



LMFI 5500 Series Melt Indexer

Setting the Standard for Evaluating
Polymer Melt Flow Characteristics

Operating Manual





Support Contact Information

Dynisco can be contacted for questions and support -

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To help us handle your questions as quickly as possible, have the following items ready before you call:

- Instrument name and model number (on back panel) Instrument serial number (on back panel)
- Current version of instrument firmware and software (Power up unit, both versions shown on “Settings” screen.)

By Internet: <http://www.dynisco.com/>

By Mail/Post:

Dynisco
38 Forge Parkway
Franklin, MA 02038



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Before You Begin

Please read this manual from beginning to end and observe all safety warnings and symbols. It is important that this instruction manual be made available to all operators of the LMI5500. Please contact us if you have any questions regarding the LMI 5500.

Maintenance and/or service should only be performed by a qualified electrician or engineer.

Melt flow index testing methods and apparatus are specified by national standards such as ASTM D1238. The applicable national standard for the test method should be studied by all operators of the LMI5500. This manual in no way supersedes that standard.

Introduction

Of all the tests used by the plastics industry, melt flow rate testing (or melt flow index) is most widely used. It has been traditionally associated with the testing of polyethylene materials to determine lot-to-lot consistency of resin lots or batches for quality control purposes. It is, however, also used for other purposes such as testing new materials, determination of material stability verses residence time within plastics processing equipment, or the assessment of regrind content within materials or moldings. It is generally a low shear rate test, however, using larger weights can increase the shear rate.

A flow rate test is a measure of a polymer's mass flow rate (grams extruded in 10 minutes) using an orifice under specified conditions of temperature and load. Machines that determine flow rate are generally called Melt Indexers or Extrusion Plastometers. Test methods by ISO, DIN, ASTM and others specify heat chamber and piston tip diameter such that the shear stress on the polymer is the same in all machines for a given load. In addition, material specification guidelines (by ISO, DIN, ASTM, GM etc) may exist which give further constraints on how a particular type of material may be run.

The melt flow rate (MFR) is reported, (ASTM D 1238) as the rate of extrusion expressed as grams per 10 minutes. The results are sometimes shown as MFR (190, 2.16) =2.3. They could also be shown as, MFR (190, 21.2) =2.3. This means that the temperature was 190°C and a load of 21.2 kg was used. It is important to specify, in any report or table, the test procedure used for testing, the nature and physical form of the material tested, the temperature, the load used, details of any material conditioning (for example, drying), the procedure used (for example, Method A or B), and any unusual behavior of the plastic material seen during the test.

The tests performed are those described by national standards ASTM D1238 and ISO 1133-1, 1133-2. The precision and accuracy of the test has been determined by the applicable national standard.

Contributing to both precision and accuracy are operator variances such as; packing technique, cleaning, cutting, weighing etc. With moisture sensitive polymers, dryness can also play a major role, and time can be a factor with thermally unstable polymers, so procedures must be identical. Dynisco has found that charging a consistent mass of material into the barrel (± 0.1 grams) is the most critical factor in getting precise data.

Several methods have been developed for running flow rate tests under D1238, with Methods A (mass of material over time) and B (volume of material over time) being the basic of all methods. Method A is simply the collection of extrudate over time, while Methods B, C and D are the measurement of time for the flow of a fixed volume of polymer. All but Method A require an encoder to measure distance traveled to determine volume of material extruded during the test.

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 source 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.



Wear Protective Clothing

Wear protective clothing (gloves, apron, goggles, etc.) approved for the materials and tools being used. Dies and piston rods are extremely hot and are designed to quickly transfer heat to the sample being tested. Even brief contact can cause a burn.



Provide Adequate Ventilation

Provide ventilation to remove heat and noxious odors and to prevent the accumulation of asphyxiates such as nitrogen gas. Many polymers (PVC, PVR etc.) are well known for giving off hazardous fumes at elevated temperatures. An exhaust system that removes fumes from both the die exit and near the top of the barrel is strongly recommended. Consideration should also be given to additives that may degrade or decompose at elevated test temperatures.



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.



Use Gloves--It's Very HOT!

To prevent burns, gloves and a long sleeve shirt (or lab coat) are essential. Dies and piston rods are extremely hot and are designed to quickly transfer heat to the sample being tested. Unfortunately, this means they will transfer heat very quickly to you as well. The indexer barrel housing can also get very hot. However, at any barrel temperature, these should not cause burns if touched for a very brief period except very near the barrel top and bottom. Consider where dies may fall. If they are dropped on nylon carpeting or similar materials, they can quickly form holes. Protective mats may be needed.

DYNISCO recommends keeping hot piston rod and hot die in the chamber/barrel; this precludes someone picking it up inadvertently. Be sure to hold the piston by the top insulator.



Electrical Hazard

Your Dynisco Lab Melt Flow Indexer contains high voltage inside the housing. DO NOT remove the housing or any part of its outer covers; there are no user serviceable parts inside. Service should only be done by a qualified DYNISCO Service Technician. Be sure the outlet used to power the indexer is properly grounded.



Calibration Thermometers May Use Mercury

To calibrate the temperature on the indexer, a thermometer containing about 8 grams of mercury may be used. Every lab with mercury thermometers or equipment containing mercury must be prepared for breakage. Note that mercury exposed to air “evaporates” at room temperature, producing an invisible, tasteless, odorless and dangerous vapor. Thermometers have been used for decades in laboratory equipment and when used properly provide an accurate and effective means of calibration.

Keep the thermometer in a safe place where it will not be crushed or otherwise broken.

When using the thermometer be careful not to drop or bend the glass. Place a hot thermometer onto cotton patches to cool. Never put a hot thermometer in contact with cold metal or cold solvent because the thermal shock can crack or shatter the glass. Do not heat the thermometer too quickly or exceed the temperature range of the thermometer or internal pressure may cause it to break.

Always confirm that the LMI5500 setpoint temperature does not exceed the range of the thermometer.

Mercury is extremely toxic and should be handled accordingly. A material safety data sheet (MSDS) for mercury (Hg) can be found on the Internet. Observe local, state and federal hazardous waste disposal laws when disposing of any broken thermometers.

If packaged in a sealed plastic container and labelled with the following symbol:



Broken thermometers and their spilled mercury can be sent back to the manufacturer. Dynisco believes UPS will accept these packages provided they are labelled and the material is in a secure container. See Princo support vendor for address information.



Pinch Points

Do not place weights in precarious positions where they can be bumped and fall to the floor. For large test weights (over 10 kg) the pneumatic lift system is recommended. The lift system has a mechanical capture rod which will not allow the weights to “fall” out of the machine. When the machine is in operation the lift system moves the weight downward somewhat quickly creating an area where anything lying beneath could be crushed. The lift system has a safety door that, when installed correctly and not tampered with, will prevent the lift from moving when open. There are redundant internal firmware and mechanical hardware safeties in place in the lift system.



Obligation of The Operator to Exercise Due Care

The LMF1 was designed and constructed taking into consideration a hazard analysis having carefully adhering to the harmonized safety standards as well as further technical specifications. Thus, the LMF1 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.

The operator must ensure that:

- The LMFI will be used only in accordance with the intended purpose.
- The LMFI will be operated in a flawless, functionally efficient condition and that the functional efficiency of the safety devices will be checked at regular intervals.
- No modifications will be made to the component except by a Dynisco service person.
- The necessary personal protective equipment for the operation, maintenance, and service will be available and used by any personnel performing these functions.
- The operating instructions are always available completely and fully legible at the installation location of the LMFI. It must be guaranteed that all persons who work with the LMFI can consult the operating instructions at any time.
- Only sufficiently qualified and authorized personnel will operate, maintain, and repair the LMFI.
- All safety and warning labels, attached to the LMFI, must not be removed and must remain fully legible.
- Additional instructions, in accordance with facility, local, state and federal industrial safety regulations and their corresponding, related ordinances for the use of work materials, will have to be made available as a supplement to the operating instructions.

Specifications

Utilities	
Electrical Requirements	100-120 VAC/220-240 VAC, 6A/4A-Peak at Power-up, 5A/2.5A, 500VA-normal operational power, 50Hz / 60Hz
Dimensions: Base Model	
Height (in/cm):	20in / 51cm
Width (in/cm):	13in / 33cm
Depth (in/cm):	21in / 53cm
Weight (lbs/kg):	47lbs / 21.4kg
Complies with ISO ASTM D1238 and ISO 1133-1, ISO 1133-2	

The LMI5500 is designed to determine the melt flow index and other thermal properties of polymers and is not intended for any other use.

The LMI5500 is designed for indoor use only:

- Temperature range 5°C to 40°C, maximum R.H. of 80% at 30°C.
- Maximum operating altitude is 3,200 meters.
- The area that it is located shall be free from vibrations.

Equipment Setup

Unpacking the Melt Flow Indexer

The Lab Melt Flow Indexer comes in a heavy-duty cardboard box. To unpack:

- Cut three straps around the cardboard box.
- Remove the box lid.
- Remove all the foam sleeves on the top and around the LMI.



- Take the packing list and documents folder from the area in front of the LMI.
- All the accessories and parts are in a U-Section on one side of the cardboard box walls. Take care when removing the cardboard walls to prevent the accessories and parts from dropping out.



- Remove the plastic bag covering the machine.



- Carefully remove the machine from the box and place it on flat surface.
- Remove the bottom flat cardboard and the weight that is in the cardboard grid.



- Check all parts and accessories against the packing list.

It is recommended that the shipping container be saved in case you need to return the unit to our factory.

Bench Requirements and Placement

Typical laboratory benches are too high for efficient use of the indexers. Cleaning and material packing can be difficult and requires awkward hand positions and forces that could lead to carpal tunnel syndrome or back discomfort. We strongly suggest a bench height of 29 inches (desk top height) for an average height operator. Place the front of the indexer flush with the front edge of the table. This will prevent the operator from having to bend forward excessively when cleaning and packing the barrel and allow easier access to the back of the machine. As a minimum, the lab bench should easily be able to support the indexer and operator (total approx. 300lbs/136.36Kg).

DYNISCO recommends placing from left to right, if using these options, the melt indexer; sample scale and computer. Shake test the melt indexer for stability. The bench top should also be able to withstand hot dies and tools being dropped on them. If carpet is present on the floor near the LMFI, carpet protection is necessary since a hot die, hot material or hot piston dropped on the carpet will quickly burn spots in it.



Adequate ventilation will also be required to remove potentially harmful fumes from samples being tested. Consult the Material Safety Data Sheets (MSDS) on the products to be tested and your material supplier to assess the magnitude of your ventilation needs. You will want to consider these ventilation needs when positioning the instrument in the laboratory.

Most of the machine comes pre-assembled to your door. However, certain parts are prone to breakage if they were placed in their normal operating position during shipping. These items will need to be installed before safe operation of the machine is possible. Other issues important to obtaining accurate data must also be addressed before valid testing can begin.

Level the Melt Indexer

Using a small round bubble level, level the melt indexer:

1. Place the level on top of the COLD barrel.
2. Using the adjustable screw feet, bring the machine into level.
3. Tighten the locking nuts to the baseplate to keep the feet in level position.
4. Test shake the melt indexer for stability – if it is not stable, repeat the steps above.
5. Be sure to remove the level before turning on the machine. The level will be damaged if it gets hot.

Some companies may choose to bolt the machines directly to their benches. This can be done by removing the levelling feet and using their mounting holes to mount the instrument to a bench or table. Use caution and remove power before doing so. Mounting the equipment this way will entail removing some covers for internal access to the internal and main instrument plate.

Instrument Overview

Front View



LMFI with encoder and auto cutoff



LMFI base unit (no options)

Rear View



The product sticker on the back of the LMFI will show the model, power requirements and the instrument serial number.

LMFI side view USB and Ethernet connection ports



Screen ICONS



Expand



Back



Test



Recipe



Permissions

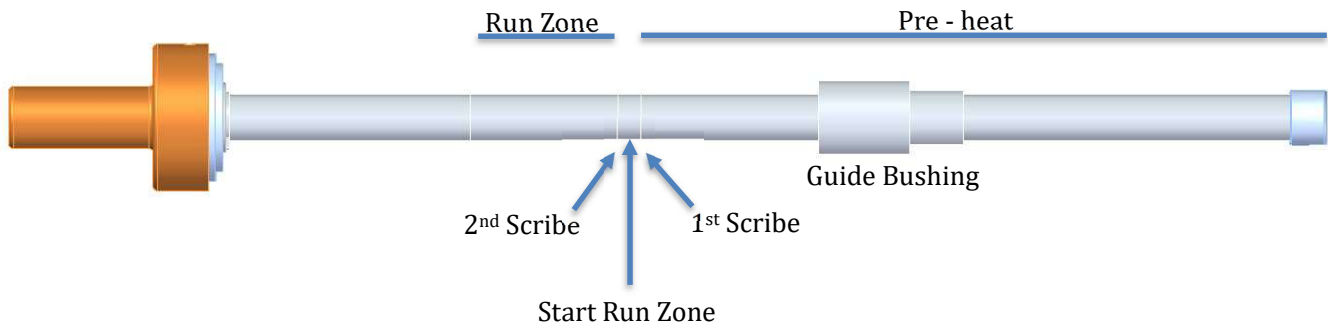


Settings

The LMFI 5500 Series Melt Indexer has an intuitive touch screen display in addition to ICON keys for ease of operation. A keyboard is also displayed when settings and values are to be entered.

Familiarize yourself with the Piston Rod

There are three scribe marks on the piston rod that define the position of the piston tip at various phases of the test. The critical features of the piston rod that allow you to determine its proper location are indicated below.



Optional Digital Encoder

Introduction

A digital encoder module is available from DYNISCO. It permits the collection of multiple data points from one charge of the barrel. The digital encoder makes operation of the instrument much faster and easier. If your LMI 5500 does not have a digital encoder, you can upgrade your LMI by ordering this optional accessory from Dynisco. Instruction and calibration can be scheduled with Dynisco Service Department.

Encoder Option

Tests using from one digital flag up to fifteen digital flags can be performed. The Dynisco Encoder for Method B tests employs an encoder coupled to a precisely calibrated arm. The tip of this arm employs a hardened and ground tip for extra-long life. Accuracy over the ASTM measurement range of 6.35mm and 25.4mm is +/-0.4%. The optical encoder, while being very accurate, also enables the test length signal to be processed & varied digitally. Thus, any test length up to 1" (ASTM) or 30 mm (ISO) may be selected. Up to 15 MFR results per barrel filling can be obtained.

The unit is securely fastened to the rear of the Melt Indexer, and the arm latches down to facilitate cleaning of the unit after the test is completed.

Encoder Advantages

- Completely Automatic Test Length Selection on Single MFR Tests. Up to 15 MFR readings per barrel filling can be obtained.
- Any test flag length up to 30 mm can be used.
- User Defined test length and test spacing for single or multiple tests can be used. Automatic test length and test spacing, for multiple tests, are used.

Why use it?

- No manual cuts are required.
- A sample can be checked as homogeneous within a charge.
- Get better precision (averages are less variable than a single observations) for tests.
- Verification as to whether barrel pressure drop is significant for sample.
- Gain ability to reject data point if bubble or air pocket existed in sample.

Optional Autocutter

The Autocutter option is for cutting the sample during either Method A or Method A/B tests.

The Autocutter will cut the extrudate at the end of the Melt Time before sampling begins. The cutter will automatically cut each sample at the time interval defined in the recipe.

The Autocutter cuts in a single, 360-degree rotation, and drops the cut sample down below the barrel onto the work surface above and behind the display. The cutting action is accomplished by using a thin, flexible blade cutting across the end of the barrel.

The Autocutter was preconfigured in the factory, so it should simply run. The door must be closed in order for the cutter to work. **If the door is not closed the cutter will not cut so the test will not be valid.**

The Autocutter can be enabled/disabled via the machine settings screen. (See page 27.)

If the cutter is not working see the troubleshooting section, page 76.

Regarding weights, local gravity, and the optional scale

Weights

Introduction

In most applications you do not have to concern yourself with weights or gravity because ASTM allows for a 0.5% accuracy on the test load. Accuracy can be improved by entering the actuals into the LMI. Remember to subtract the piston guide bushing weight from the total.

Local Gravity

Introduction

The plastometer and standards such as ASTM 1238 were developed primarily in industrialized nations which reside in areas of the earth that experience roughly the same gravitational force. As a result, the variability of gravitational force was not a significant concern in developing the apparatus or procedure.

Manufacturing facilities and other testing facilities are increasingly being located close to the earth's equator such as in countries like Malaysia, Indonesia and India. Gravitational forces in these areas are different than in the USA, Western Europe and China, given that latitude and other factors may cause gravitational force to vary, and that this difference may cause variation in MFI measurements for a given polymer. A difference of this magnitude in such a precise measurement as MFI may have significant consequences.

It should be appreciated that fluids such as molten polymer are presumed to be Newtonian over the relatively small changes in shear stress that would result from varying gravitational force, meaning that the driving forces are proportional to the rates of change of the fluid's velocity vector.

If the local gravity is entered into the LMI it will apply a correction for that shift assuming the material is Newtonian. Note, for this correction to be significant, actual weights for the weight and piston combination should be used as well.

Applying gravity correction

To activate gravity correction, select Gravity Correction to ON. There are two modes to gravity correction, Automatic and Manual. If connected to the cloud, Automatic will retrieve latitude information by design and will calculate the correction factor. In Manual mode, the user can enter location information to set a correction amount. Examples of these screens are below:

Automatic mode

☰	Print Test Report As:	.txt File	▼	
←	Sound On:	Off	▼	
	Expert Mode:	Off	▼	
📊	Rejection Mode:	OneSigma	▼	
	Units of Length	mm	▼	
📏	Units of Temperature	C	▼	
	Max Temperature	350		C
🔑	Gravity Correction	On	▼	
	Gravity Correction Amount	0.00		%
	Manual Location	Automatic	▼	
	Latitude	42.086		
⚙️	Elevation	80		m

Manual mode

☰	Print Test Report As:	.txt File	▼	
←	Sound On:	Off	▼	
	Expert Mode:	Off	▼	
📊	Rejection Mode:	OneSigma	▼	
	Units of Length	mm	▼	
📏	Units of Temperature	C	▼	
	Max Temperature	350		C
🔑	Gravity Correction	On	▼	
	Gravity Correction Amount	0.03		%
	Manual Location	Manual	▼	
	Latitude	45.0		
⚙️	Elevation	80		m

Optional Scale (Dynisco P/N 1190001)

Please refer to the manual included with the scale for generic setup procedures.

To configure scale for use with the LMI, please make the following configuration changes:

Print Function: Manual with Stability

Manual Print Format: Value

Device/Protocol: PC Text format

Note: Access to these functions is only available when scale is attached to a USB port.

PID parameters

The LMI's barrel temperature is controlled via a PID algorithm. PID is a feedback control algorithm used to control process to operate around a setpoint.

The PID algorithm calculates an output based on the difference between the setpoint of the process (the error) and the current value. The equation has a proportional, integral and derivative term. Each term has a coefficient that modifies the weight of the term. It's by modifying these coefficients that the process can be tuned.

The coefficients should only be modified by someone with experience in tuning control loops. For reference the default values of these parameters are as follows:

Zone 1 P: 460

Zone 1 I: 3.5

Zone 1 D: 600

Zone 2 %: 100

Instrument Operation/Log-In

The instrument is powered ON by turning the switch located on the rear right bottom corner of the instrument (as one faces the instrument). Toggle the switch and the unit will power-up.



After system is powered-up, select the Permissions Button (KEY ICON) to access user type. The system has 3 levels of default user types.

Below is a list of levels of access. Operator, Manager and Field Service.

Operator – No log-in necessary. Can run tests only. Cannot modify recipes. Can't modify the system configuration or calibrate the LMI.

Manager – PIN required Same rights as “Operator” plus creation/modification of recipes\machine configuration. To configure manager PIN, see below

Field service – Requires a unique PIN generated by a member of the Dynisco Field Service team that will reset once service is complete. Allows access to calibration and repair diagnostics menus.

The LMI ships without a manager PIN. To set the PIN, perform the following steps:

1. Go to the Permissions screen (the key icon of the left of the display)
2. Select Manager
3. Enter a new PIN (Message stating not right PIN)
4. Exit the field
5. Enter new PIN again
6. Manager PIN has been created

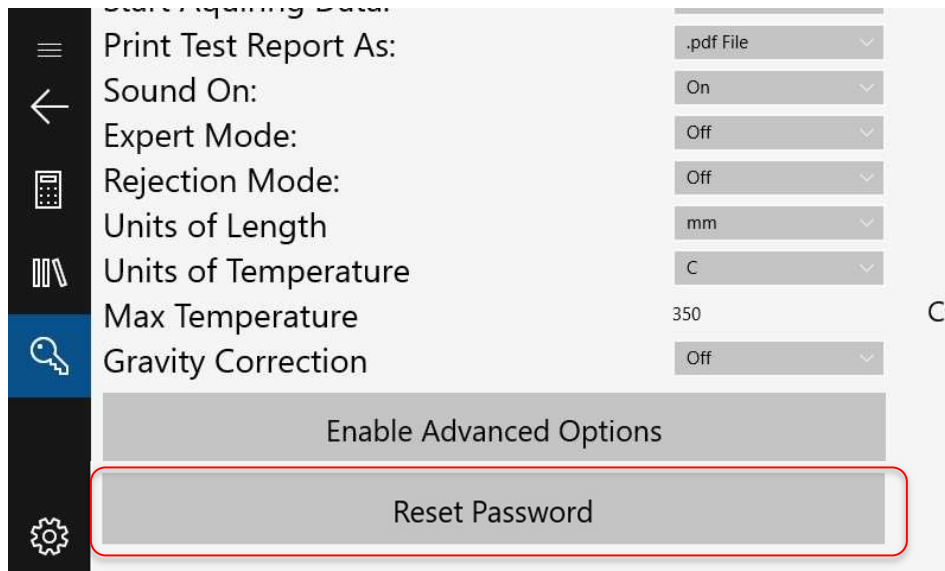
Reset Password

When the user has forgot their password, they first must contact Dynisco customer service in order to obtain a field service password for the machine.

Contact Dynisco Customer Service:

<https://www.dynisco.com/service-and-support/technical-support-request.cfm>

Then log in to the “Field Service” machine account and navigate to the machine settings menu

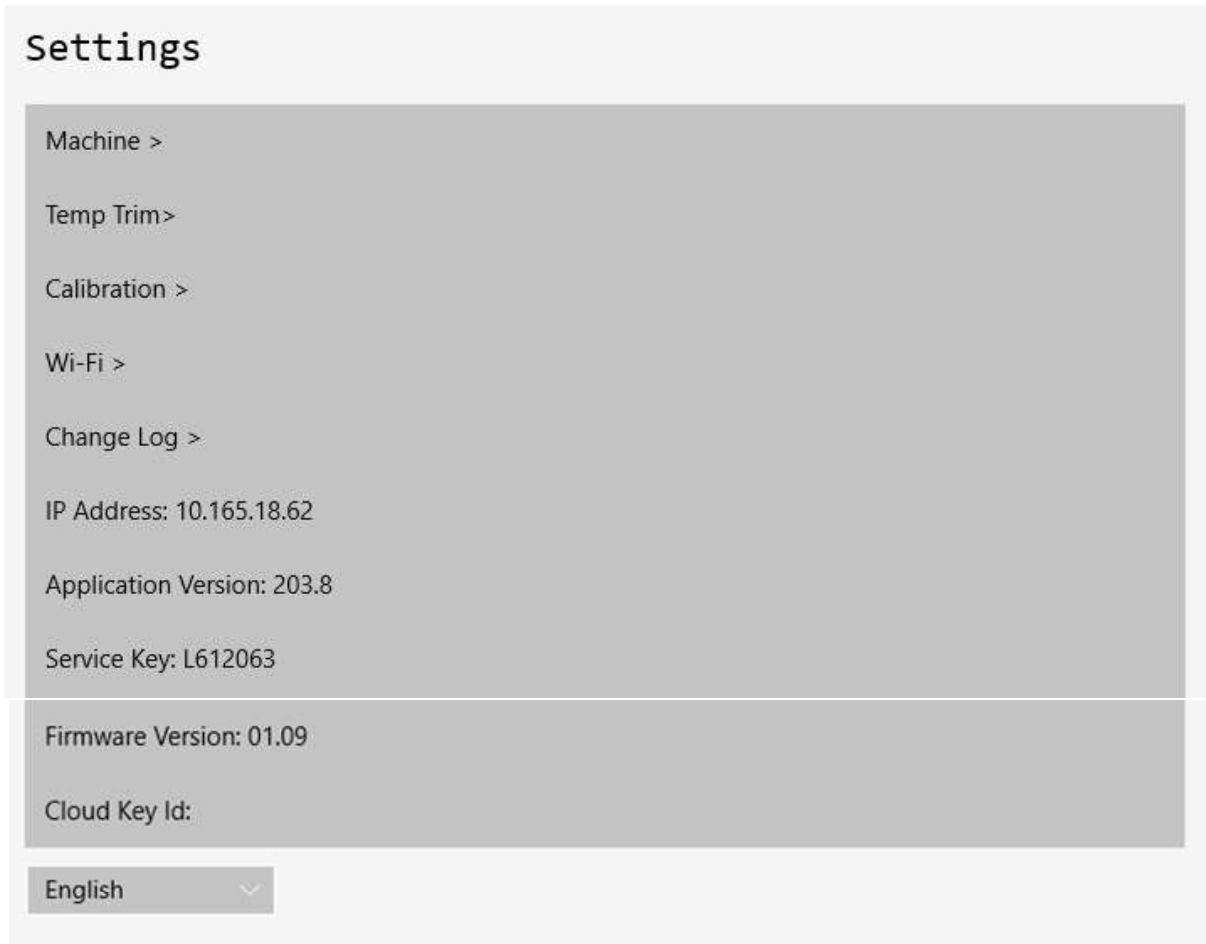


If you scroll down to the bottom, you will see a “Reset Password” button, press this and then restart the machine.

Now if you go into the Permissions menu and attempt to sign in to the manager account again, you will be prompted to set a new password.

Settings

When the gear icon is touched, the settings screen is displayed as below:



Machine – Navigates to machine settings (See next page).

Temperature Trim – Used for calibrating temperature (Field service only)

Calibration – Calibrates encoder and RTD inputs (Field service only)

Wi-Fi – Wi-Fi configuration screen (see page 29)

Change Log – Lists the recent updates and changes to the machine software and firmware

IP Address – Displays IP address if LMI is connected via Ethernet or Wi-Fi



Application Version – Current version of software

Service Key – Key that is used by field service workers to generate a field service PIN

Firmware Version – Current version of firmware on control board

Cloud Key ID – Used for linking device to Dynisco Iot (See cloud connectivity below)

Machine Settings

Company Name	Dynisco	
Machine Name	ViscoIndicator	
Time Zone Correction:	10:21	
	<input type="button" value="+1 Hour"/> <input type="button" value="-1 Hour"/> <input type="button" value="+1 Min"/> <input type="button" value="-1 Min"/>	
Theme:	Light <input type="button" value="v"/>	
IV Calculation:	Formula 2 <input type="button" value="v"/>	
Autocutter on	Off <input type="button" value="v"/>	
Start Aquiring Data:	At First Scribe Mark <input type="button" value="v"/>	
Print Test Report As:	.pdf File <input type="button" value="v"/>	
Sound On:	On <input type="button" value="v"/>	
Expert Mode:	Off <input type="button" value="v"/>	
Rejection Mode:	Off <input type="button" value="v"/>	
Gravity Correction	On <input type="button" value="v"/>	
Gravity Correction Amount	0.03	%
Manual Location	Manual <input type="button" value="v"/>	
Latitude	45.0	
Elevation	80	m
<input type="button" value="Enable Advanced Options"/>		

Company Name – Owner of LMI

Machine Name – Used to uniquely identify machine. Displayed on test report.

Time Zone Correction – Option to change the time displayed on the machine and in test reports

Theme - Option that modifies the colors of the UI, selection options include light mode, dark mode, or custom theme

IV Calculation- Option to change the method of calculation for IV measurements, Formula 1 is the default

Autocutter On - Activates Autocutter if present

Start Acquiring Data – Allows user to select whether or not the autocutter begins cutting at the end of preheat or once the first scribe mark of the piston (Enable the end of preheat option if encoder option was not purchased)

Print Test Report As – Allows user to select whether the test report saves as a .txt file or .pdf file on external USB

Sound On – Option to enable/disable sound (beeps)

Expert Mode – Expert mode is an option that allows the user to skip the instructions/animations in order to immediately start the test, only for experienced users that already know how to set up the test.

Rejection Mode – Allows user to automatically reject data from a test result if that test result falls within a defined number of standard deviations from the average. The standard deviation window is defined in this setting with options for one, two, or three standard deviations.

Units of Length – Used in flag lengths for methods B & A/B as well as capillary dimensions. Accepted values are millimeters (mm), centimeters (cm) and inches (in).

Units of Temperature – Display temperature units. Accepted values are Celsius (C), Fahrenheit (F), and Kelvin (K).

Max. Temperature – Maximum setpoint temperature of the LMI (**Read-only**)

Gravity Correction - Please see the gravity correction section on page 21.

Enable Advanced Options – Adds a further set of options to assist with field service, requires user to log in as field service in order to enable

Capturing Test Data, Connecting to Ethernet, Wi-Fi, and the Cloud

Capturing test data

There are two ways to capture test data using the “Save Data” button on the results screen.

1. If the optional cloud data portal has been purchased, the test data can be retrieved directly from the cloud.... See the appropriate sections below.
2. If a USB memory stick is inserted into the USB port of the left side of the instrument, a test report will be generated and saved to the stick.



Cloud connectivity

The LMI5500 has optional cloud connectivity utilizing Microsoft Azure services to collect and archive data in the cloud platform across a global network of Microsoft-managed datacenters.

One can leverage this functionality to generate quality records, new insights and control of their process.

The LMFI connection to Azure is usually as simple as connecting to the company network via Wi-Fi 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.

Benefits of cloud connectivity

- Accessing data remotely, via computers or mobile devices using a web browser
- Recording and archiving rheological test data
- Correlating data between machines or test runs
- Ability to download data to a computer

Even without a subscription, connecting to the cloud has benefits:



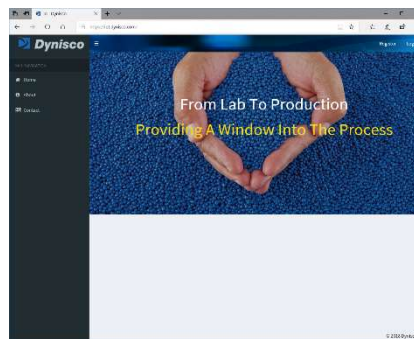
- A library of historical test results will still be stored in the cloud accessible when a subscription is purchased. This data could be used to evaluate the benefits of a subscription during a trial
- When consulting the factory, that data could be available for both troubleshooting or rheological issues
- Allows Dynisco to collect anonymous user data enabling us to support you better
- Automatic Time and Location information

Security

The ViscoIndicator leverages Microsoft Azure services. Microsoft Azure has multiple layers of security including data encryption. That said, there is no way to fully secure equipment from a hacker with physical access to it. (Dynisco believes this is true for all equipment attached to the network, not just our products.)

Registering for a cloud account

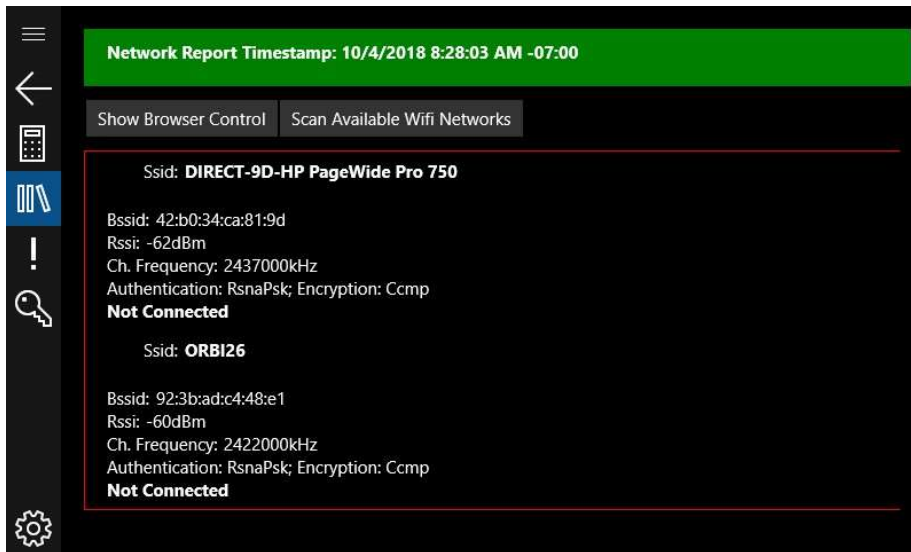
Connect to iot.dynisco.com via a web browser and select the register link in the upper right corner. Fill out the form with your email and password and press the register button. You will receive an email asking to confirm your account.



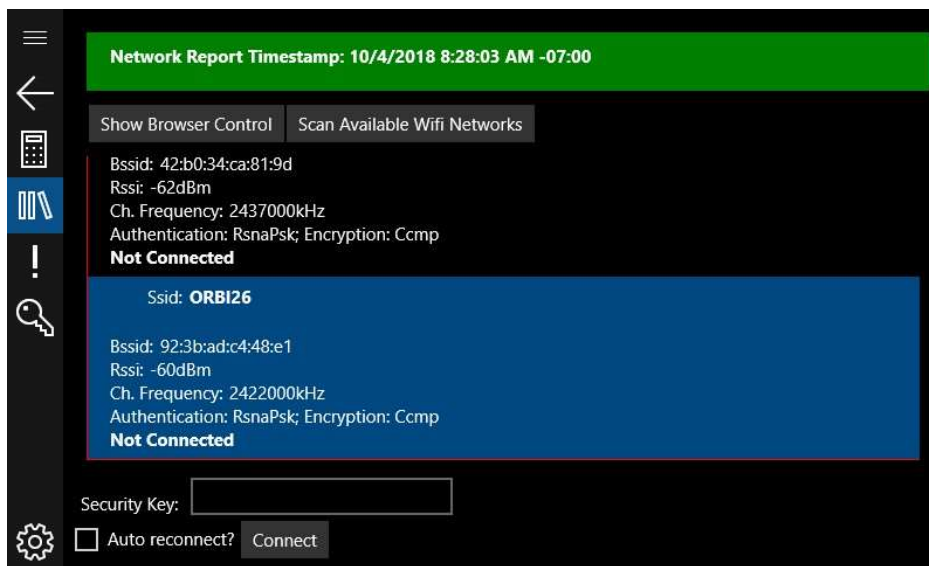
Connecting to a network

There are two methods to connect the LMI to the network: Via an ethernet cable or connecting wirelessly.

1. Connect an Ethernet cable to the left side of the LMI.
2. Connecting via a Wireless network. To connect, select the wireless network that you would like to connect to from the screen below under Wi-Fi settings which can be found under the settings screen.

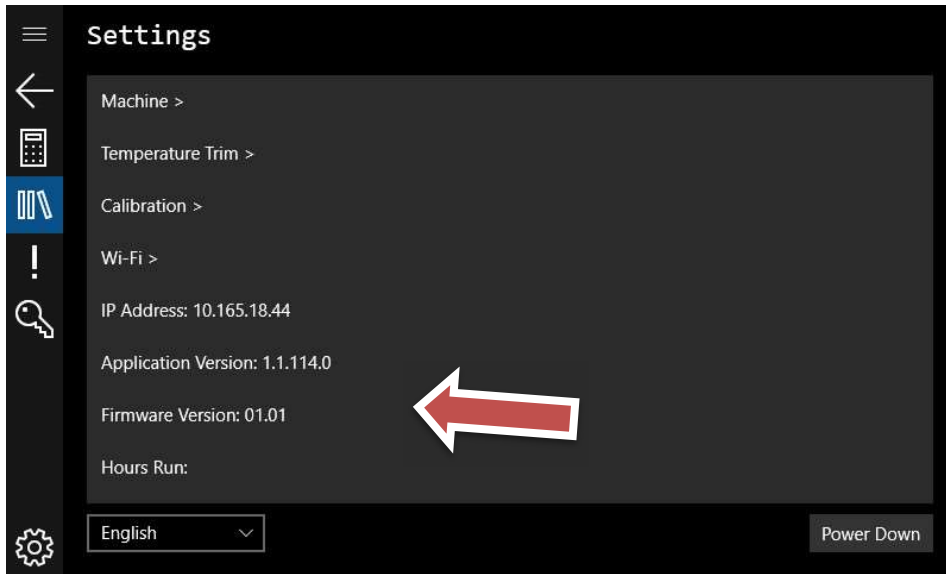


After selecting the network, enter the password in the Security Key box to connect to the network. If you would like to connect automatically after entering the password, check the Connect Automatically checkbox.



Verifying connection

Upon a successful connection, an IP address will be displayed on the settings screen as show below.



Test Techniques



Loading and Packing Material into the Barrel

- The piston rod and the die should be inserted into the barrel during heating, temperature stabilization and between tests.
- Remove the piston rod and lay on a cotton cloth.
- Check to see if the die is at the bottom of the barrel.
- Fill heat chamber/barrel with an appropriate charge (see page 34 for determining appropriate charge weight) or use about 5 grams if nothing is known about the material.
 - Put the sample into a small beaker.
 - Add about two-thirds of the material into the barrel, using the brown fill funnel.
 - The loading should be done in two increments, the first consisting of approximately two-thirds of the material.
 - Tamp down the material with the packing tool using approximately 20 pounds/9Kg of force. The packing tool can be driven through the fill funnel. If bridging (clogging) of the material occurs in the fill funnel, slide the fill funnel off to one side (without lifting) and use the fill tool to pack the material in the barrel directly. Move the fill funnel back into place. The remaining material should drop down into the barrel.
 - Repeat with the remainder of the material.
 - The procedure should be completed is less than one minute to minimize rod cooling.
- Bubbles are present in the test sample charge if a snapping/popping sound is heard as the extrudate is forced through the orifice. If bubbles appear in the extrudate, use less material between tamping down. If bubbles continue, the sample may not be sufficiently dry.
- Place the piston rod into the barrel by placing the piston rod directly over the slot/opening on the top of the indexer barrel cover.
- Seat the guide bushing down into the barrel if it has not already fallen into place. The guide bushing should be moving freely on the piston plunger.
- Place the desired test weight on the piston plunger rod and ensure the test starts when the piston is between the start of test scribe marks. Consult your national standard for guidance on this. Dynisco recommends adjusting the charge weight as described in the next section. For high flow materials use of a high flow plug may be required. For repeatable data this must be consistent run to run.

Charge Weight

National standards generally give recommendations for how much material to put in the barrel to perform a test.

However, by determining the proper charge and controlling it from run to run, testing can be made easier and more reproducible.

The distance from the top of the die to the piston's first scribe mark is about 5 cm. Filling the barrel up to the first scribe mark is the minimum charge needed to run a test. During the recommended 5-7-minute melt time, some material flows out of the die, so a larger charge is needed. The best situation would be to add just enough material, so that during the melt time, the plunger slowly falls and is just above the first scribe mark when the melt time has expired. In this way, the required melt time is satisfied and there is no excessive waiting before the first cut is made (or timing flag starts in timed tests). A conservative estimate for charge weight can be calculated if an approximate melt flow rate and melt density for the material are known by using the following formula:

$$\text{Charge Mass} = 3.6\rho + 0.6*\text{MFR}$$

Where the charge mass is in grams, ρ is the melt density in g/cc and MFR is the anticipated melt flow rate in the typical units of g/10 min. This equation will tend to slightly overestimate the charge needed. For a Polypropylene, with an anticipated MFR of 3.5 at 230 C, using the melt density of 0.738 from the above formula, the estimated charge mass would be:

$$3.6*0.738 + 0.60*3.5 = 4.76\text{g}$$

In our lab, we have found that 4.6 grams is a good charge for a 3.5MFR Polypropylene sample. The equation overestimates the charge since it assumes flow from the instant the material is packed into the barrel.

The formula may indicate a charge mass that would require a material volume that is too large to fit in the barrel. Generally, about 8 grams is the maximum you should use. If you cannot put enough material into the barrel such that after the melt time there would be enough left to test, the barrel must have a flow plug inserted at the base of the die to keep the material from escaping.

Making the Cut

There are two conditions that must be met before cutting a sample of extrudate.

1. The material must be loaded and brought to temperature by waiting the melt time (or pre-heat time.)
2. The piston must have lowered into the “run area” as denoted by the scribe marks on the piston assembly.
See page 18 for details about the piston.

A measurement may start when the 1st scribe mark has lined up with the top of the guide bushing. The run MUST start before the 2nd scribe mark lines up with the top of the guide bushing.

When using the Autocutter, the cutter engages automatically when the preheat time elapses, so the operator must verify the piston position during the test. To cut manually, use the cutting knife in a wiping like action up against the bottom of the die.

After each cut, ensure that the sample is moved away from the landing area, so samples don't fuse together.

If the second scribe mark has already passed the guide bushing before the preheat time has elapsed, the user has the following options to modify the test procedure:

- Add more material
- Reduce the test load (e.g. 2160 to 225 g)
- Reduce the test temperature (e.g. 230 to 190 C)
- Use a flow plug
- Support the plunger and piston during melt time
- Change to a non-standard die (e.g. ½ diameter, ½ height)

If the sample extrudate is so slow that the first scribe mark is not passed before 8 minutes has expired, the user has the following options:

- Add less material
- Increase the test load (e.g. 2160 to 21,600 g)
- Increase the test temperature (e.g. 190 to 230 C)
- Change to a non-standard die (typically larger diameter)
- ASTM allows material to be purged by hand or using a larger weight. ISO allows preheat time to be increased.

Be sure to document any changes made to the procedure so that consistent results will be achieved over time by different operators.

Establishing a Piston Travel Distance During MVR Testing

For best measurement resolution, use a longer distance for higher flow rates (> 10 g/10 min.) and a shorter distance for lower. The aim is to have a length long enough that the error in determining plunger speed is small resulting in precise flow rate measurements. Long lengths for slowly flowing material can make for extraordinarily long tests and the material may degrade substantially during the test.

ASTM recommends 6.35mm to 25.4mm. ISO recommends the minimum piston displacement of 0.5 mm for materials with MFR or MVR within the range of 0.1-0.15 g/10min or cc/10min, 1 mm for materials with MFR or MVR within the range of 0.15-0.4 g/10min or cc/10min, 2 mm for materials with MFR or MVR within the range of 0.4-1 g/10min or cc/10min, 5 mm for materials for materials with MFR or MVR within the range of 1-20 g/10min or cc/10min, and 10 mm for material with MFR or MVR higher than 20 g/10min or cc/10min. ISO recommends that that the time between the end of charging the barrel and the last measurement should not exceed 25 minutes.

Please note that for improved repeatability, it is critical to maintain the same distance moved for individual runs.

The encoder activates and starts to measure the time/length between the first and second scribe mark of the piston and all the measurements need to be taken before the upper scribe mark on the piston stem reaches the top edge of the cylinder.

Pre-test Checklist

- Is material properly prepared (dried, mixed, check for contaminates)?
- Machine on for 15 minutes with Die and Piston inside to temperature stabilize?
- Correct Die in machine? Correct program being run?
- Hand tools in position for run (packing funnel and tool, cleaning drill bit etc.)?
- Encoder Arm in place?
- Cutter door closed if Autocutter is installed?

Overview of Testing Methods

Determining MFR:

This test is referred to as Procedure A by the ASTM. Dynisco has historically referred to this test as Method A. Because this test is the mass measurement method it is also sometimes called the “cut-and-weigh” method. Measurement is given in g/10min.

Determining Polymer Melt Density:

This test is referred to as Method A/B by Dynisco.

This test requires a digital encoder.

It is critical to test and determine the Melt Density at the proper melt temperature. Melt Density is the density of the polymer in the molten state and is not the same as the standard or bulk density. An A/B test MUST be run before Method B testing to determine the polymer’s melt density.

In this test both the melt mass flow rate (A-type test) and mass volume rate (B-type test) results are taken. The melt density is the ratio of these two numbers and given in g/cc.

Determining MVR:

This test is referred to as Procedure B by the ASTM and Method B by Dynisco. Procedure B is a displacement – measurement method.

This method is recommended for high flow rate materials because they are hard to cut accurately. This is a “no-cuts” test that is the most convenient for busy laboratories. Measurement in cc/10min.

Procedure B can be conducted only if material melt density is known as is determined by an A/B type test.

For Very High Flow Materials:

ASTM defines a test called Procedure C can be conducted only if material melt density is known as is determined by an A/B type test. This is also known as the “half die” method. A half-length die is used and is generally used for testing high flow rate polymers. This is a “no-cuts” test that is the most convenient for busy laboratories. Measurement in cc/10min.

Flow Rate Ratio:

The LMI 5500 does not have an automatic lift so this test is not available – consult the factory for the appropriate model to use for this test.



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The Method “A” Test

General Description

Method A test involves collecting extrudate from the instrument over a fixed period, then weighing and converting the result to grams/10 minutes.

After the melt time is over and the piston is in the proper position, a sample is collected by first cutting the extrudate across the orifice face, then waiting a predetermined amount of time and then making a second cut. The sample is weighed, and the flow rate is converted to grams of flow that would have occurred over 10 minutes.

Test temperatures can be obtained from the manufacturer, from tables in your national standard such as ASTM D1238, or through experimentation. Material with Melt Flow Rates below 50 g/10 min. are generally done using Method A.

The test is manual and is sometimes called the “cut-n-weigh” method.

Calculation Method A

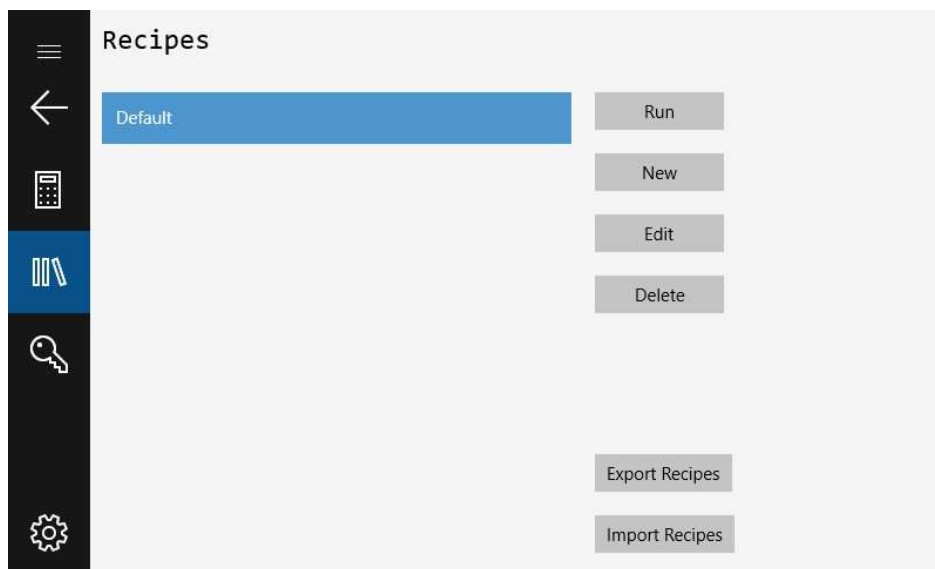
Calculations for the Method A test are straightforward

$$MFR = \frac{M 600}{T}$$

where M is the mass in grams of material collected over time T in seconds.
The MFR value has units of g/10 min. (grams/10 minutes).

Creating a Procedure A recipe

A test is performed by running a recipe. You must create a recipe if one doesn't already exist for the material to be tested. This is accomplished by pressing to go to the Recipe screen and pressing the "New" button



Upon pressing the "New" button the following screen will appear:

Recipe	Default	
Procedure	Procedure A	▼
Temp set point	190	C
Pre-heat time	360	s
MFI Low	0	g/10 min
MFI High	10	g/10 min
Load	2.16	kg
Number of samples	3	▼
Cut time	10	s
IV Offset	0	dl/g
Test Standard	ASTM	▼
Capillary Length	8	mm
Capillary Diameter	2.095	mm

These are the parameters that must be set:

Recipe – Name of recipe.

Procedure – Can be A, B or A/B – Configures type of test to be run.

Temp Set Point – Temperature that the test will run at.

Pre-heat time – Amount of time material must be at temperature before test can start. Generally, choose between 5 and 7 minutes based on your national standard for thermally stable materials.

MFI Low, MFI High – Limits that control the color that the MFI is displayed in on the results screen. Black is within the limits and red is outside the limits (Disabled if rejection mode is on).

Load – The appropriate weight to be applied to the sample. The load is the combination of the piston and weight. (If an actual weight is used for the piston, remember to subtract the weight of the piston guide bushing.)

Number of Samples – The number of samples to be generated during the test. Valid range is 1-5.

Cut Time – The time interval over which the sample is extruded between cuts.

IV Offset – A value entered by the user to offset the IV measurement if desired

Test Standard – Allows user to select whether the test is being performed to ISO or ASTM standard

Capillary Length – Length of the capillary that is being used for the test

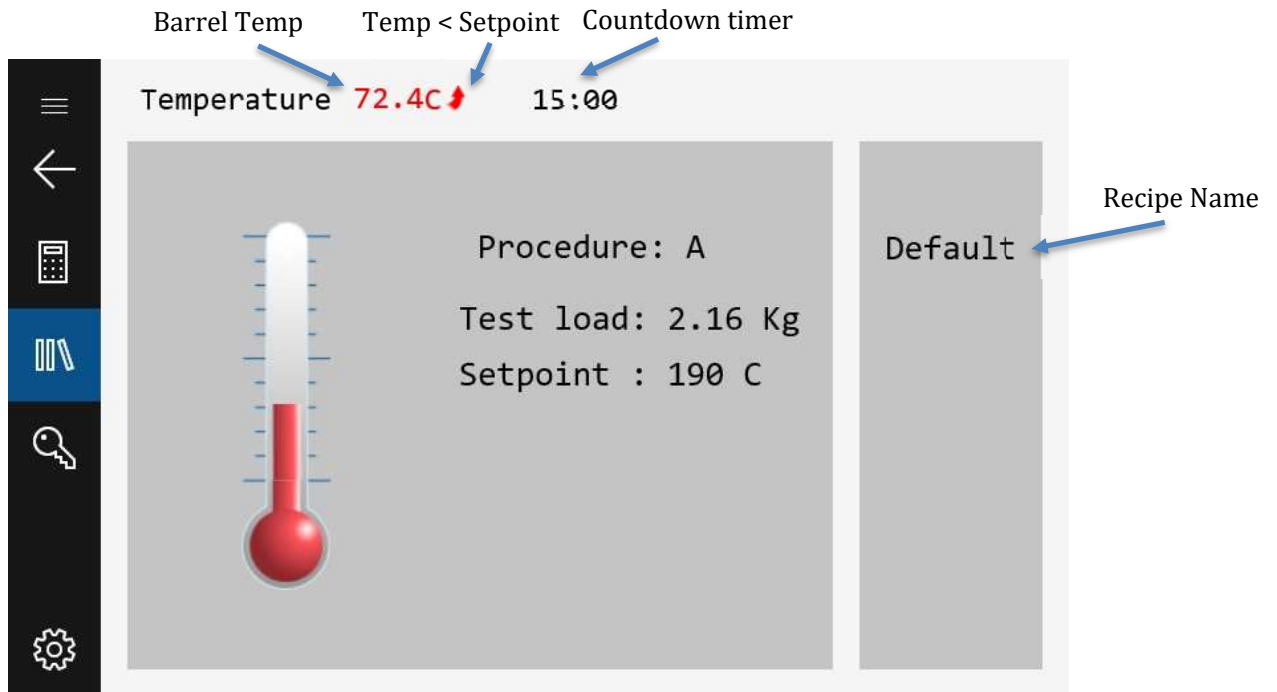
Capillary Diameter – Diameter of the capillary that is being used for the test

When all fields are complete, press the recipe button again to return to the main recipe screen. The LMI is now ready to run the test.

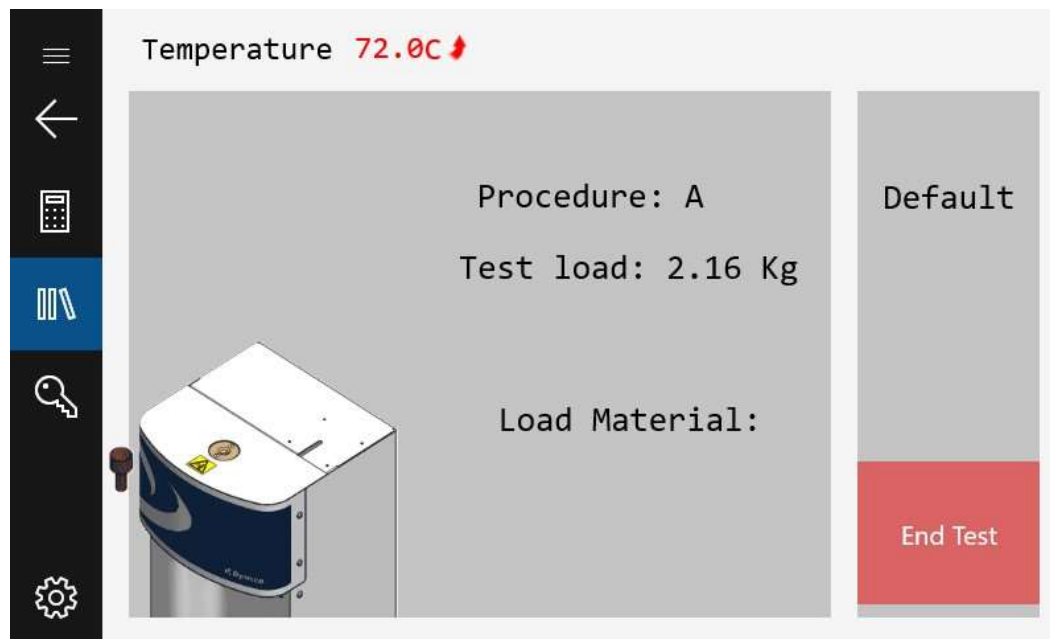
NOTE: When you turn on the machine, the last recipe run will be loaded into memory and the barrel will heat to its setpoint.

Starting the Test

Press the Run Recipe button, the screen below will appear.



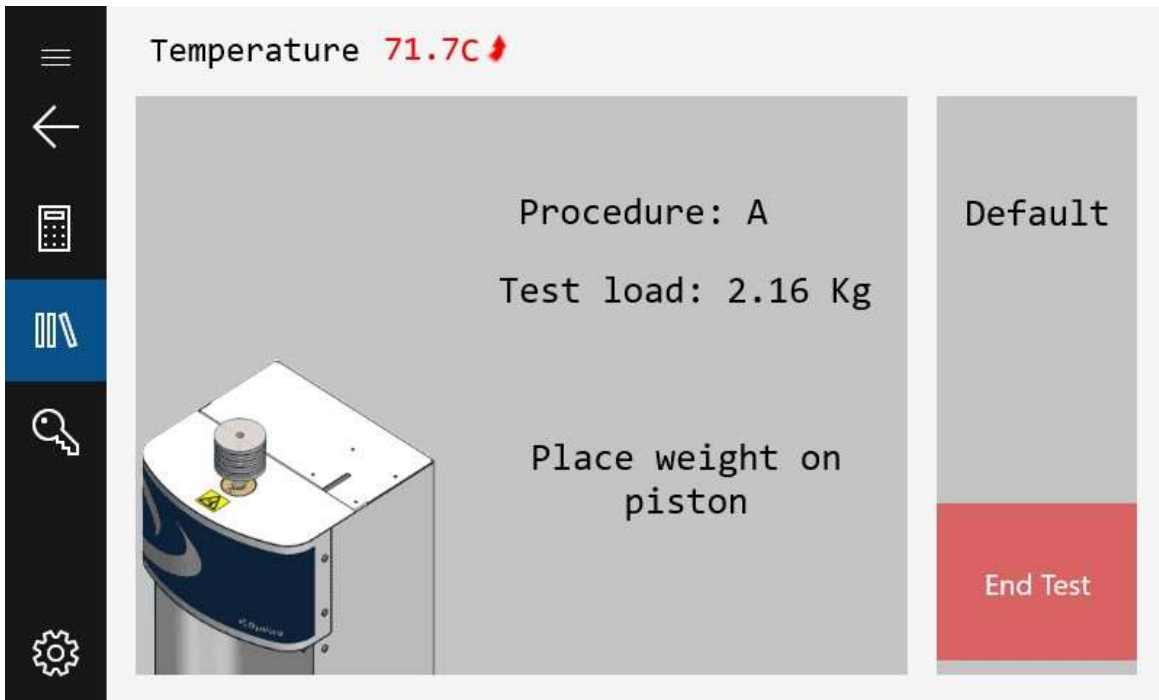
Once the LMI is at the setpoint temperature, a 15 minute count-down timer will start. *Ensure that the piston and die are in the unit.* After this timer expires, the LMI will be ready to load with material as shown below:



Loading the Sample

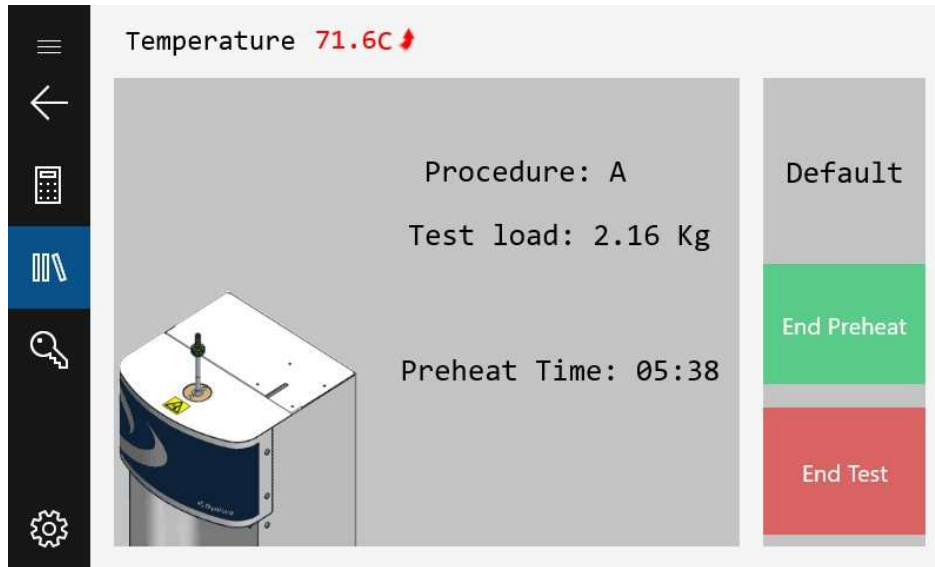
Load the sample as described in test techniques on page 33.

After loading the material, press the screen. The LMI will prompt you to insert the piston and add the weight to the LMI.



Preheat

Press the screen again when this is complete. The Preheat time will be displayed on the screen as shown below:



Collect samples

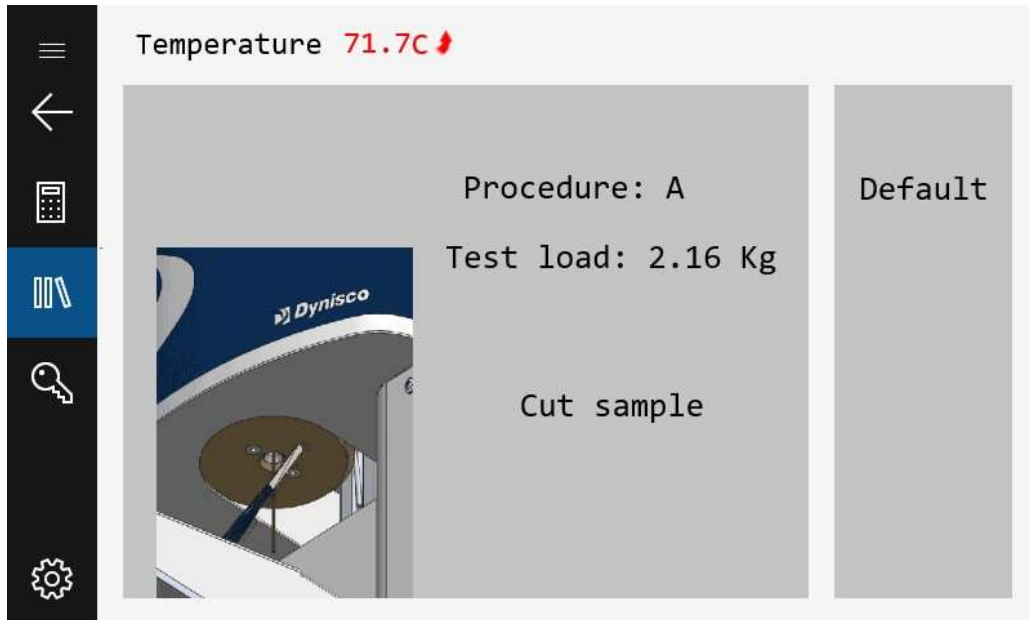
A measurement may start when the 1st scribe mark has lined up with the top of the guide bushing. The run MUST start before the 2nd scribe mark lines up with the top of the guide bushing. After melt time (pre-heat) is completed, and after the piston lowers into the “run area” as denoted by the scribe marks on the piston assembly, the extrudate formed during preheat must be removed.

If an Autocutter is not installed the LMI will prompt the user to cut the material. If manually cutting the sample, you **MUST** touch the screen as the extrudate is being cut. It is critical that the cut and touch are simultaneous to get accurate timing.

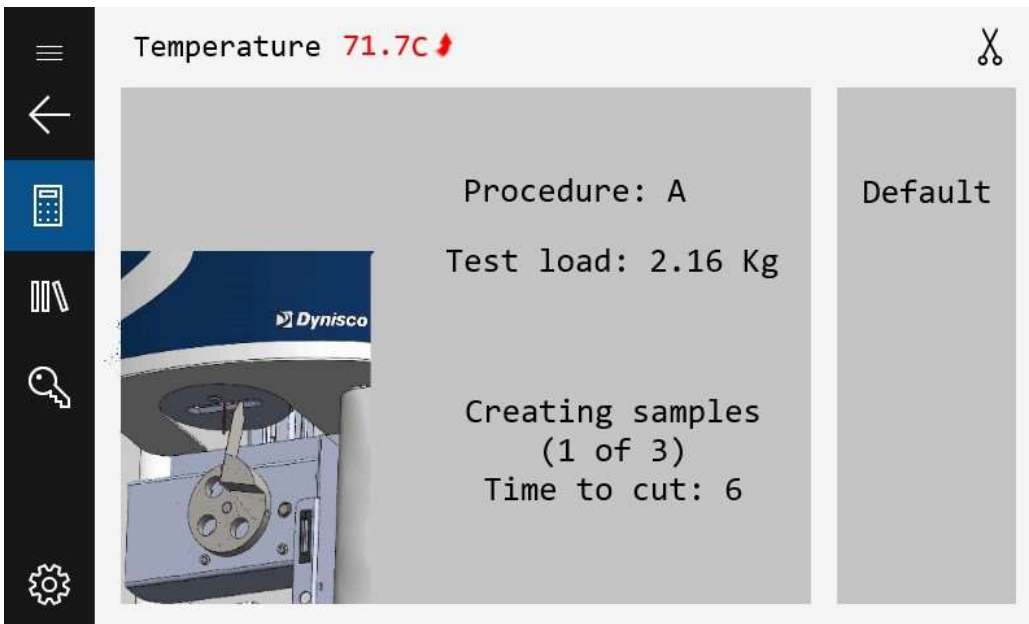
With the Autocutter, the preheat extrudate will be cut automatically.

Discard the pre-heat extrudate.

See page 35 for more on how to cut extrudate.

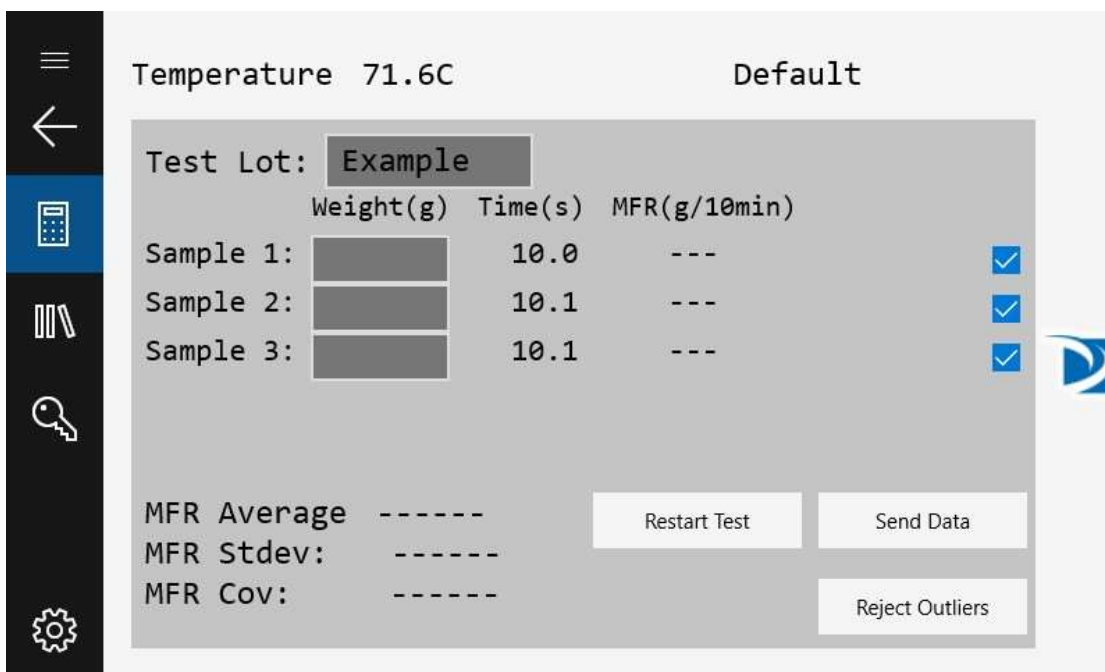


For each sample cut, the LMI will either cut (or prompt the user to cut) the sample after the sample time interval has elapsed. Ensure that the samples are moved away from the landing area, so samples don't fuse together.



Results

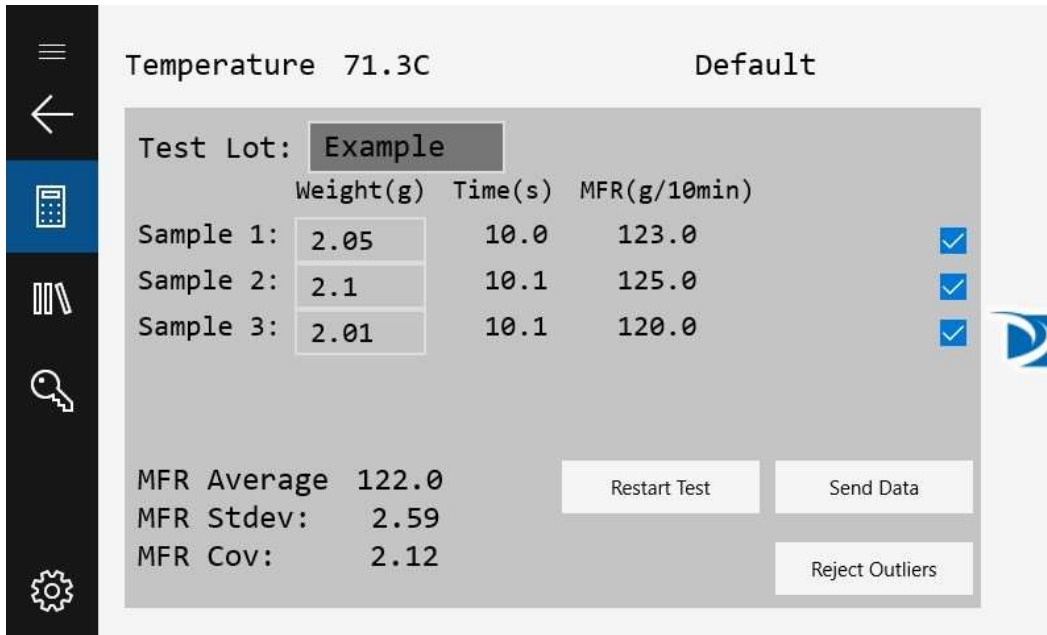
After the final cut has been performed, the results screen will appear:



Weigh the samples

Weigh the sample and enter the weight in grams using the touch panel. (A precision balance is needed to obtain precise flow rate measurements) The flow rate will be immediately calculated and displayed. An extrudate weight of about 1.0 gram or more will reduce weighing errors, adjust the cut time as needed to get at least 0.5 grams of material. If a sample needs to be excluded from the results, uncheck the checkbox to the right of the data point to be excluded. The data point will not be used in the calculations.

If the scale option has been purchased, the weights can be entered automatically. With the scale connected to USB, place the sample of the scale and wait until the measurement is stable. When stable, press the button in the upper right corner of the screen on the scale (the printed page icon). The scale will insert the weight into the currently selected text field.



When all the sample weights have been entered, the user has the option of restarting the test or saving the data. When the “Save Data” button is pressed, the data can go to up to two places. If a USB flash drive is attached to the LMI, a report will be generated and stored on the flash drive. If cloud connectivity is enabled, the data will also be sent to the cloud, accessible via Dynisco’s cloud platform. For instructions on setting up cloud connectivity, please see the Wi-Fi section of the manual on page 29.

Next perform the steps outlined in the section titled “AFTER A TEST” on page 69.

Press the restart test button to perform another test.



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The Method "A/B" Test

General Description

In a Method A/B test both a Method A test and Method B test are performed on the same charge of material. The melt flow rate, derived from Method A, is equated to the Method B flow equation and solved for apparent melt density. The value in doing this test is obtaining a valid apparent melt density which can later be used in a sole Method B test (no manual cuts of extrudate nor weighing) to achieve results equivalent to Method A (operator must make manual cuts and weigh samples).

Calculations: Method A/B

$$\text{Method B MFR} = \frac{\pi R^2 L \rho 600}{T_B}$$

$$\text{Method A MFR} = \frac{M 600}{T_A}$$

$$\rho = \frac{M T_B}{\pi L R^2 T}$$

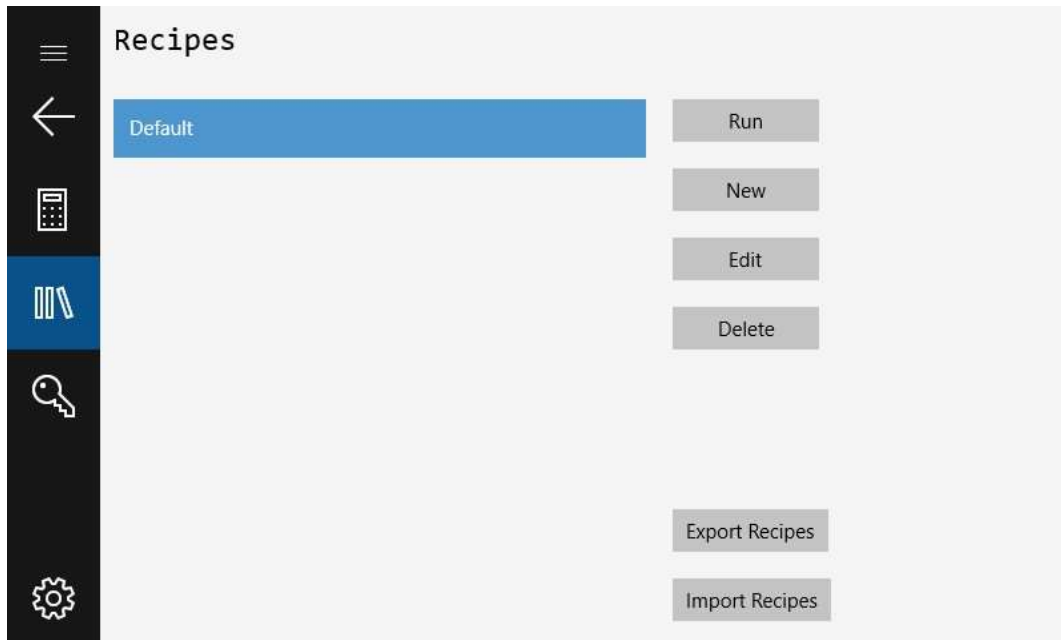
Where R= radius piston (cm), T_B is time to traverse the Method B distance L (sec), L = Method A length of flag (cm), M is the mass in grams of material collected over the time T_A in seconds. MFR has units of g/10 min. (grams/10 minutes). ρ is called the apparent melt density and is defined by equating the methods, the Method B flow rate must equal Method A.

This apparent melt density definition forces the two test methods to agree. DYNISCO recommends taking an average of apparent melt densities from at least five separate A/B tests on representative samples of polymer. This average apparent melt density can then be used for Method B tests to get Method A values without having to make cuts! It is called an "apparent melt density" because it is a correlation coefficient that forces Method A and

Method B to agree. If there were no leakage past the plunger tip and the extrudate were bubble free and few other minor factors were taken into consideration, then a true melt density could be assessed. All lengths are in mm.

Creating a Procedure A/B recipe

To perform a Procedure A/B test, you must first create a recipe if one doesn't already exist for the material to be tested. This is accomplished by going to the Recipe screen and pressing the "New Recipe" button



Upon pressing the “New Recipe” button the following screen will appear:

Recipe	Default	
Procedure	Procedure A/B	
Temp set point	190	C
Pre-heat time	360	s
MFI Low	0	g/10 min
MFI High	10	g/10 min
Load	2.16	kg
Number Of Samples/Cuts	3	
Cut time	10	s
Flag length	6	mm
IV Offset	0	dl/g
Test Standard	ASTM	
Capillary Length	8	mm
Capillary Diameter	2.095	mm

The Fields are described as follows:

Recipe – Name of recipe

Procedure – Can be A, B or A/B – Configures type of test to be run.

Pre-heat time – Amount of time material must be at temperature before test can start

MFI Low, MFI High – Limits that control the color of the MFI on the results screen. Black is within the limits and red is outside the limits.

Load – The appropriate weight to be applied to the sample. This is the combination of the piston and weight.

Number of Samples\Cuts – The number of samples to be generated during the test. Valid range is 1-5. This applies to both the Procedure A and Procedure B part of the test.

Cut Time – The amount of time allocated for each sample in the Procedure A portion of the test.

Flag Length – The distance of piston travel over which the sample time is acquired in the Procedure B portion of the test.

IV Offset – A value entered by the user to offset the IV measurement if desired

Test Standard – Allows user to select whether the test is being performed to ISO or ASTM standard

Capillary Length – Length of the capillary that is being used for the test

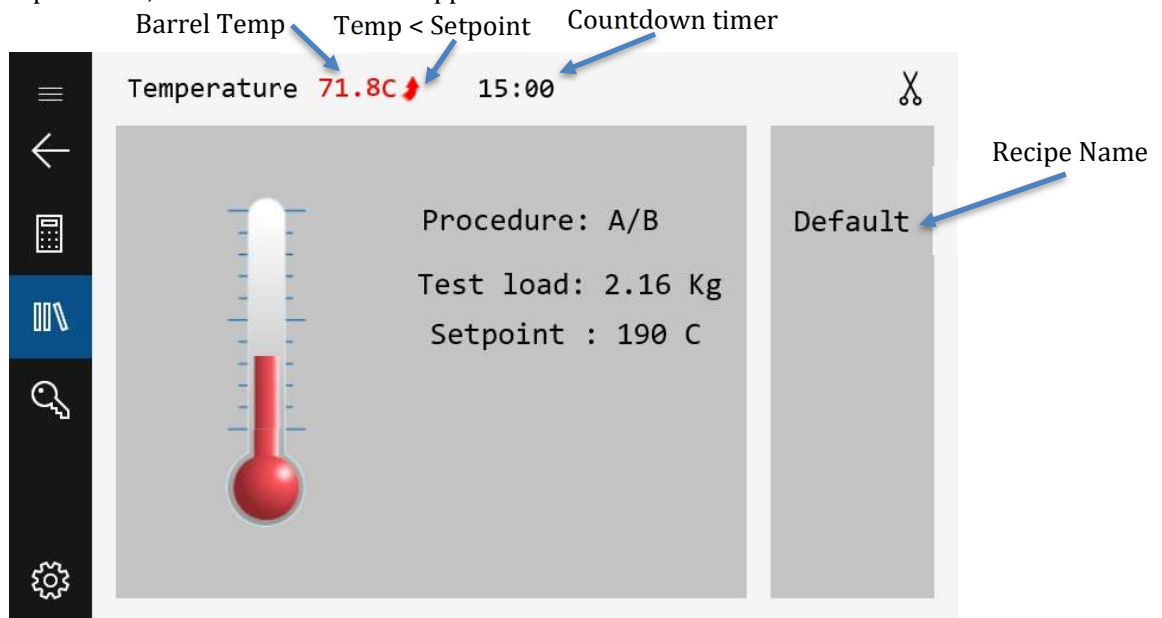
Capillary Diameter – Diameter of the capillary that is being used for the test

When all fields are complete, press the recipe button again to return to the main recipe screen. The LMI is now ready to run the test.

NOTE: When you turn on the machine, the last recipe run will be loaded into memory and the barrel will heat to its setpoint.

Starting the Test

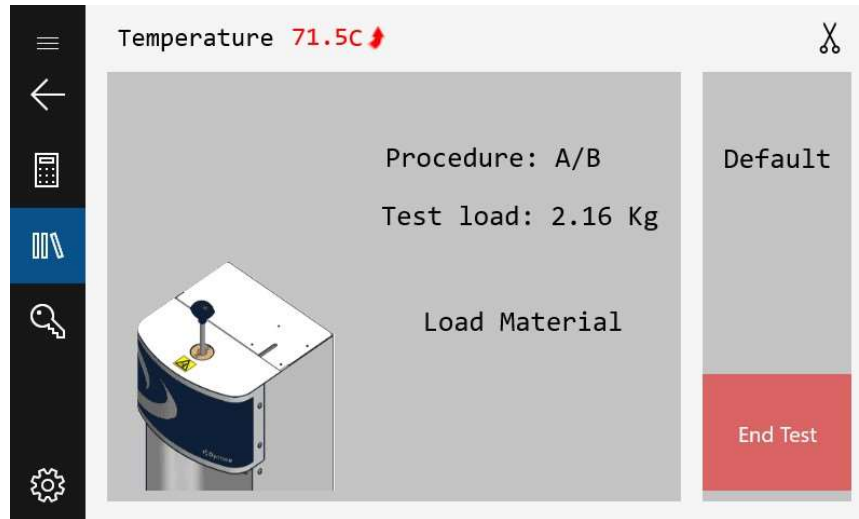
Press the Run Recipe button, the screen below will appear:



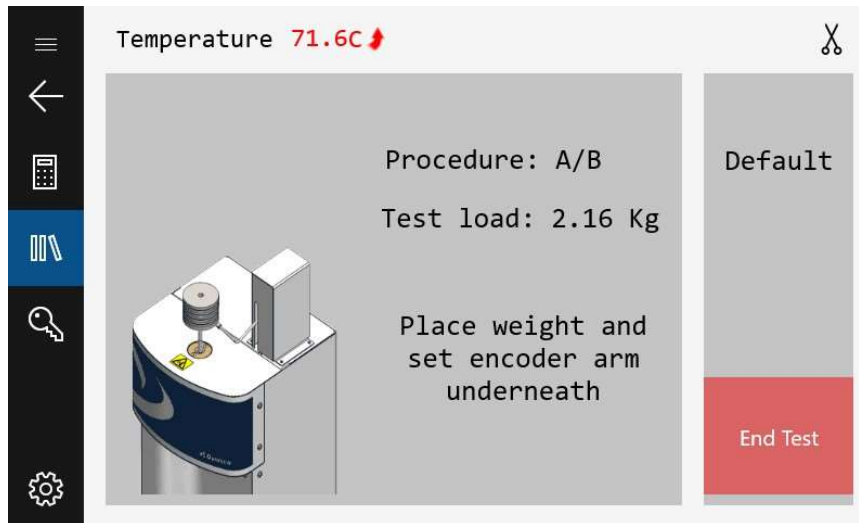
Once the LMI is at the setpoint temperature, a 15 minute count-down timer will start. *Ensure that the piston and die are in the unit.* After this timer expires, the LMI will be ready to load with material as shown below:

Loading the Sample

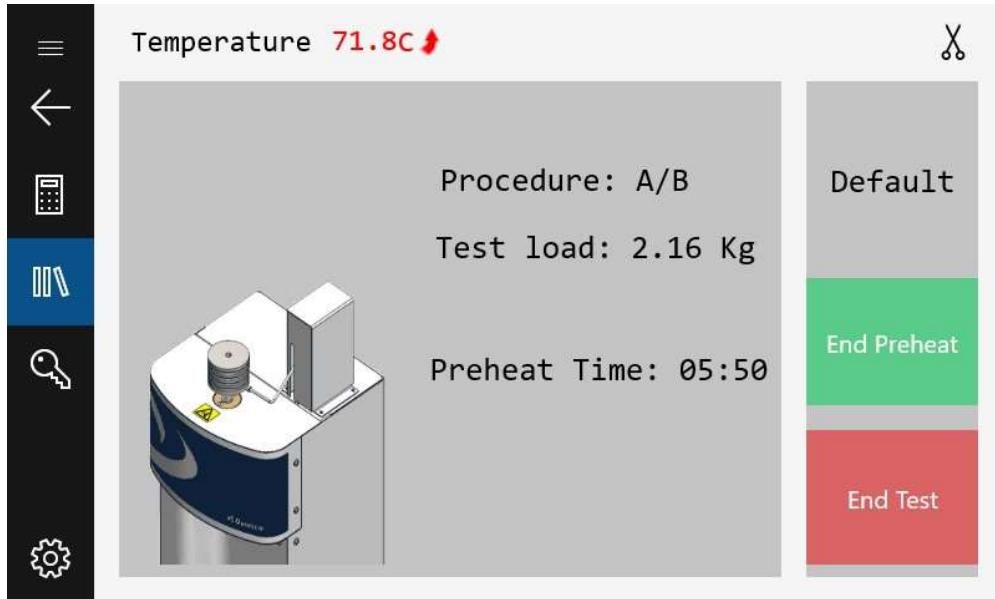
Load the sample as described in test techniques on page 33.



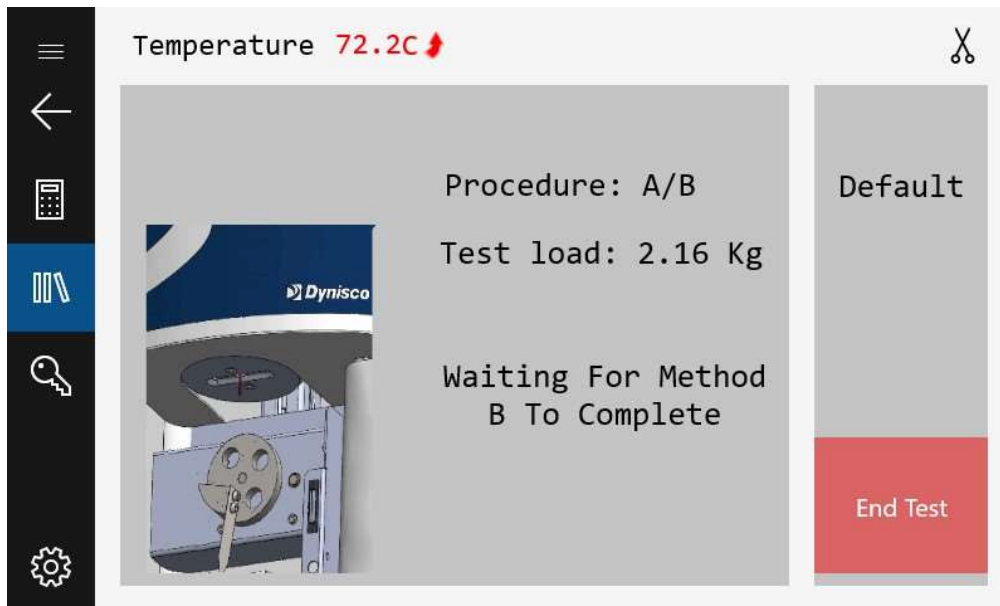
After loading the material, press the screen. The LMI will prompt you to insert the piston and add the weight to the LMI. The encoder arm must also be placed underneath the weight.



Press the screen again when loading is complete. The melt-time will be displayed on the screen as shown below:



After the Preheat time has expired, the LMI will prompt the user to cut the material if an Autocutter is not installed, otherwise the preheat extrudate will be cut automatically. If manually cutting the sample, press the screen as the extrudate is being cut.



Collect samples

A measurement may start when the 1st scribe mark has lined up with the top of the guide bushing. The run MUST start before the 2nd scribe mark lines up with the top of the guide bushing. After melt time (pre-heat) is completed, and after the piston lowers into the “run area” as denoted by the scribe marks on the piston assembly, the extrudate formed during preheat must be removed.

If an Autocutter is not installed the LMI will prompt the user to cut the material. If manually cutting the sample, you **MUST** touch the screen as the extrudate is being cut. It is critical that the cut and touch are simultaneous to get accurate timing.

With the Autocutter, the preheat extrudate will be cut automatically.

Discard the pre-heat extrudate.

See page 35 for more on how to cut extrudate.

Results

After the final cut has been performed and the piston has travelled the total distance required in the test, the results screen will appear. Note that there are two results screens, one displaying the A portion of the test and one displaying the B portion.

Weigh the samples

Weigh the sample and enter the weight in grams using the touch panel. (A precision balance is needed to obtain precise flow rate measurements) The flow rate will be immediately calculated and displayed. An extrudate weight of about 1.0 gram or more will reduce weighing errors, adjust the cut time as needed to get at least 0.5 grams of material. If the scale option has been purchased, the weights can be entered automatically. With the scale connected to USB, place the sample of the scale and wait until the measurement is stable. When stable, press the

Temperature 71.4C Default

Test Lot: Example 2 B Results

	Weight(g)	Time(s)	MFR(g/10min)	
Sample 1:	.504	10.1	30.1	<input checked="" type="checkbox"/>
Sample 2:	.522	10.1	31.1	<input checked="" type="checkbox"/>
Sample 3:	.506	10.1	30.1	<input checked="" type="checkbox"/>

MFR Average 30.4 Restart Test Send Data

MFR Stdev: 0.601

MFR Cov: 1.98 Reject Outliers

button is the upper right corner of the screen (the printed page icon). The scale will insert the weight into the currently selected text field.

When all the sample weights have been entered, the user has the option of restarting the test or saving the data. When the “Save Data” button is pressed, the data can go to up to two places. If a USB flash drive is attached to the LMI, a report will be generated and stored on the flash drive. If cloud connectivity is enabled, the data will also be sent to the cloud, accessible via Dynisco’s cloud platform. For instructions on setting up cloud connectivity, please see the Wi-Fi section of the manual on page 29.

Next perform the steps outlined in the section titled “AFTER A TEST” on page 69.

Press the restart test button to perform another test.

Temperature 71.3C		Default		
A Results		MVR	Melt Density	
	Length(mm)	Time(s)	(cm ³ /10min)	(g/cm ³)
Flag 1:	6.00	0.72	357.0	0.0841
Flag 2:	6.00	0.91	283.0	0.11
Flag 3:	6.00	1.04	249.0	0.121
Average		296.0	0.103	
Cov:		18.7	18.4	
Stdev:		55.4	0.0189	

Buttons: Restart Test, Send Data, Reject Outliers

The Method "B" Test

General Description

Method B is an assessment of a material's flow characteristics based on the volumetric displacement rather than weight of extrudate with time as in Method A. Unlike Method A, no cutting and weighing of the extrudate is required to perform a Method B test. Results from Method B test can be expressed directly as Melt Volumetric Flow Rate (MVR) in cc/10 min. To relate the results of a Method B run back to Method A, the apparent melt density must be known.

The determination of the apparent density is illustrated in the previous section using Method A/B. Without the apparent melt density MFR cannot be calculated using Method B. Some companies use MVR directly without ever determining MFR.

The piston's downward travel time is determined from a counter initiated by an optical sensor or digital encoder. The encoder system makes it possible to get as many as 15 results from one run.

Calculations: Method B

Flow rate for method B is computed as follows:

$$MVR\rho = MFR = \frac{\pi R^2 L\rho 600}{T}$$

Where R= radius piston (cm), T is time to traverse the distance L (sec), L =

length of flag (mm), ρ = apparent **melt** density of polymer (g/cc)

You should determine the melt densities for your material using your own melt indexer. Variations in technique and difference in material grades can cause differences from user to user. The following table of melt densities can be used as a general guide if you get values which differ by more than 10% from these chances are you are doing something incorrectly. Fillers, reinforcing agents etc. tend to increase the melt density of the material. Notice that apparent melt density is a function of temperature. In general, the solid-state density is a very poor estimate of the melt density and should not be used.

Some Typical Melt Densities

Temperature (Celsius):	LDPE:	HDPE:	Polybutene-1:	Polypropylene:
120	.797	-	.806	.880
130	.791	-	.800	.872
140	.785	-	.794	.864
150	.780	.780	.787	.852
160	.777	.777	.780	.840
170	.770	.770	.774	.819
180	.765	.765	.767	.758
190	.760	.760	.760	.754
200	.755	.755	.754	.750
210	.748	.748	.746	.746
220	.744	.738	.740	.742
230	.738	.738	.733	.738
240	.733	.733	.726	.734
250	.737	.727	.719	.730

Any inaccuracies in the melt density will be propagated proportionally along to the MFR values. Thus a 1% error in the melt density means a 1% accuracy error in the MFR the value.

Method B is an assessment of a material's flow characteristics based on the volumetric displacement rather than weight of extrudate with time as in Method A. Unlike Method A, no cutting and weighing of the extrudate is required to perform a Method B test. Results from Method B test can be expressed directly as Melt Volumetric Flow Rate (MVR) in ml/10 min. To relate the results of a Method B test to Method A, the apparent melt density must be known.

The determination of the apparent density is illustrated in the previous section using Method A/B. Without the apparent melt density MFR cannot be calculated using Method B. Some laboratories use MVR directly without ever determining MFR.

The piston's downward travel time is determined from a counter initiated by a digital encoder. The encoder senses distance travelled by following the bottom of the test weight(s) which are at the top of the piston. With all Dynisco Systems flags, Method A and B start in the same place. Flags may be any length desired and a test can have any number as long as the total distance of flags is no longer than the distance from the start point and where the piston would land on the top of the die ($\approx 25.4\text{mm}$). Recently, Method B has become the more common test because it is simpler to run (hands free after material load) and more precise for routine analysis. In addition, the encoder system makes it possible to get more from one run.

Calculations for the Method B test are as follows:

$$MVR\rho = MFR = \frac{\pi R^2 L \rho 600}{T}$$

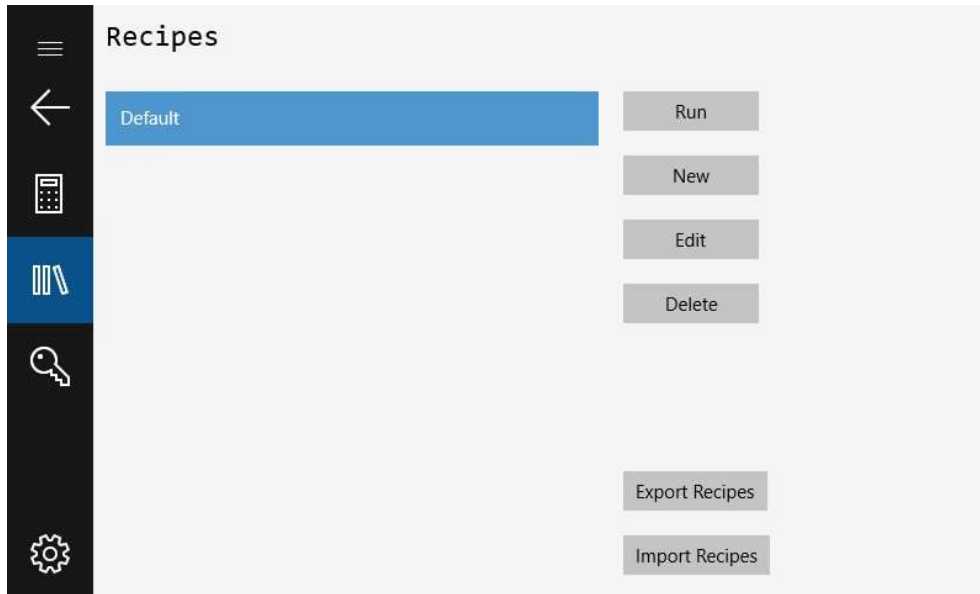
Where R= radius piston (cm), T (sec) is time to traverse the distance L, L= length of flag (mm), ρ = apparent melt density of polymer (g/cc).

You should determine the melt densities for your material using your melt indexer. Variations in technique and difference in material grades can cause differences from user to user. The table of melt densities can be used as a general guide if you get values which differ by more than 10% from these, most likely, something is being done incorrectly. Fillers, reinforcing agents etc. tend to increase the melt density of the material. Notice that apparent melt density is a function of temperature.

In general, the solid-state density is a very poor estimate of the melt density and should not be used.

Creating a Procedure B recipe

A test is performed by running a recipe. You must create a recipe if one doesn't already exist for the material to be tested. This is accomplished by pressing to go to the Recipe screen and pressing the "New" button



Upon pressing the "New" button the following screen will appear:

Recipe	Default	
Procedure	Procedure B	▼
Temp set point	190	C
Pre-heat time	360	s
MFI Low	0	g/10 min
MFI High	10	g/10 min
Load	2.16	kg
Number of flags	3	▼
Flag length	6	mm
Melt Density	0.5	g/cm ³
IV Offset	0	dl/g
Capillary Length	8	mm
Capillary Diameter	2.095	mm

These are the parameters that must be set:

Recipe – Name of recipe.

Procedure – Can be A, B or A/B – Configures type of test to be run.

Pre-heat time – Amount of time material must be at temperature before test can start. Generally, choose between 5 and 7 minutes based on your national standard for thermally stable materials.

MFI Low, MFI High – Limits that control the color that the MFI is displayed in on the results screen. Black is within the limits and red is outside the limits.

Load – The appropriate weight to be applied to the sample. The load is the combination of the piston and weight. (If an actual weight is used with the piston, remember to subtract the weight of the piston guide bushing.)

Number of Flags– The number of flags to be measured during the test. Valid range is 1-5.

Flag length – The distance interval over which the sample is timed.

Melt Density – Melt density of test material. Used in MFR calculation.

IV Offset – A value entered by the user to offset the IV measurement if desired

Capillary Length – Length of the capillary that is being used for the test

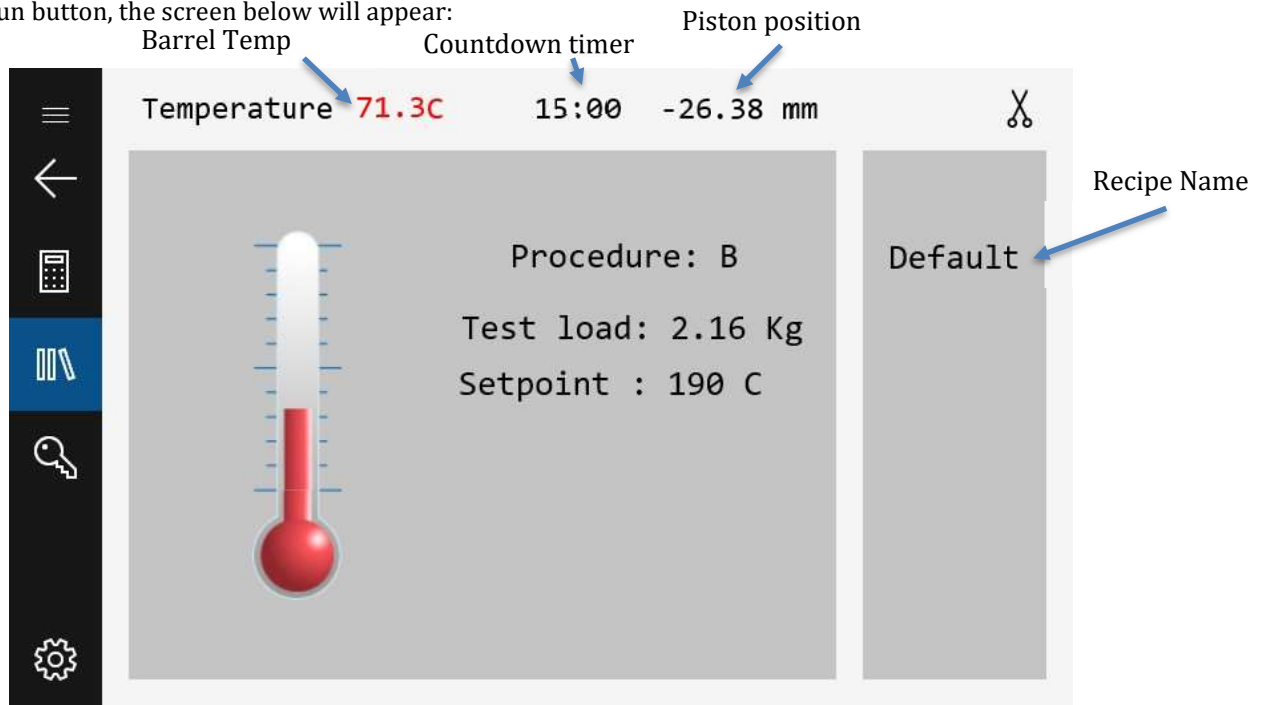
Capillary Diameter – Diameter of the capillary that is being used for the test

When all fields are complete, press the recipe button again to return to the main recipe screen. The LMI is now ready to run the test.

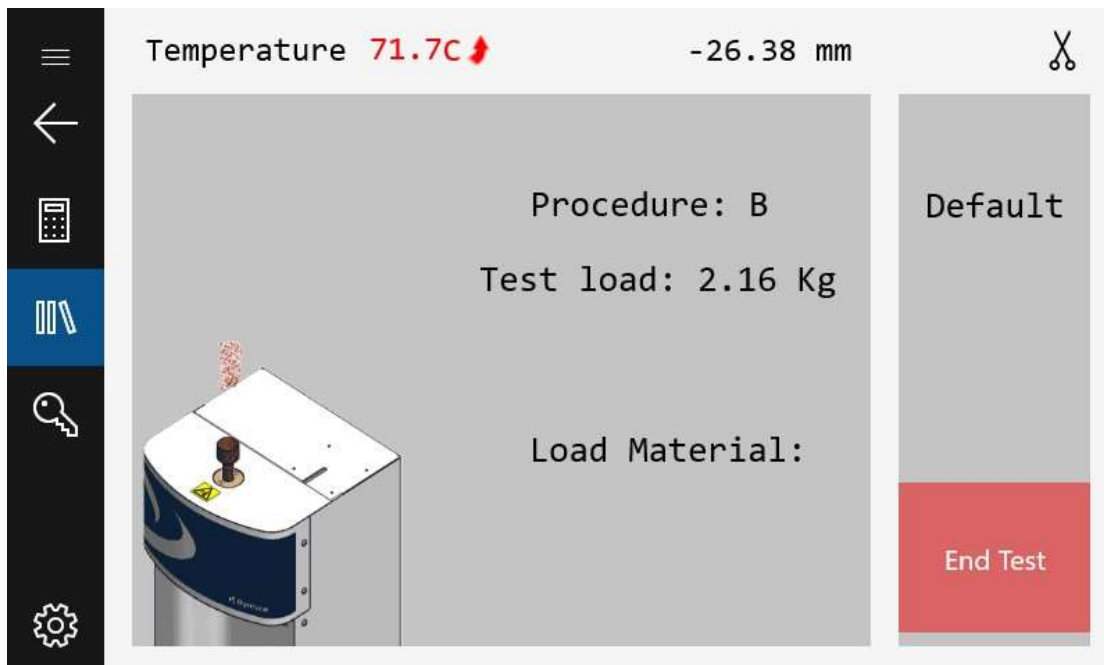
NOTE: When you turn on the machine, the last recipe run will be loaded into memory and the barrel will heat to its setpoint.

Starting the Test

Press the Run button, the screen below will appear:



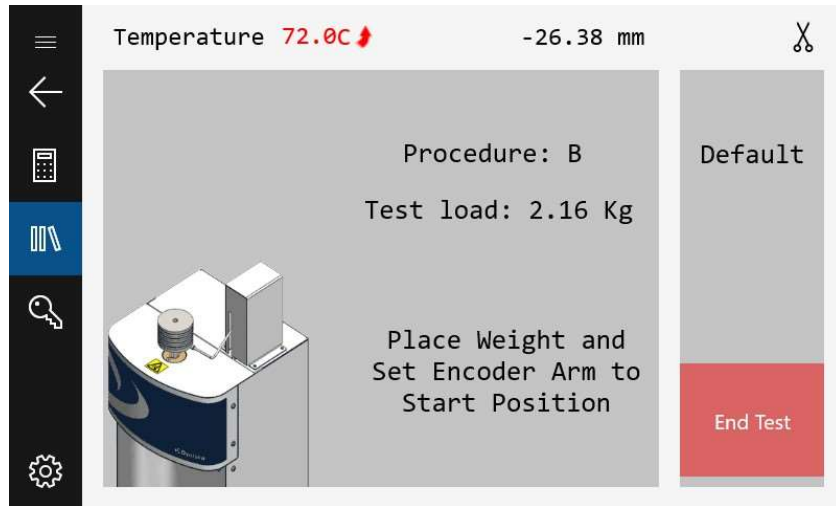
Once the LMI is at the setpoint temperature, a 15 minute count-down timer will start. *Ensure that the piston and die are in the unit.* After this timer expires, the LMI will be ready to load with material as shown below:



Loading the Sample

Load the sample as described in test techniques on page 33.

After loading the material, press the screen. The LMI will prompt you to insert the piston, add the weight to the LMI and place the encoder arm underneath the weight.



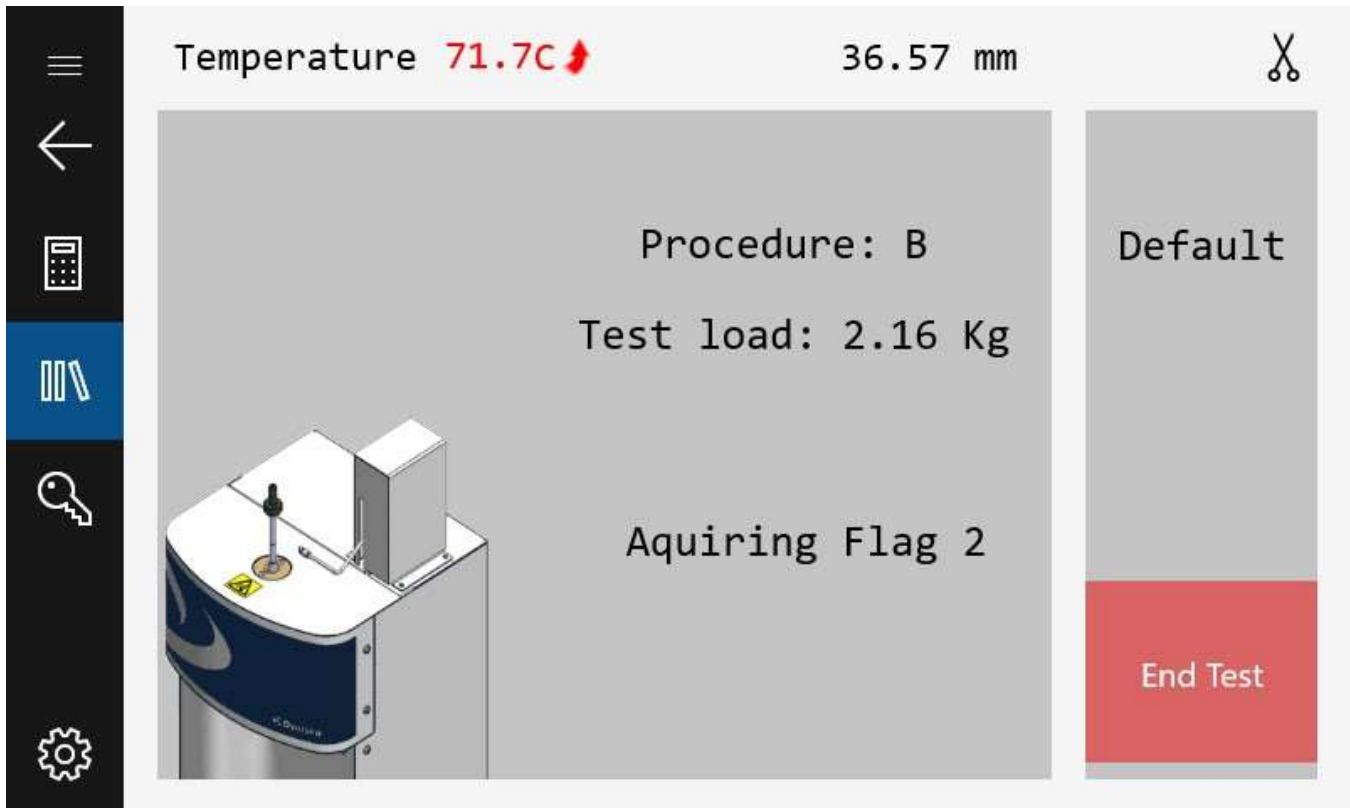
Preheat

Press the screen again when this is complete. The Preheat time will be displayed on the screen as shown below



Collect samples

Measurements will start when the 1st scribe mark has lined up with the top of the guide bushing.



For each flag length, the LMI will measure the sample time interval that has elapsed.

Results

After the final flag time has been captured, the results screen will appear:

Temperature 71.5C Default

Test Lot:	Length(mm)	Time(s)	MVR (cm ³ /10min)	MFR (g/10min)	
Example 3					
Flag 1:	6.00	0.94	275.0	137.0	<input checked="" type="checkbox"/>
Flag 2:	6.00	0.96	269.0	134.0	<input checked="" type="checkbox"/>
Flag 3:	6.00	1.13	229.0	114.0	<input checked="" type="checkbox"/>

<input type="button" value="Restart Test"/>	Average	257.0	129.0	
<input type="button" value="Send Data"/>	Cov:	9.63	9.63	<input type="button" value="Reject Outliers"/>
	Stdev:	24.8	12.4	

When the results screen is displayed, the user has the option of restarting the test or saving the data. When the “Save Data” button is pressed, the data can go to up to two places. If a USB flash drive is attached to the LMI, a report will be generated and stored on the flash drive. If cloud connectivity is enabled, the data will also be sent to the cloud, accessible via Dynisco’s cloud platform. For instructions on setting up cloud connectivity, please see the Wi-Fi section of the manual on page 29.

Next perform the steps outlined in the section titled “AFTER A TEST” on page 69.

Press the restart test button to perform another test.



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After a Test

Secure the Encoder arm

- Always place the encoder arm into the lowered and locked position before cleaning and the end of the day. This prevents damage and ensures that the encoder arm will be in the proper position upon power up.
- Never place any severe force against the side of the arm
- The real-time flow during the test is an approximate value and should not be used as an absolute value. Fractional flows below 1.0 MFI will appear to change by larger steps due to resolution of sample time.
- The encoder absolute resolution is 0.015 mm overall accuracy +/- 0.0254 mm.

Cleaning Up

Push down slowly on the weight and purge any material remaining in the barrel through the die and out of the barrel. Remove the piston rod by twisting it clockwise to break the seal created by the molten plastic then pull straight up.

Warning: If you pull the rod out too quickly you may cause a suction that pulls the die out along with the rod which may lead to a very hot die coming off and travelling through the air or onto the floor or some other undesired location.



While wearing protective gloves, wipe the piston rod with a cotton rag. Remove the die with the die removal tool. Put two cleaning patches directly over the barrel about 1/2 way overlapped and, using the cleaning tool, push the patch down into the barrel. Run the patch up and down several times and then repeat the process. A minimum of two sets of patches are generally needed to clean the barrel properly, however, some materials are harder to clean than others. Repeat the process until used patches come out clean.

When the system is clean, put the die and piston plunger back into the barrel. This allows the piston plunger and the die to reheat before the next test.

With materials that are thermally stable (less than 5% viscosity change over 1/2 hour of heat exposure) we recommend only cleaning the barrel between every second run. For materials that degrade or are moisture sensitive it is recommended that both the barrel and the die be cleaned completely between each test.

To clean the die, use the die removal rod and push the die up from the bottom of the barrel and out the top. Wipe it with a cotton rag and clean it by running the drill bit through it several times. Remove material that collects in the grooves of the drill bit and repeat until the drill passes easily through the die. Scrape the die with the sample cutting knife if needed to clean the top and bottom faces. For materials that crystallize quickly you can clean the die by first running a drill bit up into the die while it is hot and in the

indexer. This will make it much easier to get the cleaning drill bit inserted when the die is removed and the material starts to solidify.



Also, while the die is out of the barrel, look down the barrel bore to be sure it is clean (use safety glasses when looking down the barrel and beware of noxious fumes that may come from heated material inside!). Ensure the inside surface of the barrel is smooth and shiny when completely clean.

USER TIP: Experienced users often listen for a double bounce of the die when they drop it back into the barrel to know that the barrel is clean. If the barrel is dirty, the die hangs up and will not bounce when it hits the bottom of the barrel.



If you don't use gloves, you will eventually get burned.

If you are using PVC die (D3364 for unstable materials), be sure to get the material out of the conical top section. Standard dies have a flat entrance and exit.

When the die is out of the barrel it cools down quickly. The longer it is out, the longer the wait for the temperature to stabilize will be. Minimizing the time the die stays out of the machine will increase the number of tests you can run in a given time interval. When the temperature on the front display is within 0.2 C of the set point, you can begin the next test. Loading material will cause a small temperature to change even if the temperature set point is locked in. A sufficient melt time, (360 seconds, for example) will allow ample time to get the temperature to the set point and stabilize before the first data point is collected.

Always leave the machine clean. If it is going to sit at room temperature for an extended period of time, you may wish to coat the barrel with a light machine oil to prevent rusting. The oil will need to be cleaned with cleaning patches from the machine before accurate data can be obtained.



Warning: Do not heat the barrel back to elevated temperatures before cleaning the machine oil from the barrel. Noxious fumes and/or fire hazard exists if not cleaned.

For materials that are extremely hard to clean (Polystyrene, EVA and elastomers, etc.) solvents may be required. Never use flammable solvents on a HOT barrel. In general, however, DYNISCO does not recommend using solvents for health, safety, and environmental reasons.

Cleaning Up a really Big Mess

Oven cleaner (Easy-Off) sprayed onto a **cold** plunger and left overnight will do an excellent job of cleaning degraded material off of the shaft, the outside of the die and the die retainer plate. Be careful not to inhale oven cleaner vapors.

Maintenance and Servicing

Dynisco certifies that at the time of shipment this instrument met all dimensional, temperature control and performance specifications of the applicable local standard that was specified at time of order (such as ASTM D1238.)

Dynisco recommends verification of calibration at least once a year to ensure that the instrument continues to meet the standard. Contact Dynisco's Field Service Department at (508) 541-9400 or contact your local Sales & Service Representative to schedule an appointment.

Instrument Maintenance Recommendations

Daily: Remove the orifice and clean thoroughly with brush and precision drill bit. Clean your indexer barrel with cotton patches when hot. Piston should spin easily when placed into a clean barrel.

Weekly: Give it a good cleaning with a brass brush. Use oven cleaner to clean the piston rod exposed metal and orifice.

Monthly or Long Term: Depending on your company policy, a calibration or calibration check may be needed on a monthly, quarterly or yearly basis. It is recommended that a repetitive maintenance schedule be created for your instrument.

Clean unit: Clean the dust and dirt with clean air every six months to one year, more often in dirty environments. Remove the orifice and clean thoroughly. Clean your barrel. Use oven cleaner to clean the piston rod assembly and orifice.

Check Mechanical Tolerances: All dimensions and tolerances per ASTM D1238 and ISO 1133-1. Piston tip diameter = 0.3730"/9.474mm +/-0.0003"/0.0076mm; piston tip length = 0.2500"/6.35mm +/- 0.0050"/0.127mm. Assembled piston rod weighs 100 grams. GO/NO-GO gage works properly on the orifice. Orifice length = 0.3150"/8mm +/- 0.0010"/0.0254mm. Weights still weigh correctly. Digital Encoder calibration. Gages can be purchased from Dynisco.

Barrel Diameter: Once the barrel is extremely clean, all dimensional measurements are to be made at room temperature it can be checked using a bore gage. Gage can be purchased from Dynisco. At the time of manufacture, the barrel center bore measures 0.3760"/9.55mm +/- 0.0002"/0.00508mm. All dimensions and tolerances per ASTM D1238 and ISO 1133-1.



Ask for help: Call Dynisco directly at (508) 541-9400 or visit www.dynisco.com and ask for technical support. To help us handle your questions as quickly as possible, have the following items ready before you call:

1. Instrument name and model number (on back panel)
2. Instrument serial number (on back panel)
3. Current version of instrument software and firmware (See page 26 for retrieving this information).

If you n

Spares/Consumable

Item:	Part No.	Qty. (Each):
Orifice Insulator, Mica (lower)	0051-14MA	1
Screws for Lower Insulator	S0980	2
Piston Assy (Piston, Rod, Insulator, Bushing)	0051-30	1
Die Removal Tool	0051-35	1
Polymer Packing Hand Tool	0051-36	1
Orifice Cleaning Drill with Pin Vise	0051-38	1
Orifice Cleaning Drills (#45)	0051-39	1
Barrel Cleaning Tool (Used with Patches)	0051-40	1
Piston Tip	0051-41	1
Piston Tip, Hastelloy	0051-41H	1
Piston Rod Insulator without spoke	0051-42	1
Piston Rod Insulator with spoke	0051-42A	1
Piston Rod Only	0051-43	1
Piston Guide Bushing	0051-44	1
Fill Funnel	0051-45	1
Orifice (D1238 Tungsten Carbide) Standard 8mm Height	0051-46	1
Orifice (D1238 Hastelloy)	0051-46H	1
Die/Orifice (Half-Die 4mm Height Half Diameter)	0051-46S	1
Orifice (D1238 Stainless Steel)	0051-46SS	1
Orifice (D3364, Tungsten Carbide for PVC (vinyl))	0051-46V	1
Bronze Brush Rod (Handle)	0051-47	1
Knife, Palette (For Cutting- Method A)	0051-53	1

Item:	Part No.	Qty. (Each):
Level	0051-54	1
Go/No-Go Gauge	0051-55	1
Funnel, Polymer Charging	0051-80	1
Fill Funnel (Nitrogen Purge)	0051-80NP	1
High Flow Melt Plug	0051-83	1
Mirror, LMI 5500	1196030	1
Fuse, 3A	1196051	1
Insulator, Top Mica (Die Entry Point)	4051-20MA	1
Screws for Top Insulator	AS490	2
Tool Rack	6052-16	1
Piston Assembly (Tip, Piston, Weight Top)	7051-72	1
Piston Assy (Digital Encoder) Piston, Rod, Insulator, Bushing	7051-72	1
Barrel Cleaning Brush	B0555	1
Barrel Cleaning Patches	GP0103	1 BAG (1000ea)
Barrel Cleaning Patches	GP0104	1 BAG (100ea)
Loading Beaker	GP0300	1
Orifice Cleaning Brush	GP0310	1

Support Vendors

1. NIST Standard Reference Materials (SRM)

For example: Standard Material 1476 is a branched polyethylene with a MFR of 1.19 ± 0.01 . As of 2013, cost was \$870/US for 12 grams.

2. Mercury (Hg) spill kits

Mercury Clean Up Spill Kits

Mercon Products: distributed by Fisher Scientific Unit 8, 7551 Vantage Way
Delta, B.C. Canada V4G 1C9 Tech Assistance (800)926-8999
(604) 940-0975 or call Fisher Scientific

3. PRINCO Instruments Inc. (Accepts Standards Hg for Recycle)

1020 Industrial Highway
Southampton, PA 18966
(215) 355-1500

Troubleshooting

Getting wrong or non-repeatable test values:

- Was the instrument clean?
- Check Die (clean, diameter length OK?)
- If running a method B test, is density value correct?
- Check tip diameter (> 0.3727)
- Is the machine level?
- Is Annual calibration due?
- Check weights used +/- 0.5%
- Check balance/scale used to weigh extrudate
- Is the Piston Rod bent?
- Does the die actually get to bottom of barrel when it is inserted?
- When manually cutting a sample, ensure to synchronize tapping the screen with making the cut.

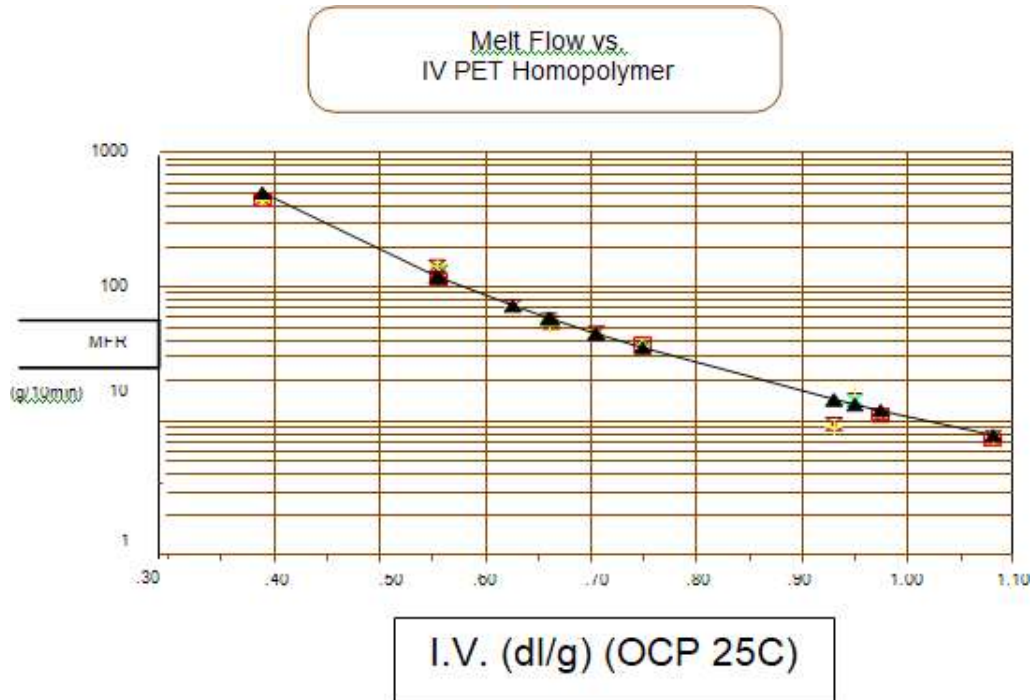
Autocutter does not operate:

- Is the door shut?
- Is the Autocutter enabled in the machine settings?
- If it is making a noise and jammed with the blade against the barrel:
 - Has the material been qualified to cut with the cutter?
 - Is the blade properly adjusted? (Adjust the screws that secure the blade to the wheel.)
- If it is making noise when the blade is not in contact with the barrel then the gears might be binding, contact Dynisco field service.
- If you wish to cut manually and the LMI doesn't prompt you, verify that the Autocutter is disabled on the Machine settings screen. (See page 27)

Intrinsic Viscosity

Calculating PET Intrinsic Viscosity (I.V.) from the Melt Indexer

This feature allows the Melt Indexer to correlate Melt Flow Rate (g/10 min.) to Intrinsic Viscosity (dl/g). Intrinsic Viscosity (IV, ASTM D3835) is a “wet chemistry” technique used to assess the specific volume of an isolated polymer chain, when dissolved in a good solvent. This value is directly related to the molecular weight of the polymer. Melt Viscosity or MFI measurement is another, empirical (non-absolute like I.V.), way to assess molecular weight. Melt Viscosity and Intrinsic Viscosity are related in such a way that IV can be directly calculated from Melt Index values. This is described in greater detail in the applications brief, “Correlating Melt Rheology of PET to Solution Intrinsic Viscosity” by J. Reilly and P.Limbach, available from DYNISCO on request.



Glossary of Terms

Die/Orifice/Capillary	A metal item with an opening of typically around 2 mm diameter that is inserted into the apparatus.
Digital Flag/Digital Encoder	A device used to measure piston travel.
Firmware	Software embedded into the instrument's hardware. Sometimes you may receive firmware upgrades.
Flow Rate	A measure of polymer's mass flow rate (grams extruded in 10 minutes) using a particular orifice under specified conditions of temperature and load.
Intrinsic Viscosity	Often used in process and quality control for specification of polymers such as PVC, nylon and PETA, I.V. is a theoretical reduced or inherent viscosity achieved when the concentration of polymer in a polymer-solvent solution approaches zero. (It is related to the size of the molecules and thus to their molecular weight.)
Melt Flow Indexer	An instrument used to perform ASTM D-1238 testing of molten plastics and other polymers.
Melt Density	The density of the polymer in the molten state. It is not the same as the standard or bulk density that is typically reported on polymer data sheets.
Method A	Measurement of the amount of extrudate accumulated for a given amount of time. The test is completely manual and is sometimes called the "cut-n-weigh" Method.



Method A/B	This test measure the amount of material extruded over time and volume extruded over a distance. A means of measuring travel is employed. To run a method B test, an A/B run MUST be run first to determine the polymer’s melt density.
Method B	Measurement of the volume of material that extrudes over time. Can be conducted only after an A/B experiment is conducted. This is a “no-cuts,” automated test that is the most convenient for busy laboratories.
MVI	Material is forced through an orifice at a specific temperature using a specific weight. The volume extruded in a 10-minute period is an MVI, in cm/10 min.
Optical Flag or Optical Eye Sensor	A component used to measure the amount of time it takes the piston rod to travel a certain distance.
Pneumatic Lift	An optional system allowing the user to automatically raise and lower weights onto the piston rod. Requires 70 psi shop air.
RTD	(Resistance Temperature Detector) A component that senses temperature and changes in temperature.
Timing Flag	A device that the optical eye uses to measure distance and time.

APPENDIX I

TEST CONDITIONS FOR EXTRUSION PLASTOMETER (MELT INDEXER)

Polymer Type	ASTM Conditions per ASTM D1238 *	REQUIRED WEIGHTS & ITEMS **
Acetals	(190/2.16) and (190/1.05)	950 gm (WT950P) and 2060 gm (WT2060P)
Acrylics	(230/1.2) and (230/3.8)	1100 gm (WT1100P), 3700 gm (WT3700P)
Acrylonitrile Butadiene Styrene - (ABS)	(200/5.0), (230/3.8) and (220/10)	3700 gm (WT3700P), 4900 gm (WT4900L), 5000 gm (WT5000L)
ABS/PC Blends	(230/3.8), (250/1.2), (265/3.8) and (265/5.0)	1100 gm (WT1100P), 3700 gm (WT3700P) and 4900 gm (WT4900L)
Cellulose Esters	(190/0.325), (190/2.16), (190/21.6) and (210/2.16)	225 gm (WT225P), 2060 gm (WT2060P), 4900 gm (WT4900L), 16600 gm (WT16600L)
Fluoroplastic (E-CTFE) per ASTM D3275	(271.5/2.16)	2060 gm (WT2060P), Corrosion resistant hastelloy barrel (4051-25HA), Hastelloy Piston Tip (0051-41H) and Hastelloy Orifice 0.0825" ID x 0.315" long (0051-46H)
Fluoropolymer (ETFE) Types I, II and III per ASTM D3159	(297/5.0)	4900 gm (WT4900L), Corrosion resistant hastelloy barrel (4051-25HA), Hastelloy Piston Tip (0051-41H) and Hastelloy Orifice 0.0825" ID x 0.315" long (0051-46H)
Nylon	(275/0.325), (235/1.0), (235/2.16), (235/5.0) and (275/5.0)	225 gm (WT225P), 900 gm (WT900P), 2060 gm (WT2060P) and 4900 gm (WT4900L)
(FEP) Fluorocarbon per ASTM D2116	(375/5.0)	4900 gm (WT4900L), Corrosion resistant hastelloy barrel (4051-25HA), Hastelloy Piston Tip (0051-41H) and Hastelloy Orifice 0.0825" ID x 0.315" long (0051-46H)
Fluorocarbon (PFA) per ASTM D3307	(372/5.0)	4900 gm (WT4900L), Corrosion resistant hastelloy barrel (4051-25HA), Hastelloy Piston Tip (0051-41H) and Hastelloy Orifice 0.0825" ID x 0.315" long (0051-46H)
Polychlorotrifluoroethylene	(265/12.5)	(3700 gm (WT3700P) X 2) + 5000 gm (WT5000L), Corrosion resistant hastelloy barrel (4051-25HA), Hastelloy Piston Tip (0051-41H) and Hastelloy Orifice 0.0825" ID x 0.315" long (0051-46H)
Polyethylene	(125/0.325), (125/2.16), (190/0.325), (190/2.16), (190/21.6) and (190/10.0)	225 gm (WT225P), 2060 gm (WT2060P), 4900 gm (WT4900L), 5000 gm (WT5000L), 16600 gm (WT16600L)
Additional Items for use with special Polyethylene	(310/12.5)	(3700 gm (WT3700P) X 2) + 5000 gm (WT5000L)
Polycarbonate	(300/1.2)	1100 gm (WT1100P)
Polymonochlorotrifluoroethylene	(265/21.6)	4900 gm (WT4900L) and 16600 gm (W16600L), Corrosion resistant Hastelloy barrel (p/n 4051-25HA), Hastelloy Piston Tip (0051-41H) and Hastelloy Orifice 0.0825" ID x 0.315" long (0051-46H)
Polypropylene	(230/2.16)	2060 gm (WT2060P)
Polystyrene	(200/5.0), (230/1.2), (230/3.8) and (190/5.0)	4900 gm (WT4900L), 1100 gm (WT1100P), 3700 gm (WT3700P)
Polyvinyl acetal	(150/21.6)	4900 gm (WT4900L) and 16600 gm (W16600L)
Polyvinylidene fluoride	(230/21.6) and (230/5.0)	4900 gm (WT4900L), 16600 gm (WT16600L), Corrosion resistant Hastelloy barrel (4051-25HA), Hastelloy Piston Tip (0051-41H) and Hastelloy Orifice 0.0825" ID x 0.315" long (0051-46H)

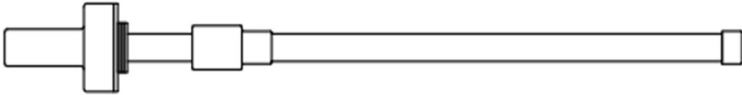

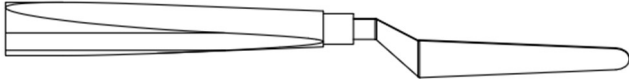

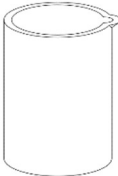
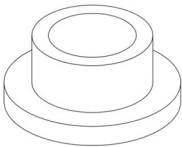
Polyphenylene-sulphide	(315/5.0)	4900 gm (WT4900L)
Styrene-Acrylonitrile (SAN)	(230/3.8), (220/10) and (230/10)	1600 gm (WT1600L), 3700 gm (WT3700P), 4900 gm (WT4900L), 5000 gm (WT5000L)
Styrenic Thermoplastic Elastomer	(190/2.16) and (200/5.0)	2060 gm (WT2060P), 4900 gm (WT4900L)
Thermoplastic Elastomer Ether-Ester (TEEE)	(190/2.16), (220/2.16), (230/2.16), (240/2.16) and (250/2.16)	2060 gm (WT2060P), 400 gm (WT400P)
Thermoplastic Elastomers (TEO)	(230/2.16)	2060 gm (WT2060P)
Vinylidene Fluoride Copolymers	(230/21.6), (230/5.0), (120/5.0) and (120/21.6)	4900 gm (WT4900L), 16600 gm (WT16600L), 5000 gm (WT5000L), Corrosion resistant hastelloy barrel (4051-25HA), Hastelloy Piston Tip (0051-41H) and Hastelloy Orifice 0.0825" ID x 0.315" long (0051-46H)

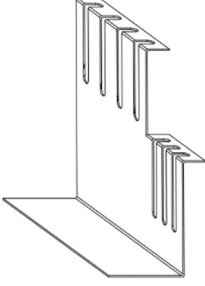


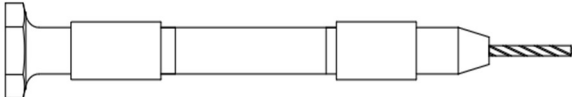

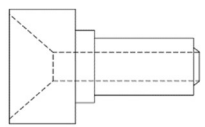
NOTE * ASTM Conditions above are identified by the currently recommended temperature in degrees Celsius, and load in Kg (designations are listed in parentheses). NOTE ** Dynisco part numbers for Required Weights & Items are listed in parentheses

Polymer Type	ASTM Conditions Other Than ASTM D 1238	
Polyvinylchloride (PVC) per ASTM D3365 for non-rigid and semi-rigid	(175/5.0) and (175/20.0)	4900 gm (WT4900L), 5000 gm (WT5000L)
Additional items for use with rigid PVC	(190/21.6)	4900 gm (WT4900L), 16600 gm (WT16600L)
Polybutylene (PB) per ASTM D2581	(190/2.16)	2060 gm (WT2060P)
Thermoplastic Polyester (PBT + PET, PBT + TEEE) per ASTM D5927	(240/2.16), (250/2.16), (250/5.0) and (285/2.16)	2060 gm (WT2060P), 4900 gm (WT4900L)
Polyether-imide (PEI) per ASTM D5205	(295/6.7), (337/6.7) and (367/6.7)	1600 gm (WT1600L), 5000 gm (WT5000L)
Polymethyl Methacrylate (PMMA) per ASTM D788	(230/3.8)	3700 gm (WT3700P)
Polyketone (PK) per ASTM D5990	(240/2.16)	2060 gm (WT2060P)

NOTE: Conditions above are identified by the currently recommended temperature in degrees Celsius, and load, in Kg (designations are listed in parentheses) NOTE: In cases where more than one condition is listed for a polymer type not all conditions may be required for testing a particular grade of that polymer. Consult the material specification sheet or your supplier to determine the applicable test conditions for your specific material.

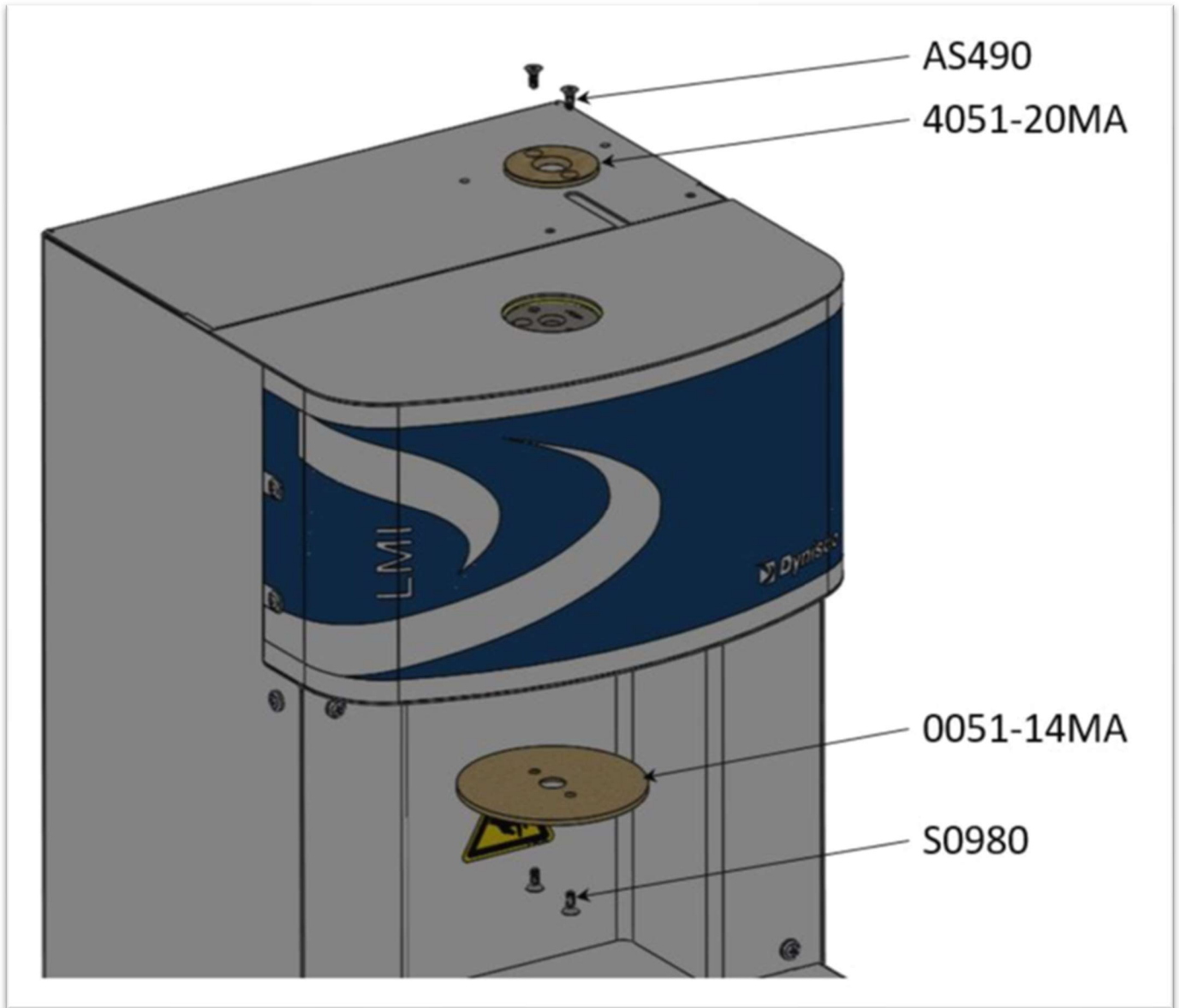
APPENDIX II

	PISTON ASSY 0051-30
	PATCH CLEANING ROD 0051-40
	PALLETTE KNIFE 0051-53
	CARBIDE ORIFICE 0051-46
	BEAKER GP0300
	LEVEL 0051-54

	TOOL RACK 6052-16
	GO/NO GO GAGE 0051-55
	ORIFICE REMOVER 0051-35
	PIN VISE 0051-38
	CLEANING ROD w/ BRUSH & HANDLE 0051-47
	FILL FUNNEL 0051-45

APPENDIX III

Replacement Mica Insulators;[



CAUTION: Parts identified above can be replaced by user. First turn off unit, disconnect power and allow unit to cool to room temperature before replacing.