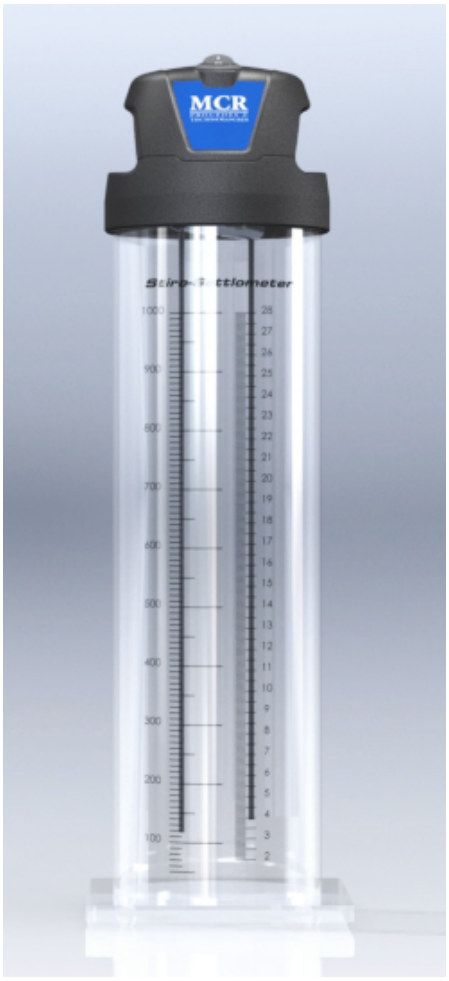

STIRO-SETTLOMETER

User manual

MCR
PROCÉDÉS & TECHNOLOGIES

Dear Customer,

Thank you for purchasing the ***STIRO-SETTLOMETER***. We want to make sure that you received the instrument in good shape and that you do not have any problems with the initial operation.

After many years of process follow-up and troubleshooting in collaboration with wastewater treatment plant operators, ***MCR Process & Technology*** has developed new tools to assist operators in their daily tasks. The Stiro-Settlometer is one of these tools, and was designed to meet a need for a more representative test, or measure, for evaluating sludge settleability in secondary clarifiers.

We hope you will be pleased with the operation and performance of your new instrument. If you have any problems related to the operation or questions about the instrument, call us at 1-418-650-9154 #221.

Thank you for letting us be of service to you.

Sincerely,

Alain Durocher, Eng.
President

MCR Process & Technologies
1328 rue Provancher, Bur. 100
Quebec (Qc) G1Y 1R6

CONTENTS

Figures

Tables

1 INTRODUCTION

The ***STIRO-SETTLOMETER*** is a laboratory equipment inspired by the method and specifications given in the Standard Methods 2710C for the evaluation of the sludge settleability. From the laboratory results it is then possible to calculate the SSVI (stirred sludge volume index), the ZSV (zone settling velocity) and the SVI (sludge volume index).

It consists of a motor, mounted on a 2-litre cylinder, which actuates a low speed 1 rpm stirring mechanism. This mechanism limits the interferences associated with floc bridging and wall effects.

Comparing SSVI results obtained using the ***STIRO-SETTLOMETER*** with the SVI test (without stirring) can reveal the importance of filamentous bridging on sludge settleability, a bad floc formation or the presence of a non-filamentous bulking effect. The result of this test can help the operator define the process strategy to eliminate a bulking situation.

2 SHIPPING INSPECTION

At the reception, inspect the contents to ensure that no damage occurred during shipment. If damage is present, save shipping box in case a damage claim is necessary. Any damage in shipment should be reported immediately.

At the reception check the following items:

- Content of the shipment is as required per your order;
    - 1 Stiro-settlometer with:
        - 1 rpm electric motor;
        - Stirring rods;
        - Graduated scales for SSVI and ZSV,
        - 2X 2L acrylic cylinders (for the kit) or 1 X 2L acrylic cylinders (for the SSVI unit alone).
    - Power supply (transfo 24 Volts)
    - Options if bought

A French version of this manual as the test data sheet are available on our website.

Thereafter, check the following items:

- Water tightness between the cylinder and the base;
- Rods gap (around 1/8" or 0,3 cm from wall. Adjust if necessary);
- Motor is working.

3 DO'S AND DON'TS

3.1 Do's

- Do read the instruction manual completely before using the instrument;
- Handle the equipment with care;
- Always use this equipment indoor;
- Remove power before any manipulation of the apparatus or cleaning operations;
- To prevent any damage to the agitation mechanism, it is important to adjust the rods' position. Rods friction on the cylinder wall could increase load on the motor and be a problem. The proper rods' position is around 1/8'' (0,3 cm) from the cylinder wall;
- Use only non-abrasive cleaners for plastics;
- Only use with mixed liquor from activated sludge system at MLSS of 5000 mg/L or less.

3.2 Don'ts

- Do not submerge this equipment;
- Do not use with viscous liquid or over 6% sludge solids consistency as this could damage the agitation mechanism and motor;
- Do not rinse or clean the equipment with water over 35°C. Hot water may cause damage to the plexiglass and graduated scales finish and can loosen the cylinder joints.

4 PART IDENTIFICATION

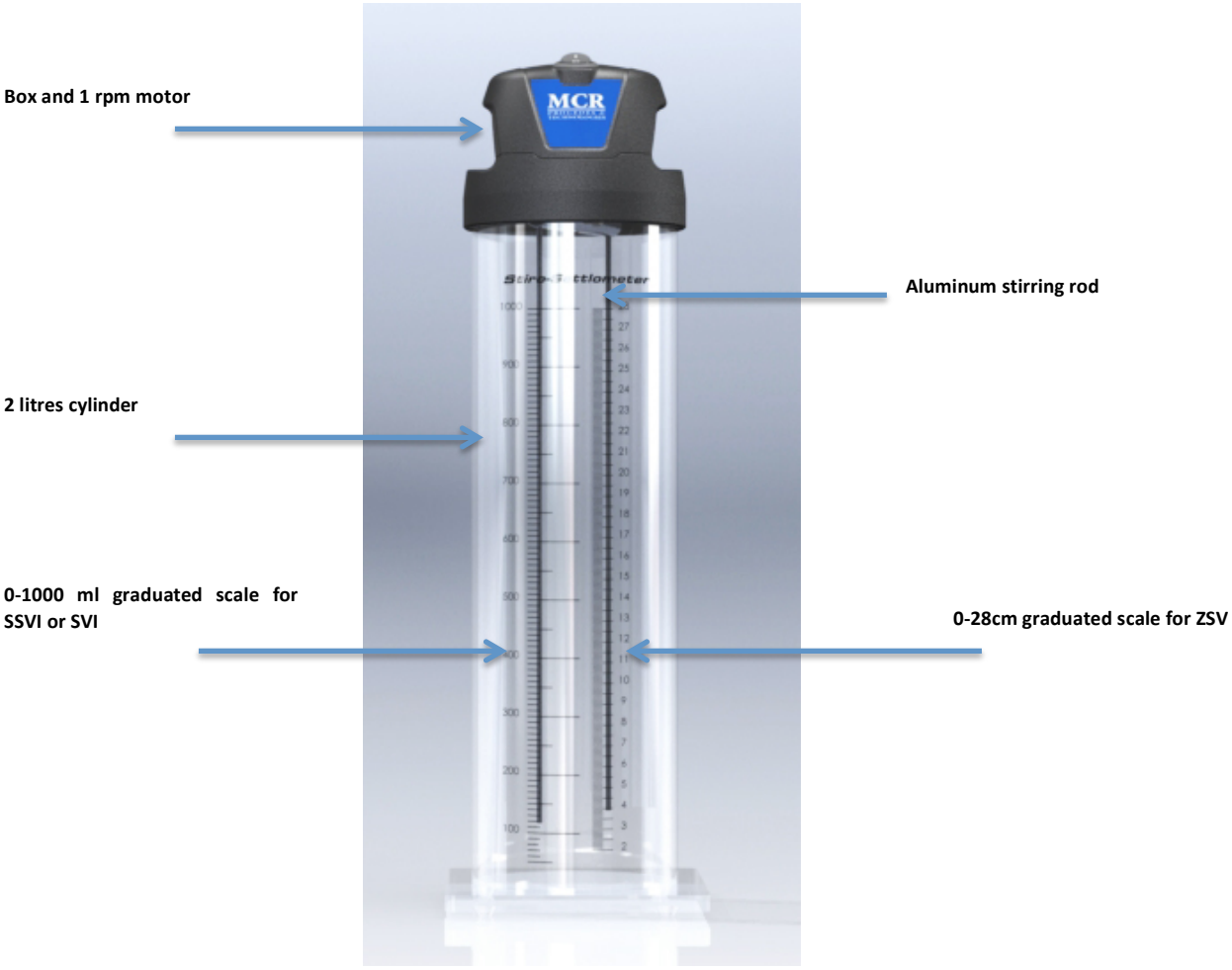

Figure 4.1 : Stiro-settlometer parts

5 TECHNICAL INFORMATION

5.1 General

After many years of process follow-up and troubleshooting in collaboration with wastewater treatment plant operators, MCR Process & Technology has developed new tools to assist operators in their daily tasks. The *STIRO-SETTLOMETER* is one of these tools, and was designed to meet a need for a more representative test, or measure, for evaluating sludge settleability in secondary clarifiers.

5.2 Sludge settleability tests

The 30-minute sludge settleability test is one of the most important measures used to qualify the settling characteristics of suspended-growth activated-sludge solids.

Using the test results, we can calculate two essential process parameters: the stirred sludge volume index (SSVI) and the zone settling velocity (ZSV). Those two parameters describe the sludge settling curve.

Figure 5.1 shows that the SSVI alone is not enough to qualify the sludge settling characteristics. For instance, two samples from the sample plant at different moments may have the same SVI value after 30 minutes, but completely different settling curves.

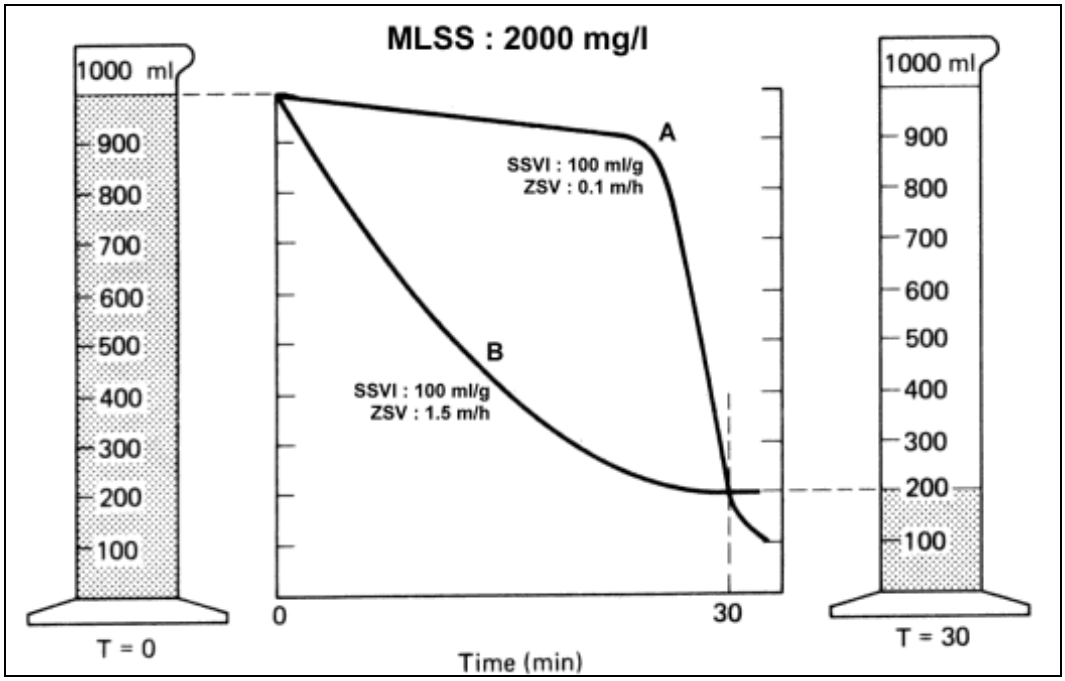

Figure 5.1 : Example of settling curves

Looking at the two curves presented in Figure 5.1, we can see that the initial settling rate for sample “A” is slower than the one measured for sample “B.” The initial settling rate is evaluated by calculating the slope of the first part of theses curves. These results will complete the information on sludge settleability.

For instance, the calculated SSVI for samples “A” and “B” is 100 ml/g, the calculated ZSV is 0.1 m/h for sample ”A” and 1.5 m/h for sample "B". The behaviour of these sludge in the secondary clarifier will be very different.

By tracking the variation of these two parameters over time in relation with sludge depth in the secondary clarifier (Figure 5.2), the operator is in position to improve his prevention strategy.

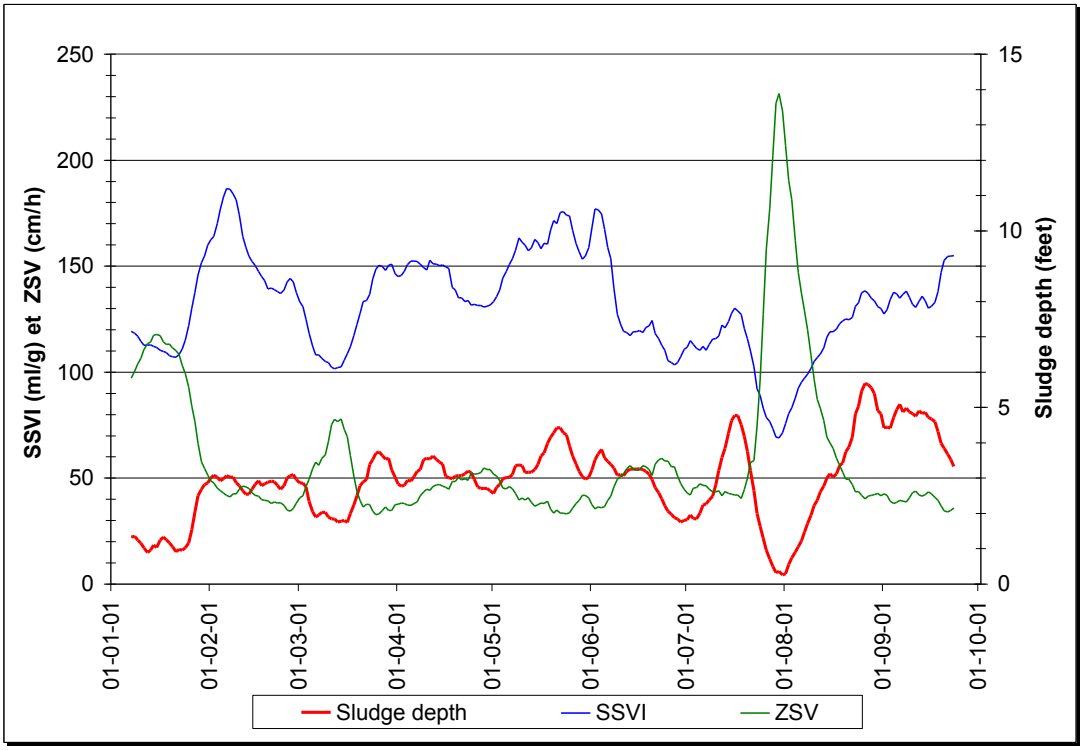

Figure 5.2 : Example of SSVI, ZSV and sludge depth survey

5.3 Existing methods of analysis

There are several methods for measuring the settleability of a sludge sample. In the past, the procedure consisted of pouring a 1,000 ml sample in a 1-L classical graduated cylinder. This procedure was criticized by many authors (1)(2)(3)(5), because of wall effects and bridging between flocs for MLSS values greater than 3000 mg/l.

Over the years, new methods were developed to improve the test. The most widely utilized are the following:

- 2-L graduated cylinder
- 2-L graduated beaker without dilution
- 2-L graduated beaker with dilution

The problems observed with these methods are again wall effects and differences in dilutions from day to day and between operators. This lead to a lack of uniformity in the test procedure and results that are often not fully representative of what is really happening in the secondary clarifier.

5.4 The Stiro-Settlometer

The Stiro-settlometer was designed to overcome these problems. For many years, *Standard Methods* has described a standardized procedure (2710C) for a 1-L graduated cylinder equipped with a stirring mechanism consisting of one or more thin rods extending the length of the column and positioned within two rod diameters of the cylinder wall. The Stiro-Settlometer utilizes the same procedure, but in a 2-L cylinder. The greater volume increases the representativeness of the sample.

It is important to remember that the main objective of this test is to represent what is "really" happening in the clarifier. Another objective of the test is to obtain a sensitivity corresponding to the behaviour of the sludge bed in the clarifier.

On several occasions, operators using conventional procedures reported SVI values of 300 to 800 ml/g, even though there was less than a foot of sludge at the bottom of the clarifier. In these cases, the tests were not representative of the real situation and resulted in a misreading of settleability and false alarms.

The wall effect, observed with the classical test, is reduced by two aluminum rods along the edge of the cylinder wall. As no dilution is generally required with the SSVI test for MLSS values up to 5000 mg/l, this standardizes the procedure on a day-to-day basis and from one operator to another. On the cylinder, there is a 0–1000 ml graduated scale to determine the SSVI and a 0–28 cm graduated scale to calculate the initial zone settling velocity (ZSV).

The main advantage of the 2-L volume and the cylinder diameter (9.5 cm) is that the operator can perform both a stirred (SSVI) and a non-stirred (SVI) settling test. The results of our own testing show that when there is bridging due to filamentous bacteria, the difference between the SSVI and the SVI will be important. In the event of non-filamentous bulking due to exocellular polysaccharides, SSVI and SVI could be high with small difference between the two results.

5.5 Recent results

The results obtained with the Stiro-Settlometer in many WWTPs show better representativeness of sludge settleabilty in relation with sludge depth in the secondary clarifier.

Figures 5.3 and 5.4 show the correlation obtained between the SSVI and sludge depth for a WWTP subject to frequent filamentous bulking episodes.

Figure 5.3 shows that the SVI (non-stirred) is more sensitive than the SSVI and produces daily variances that overvalue the real variation in clarifier sludge depth. As mentioned earlier, this can be explained by filamentous bridging in the cylinder.

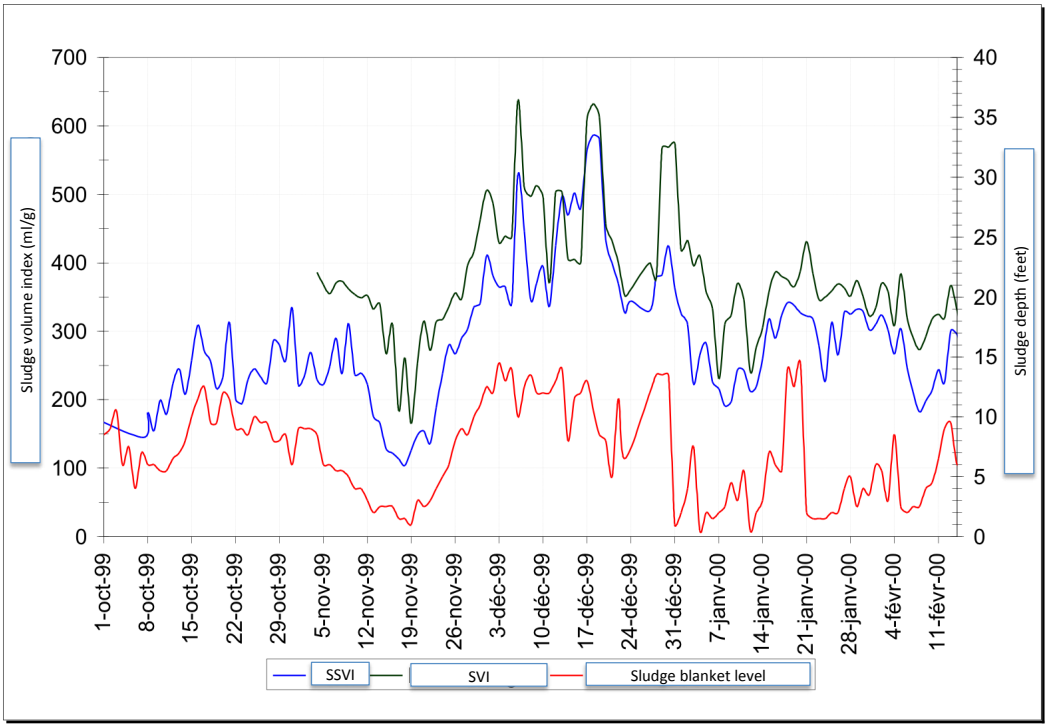

Figure 5.3 : SVI, SSVI and sludge depth variation

Figure 5.4 illustrates the relation obtained between the SSVI and sludge depth in the secondary clarifier (without addition of polymers). A linear relation is observed between these two parameters. Even though this relation is imperfect, it remains a very valuable tool to help the operator conduct daily assessments of the process situation.

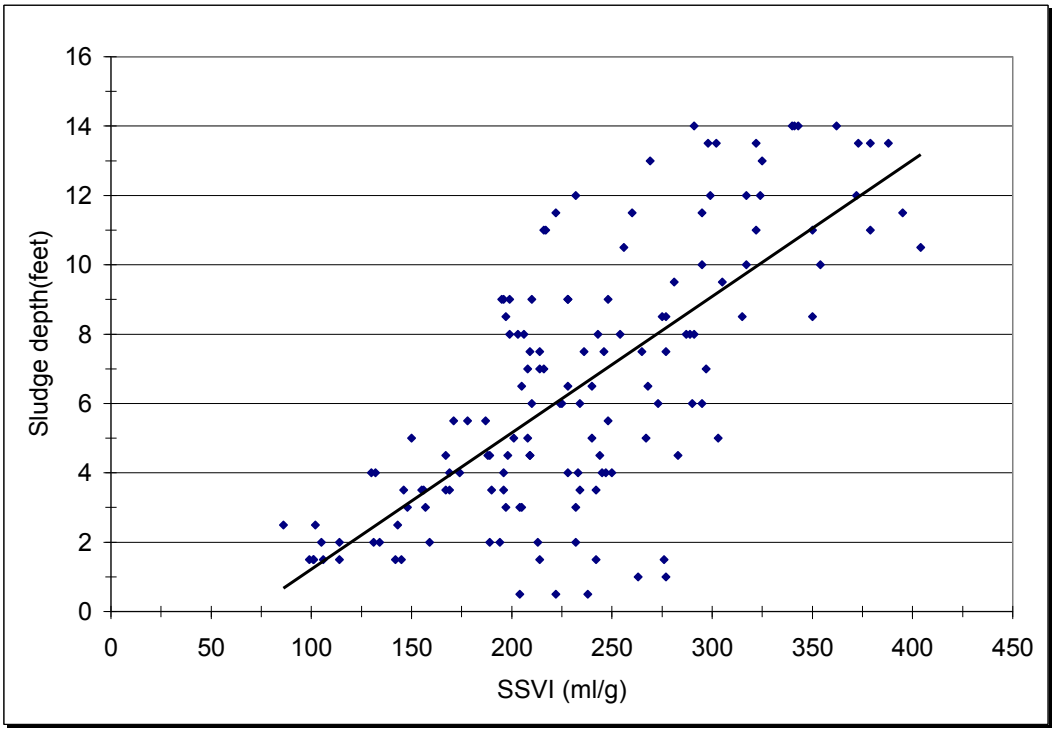

Figure 5.4 : Relation between SSVI and sludge depth in a secondary clarifier

5.6 References to technical information

1. Bye, C., and P. Dold,"Sludge volume index settleability measures: effect of solids characteristics and test parameters", Water Environment Research, 70, 1(1998).
2. Dick, R.I., and P.A. Vesilind, "The sludge volume index- What is it?", J. WPCF, 41, 7(1969).
3. Forster, C.F., and J. Newton, "Activated sludge settlement – some suppositions and suggestions", Wat. Pollut. Control, 338-351, (1980).
4. Standard Methods for the Examination of Water and Wastewater, "Method 2710 C Settled sludge volume", 19th Ed., ,(1995)
5. Vesilind, P.A., Treatment and disposal of Wastewater Sludges, Ann Arbor Science Publishers, Inc., Ann Arbor, Mich., 1974

6 PROCEDURE

6.1 General

The sludge volume index (SSVI) is the volume in millimeters occupied by 1 g of a suspension after 30 minutes settling.

The "Standard Methods 2710C" procedure uses a graduated cylinder equipped with a stirring mechanism to reduce the wall effects. Using this equipment will also result in a test more representative of what is happening in a secondary clarifier with its own rakes system.

SSVI (and SVI) is determined from the 30-min settled sludge volume from a sample taken at the aeration basin outlet. The results from that test are also used to determine the initial zone settling velocity (ZSV).

6.2 Material

- Stiro-settlometer for SSVI (you can do both the SSVI and SVI without the motor)
- Additional 2L cylinder for SVI (in option);
- Stopwatch;
- Bucket;
- Paddle.

6.3 Reagents

- None.

6.4 Sampling and storage

6.4.1 Sampling

- Grab sample;
- Be sure to take the sample in a zone of turbulence at the outlet of the aeration basin and upstream of a dosing settling aid products (if added). You can also use in addition a point sampling after the settling aid products addition; it will assess the performance of the product to improve settleability);
- Take a 4,5 L grab sample (if you want to do SSVI and SVI at the same moment with 2 cylinders) of activated sludge from the aeration basin outlet.

6.4.2 Storage

- The SSVI test should be done as soon as possible after sampling.
- No storage possible without affecting the results.

6.5 Procedure

6.5.1 Sample preparation

- Use mixed liquor sample with less than 5,000 mg/L coming from the aeration basin outlet. For concentrations over 5000 mg/L, it may be necessary to dilute the sample with the final effluent (Note: If after 30 minutes of settling, the volume of sludge in the cylinder is less than 500 ml, then it is not necessary to dilute otherwise, repeat the test by diluting the sample by two with the final effluent to the same temperature as the sample of mixed liquor);
- As possible, day-to-day testing should be done at the same temperature to be able to compare results. Avoid sun exposure during the test.
- Keep 50 to 100 ml of the sample for MLSS determination.

6.5.2 Sample treatment

- Gently mix the sample in the bucket (not too much to avoid breaking the floc or add air to the sample) and pour 2L in the Stiro-settlometer;
- If the sample settles extremely fast in the cylinders, use a paddle and mix gently to have the sludge in suspension at the 1000 ml mark;
- For the Stiro-Settlometer test, install the stirring mechanism and check that the rods are at 0,3 cm from the wall (Note: It's important to mention that we used flexible stirring rods to limit sludge drag during the SSVI test and make easier the sludge blanket level reading. It's possible that it will be necessary to adjust the rod position. The rod must be at around 1/8'' (0,3 cm) from the cylinder wall);
- Connect the line cord to a grounded three-wire AC receptacle to activate the motor. Take care to have your hands dry when plugging the instrument;
- Put the On/OFF button at ON;
- Start the stopwatch for at least 30 minutes and let the suspension settle.
- At the end of the test, put the On/OFF button at OFF.

6.5.3 Observations

- Determine the volume occupied by the suspension at measured time intervals, e.g., 5, 10, 15, 20, 30 and 60 minutes;
- Report settled sludge volume of the suspension in millilitres for an indicated interval using the data sheet provided at the end of this manual;
- After the minimum 30 minutes settling period for the SSVI, SVI and ZSV calculations let another 30 minutes to check for additional potential compaction;
- You can also let the sample in the cylinder (the one that it is not stirred) for four hours or until the next morning to verify potential gas stripping (H_2S and N_2) that can lead to sludge flotation if the sludge detention time in the clarifier is too long;
- During the test, check for floc formation, uniform settling, supernatant clearness.

5-minute test

- Observe how the sludge particles agglomerate while forming the blanket;
- Note whether the sludge compacts slowly and uniformly while squeezing clear liquor from the sludge mass;
- Is the supernatant clear or turbid?
- Observe how much and what type of straggler floc, remains in the supernatant above the main sludge mass.

30-minute test

- In general, a good settling sludge will settle to about 50% of the original volume after 5 to 10 minutes;
- Never report the 30-minute volume when you talk about sludge settleability always use SSVI or SVI values in ml/g;

60-minute test

- Provide a check on final clarifier sludge blanket characteristics;
- Predict the thickening potential of the sludge;
- A good settling sludge approaches ultimate compaction between 30 and 60 minutes.

4-hour / 24-hour test

- Observe if there is gas bubbles and if sludge starts to swell and rise, and if so, In how many minutes or hours? Compare this time with sludge detention time in the real clarifier.

- Trace the settling curves on the data sheet available on our website;
- Do the calculations on the data sheet as shown in section 6.6.

6.6 Calculations

Figures 6.1 and 6.2 will be used as examples to show the calculations.

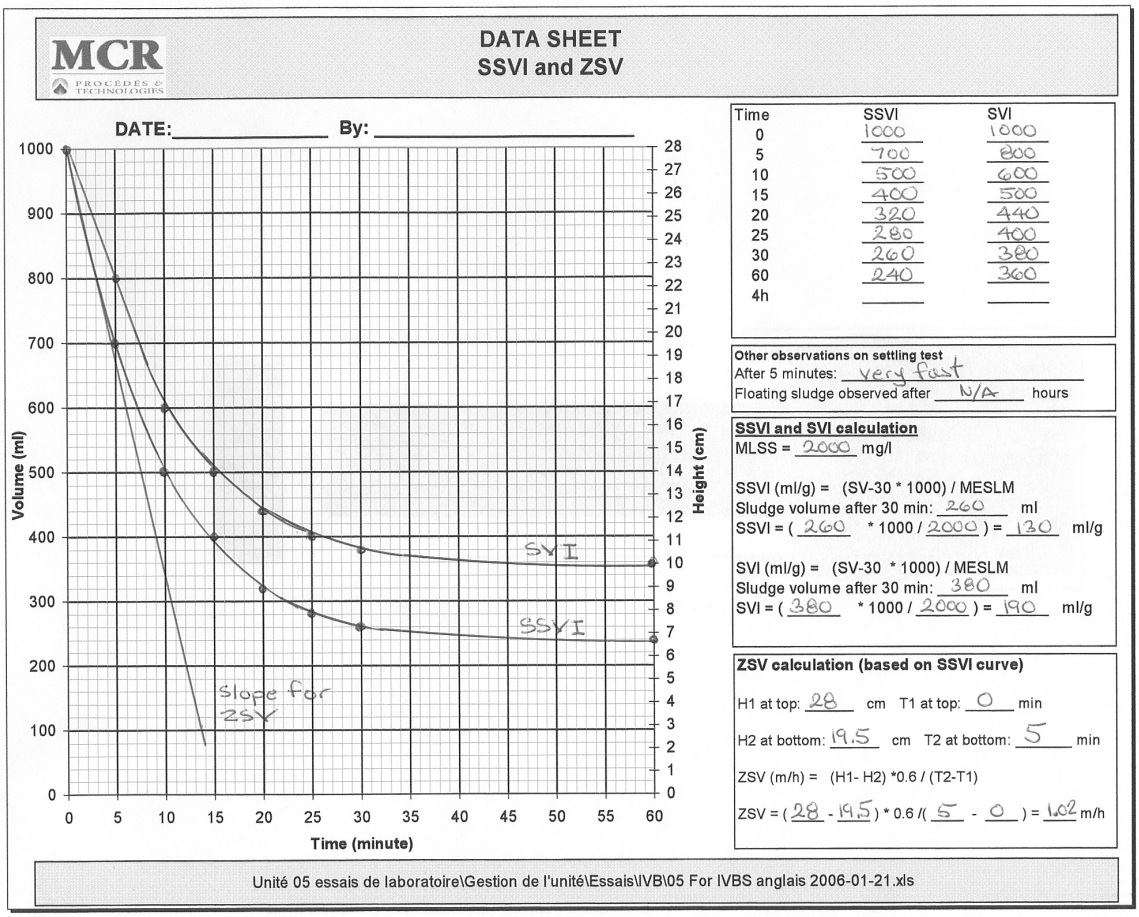

Figure 6.1 : Example of sludge settling very fast

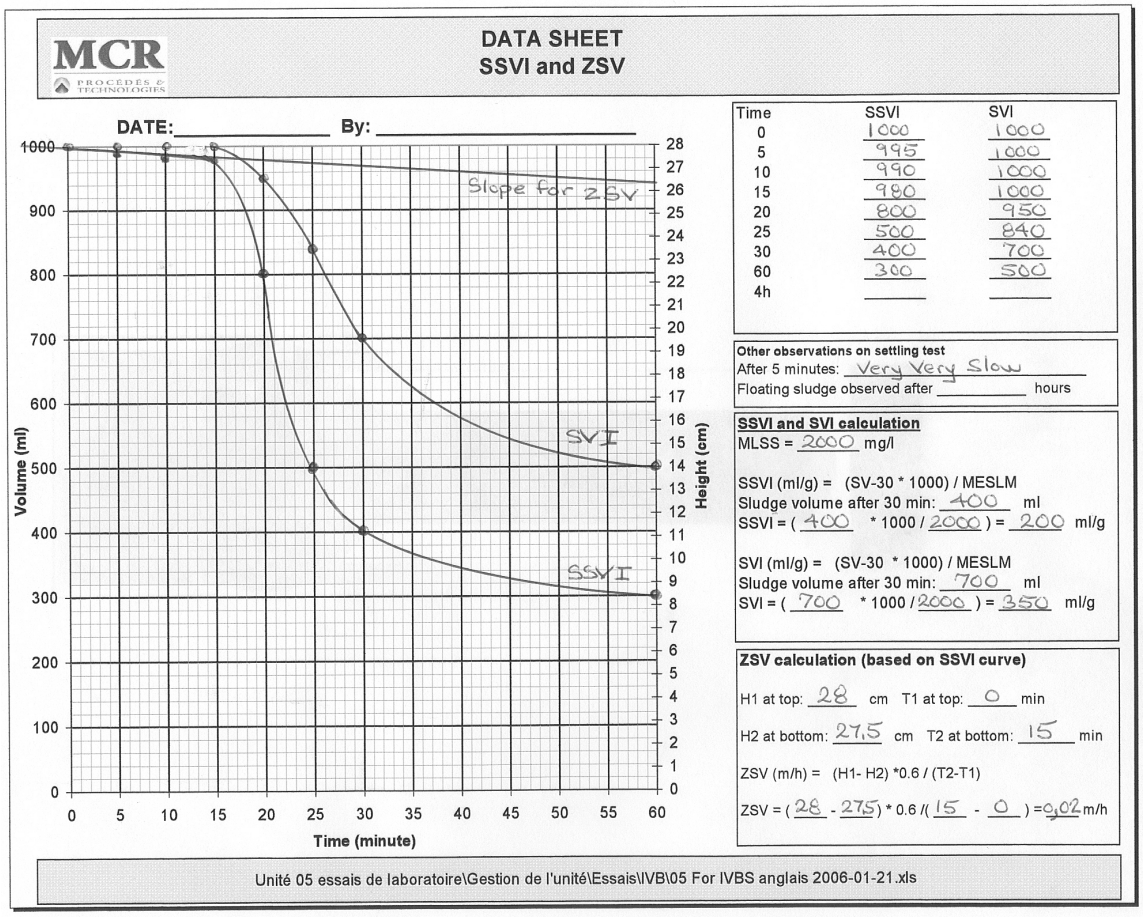

Figure 6.2 : Example of sludge settling very slow

6.6.1 SSVI and SVI calculations

Example:

$$\text{SSVI (or SVI)} = (\text{ml/g}) = \left(\frac{\text{ml of settled sludge after 30 minutes}}{\text{MLSS (mg/l)}} \right) * 1000$$

- From figure 6.1, for the SSVI we have after 30 minutes a sludge volume in the cylinder of 260 ml and a MLSS concentration of 2000 mg/l:

$$\text{SSVI} = \left(\frac{260\ \text{ml}}{2000\ \text{mg/l}} \right) * 1000 = 130\ \text{ml/g}$$

- From figure 6.1, for the SVI we have after 30 minutes a sludge volume in the cylinder of 380 ml and a MLSS concentration of 2000 mg/l:

$$\text{SVI} = \left(\frac{380\ \text{ml}}{2000\ \text{mg/l}} \right) * 1000 = 190\ \text{ml/g}$$

- From figure 6.2, for the SSVI we have after 30 minutes a sludge volume in the cylinder of 400 ml and a MLSS concentration of 2000 mg/l:

$$SSVI = \left(\frac{400\ ml}{2000\ mg/l} \right) * 1000 = 200\ ml/g$$

- From figure 6.2 for the SVI we have after 30 minutes a sludge volume in the cylinder of 700 ml and a MLSS concentration of 2000 mg/l:

$$SVI = \left(\frac{700\ ml}{2000\ mg/l} \right) * 1000 = 350\ ml/g$$

6.6.2 Initial settling velocity or zone settling velocity (ZSV) calculations

- Use the SSVI curve to take your points:

$$ZSV\ (m/h) = \left(\frac{(28\ (cm) - \text{Height of the second point choose on the slope}\ (cm)) * 0.6(m/h)}{\text{Time of the second point choose on the slope}\ (min) - 0\ (min)} \right)$$

- ZSV is the first slope that can be traced on the SSVI curve (see figures 5 and 6)
- Only the first points doing a continuous slope will be chosen.

Exemple:

- From the SSVI curve on figure 6.1, the first continuous slope ended at 5 minutes with a corresponding height in the cylinder of 19,5 cm.

$$ZSV = (m/h) = \left(\frac{(28\ cm - 19{,}5\ cm) * 0{,}6\ m/h}{5\ min - 0\ min} \right) = 1{,}02\ m/h$$

- From the SSVI curve on figure 6.2, the first continuous slope ended at 15 minutes with a corresponding height in the cylinder of 27,5 cm.

$$ZSV = (m/h) = \left(\frac{(28\ cm - 27{,}5\ cm) * 0{,}6\ m/h}{15\ min - 0\ min} \right) = 0{,}02\ m/h$$

Note: The relation between the volume on the left scale and the height on the right scales is the following (see also figure 6.3):

$$\text{Height}\ (cm) = (V(ml) * 0{,}028)$$

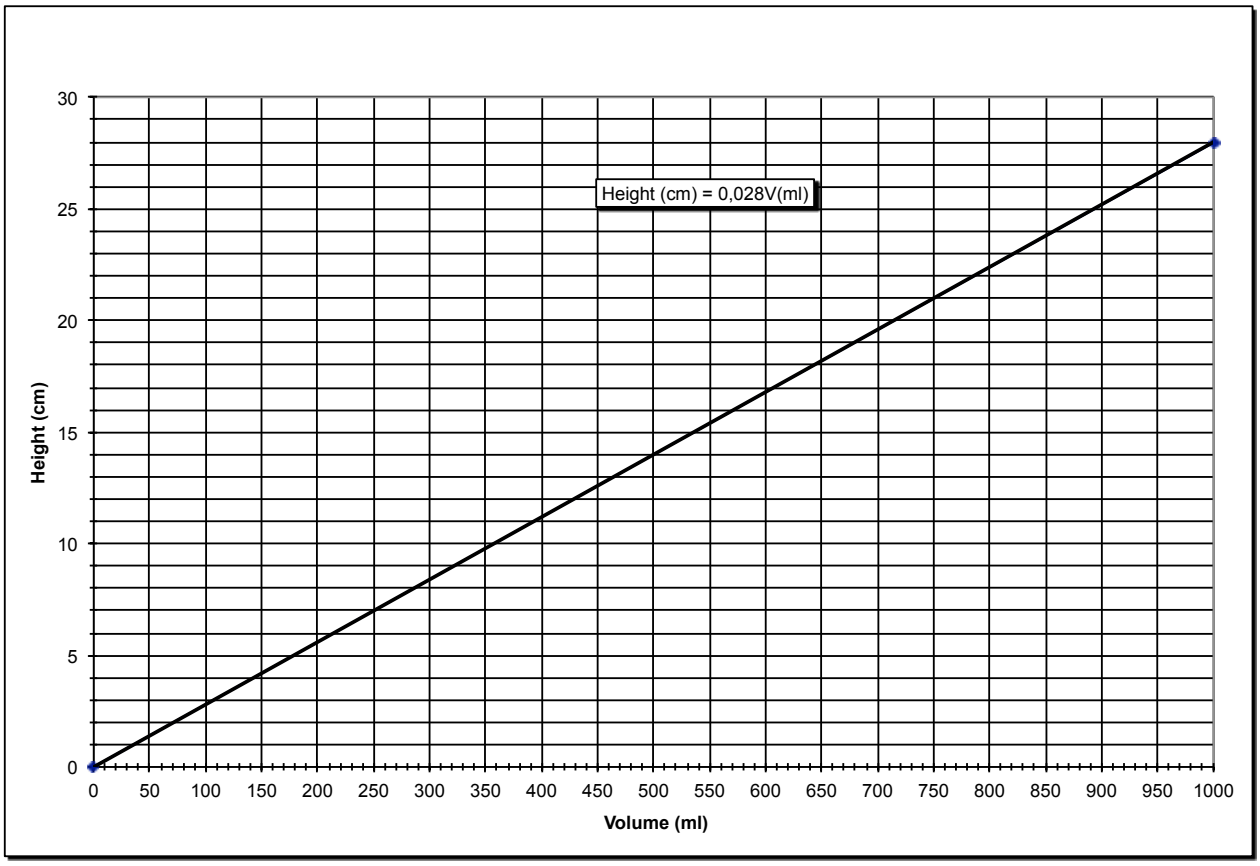

Figure 6.3 : Relation between graduated scales

6.7 Expected range of values

Table 6.1: Expected values for SSVI, SVI and ZSV

Parameters	Aeration basin outlet
SSVI (ml/g)	30 à 400
SVI (ml/g)	30 à 400
ZSV (m/h)	0,05 à 4

6.8 Data analysis

6.8.1 SSVI and ZSV results

For SSVI (values in ml/g)

SSVI <80	Sludge settling too fast, probability of high pin floc;
80 <SSVI<120	Very good settling;
120 <SSVI< 150	Begins to be slow, check the sludge blanket level, follow your process carefully and revised operation data and control parameters;
SSVI > 200	Sludge bulking, requires action if sludge blanket level is rising.

For ZSV (values in m/h)

ZSV <0,1	Very slow;
0,1< ZSV < 0,5	Slow;
0,5 < ZSV <1	Acceptable;
1 < ZSV < 2	Good to very good;
ZSV>2	Fats to very fast.

6.8.2 Day-to-day SSVI curve variations

It is important to compare day-to-day SSVI curve variations to confirm improvement or degradation of the sludge settleability. A tendency to go in one direction or the other will give information to help you revise, if necessary, your process control plan.

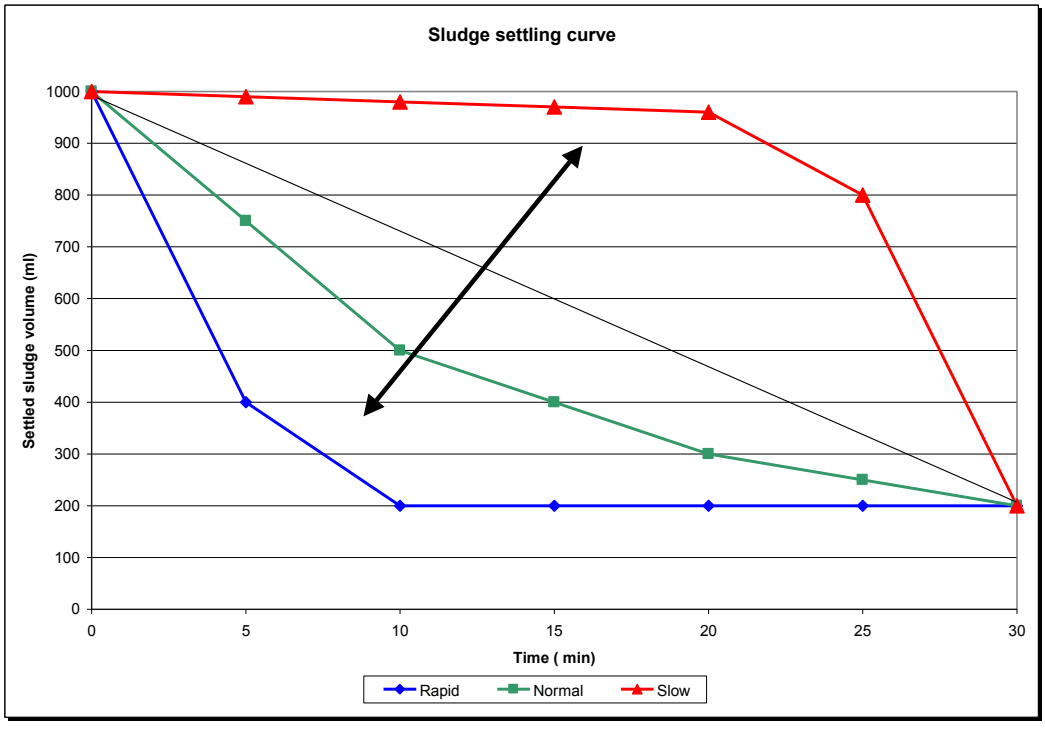

Figure 6.4 : Sludge settling curve variation

6.8.3 SSVI values compared with SVI values for the same sample

CASE	SSVI	SVI	INTERPRETATION
#	ml/g	ml/g	
1	50	50	Settling is very fast. No or few filaments, or if there is, no impact on sludge settleability. The floc is probably mid-size, round and compact. The floc is heavy.
2	50	100	Settling is very fast. Little bridging effect due to filaments. If there is no filament, the floc is probably more irregular and open. The floc is heavy enough to compensate for the bridging effect.
3	50	150	Settling is very fast on SSVI but there is a clear indication of a bridging effect due to filaments, or if there is none, that the floc morphology is in not very good. The floc is not heavy enough to compensate for the bridging effect.
4	50	200 et +	Settling is very fast on SSVI but there is a clear indication of a major bridging effect due to filaments. The floc morphology is probably also an important aggravating factor. The floc is not heavy enough to compensate for the bridging effect.
5	100	100	Perfect settling. Few or no pin floc. No or very little bridging effect that is entirely compensated by the floc weight.
6	100	>150	Same as case #3 et #4
7	150	150	Clear indication of a settling problem. If filaments as no or few impact on settleability, consequently the floc morphology could be the problem or a non-filamentous bulking as too much polysaccharides could be present. The floc is not heavy enough to compensate for the bulking situation.
8	150	200 et +	Serious settleability problem. Bridging from filaments and bad floc morphology. Possible aggravating factor: non filamentous bulking.
9	200	200+	Major settleability problem. Important bridging from filaments and bad floc morphology. Possible aggravating factor: non filamentous bulking.

6.9 Interferences

- Oil in sample or gas stripping (H_2S, NO_2-NO_3 (denitrification) stripping or too much oxygen residual) can lead to floating sludge and readings of the settled sludge will be false;
- Variations in suspension temperature, sampling and agitation methods, and time between sampling and start of the determination significantly affect the results;
- Avoid sun exposure during the test.

6.10 Recommendations

- Handle the stirring rods with care as they are flexible;
- Avoid the rods to touch the walls and increase the torque on the motor;
- Stir the initial sample slightly to maintain the floc formation of floc.

6.11 Safety

- Use laboratory gloves;
- Wash your hands after testing is ended.

6.12 Bibliography for the procedure

- Standard Methods 2710 C

7 MAINTENANCE

- This equipment requires no special maintenance.
- Always clean with a non-abrasive cleaner for plastics with a brush having soft bristles. Avoid using brushes with hard bristles that could scratch the inside of the cylinder;
- Adjust periodically the stirring rods position at around 1/8'' (0,3 cm) from the cylinder wall.

8 WARRANTY

What we cover:

MCR warrants its instruments and accessories to be free from defects in materials and workmanship under normal use and service for a period of 12 months from the date of shipment from MCR. If you experience any problems with our products, just phone, fax, email, or write and we will make every effort to resolve the matter to your satisfaction.

If your instrument becomes defective within one year of purchase, MCR will repair or replace your instrument free of charge, including surface shipping costs.

What we do not cover:

MCR is not responsible for replacing parts damaged by accident or neglect. Your instrument must be installed according to instructions in the User's Manual. Damage from corrosion is not covered. Damage caused by customer modification of the instrument is not covered. This warranty covers only MCR products and is not extended to equipment used with our products.

Shipping: Although our instruments are built to withstand hard use, we cannot be responsible for damage incurred during shipment. Therefore, to avoid both cosmetic and structural damage if the instrument is shipped in the future, we recommend that you save the original packing material in which we shipped the instrument.

Obtaining Service: Please contact us for repair service. Never ship an instrument to us without prior telephone or written contact. Often the problem is a relatively simple one that you can solve yourself with our direction.

If it is determined by MCR that the instrument should be returned for repair, a Return Materials Authorization (RMA) number will be assigned and a fixed repair price quoted for out of warranty repairs.

If you are within North America pack the instrument well; insure it; write the RMA number on the outside of the shipping carton and ship it back to us. If the instrument is under warranty, we will repair or replace the unit and pay for roundtrip shipment. If the instrument is not under warranty shipping costs, both ways are your responsibility.

If you are outside North America, you are welcome to send the instrument for a free repair within the limits of the warranty. You will be responsible to pay for shipment to us, duties and documentation costs outside North America. We will pay for return shipment. If it is not under warranty, you will be responsible to pay for roundtrip shipping, duties and documentation costs outside North America.

9 SPECIFICATIONS

Motor casing: ASB with On-OF button and power jack
Electric motor: 1 rpm
Rods: Aluminum
Graduated cylinder: Acrylic 2 litres
Scale #1: 0-1000 mL for SSVI or SVI
Scale #2: 0-28 cm for ZSV
Electrical supply (transformer 24V) : 100-240VAC, 50-60 Hz

For indoor usage only
Installation category II
Operating temperature : 0 to 35 ^{o}C
pH : 6 to 9
Air humidity : 80 % max
Altitude : 2000 m max

10 SPARE PARTS

The following spare parts are available from MCR:

- 2 litres cylinder
- Stirring rods
- Motor
- Motor casing
- Transformer 24V

11 TROUBLESHOOTING

Table 11.1: Troubleshooting guide

Problem	Verification	Solution
Motor not running	1. 1. The power cord is plugged in; 2. The transformer's power voltage is between 100-240 VAC and 50-60 Hz 3. The motor supply voltage is 24VDC 4. The On / OFF is in the On position 5. The stirring rods do not touch the cylinder wall (they should be about 1/8 "of the wall in operation) 6. Open the casing and ensure that the welds are still correct	If after checking the points # 1 to # 6 the motor still does not rotate then contact us.
Water leakage at the base	1. Identify the location of the water leak at the base.	1. Allow to cylinder to dry 2. Repair acrylic with methylene chloride or a transparent silicone for bathtub.

12 TECHNICAL ASSISTANCE

If you have any questions about the use of this product, please contact us at:

MCR Procédés & Technologies
Phone : (418) 650-9154 #221 (Alain Durocher)
Fax : (418) 650-6604

e-mail : adurocher@mcrpt.com