BROOKFIELD
MODEL TT220 PORTABLE VISCOMETER
and
MODEL TT220-XP PORTABLE VISCOMETER PROBE

Installation, Operation, and Maintenance Instructions

Manual No. M/97-550-C0807

SPECIALISTS IN THE
MEASUREMENT AND
CONTROL OF VISCOSITY

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Section 1
Portable Viscometer Description

Inspect the viscometer specification sheet to ensure that the instrument is compatible with the intended use.

Please read and study the attached instructions before attempting to place the viscometer in operation.

The viscometer has a number of different materials of construction. Be sure that the materials noted on your Viscometer Specification Sheet are compatible with your process. Particular attention should be paid to the viscometer seals and o-rings that will contact the measured liquid.

Introduction

This manual contains information on the construction, operation and maintenance of the Brookfield Model TT220 Portable Viscometer and the TT220-XP Explosion Proof Portable Viscometer Probe. No attempt is made to explain the principles of rheology or to help interpret the viscosity readings that the instrument will deliver. For a more thorough discussion of this subject, you may request a copy of "More Solutions to Sticky Problems - A Guide To Getting More From Your Brookfield Viscometer."

Description

Model TT220-Nema 1 or Nema 4

The Brookfield Model TT220 is a portable viscometer for measuring the viscosity of liquids, intended for use in field or process measurement applications. It is a two-piece unit consisting of an electronics enclosure and a portable probe assembly (see Drawing CD4-001 in Appendix F). These are connected by a flexible cord to permit permanent mounting of the electronics enclosure.

Model TT220-XP

The Model TT220-XP is an explosion-proof viscometer probe approved for use in hazardous locations by Factory Mutual Research. This probe may be used in Class 1, Division 1, Groups C&D areas as defined by the NEC. This approval is limited to the probe and the heavy duty S.O. cord supplied with it. No other components are included in the explosion-proof approval.

Electronics Enclosure

The electronics enclosure contains the electronics for the unit and is the central power and signal distribution center. It is connected to a suitable power source of either 115 volts or 230 volts 50/60 Hz. A 4-20 mA signal or a voltage output are available for a readout or a controller, and strain reliefs are provided as protection for the various cord connections. Span and zero adjustment controls and a High-Low range selector switch are located inside the enclosure.

Theory of Operation - Viscometer

The viscometer probe assembly has a fixed speed motor driving a shaft through a set of reduction gears. The torque sensing element assembly, located on the bottom end of the shaft, consists of a spindle, a torsion element, and a transducer. The sensing element assembly rotates inside the stationary probe sleeve which provides coaxial narrow gap geometry required for precision signal generation.

When the viscometer probe is immersed in liquid, the liquid between the rotating spindle and the stationary probe sleeve creates a drag on the spindle that is proportional to the viscosity of the liquid. This drag works to twist the torsion element causing rotational movement, or “lag”, of the rotor in the transducer field. The transducer then generates an electrical output that is proportional to this movement. The electronics conditions this output so that it is usable for the controller. It is interesting to note that the total rotational “lag” of the rotor is only 1° or so relative to the transducer field at the full scale viscosity condition.

For a thorough discussion of viscosity measurement, refer to “More Solutions to Sticky Problems” available from Brookfield Engineering.

Section 2 - Installation

Safety Symbols and Precautions

Safety Symbols

The following explains safety symbols which may be found in this operating manual.

⚠ Refer to the manual for specific warning or caution information to avoid personal injury or damage to the instrument.

Precautions

⚠ If this instrument is used in a manner not specified by the manufacturer, the protection provided by the instrument may be impaired, and injury may occur, or damage to the instrument itself.

⚠ In case of emergency, turn off the instrument and then disconnect the electrical cable connections.

⚠ The user should ensure that the substances placed under test do not release poisonous, toxic or flammable gases at the temperatures which they are subjected to during the testing.

Unpacking and Inspection

Examine the outer box for obvious signs of damage or mishandling. The viscometer is shipped in a single box which contains the following:

- **Instruction Manual**
- **TT220 Viscometer Specification Sheet**
- **Probe with Flexible Cord**
- **Electronics Enclosure**
- **One Spindle Assembly S**
- **One Calibration Bar***

Open the box and examine the contents. Retain all shipping materials until the equipment is set up and found to be in good operating condition! Check to ensure that the information on the viscometer specification sheet agrees with:

- **The serial number on the probe nameplate**
- **Calibration bar ratings for high and low range*.**

Contact Brookfield Engineering Laboratories, Inc. if any of the parts listed are missing, or if any numbers on the hardware disagree with the viscometer specification sheet.

If, upon receipt, any of the equipment shows external or internal damage, or does not operate properly, contact the transportation company immediately and file a damage claim. Under ICC regulations, this is the responsibility of the receiving company.

*If the low range and high range calibration bar ratings on the specification sheet are the same, only one calibration bar is included. Otherwise, two different bars are always required.

Electronics Enclosure Installation Instructions

Utilities and Operating Environment

Input Voltage:	115 VAC or 230 VAC
Input Frequency:	50/60 Hz
Power Consumption:	100 Watts

Main supply voltage fluctuations are not to exceed ±10% of the nominal supply voltage.

Operating Environment:	0°C to 40°C temperature range (32°F to 104°F) 20%-80% R.H.: Non-condensing atmosphere
Fuse Type:	1/4" x 1-1/4" glass fuse, 2 amp, 3AG, fast-acting cartridge type

Mounting

Locate the electronics enclosure near a power receptacle. The on/off switch for the probe motor is on the enclosure (not used for TT220-N1 model) so it is recommended that it be located in an easily accessible area. Note that the cover is hinged, and therefore, extra clearance is needed to open and close it. The enclosure offers the best protection against water if installed with the cord connections facing down.

Attaching the Cords

There are three strain reliefs for connecting the various input and output cords and cables to the electronics enclosure.

Mounting the Primary Zero Adjust Potentiometer Remotely (optional)

There is a potentiometer in the electronics enclosure on a bracket above the circuit board. This is the primary zero adjust potentiometer. It may be mounted remotely, if desired, as described below.

1. De-energize the electronics to avoid electrical shock.
2. Remove the potentiometer and unsolder the wires from it, making note of the wire positions.
3. Mount the potentiometer where desired in accordance with local safety practices.
4. Complete the wiring using a suitable control cable.

The cable should enter the electronics enclosure through the middle cable entry with the signal output cable. Preferably, these conductors should all be in the same cable.

Mounting the High-Low Range Selector Switch Remotely (optional)

A toggle switch is located on a bracket in the electronics enclosure for selecting the high or low range viscosity sensing modes. It may be mounted remotely as described below.

1. De-energize the electronics to avoid electrical shock.
2. Remove the switch making note of the wire positions.
3. Mount the switch where desired in accordance with local safety practices.
4. Complete the wiring using a suitable control cable.

The cable should enter the electronics enclosure through the middle cable entry with the signal output cable. Preferably, these conductors should all be in the same cable.

Optional Viscosity Controller

A programmable controller package is an option which replaces the electronics enclosure. Appendix C covers this option in detail.

Wiring the Assembly

CAUTION

The cord connection at the TT220-XP probe must not be removed or turned. This will cause wire twist and possible shorting inside the probe. The cord is bonded into the metal connector.

Verify that the serial number on the electronics circuit board matches the viscometer specification sheet. Verify that the electrical power available complies with the power requirement on the specification sheet.

Wiring the Probe to the Electronics Enclosure

The viscometer was shipped with the probe flexible cord wired into the electronics enclosure. If the wires in the electronics enclosure are removed, replace them taking care to route the individual wires away from sharp edges and the transformer. Refer to the electrical schematic CD2-009 in Appendix F.

Wiring the Signal Output

The signal cable to the readout and/or controller must be connected before power is applied. The signal cable should be routed through the middle strain relief and all wiring inside the electronics enclosure should be kept away from sharp edges and the transformer.

Connecting the Power Source

Ensure that the toggle switch (if included) of the electronics enclosure is toward the bottom (off). Connect the power cord from the electronics enclosure to power source.

⚠ Main power supply must have an earth conductor that is connected to the building earth ground to ensure against electronic failure or personal injury.

Mounting of the Probe Viscometer

If the TT220 Probe Viscometer is to be mounted in a fixed installation, please do so in accordance with Drawing CD4-004 in Appendix F.

⚠ Do not position the viscometer such that it would be difficult to disconnect any cables.

Initial Start-Up

Examine the lower end of the probe to see that there are no packing materials. Turn on the toggle switch. Verify that the motor and sensing assembly are turning. Turn switch off. Verify that output signal is available.

Section 3 - Calibration

Introduction

The TT220 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 TT220 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
3/32 Allen Wrench	1
Calibration Bars	1 or 2*
1/8 Hex Wrench	1

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

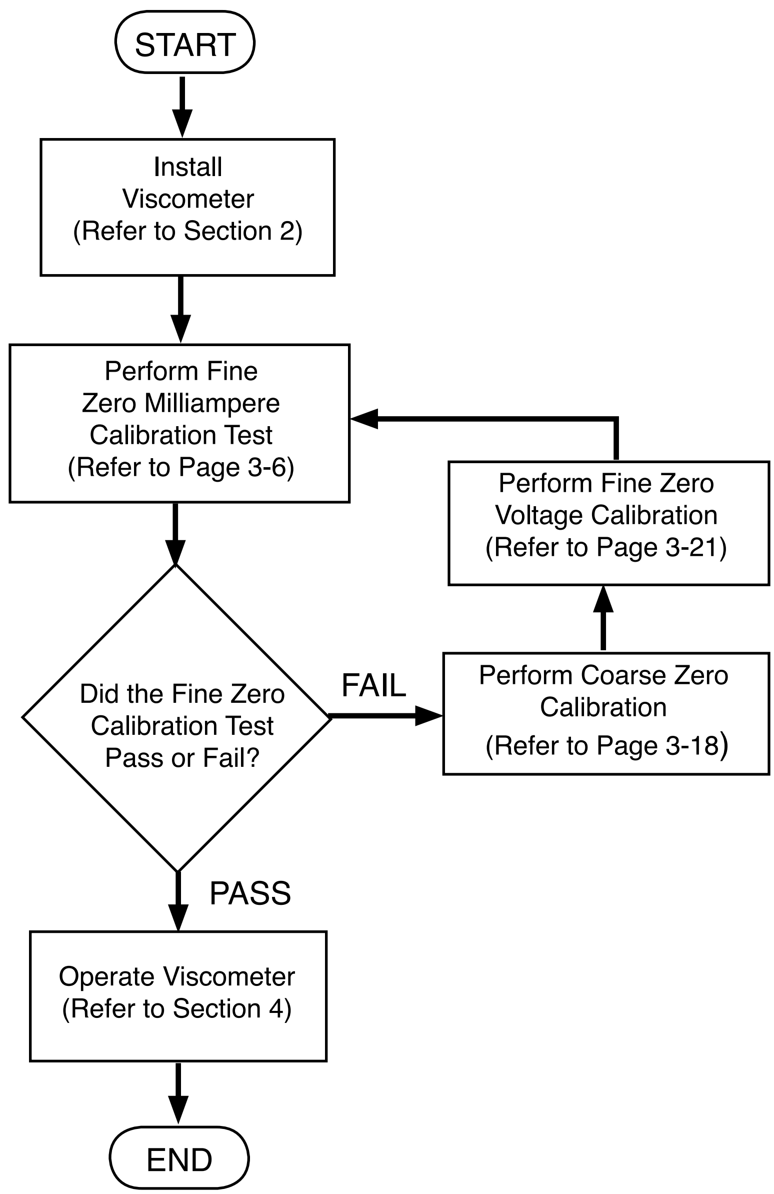


Figure 3-1: Typical Installation Calibration Flowchart

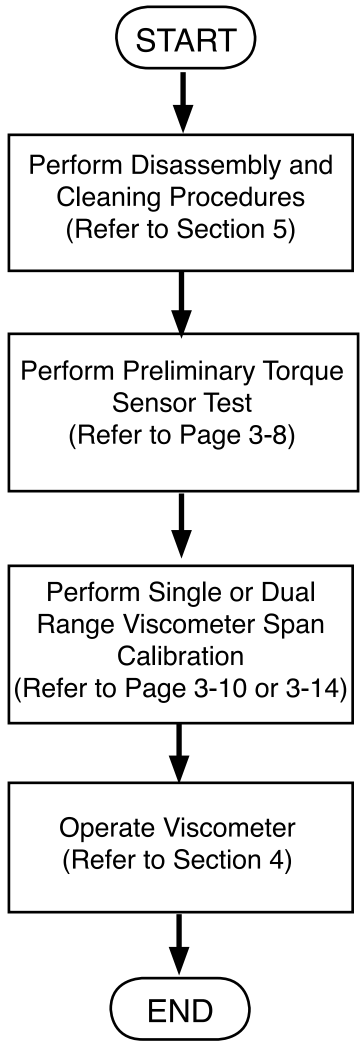


Figure 3-2: Typical Calibration after Viscometer Disassembly and Cleaning

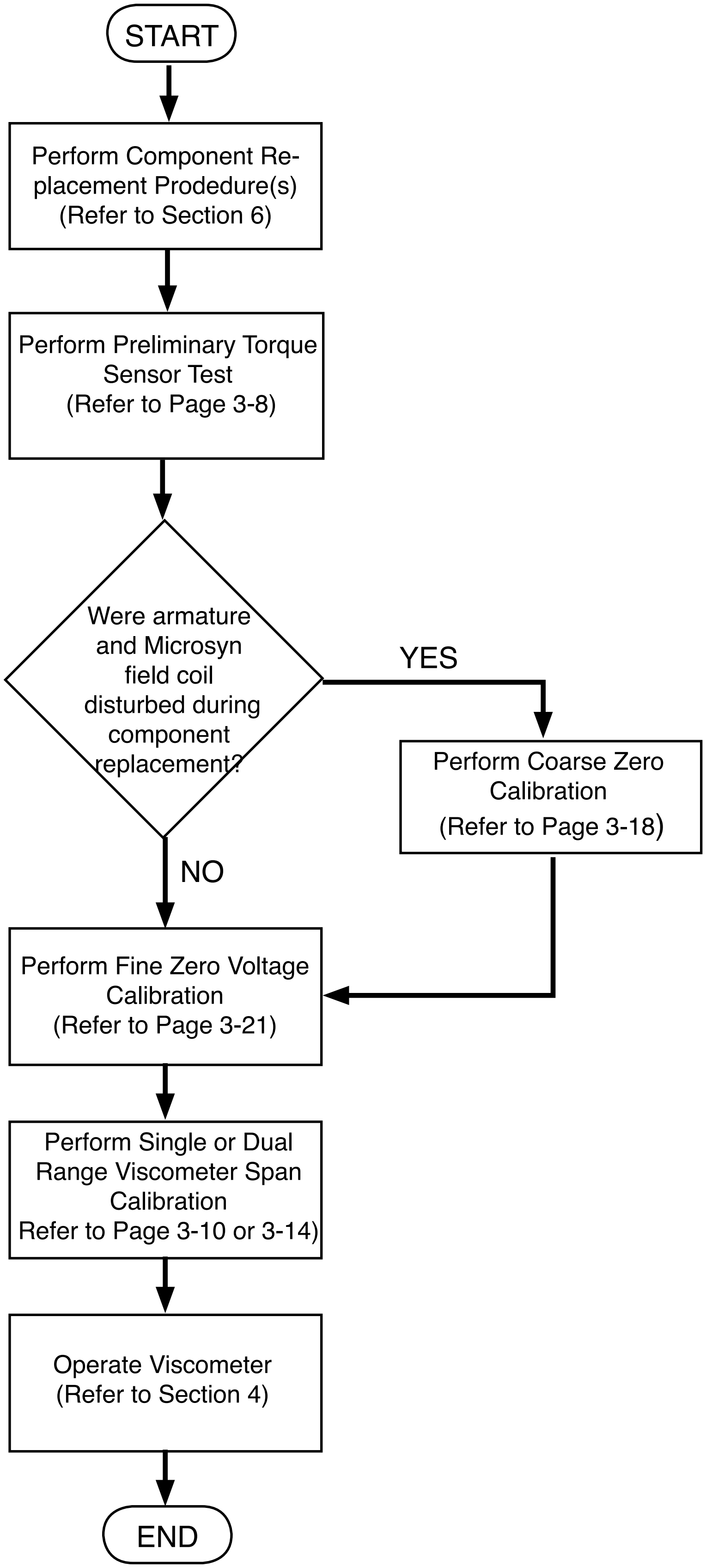


Figure 3-3: Typical Calibration after Component Replacement

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**.

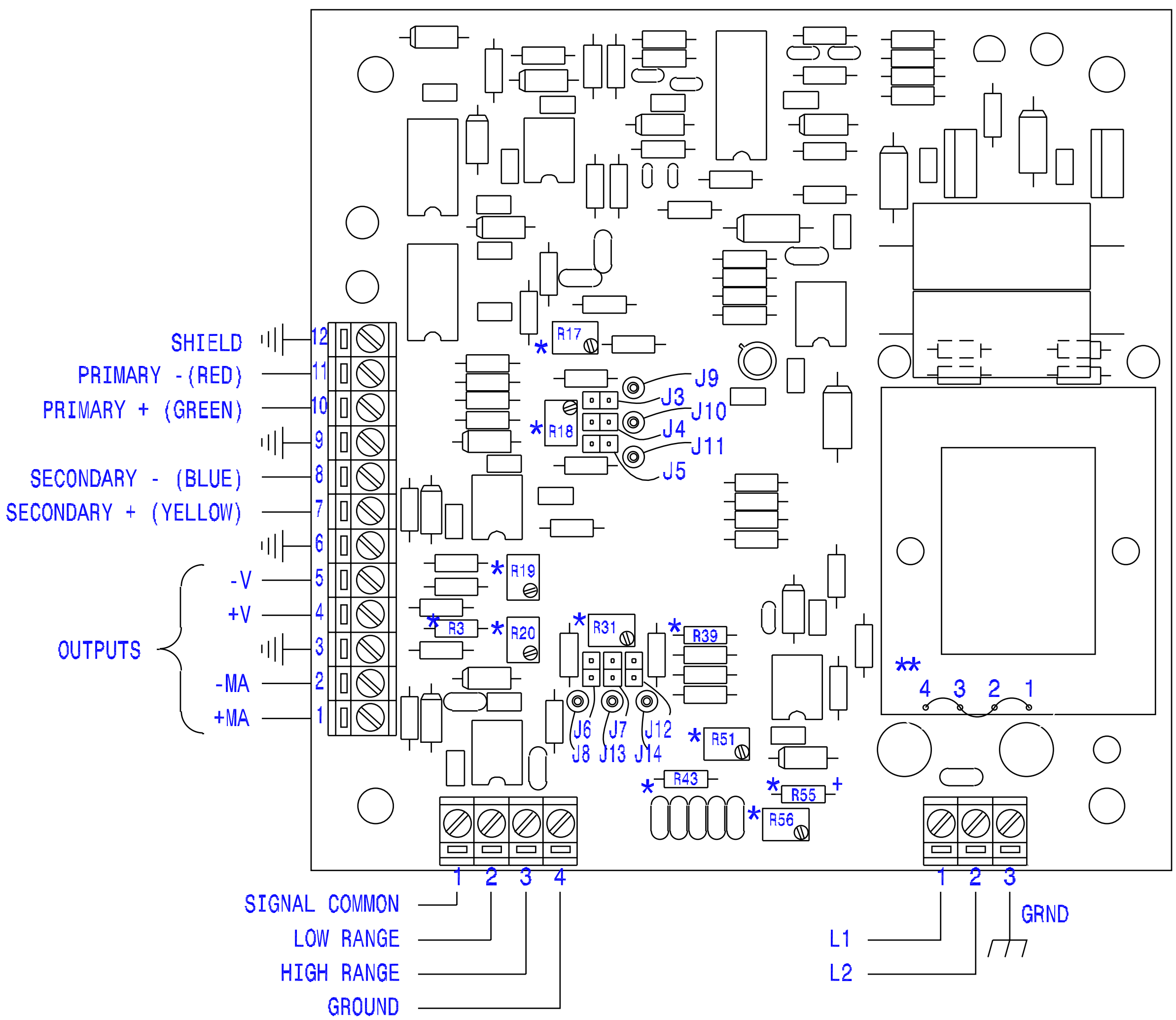


Figure 3-4: Torque Sensor Electronics Board Adjustment Component Locations

Preliminary Torque Sensor Test

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

1. Remove the outer sleeve as follows:
   Using the 1/8” hex wrench, turn the outer sleeve set screw located at the top of the outer sleeve CLOCKWISE at least 3 turns. Carefully gripping the outer sleeve so as not to damage the torsion element, slide the outer sleeve off. Rotating the sleeve as it is being removed may ease any friction.

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 stator, 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.

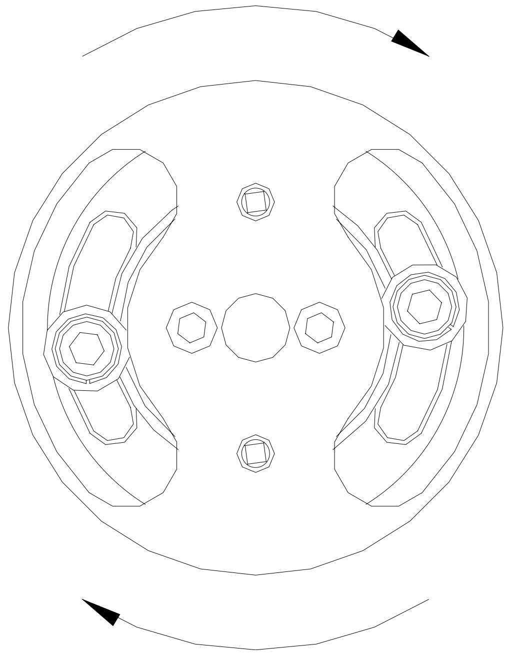


Figure 3-5: Applying Torque to the Stator

k. Release the stator 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 ± 0.05 mA and from opposite directions within ± 0.1 mA, then the viscometer will not be able to be calibrated. 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: *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 spindle (see Figure CD4-019).

3. Remove the Outer Sleeve as follows:
   Using the 1/8” hex wrench, turn the outer sleeve set screw located at the top of the outer sleeve CLOCKWISE at least 3 turns. Carefully gripping the outer sleeve so as not to damage the torsion element, slide the outer sleeve off. Rotating the sleeve as it is being removed may ease any friction.

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

3. Carefully place the TT220 in a vise to hold it secure and parallel to the work surface as shown in Figure 3-6.

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.

6. 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.

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).

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 (or external zero).

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.*

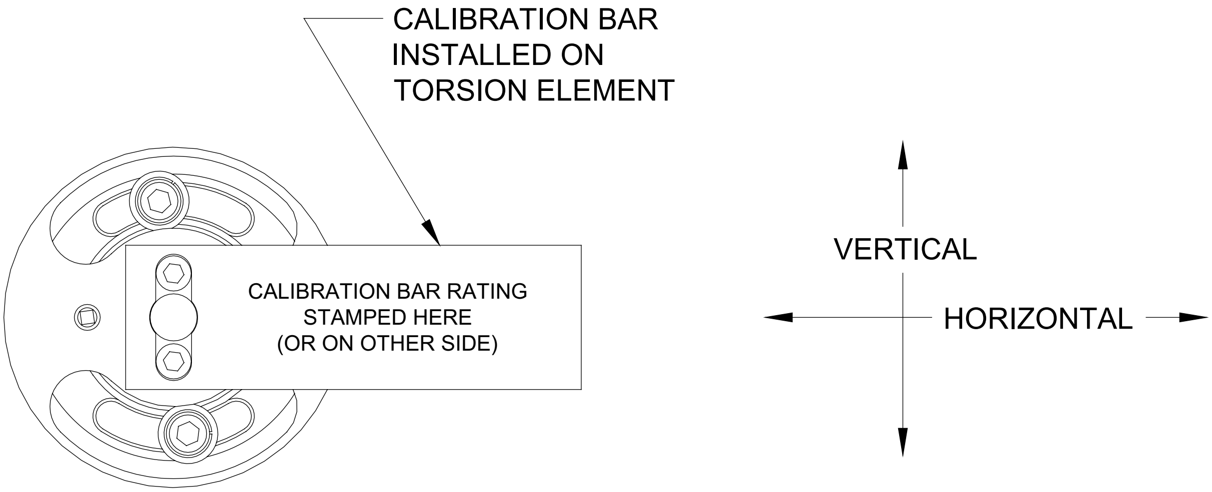
NOTE: *To ensure proper span calibration, make sure the calibration bar is installed as shown in Figure 3-6.*

NOTE: *Both the torsion element axis and the calibration bar axis must be within 8^{o} 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 ± .02 mA.

***NOTE:** If steps 13 and 14 cannot be achieved, refer to Appendix ** 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 milliampere cable to J1 Pins 1 and 2 on the torque sensor electronics circuit board and install the enclosure cover.

20. Remove the TT220 from the vise and carefully install outer sleeve.

21. Turn power ON to the torque sensor electronics enclosure.

Dual Range Viscometer Span Calibration

In this procedure, a calibration bar will be used to simulate 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 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: *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 Outer Sleeve as follows:
   a. Using the 1/8” hex wrench, turn the outer sleeve set screw located at the top of the outer sleeve CLOCKWISE at least 3 turns. Carefully gripping the outer sleeve so as not to damage the torsion element, slide the outer sleeve off. Rotating the sleeve as it is being removed may ease any friction.

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 one wire to J1-Pin 1.
   d. Connect the second wire to J1-Pin 2.

4. Connect a range jumper wire between J2-Pin 1 and J2-Pin 3 (HIGH range).

5. 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.*

6. Set the digital volt meter (DVM) to the 0 - 20.00 mA scale.

7. Connect the DVM positive lead to the wire on J1-Pin 1.

8. Connect the DVM negative lead to the wire on J1-Pin 2.

9. Observe the DVM reading. Adjust R18 for 4.00 mA.

10. Move the range jumper wire between J2-Pin 1 and J2-Pin 2 (LOW range).

11. Observe the DVM reading. It should indicate 4.00 mA.

12. Move the range jumper wire between J2-Pin 1 and J2-Pin 3 (HIGH range).

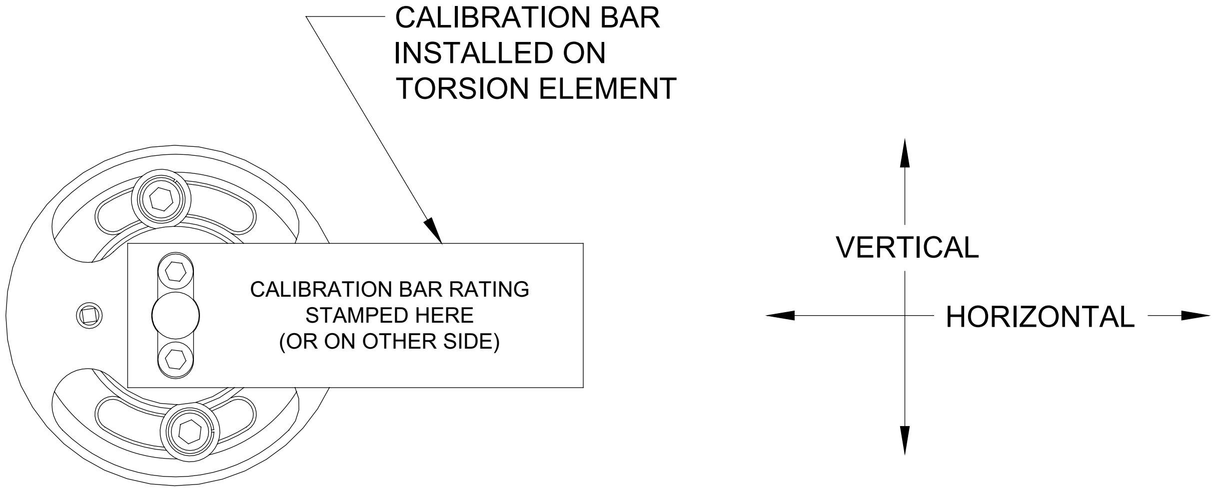
NOTE: *If 4.00 ± .02 mA is not displayed on the DVM after switching the range jumpers, then perform the Fine Zero Voltage Calibration procedure.*

CAUTION

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

13. Install the heaviest of the two calibration bars 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 3-7.

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.*



NOTE: Torque may be applied in the opposite direction for some viscometer models.

Figure 3-7: Calibration Bar Installation

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

NOTE: *If 4.00 ± .02 mA cannot be achieved in step 16, refer to Appendix A and call Brookfield Engineering Laboratories, Inc. for assistance.*

15. Remove the calibration bar. The DVM should indicate 4.00 ± .02 mA.

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

17. Observe the DVM reading.

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

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

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

NOTE: *If 4.00 ± .02 mA cannot be achieved, refer to Appendix A and call Brookfield Engineering Laboratories, Inc. for assistance.*

20. Remove the calibration bar. The DVM should indicate 4.00 ± .02 mA

21. Repeat steps 11 - 22 to ensure calibration repeatability.

22. Turn power OFF to the torque sensor electronics enclosure.

23. Remove the DVM wire connections from the torque sensor electronics circuit board.

24. Reconnect the milliampere cable to J1 Pins 1 and 2 on the torque sensor electronics circuit board and install the enclosure cover.

25. Install the outer sleeve.

26. Turn power ON to the torque sensor electronics enclosure.

Coarse Zero Calibration

> **CAUTION**
>
> If the Microsyn/Torsion Element has been removed, **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 Microsyn 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 outer sleeve.
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).
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 as shown in Figure 3-8.

12. Rotate the Microsyn field coil assembly, as shown in Figure 3-8, until 0 ± .2 VDC is observed on the DVM. Tighten the mounting screws.

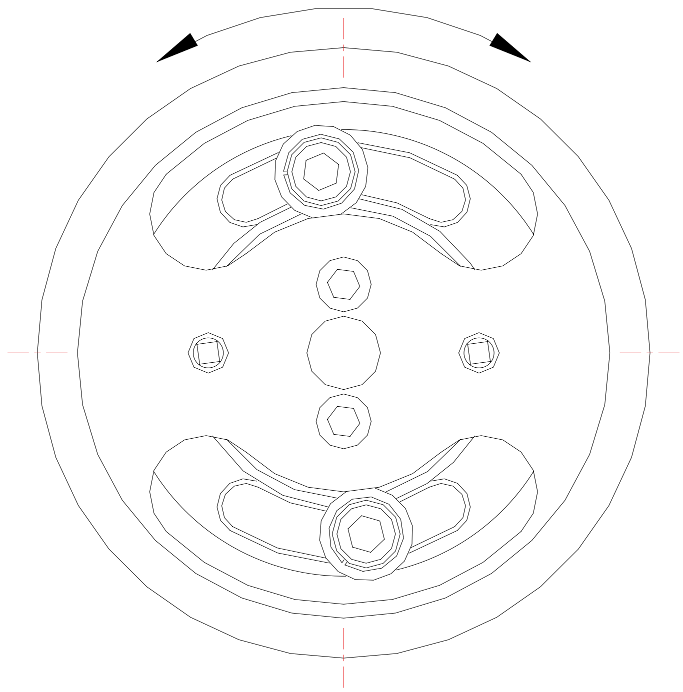


Figure 3-8: Microsyn Field Coil Assembly Rotation

13. Rotate the stator as shown in Figure 3-9. 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 ± .2 VDC position. Tighten the screws.

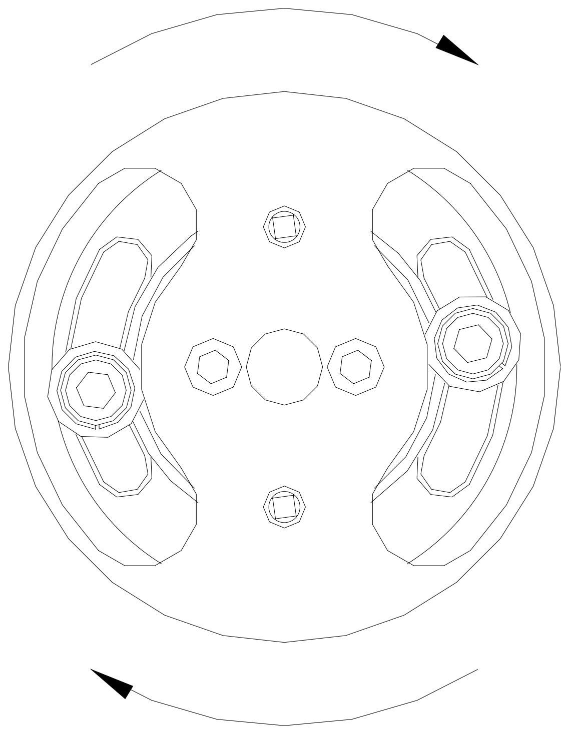


Figure 3-9: Stator Direction of Rotation

14. Rotate the stator once again as shown in Figure 3-9. The DVM should increase in a positive direction.

15. 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).
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 ±.005 VDC.

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

12. Verify the DVM indicates 0 ±.005 VDC. If not, adjust R31 to 0 ±.005 VDC.

13. Proceed with **Single or Dual Range Viscometer Span Calibration**.

Section 4 - Operation

Operation

Install spindle (refer to CD4-019 in Appendix F) and tighten finger tight. The outer sleeve may be inserted into an opening 2” in diameter or larger, and a support collar is provided to support the weight of the instrument. It is important that the spindle is completely immersed in the fluid as shown in Drawing CD4-004 in Appendix F.

Operate the viscometer as follows:

1. Set range selector switch to High.
2. Turn on power to the electronics enclosure.
3. Turn on toggle switch on the electronics enclosure

CAUTION

Keep clear of any moving parts while viscometer is operating.

The output reading may take up to 15 seconds to stabilize depending on the fluid. If the reading stabilizes at the low end of scale, set range selector switch to Low for increased sensitivity. Unit will give a continuous reading and show changes in viscosity if they should occur. (Unit may be left on to run continuously if desired).

CAUTION

If sample is of a nature that will solidify after a period of time such as when left overnight, be sure not to start unit again until sample has a chance to liquify. If this is not done, damage to the torsion element could result.

If not using the unit for continuous operation, it is best to remove the probe from the sample between uses and either rinse the probe or store for short periods of time immersed in solvent.

Handling

Care should be taken to avoid hitting the outer sleeve while handling the instrument. The spindle should not be handled except as indicated in the sections on cleaning, disassembly, storage and troubleshooting.

Section 5 - Maintenance

Cleaning

Cleaning the Viscometer Probe

For proper operation, it is important to keep the sensing area inside the lower end of the probe clear of anything that may interfere with the flow of sample between the spindle and the outer sleeve. This includes dried or caked sample. Therefore, it is necessary to keep this area clean with regular maintenance. Using a solvent (specific to the sample), the probe should be flushed by immersion immediately after each operation and before storing. With some samples, dipping may be more effective if the motor is running. Storing the probe sensing end in a solvent between uses will do much to keep the unit clean.

Disassembly for Cleaning

Disassemble the sensing end of the viscometer probe as follows:

1. Remove the spindle by turning the spindle screws counterclockwise.

2. Loosen the support collar with an Allen wrench and remove by sliding off end of probe sleeve.

3. Turn the probe sleeve retaining screw ***clockwise*** with an Allen wrench until the screw is below the probe sleeve.

4. Slide the outer sleeve carefully off. This will be easier if it is twisted while sliding.

CAUTION

The torsion element at the bottom of the probe is fragile. Slide the probe sleeve straight off to avoid bumping the torsion element.

Clean all exposed surfaces using an appropriate solvent. There is Teflon coating on the torsion element. Do not scratch this coating or use sharp objects near it. Ensure that all matter is cleaned from the stop posts.

When Clean, reassemble as follows:

1. Slide the probe sleeve back onto the probe, again being careful not to bump the torsion element. Align hole in probe sleeve with probe sleeve retaining screw on bearing support assembly.

2. Turn retaining screw counterclockwise until secure.

3. Install spindle (See Figure CD4-019).

Storage

When storing the unit for long periods of time, the unit should be completely cleaned. Storing the unit with the spindle in place is recommended. The probe sleeve should be left in place for storage.

Section 6 - Troubleshooting

Note: *Troubleshooting guide is for use by qualified technicians only.*

Viscometer

Motor does not turn when "power" and "probe" switches are turned on:

If both switches light, then power is getting to the probe and it must be disassembled for inspection.

If power is not getting to the probe, then check the fuse in the fuse holder located on the rear of the controller. Replace fuse if necessary.
Fuse Type: 1/4" x 1-1/4" glass fuse, 2 amp, 3AG, fast-acting cartridge type

Viscometer Controller Reading not responding:

1. **Display not lit:**
   Check for power to controller. If power is available, the controller must be replaced.

2. **Display lit:**
   Turn reading adjust knob on control panel. If reading changes, controller and transducer electronics are likely functioning. Check the probe transducer circuit by checking resistance at the circular Amphenol Connector as follows:

Pin	to	Pin	Resistance
E		D	1 - 5 Ω
B		C	1500 ± 300
B		D	OPEN
C		D	OPEN

If all of the above resistances are correct, the problem is likely in the transducer electronics. To check transducer electronics, remove the probe cover and examine the brush/slip ring assembly. Inspect to see that slip ring contact brushes are aligned and in place with their respective tracks. If these appear correct, the problem is probably inside the microsyn housing. Contact Brookfield Engineering Laboratories' Customer Service Department.

Note: It is the nature of the slip rings and brushes to develop a gel-type substance on the brushes. Usually, this substance is black. This is normal and should be left alone as it aides in lubrication.

Ringing, rubbing or scraping noise in the area of the sensing element:

Turn motor off and remove the spindle. Turn motor on and listen for noise. If it has not stopped, turn motor off and consult the factory. If it has stopped, check outside of spindle and inside of outer sleeve to see if there is anything caked onto the surfaces. If there is, clean as required and replace spindle. Turn motor on and recheck for noise. If the noise still occurs, turn off the motor and remove the spindle and outer sleeve. Turn motor on and look for wobble at the torsion element at the end of the shaft. If there is wobbling, the torsion element is bent and must be replaced. Contact the factory.

Signal non-repeatable:

Determine if there is a mechanical problem as follows:

1. With probe assembled, dry, and vertical, turn on the motor.

2. If the signal is stable after running for 15 seconds, immerse the probe into a sample liquid with a known viscosity. If a stable signal results, remove it and re-immerse. If the readings are the same, the non-repeatable signal was likely due to fluid borne particulate matter so large as to cause intermittent rubbing of the spindle. If the readings do not repeat, remove the outer sleeve and spindle, and examine the torsion element for damage. Contact Brookfield Engineering for further guidance.

3. Lie the probe down horizontally and watch the end of the torsion element with the motor running. The allowable runout of the torsion element end is .020” (0.5mm). If there is more side-to-side motion than this, the torsion element is damaged and must be replaced.

4. If the runout is within the limits in step 3, remove the outer sleeve and examine the torsion element and the stops. The stops must not be touching any part of the torsion element and they must be centered and secure. Look for any indication of damage to the torsion element. If any damage is seen, replace the torsion element. If the torsion element appears undamaged, the problem is in the electronics. Contact Brookfield Engineering for guidance.

Signal erratic:

1. With probe assembled, dry and vertical, turn on the motor.

2. If the signal is not stable after 15 seconds, stop the motor, remove the spindle and look for damage to the torsion element. If there is damage, contact Brookfield Engineering.

For any other problems or questions, consult the factory.

Appendix A
Changing the Instrument's Capability

Occasionally, the needs of the user change such that viscosity information is needed which is beyond the range of their viscometer. In most cases, their instrument can be modified by changing one or more of the following:

- Spindle
- Torsion Element
- Shaft Speed

Each affects the usable viscosity range of the instrument to different degrees as described below.

Spindle

This is the easiest and least expensive change and should always be considered first. A detailed explanation of spindle changes is presented in Appendix B.

Torsion Element

The torsion element is designed to twist in response to viscous forces acting on the spindle. The upper limit of useful twist is approximately 1 degree at the full scale viscosity point, and mechanical stops are installed to limit the angular travel to 3° to prevent damage. The stiffness of a torsion element cannot be changed, but there are several different ones available which can be used as replacements. These relate to each other as shown in Table 1 below:

Torsion Element Part No.*	Stiffness Ratio (SR)
TT220-10Y	1
TT220-20Y	2
TT220-30Y	7
TT220-40Y (stiffest)	21

Table 1

*From Viscometer Specification Sheet

The stiffness ratios may be used directly to calculate the full scale viscosity of a replacement torsion element as follows:

$$\text{New F.S.V.} = \text{Present F.S.V.} \times \frac{\text{New S.R.}}{\text{Present S.R.}} \qquad (1)$$

where F.S.V. = Full Scale Viscosity (high range)
(Present F.S.V. is on the specification sheet)
SR = Stiffness Ratio from Table 1.

Example:
A viscometer has a TT220-20Y torsion element and a high range full scale viscosity of 1000 cps. What other full scale viscosities can be measured with the other torsion elements?

From Table 1, SR = 2, and using equation (1):

$$\text{New F.S.V.} = 1000 \text{ cps} \times \frac{\text{New S.R.}}{2} = 500 \times \text{New S.R.}$$

For TT220-10Y, New S.R. = 1 and:
New F.S.V. = 500 x (1) = 500 cps

For TT220-30Y, New S.R. = 7 and:
New F.S.V. = 500 x (7) = 3,500 cps

For TT220-40Y, New S.R. = 21 and:
New F.S.V. = 500 x (21) = 10,500 cps

Before changing the torsion element, it is recommended that the application engineering department of Brookfield be consulted.

Shaft Speed

A change in the shaft speed will cause a change in the output signal of the instrument. The relationship between shaft speed and output signal is a topic of much discussion since shear rate and viscosity do not usually track in a linear fashion. For a better understanding of the rheology of fluids, the Brookfield publication, "More Solutions to Sticky Problems," is available upon request.

If the shaft speed is to be changed, the probe must be disassembled and the transmission must be replaced. Table 2 below lists the transmissions available and the resultant shaft speeds.

Transmission Speed	**Shaft Speed**	
Reduction	60hz Power	50hz Power
3:1	600 rpm	500 rpm
5:1	360	300
9:1	200	167
18:1	100	83
36:1	50	42
90:1	20	17
180:1	10	8

Table 2

There are no simple relationships presented here to predict the instrument's performance after a speed change because of the complexities of the real world fluids measured. Contact Brookfield's Application Engineering Department for further

Appendix B - Spindle Changes

The spindles are by far the least expensive and easiest components to change on the TT220. They are positioned and secured in place by a locking nut which allows ease of removal and installation, usually for routine cleaning and inspection. To determine what other viscosity ranges could be measured by changing spindles, proceed as follows:

1. Get the "Full Scale Viscosity, High Range" from the calibration data on the viscometer specification sheet.

2. Get the spindle part number from the viscometer specification sheet.

3. From Table 1 below, get the spindle factor.

Spindle Part Number	Spindle Factor	Notes
TT220-23Y	100	(largest diameter for lower viscosity fluid)
TT220-22Y	66	
TT220-21Y	28.2	
TT220-25Y	12	(smallest diameter for higher viscosity fluid)

Table 1

4. To find the full scale viscosities that can be measured with each spindle, calculate as follows:

$$\text{New Full Scale Viscosity} = \text{Present Full Scale Viscosity} \times \frac{\text{Present Spindle Factor}}{\text{New Spindle Factor}} \qquad (1)$$

For example, a TT220 has a TT220-22Y spindle and a full scale viscosity of 1000 cps in high range. What full scale viscosities can be measured with the other spindles?

spindle factor = 66 (from Table 1)
present full scale viscosity = 1000 cps (from above)

With spindle TT220-23Y, spindle factor = 100, and using equation (1):

$$\text{New full scale viscosity} = 1000 \times \frac{66}{100} = 660 \text{ cps.}$$

With spindle TT220-21Y, spindle factor = 28.2, and using equation (1):

$$\text{New full scale viscosity} = 1000 \times \frac{66}{28.2} = 2340 \text{ cps}$$

With spindle TT220-25Y, spindle factor = 12, and using equation (1):

$$\text{New full scale viscosity} = 1000 \times \frac{66}{12} = 5500 \text{ cps}$$

These calculations should be used only as rules of thumb. Before making a change, contact the application engineering department at the factory.

Appendix C
TT220 Viscosity Controller Assembly
(TTVC-115, TTVC-230)

Installation

Plug the probe into the rear of the controller assembly. Tighten by hand.

Note: Each probe is calibrated to a controller assembly. Ensure that the probe serial number is the same as the serial number of the controller assembly.

1. Set the three rocker switches to the OFF position.
2. Set the "Range" switch on the rear panel (if provided) to the desired position (see specification sheet for further information).
3. Plug in the solvent solenoid valve to the receptacle on the rear panel.
4. Plug in the power cord to the appropriate voltage and frequency as identified on the nameplate.

Operation

1. Turn on the "Power" rocker switch. This switch will light, and after approximately five (5) seconds delay, the controller display will light also.
2. Turn on the "Probe" rocker switch. This switch will light and the probe motor will run.
3. Press the "Manual" solenoid valve push button switch briefly to ensure that the indicator light energizes. This push button switch may be used any time that the "Power" switch is on to manually open the solvent solenoid valve.

Note: This system is designed for use with only "Normally Closed" solenoid valves (valve closed when not energized).

4. Switch the "Solenoid Valve" rocker switch to "AUTO." This puts the solenoid valve under the control of the programmable controller. The indicator light will now automatically energize when the solenoid valve is open.

The viscosity control system must be tuned to the user's hardware and fluid being monitored. The most familiar method of measuring the viscosity of inks is the Zahn Cup. The TT220 may be used to control and display in Zahn Cup seconds.

For Example: The results of testing with a #2 Zahn Cup are often related to viscosity as follows:

#2 Zahn Cup	Viscosity
18 seconds	20 centipoise (cps)
19	25
20	30

A viscometer is calibrated to measure 0-100 cps process fluid in low range. If the area of interest is 25 cps (19 sec. #2 Zahn), then the controller may be set to display viscosity in Zahn seconds as follows:

> The table shows that a 1 sec. change corresponds to a 5 cps change within the 20 to 30 cps range. Therefore, 0 cps would mathematically equal 14 sec. and 100 cps would equal 34 sec. These numbers (14 and 34) may be used for upper and lower limits of the controller so that the readout will be correct at 18, 19 and 20 seconds. Set the controller lower limit to 14.0 and the upper limit to 34.0. Under this condition, viscosities of 20, 25 and 30 cps will read 18, 19 and 20 seconds.

Similar logic may, of course, be used for any set of conditions. Detailed instructions on how to set the controller are given later in this appendix.

Alarms

The controller is equipped with high and low alarms. The customer supplied wiring may be brought into the controller assembly through the capped 1/2" hole on the rear panel. A strain relief is provided to protect the wiring if the alarms are used.

Front Panel Keys and Displays

Figure C-1: Keys and Displays

ITEM		FUNCTION
1	Control output lamp (green)	C1: Control output 1 indication (lamp is lit at ON) C2: Control output 2 indication (lamp is lit at ON) (option)
2	Measured value (PV)	Indication of measured value
3	Set value (SV) lamp	Lamp is lit at indication of SV
4	Parameter lamp (green)	Indication of set value and various parameters (PID, high/low alarm, heater break alarm)
5	Down key (common to all digits)	Numeric value of digit selected by UP key goes down
6	Direct SV select	Set value is indicated by pressing this key
7	Parameter Select (S)	Parameters are indicated in order at each press of this key
8	Data key (D)	Indication of parameter data selected by Parameter Select key
9	Data Entry key (E)	Data are registered after they have been changed. Changed data cannot be registered unless this key is pressed.
10	1-digit Up key	Numeric value of digit flickers when key is pressed, and goes up while repeating to press key.
11	10-digit Up key	Numeric value of 10-digit flickers when key is pressed, and goes up while repeating to press key.
12	100-digit Up Key	Numeric value of 100-digit flickers when key is pressed, goes up while repeating to press key. Returns to 0 after 9, and at same time, 1000th digit goes up by 1.
13	Heater break alarm lamp (red)	Lamp is lit at ON of heater break alarm output (option)
14	Alarm lamp (red)	Ind. is ON at low or high alarm (option)
15	Auto tuning lamp	Light flickers during PID auto tuning

Setting Parameters

Once power has been applied to the instrument, the unit must be set up for the particular application. The controller has two different menus (parameter lists). The first menu is the operation menu. This is used for operation of the controller and allows changing of set point (set value), tuning parameters, alarms, cycle time, etc.

The second menu (the set-up menu) must be set when the controller is first going to be put into operation. It allows the user to set the type of control action, input type, digital filter, limits of range, alarm type, and decimal point position. The set-up menu contains the type of parameters that the user will normally have to set when the controller is first applied to a particular application, but would normally not be changed again for normal operation.

CAUTION

Output should be disconnected while second menu is being changed to prevent inadvertent activating of the solenoid valve.

To access this second menu, use the following procedure:

1. Scroll up to “P” by pressing the “S” key.
2. Hold the “S” button in for up to 12 seconds. Display will show “P-n1.”

You are now in the set-up menu.

To get back to the operation menu after set-up is finished, scroll using the “S” key until it says “P-n1.” Then press the “S” key and hold for up to 12 seconds. The display will show “P.”

Example of Setting Parameters

Once power has been applied to unit:

Unit displays Process Variable (PV) and Setpoint (SV).

1. Press “S” key and release.
2. Unit will display: “P” (where setpoint had been displayed). You are now in the Operation Menu.

3. Press “S” key and hold for 5 to 12 seconds.

4. Unit will display: P-n1. You are now in the Set-Up menu.

5. To scroll to the parameter to change, press the “S” button and release.

6. To change a parameter, press “D” once and the parameter number to be changed will be displayed.

7. To change the value displayed, the UP and DOWN arrows are used.

Note: To change 0 to 100, for example, press the third UP arrow from the right side to get proper digit flashing, and then press same UP arrow once again to change digit to 1. Press “E” to store in memory. The DOWN arrow can be used to decrease any flashing digit. Only the digit flashing can be changed. Change is not complete until the “E” button is pressed.

Explanation of Set-Up Menu

1. **P-n1**
   This allows the user to change the control action which allows the output to be set for reverse or direct operation. Note that control action of the output is set for direct action. Brookfield factory set at function code 16. **DO NOT CHANGE**.

2. **P-n2**
   This allows the user to set input type. Brookfield factory set for function code 31 (4-20 ma DC input). **DO NOT CHANGE**.

3. **P-dF**
   Digital filter which can be used to slow the response time of the controller and display for noisy signals. Allowable values are from 0 to 201 seconds. The unit will respond to 63% of a step change in the input in half the time selected. For typical control systems, the initial value of 2 should give good results.

4. **P-SL**
   Lower limit of input range. This can be used to set a lower limit to which the operator can set the setpoint for viscosity input units. This is the lower value for scaling of current input. Brookfield factory set per customer requirement.

5. **P-SU**
   Upper limit of input range. Used to set an upper value to which the operator can set the setpoint for temperature input units (TR). This is the upper value for scaling of current input. Brookfield factory set to customer requirement.

6. **P-Ab**
   Option not utilized (0 display).

7. **P-An**
   Option not utilized (0.1 display)

8. **P-dP**
   Decimal point position used for scaling current input. Brookfield factory set at 2.
   DO NOT CHANGE.

9. **P-48**
   Factory setting. **DO NOT CHANGE**.

10. **P-C7**
    Option not utilized.

11. **PVOF**
    PV offset. Option not utilized or required.

12. **SVOF**
    Setpoint offsets. Option not utilized or required.

13. **P-F**
    Selection of degrees Celsius (C) or Fahrenheit (F). Option not utilized or required.

Set-Up Menu (Parameter List)

Parameter Symbol	Item	Meaning	Description	Initial Value
P-n1	P-n1	Control action	Setting of direct or reverse action	17 (direct action)
P-n2	P-n2	Input type	4-20mA DC	31
P-dF	P-dF	Input filter response time	Half of data value is 63% response time (Code 0 to 201 sec)	2
P-SL	P-SL	Lower limit of input range	Set at "1000" for high range	1000
P-SU	P-SU	Upper limit of input range	Set at "1000" for high range	1000
P-Ab	P-Ab	Alarm type	User specification	79
P-An	P-An	Hysteresis of alarm	Option not included	N/A
P-dP	P-dP	Decimal point position	Selection of the position of decimal point For example: Code 0 - no decimal point (9999) Code 2 - 999.9 Code 4 - 99.99 Code 8 - 9.999	CODE:__Ø__
P-48	P-48		Setting need not be changed	2
P-C7	P-CT	Setting of heater rated voltage	Option not included	N/A
PUOF	PVOF	PV offset	PV indicated value is changed, however, PV is unchanged. (Setting range: -1999 to +2000	0
SUOF	SVOF	SV offset	Option not included	0
P-F	P-F	°C / °F selection	Option not included	N/A

Table C-1

Operation Menu

The operation menu allows the user to initially set the following parameters. These might be changed again if operating experience reveals a need.

- Set Point
- Control for on/off or PID
- PID parameters (tune controller)
- Alarm levels
- Cycle time
- On/off deadband (hysterisis)
- Autotune for PID settings
- Lock out operator from changing above settings

To access the operation menu if the process variable is displayed:

1. Press the “S” and release. Unit displays “P” (code for proportional band).
2. The entire menu can be scrolled through by repeatedly pressing the “S” button.

To change a parameter when the code for that parameter is displayed, press the “D” button. Change the number displayed using the UP and DOWN arrows.

Note: To change 0 to 100, for example, press the third UP arrow from the right side to get proper digit flashing, and then press same UP arrow to change digit to 1. Press “E” to store in memory. The DOWN arrow can be used to decrease any flashing digit. Only the digit flashing can be changed. Change is not complete until the “E” button is pressed.

Explanation of the Operational Menu

1. **SV - Setpoint (set value)**
   This is displayed on the lower display during normal operation. The setpoint may be changed to any value within the lower limit and upper limit of range (see operational menu).

2. **P - Proportional Band**
   The area around the setpoint (both above and below) as a percentage of the full span where the proportional action is between 0 and 100% of full output. Can be set from 0.0 top 999.9 percent of span. Set to 0.0 for on/off control.

3. **I - Integral Time**
   The integral function (also known as automatic reset) will attempt to automatically eliminate offset between setpoint and process due to load changes. The integral action will allow the controller to shift the proportional band up or down over a period of time to account for the offset. If the integral time is too long, the process will take too long to return to setpoint after a change in load. An integral time too short can cause oscillation by shifting the proportional band too fast for the process.

   The integral time can be set between 0 and 9999 seconds. There is no integral action when it is set to zero (0). The integral time will be calculated automatically when autotune is used.

4. **D - Derivative Time**
   The derivative action (also known as rate) helps the system compensate for a rapidly changing process variable (temperature). This helps the controller eliminate overshoot on start-up and to speed up response to disturbances in the system.

   It allows the controller to shift the proportional band to take corrective action based on rate of change of the process variable. The derivative time relates to how quickly the proportional band is shifted. A derivative time too long will not allow the system to react to a disturbance, and so oscillations can be observed. A derivative time too short could also cause oscillation by having the controller overreact to load changes.

   The derivative time can be set from 0 to 3600 seconds. There is no derivative action when set to zero (0). The derivative time is calculated automatically when autotune is used.

5. **AL**
   Low alarm setting within input range. See alarm operation table for type of alarm settings available.

6. **AH**
   High alarm setting within input range. See alarm operation table for type of alarm settings available.

7. **TC - Cycle Time**
   The cycle time (also called duty cycle) sets the total time period which the relay or output device will be on or off when inside the proportional band. The cycle time should be shorter than the reaction time of the system.

Cycle times can be set from 0 to 150 seconds. A setting of 0 will give the minimum cycle time of 0.5 seconds unless the proportional band is also zero.

8. **HYS**
Hysteresis (deadband) of control output. The hysteresis or deadband is the percentage of the span which the viscosity or process variable must fall (or rise) before the relay changes state. The deadband is centered around the setpoint.

Hysteresis can be set from 0.0 to 20.0 percent of span. In a fast-acting system, the deadband should be wide enough to avoid relay chatter.

9. **AT**
Auto tuning allows the controller to automatically calculate the optimum PID parameters for any operating system. See the section on auto tuning for detailed discussion of this feature.

10. **LOC - Lockout**
This setting will help prevent unauthorized adjustment of the other parameters.

Allowable settings:

0 - Allows changing of all parameters
1 - Disables changing of all parameters
2 - Allows setpoint (SV) to be changed, but disables all other parameters.

Operational Menu

Parameter Symbol	Item	Meaning	Description	Recommended Initial Value
SV	SV	Set value	Settable within the input range	User set
P	P	Proportional band	Setting range: 0.0 to 999.9% For On/Off zero setting (TC should also be set to “0”)	Use std. auto tune or set at
I	I	Integral time	Setting range: 0 to 9999 sec. Integral action is OFF at “0”	Use std. auto tune or set at
d	D	Derivative time	Setting range: 0 to 3600 sec. Derivative action* is OFF at “0”	Use std. auto tune or set at
AL	AL	Low	Settable within the input range Not indicated without alarm function	
AH	AH	High	Settable within the input range Not indicated without alarm function	
7C	TC	Control cycle of control output 1	Setting range: 0 to 150 sec. “0” means 0.5 sec. Set to “0” at P - 0 for On/OFF. Not indicated at current output	
HYS	HYS	Hysteresis width of control output 1	Setting range: 0.0 to 20.0%	1%
A7	AT	Auto tuning	Used for automatic setting PID parameters 0: Disable 1: Standard type autotuning	
Lo[	LoC	Key lock	Data setting inhibit 0” Release (all data settable) 1: Inhibit changing all data 2: Inhibit changing all data other than set value (SV)	0

*(ON-OFF action): Control output turns ON or OFF by comparing PV with SV

Table C-2

Setting the Setpoint (SV)

The setpoint (or set value) can be changed without using either menu. It can be changed using the UP and DOWN arrows as illustrated below in Table C-3.

Example: SV is at 0. Set it to 250.

	Setting of SV to 250	
Key Operation	Description	Indication
SV	• Press the SV key to indicate set value. (This operation can be omitted when a set value is indicated.)	0
Λ Λ Λ Λ	• Press Λ key of any digit to be set. In this example, the Λ key of 10-digit is pressed. The 10-digit indication flickers.	0 0
Λ Λ Λ Λ	ΥPress the Λ key (5 times) to indicate "5." (0>1>2>3>4>5)	5 0
Λ Λ Λ Λ	ΥPress Λ key of 100-digit. The 100-digit indication flickers.	0 5 0
Λ Λ Λ Λ	ΥPress the Λ key (2 times) to indicate "2." (0>1>2)	2 5 0
E Λ	ΥPress the E key. The indication stops flickering and the set value of 250 is indicated. - Operation is completed. -	2 5 0

Table C-3

Changing Alarm Operation (Option)

Alarm operation has 18 types of functions. Select the second parameter "P-Ab" and set the function code as. Then the alarm type can be changed. The low alarm hold function inhibits the low alarm output when the power of the controller is turned on.

Using Auto Tuning Function

PID parameters can be automatically set by the controller using the auto tuning function. The unit can be manually tuned if autotune does not prove acceptable.

The auto tuning function should be used after the set value (SV), alarm setting (AL, AH), and cycle time (TC) are set up.

1. Press the parameter select key to indicate A-7.
2. Press "D" to indicate data. Auto tuning disable code "0" is indicated.
3. Press the UP arrow to set "1". This is the code number for standard type auto tuning.
4. Press "E" to start auto tuning. The decimal point on the first digit flickers during auto tuning.
5. Press "SV" to again display the set point.
6. At the end of auto tuning, the flashing will stop and the auto tuning code is automatically reset to "0".

Auto Tuning Data Selections

Code 0:	Auto tuning is disabled.	
Code 1:	Standard type auto tuning:	PV is compared with SV during auto tuning
Code 2:	Auto tune below set point:	PV is compared with SV-10% FS during auto tuning. This helps the system avoid large overshoot of set point while auto tuning.

When auto tuning is completed, the PID parameter is saved even if the power is turned off.

Note: During auto tuning, PV may be oscillated greatly depending on process. If this is not desirable, do not use the auto tuning function.

When auto tuning is not completed within four (4) hours, this means that the auto tuning function is not able to function correctly on the system. Check the control system and then repeat the auto tuning. If it still does not work, manual tuning is required.

When the process operating condition has changed, carry out the auto tuning again.

Error Codes

The controller is equipped with a self-diagnostic function. After an error has been corrected, be sure to turn power OFF, then ON again to clear the error indication.

Indication	Cause
UUUU	Input signal in excess of 30% at upper limit setting on measuring range.
LLLL	Input signal be ow 30% at lower limit setting on measuring range.

Table C-4

Appendix D - Warranty Information

Guarantee

We hereby guarantee this Brookfield Instrument 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 date of purchase to our factory, it will be repaired or replaced at factory without charge; transportation shall be at purchaser'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 and 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.

Appendix E
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 when calling so that we may assist you:

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

Instrument Repair Procedure and Guidelines

In the event that your Process Viscometer should require factory maintenance, Brookfield Engineering has provided the following guidelines and recommendations to follow to ensure a prompt turnaround time for all repaired items.

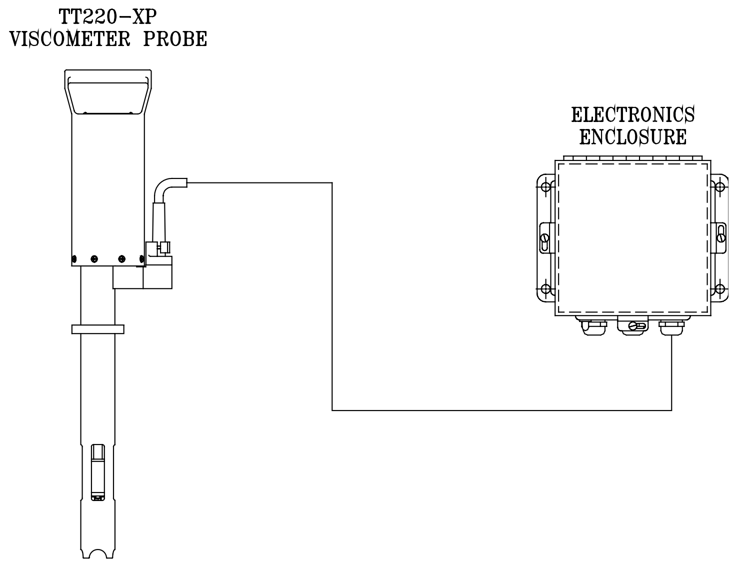
Before returning any Brookfield Process Viscometer, please contact our Process Service/Sales Department to obtain a **Return Materials Authorization Number** (RMA #). This will ensure that your instrument is routed to the proper Repair Department when received. Unnecessary delays result when "unannounced" repairs arrive at our facility and have to be sorted and routed outside standard procedures. To contact the Process Service/Sales Department, please call **508-946-6200 or 800-628-8139;** or you may prefer to email us at **service@brookfieldengineering.com.**

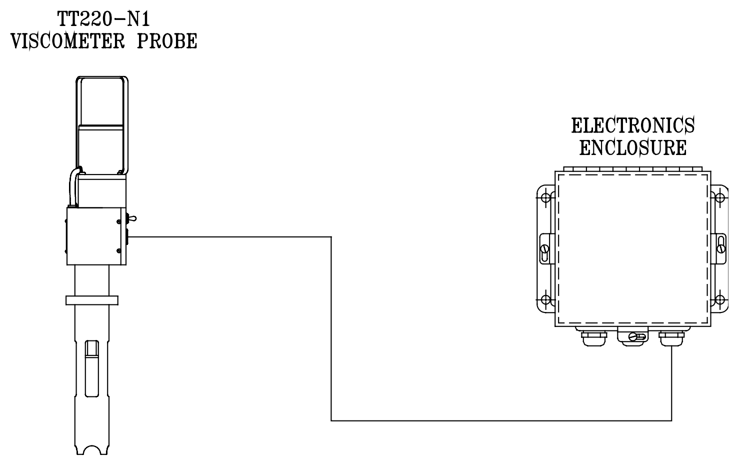
Please be sure to follow these guidelines when returning your instrument:

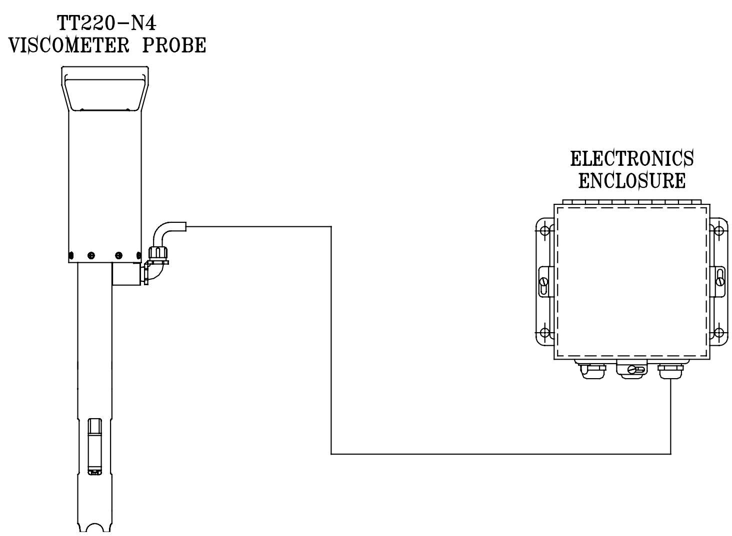
1. The RMA form received from us is completely filled out with the correct information.

2. Ensure that the MSDS section of the RMA is completed and any applicable MSDS sheets are also included with your instrument to be repaired. Failure to comply with MSDS regulations may result in delays to your repair.
3. Including a Purchase Order Number with your RMA will allow us to complete repairs to a specified dollar amount determined by the product type, and thereby, by-passing the need to complete an "Estimate of Repair" to submit for your approval. If you wish to be informed of repair cost before proceeding, please specify on the RMA form.
4. Our method of return shipment is via UPS. Should you prefer a different method or wish to charge to your carrier account number, be sure to include this information.

Appendix F - Drawings

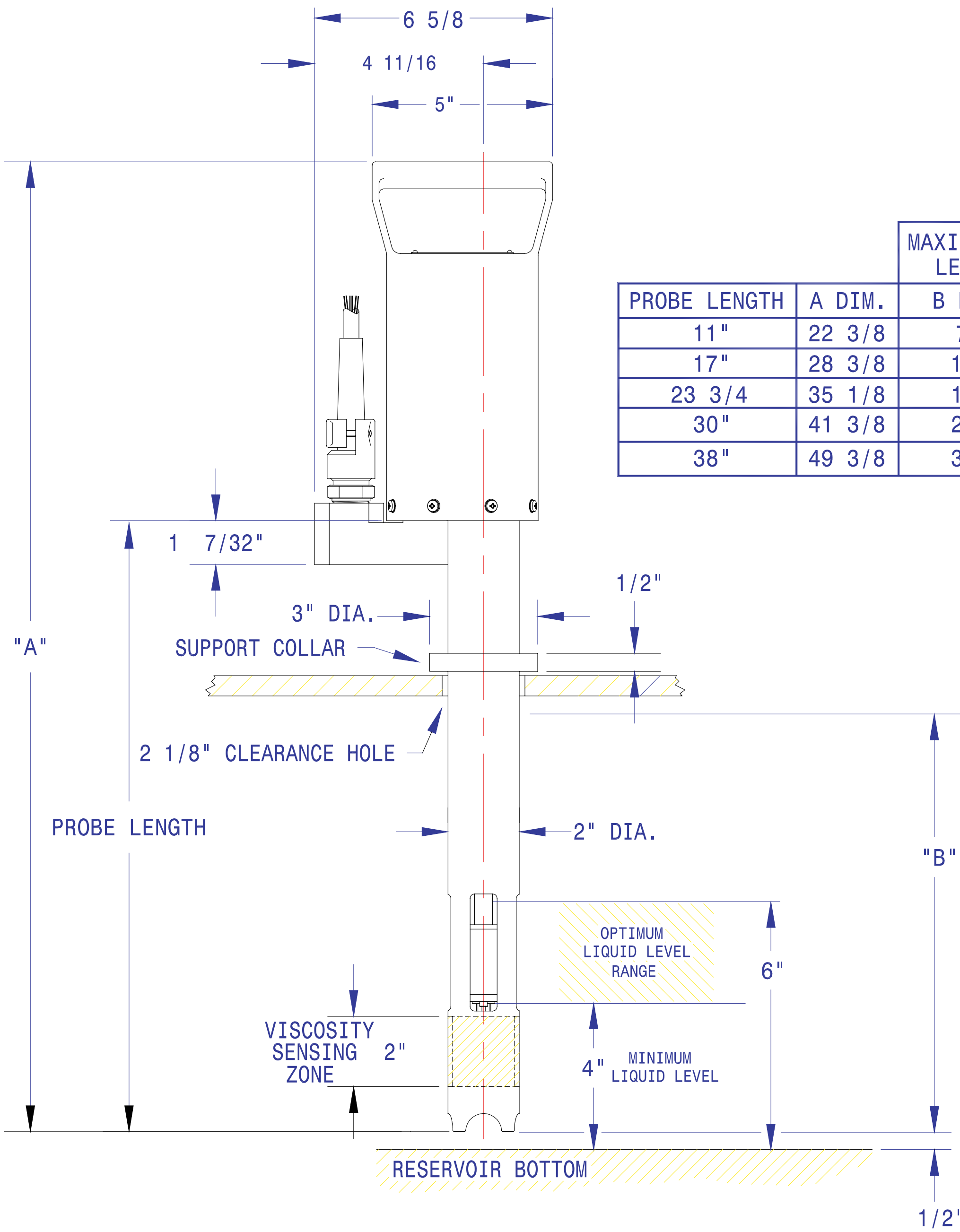






BROOKFIELD

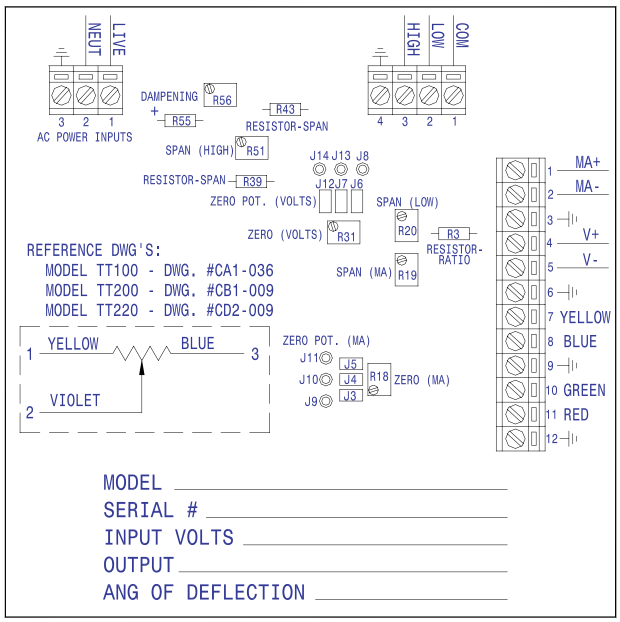
BROOKFIELD	TITLE	DOCUMENT NO. CD4-004	
CREATED BY KFM	**TT220 VISCOMETER MOUNTING, CLEARANCE & IMMERSION DIMENSIONS**	PAGE NO. 1 OF 1	
APPROVED BY DJO		REV. NO. 3	DATE 7/10/98
DATE 11/1/94		CHK. BY	

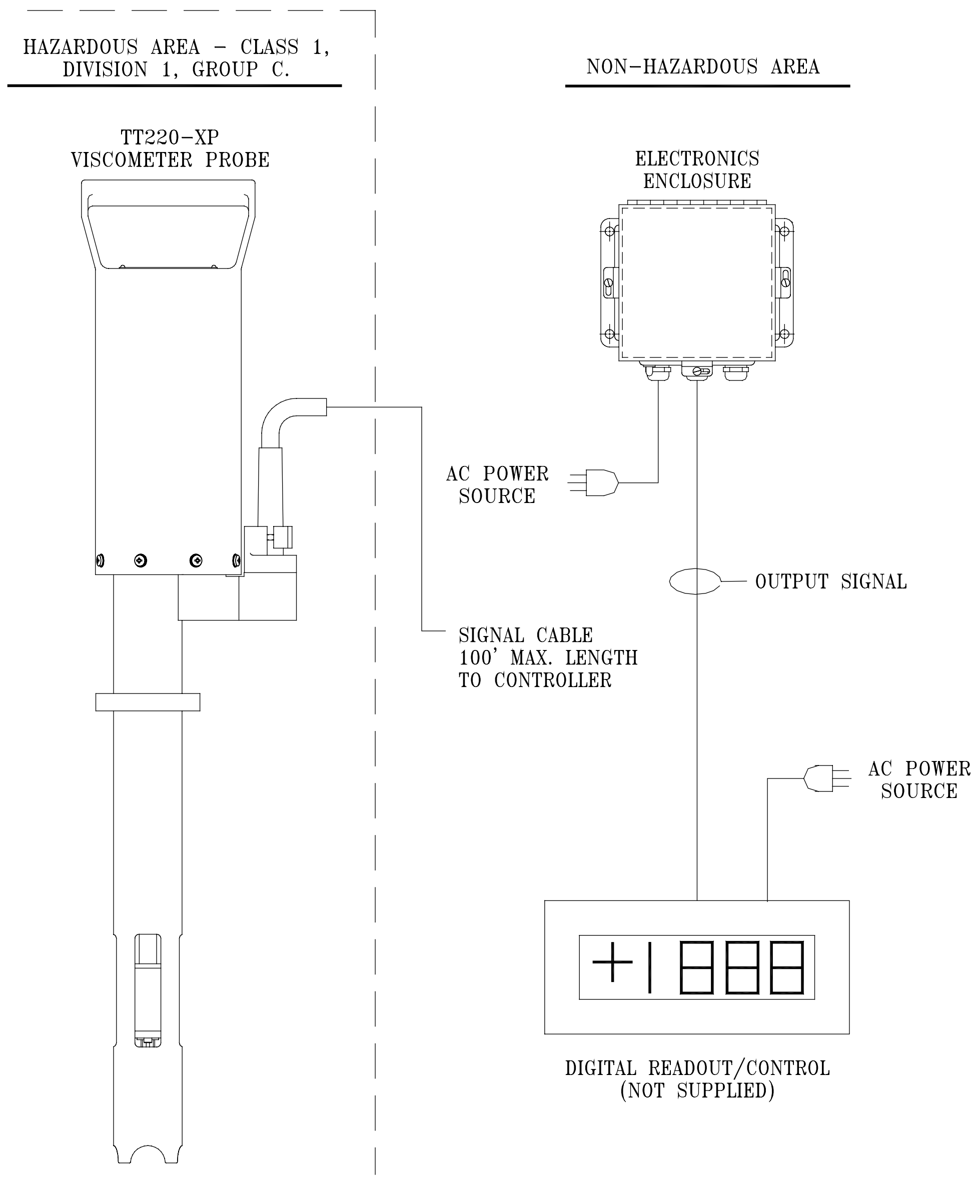


PROBE LENGTH	A DIM.	MAXIMUM LEVEL B DIM.
11"	22 3/8	7"
17"	28 3/8	11"
23 3/4	35 1/8	18"
30"	41 3/8	22"
38"	49 3/8	30"

BROOKFIELD	TITLE	DOCUMENT NO. CA1-037
CREATED BY KFM	**TT MICROSYN ELECTRONICS**	PAGE NO. 1 OF 1
APPROVED BY JRM	**ENCLOSURE LABEL**	REV. NO. 4 / DATE 1/30/97 / CHK. BY
DATE 1/7/95		

STARTING WITH ND SERIAL NOS.

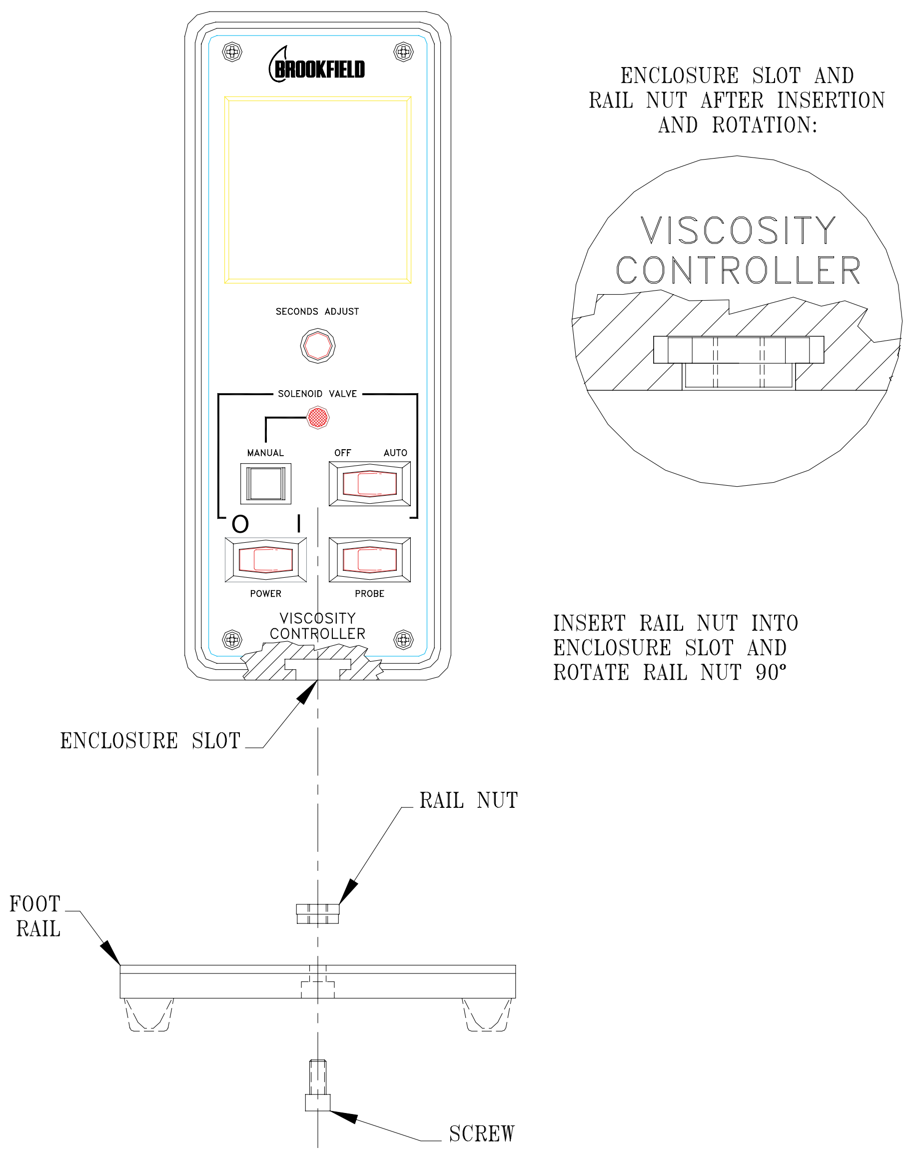




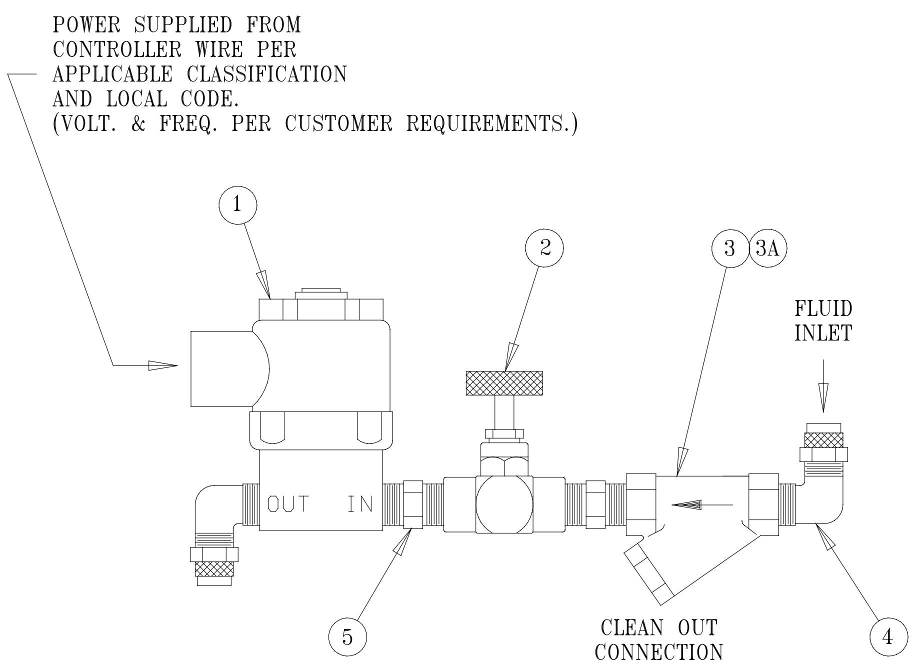
TT220-XP INSTALLATION

CD2-002

BROOKFIELD	TITLE	DOCUMENT NO. DE4-001		
CREATED BY KFM	FOOT RAIL ASSEMBLY	PAGE NO. 1 of 1		
APPROVED BY DOC		REV. NO.	DATE	CHK. BY
DATE 1/18/91		1	8/21/92	



BROOKFIELD	TITLE	DOCUMENT NO. CE4-003
CREATED BY KFM	VTA 106-155Y,-156Y,-157Y,-158Y SOLENOID VALVE ASSEMBLIES-STAINLESS STEEL TEFLON FITTED, EXPLOSION PROOF	PAGE NO. 1 OF 1
APPROVED BY DOC		REV. NO. 1 · DATE 1/10/94 · CHK. BY
DATE 5/13/91		



1. VTA 106-155 - SOLENOID VALVE 115/60

   VTA 106-156 - SOLENOID VALVE 115/50

   VTA 106-157 - SOLENOID VALVE 230/50

   VTA 106-158 - SOLENOID VALVE 230/60

   (ABOVE VALVES FOR HAZARDOUS LOCATIONS CLASS 1 GROUPS C & D. CLASS 2 GROUPS E, F & G. 1/4 NPT PORTS STAINLESS STEEL 2 WAY NORMALLY CLOSED 5/32 ORIFICE 75 P.S.I. MAX. TEFLON FITTED.)

2. VTA 106-81 - NEEDLE VALVE, BRASS, 1/4 NPT TEFLON O-RING

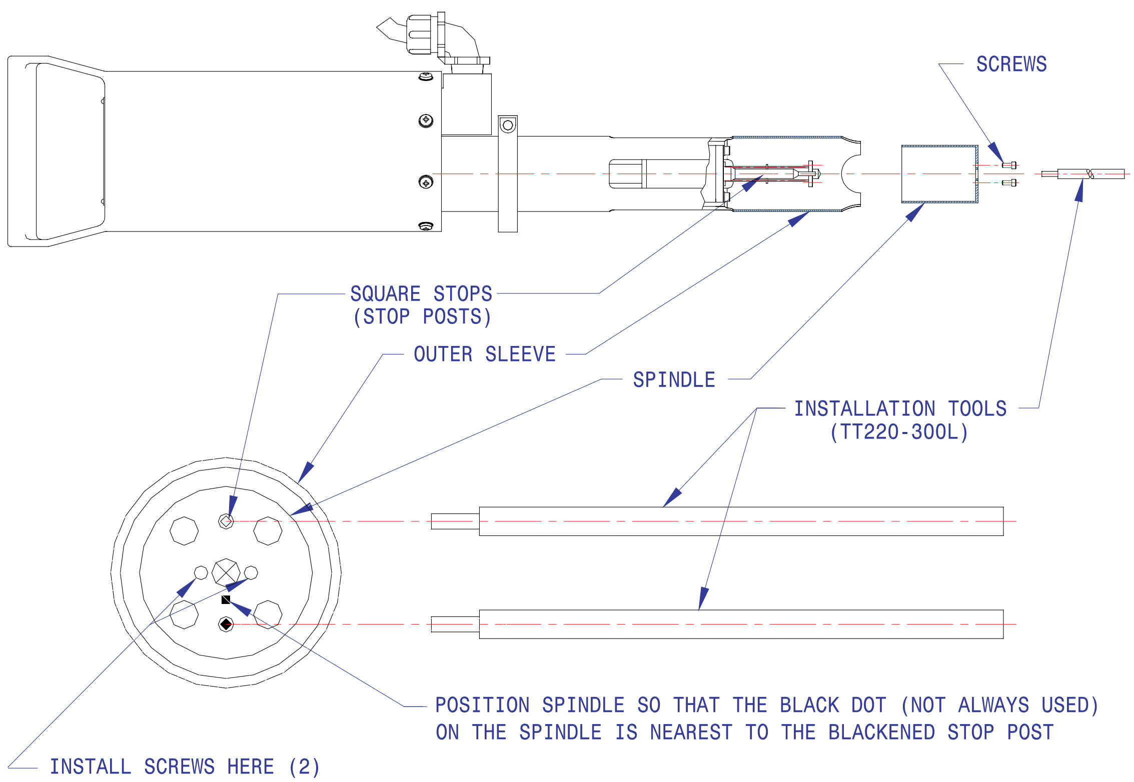
3. VTA 106-120 - 2-WAY STRAINER, BRASS, 1/4 NPT

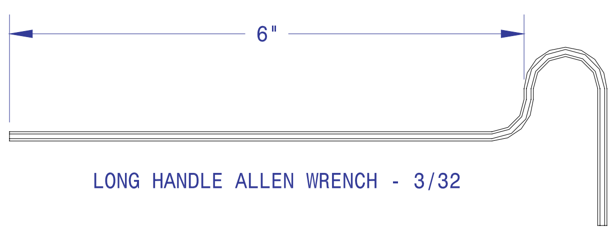
3A. VTA 106-120A - REPLACEMENT STRAINER FILTER

4. VTA 106-123 - 1/4 MPT-3/8 POLY-FLO ELBOW (2)

5. VTA 106-57A - HEX NIPPLE, BRASS, 1/4 NPT (2)

BROOKFIELD	TITLE	DOCUMENT NO. CD4-019
CREATED BY M.D.	**TT220 SPINDLE INSTALLATION PROCEDURE**	PAGE NO. 1 OF 1
APPROVED BY DJO		REV. NO. 1 / DATE 3/3/97 / CHK. BY
DATE 2/9/95		

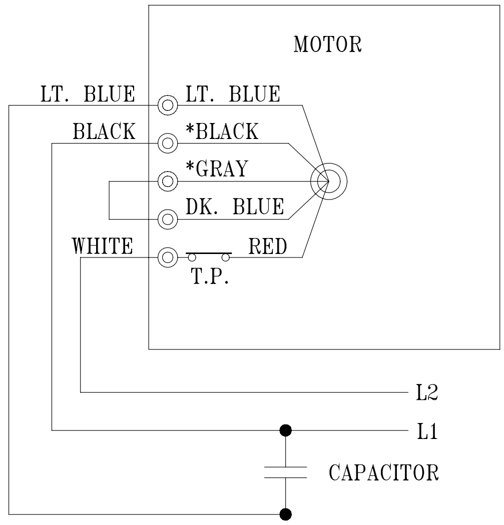




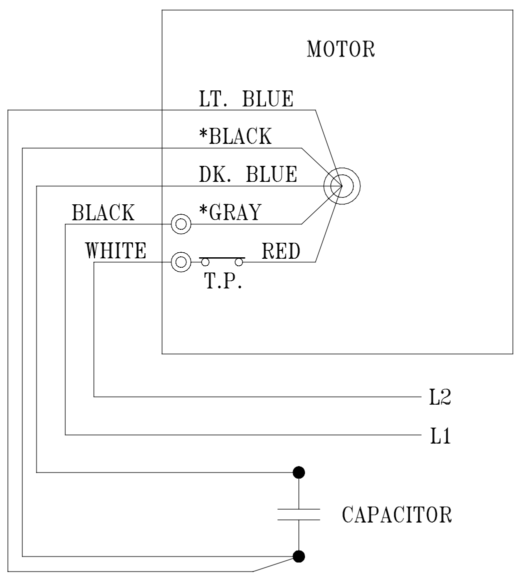
LONG HANDLE ALLEN WRENCH - 3/32

SPINDLE INSTALLATION PROCEDURE

1. PLACE SPINDLE INSIDE THE OUTER SLEEVE AND POSITION IT SO THAT THE SQUARE STOPS LOCATE INSIDE THE TWO HOLES AS SHOWN. POSITION SPINDLE BLACK DOT(IF USED) NEAR BLACKENED STOP POST.
2. INSTALL THE TWO SCREWS LOOSELY
3. PLACE THE INSTALLATION TOOLS OVER THE STOP POSTS.
4. TIGHTEN THE SCREWS, WHILE HOLDING THE TWO TOOLS TO KEEP THE SHAFT FROM ROTATING. USE OF A 6" LONG ALLEN WRENCH IS RECOMMENDED.(3/32 SIZE)
5. REMOVE THE TOOLS. CHECK TO VERIFY THAT THERE IS A GAP BETWEEN THE STOPS AND THE SPINDLE.



MOTOR WIRING
115V 50/60 HZ
CCW ROTATION VIEWING
THE MOTOR SHAFT



MOTOR WIRING
230V 50/60 HZ
CCW ROTATION VIEWING
THE MOTOR SHAFT

VOLTAGE	FREQUENCY	CAPACITOR VALUE
115V	50 HZ	3.0 MFD
115V	60 HZ	1.5 MFD
230V	50 HZ	3.0 MFD
230V	60 HZ	3.0 MFD

*TO REVERSE ROTATION, GRAY & BLACK
MOTOR LEADS ARE INTERCHANGED.

MODEL TT220
AC MOTOR WIRING DIAGRAM
115V 50/60 HZ & 230V 50/60 HZ

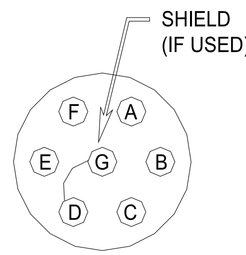
CD1-003

BROOKFIELD	TITLE	DOCUMENT NO. CD5-006
CREATED BY M.D.	**INSTRUCTIONS TO USE 8 CONDUCTOR SHIELDED CABLE TT 220 PROBE IN PLACE OF 6 CONDUCTOR PROBE**	PAGE NO. SHT. 1 OF 1
APPROVED BY		REV. NO. / DATE / CHK. BY
DATE 2/14/95		

APRIL 6, 1994

INSTRUCTIONS FOR USING AN 8-CONDUCTOR SHIELDED CABLE TT220 PROBE IN PLACE OF A 6-CONDUCTOR UNSHIELDED WIRE TT220 PROBE. (IF THE 6-CONDUCTOR PROBE HAS A CIRCULAR AMPHENOL CONNECTOR INSTALLED) THE CIRCULAR AMPHENOL CONNECTOR MUST BE INSTALLED ON THE END OF THE 8-CONDUCTOR CABLE AS FOLLOWS;

6-CONDUCTOR	8-CONDUCTOR	PIN
WHITE	WHITE	F (MOTOR COMMON)
BLACK	BLACK	A (MOTOR LIVE)
RED	RED	E (PRIMARY)
GREEN	GREEN	D (GROUND)
	RED/BLACK	D (GROUND)
BLUE	BLUE	C
ORANGE	ORANGE	B
	WHITE/BLACK	NOT USED
	SHIELD *	G



CIRCULAR AMPHENOL CONNECTOR

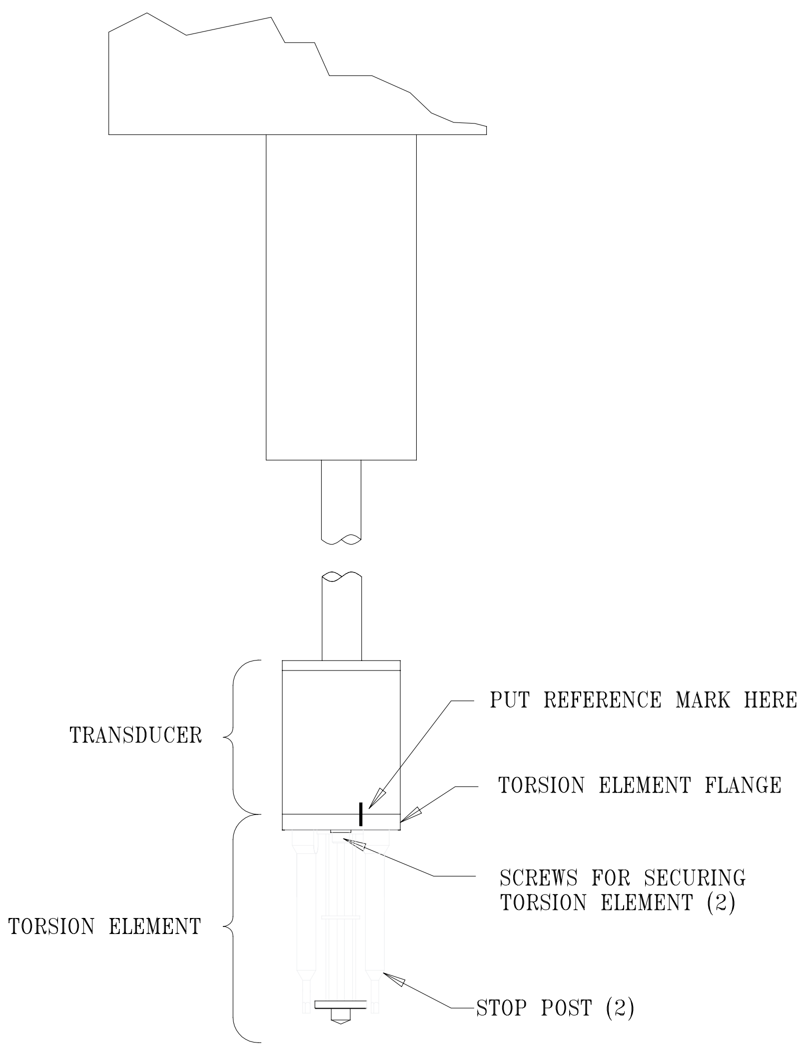
* NOTE - THE 8-CONDUCTOR CABLE HAS AN OUTER SHIELD WHICH IS USEFUL IN SOME INSTALLATIONS WHICH ARE PROXIMAL TO HIGH RF OR EMI EMITTING DEVICES. IF SIGNAL NOISE PROBLEMS DID NOT OCCUR WITH THE 6-CONDUCTOR CABLE, IT IS NOT NECESSARY TO USE THE SHIELD. IF USED, A JUMPER MUST BE INSTALLED FROM PIN D TO G OF EITHER THE MALE OR FEMALE CONNECTOR.

THIS WILL ALLOW INTERCHANGEABILITY BETWEEN THE TWO PROBES. HOWEVER, THE CALIBRATION OF EACH INSTRUMENT WILL NOT BE THE SAME AND RE-CALIBRATING WILL BE NECESSARY WHEN THE PROBES ARE SWAPPED.

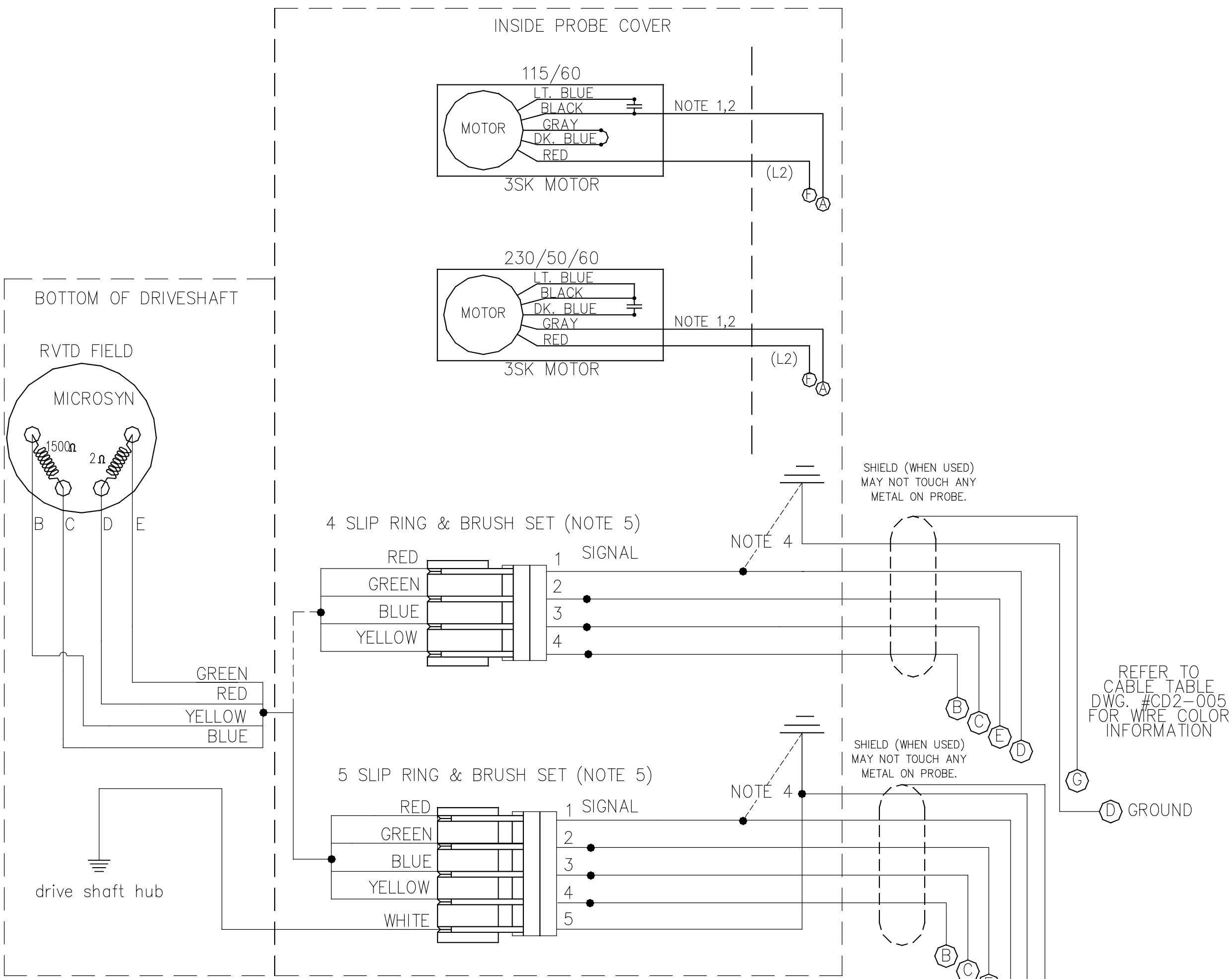
BROOKFIELD	TITLE	DOCUMENT NO. CD2-005		
CREATED BY RAV	TT220 CABLE TABLE	PAGE NO. 1 OF 1		
APPROVED BY DJO		REV. NO.	DATE	CHK. BY
DATE 03/21/94		4	02/23/98	

Reference #	CABLE Part #	COLOR/ letter	COLOR/ letter	COLOR/ letter	COLOR/ letter	COLOR/ letter	COLOR/ letter	COLOR/ letter	COLOR/ letter	COLOR/ letter	Comments
CD2-005-1	TT220-90	black/A	white/F	red/E	green/D	blue/C	orarge/B				S0/18-6
CD2-005-2	TT220-115	blue & white pair blue/C	white/F	group of four signal wires red/E	black/A	green/D	yellow/B	shield/G			2 & 4/shield
CD2-005-3	TT220-222	black & red pair #1 black/B	red/E	black & white pair #2 black/A	white/F	black & green pair #3 black/C	green/D	drain/G			18- 6 3 pairs/shield
CD2-005-4	TT220-228	black/A	white/F	red/E	green/D	blue/C	orange/B	shield/G			S0/18-6 shield
CD2-005-5	TT220-281	black/A	white/F	red/E	green/D	blue/C	orange/B	red/black/D	white/black/ not used	shield/G	S0/18-8 shield
CD2-005-6	TT220-277	black/A	white/F	red/E	green/D	blue/C	orange/B	shield/G			Retractile- #23-6 w/shield
CD2-005-7	TT220-336	black & red pair black/B	red/E	black & white pair black/A	white/F	black & green pair	green/G	black & blue pair black/C	blue/D	drain/G	18-8 4 pairs/shield
CD2-005-8	TT220-345	black/A	white/F	red/E	green/D	blue/C	orange/B	red/black/D		shield/G	SO/18-7 shield

BROOKFIELD	TITLE	DOCUMENT NO. CD4-003
CREATED BY KFM	COARSE MECHANICAL ZERO ADJUSTMENT	PAGE NO. 1 OF 1
APPROVED BY DOC		REV. NO. 1 / DATE 1/11/94 / CHK. BY
DATE 12/19/90		



BROOKFIELD	TITLE: MODEL TT 220 PROBE SCHEMATIC NEMA 4 & NEMA 7 (FOR USE WITH TT100-466 ELECTRONICS)	DOCUMENT NO. CD1-032
CREATED BY M.D.		PAGE NO. SHT. 1 OF 1
APPROVED BY DJO		REV. NO. 3 / DATE 5/11/04 / CHK. BY
DATE 8/2/95		

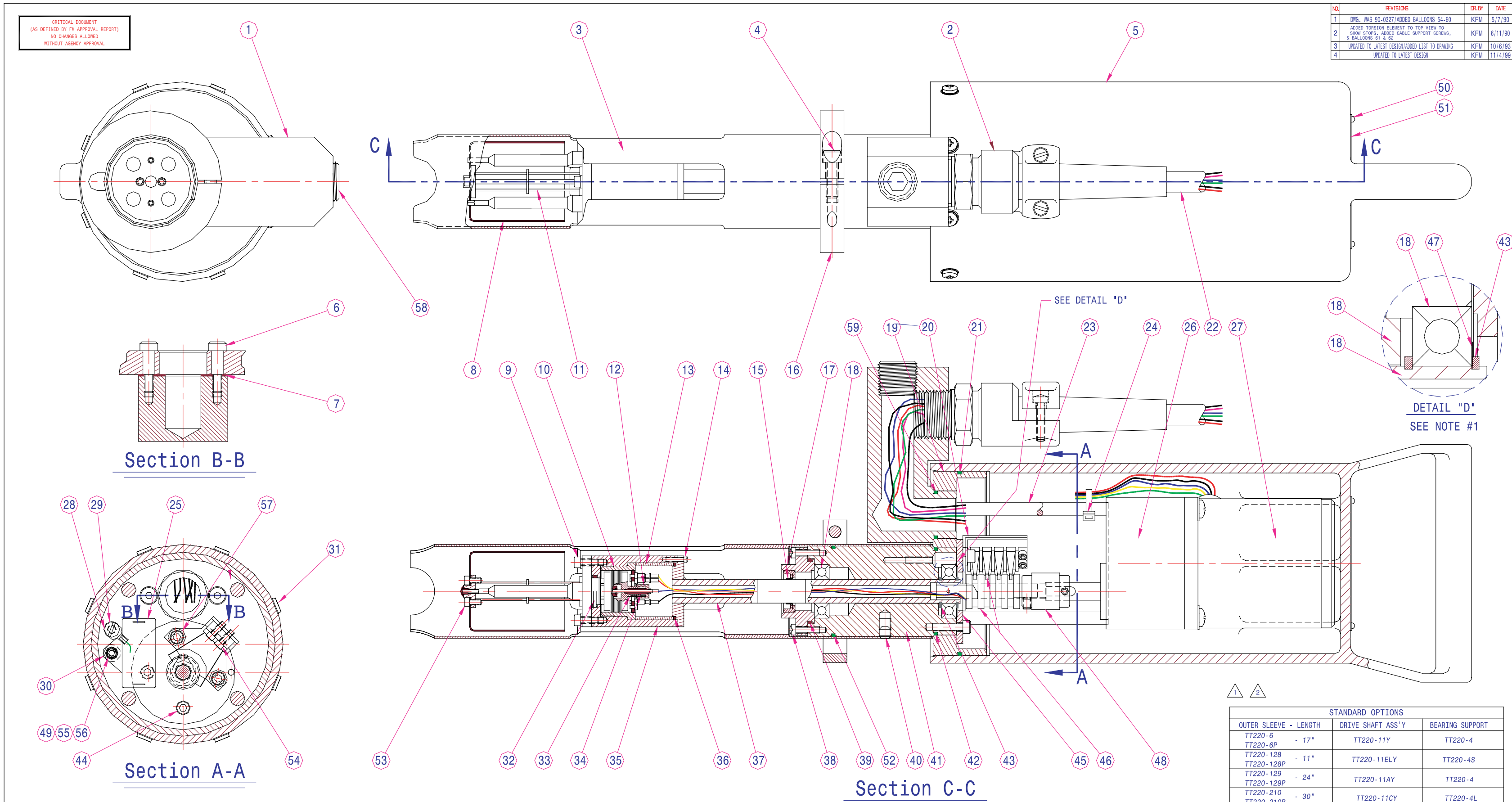


NOTES:

1. MOTOR WIRING IS SHOWN FOR CCW ROTATION VIEWING THE MOTOR SHAFT. TO REVERSE ROTATION, GRAY & BLACK MOTOR LEADS ARE INTERCHANGED.
2. FOR 115V/50Hz LINE VOLTAGE, THE PROBE MOTOR OPERATES AT 230V/50HZ (3SK MOTOR ONLY) IN ALL COVERED MOTOR PROBES (N4 & N7). A STEP-UP TRANSFORMER IS PROVIDED IN THE ELECTRONICS ENCLOSURE TO CHANGE THE 115V/50HZ TO 230V/50HZ FOR THE MOTOR ONLY. THEREFORE, THE MOTOR MUST BE WIRED FOR 230V/50HZ WHEN THE LINE VOLTAGE IS 115V/50HZ.
3.
4. WHEN ONLY ONE "D" WIRE IS AVAILABLE, JOIN THE SIGNAL TO EARTH GROUND INSIDE THE PROBE.
5. EVERY TT220 WILL EITHER HAVE A 4 SLIP RING & BRUSH SET OR A 5 SLIP RING & BRUSH SET, DEPENDENT ON DATE OF MANUFACTURE.

	3SK MOTOR	
LINE VOLTAGE	CAPACITOR VALUE	COMMENTS
115/50	3.0 MFD	SEE NOTE #2
115/60	1.5 MFD	-------
230/50	3.0 MFD	-------
230/60	3.0 MFD	-------

NO.	REVISIONS	DR.BY	DATE	CH.BY
1	DWG. WAS 90-0327/ADDED BALLOONS 54-60	KFM	5/7/90	DJO
2	ADDED TORSION ELEMENT TO TOP VIEW TO SHOW STOPS. ADDED CABLE SUPPORT SCREWS, & BALLOONS 61 & 62	KFM	6/11/90	DJO
3	UPDATED TO LATEST DESIGN/ADDED LIST TO DRAWING	KFM	10/6/93	DJO
4	UPDATED TO LATEST DESIGN	KFM	11/4/99	



STANDARD OPTIONS		
OUTER SLEEVE - LENGTH	DRIVE SHAFT ASS'Y	BEARING SUPPORT
TT220-6 TT220-6P - 17"	TT220-11Y	TT220-4
TT220-128 TT220-128P - 11"	TT220-11ELY	TT220-4S
TT220-129 TT220-129P - 24"	TT220-11AY	TT220-4
TT220-210 TT220-210P - 30"	TT220-11CY	TT220-4L
TT220-211 TT220-211P - 38"	TT220-11DY	TT220-4L

"P" INDICATES PERFORATED SLEEVE

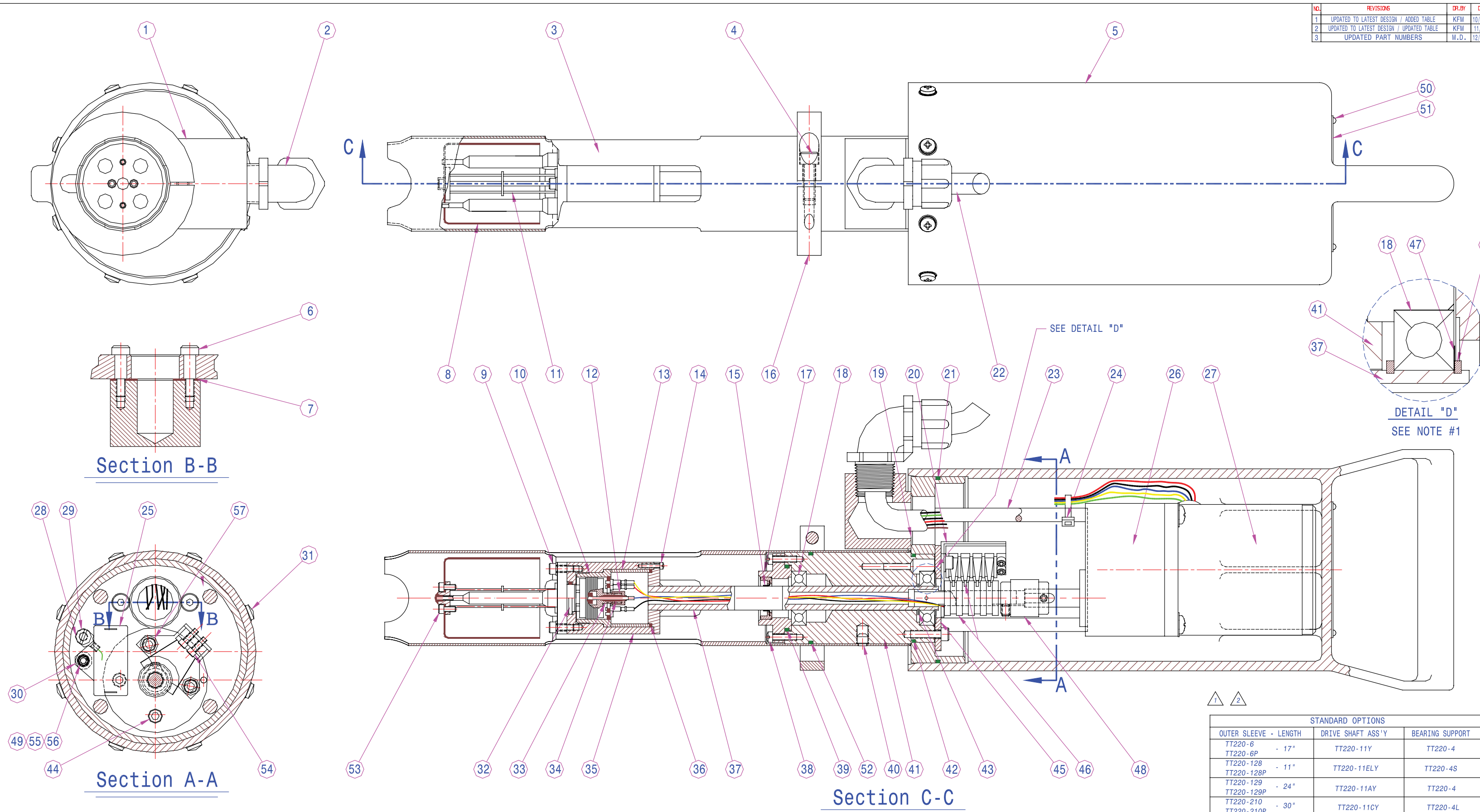
NOTES:
1. ADD SHIMS (ITEM 47) SUCH THAT THE AXIAL MOVEMENT OF THE DRIVESHAFT IN THE BEARING IS .001/.006.

ITEM NO.	PART NO.	DESCRIPTION	QTY.
1	TT220-218	INPUT BLOCK	1
2	TT220-82	SEALING CONNECTOR	1
3	SEE TABLE	OUTER SLEEVE	1
4	50S252024E140	SCREW,1/4-20,3/4LG.,SOC. HD.CAP SS	1
5	TT220-111	HOUSING	1
6	50S102416S38H	SCREW,1/4X1/2,HEX. SOC SHOULDER,STL.	2
7	TT220-220	GASKET	1
8	PER CUST. SPEC.	SPINDLE	1
9	50S063212D140	SCREW,6-32,3/8LG,SOC. HD. CAP SS	2
10	TT200-29Y	MICROSYN CAGE ASSEMBLY	1
11	PER CUST. SPEC.	TORSION ELEMENT & JEWEL ASS'Y	1
12	TT-100-57A	ROTOR CLAMPING NUT	1
13	TT200-2	SLEEVE	1
14	50S025610E070	SCREW,2-56,5/16LG,FILLISTER HD. SS	3
15	TT220-95	LIP SEAL	1
16	TT220-16	MOUNTING FLANGE	1
17	TT220-89	SEAL RETAINER	1
18	TT220-39	BEARING	2
19	TT220-3	BASE PLATE	1
20	TT220-290	BRUSH ASSEMBLY BRACKET	1
21	TT220-36	O-RING (VITON)	1
22	PER CUST. SPEC.	CABLE	PER CUST. SPEC.
23	TT220-350Y	MOUNTING POST ASSEMBLY	4
24	M-35	MOTOR STRAP	1
25	PER CUST. SPEC.	CAPACITOR	1
26	PER CUST. SPEC.	GEARBOX	1
27	TT220-226	MOTOR	1
28	TT220-131	SOLDER TERMINAL	1
29	50S083208B280	SCREW,8-32,1/4LG,BINDING HEAD, BRASS	1
30	TT220-360	SPACER	1
31	TT220-112	SEM,8-32,7/16LG,PHILLIPS PAN HD. M/S	8
32	TT220-94	O-RING (VITON/TEFLON)	1
33	TT-100-57Y	TRANSDUCER ROTOR ASSEMBLY	1
34	TT-100-57B	COLLET	1
35	PER CUST. SPEC.	MICROSYN HOUSING	1
36	TT200-82	O-RING (VITON/TEFLON)	1
37	SEE TABLE	DRIVE SHAFT ASSEMBLY	1
38	50S063216E070	SCREW,6-32,1/2LG,FILLISTER HD. SS	4
39	TT220-86	O-RING (VITON)	1
40	TT220-61	SET SCREW	1
41	SEE TABLE	BEARING SUPPORT	1
42	TT220-92	O-RING (VITON)	1
43	TT220-41	SNAP RING	2
44	50S083216E140	SCREW,8-32,1/2LG,SOC. HD. CAP SS	4
45	TT220-15	BRUSH PLATE	1
46	TT220-97Y-2	SLIP RING ASSEMBLY	1
47	TT220-280	SHIM	A/R
48	TT220-359	COUPLING,GEAR GRIP	1
49	500907032E330	FLAT WASHER,#6	1
50	50P075006E010	DRIVE SCREW,#0 X 3/16LG.SS	4
51	TT220-188	NAMEPLATE,TT220,NEMA 4	1
52	TT220-93	O-RING(VITON)	1
53	50S044008D140	SCREW,4-40,1/4LG,SOC. HD. CAP, 316 SS	2
54	50S044012E140	SCREW,4-40,3/8LG,SOC. HD. CAP, SS	2
55	500908031D320	LOCK WASHER,#6	1
56	50S063224E140	SCREW,6-32,3/4 LG,SOC. HD. CAP, SS	1
57	501214049E330	FLAT WASHER,#8	2
58	TT220-235	PIPE PLUG	1
59	TT220-110	O-RING (VITON)	1

TOLERANCES (UNLESS OTHERWISE SPECIFIED)
FRACTIONS ± .010 ANGLES ± 1/2°
.XXX ± .003
.XXXX ± .0005
63
DO NOT SCALE DRAWING!

MATERIAL	AS NOTED
SCALE	NTS
FINISH	
DR.BY	KFM
DATE	10/30/92
CH.BY	DJO
TITLE	TT220 PROBE (NEMA 7) PARTS IDENTIFICATION
DWG.NO.	TT220-XP

NO.	REVISIONS	DR.BY	DATE	CH.BY
1	UPDATED TO LATEST DESIGN / ADDED TABLE	KFM	10/27/93	DJO
2	UPDATED TO LATEST DESIGN / UPDATED TABLE	KFM	11/4/99	DJO
3	UPDATED PART NUMBERS	M.D.	12/21/99	



STANDARD OPTIONS		
OUTER SLEEVE - LENGTH	DRIVE SHAFT ASS'Y	BEARING SUPPORT
TT220-6 / TT220-6P - 17"	TT220-11Y	TT220-4
TT220-128 / TT220-128P - 11"	TT220-11ELY	TT220-4S
TT220-129 / TT220-129P - 24"	TT220-11AY	TT220-4
TT220-210 / TT220-210P - 30"	TT220-11CY	TT220-4L
TT220-211 / TT220-211P - 38"	TT220-11DY	TT220-4L

"P" INDICATES PERFORATED SLEEVE

NOTES:

1. ADD SHIMS (ITEM 47) SUCH THAT THE AXIAL MOVEMENT OF THE DRIVESHAFT IN THE BEARING IS .001/.006.

ITEM NO.	PART NO.	DESCRIPTION	QTY.
1	TT220-219	INPUT BLOCK	1
2	TT220-223	STRAIN RELIEF CONNECTOR (90°)	1
3	SEE TABLE	OUTER SLEEVE	1
4	50S252024E140	SCREW,1/4-20,3/4LG.,SOC. HD.CAP SS	1
5	TT220-111	HOUSING	1
6	50S102416S38H	SCREW,1/4X1/2,HEX. SOC SHOULDER,STL.	2
7	TT220-220	GASKET	1
8	PER CUST. SPEC.	SPINDLE	1
9	50S063212D140	SCREW,6-32,3/8LG,SOC. HD. CAP SS	2
10	TT200-29NY	MICROSYN CAGE ASSEMBLY	1
11	PER CUST. SPEC.	TORSION ELEMENT & JEWEL ASS'Y	1
12	TT-100-57A	ROTOR CLAMPING NUT	1
13	TT200-2	SLEEVE	1
14	50S025610E070	SCREW,2-56,5/16LG,FILLISTER HD. SS	3
15	TT220-95	LIP SEAL	1
16	TT220-16	MOUNTING FLANGE	1
17	TT220-89	SEAL RETAINER	1
18	TT220-39	BEARING	2
19	TT220-3	BASE PLATE	1
20	TT220-290	BRUSH ASSEMBLY BRACKET	1
21	TT220-36	O-RING (VITON)	1
22	PER CUST. SPEC.	CABLE	PER CUST. SPEC.
23	TT220-350Y	MOUNTING POST ASSEMBLY	4
24	M-35	MOTOR STRAP	1
25	PER CUST. SPEC.	CAPACITOR	1
26	PER CUST. SPEC.	GEARBOX	1
27	TT220-226	MOTOR	1
28	TT220-131	SOLDER TERMINAL	1
29	50S083208B280	SCREW,8-32,1/4LG,BINDING HEAD, BRASS	1
30	TT220-360	SPACER	1
31	TT220-112	SEM,8-32,7/16LG,PHILLIPS PAN HD. M/S	8
32	TT220-94	O-RING (VITON/TEFLON)	1
33	TT-100-57Y	TRANSDUCER ROTOR ASSEMBLY	1
34	TT-100-57B	COLLET	1
35	PER CUST. SPEC.	MICROSYN HOUSING	1
36	TT220-209	O-RING (VITON/TEFLON)	1
37	SEE TABLE	DRIVE SHAFT ASSEMBLY	1
38	50S063216E070	SCREW,6-32,1/2LG,FILLISTER HD. SS	4
39	TT220-86	O-RING (VITON)	1
40	TT220-61	SET SCREW	1
41	SEE TABLE	BEARING SUPPORT	1
42	TT220-92	O-RING (VITON)	1
43	TT220-41	SNAP RING	2
44	50S083216E140	SCREW,8-32,1/2LG,SOC. HD. CAP SS	4
45	TT220-15	BRUSH PLATE	1
46	TT220-289	SLIP RING ASSEMBLY	1
47	TT220-280	SHIM	A/R
48	TT220-359	COUPLING,GEAR GRIP	1
49	500907032E330	FLAT WASHER,#6	1
50	50P075006E010	DRIVE SCREW,#0 X 3/16LG.SS	4
51	TT220-188	NAMEPLATE,TT220,NEMA 4	1
52	TT220-93	O-RING(VITON)	1
53	50S044008D140	SCREW,4-40,1/4LG,SOC. HD. CAP, 316 SS	2
54	50S044012E140	SCREW,4-40,3/8LG,SOC. HD. CAP, SS	2
55	500908031D320	LOCK WASHER,#6	1
56	50S063224E140	SCREW,6-32,3/4 LG,SOC. HD. CAP, SS	1
57	501214049E330	FLAT WASHER,#8	2

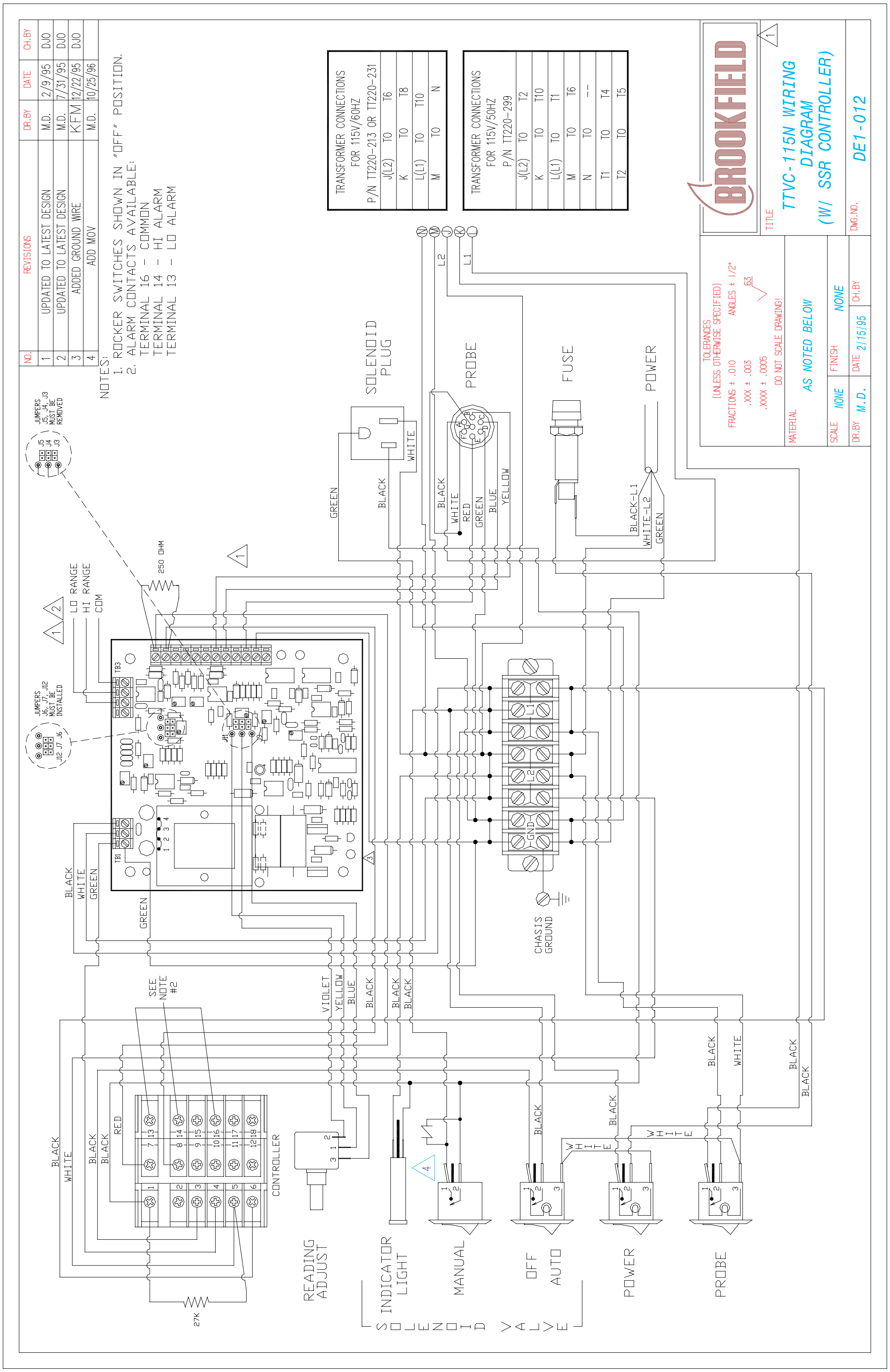
AS NOTED

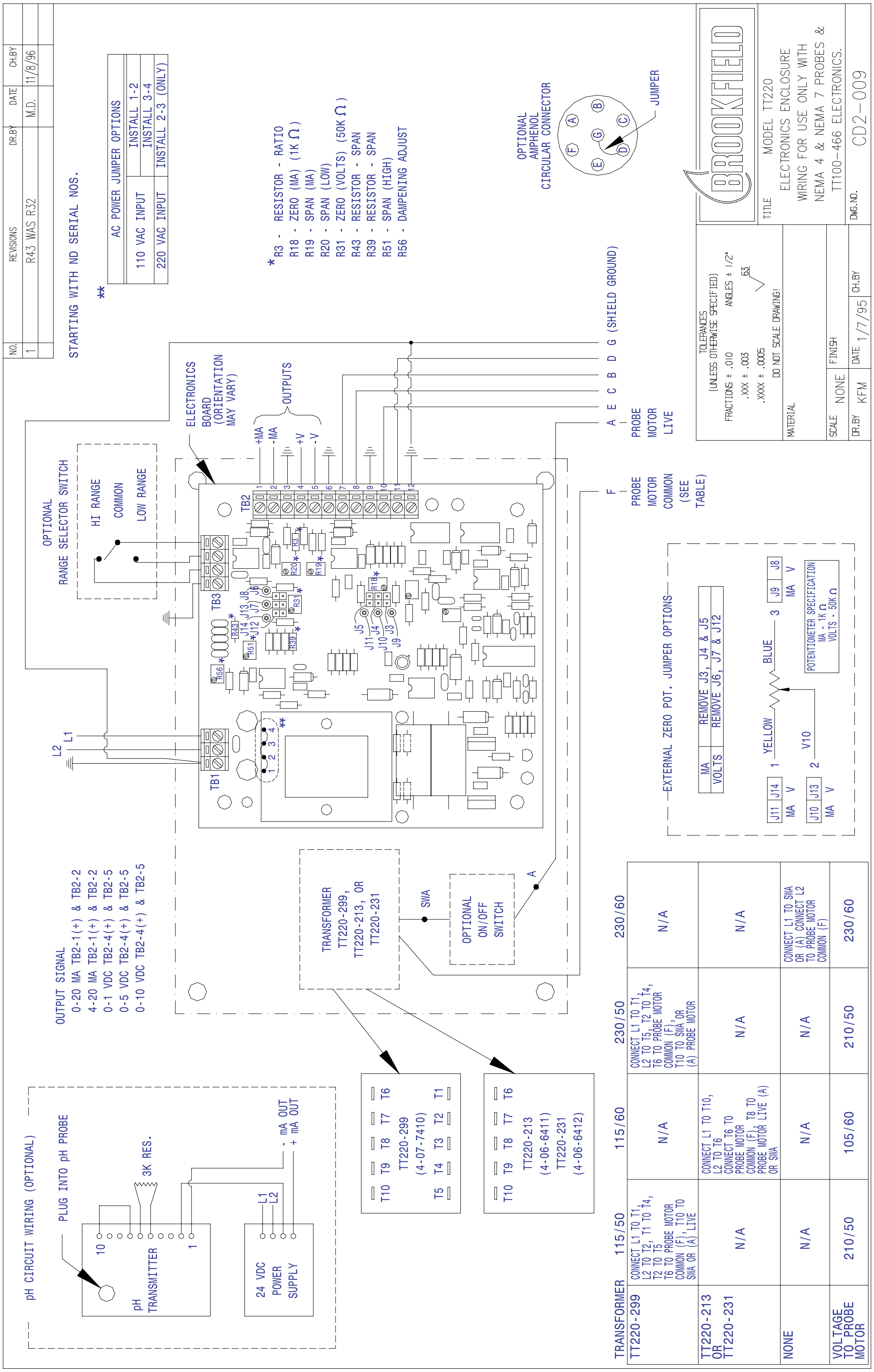
NTS

KFM 10/30/92 DJO

TT220 PROBE
(NEMA 4)
PARTS IDENTIFICATION

TT220-N4


REVISIONS
NO.
DR.BY
DATE
CH.BY
1 UPDATED TO LATEST DESIGN M.D. 2/9/95 DJO
2 UPDATED TO LATEST DESIGN M.D. 7/31/95 DJO
3 ADDED GROUND WIRE KFM 12/22/95 DJO
4 ADD MOV M.D. 10/25/96
NOTES:
1. ROCKER SWITCHES SHOWN IN "OFF" POSITION.
2. ALARM CONTACTS AVAILABLE:
TERMINAL 16 - COMMON
TERMINAL 14 - HI ALARM
TERMINAL 13 - LO ALARM
TRANSFORMER CONNECTIONS FOR 115V/60HZ P/N TT220-213 OR TT220-231
J(L2) TO T6
K TO T8
L(L1) TO T10
M TO N
TRANSFORMER CONNECTIONS FOR 115V/50HZ P/N TT220-299
J(L2) TO T2
K TO T10
L(L1) TO T1
M TO T6
N TO --
T1 TO T4
T2 TO T5
BROOKFIELD
TITLE
TTVC-115N WIRING DIAGRAM (W/ SSR CONTROLLER)
DWG.NO.
DE1-012
TOLERANCES (UNLESS OTHERWISE SPECIFIED)
FRACTIONS ± .010
ANGLES ± 1/2°
.XXX ± .003
.XXXX ± .0005
DO NOT SCALE DRAWING!
MATERIAL
AS NOTED BELOW
SCALE NONE
FINISH NONE
DR.BY M.D.
DATE 2/15/95
CH.BY
SOLENOID PLUG
PROBE
FUSE
POWER
CHASIS GROUND
JUMPERS J5, J4, J3 MUST BE REMOVED
JUMPERS J6, J7, J12 MUST BE INSTALLED
250 OHM
LO RANGE
HI RANGE
COM
TB3
TB1
SEE NOTE #2
CONTROLLER
27K
READING ADJUST
INDICATOR LIGHT
MANUAL
OFF AUTO
POWER
PROBE
SOLENOID VALVE


NO. REVISIONS DR.BY DATE CH.BY
1 R43 WAS R32 M.D. 11/8/96
STARTING WITH ND SERIAL NOS.
** AC POWER JUMPER OPTIONS
110 VAC INPUT INSTALL 1-2
INSTALL 3-4
220 VAC INPUT INSTALL 2-3 (ONLY)
* R3 - RESISTOR - RATIO
R18 - ZERO (MA) (1K Ω)
R19 - SPAN (MA)
R20 - SPAN (LOW)
R31 - ZERO (VOLTS) (50K Ω)
R43 - RESISTOR - SPAN
R39 - RESISTOR - SPAN
R51 - SPAN (HIGH)
R56 - DAMPENING ADJUST
OPTIONAL AMPHENOL CIRCULAR CONNECTOR
JUMPER
ELECTRONICS BOARD (ORIENTATION MAY VARY)
OUTPUTS
+MA -MA +V -V
G (SHIELD GROUND)
A E C B D
PROBE MOTOR LIVE
F
PROBE MOTOR COMMON (SEE TABLE)
OPTIONAL RANGE SELECTOR SWITCH
HI RANGE
COMMON
LOW RANGE
TB1 TB2 TB3
L1 L2
EXTERNAL ZERO POT. JUMPER OPTIONS
MA REMOVE J3, J4 & J5
VOLTS REMOVE J6, J7 & J12
YELLOW BLUE V10
POTENTIOMETER SPECIFICATION MA - 1K Ω VOLTS - 50K Ω
OUTPUT SIGNAL
0-20 MA TB2-1(+) & TB2-2
4-20 MA TB2-1(+) & TB2-2
0-1 VDC TB2-4(+) & TB2-5
0-5 VDC TB2-4(+) & TB2-5
0-10 VDC TB2-4(+) & TB2-5
TRANSFORMER TT220-299, TT220-213, OR TT220-231
SWA
OPTIONAL ON/OFF SWITCH
TT220-299 (4-07-7410)
TT220-213 (4-06-6411) TT220-231 (4-06-6412)
T1 T2 T3 T4 T5 T6 T7 T8 T9 T10
pH CIRCUIT WIRING (OPTIONAL)
PLUG INTO pH PROBE
3K RES.
- mA OUT
+ mA OUT
pH TRANSMITTER
24 VDC POWER SUPPLY
TRANSFORMER 115/50 115/60 230/50 230/60
TT220-299: CONNECT L1 TO T1, L2 TO T2, T1 TO T4, T2 TO T5, T6 TO PROBE MOTOR COMMON (F), T10 TO SWA OR (A) LIVE | N/A | CONNECT L1 TO T1, L2 TO T5, T2 TO T4, T6 TO PROBE MOTOR COMMON (F), T10 TO SWA OR (A) PROBE MOTOR | N/A
TT220-213 OR TT220-231: N/A | CONNECT L1 TO T10, L2 TO T6, CONNECT T6 TO PROBE MOTOR COMMON (F), T8 TO PROBE MOTOR LIVE (A) OR SWA | N/A | N/A
NONE: N/A | N/A | N/A | CONNECT L1 TO SWA OR (A) CONNECT L2 TO PROBE MOTOR COMMON (F)
VOLTAGE TO PROBE MOTOR: 210/50 105/60 210/50 230/60
TOLERANCES (UNLESS OTHERWISE SPECIFIED)
FRACTIONS ± .010 ANGLES ± 1/2°
.XX ± .003
.XXX ± .0005
DO NOT SCALE DRAWING!
MATERIAL
FINISH
SCALE NONE
DR.BY KFM DATE 1/7/95 CH.BY
BROOKFIELD
TITLE MODEL TT220 ELECTRONICS ENCLOSURE WIRING FOR USE ONLY WITH NEMA 4 & NEMA 7 PROBES & TT100-466 ELECTRONICS.
DWG.NO. CD2-009

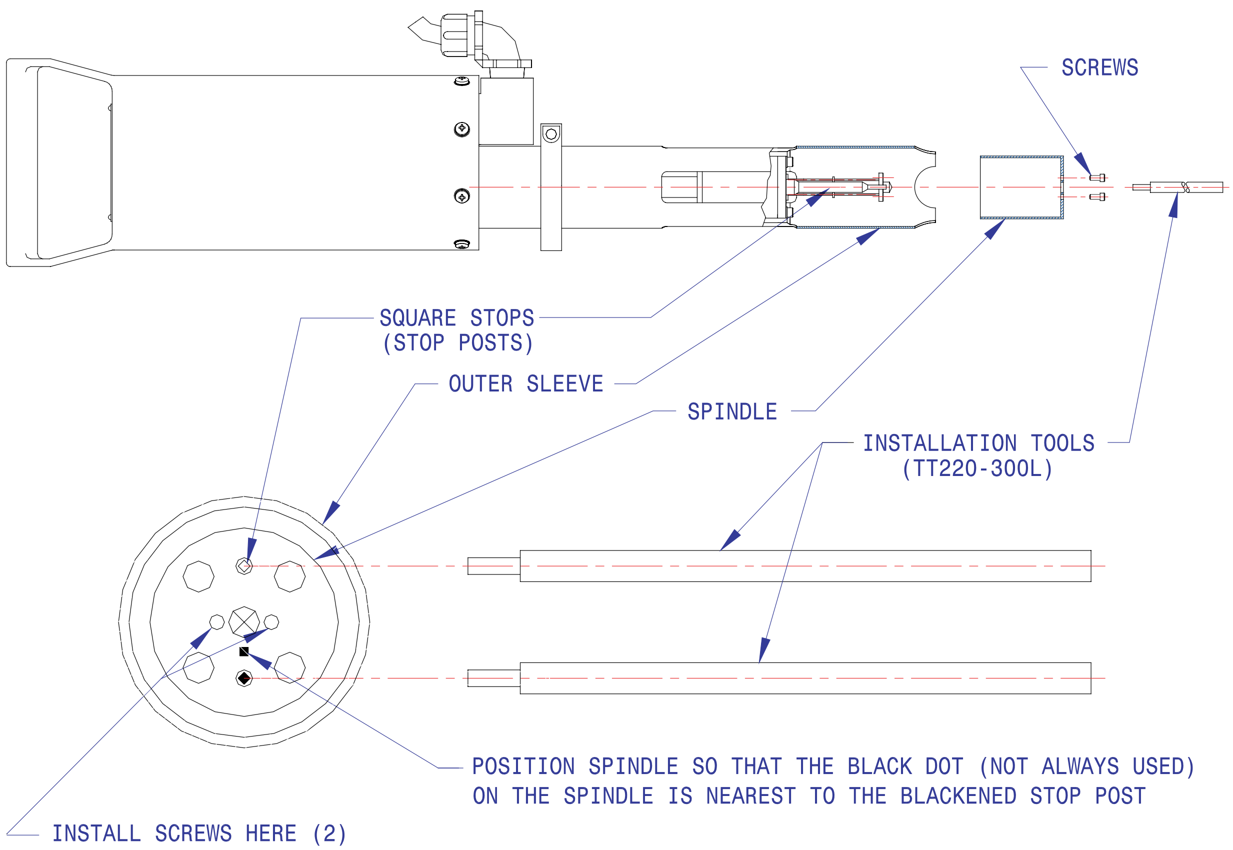
TT220 In-Line Process Viscometer Spare Parts List

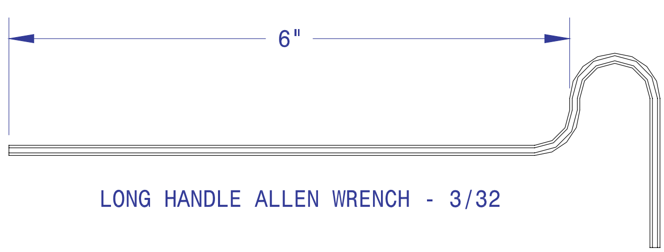
NOTE: Before placing parts order, please review your viscometer specification. Instrument serial number must be noted on purchase order.

PART NUMBER	DESCRIPTION
TT220-21L	Spindle, 316 s/s
TT220-22L	Spindle, 316 s/s
TT220-23L	Spindle, 316 s/s
TT220-25L	Spindle, 316 s/s
TT220-25N	Spindle, serrated
TT220-27N	Spindle
Calibration Bars	
TT-100-1885Y	Calibration bar
TT-100-18810Y	Calibration bar
TT-100-18820Y	Calibration bar
TT-100-18825Y	Calibration bar
TT-100-188830Y	Calibration bar
Motor and Gearboxes	
TT220-226	Motor, Oriental, 115VAC or 230VAC
TT220-227	Oriental gearbox, 9:1 ratio
TT220-227A	Oriental gearbox, 18:1 ratio
TT220-227B	Oriental gearbox, 36:1 ratio
TT220-227C	Oriental gearbox, 90:1 ratio
TT220-227D	Oriental gearbox, 5:1 ratio
TT220-227E	Oriental gearbox, 3:1 ratio
TT220-227F	Oriental gearbox, 180:1 ratio
TT220-227G	Oriental gearbox, 150:1 ratio
Outer Sleeves	
TT220-6	Outer sleeve (17" probe length)
TT220-6P	Outer sleeve with perforations (17" probe length)
TT220-128	Outer sleeve (11" probe length)
TT220-128P	Outer sleeve with perforations (11" probe length)
TT220-129	Outer sleeve (24" probe length)
TT220-129P	Outer sleeve with perforations (24" probe length)
TT220-210	Outer sleeve (30" probe length)
TT220-210P	Outer sleeve with perforations (30" probe length)
TT220-211	Outer sleeve (38" probe length)
TT220-211P	Outer sleeve with perforations (38" probe length)
TT220-329	Outer sleeve with extended zone (17" probe length, 19" sleeve)
TT220-217	Adapter sleeve (used with pumping helix on Microsyn housing)

BROOKFIELD

BROOKFIELD	TITLE	DOCUMENT NO. CD4-019
CREATED BY M D.	**TT220 SPINDLE INSTALLATION PROCEDURE**	PAGE NO. 1 OF 1
APPROVED BY DJO		REV. NO. 1 / DATE 3/3/97 / CHK. BY
DATE 2/9/95		





LONG HANDLE ALLEN WRENCH - 3/32

SPINDLE INSTALLATION PROCEDURE

1. PLACE SPINDLE INSIDE THE OUTER SLEEVE AND POSITION IT SO THAT THE SQUARE STOPS LOCATE INSIDE THE TWO HOLES AS SHOWN. POSITION SPINDLE BLACK DOT(IF USED) NEAR BLACKENED STOP POST.
2. INSTALL THE TWO SCREWS LOOSELY
3. PLACE THE INSTALLATION TOOLS OVER THE STOP POSTS.
4. TIGHTEN THE SCREWS, WHILE HOLDING THE TWO TOOLS TO KEEP THE SHAFT FROM ROTATING. USE OF A 6" LONG ALLEN WRENCH IS RECOMMENDED.(3/32 SIZE)
5. REMOVE THE TOOLS. CHECK TO VERIFY THAT THERE IS A GAP BETWEEN THE STOPS AND THE SPINDLE.

Transducers, Microsyns and Brush Assemblies

TT200-29NY	Microsyn cage assembly
TT200-68	Microsyn housing
TT220-74Y	Jewel support assembly
TT220-289	Brush and slip ring assembly
TT220-290	Brush bracket assembly
TT100-466 (115)	Transducer electronics P.C.B., 115 VAC
TT100-466K2(115)	New style Microsyn and Transducer electronics kit, 115 VAC
TT100-466(230)	Transducer electronics P.C.B., 230 VAC
TT100-466K2(230)	New style Microsyn and Transducer electronics kit, 230 VAC
PH SIMULATOR	Apparatus for checking function of pH amplifier and circuitry (inserts in place of pH sensor tip)

TT220-39	Bearing, Barden SR8FF3 (2 required)
TT220-36	O-Ring, (cover to base assembly)
TT220-93	O-Ring, (bearing support)
TT220-94	O-Ring, (Microsyn housing to torsion element)
TT220-209	O-Ring (Microsyn housing, inside)
TT220-10NY	Torsion element
TT220-20NY	Torsion element
TT220-30NY	Torsion element
TT220-55N	Stop post (2 required)
TT220-10NYJ	Torsion element, jewel assembly and stop posts
TT220-20NYJ	Torsion element, jewel assembly and stop posts
TT220-30NYJ	Torsion element, jewel assembly
TT220-293Y	Motor coupling (gearbox)
TT220-291Y	Motor coupling (drive shaft)
TT220-292	Motor coupling spider
TT220-35	1.5 mF capacitor, Oriental motor, 115 VAC
TT220-71	3 mF capacitor, Oriental motor, 230 VAC
PVT-145	pH sensor immersion tip (electrode-preamplifier assembly)
TT220-253S	pH sensor immersion tip (electrode only) ***(Limited supply - obsolete item)***

Addendum

THIS INSTRUMENT IS SHIPPED ESSENTIALLY ASSEMBLED. SPINDLE MUST BE ATTACHED TO TORSION ELEMENT PRIOR TO OPERATION (SEE SPINDLE INSTALLATION INSTRUCTIONS) AND DOES NOT NEED TO BE DISASSEMBLED FOR INSTALLATION. INSTRUMENT ZERO (4 MA) IS SET. IF ADDITIONAL ADJUSTMENT IS REQUIRED, FOLLOW ZEROING PROCEDURE.

THIS INSTRUMENT IS SHIPPED COMPLETELY CALIBRATED AND TYPICALLY DOES NOT NEED TO BE RECALIBRATED FOR INSTALLATION. IF CALIBRATION VERIFICATION OR RECALIBRATION IS REQUIRED, FOLLOW FIELD CALIBRATION PROCEDURE.

NOTE 1: *FOR MULTI-UNIT INSTALLATIONS BE CERTAIN TO ATTACH THE APPROPRIATE PROBE AND CONTROLLER TOGETHER BY MATCHING THEIR SIMILAR SERIAL NUMBERS.*

NOTE 2: *ALL CONTROLLERS ARE PRE-PROGRAMMED TO DISPLAY AND CONTROL IN "CUSTOMER-SPECIFIED" UNITS OF MEASURE. (FOR EXAMPLE: CENTIPOISE, #2 ZAHN CUP SECONDS, ETC.) CONSULT FACTORY FOR RE-PROGRAMMING INSTRUCTIONS TO CHANGE DISPLAYED UNIT OF MEASURE!!!!!*

NOTE 3: *PH PROBE AND REMOVABLE TIP SHOULD REMAIN ASSEMBLED AT ALL TIMES TO ELIMINATE THE POSSIBILITY OF MOISTURE/CONDENSATION FROM ENTERING THE PH PROBE RECEPTACLE. SHOULD MOISTURE/INK ENTER AT THIS POINT, IRREVERSIBLE DAMAGE TO ELECTRICAL CONTACTS WILL OCCUR AND REQUIRE PROBE REPLACEMENT.*

NOTE 4: *WHEN REPLACEMENT OF PH PROBE TIP IS REQUIRED, ENSURE THAT THE PH PROBE IS CLEAN AND DRY BEFORE PROCEEDING!!!!!*

Addendum

THIS INSTRUMENT IS SHIPPED COMPLETELY ASSEMBLED AND DOES NOT NEED TO BE DISASSEMBLED FOR INSTALLATION. INSTRUMENT ZERO (4 MA) IS SET. IF ADDITIONAL ADJUSTMENT IS REQUIRED, FOLLOW ZEROING PROCEDURE.

THIS INSTRUMENT IS SHIPPED COMPLETELY CALIBRATED AND TYPICALLY DOES NOT NEED TO BE RECALIBRATED FOR INSTALLATION. IF CALIBRATION VERIFICATION OR RECALIBRATION IS REQUIRED, FOLLOW FIELD CALIBRATION PROCEDURE.

NOTE: *FOR MULTI-UNIT INSTALLATIONS BE CERTAIN TO ATTACH THE APPROPRIATE PROBE AND CONTROLLER TOGETHER BY MATCHING THEIR SIMILAR SERIAL NUMBERS.*