



ViscoIndicator

Rheological Sensing for the Masses

Operations Manual



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Safety

All safety instructions must be heeded and observed. Non-observance of safety instructions may cause damage to life and health of persons, environmental damage and/or extensive damage to property.

Observing the safety instructions included in the operating instructions will help to avoid dangers, to operate the installation profitably and to secure the full use of the product.

1.1 Safety summary

The following are recommended safety precautions unrelated to any specific procedures in this manual and therefore do not appear elsewhere. Personnel must understand and apply them as appropriate during all phases of operation and maintenance. IN ALL CASES, BE PRUDENT.

Keep away from live circuits

Do not replace components or make adjustments inside equipment with power turned on. To avoid injuries, always remove power and discharge and ground a circuit before touching it. When making electrical connections, the services of a qualified electrician must be employed. Contact with live electrical circuits can cause serious personal injury or death. Be sure no circuits are energized during installation, connection or removal of any electrical cables or lines.

Examine the cabling and housings regularly for damage. Machines with damaged wiring or control systems must be disconnected from the power line immediately and must not be operated again until they have been repaired by qualified personnel.

Wear protective clothing

Wear protective clothing (gloves, apron, goggles, etc.) approved for the materials and tools being used.

Provide adequate ventilation

Provide ventilation to remove heat and noxious odors and to prevent the accumulation of asphyxiates such as nitrogen gas.

Avoid hot surfaces

Keep hands away from hot surfaces and materials. Contact with hot surfaces or materials can cause blistering and third degree burns. Wear approved, clean, thermally insulated gloves when handling these components. Should injury occur; immerse injured area in cold water and get immediate medical attention.

Avoid tipping the stand

After assembling the stand, install the RCU on the stand before installing the RSU. Installing the RSU to the stand before installing the RCU can make the stand unstable. Take care to follow this assembly order unless the stand has been properly secured.



The optional stand has flexible configuration capability. It is possible to configure it in such a way that it is unstable. Take care not to use it this way unless it is properly secured.

Take care to avoid tipping the stand due to an impact (from something/somebody running into the stand), or from a collision (a forklift or crane load, etc being driven into it), or while moving the stand. Do not climb on or support yourself with this stand. Use signs or barriers as appropriate.

When moving the stand around on its castors, there is danger that it could suddenly stop sharply when it rolls over uneven floor surfaces or other obstructions (screws, granules), and could tip. Appropriate caution must therefore be taken - roll the unit slowly!

The castors on the base of the stand must be examined regularly for damage and secure fit, damaged castors are to be replaced immediately.

1.2 Obligation of the operator to exercise due care

The Dynisco component conforms to the state of the art technology and ensures a maximum of safety. In practical operation, this safety can, however, be achieved only if all necessary measures are taken. The obligation of the plant operator to exercise due care includes planning these measures and supervising their execution.

Especially, the operator has to ensure that:

The Dynisco component will be used only in accordance with the intended purpose.

The Dynisco component will be operated in a flawless, functionally efficient condition and that, in particular, the functional efficiency of the safety devices will be checked at regular intervals.

The necessary personal protective equipment for the operating, maintenance, and service personnel will be available and used by them.

The operating instructions are always available completely and fully legibly at the installation location of the Dynisco component. It must be guaranteed that all persons who have to work with the Dynisco component can consult the operating instructions at any time.

Only sufficiently qualified and authorized personnel will operate, maintain, and repair the Dynisco component.

Instructions concerning all relevant questions of industrial safety and environmental protection will regularly be given to the personnel, and that these persons will know and understand the operating instructions and, particularly, the safety instructions contained.

All safety and warning instructions, attached to the Dynisco component, will not be removed and will remain fully legible.

The service instructions in accordance with the industrial safety legislation and the ordinance for the use of work materials will have to be made available as a supplement to the operating instructions.

1.3 Obligation of the personnel to exercise due care

The ViscoIndicator melt rheometer may only be operated by persons trained, instructed and authorized to do so. These persons must know the operating instructions and act accordingly. The respective competences of the staff must be clearly determined.

The ViscoIndicator should only be operated by qualified persons.

Especially, the staff has to ensure that:

Inexperienced operating personnel should only work with the Dynisco component while directly monitored by an experienced person.

All persons operating and maintaining the Dynisco component must read the operating instructions and confirm by their signature that they understood the operating instructions.

Unauthorized persons do not stay in the working area of the Dynisco component.

The working area will be left only if all movable parts have come to a stop after having switched off the Dynisco component.

In addition to the operating instructions, the service instructions within the meaning of the industrial safety legislation and the ordinance for the use of work materials will be observed.

In case of malfunctions, the operator or the supervisors will be informed.

The necessary personal protective equipment for the operating, maintenance, and service personnel will be used.



2 How to use this manual

Read this manual (Dynisco part number 974175) to understand how to operate the ViscoIndicator.

For information on assembly, installation & service of the ViscoIndicator, please see the Assembly, Installation & Service manual (Dynisco part number 975389).

For further information as well as technical support, please contact Dynisco.

3 Contact Us

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3.1 About Us

Dynisco has been a global leader providing innovative solutions for materials testing and extrusion-control monitoring for the plastics industry for decades. Among our early pioneering achievements was the first transducer to successfully measure melt pressure during the extrusion process.

Today, it is more vital than ever for us to offer our customers leading-edge technology, manufactured to ISO 9000 quality standards, so they can achieve maximum manufacturing efficiency and productivity.

4 Abbreviations and System Description

Abbreviations

MFR - Melt Flow Rate
IV - Intrinsic Viscosity
VI - ViscoIndicator system
HMI - Human Machine Interface
RSU - Rheometer Sensing Unit
RCU - Rheometer Control Unit
PIV - Process Isolation Valve

System Description

The ViscoIndicator can provide continuous measurement of melt flow rate, apparent viscosity, or intrinsic viscosity directly on an extruder.

Process Connection

Material is sampled through a connection port in the extruder and travels up through one (Aux1) or two (Aux1 & Aux2) heated process connection tubes into the PIV and then into the RSU.

PIV

A heated valve positioned between the process connection and the RSU allows the process flow to be isolated from the RSU if required.

RSU

Inside the RSU, a metering pump controls the rate of polymer flow through a heated flow block while measurements are taken to determine rheological properties before the polymer passes thru a capillary and exits to the plant floor/collection bin (material is not returned to the process stream).

RCU

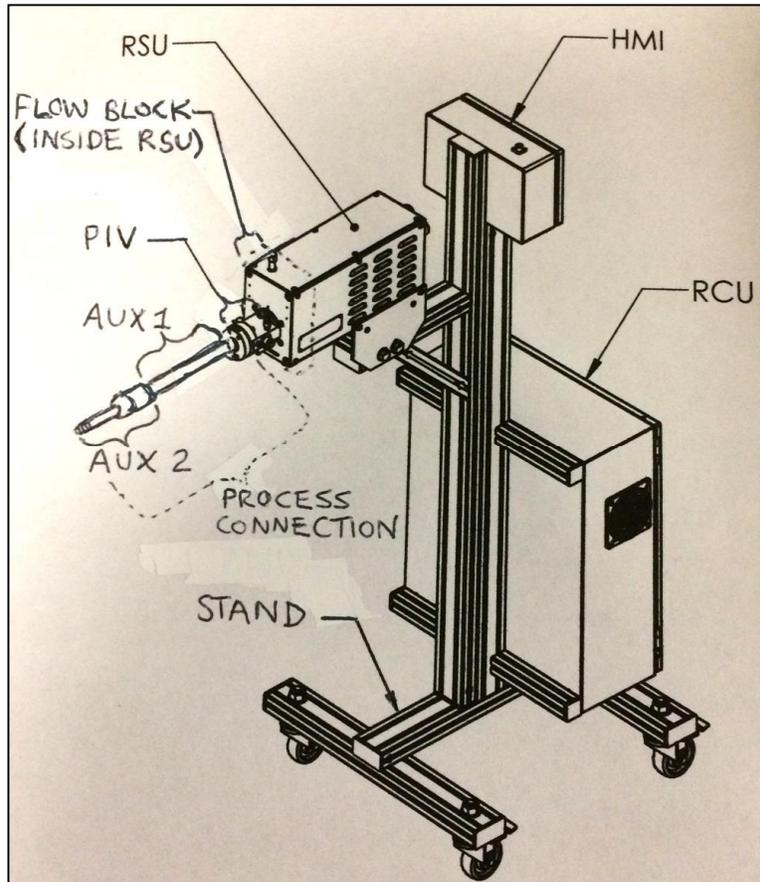
The RCU is an electrical cabinet containing components that provides power and control to the RSU.

HMI

The HMI contains a small computer that is the user interface to the VI, providing control and display of machine and recipe variables and rheological information.

STAND

The stand is an optional item that can be used to mechanically support the RSU, RCU, and HMI.



General VI System Outline

5 VI Start Guide

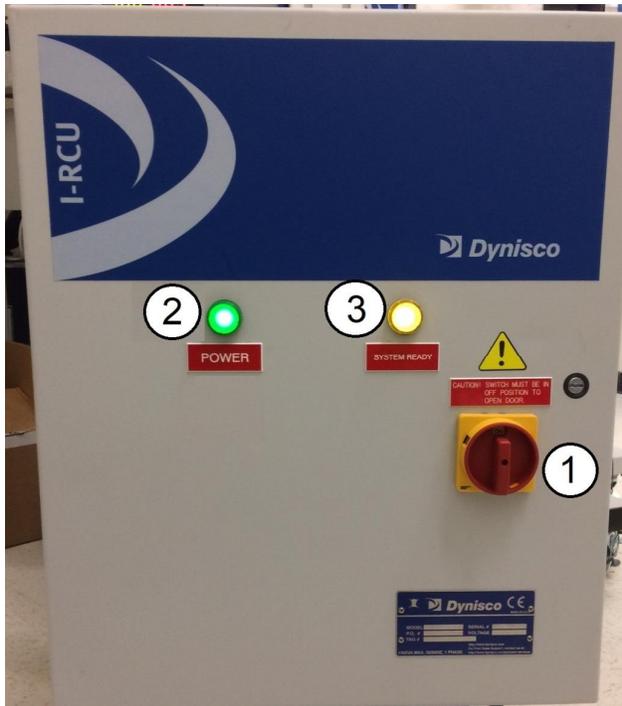
Note: Details for each step below can be found in later sections of this manual.

1. **Turn the VI on**
2. **Confirm or change Machine Values**
Settings --> Machine
3. **Confirm or change Rule Settings**
Settings --> Rules
Settings --> Overflow Protection
4. **Confirm or change Recipe Values**
Recipes --> Edit
5. **Run Recipe**
Recipes --> Run
6. **Turn on Heat and observe each temp zone is rising**
PV --> Heat
7. **Wait for system to come to recipe temperature set points, then wait 10 minutes**
8. **Calibrate Pressure Transmitter if zero value not within 1psi of zero**
Calibration --> Pressure
9. **If motor has not run for several days:**
 - create a speed mode recipe with 1/4 the motor speed you would normally run, and with rule 10 pressure set to 0 psi.
 - run for 3-4 minutes, observing the pressure
 - PV-->Motor
 - if pressure builds up then shut off the motor and run the normal recipe
 - if pressure doesn't build up, shut off motor and read troubleshooting section
10. **If motor was run within the last few days:**
 - run standard recipe and observe motor speed and pressure
 - PV-->Motor
 - if pressure does not begin to build up in 3-4 minutes, shut off motor and follow step 9.

5.1 One time/infrequent steps

1. If you purchased a cloud account, register at iot.dynisco.com
2. Setup Manager Account pass code
3. Configure Wi-Fi
4. Confirm PIV is open (The PIV valve must be in the open position during VI operation)
5. changing rule settings
6. insulate process connection and PIV

7 Turning the ViscoIndicator ON/OFF



1. **RCU Power Knob** - turn the VI on by turning the large red knob on the RCU door 90deg clockwise to the ON position.
2. **Green Power light** - should illuminate once the RCU power knob is turned to the ON. This light indicates that the RCU is receiving power.
3. **Yellow System Ready light** - should illuminate shortly after the green power light. This light indicates that the RCU is functioning correctly.
4. **HMI display screen** - should also turn on and begin booting up shortly after the RCU power knob is turned ON. It may take several minutes for the HMI to fully power up and get to the PV software screen (see following sections describing software function).

Turning the ViscoIndicator OFF

The ViscoIndicator can be turned off by turning the RCU Power Knob back to the OFF position.

8 Operating the VI using the HMI Software

The VI is controlled with software via a tablet-sized touch screen interface (HMI). How to operate the VI software is described in the following sections.

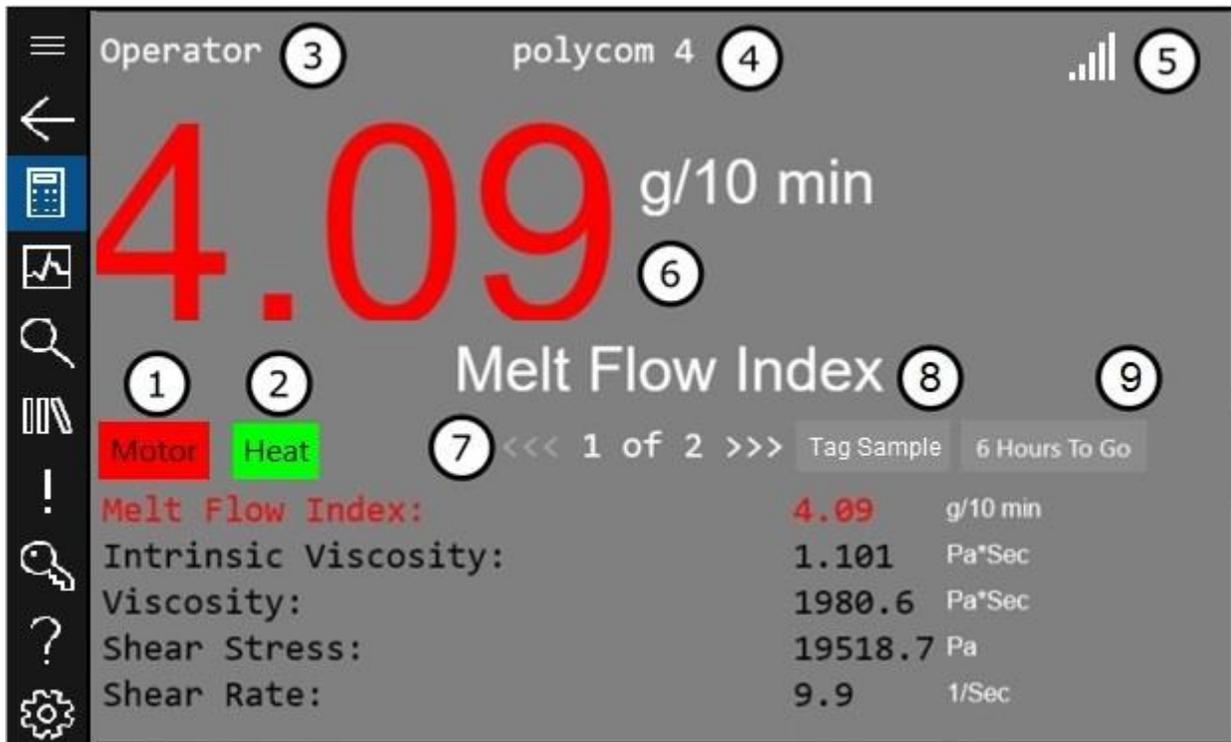


The VI software functions are broken down into eight main software interface screens:

1. **PV Screen** - Shows measured and calculated variables, controls motor & heat, select plot display variable
2. **Plot display** ó Graphically displays selected variable
3. **Machine state** ó Pictorial overview of machine set points and current values
4. **Recipes** ó Material specific parameters for configuring tests
5. **Alarms / Events** ó History of alarms and variable deviations
6. **Permissions** ó Allows different levels of machine access depending on operator level
7. **Help** ó VI Help information
8. **Settings** ó Machine specific settings

9 PV Screen

The PV screen is the primary screen used to both view and control the state of the VI through measured and calculated variables.



The sections of the screen are described as follows:

1. **Motor button** 6 turns the motor ON/OFF, and displays the motor state by button color and text:
 - red - denotes motor is off
 - yellow - denotes motor is running, but at a speed outside the limits in the recipe
 - green - denotes motor is running, and at a speed within the limits in the recipe
 - "wait" text - is displayed if a user attempts to restart the motor within 45 seconds of the motor being last on. This is a safety feature to protect the motor from being turned on and off rapidly, which could damage the motor. Once the text changes back to "motor" the motor can be started again.

NOTE: The motor cannot be turned on/will stop running if the temperature of any temperature zone is not with the temperature limits as defined in the recipe.

2. **Heat button** 6 turns heat ON/OFF for all temp zones and displays the heat state by button color:
 - red - denotes heat is off
 - yellow 6 denotes heat is on, but at least one temp zone is outside the limits in the recipe.
 - green - denotes heat is on, and all temp zones are within the limits in the recipe



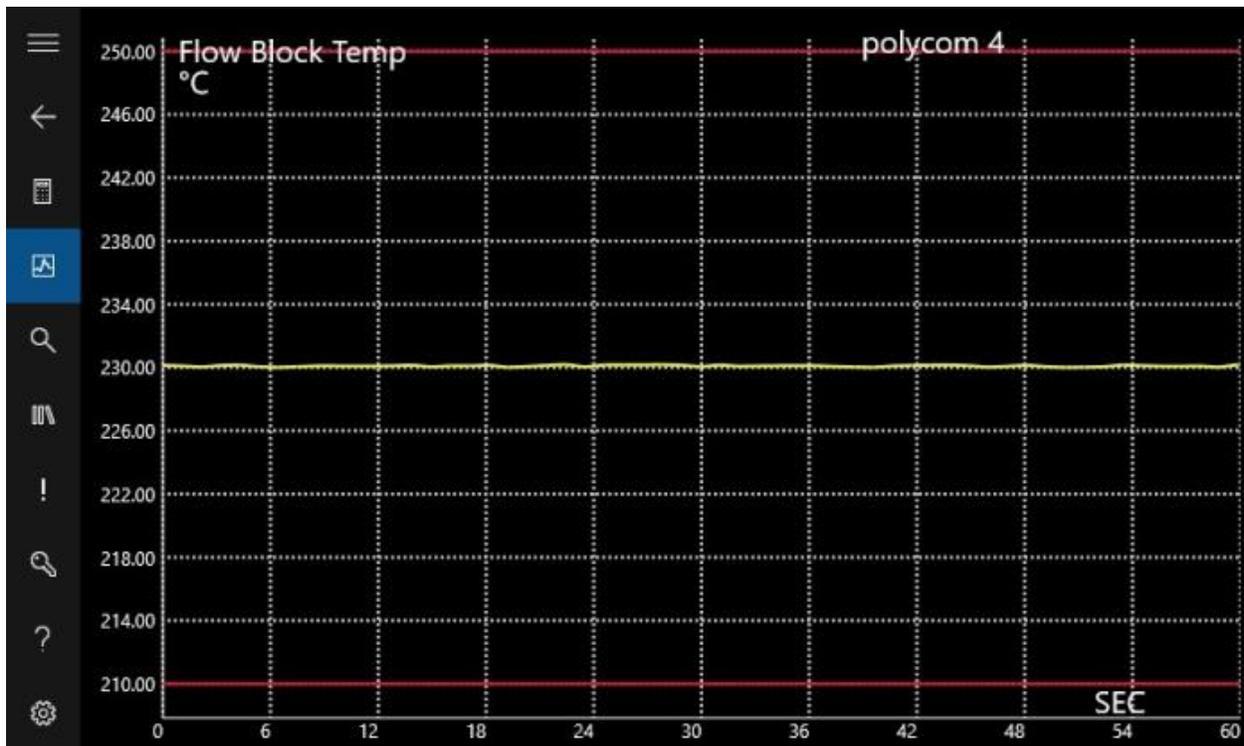
3. **Machine access level** ó Displays current access level of machine. There are three access levels:
 - Operator - No login Required. No access to Machine State, Recipes, or Settings screens
 - Manager -4 digit login code required - Access to all screens except the field service screen under settings, and access to all functions except field service specific functions
 - Field Service - 4 digit login code required - Used by Dynisco field service personnel only.
4. **Current Recipe** ó Displays name of recipe that is currently running. A recipe consists of material specific parameters that are followed (temperatures, motor speed, etc.) while running a test. A different recipe can be selected and run from the recipe screen when changing to a different material in the extruder.
5. **WIFI connection status** - Displays the current WIFI state of the HMI. If graduated bars are displayed the HMI is connected to a WIFI network. If a circle with a slash is displayed the HMI is not connected to a WIFI network. More details about the WIFI connection can be found under the Settings screen.
6. **Focus variable** ó The variable shown in large font in the upper left section of the screen. To change the focus variable, select another variable by touching it in the bottom half of the screen. The current focus variable is also displayed on the plot display screen.
7. **Variable list toggle** ó Press either <<< or >>> to switch between two sets of variables on the bottom half of the screen:

<u>List 1</u>	<u>List 2</u>
Melt Flow Index	Flow Block Temperature
Intrinsic Viscosity	PIV Temperature
Viscosity	Auxiliary 1 Temperature
Shear Stress	Auxiliary 2 Temperature
Shear Rate	Driving Pressure
	Pump Speed

8. **Tag Sample button** - When this button is touched a "snapshot" is taken of the process conditions and this data is sent to the cloud (often used for correlation with lab equipment).
9. **Overflow protection button** ó When enabled, a countdown begins in the overflow protection button location when the motor is turned ON. The timer will pause if the motor is turned OFF. If the motor is again turned on, the timer will reset. If the timer reaches zero while the motor is running the motor will turn off. The VI operator should periodically clear any extrudate building up under the RSU and then touch the overflow protection button before the time reaches zero, resetting the countdown. The countdown can be disabled under the Settings --> Rules screen by turning rules 4 & 5 off, and it can also be disabled and the time limit changed under the Settings -> Overflow protection screen.

10 Plot Screen

The plot screen gives a graphical representation of the current focus variable on the PV screen.



X axis scale

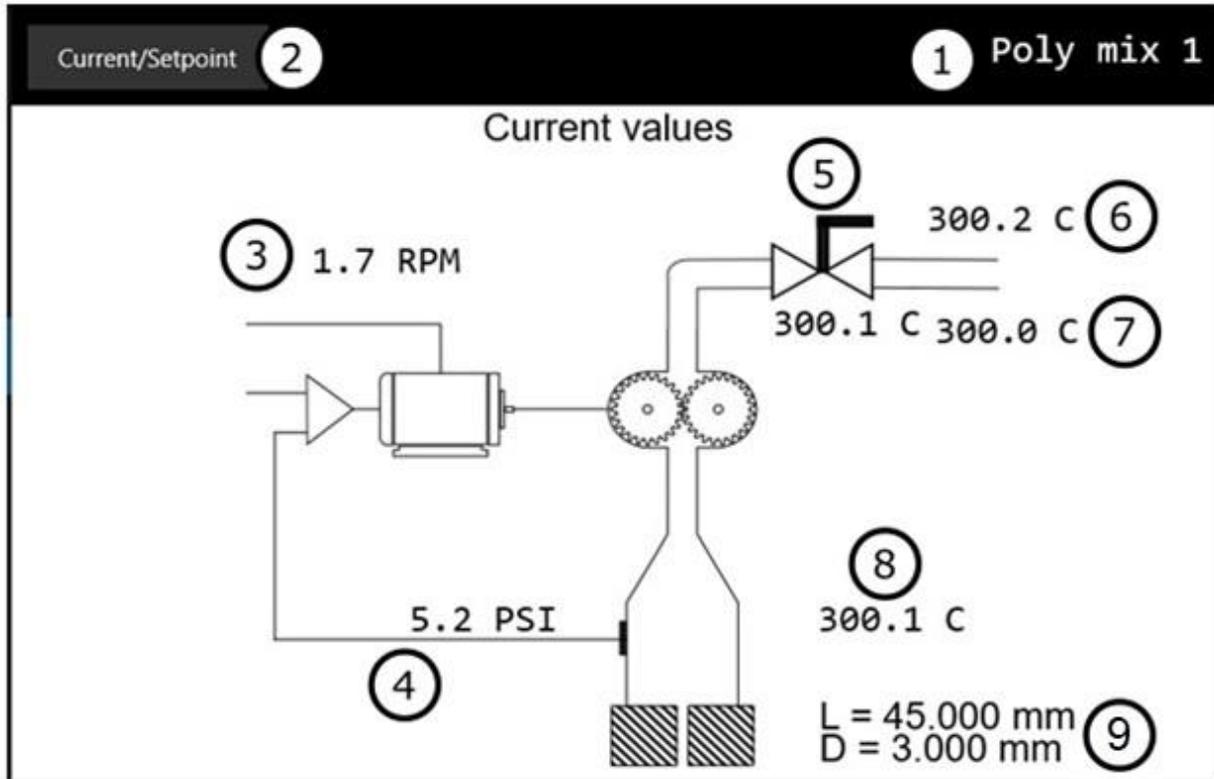
By default, the graph shows data taken over the last minute. Touching the screen will change the time duration from 60 seconds, to 60 minutes, to 60 hours, then back to 60 seconds.

Y axis scale

The lower and upper values displayed on the Y axis are fixed and are shown as red lines. They are equal to the lower and upper limits in the current recipe for the plotted variable.

11 Machine State

This screen is a visual representation of the system with current values or set points of measured parameters displayed. The variable set points can be seen without having to go to the recipe screen. The current set points can also be changed from this screen.



1- Currently running recipe name

2- **Current/Setpoint button** - This button toggles the display between currently measured values and current set points. A set point can be changed from either mode by touching the value to bring up a numeric keypad.

NOTE: changing a set point through the Machine state screen does not modify the set point in the saved recipe.

3- Current motor speed / speed set point

NOTE: motor speed set point only controls the motor speed in speed control mode

4- Current pressure / pressure set point

NOTE: pressure set point only controls the pressure in pressure control mode

5- PIV temperature / set point



6- **Auxiliary 1 temperature / set point** (if Auxiliary 1 zone is enabled)

7- **Auxiliary 2 temperature / set point** (if Auxiliary 2 zone is enabled)

8- **Flow block temperature / set point**

9- **Die characteristics (Length and Inner Diameter)**

NOTE: The Length and inner diameter of the die can only be changed in the machine settings

12 Recipes Screen

Recipes are used to configure some of the settings required to measure the viscosity, MFR, etc. of a particular material. The remainder of the settings required are configured from the Settings screen. Each time a different recipe is run, different temperatures, test types and material parameters are loaded.

Recipe management



- 1- **Recipe List** 1 This area lists all available recipes. You may need to scroll down to see all recipes.
- 2- **Currently Recipe** 2 Displays the name of the recipe that is currently running. A recipe consists of material specific parameters that are needed for control/display of the VI when running a test.
- 3- **Selected Recipe** - Touching a recipe in the recipe list selects that recipe (recipe will be highlighted in blue). After selecting a recipe, press one of the buttons on the right side of the screen (buttons 4 thru 7 described below) to perform that action.
- 4- **Run Recipe button** 4 Makes the selected recipe the current recipe (updates the current parameters of the VI)
- 5- **New Recipe button**- Makes a copy of the selected recipe. The new recipe name will have the same name as the selected recipe except several random digits will be appended to the name.



- 6- **Edit Recipe button** ó Opens the selected recipe for editing.
- 7- **Delete Recipe button** ó Deletes the selected recipe. There is a confirmation screen to verify the user wants to delete the recipe.
NOTE: It is not allowed to delete the current recipe.
- 8- **Export Recipes button** ó If a USB memory stick is attached to the HMI housing, pressing this button will export all recipes to the memory stick.
- 9- **Import Recipes button** ó Imports recipes from a memory stick into the ViscoIndicator's memory.

12.1 Edit recipe screen

After selecting a recipe then pressing edit, the Edit recipe screen will appear. The edit recipe screen lists all the recipe variables available for editing, along with their current values. A value can be changed by touching the box containing the value (an editing keyboard will then pop up).

☰	Recipe Name	190 - Speed	
←	Test Mode	Speed	▼
☰	Melt Density	0.8	pm
📈	MFI Low Limit	0	g/10 min
🔍	MFI High Limit	10	g/10 min
📊	Correlation Factor	1	
!	Reference Temperature	190.00	C
🔑	Activation Energy	0	J/mol
?	Flow Block Temperature Setpoint	190.00	C
⚙️	Flow Block Temperature Low Limit	180.00	C
	Flow Block Temperature High Limit		

Notes for all low and high limit values

- Values on the PV screen will be displayed in red text if outside the limits
- The Graph screen Y axis limits equal the recipe limits

Notes for all low and high temp limit values

- Low temp limits must be below set points but at a high enough temperature so the polymer is molten and flowing freely. Typically set to 5deg C below set point.
- Set high temp limits must be above set points but at a low enough temperature so the polymer will not degrade significantly. Typically set to 5 deg C above set point.
- Rules 13 & 14 - If any temperature zone value is outside the limits, the motor will shut off/cannot be turned on

Notes for all temperature set points

- typically set to the polymer temperature in the extruder near the VI process connection location
- Temperature set points control the temperature of the polymer during VI rheological measurements and therefore can affect calculated IV/MFR values.

Descriptions of each recipe variable

Recipe name ó Name of recipe being edited. Try to enter a name that is descriptive of the test and material being run. A suggested format is temperature set point - test mode - primary calculated variable, for example: "285C - speed - IV"

Test mode ó The VI can be run in two different modes, Speed and Pressure. Speed mode is used to measure viscosity while pressure mode is used to measure melt flow rate.

- Speed mode - holds the motor speed constant and allows the pressure to vary
- Pressure mode - holds the pressure constant and allows the motor speed to vary

Melt density ó Melt density of the material being sampled by the VI for rheological measurement. Used in calculations of viscosity and melt flow rate.

MFI low limit ó Lower acceptable limit of melt index.

MFI high limit - Highest acceptable limit of melt index.

Correlation factor ó A multiplicative factor that can change the MFR value calculated by the VI. It can be used to improve correlation between the ViscoIndicator and laboratory equipment.

- If the value = 1 the correlation factor has no effect
- In the form: $VI_MFR_{corrected} = VI_MFR_{raw} * \text{Correlation factor}$

Reference temperature ó Laboratory equipment polymer test temperature (typically ASTM standard specified temperature)

- When the laboratory test temperature does not match the extruder temperature, activation energy can be used to compensate for the difference (see activation energy below)
- Default value equal 190C for typical ASTM MFR test

Activation energy - Please see "Using Activation Energy with the ViscoIndicator" section later in this guide for a description on how activation energy is used in to correct for differences in melt flow and viscosity due to temperature differences between the ViscoIndicator and laboratory equipment.

- If the value = 0 activation energy has no effect

Flow block temperature set point ó Temperature set point of the flow block (inside the RSU).

The flowblock is inside the RSU and is the location where the VI pressure, temperature, and motor speed measurements are taken that are used to calculate viscosity/MFR.

Flow block temperature low limit - Lower acceptable limit of flow block temperature.

Flow block temperature high limit - Higher acceptable limit of flow block temperature.

PIV temperature set point ó Temperature set point of the process isolation valve (PIV)

The PIV is located in-between the process connection and the RSU. It can be used to isolate the process flow from the RSU. The PIV valve must be in the open position during VI operation.

PIV temperature low limit - Lower acceptable limit of PIV temperature

PIV temperature high limit - Higher acceptable limit of PIV temperature

Aux 1 temperature set point ó Set point of Auxiliary 1 temperature (optional zone)

The Aux 1 is the auxiliary heat zone adjacent to the PIV. It typically heats a metal tube used to transfer material from the extruder to the RSU/PIV when space constraints do not allow the RSU/PIV to be positioned up against the extruder.

Aux 1 temperature low limit - Lower acceptable limit of Aux 1 temperature.

Aux 1 temperature high limit - Higher acceptable limit of Aux 1 temperature.

Aux 2 temperature set point ó Set point of Auxiliary 2 temperature (optional zone)

The Aux 2 is the auxiliary heat zone adjacent to the Aux 1 zone, closest the extruder. It typically heats a metal tube that is threaded directly into the extruder port, sampling material.

Aux 2 temperature low limit - Lower acceptable limit of Aux 2 temperature.

Aux 2 temperature high limit - Higher acceptable limit of Aux 2 temperature.

Speed set point ó Set point of motor speed in RPM (used in speed mode when measuring viscosity)

Speed low limit - Lower acceptable limit of motor speed.

Speed high limit - Higher acceptable limit of motor speed.

The motor will continue to run if this speed is reached. There is a fixed factory set 80 RPM limit (displayed under Machine -->settings screen)

Load ó LMI test ASTM load in kg (used in pressure mode when measuring MFR).

Any value entered in this field is automatically calculated as a pressure and entered into the pressure set point field of the recipe.

Pressure set point ó Pressure that will be maintained at the entrance to the die (used in pressure mode when measuring MFR)

Any value entered in this field is automatically calculated as a load and entered into the Load field of the recipe.

Pressure low limit - Lower acceptable limit of pump pressure.

Pressure high limit - Higher acceptable limit of pump pressure.

Rule 12 - If this limit is reached the motor will turn off

IV coefficient - Value of the IV coefficient term used in IV calculation (Default value = 0.2157)

IV exponent - Value of IV exponent term used in IV calculation. (Default value = 0.2147)



IV Set point - has no effect in current version of software (ignore)

IV low limit - Lower acceptable limit of intrinsic viscosity.

IV high limit - Higher acceptable limit of intrinsic viscosity.

Rule 10 pressure - Minimum delta pressure that the pump needs to make and maintain for the motor to stay on. The delta pressure must be achieved before Rule 10 Delta time occurs after first turning the motor on. The delta pressure must be maintained the entire time the motor is on.

Rule 10 Delta Time - Time limit to achieve rule 10 delta pressure after first turning the motor on.

Rule 10 Example: If rule 10 pressure = 10psi, if rule 10 delta time = 1 minute, if current system pressure = 2psi with motor off:

The motor will shut off if the VI doesn't reach at least 12psi within 1 minute of turning the motor on. If while the motor is on the VI pressure falls below 12psi for more than 1 minute the motor will shut off.

See troubleshooting section if rule 10 occurs repeatedly making it difficult to run the VI.

13 Alarms / Events

This screen records events and alarms relating to measured or calculated values. If a value falls outside a limit, an entry is added to this screen.

An entry on this screen usually indicates a problem that needs to be addressed before restarting the VI. Most entries are related to rule violations (see Rules screen section)

The screenshot shows the 'Events' screen with a scrollable list of events. The events are as follows:

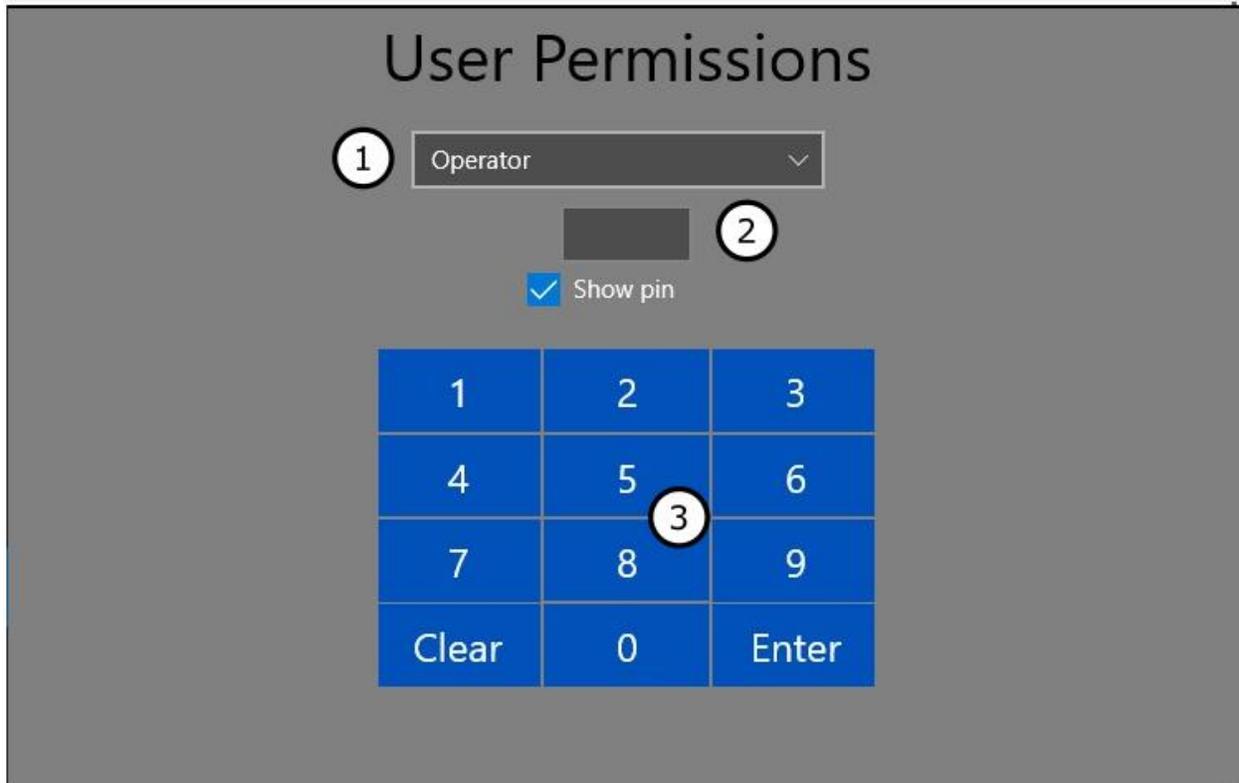
- Flow Block Temperature 305.766 5/17/2017 2:01:52 PM Out of specification
- Flow Block Temperature 304.333 5/17/2017 2:01:53 PM In specification
- Flow Block Temperature 305.343 5/17/2017 2:03:39 PM Out of specification
- Flow Block Temperature 300.1051 5/17/2017 2:03:41 PM In specification
- Flow Block Temperature 305.343 5/17/2017 2:05:25 PM Out of specification
- Flow Block Temperature 300.1051 5/17/2017 2:05:28 PM In specification
- Flow Block Temperature 305.343 5/17/2017 2:07:12 PM Out of specification
- Flow Block Temperature 300.1051 5/17/2017 2:07:14 PM In specification

At the bottom of the screen, there are two buttons: 'Clear' (labeled 2) and 'Export Events' (labeled 3).

- 1- **Events List** - Scrollable list of past events since last time list was cleared (the most recent events are at the bottom of the screen)
- 2- **Clear button** - current list of events
- 3- **Exports events button** - to memory stick connected to HMI enclosure

14 User Permissions

The user permissions screen is used to change access to the ViscoIndicator's functions. There are three access levels - Operator, Manager and Field Service. Various functions are only accessible to manager or field service access levels. The VI system will automatically logout of manager level access after 60 minutes if the display is not touched

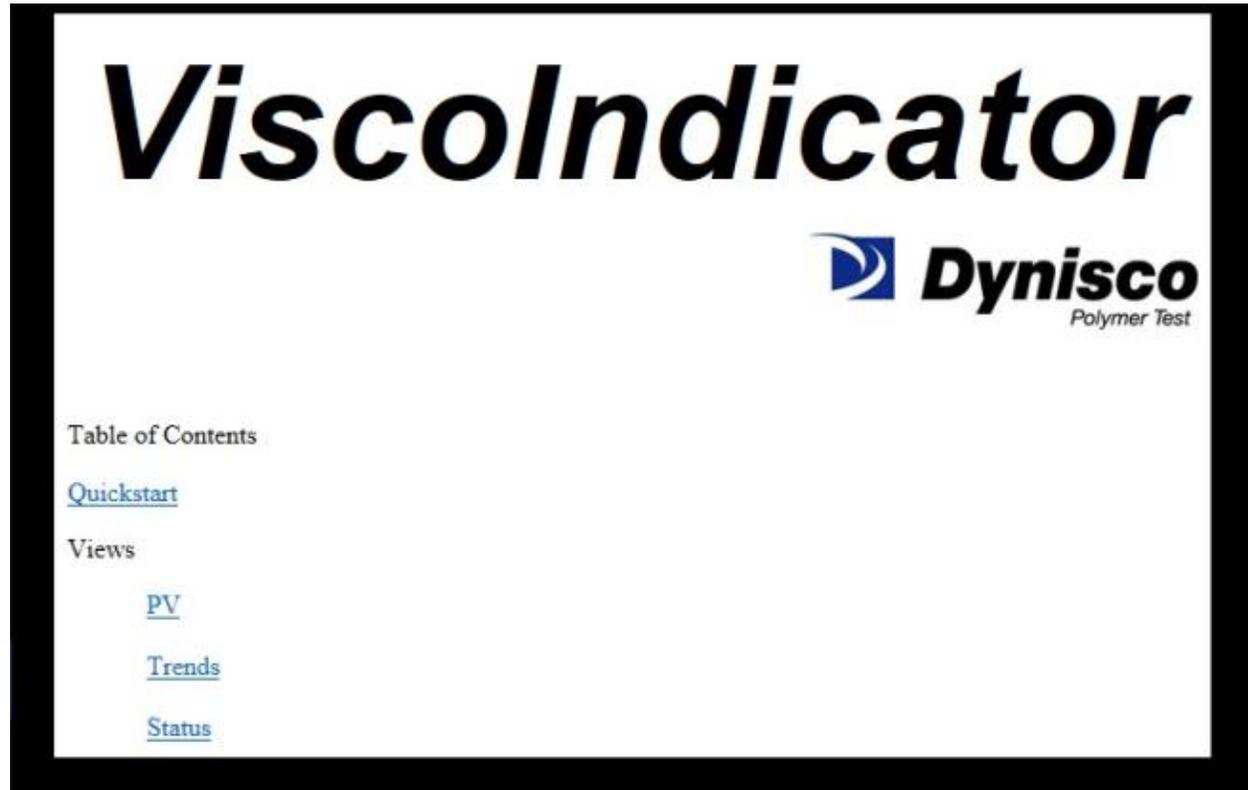


1. **Access level dropdown list** ó Use this drop down box to select the appropriate access level
2. **Pin display box** ó A 4 digit PIN must be entered at levels above operator. If a pin hasn't been created for the manager level, enter a 4 digit pin number using the keypad and press enter. The system will then ask you if you want to save this number going forward as the manager login number.
3. **Keypad** – Used for entering PIN.
4. **Logout button** - (button not shown in image above, is displayed beside the Access level drop down list when logged in as a manager) - touch this button to logout of manager level.

- Operator - No login Required. No access to Machine State, Recipes, or Settings screens
- Manager -4 digit login code required - Access to all screens except the Settings--> field service screen, and access to all functions except field service specific functions
- Field Service - 4 digit login code required - Used by Dynisco field service personnel only

15 [Help](#)

The help screen contains information on operation of the ViscoIndicator in a HTML format. Please refer to the Operation manual, not the Help screen, for the most current information on operating the VI.



ViscoIndicator



Polymer Test

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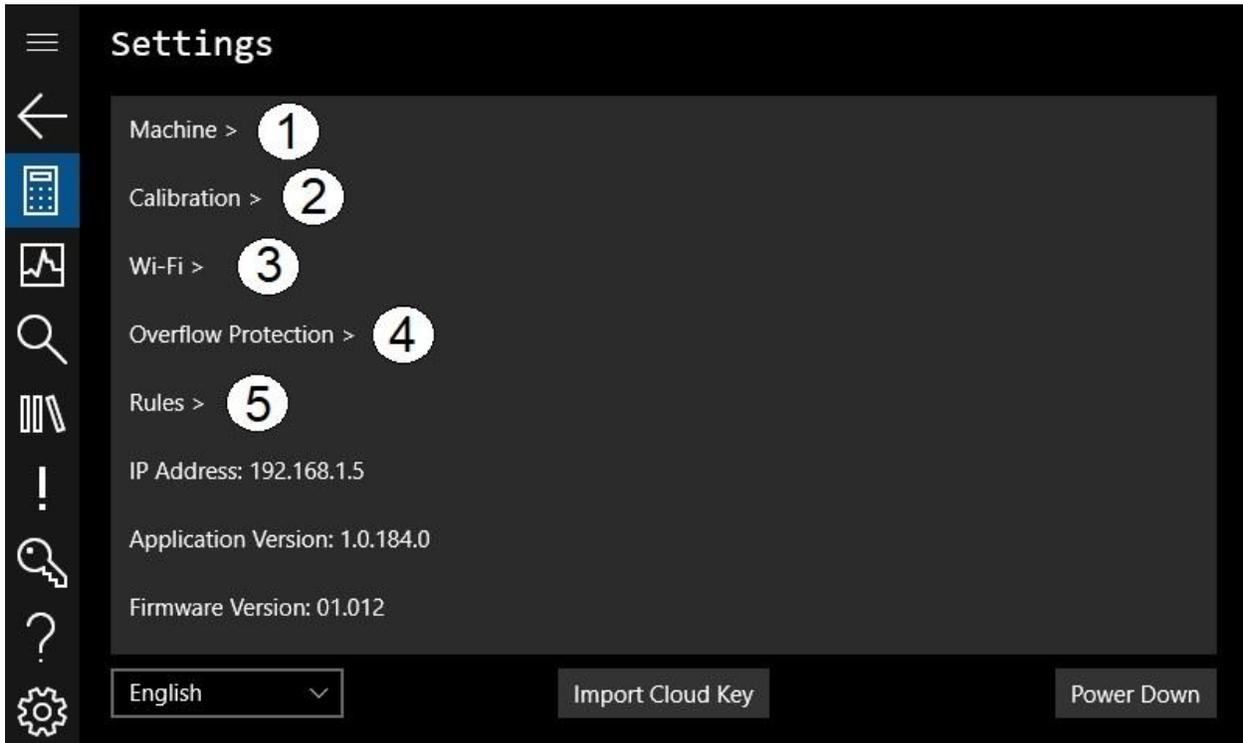
[Quickstart](#)

Views

- [PV](#)
- [Trends](#)
- [Status](#)

16 Settings screen

The Settings screen can be used to access several additional screens to modify machine specific settings. Parameters should only be modified by trained service personnel. The settings screen also displays several machine specific variables.



Additional screens accessible through the settings screen

1. **Machine Screen** ó Main screen to enter machine specific parameters that don't vary by recipe.
2. **Calibration Screen** ó Access to and pressure calibration and Rules, as well as temperature calibration and Field Service screens only used by Dynisco Field Service personnel
3. **WIFI** ó Screen for configuring the VI WIFI/Ethernet connection required for cloud data
4. **Overflow protection** ó Screen for setting overflow protection parameters (rules 4 & 5)
5. **Rules** ó Screen for turning the VI system rules on/off

Language Selection Dropdown list - At the bottom left corner of the screen a drop down menu is located where the displayed language of the HMI can be changed.

Machine specific variables listed on the Settings screen

IP address of the VI HMI

Application Version (software version)

Firmware Version

Hours Run: (Hours the VI has been on)

Cloud Key Id (Unique VI machine cloud data identification number)

17 Machine Screen

This is the main screen to enter machine specific parameters that don't vary by recipe. Touch the text box of any listed variable to bring up a keyboard to change the value. NOTE - only values inside a text box can be changed (some machine settings are fixed at the factory)

☰	Company Name	Dynisco
←	Machine Name	ViscoIndicator
☰	Serial Number	1
📈	Model	1
🔍	Units of Length	mm
📏	Units of Temperature	C
⚠️	Units of Viscosity	PaS
🔑	Auxiliary 1 zone on/off	On
🔑	Auxiliary 2 zone on/off	Off
?	Units of Pressure	PSI
⚙️	Max Temperature	350.00

Company Name ó Owner of the ViscoIndicator

Machine Name - Descriptive name of machine

Serial Number ó ViscoIndicator Serial number

Model ó Model number of ViscoIndicator

Units of Length ó Units for capillary dimensions

Units of Temperature ó Units for temperature zones

Units of Viscosity ó Units for viscosity measurements

Auxiliary 1 Zone on/off ó Turns auxiliary 1 temperature zone heater and RTD on/off

Auxiliary 2 Zone on/off ó Turns auxiliary 2 temperature zone heater and RTD on/off

Units of Pressure ó Units for driving pressure (pressure transmitter inside the RSU)

Max Temperature ó VI maximum temperature limit (Fixed Factory set value = 350C)

Max Motor Speed ó Maximum allowed speed of pump (Fixed Factory set value = 80 RPM)

Pump displacement ó Displacement of one revolution of gear pump (Factory set)

Capillary Length ó Length of capillary die

Capillary Diameter ó Inner Diameter of capillary die

Pressure Sensor Range ó Range of pressure sensor installed in RSU (Factory set)

Note: if pressure exceeds this value during operation motor will shut off

Pressure Zero Trim - has no effect in current version of software (ignore)

Pressure Span Trim ó has no effect in current version of software (ignore)

FB PID P, I, D -PID parameters for flow block temperature control (Factory Set)

PIV PID P, I, D - PID parameters for PIV temperature control (Factory Set)

Aux1 PID P, I, D - PID parameters for auxiliary 1 zone temperature control (Factory Set)

Aux2 PID P, I, D - PID parameters for auxiliary 2 zone temperature control (Factory Set)

Speed PID P, I, D ó has no effect in current version of software (ignore)

Pressure PID P, I, D - PID parameters for driving pressure control (Factory Set)

Simulation Mode ó Reads data from internal file instead of taking active measurements

Leave in OFF position

Calibration Mode ó Displays raw sensor readings without scaling

Leave in OFF position

18 Calibration Screens

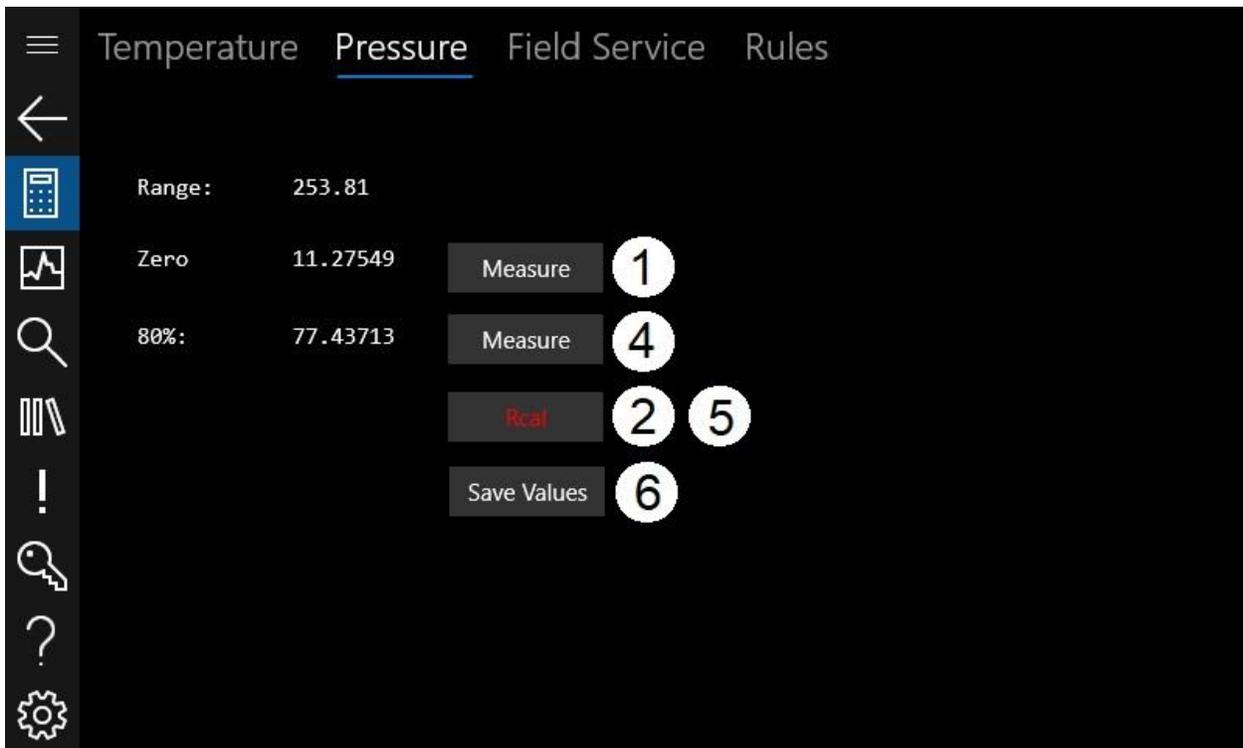
This screen gives access to the Pressure calibration and the Rules screens, as well as Temperature calibration and Field Service screens, which are used only by Dynisco Field Service Personnel.

To access the Pressure or Rules screens, touch the text at the top of the screen



19 Pressure Screen (calibrating the Pressure transmitter)

This screen gives access to calibrate (zero and 80% - Rcal) the pressure transmitter in the RSU.



When to calibrate (zero & 80% Rcal) the pressure transmitter

The pressure transmitter can be calibrated after the VI has been at the flow block temperature set point for at least 10 minutes with the motor off, and the pressure hasn't changed by more than 1 psi in 10 minutes. It is generally on necessary to calibrate the pressure transmitter if the value is more than 1psi away from zero.

To calibrate the Pressure transmitter:

1. Press the zero measure button (the number beside the zero text should change)
2. Press the red text Rcal button (the Rcal button text should change from red to green)
 - Rcal simulates 80% of full scale pressure and is created in the pressure transmitter circuitry.
 - Rcal is ON when the Rcal button text is green.
3. Wait 5 seconds
4. Press the 80% measure button (the number beside the 80% text should change, it should be several times the value of the zero number)
5. Press the green text Rcal button again (the button text color should change back to red)
6. Press the Save Values button (this must be done or the measured values will be lost)



20 Temperature and Field Service Screens

These screens give access to temperature calibration and Field Service functions. Temperature calibration and Field Service should only be carried out by Dynisco field service personnel.

21 Rules Screen

See separate rules section later in this manual

22 Wi-Fi Screen

Use this screen to connect to an available Wi-Fi network to allow VI cloud access.



Press the scan available Wi-Fi networks button to find available Wi-Fi networks.

To connect to a Wi-Fi network

1. Scroll up or down to select the correct network (when selected, the network will be highlighted in blue).
2. When prompted, enter the security key (password) for the network by touching inside the security key text box. Select the "Auto reconnect?" check box if this will be the network the VI will normally be connecting to
3. Touch the Connect button. If successful, the VI will state a successful connection was made.

Also in the upper right hand corner of the PV screen, graduated bars are displayed if the HMI is connected to a WIFI network. If a circle with a slash is displayed the HMI is not connected to a WIFI network.

VI Cloud background information

The VI is an industrial machine that connects a computing device and embedded sensors. The VI is able to efficiently collect and send sensor and rheological data. It utilizes Microsoft Azure services to collect and archive data in the cloud platform (across a global network of Microsoft-managed datacenters).



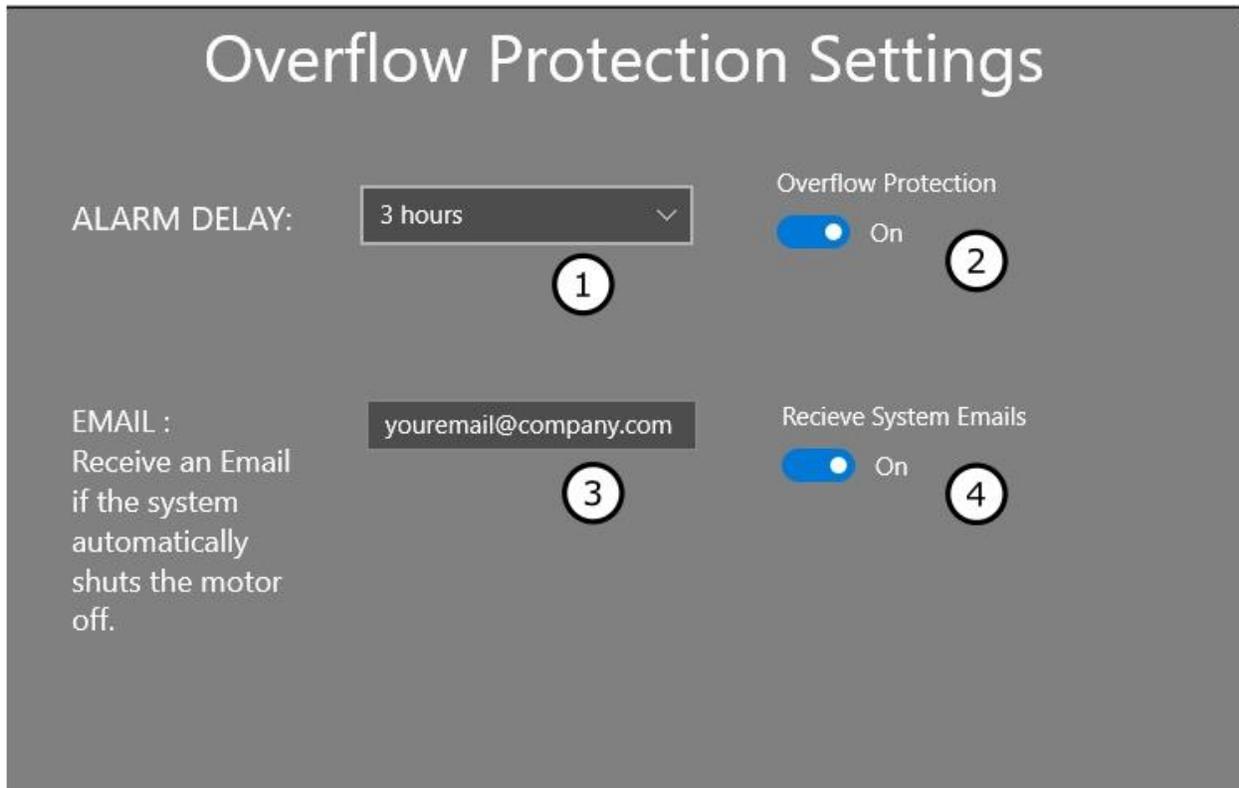
The ViscoIndicator connection to Azure is sometimes as simple as connecting the VI to a company network via WIFI or Ethernet. Data is pushed into Azure storage via ports 80/443. These are the same ports that Office 365 requires so they are generally reachable. If your IT department only allows plant floor equipment restricted internet access using ports 80/443, the specific URL we are using with Microsoft Azure is:

`viscoindicator-hub.azure-devices.net`

The VI computing device/HMI is a Raspberry Pi built with the ARM architecture running the Windows IoT operating system. Viruses and malware written for Windows PC only run on x86 architecture. On Windows IoT, only one application can run at a time. Communication is only in one direction from the ViscoIndicator to the server (the VI doesn't accept data from the network), and all data that is sent out is encrypted and compressed, using Microsoft APIs. Server-side security is administered by Microsoft.

23 Overflow Protection Settings

This screen is accessed from the machine settings screen to configure the overflow protection timer (rules 4 & 5).



When enabled, a countdown begins in the overflow protection button location on the PV screen when the motor is turned ON.

- The timer will pause if the motor is turned OFF.
- When the motor is turned on again, the timer will reset.
- If the timer reaches zero while the motor is running the motor will turn off.
- The timer can be reset by touching the overflow protection button on the PV screen.
- The VI operator should periodically clear any extrudate building up under the RSU and then touch the overflow protection button before the time reaches zero, resetting the countdown and allowing the motor to run uninterrupted.

- 1- **Alarm Delay Dropdown list** - Configures the amount of time before timers expires. This can be set from 1 to 18 hours in 1 hour increments.
- 2- **Overflow Protection Toggle** - Turns overflow protection on or off (any change is also reflected in the Rules screen)
- 3- **email address box** - When the timer expires, the ViscoIndicator can send an email to the specified address (NOTE: this feature is not active in the current software version)



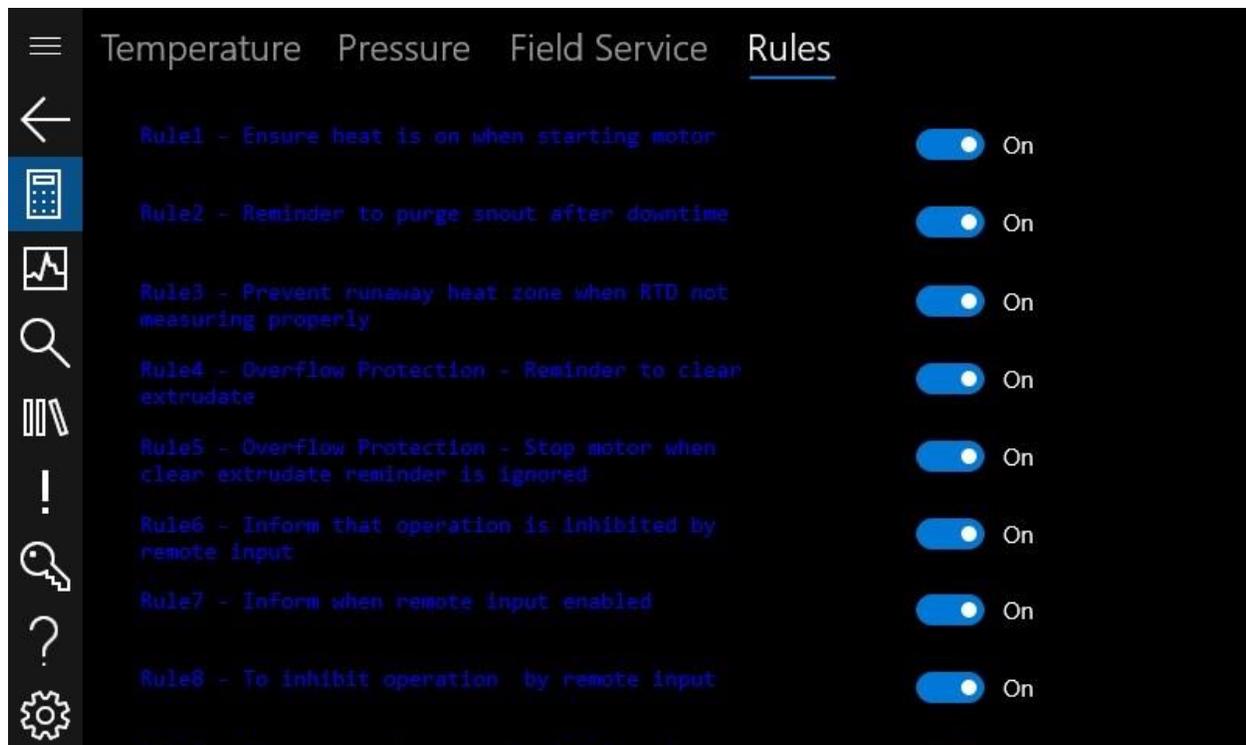
- 4- **Receive System emails toggle** - Turns Receiving emails on/off (NOTE: this feature is not active in the current software version)

24 Rules screen (Configurable Machine Protection/Safety Settings)

Important ViscoIndicator functions can be modified by a set of configurable operating conditions (rules). These rules exist to help prevent unsafe conditions or machine damage. When triggered, each rule can change the state of the ViscoIndicator or simply display an informational message on the status screen. Rules can be individually enabled/disabled with a user permission level of manager.

Please note that Dynisco recommends all rules be enabled if possible for safe and proper operation, exceptions as noted below in the details for each rule discussed later in this section.

The Rules screen can be accessed from the Settings screen or from anyone of the calibration screens.



Please see descriptions of each rule below.

General Rules (Rules 1 thru 5)

These general rules protect various parts of the VI (motor, heaters, RSU cabinet) from damage. It is important that rules 1 & 3 are always on during operation. Rule 2 may be turned off if it is highly unlikely that material degradation will occur with normal operation.

				Rule Performs these actions after event			
Rule #	Purpose	State before event	Event	Alarm	Heat	Motor	Message
1	Ensure heat is on when starting motor	Heat off, Motor off	User presses motor button	None	No change of state	No change of state	Heat must be on
2	Reminder to purge snout after downtime	Motor off	Motor Off for more than 24 hours	None	No change of state	No change of state	Please purge snout using dump valve before starting motor if material degradation is possible
3	Prevent runaway heat zone when RTD not measuring properly	Heat on	Max power applied for 5 minutes, zone temp increase < 5C	Yes	off	off	Full power was applied to a temperature zone for one minute without appropriate temperature rise
4	Reminder to clear extrudate	Motor on	Motor running for an hour Variable	Yes?	No change of state	No change of state	Warning that motor will shut off in 10 minutes, please confirm that you have cleared extrudate
5	Stop motor when clear extrudate reminder is ignored	Motor on	Motor running for 10 minutes after warning	Yes?	No change of state	off	Please confirm that you have cleared extrudate before restarting motor

Remote Input Rules (Rules 6 thru 8)

The Remote Input Rules can allow the RSU motor function to be electrically tied to the extruder screw function so the motor will only turn when the extruder screw is turning. This can be accomplished if the RCU is provided with a 2-wire 24V signal when the screw is turning, which changes to a 0V signal when the screw is not turning. Please consult Dynisco for more details. If this signal cannot be provided/isn't setup, rules 6 thru 8 must be turned off to operate the VI.

				Rule performs these actions after event			
Rule #	Purpose	State before event	Event	Alarm	Heat	Motor	Message
6	Don't allow the VI motor to turn on if the extruder screw is not turning	Remote off (no 24V signal from extruder to RCU relay)	User presses motor button	None	No change of state	Off	Remote input is signaling to shut off ó this must be cleared
7	Inform operator that the extruder screw has started turning	Remote off (no 24V signal from extruder to RCU relay)	Remote input changes to on	None	No change of state	No change of state	ViscoIndicator remotely enabled
8	Turn the VI motor off when the extruder screw stops turning	Remote on (24V signal from extruder to RCU relay)	Remote input changes to off	None	No change of state	Off	ViscoIndicator remotely disabled

Pressure Rules (9 thru 12)

The pressure rules help protect the pump and pressure transmitter from damage. It is important that they are always on during VI operation. See troubleshooting section if rule 10 occurs repeatedly making it difficult to run the VI.

				Rule performs these actions after event			
Rule #	Purpose	State before event	Event	Alarm	Heat	Motor	Message
9	Protect pump from running at a high speed that will cause pump damage	Motor on, pressure mode	Reach 80 RPM limit for 10 seconds	yes	No change of state	Off	Pressure reading implies that material not feeding properly from extruder through the pump
10	Protect pump from running empty (pump damage)	speed mode	Pressure rise after recipe Rule 10 time < Recipe Rule 10 Pressure	yes	No change of state	Off	Pressure reading implies that material not feeding properly from extruder through the pump
11	Protect pump from running with material that is too viscous (pump damage)	Motor on	Feedback <0.3 rpm for 10 seconds	no	No change of state	Off	Motor appears to have difficulty turning
12	Protect Pressure transmitter from overpressure (Pressure transmitter damage)	Motor on	Pressure above recipe upper limit	yes	No change of state	Off	Invalid Pressure reading

Temperature Rules (13-17)

The temperature rules help protect the motor, heater, and RTD elements. It is important that they always be on during VI operation.

				Rule performs these actions after event			
Rule #	Purpose	State before event	Event	Alarm	Heat	Motor	Message
13	Don't allow motor to turn on if material too viscous or too hot	temperature outside recipe temp limits & motor off	User presses motor button	None	No change of state	No change in state	Temperature must be within zone limits
14	Shut motor off if material too viscous or too hot	Motor on	Temperature outside recipe temp limits	Yes	No change of state	off	Motor stopped due to rule violation Temperature must be within zone limit
15	Protect machine from over temperature/heater or RTD malfunction	Heat & Motor on, or just Heat on	Temperature above 400C	Yes	off	off	Issue with temperature zone
16	Protect machine from heater or RTD malfunction	Heat & Motor on, or just Heat on	Temperature below -40C	Yes	off	off	Issue with temperature zone
17	Protect machine from polymer degradation if at temperature but not operating	Motor off, heat on	Motor off for 16 hours	No	off	off	Heat shut off due to inactivity

25 Using Activation Energy with the ViscoIndicator

Often, the temperature at which the polymer is being processed at is not the same as the test temperature used in the lab to verify the melt flow index.

A polymer's melt flow index is dependent upon its temperature. Therefore, if the polymer is processed at a different temperature from the lab, there can be a difference in melt flow indexes.

In order to correlate these differences a correction needs to be implemented to compensate for the temperature differences in the two processes.

This correction is in the form of an Arrhenius relationship.

The Arrhenius equation is a formula (an exponential relationship) for the temperature dependence of reaction rates

Although Arrhenius provided a physical justification and interpretation for the formula it is currently seen as an empirical relationship. It can be used to model the temperature variation of diffusion coefficients, population of crystal vacancies, creep rates, and many other thermally-induced processes. Wikipedia has a great article on the topic.

The Arrhenius equation has been applied to rheological flow variables such as MFR. The key point for us to use this relationship is to determine the so-called activation energy for the material at the shear stress we are running MFI test at.

This relationship can be rearranged into a linear form with the slope being Activation Energy.

The included spreadsheet will calculate activation energy given melt index values at two temperatures: Process temperature and the temperature of the lab test (normally the ASTM test temperature).

Method "A" test temperature (C)	Average MFR (g/10 min)	Corrected MFI				
190	0.695	0.695			Activation energy:	33031.37
320	4.555	0.695				

The activation energy is entered into the recipe for the polymer being tested. This should compensate for the difference in process vs. test temperatures.

Correlation Factor	1	
Reference Temperature	190	ASTM test temperature
Activation Energy	37235	Activation Energy

26 ViscoIndicator calibration

Dynisco recommends the following steps:

- 1- Run the VI in "Pressure Mode" setting the pressure set point equal to the standard pressure from ASTM standard weight for the material.
- 2- Once the pressure on the PV screen matches the set point, read the value of pump speed from the screen. This is the pump speed necessary to generate the ASTM weight.
- 3- Shift the mode of the VI to the "Speed Mode" and set the gear pump speed to the amount of reading (rpm) from step 2.
- 4- Collect the output from capillary of VI for one minute and measure its weight.
- 5- The weight of the collected sample from VI at 1 minute should be equal to the equation below:

$$\frac{W}{V} = \rho \cdot \frac{V}{t} \cdot \frac{1}{RPM}$$

Where:

$\frac{W}{V}$: Pump volume (Corresponds to the volume of the material extruded from the rheometer die at each revolution. This value is available from the machine settings screen.

$\frac{RPM}{RPM}$: Gear pump speed

ρ ($\frac{g}{cm^3}$): Polymer melt density

- 6- Verify that the weight matches the expected value based on the pump volume, gear pump speed, and the polymer melt density. To the extent the weight is not right, polymer melt density parameter needs to be adjusted.



For example: If a material had a melt density of $0.5 \left(\frac{\text{g}}{\text{cm}^3}\right)$, a pump volume of $0.663 \frac{\text{cm}^3}{\text{min}}$ and a speed determined from step 2 to be $7 \frac{\text{cm}^3}{\text{min}}$. The expected extrudate weight would be:

$$= 0.663 * 7 * .5 = 2.32 \frac{\text{g}}{\text{min}}$$

Deviation from this value, by more than a couple of percent can be caused by errors in the melt density value.

27 Laboratory Correlation of Results

Upon installation of instrument into process line and with subsequent blends, mixtures and grades, one must compare, and if necessary, correlate laboratory results to ViscoIndicator results. The ViscoIndicator has different flow geometry than a laboratory melt indexer (LMI) and may stress materials differently than a dynamic mechanical analyzer (DMA). The ViscoIndicator recreates the stress and/or strain of these other instruments but depending on the material's properties, may not yield the same results.

Also, one may need a correlation factor due to the ViscoIndicator sample point of material being upstream from the final product. For example, if the ViscoIndicator is sampling material ahead of a sheet die, the additional time the material is under heat and stress from this point to the final, rolled product may change its properties somewhat. So, if comparing ViscoIndicator results to final product, lab testing, one may need to correlate these values.

The ViscoIndicator allows for this with a correlation factor which is a simple scalar that can be used for individual materials, if needed. It's difficult to predict whether this factor will be needed or not. A material's elasticity may show the need for using a correlation factor but sometimes it doesn't affect the final results. One should also do lab to ViscoIndicator comparisons periodically to verify proper operation of the ViscoIndicator.

Correlation Factor is Recipe dependant so one can have multiple correlation factors that are material, grade or blend dependant. A correlation factor of 1.0 does not make any adjustment of the final Melt Flow Rate (MFR). The final MFR reported by the system is:

- $VI_MFR_{corrected} = VI_MFR_{raw} * \text{Correlation factor}$

Correlation Factor is entered in recipe screens shown here:



To find out what the correlation factor should be, simply take readings from the ViscoIndicator versus lab results and baseline the current process and/or material. For example, if the ViscoIndicator, with a correlation factor of 1.0 is reading a MFR of 10 but the lab samples are yielding a result of 11 MFR, simply change the correlation factor for that material to 1.1.

28 Troubleshooting

Always review the Alarms/Events screen when troubleshooting, as information may be displayed related to rule violations that will help troubleshoot system issues. Refer to Service and Installation Manual, PN 974175 for identification, location and operation of parts or assemblies referenced below.

Fault	Possible Cause	Resolution
Motor won't turn on	Heat is off or Rule 13 - Temperature not at minimum value or above maximum value	Turn on heat and/or wait until all temperature values on PV screen turns from red to black.
	Motor was shut off less than 45 seconds ago	Wait until motor button text on PV screen changes from "wait" back to "motor"
	Rule 6 - remote 24V relay signal not present (extruder screw not turning)	Turn on extruder screw/provide 24 relay signal/turn off rule 6
	Rules 4 & 5 are on (overflow protection) but overflow protection alarm delay is set to 0 hours	Change overflow alarm delay value in Settings -->Overflow protection screen
Motor won't stay on	Rule 10 - not enough pressure is being built up in the extruder in rule 10 recipe time period	Open PIV
		Create a "startup" recipe with rule 10 pressure set to 0 psi, speed mode, and run at 1/4 normal speed, carefully watch pressure build up for 3-4 minutes. If pressure begins to build up, then switch back to original recipe

Fault	Possible Cause	Resolution
<p>Result on ViscoIndicator doesn't correlate with LMI.</p>	<p>Lab Results vs. ViscoIndicator Results may need correlated.</p>	<p>See Section 27—Laboratory Correlation of Results</p>
	<p>Activation energy needs to be entered into the recipe.</p>	<p>See Section 25--Using Activation Energy with the ViscoIndicator.</p>
	<p>The Activation Energy value or the correlation factor are not correct in the recipe</p>	<p>Review recipe section of this manual and current recipe values</p>
<p>No Material Comes out of Material Exit/Capillary and Pressure Either not Building or System Over-pressuring When Run</p>	<p>Material Pathway Clog preventing Material from Reaching Pump and Capillary Sections No Pressure Build across Capillary before fault.</p>	<p>Open Dump Valve ahead of Process Valve to see if Process Material is Flowing to this point. If not, ensure heated process connection is heated fully by placing external temperature sensor on several spots of connection. If temperatures look good, try heating up process connection further, in 10-20°C steps, to get material to flow to dump valve port.</p>
	<p>Material Pathway Clog preventing Material from Reaching Pump and Capillary Sections--No Pressure Build across Capillary before fault.</p>	<p>If heating process connection does not clear pathway to dump valve port, with extruder down, remove process connection and inspect for clogs of contaminants or degraded materials. Clean and clear as needed.</p>
	<p>Material Pathway Clog preventing Material from Reaching Pump and Capillary Sections-- No Pressure Build across Capillary before fault.</p>	<p>If material is good to dump valve port but does not reach pump, i.e., no pressure builds while running, try heating up PIV and Flow Block zones further, in 10-20°C steps. After each step, start motor/pump slowly in speed mode and watch for several minutes to ensure pressure builds.</p>

Fault	Possible Cause	Resolution
<p>No Material Comes out of Material Exit/Capillary and Pressure Either not Building or System Over-pressuring When Run</p>	<p>System has trapped material causing nearly immediate over pressure fault when motor/pump is started.</p>	<p>Remove capillary from system. Remove pressure relief port. Run a cleanout rod from pressure relief mounting hole to capillary exit. If material is hardened inside, try heating flow block in 10-20°C steps and see if material further melts/softens for removal.</p> <p>If problem persists or if material is hardened within flow channels and does not seem to fully melt, consult Dynisco for further assistance.</p>

29 Warranty

DYNISCO guarantees, that each product has been developed and produced in accordance with the current state of technology. DYNISCO guarantees, that each individual product at the time of delivery is free of errors in manufacturing or material and meets the specifications and performance standards described in the applicable documents and data sheets under the operating conditions described for each case.

As the guarantee period, DYNISCO grants a 12-month guarantee from the date of delivery, when the ViscoIndicator is used in single-shift operation. If it is used in multiple-shift operation, the duration of the guarantee is reduced to 6 months.

The guarantee covers - assuming appropriate usage and excluding willful damage - the primary design and error-free manufacture of the product, but not wearing parts such as knives, screens, power supply cables and connectors, etc.

The guarantee is void if the operator makes changes to the ViscoIndicator which DYNISCO has not specifically approved, or if the ViscoIndicator is used for other purposes than those described by Dynisco.