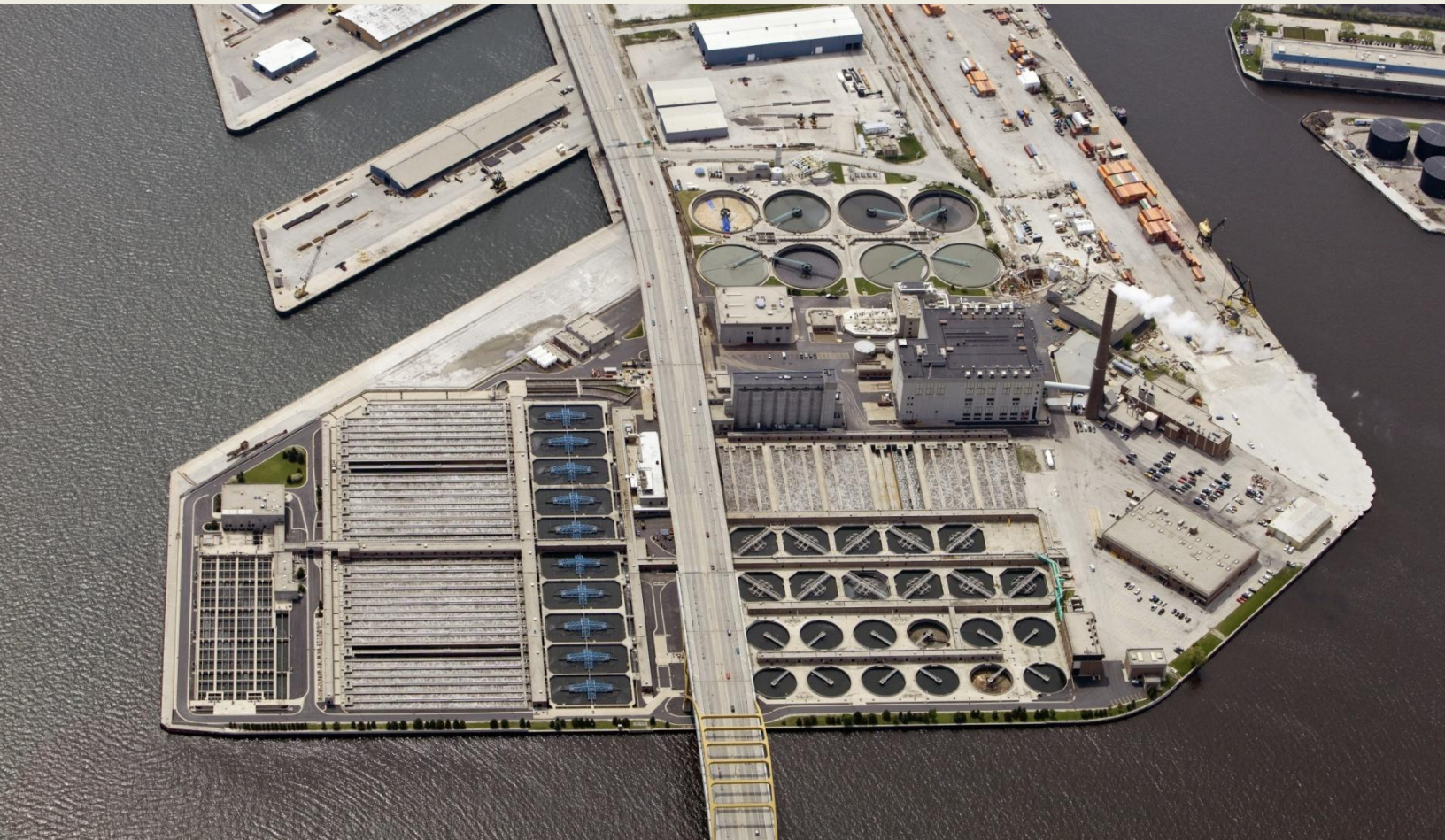
Tools and Procedures for Optimum Performance
Wastewater Process Control



Introduction

These procedures and control tests are intended to assist the operator in understanding, maintaining and adjusting the activated sludge process.

Accepted by industry for over 40 years and backed by scientific research, these procedures and control tests will provide reliable information to support the operational adjustments of Return Activated Sludge Flow and Waste Activated Sludge Flow. And in doing so, the operator will gain a more intimate knowledge of the wastewater treatment process.

Raven's products are designed to perform the control tests contained in the following manuals published by US EPA and Water Environment Federation (formerly Water Pollution Control Federation):

Operational Control Procedures for the Activated Sludge Process
Alfred W. West, P.E., Chief Operational Technology Branch US EPA

Activated Sludge Manual of Practice OM-9, 1st Edition
Water Environment Federation

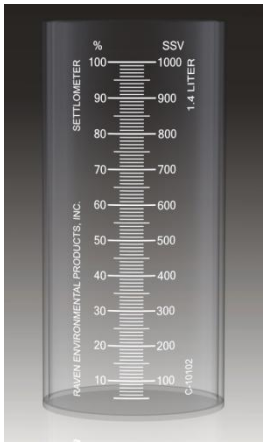
"These operational control procedures were developed to help activated sludge plant operators satisfy all significant interrelated process requirements simultaneously. Information provided by simple control tests reveal the coordinated control adjustments needed to maintain or restore optimum process balance, sludge quality and final effluent quality.

Alfred W. West, PE, Chief Operational Technology Branch

Knowledge and Tools

With a good understanding of the activated sludge process and the proper tools you will have better operators and better effluent.

Centrifuge spins samples from strategic points in the process to show solids concentrations in just 15 minutes. A workhorse in the industry since 1983.



Settlometer shows settling quality of sludge as if it were in the secondary clarifier. A simple but powerful tool when used properly.

CORETAKER® sludge core sampler extracts the samples for the centrifuge spin and shows sludge blanket height and sludge color. Tubes lock together to form a 16 foot durable polycarbonate sampler. Lifetime Break-Free Guarantee.

These tools combined with Raven's complete Process Control Manual make up the Process Control Package.

Key Point

Operator turnover

It's hard enough attracting good people to work at a sewage treatment plant; and even harder keeping the good ones to make a career of it.

Raven provides a hands-on approach to understanding and controlling the activated sludge process. Operators will learn to appreciate the importance of what they do and feel empowered as they begin to control the process.

And that leads to more job satisfaction and less turnover.

Return Activated Sludge (RAS)

RAS is the continual process of returning concentrated sludge from the bottom of the secondary clarifier to the oxygen and nutrient rich environment of the aeration tank.

"RAS is about keeping the right amount of sludge in the right tank for the right amount of time."
Lynn Marshall
Trainer, former US EPA, contributing author WEF Activated Sludge Manual of Practice 1st Edition

At each step in the process, sludge has a different purpose. The RAS flow rate has a direct impact on the ability of sludge to perform that purpose.

Aerator Tank – Sludge consumes pollutants (food) and reproduces rapidly.

- **Sludge Quantity**
  Excess sludge in the aerator creates an environment where sludge must compete for food. Filamentous sludge, undesirable in large quantities, will out-compete regular floc sludge for food. This usually occurs when the Return rate is too high or the Wasting rate is too low.

  A shortage of sludge in the aerator creates an environment where the incoming pollutants (food) outnumber the sludge available to consume the food. Pollutants are sent to the clarifier before being consumed in the aerator. In the clarifier, sludge will continue to consume pollutants but at a significantly reduced rate.

- **Detention Time**
  Sludge needs to stay in the aerator long enough to benefit from the oxygen, consume food and reproduce young healthy sludge. At the appropriate rate of flow the sludge is sent to the secondary clarifier where it has a completely different purpose.

Secondary Clarifier – Sludge settles and concentrates at the bottom trapping suspended solids along the way.

- **Sludge Quantity**
  Excess sludge in the clarifier creates an environment where compacted sludge may become septic (rotting bacteria) due to the anaerobic conditions (lack of oxygen) within the sludge blanket. The buildup of sludge in the clarifier may cause a shortage of sludge in the aerator.

  A lack of compacted sludge in the clarifier is usually caused by excessively high return rates. Sludge is not permitted to concentrate at the bottom of the tank and likely remains suspended due to the turbulence in the clarifier caused by high flows through the tank. Excess wasting of sludge will create a shortage of sludge in the entire system.

- **Detention Time**
  The type of sludge determines how long it should remain in the clarifier. Sludge is categorized by the speed in which it settles – Rapid, Normal or Slow. The goal is to have Normal settling sludge. To achieve Normal settling sludge, the first step is to adjust the RAS flow rate to match the type of sludge currently in the system. The second step is to adjust the waste flow rate to manage the amount of sludge and how long it remains in the system.

Key Point

Sludge Settling Quality

Identifying the type of the sludge using the Settlometer is the first step in optimizing return sludge flow rates. If sludge always settled properly, balancing between the aeration tank and the clarifier would be simple. But sludge reacts to its environment and settles differently when circumstances change. It is critical to know how the sludge is settling so that return flow rates can be adjusted to deal with the sludge's settling quality.

"In well designed secondary clarifiers, sludge settleability is the single most important factor affecting clarifier capacity and performance."
Griborio et al (2009)

Waste Activated Sludge (WAS)

WAS is the continual process of removing excess sludge from the system in order to balance the amount of sludge (bacteria) with food (pollutants). Managing wasting rates based on the quantity and age of sludge is a powerful process control for optimizing plant performance. This method is commonly referred to as Mean Cell Residence Time (MCRT).

"The wasting of sludge affects the process more than any other process control adjustment."
Activated sludge Manual of Practice OM9 – 1st Edition Water Environment Federation

Sludge is the lifeblood of the treatment plant. Wasting sludge from the system should be a routine process. But such a powerful tool should only be used with a proven scientific method.

Sludge Quantity and Age

Measuring the amount of sludge in the secondary activated system is simple using the Centrifuge and Coretaker®. With the amount of sludge known, the operator can control how long it stays in the system. The impact of small adjustments to the amount being wasted can be verified to make sure the plant is staying on course. A single day adjustment in sludge age takes two days to notice a change in quantity and quality of sludge. Adjustments to waste sludge rates take longer to verify than do adjustments to return sludge rates.

The age of the sludge is constantly changing. To manage the age of the sludge, a certain amount is wasted at regular intervals. As a result, the average age of the sludge population can be controlled. Calculating the amount to waste is based on a simple formula:

Total Sludge in the System ÷ Desired Age of Sludge in Days = Sludge to Waste Daily

For example, a plant wants an average sludge age of 10 days. Spinning samples from the aerator and the secondary clarifier in the Centrifuge provides the percentage of solids concentration in each tank. Multiplying the percentage of solids by the volume of the tank yields the amount of solids in the tank. The formula above becomes:

(Total Aerator Solids + Total Clarifier Solids) ÷ 10 Days = Sludge to Waste Daily

The Centrifuge works with a unit of measure called a Sludge Unit (SU). This is a measure of how much the sludge concentrates in the centrifuge tube. The Sludge Unit overcomes the issues of measuring volume of sludges with different characteristics. It does not matter if the sludge is light and fluffy or tight and grainy, they will concentrate in the centrifuge tube. The formula now becomes:

Aerator Sludge Units (ASU) + Clarifier Sludge Units (CSU) ÷ 10 Days = Waste Sludge Units (WSU)

Finally, Waste Sludge Units is converted to gallons to be meaningful for flow rates as follows:

WSU ÷ Waste Sludge Concentration (WSC) = Gallons to Waste Daily

Key Point

Adjustments to the rate of wasting should be made in small increments. No more than 10% increase or decrease per day and limited to a total of 20% net in a week. Waste rate adjustments should be small and frequent.

Centrifuge Use and Application

Centrifuge Basics

Tubes filled with a sample are spun at high speed to separate the liquid from the solids. Solids are concentrated into the bottom to the tube. The amount of solids in the bottom of the tube represents the "Percent of Solids" of the sample. Fifteen minutes is all it takes to determine solids concentrations that are used for return and waste sludge flow rates. For daily process control, Concentrations can also be easily correlated to MLTSS using the **Weight to Concentration Ratio** (WCR) formula:

MLTSS / ATC = WCR. Where MLTSS is mixed liquor total suspended solids and ATC is aeration tank concentration obtained from the centrifuge 15 minute spin. In other words, the Weight is the MLTSS and the Concentration is the % solids in the centrifuge tube. For example, 4000 mg/l MLTSS and a 5% reading on the centrifuge tube equates to 4000/5 = 800 WCR. (your denominator can be expressed in a whole number, 5, or a decimal .05. Just maintain consistency with every calculation.) This 800 WCR is now correlated to the MLTSS and can be used as a reference for daily centrifuge spins. For example, if 20 days later a spin results in 7% ATC in the tube, it can be reasonably inferred that the MLTSS would be our baseline WCR of 800 X 7 = 5600 mg/l. Consider starting each month with a new WCR determination. This requires one aeration tank sample to perform both the MLTSS and the baseline Aeration Tank Concentration. Spinning samples for 15 minutes is much easier and faster than performing the MLTSS procedure, so it makes sense to spin for daily process control. A simple worksheet will calculate this and allow keen operators to spot trends. How would you interpret this increase just 20 days after your monthly baseline WCR?

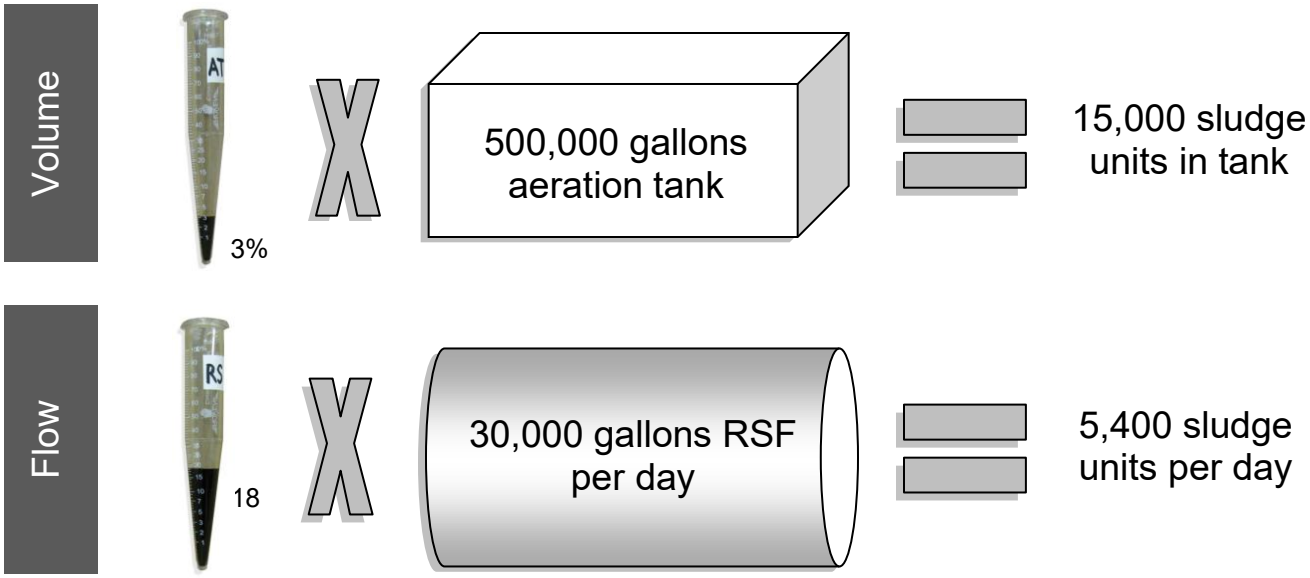
Source of Sample	Name of Sample	Symbol	Location of Sample	Tool
Aeration Tank	Aeration Tank Concentration	ATC	discharge flume	Mini Dipper
Clarifier - Secondary	Clarifier Sludge Concentration	CSC	1/3 from sidewall	CORETAKER®
Return Sludge	Return Sludge Concentration	RSC	return sludge line	Mini Dipper
Waste Sludge	Waste Sludge Concentration	WSC	waste sludge line	Mini Dipper

Application to Wastewater Process Control

The Percent of Solids shown on the centrifuge tube is the basis for calculating the amount of sludge in a given tank or flowing through a pipe. The unit of measure is called a Sludge Unit (SU).

Number of Sludge Units in Tank = Percent of Solids x Tank Volume

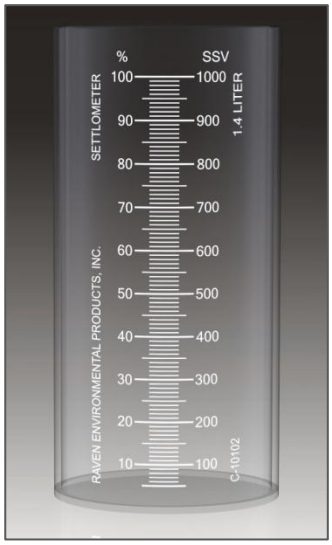
Number of Sludge Units in Flow = Percent of Solids x Gallons of Flow Per Day



Settlometer Use and Application

Settlometer Basics

The Settlometer shows the solids liquid separation capability in the secondary clarifier. Sludge must separate from the liquid for settling to occur. Settling of sludge in the clarifier is a critical part of the activated sludge process. Poorly settling sludge is a strong indication of process problems and solids loss in final effluent.



The scale printed on the Settlometer measures how far a sample has settled. "SSV" is the abbreviation for Settled Sludge Volume. "%" shows the settled sludge volume as a percentage of the entire sample.

Use of Settlometer (C-10202)

Worksheet

Have the Process Control Worksheet ready to record settling progress.

Gather Sample

Collect sample from the aeration tank effluent to fill the Settlometer to 100% and transport immediately for testing indoors or out of direct sunlight. Use lid to prevent spillage.

Mix Sample

Using the wide paddle, gently mix back and forth until sample is thoroughly mixed. Leave paddle in Settlometer briefly to help calm any turbulence. Remove paddle.

Begin Timing

The first five minutes of settling is very informative. If the sludge doesn't settle to 800 or less in five minutes, the operator can be sure that separation in the clarifier is failing. Record the SSV at each time interval on the worksheet.

Observe Settling Characteristics

Normal sludge forms a floc and gently squeezes the water out of the blanket forming on the bottom. Normal sludge settles between 800 and 700 in five minutes.

Rapid sludge settles like dark grains of sand leaving behind a turbid supernatant with suspended solids. Rapid sludge settles to 700 or less in five minutes.

Slow sludge appears to be stuck in the settling process with little or no progress but with very clear supernatant. Slow sludge does not settle to 800 in five minutes. Perform the Multi-Dilution test to determine if slow settling is caused by density or concentration. See Troubleshooting Slow Sludge below.

Troubleshooting Slow Sludge

Slow settling sludge can be caused by high density sludge or high concentrations of sludge. The Multi-Dilution Test is perfomed with two Settlometers.

Multi-Dilution Test

One Settlometer is filled to 100% with aeration tank mixed liquor. The second Settlometer is filled 50% with mixed liquor and 50% with final effluent.

Density Issue

Settlometer on left at 50% dilution.

Settlometer on right not diluted.

Even with dilution, the unit on the left fails to settle. Indication of filaments.

Concentration Issue

Settlometer on left at 50% dilution.

Settlometer on right not diluted.

The greater the difference in the first 2 minutes, the more likely there is too much sludge in the aeration tank.

Diluted settlometer settles properly.

Application to Process Control

- Settling – Rapid, Normal or Slow.
- SSV is used in calculating return sludge flow rates.
- Troubleshooting settling problems to determine a density or a concentration issue.
- Timing when denitrification occurs and sludge rises to surface.

CORETAKER® Use and Application

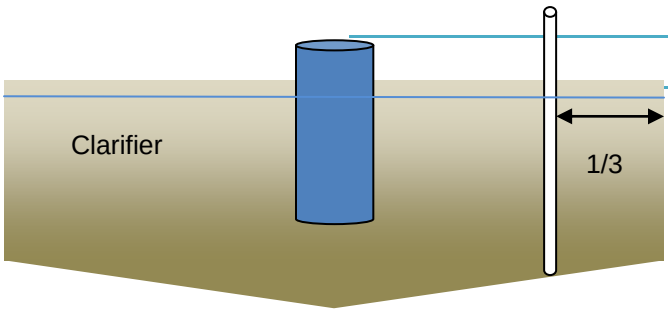
CORETAKER® (B-10104)

CORETAKER® shows the operator a cross section of the clarifier from top to bottom. An automatic check valve allows liquid to enter while being lowered into the tank. The valve automatically shuts when the unit is raised from the tank. The settled sludge blanket is measured and examined for color. The contents can be purged into a bucket for measuring sludge concentration with the Centrifuge.

Use of CORETAKER®

Sample Location

1/3 of the distance from the clarifier side wall to the center. This same location should be used every time a core sample is taken. Mark this spot on the railing for all operators to use.



Lowering into the Tank

Too fast of a rate will distort the sample inside the tube. The sludge blanket will be much lower than actual. The proper rate to lower CORETAKER® to tank bottom is about one foot per second. Do not bounce the check valve on the tank bottom.

Raising from the Tank

Raise the unit smoothly from the tank to vertical position and examine its contents. Start and stop movements can distort the sample.

Examine Contents

Note how high the sludge blanket rises in the bottom tube. Examine color of settled sludge. Dark sludge may indicate old age while light sludge may indicate young age. Note the nature of the interface of the sludge and the supernatant. Is there a ragged edge or a well defined straight edge? Note clarity of liquid above the settled sludge. Is it turbid or clear?

Save the Sample

The sample in the CORETAKER® is valuable because it is representative of the tank from top to bottom. Purge it into a bucket for concentration measurement in the Centrifuge.

Application to Process Control

- Primary and secondary clarifier sludge blanket thickness and color
- Retrieving samples from secondary clarifiers to measure Clarifier Sludge Concentration (CSC)
- Calculate sludge inventory, detention time and return sludge flow adjustments

Sludge Interface Detector

SID-20200

Measure Sludge Level Quickly and Accurately

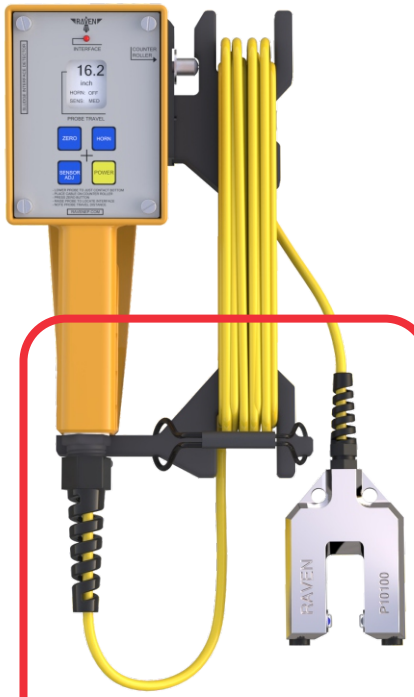
SID-20200
REPLACES
SID-10200
EFFECTIVE
MARCH 2022

NEW FOR 2022

DIGITAL CONTROLLER
displays sludge/solids level

COUNTER ROLLER
measures sludge level

- LOWER PROBE TO TANK BOTTOM
- PLACE CABLE ON COUNTER ROLLER
- PRESS ZERO
- RAISE PROBE UNTIL LIGHT AND/OR HORN SOUNDS
- NOTE PROBE TRAVEL DISTANCE



INFRARED PROBE
stainless steel

COUNTER ROLLER	DIGITAL CONTROLLER	BACKLIT DISPLAY
SENSITIVITY SETTINGS	NO CALIBRATION NEEDED	RED LED / HORN SIGNAL
STRAIN RELIEVED CABLE 20 FT & 30 FT STANDARD	IP66 WEATHERPROOF YELLOW ENCLOSURE	IP68 WATERPROOF PROBE
IP68 WATERPROOF SIGNAL CABLE	3 AAA BATTERIES	1 YR WARRANTY MADE IN USA

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Raven Environmental Products Inc.
St. Louis, MO 63122
314-822-1197
ravenep.com