
• PRE-AERATE THE RBC's INFLUENT
• CHECK PRIMARY CLARIFIER AND DIGESTER OPERATION
WATCH THE MEDIA!

**WHITE APPEARANCE**

MAY BE CAUSED BY:

- HIGH LOADING CONDITIONS
- INDUSTRIAL DISCHARGES WITH **SULFUR** COMPOUNDS
WATCH THE MEDIA!

WHITE APPEARANCE

CORRECTIVE ACTIONS

• PLACE ANOTHER RBC IN SERVICE

• PRE-AERATE THE INFLUENT

  • REMOVE BAFFLE BETWEEN FIRST TWO STAGES DURING OVERLOAD
WATCH THE MEDIA!

WHITE APPEARANCE

CORRECTIVE ACTIONS (con’t)

• PRE-CHLORINATE TO CONTROL SULFUR LOVING BACTERIA

• DRAIN DRUM HOUSING AND CLEAN OUT ANY BUILT-UP SLUDGE BELOW THE DRUM
WATCH THE MEDIA!

SEVER SLOUGHING

MAY BE CAUSED BY TOXIC or INHIBITORY SUBSTANCES

• LOCATE AND ELIMINATE THE SOURCE OF THE TOXICS

• DILUTE, CONTROL INFLOW TO PLANT, or RECYCLE EFFLUENT
WATCH THE MEDIA!

SEVER SLOUGHING (con’t)

IF CAUSED BY FLOW/LOADING VARIATIONS:

• THROTTLE PLANT INFLUENT

• RECYCLE SECONDARY CLARIFIER OR RBC EFFLUENT

• TRY TO MAINTAIN A HYDRAULIC LOADING OF 1 to 1.5 gpd/ft²
TROUBLESHOOTING

SEE TABLE 7.2, PAGE 230 IN YOUR TEXT
1. HIGH or LOW FLOWS
2. HIGH or LOW ORGANIC LOADINGS

REFER TO TABLE 7.2 IN TEXT
ABNORMAL OPERATIONS

3. POWER OUTAGES

• IF LESS THAN 4 hrs: NO SPECIAL ACTION

IF GREATER THAN 4 hrs:

a. TURN OFF-LOCK OUT POWER

B. TURN SHAFT \( \frac{1}{4} \) TURN EVERY 4 hrs

C. GENTLY SPRAY THE EXPOSED BIOMASS TO KEEP MOIST
SAFETY

BE CAREFULL WITH "SLOW MOVING EQUIPMENT" and SLIPPERY SURFACES

PRACTICE GOOD PERSONAL HYGIENE (wash hands regularly)
NUTRIENT REQUIREMENTS for BIOMASS

TO PROPERLY GROW AND TREAT WASTEWATER, BIOMASS NEEDS:

• CARBON (SOURCE IS THE BOD)
• NITROGEN (SOURCE IS NH₃)
• PHOSPHORUS (SOURCE IS PO₄)
NUTRIENT REQUIREMENTS for BIOMASS

KNOWN AS THE “CNP” RATIO and is expressed as C:N:P

FOR ATTACHED GROWTH SYSTEMS (i.e. trickling filters and RBCs), the CNP ratio is:

100:5:1
NUTRIENT REQUIREMENTS for BIOMASS

CNP = 100:5:1 means:

It takes 100 pounds of Carbon (BOD), 5 pounds of Nitrogen (Ammonia), and 1 pound of Phosphates

For proper biomass growth
NUTRIENT REQUIREMENTS for BIOMASS

DOMESTIC WASTEWATER (SEWAGE) HAS A PROPER BLEND OF NUTRIENTS FOR GOOD GROWTH

INDUSTRIAL WASTEWATER OFTEN LACKS NUTRIENTS---SO, C, N or P MUST BE ADDED TO GET GOOD TREATMENT
LOADING CALCULATIONS

ORGANIC LOADINGS ARE BASED ON “SOLUBLE BOD”

ORGANIC LOADING = lbs SOLUBLE BOD per day per 1000 ft² of MEDIA

SOLUBLE BOD IS MEASURED ON FILTERED WASTEWATER
BOD REVIEW:

SAMPLE OF FILTERED WASTEWATER IS STORED IN BOD BOTTLES FOR 5 days at 20°C. DISSOLVED OXYGEN IS MEASURED AT THE BEGINNING AND THE END TO DETERMINE THE OXYGEN DEMAND.
“BOD” REVIEW
EXAMPLE: BOD = 300 mg/L

RAW

100 mg/L SOLUBLE
100 mg/L SUSPENDED
100 mg/L SETTLEABLE

AFTER PRIMARY SETTLING

100 mg/L SOLUBLE
100 mg/L SUSPENDED
ESTIMATING SOLUBLE BOD

SOLUBLE BOD CAN BE ESTIMATED ON THE BASIS OF TOTAL BOD AND SUSPENDED SOLIDS (TSS)

SOLUBLE BOD, mg/L =
TOTAL BOD, mg/L - (K x TSS, mg/L)

Where K = 0.5-0.7 (for sewage)
EXAMPLE:

AN RBC RECEIVES AN INFLUENT BOD of 220 mg/L and 230 mg/L SUSPENDED SOLIDS. WHAT IS THE ESTIMATED SOLUBLE BOD IN THIS WASTEWATER?

SOLUBLE BOD, mg/L =

220 mg/L - (0.5 \times 230 mg/L) =

220 mg/L - 115 mg/L = 105 mg/L
WHAT IS THE ORGANIC LOADING FOR THE FOLLOWING RBC?

- FLOW = 2.5 MGD
- SOLUBLE BOD = 115 mg/L
- MEDIA SURFACE AREA = 800,000 ft²
ORGANIC LOADING =

\[
115 \text{ mg/L} \times 2.5 \text{ MGD} \times 8.34 \frac{\# \text{ -L}}{\text{mg-Mgal}} \times \frac{800,000 \text{ ft}^2}{1000}
\]

= 3 lbs BOD per day/1000 ft²
HYDRAULIC LOADING

HYDRAULIC LOADING IS:

GALLONS per DAY/FT² of MEDIA

WHAT IS THE HYDRAULIC LOADING FOR THE PREVIOUS EXAMPLE?

2,500,000 gpd/800,000 ft² = 3.1 gpd/ft²
TYPICAL LOADING RATES

HYDRAULIC LOADING

BOD REMOVAL                     1.5 - 6 GPD/ft²
NITROGEN REMOVAL                1.5 - 1.8 GPD/ft²

ORGANIC LOADING

SOLUBLE BOD                     2.5 - 4 lbs BOD/day/1000 ft²
TOTAL BOD                       6 - 8 " " " " 