

**BROOKFIELD MODEL TT200**

**IN-LINE VISCOMETER**

Installation, Operation, and Maintenance Instructions

Manual No. M/97-540-A0904



SPECIALISTS IN THE  
MEASUREMENT AND  
CONTROL OF VISCOSITY

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# Section 1 - In-Line Viscometer Description

## Introduction

The Brookfield Model TT200 In-Line Viscometer is a highly sensitive versatile instrument that measures process fluid viscosity in a fully flooded product stream, or tank, under pressure or vacuum. Brookfield In-Line Viscometers are unaffected by changes in pressure, laminar flow, or density.

The TT200 In-Line Viscometer generates a 4 - 20 milliamper (mA) or 0 - 10 Volts DC (VDC) signal proportional to process fluid viscosity. The signal is stable, can be transmitted over long distances with minimal loss, and is not affected by noise. Adjustable electronic damping maintains signal quality under severe process conditions.

The TT200 In-Line Viscometer, shown in Figure 1-1 can be used in a variety of industrial applications where the viscosity of chemical, coating, fuel oil, and many other process fluids must be controlled or monitored.

## Features and Benefits

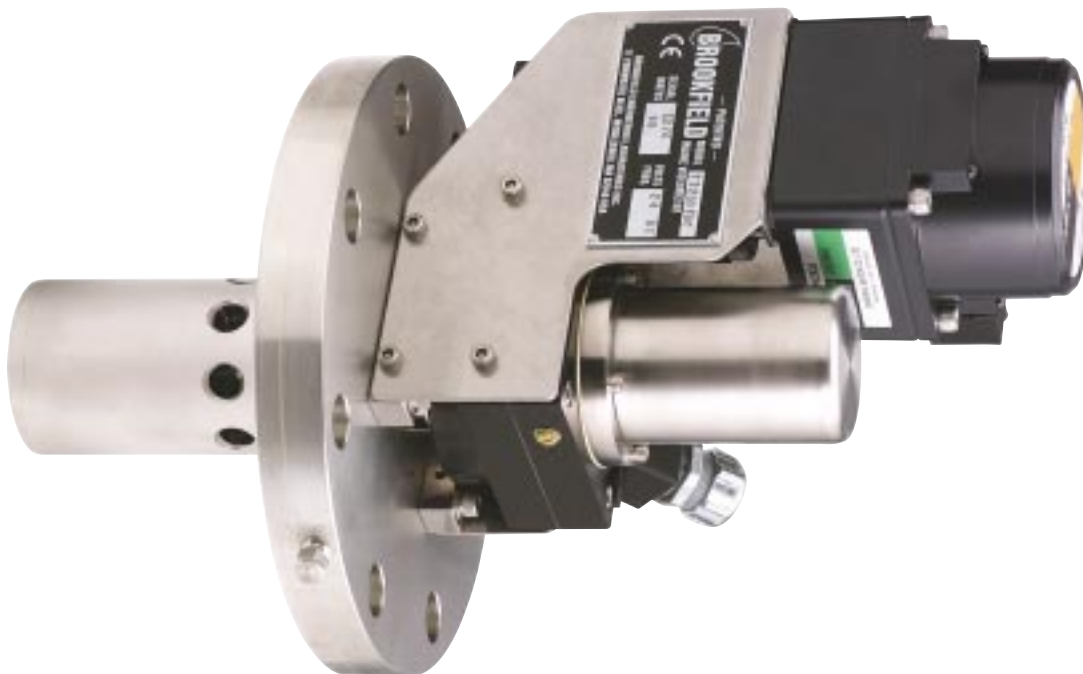
The TT200 In-Line Viscometer incorporates the following features:

- Easy start-up, operation, and cleaning
- Instantaneous response
- Optional selectable dual viscosity range
- Continuous linear output signal (4 - 20 mA) or (0 - 10 VDC)
- Coaxial cylinder measurement geometry for viscosity values at defined shear rates
- Optional temperature compensation

The TT200 In-Line Viscometer provides the following benefits:

- Highly sensitive measuring system unaffected by changes in pressure, laminar flow, or density.
- Can be cleaned-in-place thereby minimizing downtime.
- Eliminates manual procedure for lab viscosity analysis. Provides early detection of anomalous processing.

- Accurate and proven control - optimizes product consistency and quality.
- Provides a permanent record for quality control when used with a recorder or integrated computer system.
- Due to the unique design of the torsion element, pressure does not affect its response.
- Operates continuously and instantly responds to changes in viscosity.
- No pressure drop.
- Linear output signal is proportional to viscosity and compatible with most industrial process control equipment.
- Installs directly on tank or pipeline.
- Optional features and accessories are available to enhance In-Line Viscometer performance.

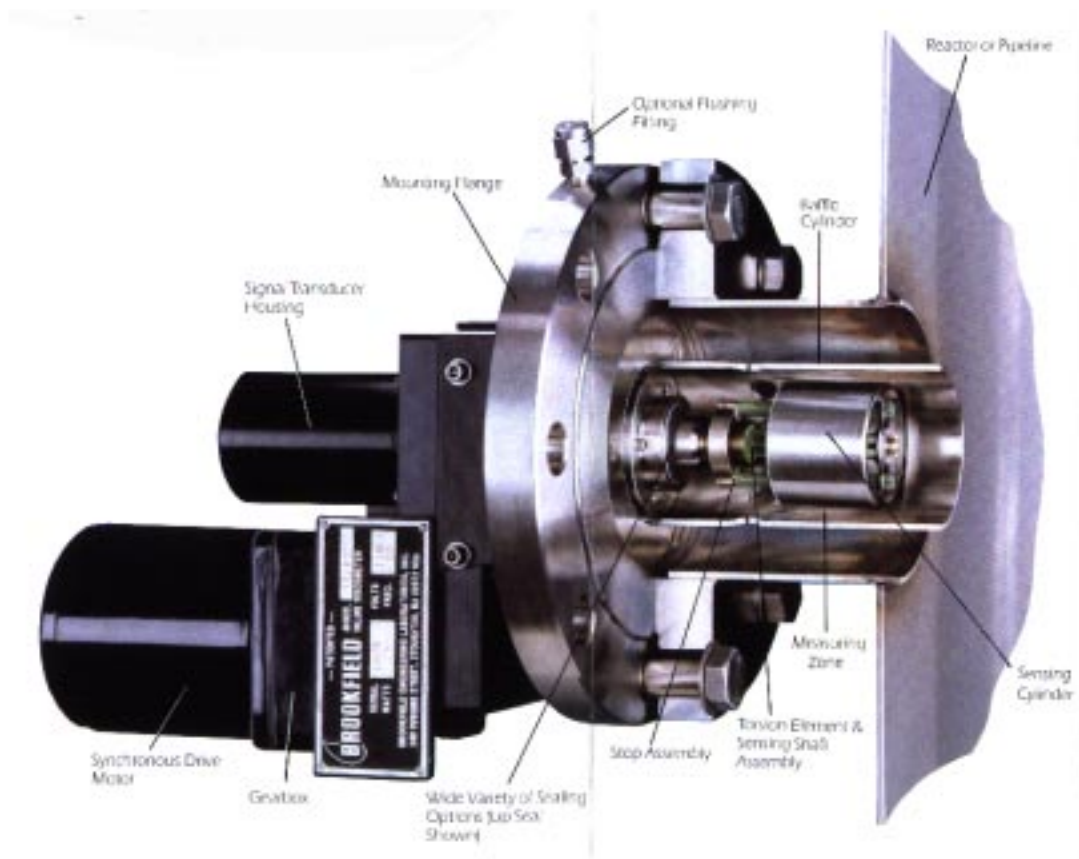


**Figure 1-1: Typical TT200 In-Line Viscometer with Oriental Motor**

## Theory of Operation

The product stream flows through the inlet into the TT200 In-Line Viscometer measuring chamber, as shown in Figure 1-2, where it pushes against a cylinder or stator driven by a drive motor. The rotation of the stator causes a gentle pumping action forcing the product to flow into the measuring annulus between the outer cylinder and the stator. The viscous drag of the product on the stator is resisted by a torsion element which transmits an angular deflection signal to a rotary transformer drive transducer. This signal is processed through solid state torque sensor electronics in a remote enclosure to produce a linear 4 - 20 mA signal proportional to the viscometer's viscosity range.

Measuring range and shear rate can be varied by changing rotational speed (via gearbox or by speed control) or by changing the rotor and/or stator as specified in Table D-1. Refer to **Appendix D** for more information on changing geometrical components.



**Figure 1-2: TT200 In-Line Viscometer Product Stream Flow**

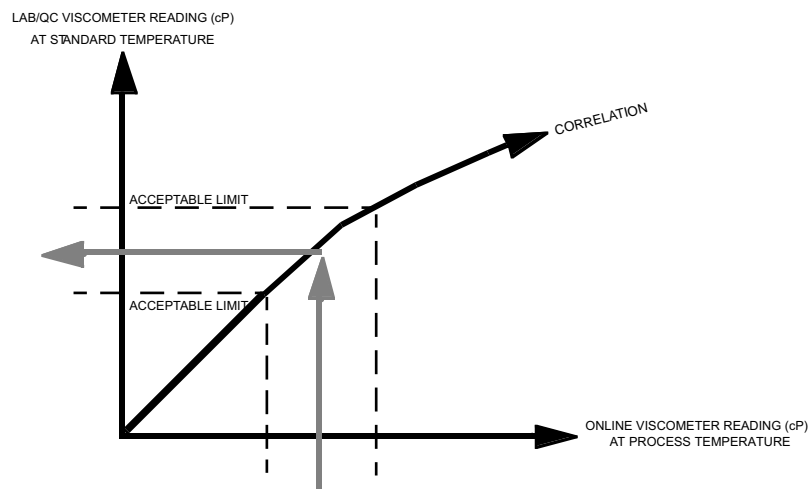
## Correlation with Other Measurements

Typically, there is a difference between laboratory and process viscosity measurements. Laboratory measurements, for a given fluid, are usually higher than process measurements.

Viscosity measurements are unique among common types of fluid measurement in that, for most fluids, numerical values that are generated are dependent upon flow conditions in the fluid being measured (shear rate or velocity gradient). Other factors such as temperature change, turbulence, and pressure among the most prominent, also affect the readings.

Frequently it may become necessary to correlate readings provided by your on-line viscometer to those factors that influence viscosity obtained by other methods. The correlation consists of holding the viscosity dependent factors constant, as mentioned above, and plotting the on-line viscosity value against the other reading as shown in Figure 1-3. A successful empirical correlation will assure the process operator that an on-line reading can be matched to a viscosity value derived by the other method. The correlation of these readings may be instrumental in educating process operators how the process stream relates to bench-top derived viscosity measurements.

Many factors beyond those noted above, which are more difficult to control in an on-line situation than in a laboratory environment, can potentially affect your correlation. Refer to **Appendix A** and contact Brookfield Engineering Laboratories, Inc. for assistance in generating an empirical correlation.



**Figure 1-3: In-Line Viscometer Correlation with Other Measurement Techniques**

## Specifications

The TT200 In-Line Viscometer is available in standard or optional configurations as listed in Table 1-1.

**Table 1-1: Model TT200 In-Line Viscometer Specifications**

Parameter	Standard Configuration	Optional Configuration
Viscosity Range (See Note 1)	10 - 500,000 cP	10 - 500,000 cP
Shear Rate Range	10 - 1000 sec <sup>-1</sup>	0.02 - 12,000 sec <sup>-1</sup>
Temperature Range (See Note 2)	-40° - 300° F	-40° - 500° F
Pressure Range (See Note 3)	0 - 200 psi	Vacuum to 500 psi
Reproducibility	± 0.5% of span	± 0.5% of span
Signal Output	4 - 20 mA	0 - 20 mA, 0 - 10 VDC
Power Requirements	115VAC 50/60Hz 100 Watts	230VAC 50/60Hz 100 Watts
Chamber	300 Series S/S 1 inch NPT (Female) inlet and outlet	316 S/S wetted parts construction 1, 1-1/2, or 2 inch threaded or flanged, 4 inch flanged
Motor	Single-speed synchronous	Multiple-speed with speed control
Construction	NEMA 4 Water tight and dust tight	Refer to Appendix D
Weight	50 lbs. (23 kg)	50 lbs. (23 kg)

\* Optional Configurations offer dual range capability, custom mounting and/or special viscosity ranges and shear rates.

**NOTE 1:** Range is calibrated with a 0 cP lower limit. The upper limit can be any value between 10 - 500,000 cP.

**NOTE 2:** Under certain conditions, temperatures as high as 700° F may be accommodated.

**NOTE 3:** Under certain conditions, pressures as high as 1000 psi may be accommodated.



## Required Utilities

The TT200 In-Line Viscometer requires the utility connections listed in Table 1-2 to operate.

Parameter	Value
Supply Voltage	115/230 VAC
Line Frequency (See Note 1)	50 or 60 Hz
Power	100 Watts
Flushing Requirements (See Note 2)	3 - 10 gpm 30 - 40 psig 1/8 inch pipe thread endcap connection
Barrier Fluid Pressure (See Note 3)	20 psi above maximum process flow pressure

**NOTE 1:** Variations in line frequency will affect instrument span and accuracy.

**NOTE 2:** If viscometer is equipped with flushing option.

**NOTE 3:** If viscometer is equipped with double mechanical seals.

## Current Draw - Starting & Running

The normal running power requirement for TT200 In-Line Viscometer is 100 watts. However, the instantaneous starting current requirement for the TT200 drive motor can be at least five times greater.

Brookfield Engineering Laboratories, Inc. recommends that any inverter, transformer, or similar device that is used with the Model TT200 should be rated at 750 volt-amperes or greater.

## Cleaning

To ensure proper viscometer operation, it is important to properly clean or flush the viscometer at regularly scheduled intervals. Solids can build up on the opposing cylinder surfaces and interfere with the angular movement of the stator and torsion element and their movement in relation to the stop posts which protrude through the stator. Additionally, solids can build up at the mechanical seal which may affect its ability to maintain leak-free operation.

The user must establish cleaning procedures and cleaning fluids. Clean-In-Place (CIP) is strongly recommended as the cleaning procedure of choice. In addition to CIP, the user may choose the flushing option in order to direct cleaning fluid to the internal components to enhance the cleaning process. The third choice for cleaning is to manually clean the internal components. This is not a recommended practice due to the damage that can be caused on the torsion element when exposed to this manual cleaning.

The clean-in-place procedure can be accomplished with high flow rate cleaning fluid or steam.

**NOTE:** *The cleaning fluid must be compatible with the seal. Steam Temperature should not be higher than the temperature rating of the viscometer.*

In some instances, the instrument installation can be plumbed with 2 three-way valves with the cleaning fluid introduced and drained through the side ports of these valves.

Refer to **Section 5 - Maintenance** for clean-in-place or flushing procedures.

## Component Identification

The following paragraphs provide a brief description of each component within the TT200 In-Line Viscometer. Refer to Figure 1-4 for the component location within the viscometer.

### Torque Sensor Assembly

The Torque Sensor Assembly contains the torsion element, armature, and field coil. These components generate an electrical signal proportional to the viscous drag of the process fluid which is sent to the torque sensor electronics enclosure for signal processing.

### Sensing Endcap

The Sensing Endcap contains the torque sensor assembly and all related components.

### Stator

The Stator, which is mounted on the torsion element, applies torque generated by viscous drag to the torsion element. The dimensions of the stator, in conjunction with the rotor, are critical to the accuracy of the viscometer. Many different stator sizes are available which provide different viscometer measurement ranges.

### Stop Posts

The Stop Posts limit stator/torsion element movement to prevent torsion element damage.

### OuterCylinder

The Outer Cylinder fits over the Stator and is secured to the flange plate. Its purpose is to provide the Annular Gap between the Stator so that a defined Shear Rate can be determined.



### **Motor Cable**

The Motor Cable supplies electrical power to the motor from the motor control enclosure, or directly from a power source.

### **Gearbox**

The Gearbox reduces rotational speed and allows the drive shaft to rotate slower than the motor. The rotational speed of the drive shaft is determined by Brookfield Engineering Laboratories, Inc. based upon customer viscosity range requirements.

### **Drive Motor**

The Drive Motor is an electric motor which provides a constant rotational speed to the gear box, drive coupling, and viscometer drive shaft. The drive motor is usually a single-speed synchronous motor but is also available in a controlled variable speed induction motor for custom applications.

### **Bleed Screw**

The Bleed Screw is used to vent air from the viscometer which may be trapped within the measuring chamber.

### **Measuring Chamber**

The Measuring Chamber is the area in which process fluid viscosity is measured. Process fluid may flow through it in either direction.

### **Measuring Annulus**

The Measuring Annulus is the space between the stator and outer cylinder. Process fluid is continuously sheared within the measuring annulus which creates viscous drag on the stator.

### **Sensing Cable**

## **CAUTION**

Changing the length of the sensing cable will affect viscometer calibration. Refer to **Appendix A** and contact Brookfield Engineering Laboratories for more information.



The Sensing Cable carries the electrical signal that is proportional to the viscous drag of the process fluid. The signal is sent to the torque sensor electronics enclosure for processing. The Sensing Cable also carries an excitation current from the torque sensor electronics enclosure to the torque sensor assembly.

### **Torsion Element**

The Torsion Element, which is part of the torque sensor assembly, senses the torque from the viscous drag on the stator. The twist or deflection of the torsion element is proportional to the torque applied to it.

### **Heat Baffle**

The Heat Baffle, which is sometimes referred to as an insulator, dissipates heat from the viscometer that has been transferred from the process fluid. The transfer of heat to the baffle protects the field coil from high temperatures.

### **Torque Sensor Electronics Enclosure**

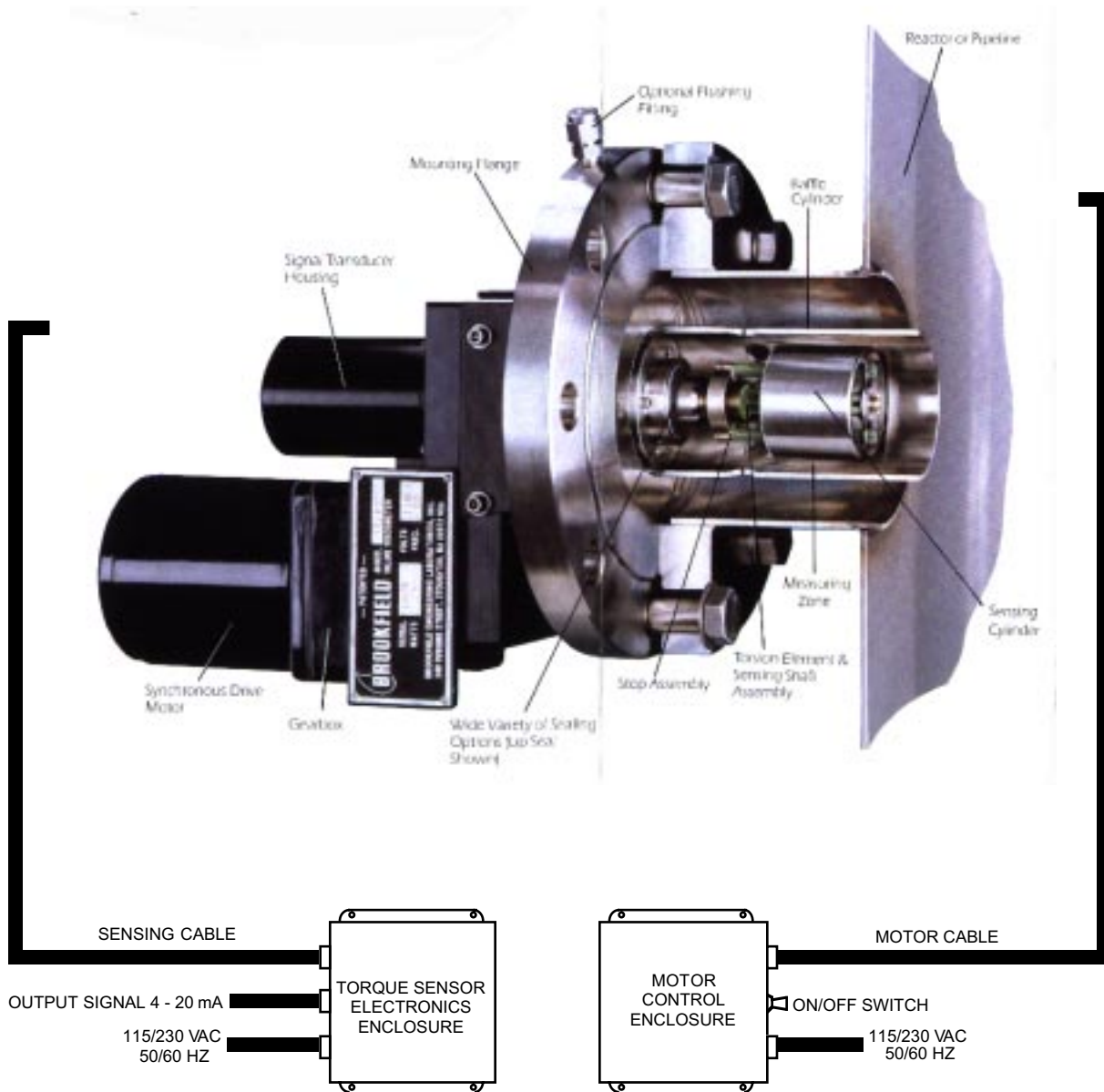
The Torque Sensor Electronics Enclosure contains a circuit board which processes the signal from the torque sensor assembly and generates a linear electrical signal (4 - 20 mA) proportional to the viscosity of the process fluid in the measuring annulus. The circuit board also provides an excitation current to the field coil.

The 4 - 20 mA signal can be:

- Observed on a readout display
- Transmitted to a personal computer for process monitoring and control
- Recorded for process control records

### **Motor Control Enclosure**

The Motor Control Enclosure accepts 115/230 VAC and supplies appropriate power to the drive motor. The enclosure also contains the motor ON/OFF power switch and optional motor speed controller for variable speed motor applications.



**Figure 1-4: Typical Model TT200 In-Line Viscometer Component Identification (NEMA 4 Shown)**

**Options**

The following optional equipment is available to enhance the operation of the TT200 In-Line Viscometer when installed within certain product stream applications. Refer to **Appendix A** and contact Brookfield Engineering Laboratories, Inc. for more information on these options and accessories.

### **Double Mechanical Seal**

A double mechanical seal can be installed in the following the service conditions which are too severe for the standard (single) mechanical seal:

- Vacuum
- Abrasive Slurries
- Toxic Fluids
- Fluids which harden when exposed to air and/or elevated temperatures

### **Serrated Stator**

The Serrated Stator can be installed to ensure shearing by overcoming slippage between the stator and the fluid being measured. The serrated stator is useful with certain product streams such as slurries.

### **Flushing Endcap**

The Flushing Endcap design facilitates cleaning the measuring annulus and torsion element. Compatible solvent can be introduced under pressure when cleaning while the In-Line Viscometer is on-line and empty of process fluid.

### **Accessories**

The following accessories are available to display, control, and record data from the TT200 In-Line Viscometer.

- Analog Display
- Digital Display
- Controller
- Recorder
- Temperature Indication
- Temperature Compensation

## Section 2 - Installation

### Unpacking and Inspection

*NOTE: Upon receipt, inspect the shipping carton and viscometer components for shipping damage. Report any damage to the shipping company immediately.*

The shipping carton should contain the following components:

- TT200 In-Line Viscometer
- Torque Sensor Enclosure and Cable
- Motor Controller Enclosure and Cable\*
- Instruction Manual
- Calibration Bars and Tools
- Optional Equipment

\*Not supplied with certain options

*NOTE: Make sure the calibration bars are kept in a safe place and accessible for use during calibration.*

### Installation Requirements

*NOTE: Refer to the TT200 In-Line Viscometer Specification sheet to determine the configuration of the viscometer.*

The TT200 In-Line Viscometer must be installed in a manner that will optimize its performance. The installation requirements are:

- Provide a continuous product stream to the viscometer with a minimum time lag between changes in process and their effects on the viscometer. This stream must be representative of other process fluid.
- Install the viscometer so that it is always full of fluid without air pockets or voids. Upflow line mounting is recommended as shown in Figure 2-1. Avoid pipe configurations which allow air or solids to collect in the viscometer. The viscometer can only measure the viscosity of fluids contained in the measuring annulus.



- Installation of the TT200 with its axis projecting slightly (10-15°) above vertical can aid in solids removal without allowing air to collect.
- Provide a continuous product stream flow rate which provides a fresh supply of fluid to the measuring annulus.
- Provide a straight pipe leading into the viscometer that is at least ten times the pipe diameter in length.
- Know the product stream's rheology and how it responds to other factors occurring in the process such as temperature, pH, pressure, etc. Control or monitoring of the product stream's temperature may be required.
- Power: Single phase, 115 or 230 VAC 50 or 60 Hz, or 24VDC
- For NEMA 7 applications, the customer must provide a 600 VAC, 18 Gauge, two conductor with ground viscometer power cable between the Motor Control Enclosure and the viscometer motor which must conform to local electrical codes.
- Flushing connection: 1/8 inch-27 NPT thread; 5 - 10 GPM of flushing fluid at 40 - 90 psig.
- If equipped, double mechanical seals require clear barrier fluid under pressure at 20 psi above maximum process pressure connected to a 1/8 inch standard pipe thread connection in the drive endcap. No flow is required, but venting of air from the seal is required to avoid premature seal wear.
- If the viscometer is to be cleaned in place, isolation valves, flow boosters, or other auxiliary items may be required.

## Calculating Minimum Straight Pipe Length (Pipeline Installation)

*NOTE: The TT200 In-Line Viscometer does not require special supports or special pipe alignment.*

Refer to Figure 2-1 and the following procedure to install the viscometer.

1. Calculate the minimum straight pipe length leading to the viscometer as follows:

$$\text{Pipe Diameter} \times 10 = \text{minimum straight pipe length}$$

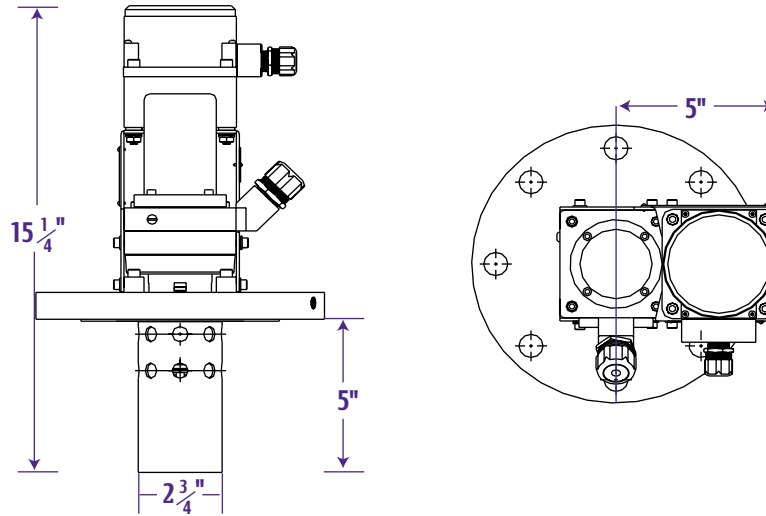
2. Select an installation location that will provide clearance of 12 inches from the mounting flange, as shown in Figure 2-1.
3. Using standard plumbing practices for the appropriate viscometer flange type, install the viscometer in the preferred position as shown in Figure 2-1.
4. If equipped, install the flushing fluid supply using the appropriate valves.
5. If equipped, install the double mechanical seal barrier fluid supply using appropriate valves as follows:
  - a. Connect the barrier fluid to the lower valve.
  - b. Vent the barrier fluid from the upper valve.

*NOTE: The viscometer may be equipped with an optional pressure sensing switch which is mounted on the double mechanical seal housing. If the appropriate barrier fluid pressure is not sensed, the motor will not operate.*

## Installation

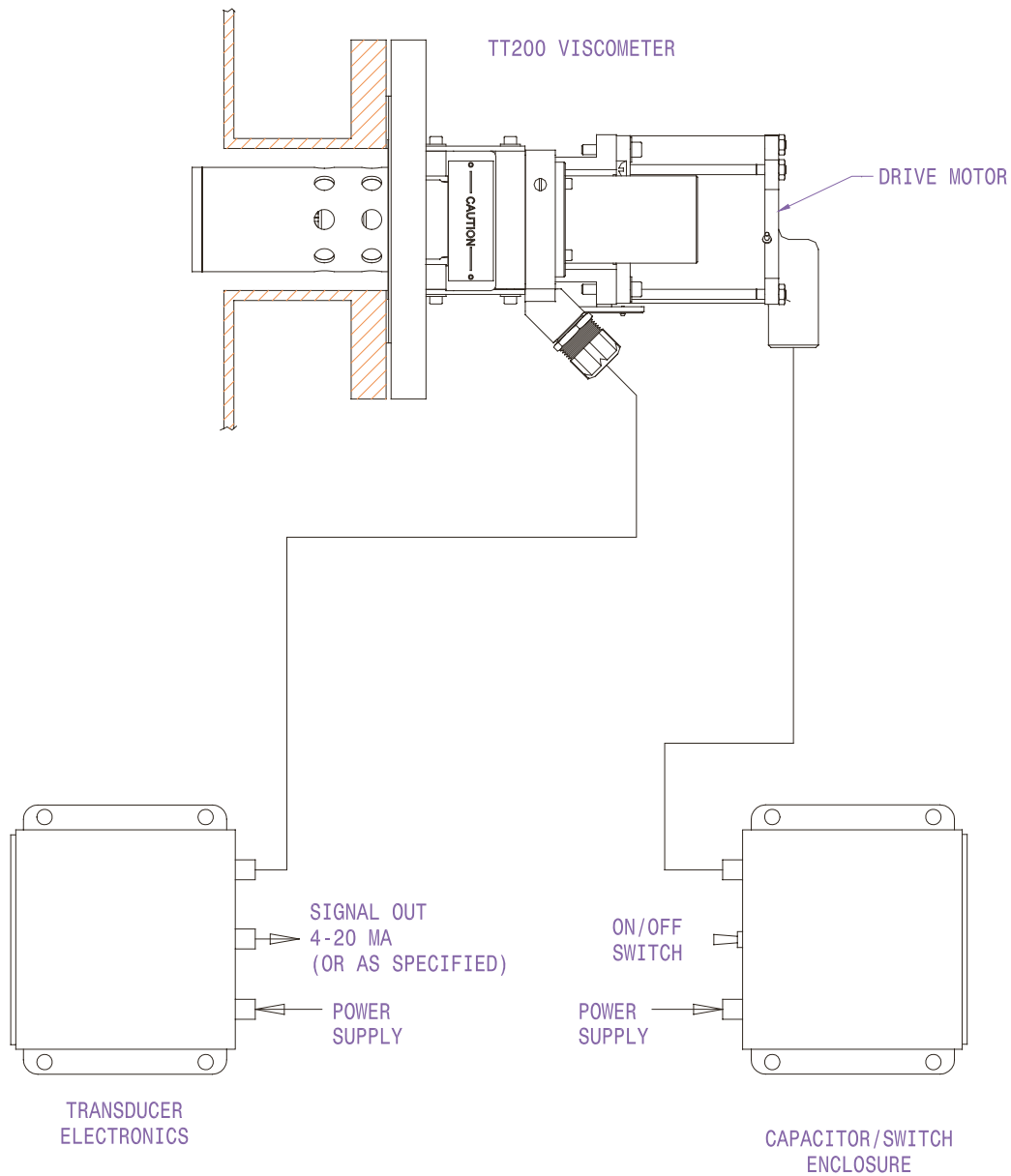
*NOTE: Refer to the TT200 In-Line Viscometer Specification sheet to determine the configuration of the viscometer.*

1. Depending upon your configuration, refer to the appropriate installation diagram as shown in Figures 2-2 through 2-4 to install the viscometer.

**TYPICAL INSTALLATION**

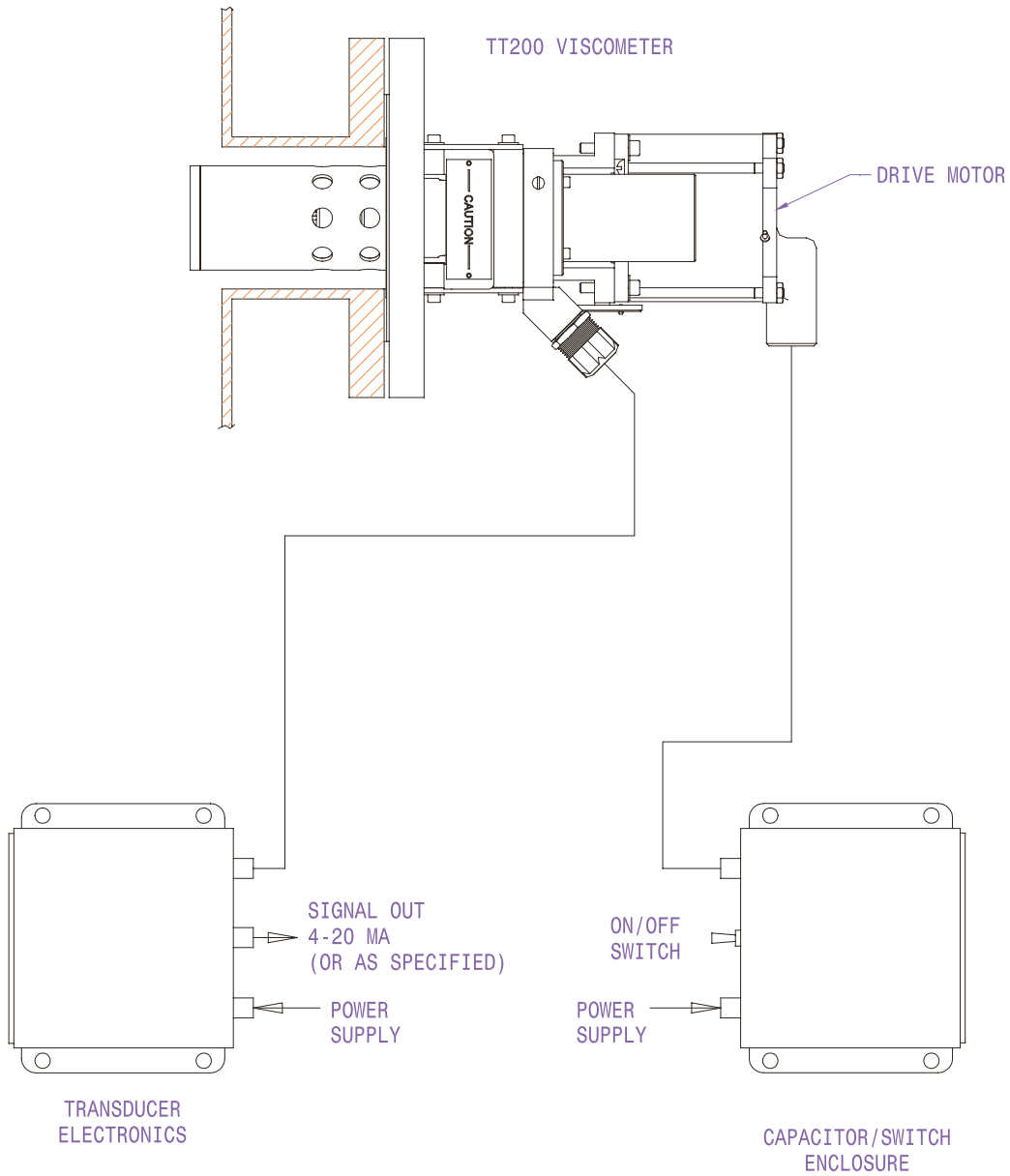
**NOTE:** When installing the viscometer in the alternate position, rotate the viscometer on the pipe axis to minimize pockets where air or solids may collect. Axis inclined slightly upward (10-15°) is recommended.

**Figure 2-1: Typical In-Line Viscometer Installation**



**NOTE:** REFER TO DRAWING NUMBER CA1-001 (115 VAC) OR CA1-047 (230 VAC) IN APPENDIX B FOR ELECTRICAL CONNECTIONS.

**Figure 2-2: NEMA 4 - 115 or 230 VAC 50/60 Hz Installation**



**NOTE:** REFER TO DRAWING NUMBER CA1-035 IN APPENDIX B FOR ELECTRICAL CONNECTIONS.

**NOTE:** ALL CONNECTIONS SHALL BE TERMINATED ACCORDING TO FACTORY MUTUAL NEMA 7 SPECIFICATIONS.

**Figure 2-3: NEMA 7 - Explosion Proof 115 VAC 50/60 Hz Installation**



## Flushing Connections

*NOTE: The flushing connections and lines are application specific.*

1. Remove the flushing connection plug from the instrument flange.
2. Install the flushing line connector.
3. Connect the flushing line to the connector.
4. Proceed with **Section 3 -Calibration**.

## Section 3 - Calibration

### Introduction

The TT200 In-Line Viscometer is custom calibrated at the factory and shipped ready for service. Brookfield Engineering Laboratories, Inc. recommends that certain calibration procedures be performed after any of the following events have occurred:

- Installation
- Disassembly and Cleaning
- Component Replacement

The flowcharts in Figures 3-1, 3-2, and 3-3 describe the appropriate calibration procedures that should be performed after installation, disassembly and cleaning, and component replacement.

### CAUTION

The length of the sensing cable should not be changed. Contact Brookfield Engineering Laboratories, Inc. for more information.

### CAUTION

The viscometer must be empty of process fluid, clean, and free of obstructions before it can be calibrated. Refer to **Section 5 - Maintenance** and perform the appropriate cleaning procedure for the process fluid application.

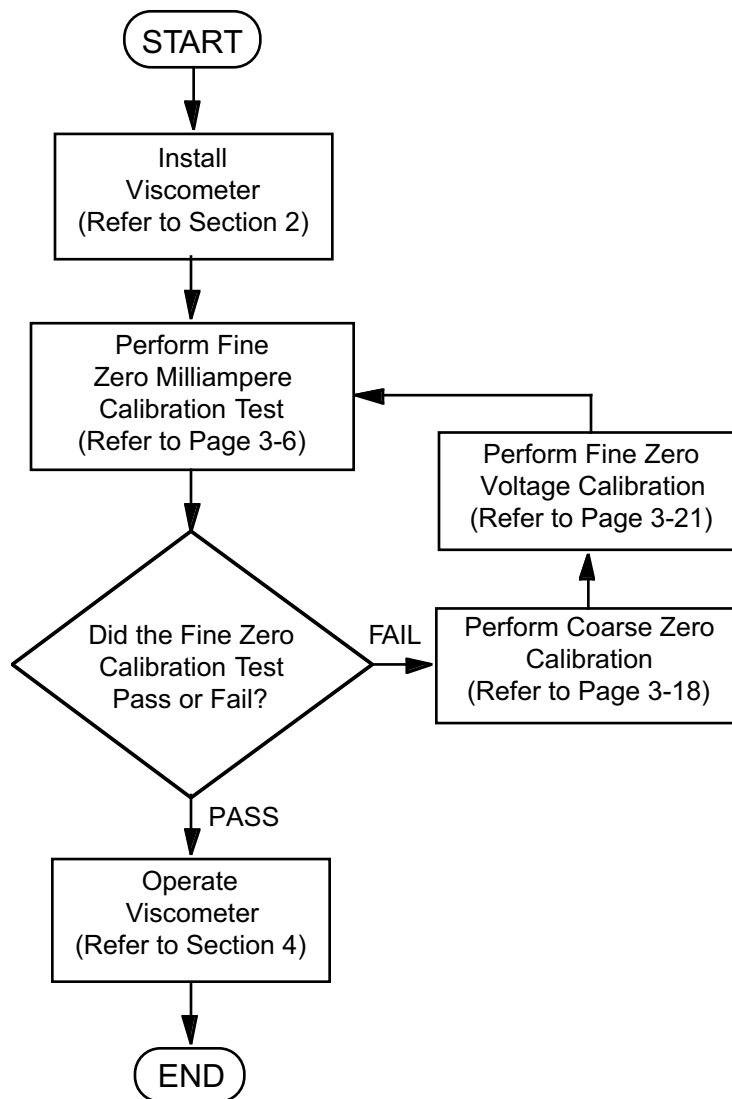
## Tools Required

The tools listed in Table 3-1 are required for calibrating the TT200 In-Line Viscometer.

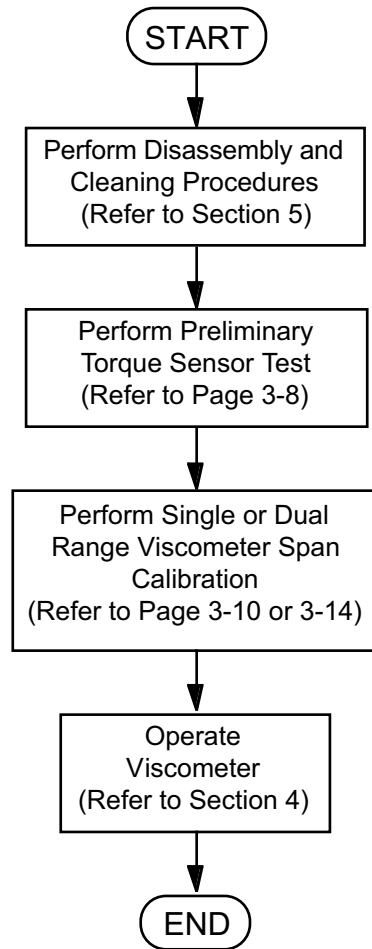
**Table 3-1: Tools Required**

Tool	Quantity
Digital Volt Meter	1
#18 - 24 AWG Insulated Wires - 6 inches long	2
Medium Straight Blade Screwdriver	1
Small Straight Blade Screwdriver	1
5mm Hex Wrench	1
Calibration Bars	1 or 2*

\* Dual range viscometers may be supplied with two calibration bars.

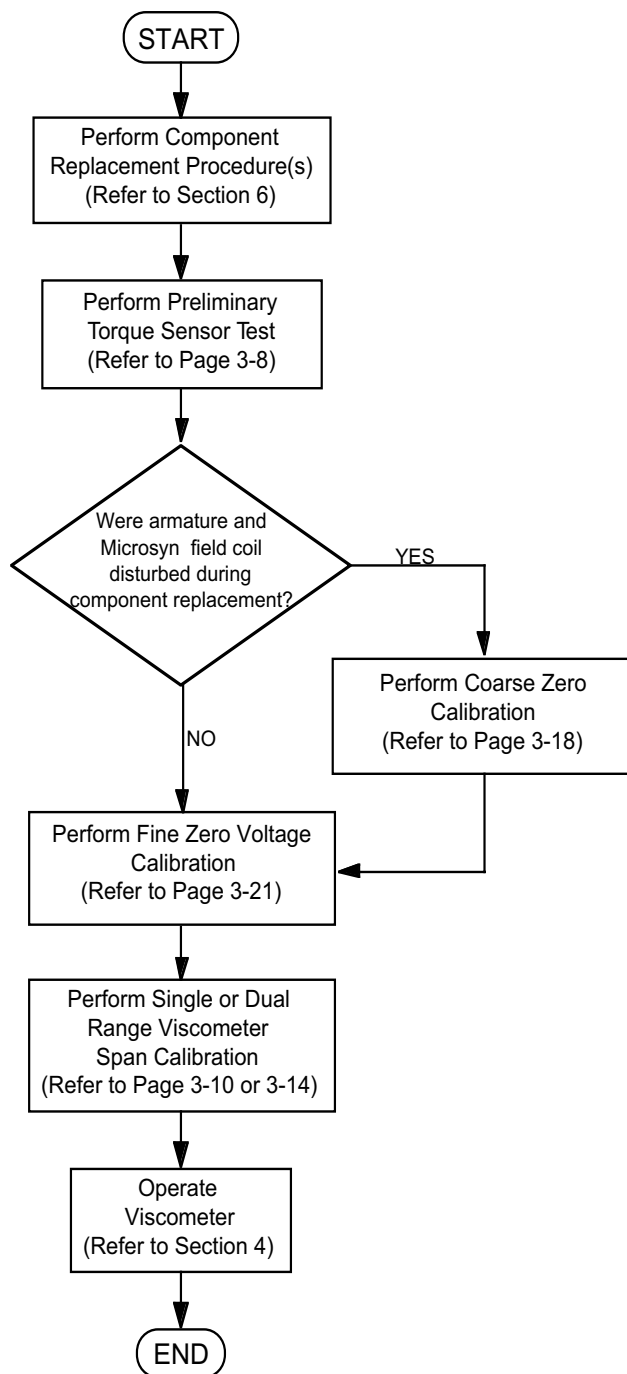


**Figure 3-1: Typical Installation Calibration Flowchart**



*NOTE: This flowchart assumes that the Microsyn housing cover has not been removed during the cleaning process.*

**Figure 3-2: Typical Calibration after Viscometer Disassembly and Cleaning**



**Figure 3-3: Typical Calibration after Component Replacement**

## Fine Zero Milliampere Calibration Test

The Fine Zero Milliampere Calibration Test should be performed after the viscometer has been installed and before process fluid has been introduced into the viscometer. This procedure ensures that the zero position of both the Microsyn field coil assembly and the torque sensor electronics are matched.

### CAUTION

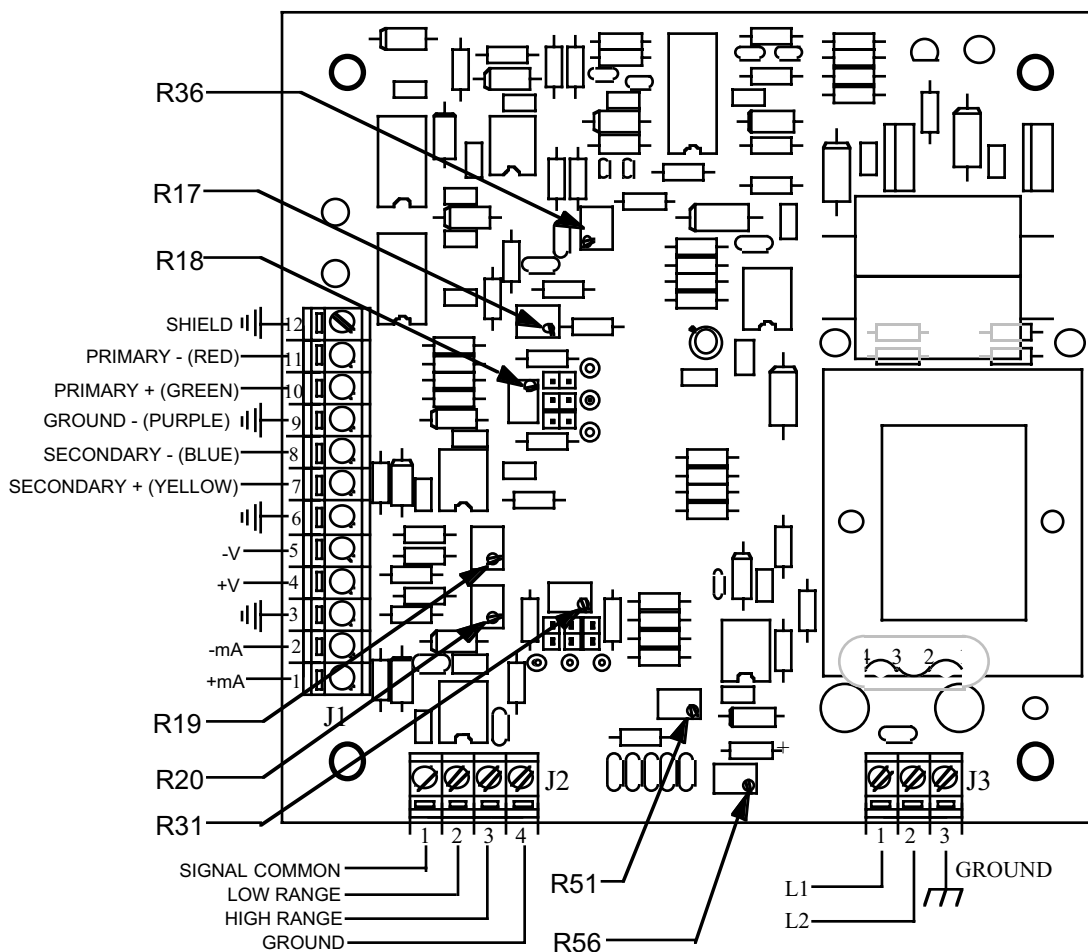
The internal components of the viscometer must be empty of process fluid, clean, and free of obstructions before it can be calibrated. Refer to **Section 5 - Maintenance** and perform the appropriate cleaning procedure for the process fluid application.

*NOTE: Refer to Figure 3-4 for torque sensor circuit board component locations.*

1. Turn power OFF to the motor controls and torque sensor electronics enclosure.
2. Open the cover to the torque sensor electronics enclosure.
3. Disconnect milliampere output cable from J1 Pins 1 and 2 on the torque sensor electronics circuit board.
4. Perform the following steps to allow Digital Volt Meter (DVM) connections to the torque sensor printed circuit board:
  - a. Cut two lengths of #18 - 24 AWG wire 6 inches long.
  - b. Strip approximately 1/8 inch of insulation off each end.
  - c. Connect the first wire to J1-Pin 1.
  - d. Connect the second wire to J1-Pin 2.
5. Set the Digital Volt Meter (DVM) to the 0 - 20.00 mA scale.
6. Connect the DVM positive lead to the wire installed on J1-Pin 1.
7. Connect the DVM negative lead to the wire installed on J1-Pin 2.
8. Turn power ON to the torque sensor electronics enclosure.
9. Adjust R18 (or the Remote Zero potentiometer if so equipped) until the DVM indicates 4.00 mA.

**NOTE:** If 4.00 mA cannot be achieved, perform the Coarse Zero Calibration procedure.

10. Turn power OFF to the torque sensor electronics enclosure.
11. Remove the DVM connections and wires from J1 on the circuit board.
12. Reconnect the milliampere output cable to J1 Pins 1 and 2 on the torque sensor electronics circuit board.
13. Install the enclosure cover.
14. Turn power ON to the torque sensor electronics enclosure.
15. Refer to **Section 4 - Operation**.



**Figure 3-4: Torque Sensor Electronics Board Adjustment Component Locations**

## Preliminary Torque Sensor Test

Perform the following checks to make sure the torque sensor is not damaged before calibrating the viscometer.

1. Remove the viscometer from its mounting:

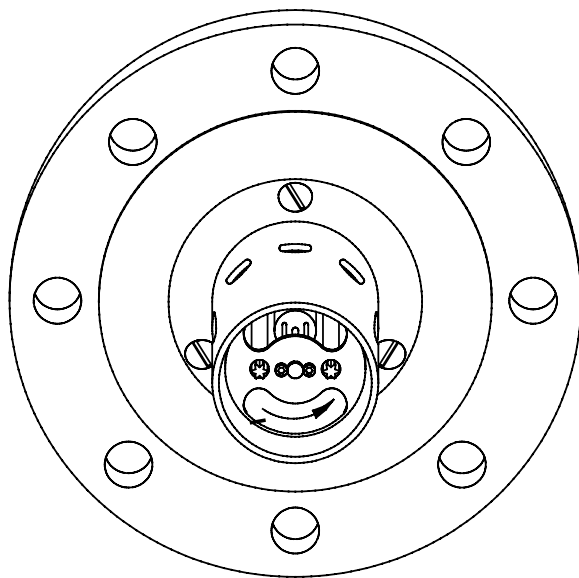
### CAUTION

The internal components of the viscometer must be empty of process fluid, clean, and free of obstructions before it can be calibrated. Refer to **Section 5 - Maintenance** and perform the appropriate cleaning procedure for the process fluid application.

Handle the instrument with care when removing it from the measuring chamber. Damage to the torsion element may result by contacting the inner cylinder with the outer sleeve.

- a. Carefully place the viscometer flange in a vise to hold it secure and parallel to the work surface as shown in Figure 3-5.
2. Visually inspect the torsion element to make sure the wires are straight and square. Gently straighten any minor deviations.
3. Check for the absence of friction within the torque sensor assembly by performing the following steps:
  - a. Cut two lengths of #18 - 24 AWG wire 6 inches long.
  - b. Strip approximately 1/8 inch of insulation off each end.
  - c. Remove the cover from the torque sensor electronics enclosure.
  - d. Connect the first wire to J1-Pin 1 torque sensor printed circuit board.
  - e. Connect the second wire to J1-Pin 2 torque sensor printed circuit board.
  - f. Set the Digital Volt Meter (DVM) to the 0 - 20.00 mA scale.
  - g. Connect the DVM positive lead to the wire installed on J1-Pin 1.
  - h. Connect the DVM negative lead to the wire installed on J1-Pin 2.
  - i. Turn power ON to the torque sensor electronics enclosure.

- j. *Gently* apply torque to the inner cylinder, as shown in Figure 3-5, and observe the DVM display for a rapid, smooth response to the torque applied to a maximum of + 20.00 mA.



**Figure 3-5: Applying Torque to the Inner Cylinder**

- k. Release the inner cylinder and note the final (zero) position DVM reading.
- l. Repeat steps j and k to apply torque in the opposite direction.
- m. Repeat steps j - l several times. If the zero position DVM readings from one direction of torque are not within  $\pm 0.05$  mA and from opposite directions within  $\pm 0.1$  mA, then the viscometer will not be able to be calibrated. Refer to **Appendix A** and call Brookfield Engineering Laboratories, Inc. for assistance.
- n. Proceed with Single or Dual Range Viscometer Calibration.

## Single Range Viscometer Span Calibration

In this procedure, a calibration bar will be used to simulate torque the torsion element will encounter during single range measurement of your specific process fluid. Span calibration allows the torque sensor electronics to be adjusted for the specific range gain in milliamperes from the no torque or (zero point) set at 4.00 mA through 20.00 mA with the calibration bar applied.

### CAUTION

The internal components of the viscometer must be empty of process fluid, clean, and free of obstructions before it can be calibrated. Refer to **Section 5 - Maintenance** and perform the appropriate cleaning procedure for the process fluid application.

***NOTE:** This procedure must be performed before process fluid is introduced into the viscometer.*

***NOTE:** The value of the calibration bar is determined by viscosity range, torque range, and the geometry of the cylinders and should not be considered to represent full scale.*

***NOTE:** Refer to the range information within the **Viscosity & Calibration Data** on the *Viscometer Specification Sheet*, that came with your viscometer, for the appropriate single range calibration information to be used for this calibration procedure.*

***NOTE:** Refer to *Figure 3-4* for torque sensor circuit board component locations.*

1. Turn power OFF to the motor controls and torque sensor electronics enclosure and remove the cover.
2. Remove the sensing endcap from the viscometer from its mounting:

### CAUTION

Handle the instrument with care when removing it. Damage to the torsion element may result by contacting the inner cylinder with the outer sleeve.

***NOTE:** Both the torsion element axis and the calibration bar axis must be within 8° of horizontal for calibration within the limits of the instrument.*



3. Carefully place the viscometer in a vise to hold it secure and parallel to the work surface as shown in Figure 3-6.
  - a. Remove the outer sleeve by removing its three securing screws.
4. Make sure the torsion element is clean. Refer to **Section 5 - Maintenance** for more information.
5. Disconnect milliampere output cable from J1 Pins 1 and 2 on the torque sensor electronics circuit board.
  - a. Perform the following steps to allow Digital Volt Meter (DVM) connections to the torque sensor printed circuit board:
    - b. Cut two lengths of #18 - 24 AWG wire 6 inches long.
    - c. Strip approximately 1/8 inch of insulation off each end.
    - d. Connect one wire to J1-Pin 1.
6. Connect the second wire to J1-Pin 2.
7. Depending upon your viscometer's range (refer to viscometer specification sheet), verify that the range jumper wire between J2-Pin 1 and J2-Pin 3 (HIGH range) or J2-Pin 1 and J2-Pin 2 (LOW range) or the range switch is in the proper position.
8. Turn power ON to the torque sensor electronics enclosure.
9. Set the digital volt meter (DVM) to the 0 - 20.00 mA scale.
10. Connect the DVM positive lead to the wire on J1-Pin 1.
11. Connect the DVM negative lead to the wire on J1-Pin 2.
12. Observe the DVM reading. Adjust R18 for 4.00 mA.

**NOTE:** *If you cannot obtain 4.00 mA by adjusting R18, set R18 to mid point (approximately 7.5 turns) and then perform the Fine Zero Voltage Calibration procedure.*

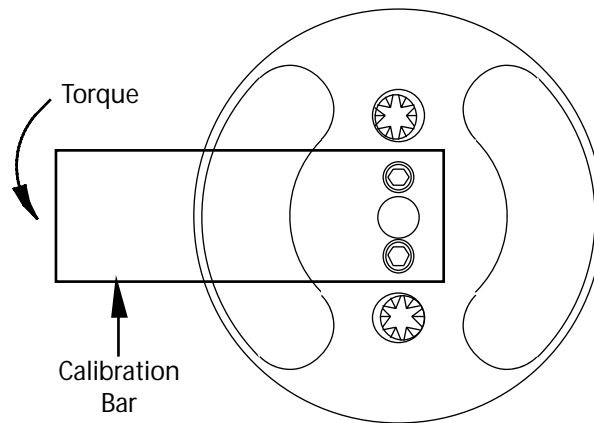
**NOTE:** *To ensure proper span calibration, make sure the calibration bar is installed as shown in Figure 3-6.*

**NOTE:** *Both the torsion element axis and the calibration bar axis must be within 8° of horizontal for calibration within the limits of the instrument.*

## CAUTION

Do not apply extra torque beyond that which is provided by the calibration bar. Damage to the torsion element may result.

13. Install the calibration bar, that came with your viscometer, on the stator mounting screws, parallel to the work surface, and in the direction to which torque will be applied, as shown in Figure 3-6.



**NOTE:** The viscometer may actually be calibrated to sense torque in either direction. The viscometer motor can be wired to rotate in either direction. Calibration and the direction of rotation must be matched. The standard calibration method is shown in Figure 3-6.

**Figure 3-6: Calibration Bar Installation**

14. Adjust R20 for the single LOW range or R51 for the single HIGH range mA value shown on the Viscometer Specification Sheet.
15. Remove the calibration bar. The DVM should indicate  $4.00 \pm .02$  mA.

**NOTE:** If steps 13 and 14 cannot be achieved, refer to **Appendix A** and call Brookfield Engineering Laboratories, Inc. for assistance.

16. Repeat steps 12 - 14 to ensure calibration repeatability.
17. Turn power OFF to the torque sensor electronics enclosure.

18. Remove the DVM wire connections from the torque sensor electronics circuit board.
19. Reconnect the milliamper cable to J1 Pins 1 and 2 on the torque sensor electronics circuit board and install the enclosure cover.

### **CAUTION**

Handle the viscometer with care when installing it into the measuring chamber. Damage to the torsion element may result by contacting the inner cylinder with the outer sleeve.

20. Remove the viscometer from the vise and carefully install it into its mounting.
21. Turn power ON to the torque sensor electronics enclosure.

### **CAUTION**

Do not run the motor without fluid in the viscometer. Damage to the mechanical seals may result.

## **Dual Range Viscometer Span Calibration**

In this procedure, calibration bars will be used to simulate a torque the torsion element will encounter during dual (high and low range) measurement of your specific process



fluid. Span calibration allows the torque sensor electronics to be adjusted with the calibration bar applied for the specific range gain in milliamperes from the no torque (zero point) set at 4.00 mA through 20.00 mA.

## CAUTION

The internal components of the viscometer must be empty of process fluid, clean, and free of obstructions before it can be calibrated. Refer to **Section 5 - Maintenance** and perform the appropriate cleaning procedure for the process fluid application.

***NOTE:** Refer to the high and low range information within the **Viscosity & Calibration Data** on the Viscometer Specification Sheet, that came with your viscometer, for the appropriate range calibration information to be used for this calibration procedure. Only one calibration bar may be supplied with dual range units if the same bar is used to calibrate both ranges.*

1. Turn power OFF to the motor controls and torque sensor electronics enclosure and remove the cover.
2. Remove the viscometer from its mounting:

## CAUTION

Handle the instrument with care when removing it to prevent damage to the torsion element.

3. Carefully place the viscometer flange in a vise to hold it secure and parallel to the work surface as shown in Figure 3-7.
  - a. Remove the outer sleeve by removing its three securing screws.
4. Make sure the torsion element is clean. Refer to **Section 5 - Maintenance** for more information.
5. Perform the following steps to allow Digital Volt Meter (DVM) connections to the torque sensor printed circuit board:



- a. Cut two lengths of #18 - 24 AWG wire 6 inches long.
  - b. Strip approximately 1/8 inch of insulation off each end.
  - c. Connect one wire to J1-Pin 1.
  - d. Connect the second wire to J1-Pin 2.
6. Connect a range jumper wire between J2-Pin 1 and J2-Pin 3 (HIGH range).
- NOTE:** Certain instruments may utilize a SPDT range switch in lieu of a jumper wire. In this case, move the switch to "high" position.*
7. Turn power ON to the torque sensor electronics enclosure.
- NOTE:** To ensure proper span calibration, make sure the calibration bar installed as shown in Figure 3-7.*
8. Set the digital volt meter (DVM) to the 0 - 20.00 mA scale.
9. Connect the DVM positive lead to the wire on J1-Pin 1.
10. Connect the DVM negative lead to the wire on J1-Pin 2.
11. Observe the DVM reading. Adjust R18 for 4.00 mA.
12. Move the range jumper wire between J2-Pin 1 and J2-Pin 2 (LOW range) or move the range switch to "low" position.
13. Observe the DVM reading. It should indicate 4.00 mA.
14. Move the range jumper wire between J2-Pin 1 and J2-Pin 3 (HIGH range).

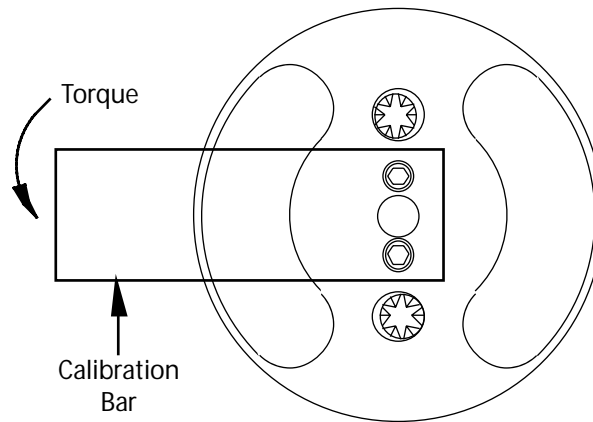
***NOTE:** If  $4.00 \pm .02$  mA is not displayed on the DVM after switching the range jumpers, then perform the Fine Zero Voltage Calibration procedure.*

## CAUTION

Do not apply extra torque beyond that which is provided by the calibration bar. Damage to the torsion element will result.

15. Install the heaviest of the two calibration bars that came with your viscometer, on the inner cylinder mounting screws, parallel to the work surface, and in the direction to which torque will be applied, as shown in Figure 3-7.

**NOTE:** Some dual range viscometers may be supplied with one calibration bar. If so, only one calibration bar will be shown on the viscometer specification sheet.



**Figure 3-7: Calibration Bar Installation**

16. Adjust R51 for the HIGH range mA value shown on the Viscometer Specification Sheet.

**NOTE:** If high range  $\pm .02$  mA cannot be achieved in step 16, refer to **Appendix A** and call Brookfield Engineering Laboratories, Inc. for assistance.

17. Remove the calibration bar. The DVM should indicate  $4.00 \pm .02$  mA.

18. Remove the range jumper wire from J2-Pin 3 and connect it to J2-Pin 2 (LOW range).

19. Observe the DVM reading.

**NOTE:** If  $4.00 \pm .05$  mA is not displayed on the DVM after switching the range jumpers, then perform the Fine Zero Voltage Calibration procedure.

20. Install the lightest of the two calibration bars, that came with your viscometer, on the inner cylinder mounting screws, parallel to the work surface as shown in Figure 3-7.

21. Adjust R20 for the mA LOW range value shown on the Viscometer Specification Sheet.

**NOTE:** If low range  $\pm .02$  mA cannot be achieved, refer to **Appendix A** and call Brookfield Engineering Laboratories, Inc. for assistance.



22. Remove the calibration bar. The DVM should indicate  $4.00 \pm .02$  mA.
23. Repeat steps 11 - 22 to ensure calibration repeatability.
24. Turn power OFF to the torque sensor electronics enclosure.
25. Remove the DVM wire connections from the torque sensor electronics circuit board.
26. Reconnect the milliamper cable to J1 Pins 1 and 2 on the torque sensor electronics circuit board and install the enclosure cover.
27. Remove the viscometer from the vise and carefully install it into its mounting.
28. Turn power ON to the torque sensor electronics enclosure.

## **CAUTION**

Do not run the motor without fluid in the viscometer. Damage to the mechanical shaft seals may result.

## Coarse Zero Calibration

### CAUTION

If the viscometer has been disassembled, then **Coarse Zero Calibration** must be checked before fine zero voltage calibration can occur. Failure to check the coarse zero calibration may cause problems with fine zero voltage calibration. If the viscometer has not been disassembled, then fine zero voltage calibration can be performed without checking the coarse zero calibration.

The internal components of the viscometer must be empty of process fluid, clean, and free of obstructions before it can be calibrated. Refer to **Section 5 - Maintenance** and perform the appropriate cleaning procedure for the process fluid application.

1. Turn power OFF to the motor controls and torque sensor electronics enclosure.
2. Remove the Microsyn housing cover.
3. Open the cover to the torque sensor electronics enclosure.
4. Connect a range jumper wire between J2-Pin 1 and J2-Pin 3 (HIGH range) or move the range switch to the "high" position.
5. Set R31 to its mid point position (approximately 7.5 turns).
6. Turn power ON to the torque sensor electronics enclosure.
7. Perform the following steps to allow Digital Volt Meter (DVM) connections to the torque sensor printed circuit board:
  - a. Cut two lengths of #18 - 24 AWG wire 6 inches long.
  - b. Strip approximately 1/8 inch of insulation off each end.
  - c. Connect the first wire to J1-Pin 2.
  - d. Connect the second wire to J1-Pin 4.
8. Set the DVM to the 0 - 10 VDC scale.



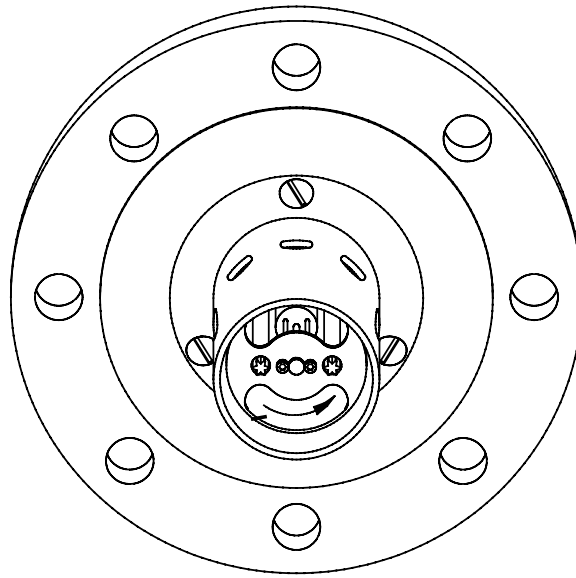
9. Connect the DVM positive lead to the wire installed on J1-Pin 4.
10. Connect the DVM negative lead to the wire installed on J1-Pin 2.
11. Loosen, but do not remove the Microsyn field coil assembly mounting screws.
12. Rotate the Microsyn field coil assembly until  $0 \pm .2$  VDC is observed on the DVM. Tighten the mounting screws.
13. Remove the from the viscometer from its mounting as follows:

### CAUTION

Handle the instrument with care when removing it. Damage to the torsion element may result by contacting the inner cylinder with the outer sleeve.

*NOTE: Both the torsion element axis and the calibration bar axis must be within  $8^\circ$  of horizontal for calibration within the limits of the instrument.*

14. Carefully place the viscometer flange in a vise to hold it secure and parallel to the work surface.
  - a. Remove outer sleeve by removing its three securing screws.
15. Rotate the inner cylinder as shown in Figure 3-8. The DVM should increase in a positive direction. If the DVM reading does not increase in a positive direction, loosen the Microsyn field coil mounting screws and rotate the field coil to obtain the next possible  $0 \pm .2$  VDC position. Tighten the screws.



**Figure 3-8: Inner Cylinder Direction of Torque**

16. Rotate the inner cylinder once again as shown in Figure 3-8. The DVM should increase in a positive direction.
17. Proceed with Fine Zero Voltage Calibration.

### **Fine Zero Voltage Calibration**

#### **CAUTION**

The internal components of the viscometer must be empty of process fluid, clean, and free of obstructions before it can be calibrated. Refer to Section 5 - Maintenance and perform the appropriate cleaning procedure for the process fluid application.



Fine Zero Voltage Calibration ensures that the zero voltage level has been properly calibrated.

This procedure can be used to perform fine zero voltage adjustment once the viscometer has been installed, or after a component requiring calibration has been replaced.

1. Turn power OFF to the motor controls and torque sensor electronics enclosure.
2. Open the cover to the torque sensor electronics enclosure.
3. Perform the following steps to allow Digital Volt Meter (DVM) connections to the torque sensor printed circuit board:
  - a. Cut two lengths of #18 - 24 AWG wire 6 inches long.
  - b. Strip approximately 1/8 inch of insulation off each end.
  - c. Connect the first wire to J1-Pin 2.
  - d. Connect the second wire to J1-Pin 4.
4. Turn power ON to the torque sensor electronics enclosure.
5. Adjust R31 on the torque sensor printed circuit board to its mid-point position (approximately 7.5 turns).
6. Connect the range jumper wire between J2-Pin 1 and J2-Pin 3 (HIGH range) or move the range switch to the "high" position.
7. Set the digital volt meter (DVM) to the 0 - 10 VDC scale.
8. Connect the DVM positive lead to the wire on J1-Pin 4.
9. Connect the DVM negative lead to the wire on J1-Pin 2.
10. Adjust R31 until the DVM indicates  $0 \pm .005$  VDC.
11. Remove the range jumper wire from J2-Pin 3 and connect it to J2-Pin 2 (LOW range) or move the range switch to the "low" position.
12. Verify the DVM indicates  $0 \pm .005$  VDC. If not, adjust R31 to  $0 \pm .005$  VDC.
13. Proceed with Single or Dual Range Viscometer Span Calibration.

## Section 4 - Operation

### Introduction

Once the TT200 In-Line Viscometer has been installed as described in **Section 2 - Installation** and calibrated as described in **Section 3 - Calibration**, the viscometer is ready to be used.

#### CAUTION

Do not proceed with the operation of the viscometer unless the calibration has been verified as described in *Fine Zero Milliampere Calibration Test* in **Section 3 - Calibration**.

### Mechanical Seal Requirements

The TT200 In-Line Viscometer is provided with mechanical face seal(s) which prevents the leakage of process fluid into or from the instrument at the drive shaft entry point. The seal(s) are designed for continuous operation only if lubricated (wetted) by a film of clear fluid at their point of face contact.

#### CAUTION

Do not operate the viscometer motor for more than five (5) revolutions when it is empty. The mechanical seal(s) may be damaged.

Do not operate a TT200 In-Line Viscometer equipped with a double mechanical seal unless the seal housing is supplied with an appropriate pressurized fluid as described in **Section 2 - Installation**.

## Normal Operation Observations

The following conditions are considered to be normal while the TT200 In-Line Viscometer is operating:

- The drive motor will be hot to the touch (synchronous, single-speed motors only).
- The TT200 In-Line Viscometer generates a continuous output signal that is proportional to the apparent viscosity of the process fluid being measured.
- Depending upon the viscosity, flow rate, and resultant mixing near the measuring chamber, the viscometer will respond quickly to the introduction of new process fluid.
- Since shear conditions, temperature, shear history may differ between the viscometer and another measurement, it is not unusual for numerical values to differ. Refer to *Correlation with Other Measurements* in **Section 1 - Introduction** for more information.
- If solids are allowed to form on the internal surfaces of the viscometer, they may alter span by changing the measuring annulus dimensions. Solids may also limit the torsion element motion. Refer to *Cleaning In Place* in **Section 5 - Maintenance** for more information.

## Interlocks

Viscometer interlocks are options that prevent the viscometer from being damaged due to abnormal process fluid temperature or double mechanical seal assembly pressure. The interlocks prevent the viscometer motor from being activated when below the calibrated setpoint.

### CAUTION

Do not disconnect an interlock from the viscometer. Viscometer damage may result.

## Start-up

Once the TT200 In-Line Viscometer has been installed as described in **Section 2 - Installation** and proper calibration has been verified as described in **Section 3 - Calibration**, the viscometer can be energized.

### CAUTION

Do not energize the TT200 In-Line Viscometer motor equipped with a double mechanical seal housing unless the fluid pressure has been applied. Damage to the double mechanical seal assembly may occur.

Do not operate the TT200 In-Line Viscometer motor for more than five (5) revolutions when it is empty. The mechanical seal(s) may be damaged.

Do not operate the TT200 In-Line Viscometer motor if the process fluid temperature or double mechanical seal assembly pressure is not within normal operating specifications. Damage to the viscometer may result.

1. If the TT200 In-Line Viscometer is equipped with a double-seal housing, apply the barrier fluid.
2. Add process fluid to the system in which the viscometer is mounted.
3. Check the viscometer motor for proper operation by performing the following steps:
  - a. Set the **POWER** switch on the Torque Sensor Electronics Enclosure to the ON position.
  - b. Set the **POWER** switch on the Motor Control Enclosure to the ON position.
  - c. Observe the display device. The torque sensor output signal should increase in a positive direction.

## Shutdown

### CAUTION

Do not allow the process fluid to dry or solidify. Damage to the TT200 In-Line Viscometer may result.

1. Shut the TT200 In-Line Viscometer OFF by performing the following steps:
  - a. Set the POWER switch on the Torque Sensor Electronics Enclosure to the OFF position.
  - b. Set the POWER switch on the Motor Control Enclosure to the OFF position.
  - c. If equipped with a double mechanical seal assembly, release the pressure on the pressurized seal fluid if process pressure is also released.

**NOTE:** *Maintaining pressure of barrier fluid within the double mechanical seal assembly at all times is not harmful.*

## Operation with Multiple Speed Motors

### Start-up

Once the TT200 In-Line Viscometer has been installed as described in **Section 2 - Installation** and proper calibration has been verified as described in **Section 3 - Calibration**, the viscometer can be energized.

### CAUTION

Do not energize the TT200 In-Line Viscometer motor equipped with a double mechanical seal housing unless the fluid pressure has been applied. Damage to the double mechanical seal assembly may occur.

Do not operate the TT200 In-Line Viscometer motor for more than five (5) revolutions when it is empty. The mechanical seal(s) may be damaged.

Do not operate the TT200 In-Line Viscometer motor if the process fluid temperature or double mechanical seal assembly pressure is not within normal operating specifications. Damage to the viscometer may result.

1. If the TT200 In-Line Viscometer is equipped with a double-seal housing, apply the barrier fluid.
2. Add process fluid to the system in which the viscometer is mounted.
3. Check the viscometer motor for proper operation by performing the following steps:
  - a. Set the POWER switch on the Control Enclosure to the ON position.
  - b. Open the cover to the Control Enclosure. Adjust both the "range" switch and the "speed control" switch to their intended positions using the "Speed/Viscosity Selection Guide" table on the inside cover for reference.\*
  - c. Set the MOTOR switch on the Control Enclosure to the ON position.
  - d. Observe the display devices. The torque sensor output signal should increase in a positive direction and the proper speed should be displayed.

\*Certain multiple speed instruments may have a continuously variable rheostat instead of a multiple position switch. Adjust as needed.

## Shutdown

### CAUTION

Do not allow the process fluid to dry or solidify. Damage to the TT200 In-Line Viscometer may result.

1. Shut the TT200 In-Line Viscometer OFF by performing the following steps:
  - a. Set the MOTOR switch on the Control Enclosure to the OFF position.
  - b. Set the POWER switch on the Control Enclosure to the OFF position.
  - c. If equipped with a double mechanical seal assembly, release the pressure on the pressurized seal fluid if process pressure is also released.

***NOTE:** Maintaining pressure of barrier fluid within the double mechanical seal assembly at all times is not harmful.*

## Section 5 - Maintenance

### Introduction

There are three different methods for cleaning the internal components of the TT200 Process Viscometer. The Clean-in-Place method, which is typically used, provides minimal downtime and effective cleansing of the viscometer during process system cleaning. The Flushing method is used when additional internal viscometer cleansing is required. The Disassembly and Cleaning method is used when the process system is seriously contaminated and the viscometer cannot otherwise be cleaned.

### Clean-In-Place

*NOTE: The solvent used for cleaning the viscometer is dependent upon the process fluid being measured.*

1. Refer to **Section 4 - Operation** and perform the *Shutdown* procedure.

*NOTE: It may be preferable to isolate the section of pipe or tank in which the viscometer is installed from the main process system.*

2. Drain the process fluid from the system, tank, or isolated section of pipe in which the viscometer is installed.
3. Fill the system tank, or isolated section of pipe in which the viscometer is installed, with cleaning fluid.
4. If equipped with a double mechanical seal assembly, apply the barrier pressurized fluid pressure.

*NOTE: The time duration of step 5 varies by the amount of process fluid build-up and its cleaning characteristics.*

5. Set the **POWER** switch on the Motor Control Enclosure to the ON position. Allow the viscometer motor to operate until the viscometer is clean.
6. Set the **POWER** switch on the Motor Control Enclosure to the OFF position.
7. Drain the cleaning fluid from the system, tank, or isolated section of pipe in which the viscometer is installed
8. Refer to **Section 4 - Operation** and perform the *Start-up* procedure.



## Flushing

*NOTE: This procedure assumes that flushing connections have been made to the TT200 Viscometer as defined in **Section 2 - Installation**.*

*NOTE: The solvent used for cleaning the viscometer is dependent upon the process fluid being measured.*

1. Refer to **Section 4 - Operation** and perform the Shutdown procedure.

*NOTE: If possible, isolate the section of pipe, or tank, in which the viscometer is installed from the main process system.*

2. Drain the process fluid from the system, tank, or isolated section of pipe in which the viscometer is installed.

*NOTE: The time duration of step 3 varies by the amount of process fluid build-up.*

3. With the system drain valve open, open the flushing fluid valve and allow the fluid to flow through the viscometer and out through the drain valve.
4. Close the flushing fluid valve.
5. Close the process fluid system drain.
6. Refer to **Section 4 - Operation** and perform the Start-up procedure.

## Disassembly and Cleaning

The following procedures will guide you through this process. The solvent used for cleaning the viscometer is dependent upon the process fluid being measured.

### CAUTION

Always replace endcap O-rings when disassembling and cleaning the viscometer. Refer to **Appendix A** and contact Brookfield Engineering Laboratories, Inc. to order replacement O-rings.

### CAUTION

Depending upon the application, the torsion element and other internal components may be coated with Teflon. Make sure the solvent being used does not harm Teflon. Do not scrape surfaces coated with Teflon.

## Cleaning the Viscometer Assembly

### WARNING



Make sure power has been turned OFF at the motor and torque sensor electronics enclosures before servicing the viscometer.

1. Shut power OFF to the motor and torque sensor electronics enclosures.

### CAUTION

Handle the viscometer with care when removing it from its mounting to prevent damage to the torsion element.

2. Remove outer sleeve by removing its three attaching screws. Clean it, and set it aside.

3. Using an appropriate solvent, carefully clean any process fluid build-up from the outside of the inner cylinder, between the stop posts and the inner cylinder as shown in Figure 5-1, from the inside of the inner cylinder, and from the flange. If required, remove the inner cylinder to clean the inside mechanism as follows:

### CAUTION

If the torsion element is coated with Teflon (blue/green color), make sure the solvent being used does not harm Teflon. Do not scrape surfaces coated with Teflon. Do not touch the torsion element with a sharp object. Clean only by using a stream of solvent or soft bristle brush.

Do not apply torque to the torsion element while removing the inner cylinder mounting screws. Damage to the torsion element may result.

- a. Remove the mounting screws from the inner cylinder stator as shown in Figure 5-1.
- b. Carefully remove the inner cylinder.

### CAUTION

Visually inspect the torsion element wires. They should be straight and parallel to each other. If they are not, refer to **Appendix A** and contact Brookfield Engineering Laboratories, Inc. for a replacement torsion element.

- c. Clean the inside and outside of the inner cylinder.

### CAUTION

Be careful not to damage the torsion element wires if step d is performed.

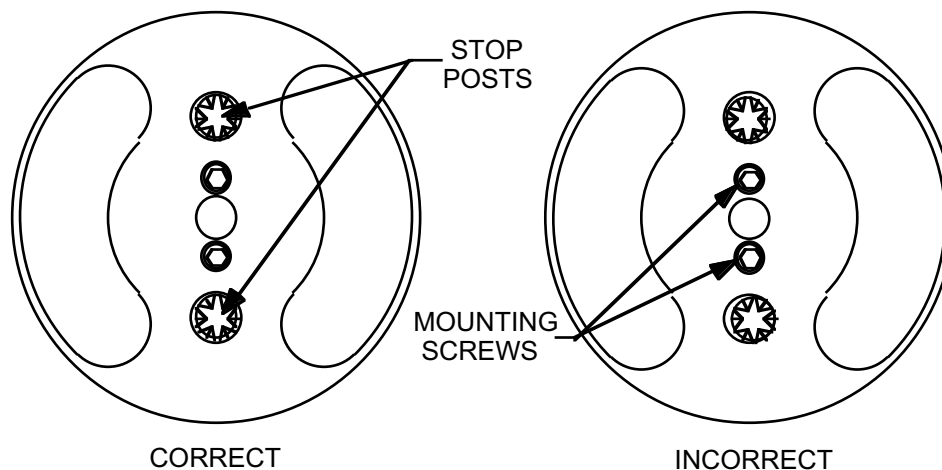
- d. If normal cleaning procedures are not successful, use solvent and a soft bristle brush and carefully clean between the torsion element wires.
4. Carefully install the inner cylinder and install the mounting screws but do not tighten.

**NOTE:** The stop posts must be centered within the holes on the inner cylinder as shown in Figure 5-1 to ensure free movement of the inner cylinder.

## CAUTION

Do not apply torque to the torsion element while installing the stator mounting screws. Damage to the torsion element may result.

5. With the inner cylinder mounting screws loose, rotate the inner cylinder so the stop posts are aligned in the center of the holes in the inner cylinder as shown in Figure 5-1. Tighten the mounting screws and check the alignment of the stop posts.



**Figure 5-1: Inner Cylinder Installation and Stop Post Centering**

**NOTE:** If the stop posts will not align in the center of the inner cylinder holes, remove the mounting screws and rotate the stator 180°. Install the screws and repeat step 5. The stop posts may also be rotated or slightly bent to insure correct alignment. Refer to **Appendix A** and contact Brookfield Engineering Laboratories if the stop posts cannot be properly aligned.

### Reassembly

1. Carefully reinstall the instrument on its mounting flange.
2. Turn power to the motor controller enclosure OFF.

### CAUTION

Do not damage the torsion element when installing the drive endcap assembly into the measuring chamber.

3. Refer to **Section 3 - Calibration** and perform the calibration procedures shown in Figure 3-2.



# Appendix A - Customer Support

## Introduction

Use the following information to Contact Brookfield Engineering Laboratories, Inc. for technical assistance or service:

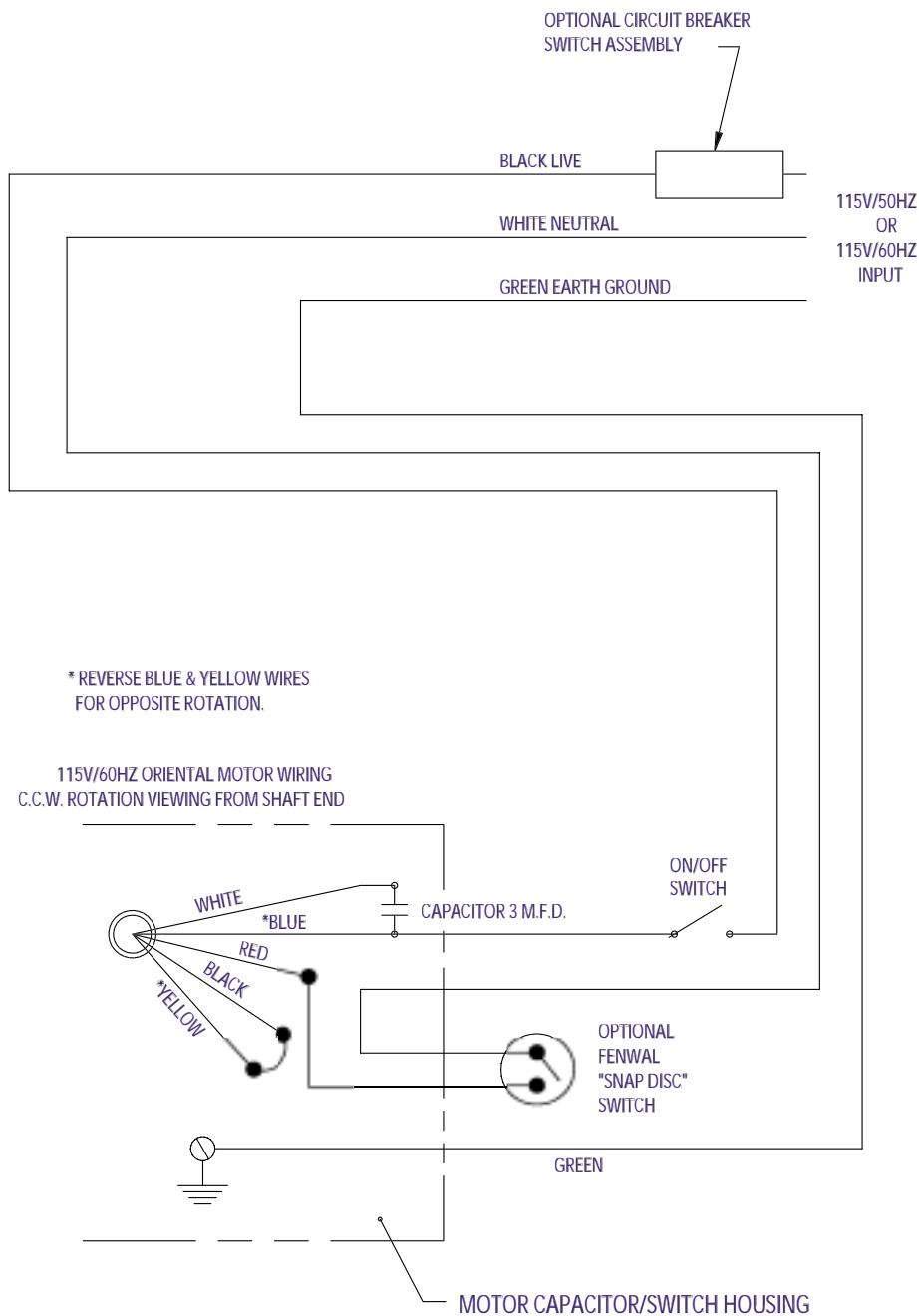
Brookfield Engineering Laboratories, Inc.  
11 Commerce Boulevard  
Middleboro, Massachusetts 02346 U.S.A.  
TEL: 508-946-6200  
800-628-8139 (USA only - excluding MA)  
FAX: 508-946-6262

Please have the following information available when calling so that we may assist you:

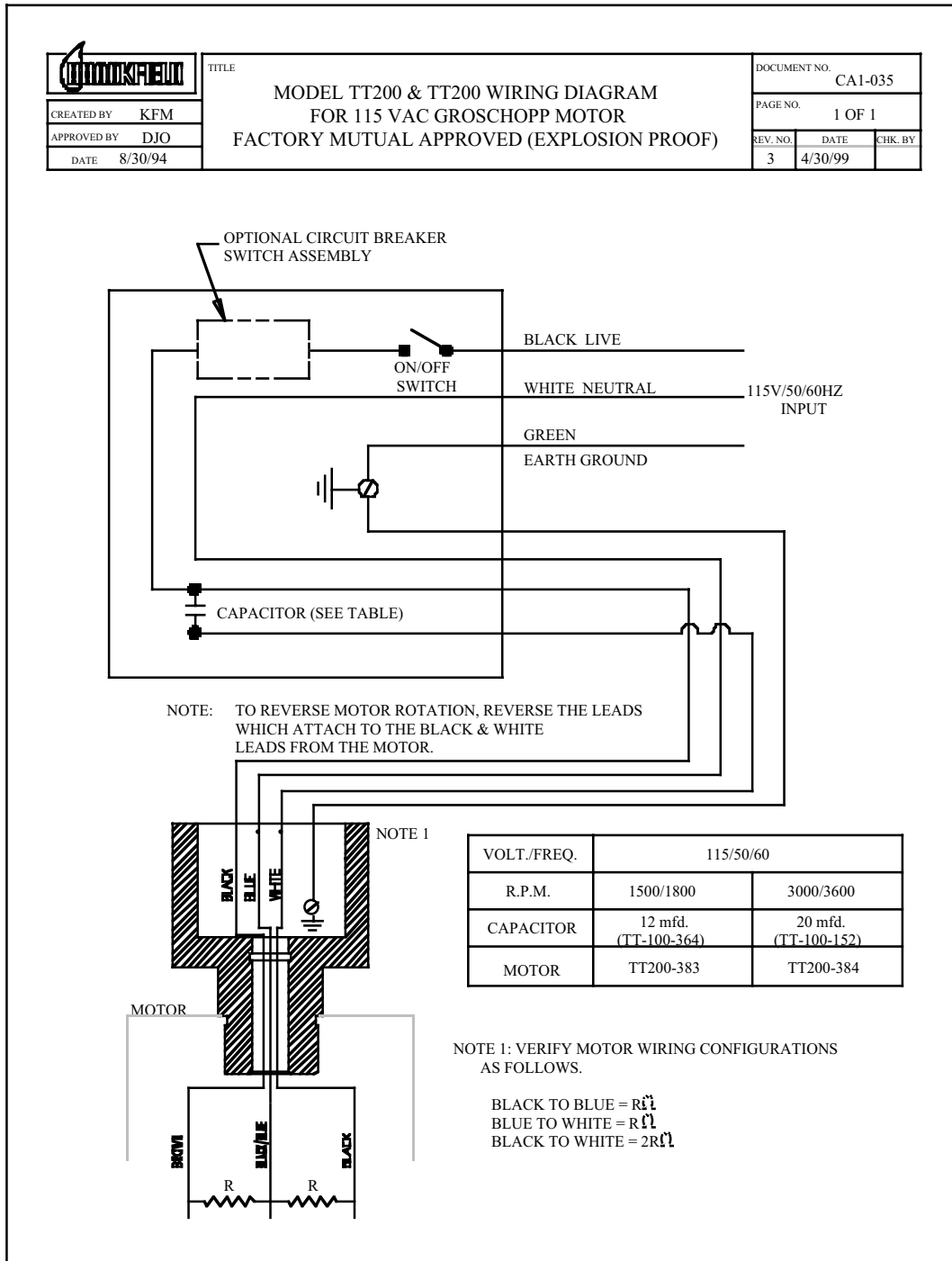
- Product Part Number
- Product Serial Number
- Product Application
- Specific Problem Area
- Hours of Operation
- Equipment Type

# Appendix B - Drawings

	TITLE	DOCUMENT NO.
	WIRING DIAGRAM FOR NEMA 4 ORIENTAL MOTOR (TT100-455RY)	CA1-050
	CREATED BY KFM	PAGE NO. 1 OF 1
APPROVED BY		REV. NO.
DATE 4/20/99		DATE
		CHK BY



**Figure B-1: NEMA 4 Oriental Motor Wiring Diagram**



**Figure B-2: Groschopp Motor Wiring Diagram (Factory Mutual Housing)**

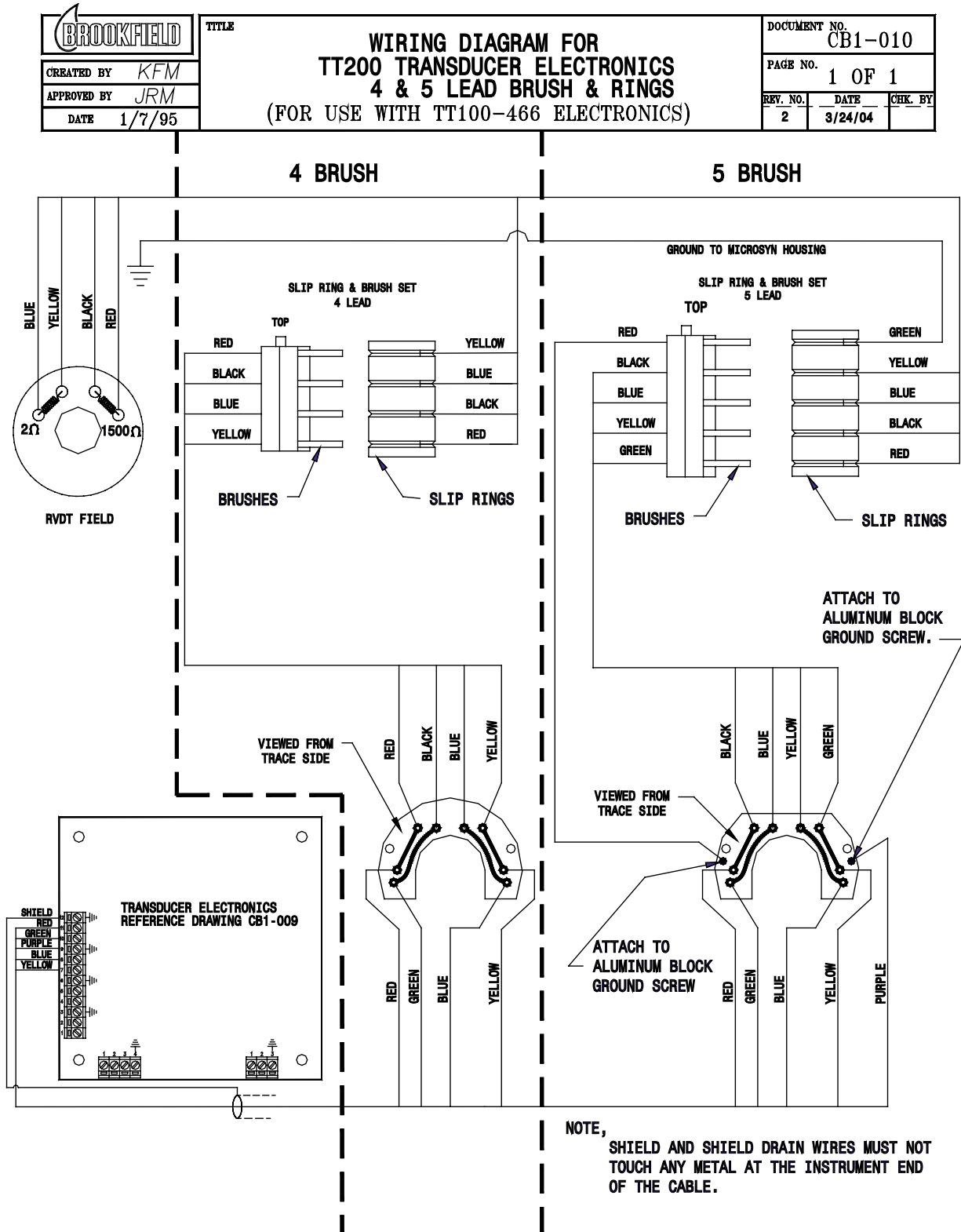
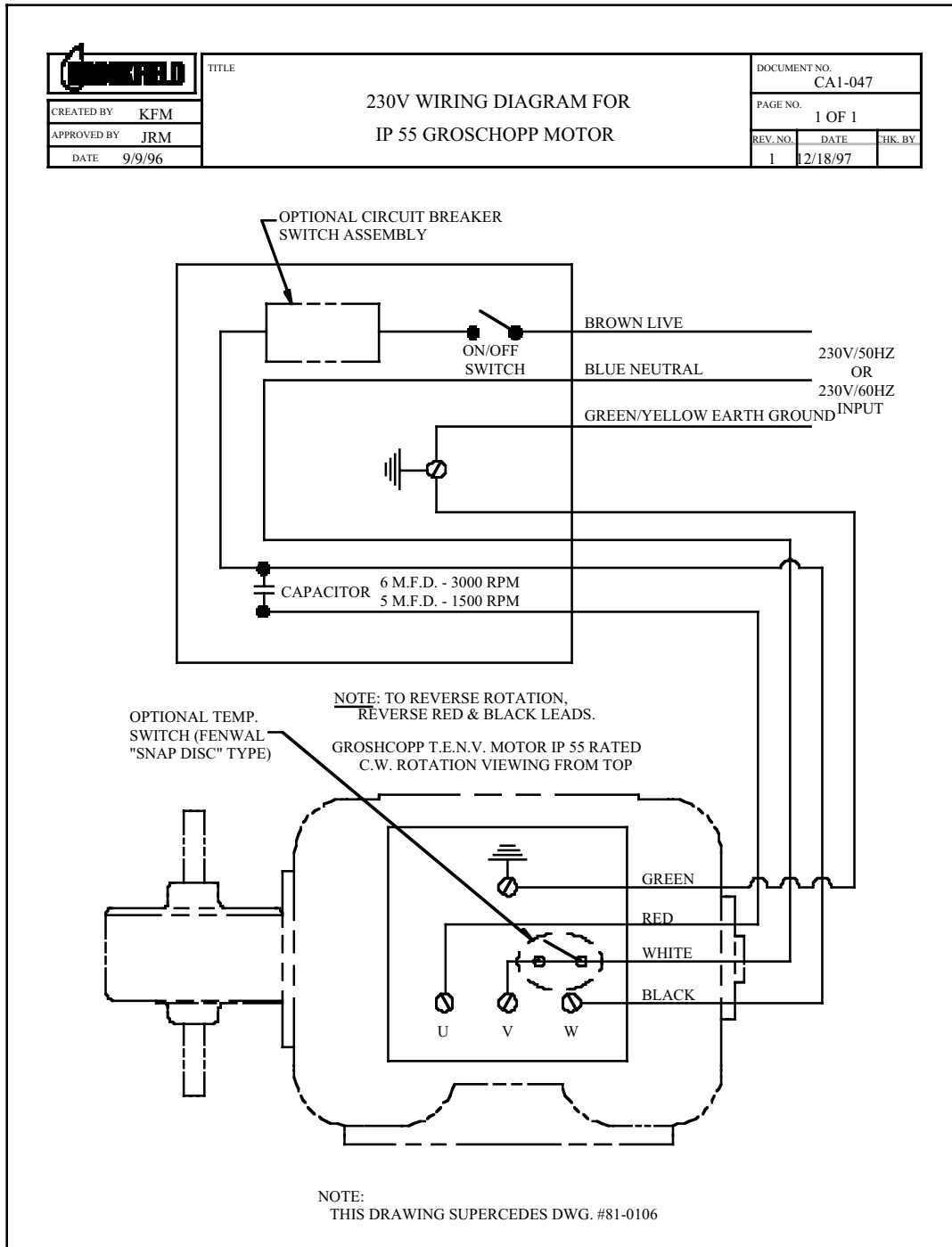
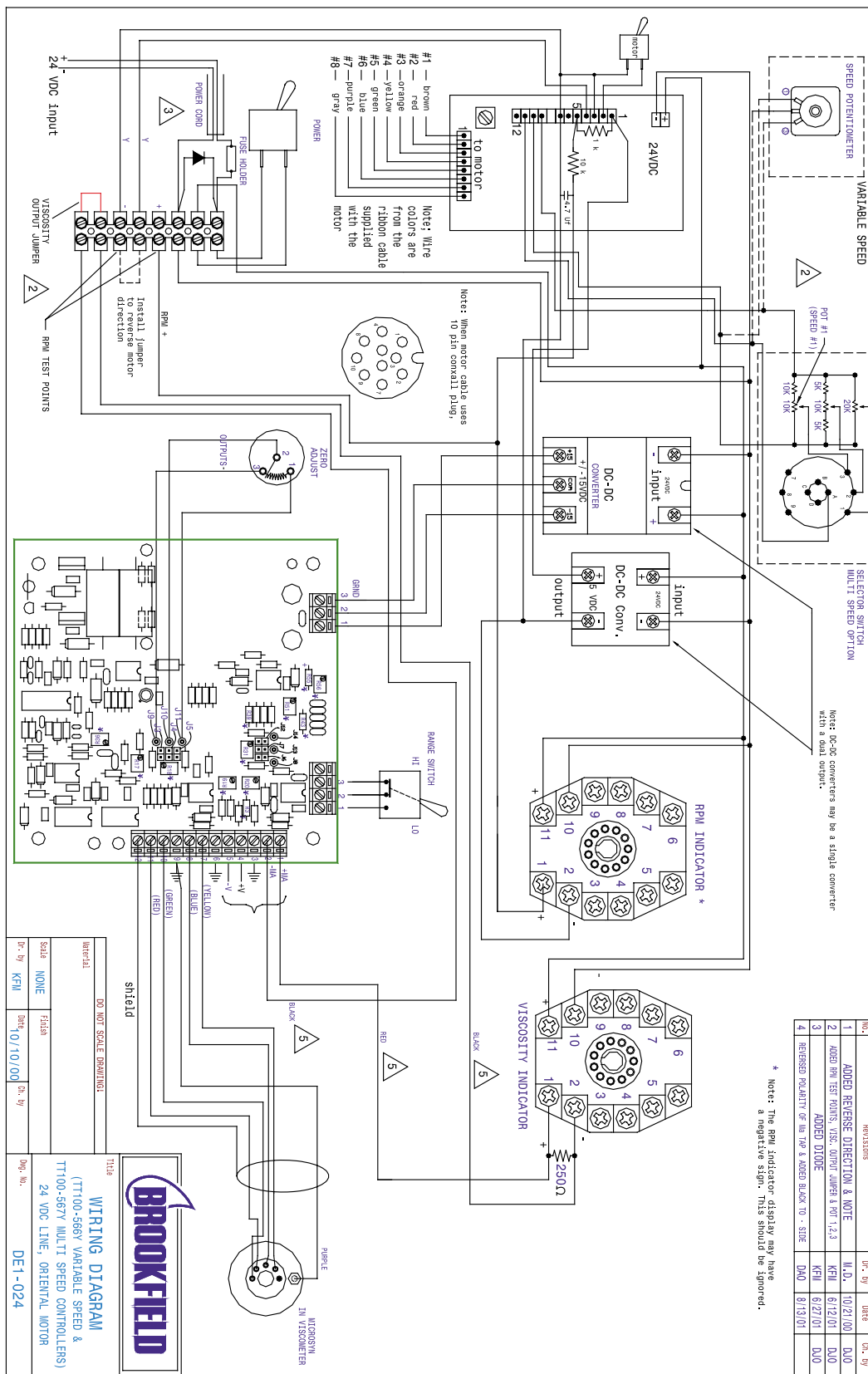


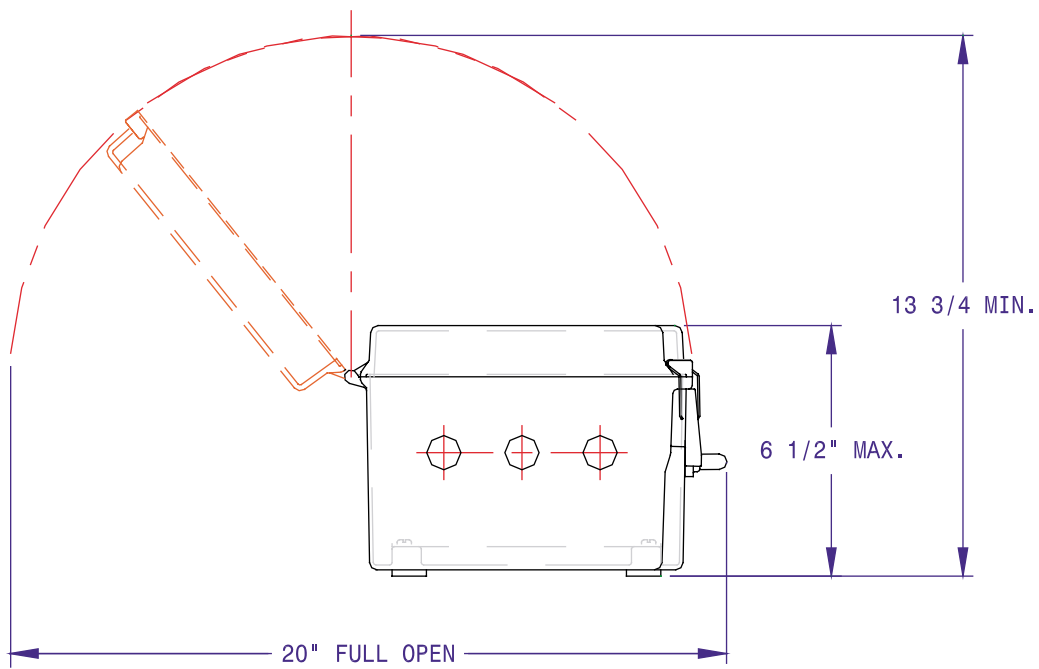
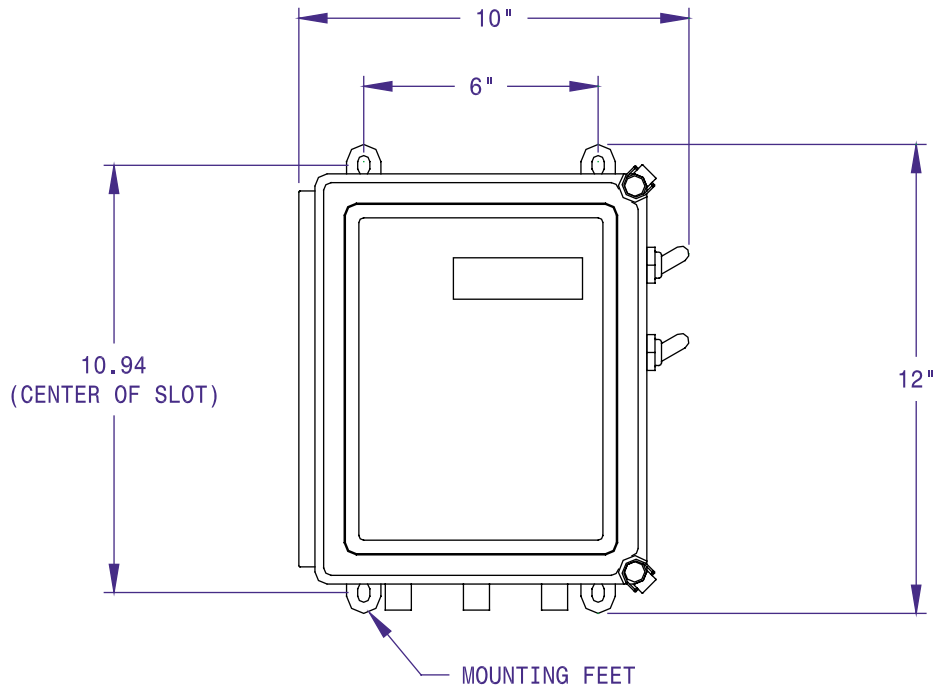
Figure B-3: Torque Sensor Wiring Diagram



**Figure B-4: 230 VAC Wiring Diagram for IP 55 Groschopp Motor**



	TITLE	DOCUMENT NO.
	ELECTRONIC ENCLOSURE (24VDC-VARIABLE/MULTI SPEED) MOUNTING & CLEARANCE DIMENSIONS	CB3-020
	CREATED BY KFM	PAGE NO. 1 OF 1
	APPROVED BY	REV. NO. DATE CHK. BY
DATE 03/02/01		

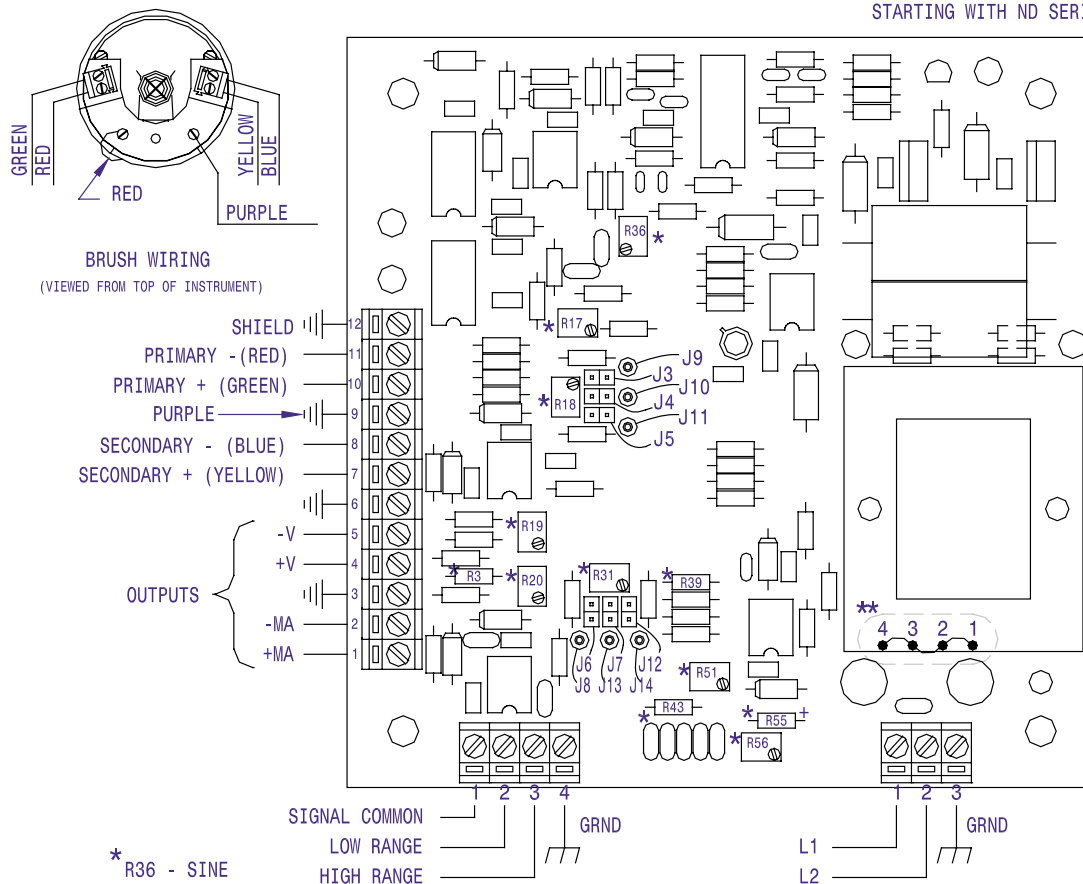


**B-5: CENELEC 115 VAC Groschopp Motor Wiring Diagram**



	TITLE	DOCUMENT NO.
	TT MICROSYN ELECTRONICS	CB1-009
CREATED BY KFM	TT200	PAGE NO.
APPROVED BY JRM		1 OF 1
DATE 1/7/95		REV. NO. DATE CHK. BY
		4 3/24/04

STARTING WITH ND SERIAL NOS.



- \* R36 - SINE
- R17 - PHASE
- R3 - RESISTOR - RATIO
- R18 - ZERO (MA) (1K  $\Omega$ )
- R19 - SPAN (MA)
- R20 - SPAN (LOW)
- R31 - ZERO (VOLTS) (50K  $\Omega$ )
- R43 - RESISTOR - SPAN
- R39 - RESISTOR - SPAN
- R51 - SPAN (HIGH)
- R56 - DAMPENING ADJUST

\*\*

AC POWER JUMPER OPTIONS	
110 VAC INPUT	INSTALL 1-2
	INSTALL 3-4
220 VAC INPUT	INSTALL 2-3 (ONLY)

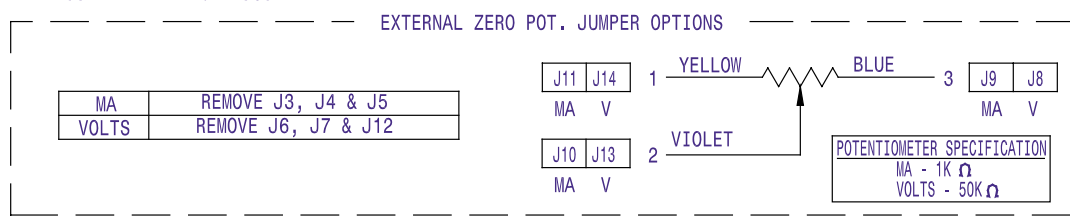
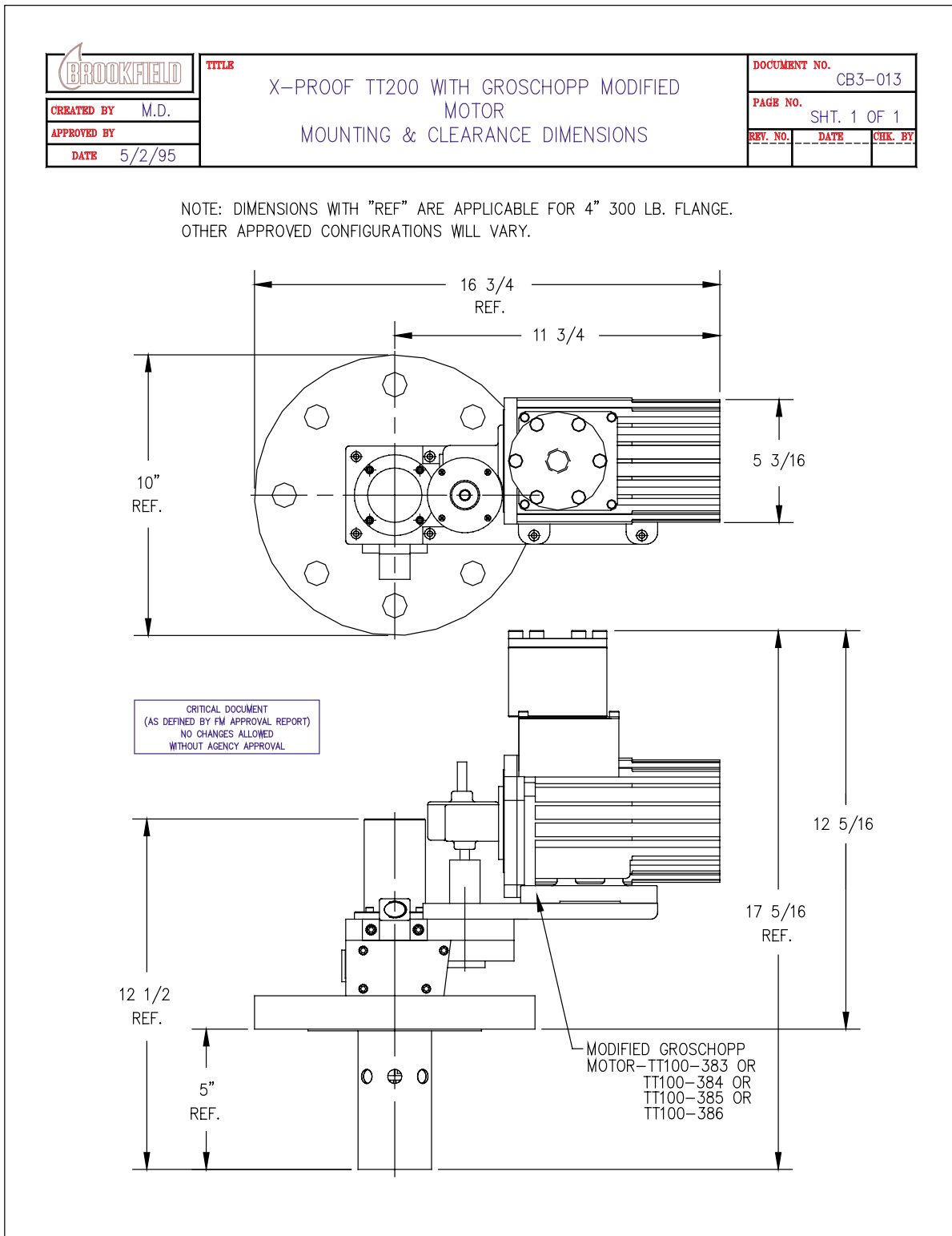
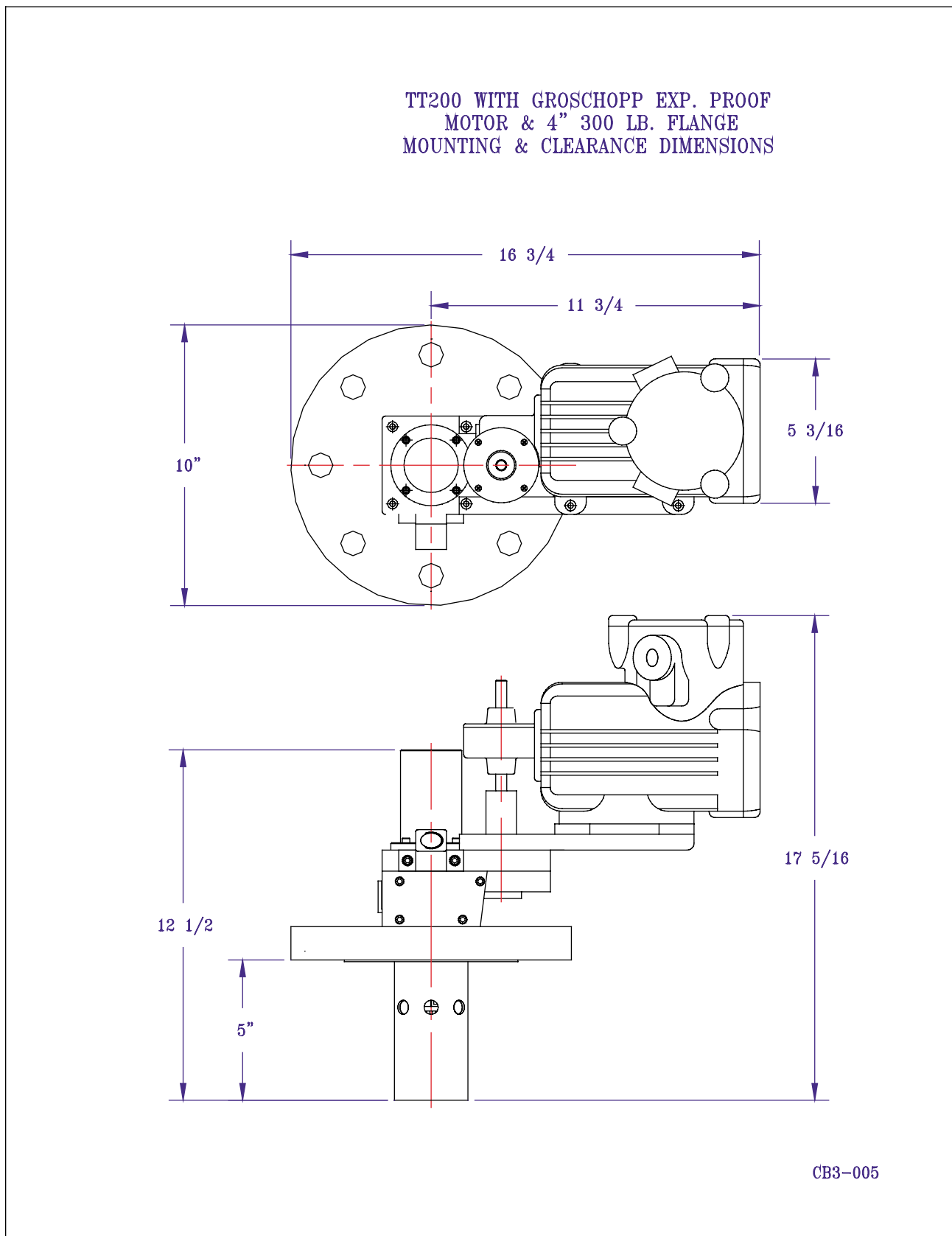


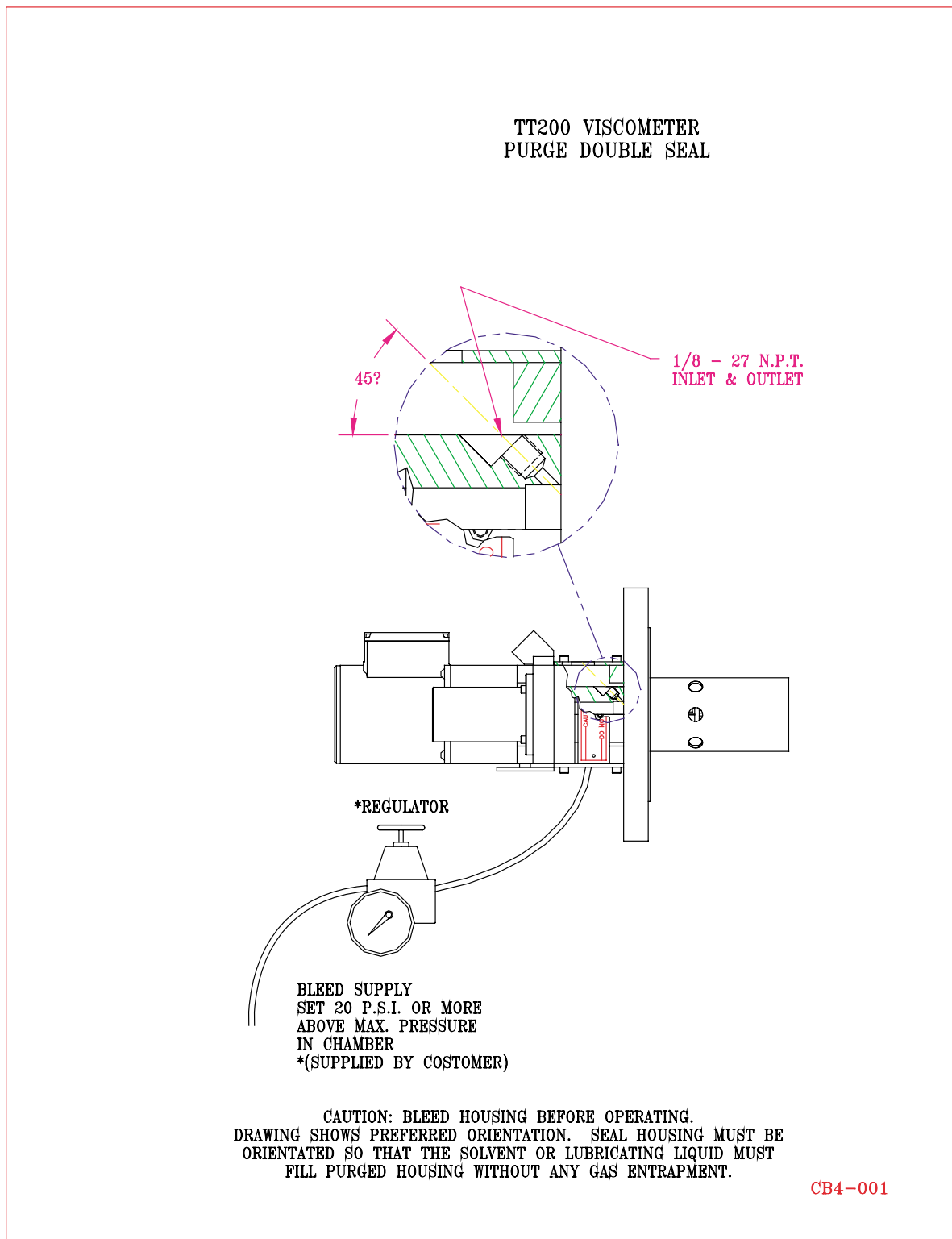
Figure B-6: CENELEC 230 VAC Groschopp Motor Wiring Diagram



**Figure B-7: TT200 In-Line Viscometer (NEMA 4 with Oriental Motor)**



**Figure B-8: TT200 Viscometer for Hazardous Areas (NEMA 7)**



**Figure B-9: TT200 In-Line Viscometer Double Mechanical Seal Connections**

# Appendix C - Viscosity Range Change

## Introduction

The model TT200 viscometer operates under defined shear conditions.

As a single speed instrument, the viscometer measures viscosity at one specific shear rate as determined by the speed of rotation and the internal measuring geometry.

Depending on the application, the model TT200 viscometer can be redesigned, with minimal effort, to change the measured viscosity range and/or the shear conditions. With the design of this viscometer, the viscosity range is inversely proportional to speed, and shear rate.

With the limited single-point viscosity measurement, on a bench-top (laboratory) viscometer, little is known about the viscosity of the process fluid while it flows under different conditions in the process stream. Therefore, we normally provide some built-in flexibility in the measured viscosity range and shear rate to allow changes to be made in instrument ranging after initial shipment.

## Changing Range or Shear Rate

Reasons for changing the existing viscosity range:

- Better accuracy; accuracy is defined as + 1% of full scale range. Accuracy improves with a finer viscosity range.
- Formulation change in the process.
- Over-ranging, requires broader viscosity range.

Reasons for changing the existing shear rate:

- Measure viscosity at a different part of the rheogram curve.
- Correlate/track with bench-top viscosity measurements in the laboratory.

In order to change both the shear rate and viscosity measurement range, the rotating cylinder (stator), outer sleeve, and/or the gear box (speed of rotation) must be replaced.



## Speed of Rotation Change

If only the speed of rotation is altered, the measured viscosity range changes to the proportion of:

$$\text{SPEED OF ROTATION CHANGE} = \frac{\text{OLD VISCOSITY RANGE X OLD SPEED}}{\text{NEW SPEED}}$$

$$\text{EXAMPLE: } \frac{1000 \text{ cP} \times 100 \text{ RPM}}{200 \text{ RPM}} = 500 \text{ cP}$$

By doubling the speed of rotation, the shear rate will double and the measured viscosity range is decreased by a factor of two. If the old measured shear rate was 67 sec<sup>-1</sup>, the new shear rate will be 134 sec<sup>-1</sup>.

Each stator has a shear rate constant, that when multiplied by the speed of rotation, yields the measured shear rate.

Rule of thumb; with all else equal, by increasing the speed of rotation (rpm), the measured viscosity range is more refined but at a larger shear rate. By decreasing the speed of rotation, the viscosity range broadens and with certain drive motor options, the speed of rotation may be varied and indicators of both speed (RPM) and torque are provided. Selection of both speed and torque range (0-100%) is done within the control box. See Drawing DE1-024 on page B-5 for details.

## Geometry Change

By only changing the stator, the shear rate and viscosity range will change by the ratio of factors for shear rate and geometry (ranging).

$$\text{NEW SHEAR RATE} = \frac{\text{OLD SHEAR RATE X NEW SHEAR RATE FACTOR}}{\text{OLD SHEAR RATE FACTOR}}$$

$$\text{NEW RANGE} = \frac{\text{OLD RANGE X NEW GEOMETRY FACTOR}}{\text{OLD GEOMETRY FACTOR}}$$

Rule of thumb; with all else equal, by changing to a stator which decreases gap size, the viscosity range is more refined, but the shear rate increases. By increasing the measurement zone gap, the viscosity range broadens, but the shear rate decreases.

## Torsion Element Change

The third item which may be replaced, or have its response (calibration) altered is the torsion element or viscosity sensing device. There are four different torsion elements available, each capable of being calibrated over relatively wide limits, depending upon the sensitivity required. By only changing the torsion element, or its calibration, the viscosity range will change without changing the shear rate.

***NOTE:** Torsion element replacement should be accomplished by the factory or an experienced maintenance technician.*

## Electronic Change

The output signal can be altered by changing resistors on the torque sensor electronics board in order to change calibration/and change viscosity sensing ranges. Refer to **Appendix A** and contact Brookfield Engineering Laboratories for more information.

A selectable high/low range provision exists within the electronics board for greater accuracy. Factory calibration for both ranges is optional. If not selected at the time of purchase, dual range calibration may be added. Refer to **Appendix A** and contact Brookfield Engineering Laboratories for more information.

## Summary

Viscosity range can be accomplished with any of four methods, in usual order of practicality; most to least:

- a. Geometry Replacement
- b. Gearbox Replacement
- c. Electronics Adjustment
- d. Torsion Element Replacement

***NOTE:** Refer to Tables C-1 and C-2 for shear rate factors and geometry factors for all rotor/stator combinations.*

**Table C-1: Shear Rates and Factors for 2.440 ID Outer Sleeve**

Stators/RPM	Shear Rate SEC <sup>-1</sup> /RPM	Geometry Factor Uncoated	Geometry Factor Teflon Coated
TT100-4	2	1.101	1.02
TT100-4B	4	0.504	0.476
TT100-4C	1.161	2.804	1.91
TT100-4CZ	1.161	1.916	1.88
TT100-4D	0.67	4.13	3.817
TT100-4E	0.37	12.5	-
TT100-4F	-	29.41	-
TT100-4G	1.42	1.353	1.333
TT100-4H	0.34	13.513	-
Serrated	1.00	1.962	1.60



# Appendix D - Agency Approvals

## Introduction

The following agencies have given the TT200 In-Line Process Viscometer their approval for operation in the areas listed in Table D-1.

**Table D-1: Agency Approvals - TT200 In-Line Process Viscometer**

<b>Viscometer</b>	<b>Approval</b>	<b>Approval Agency</b>	<b>Protection Concept</b>
TT200-XP	Class 1, Division 1 and 2, Group C and D (NEMA 7)	Factory Mutual (FM)	Hazardous area use: explosion proof
TT200 all models	CE		Radiated Emissions



## Appendix E - Warranty Information

### Guarantee

We hereby guarantee this Brookfield Viscometer to be free from defects in workmanship and materials. If found to be defective in workmanship or materials upon being returned, within one year from the date of purchase to our factory, it will be repaired or replaced at the factory without charges. Transportation charges shall be at the owner's expense.

However, if upon being so returned and after inspection, we determine that the instrument has been subjected to tampering, careless handling, improper or faulty application or installation, the above guarantee shall not be applicable and we shall have the right in any such case to make a charge to cover the cost of repairs or servicing. Brookfield Engineering Laboratories, Inc. assumes and shall have no liability for consequential damages resulting from the use or misuse of the instrument.

The foregoing guarantee is in lieu of all other guarantees or warranties, expressed or implied, and of all other obligations or liabilities, contractual or otherwise, either to the original purchaser of said instrument or to any other person whomsoever.

# Glossary

## **Control High and Low Limits**

The measured values, expressed in engineering units, which cause control output to change.

## **Centipoise/milli-pascal-seconds**

Units of absolute viscosity. The viscosity of water at room temperature is 1 centipoise or 1 milli-pascal-second.

## **Correlation**

A relationship, usually shown as a graph, between one measurement and another. When correlating two viscosity measurements, it must be shown that a particular value from one measurement always corresponds to a particular value in the other. The conditions (method, temperature, amount of rotations, etc.) should remain constant to obtain this correlation.

## **Cup Seconds**

The amount of time required for a given fluid to flow completely from an efflux cup through its chamber and accurately machined bottom orifice.

## **Dyne-centimeter/milli-Newton-meter**

Units of torque that is measured as a force acting at a distance from a reference point, such as the axis of rotation of an object.

## **Engineering Units**

Units of viscosity as displayed on the readout panel of a viscometer. These units may be in centipoise, or other units which relate to absolute viscosity, such as cup seconds.

## **Full Scale**

The upper limit, in engineering units, of a viscometer. For Brookfield Process Viscometers, this value must be calculated from the torque capacity, rotational speed, and the spindle design of the instrument.

**Laboratory Measurements**

Viscosity measurements made off-line by a different instrument, usually for purposes of quality control. Due to the unique nature of viscosity measurement, the numerical value of this measurement may not agree with that measured by Brookfield Process Viscometers.

**Laminar Flow**

Flow which occurs when layers of fluid move uniformly with respect to one another, without mixing between elements.

**Measuring Chamber**

The container through which a fluid is caused to flow, in laminar flow conditions, and where its viscosity is measured.

**Repeatability**

The ability of an instrument to measure the same value whenever identical conditions of viscosity are presented to it. For Brookfield Process Viscometers, deviation is expressed as a percentage of full scale.

**Shear Rate**

The speed at which layers of fluid move with respect to one another. Also known as velocity gradient.

**Shear Stress**

The force per unit area required to move layers of fluid with respect to one another.

**Spindle**

The cylindrical object which is rotated in the fluid by the viscometer. Its motion in the fluid causes a resistance called viscous drag which is measured by the instrument as % torque. Its rotation causes fluid shearing to occur.

**Turbulent Flow**

Flow which occurs when fluid moves randomly with respect to other elements of fluid, with mixing between elements.

**Viscous Drag**

The resistance to rotation produced by an object such as a spindle when it is rotated in a fluid.



### **Viscosity**

A measure of the internal resistance within a fluid to resist flow. Mathematically defined as shear stress divided by shear rate. Sometimes called absolute viscosity.

### **4-20 mA Signal**

The continuous electrical output produced by a viscometer which is proportional to the % torque being measured and also proportional to the scale. For Brookfield Process Viscometers, 4 mA = 0 cP, 12 mA = half of full scale, and 20 mA = full scale, linear between 0cP and full scale.

### **% Torque**

Brookfield Process Viscometers function as a rotating torque meter, whose response is linear with respect to viscosity. A % torque measurement displays the proportion of full scale which a measured fluid produces. This factor is applied to full scale in order to give a measurement in engineering units.