

# MFI 10 Melt Flow Indexer

## User Manual



## **WARRANTY**

This instrument is warranted against defects in workmanship, material and design for one (1) year from date of delivery to the extent that AMETEK will, at its sole option, repair or replace the instrument or any part thereof which is defective, provided, however, that this warranty shall not apply to instruments subjected to tampering or, abuse, or exposed to highly corrosive conditions.

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This warranty is voidable if the purchaser fails to follow any and all instructions, warnings or cautions in the instrument's Instruction Manual.

If a manufacturing defect is found, AMETEK will replace or repair the instrument or replace any defective part thereof without charge; however, AMETEK's obligation hereunder does not include the cost of transportation, which must be borne by the customer. AMETEK assumes no responsibility for damage in transit, and any claims for such damage should be presented to the carrier by the purchaser.

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## ICONS



### **WARNING**

The raised hand icon warns of a situation or condition that may lead to personal injury or death. Do not proceed until the warning is read and thoroughly understood. Warning messages are shown in bold type.



### **DANGEROUS VOLTAGE**

The lightning icon warns of the presence of an uninsulated dangerous voltage within the product enclosure that might be of sufficient magnitude to cause serious shocks or death. Never open the enclosures unless you are an authorized and qualified LLOYD INSTRUMENTS' service personnel. Never open any enclosure when power is connected to the system or its components.



### **CAUTION**

The exclamation point icon indicates a situation or condition that may lead to equipment malfunction or damage. Do not proceed until the caution message is read and thoroughly understood. Caution messages are shown in bold type.



### **NOTE**

The note icon indicates additional or supplementary information about the action, activity or concept. Notes are shown in bold type.

## CAUTION

**HIGH TEMPERATURES AND MOLTEN PLASTIC ARE INVOLVED IN THE MFI PROCESSES.**

**ALL SPECIFIED SAFETY PROCEDURES SHOULD BE STRICTLY ADHERED TO.**

**READ THIS MANUAL BEFORE USING THE MFI MODEL 10.**

**THE THERMOMETER(S) SUPPLIED ARE GLASS AND CONTAIN MERCURY, PLEASE STUDY SECTION 8 OF THIS MANUAL.**

**BEFORE USING THE MATERIALS TESTING MACHINE.**

### **General Safety**

General safety precautions must be followed when using this LLOYD INSTRUMENTS product. Failure to observe precautions and warnings may result in damage to the equipment, or injury to personnel.

It is understood that safety rules within companies vary. If a conflict exists between the material contained in all LLOYD INSTRUMENTS' User's Guides and the rules of a company using a LLOYD INSTRUMENTS product, the more stringent rules should take precedence.

### **Safety Considerations**

The MFI 10 is completely enclosed and provides no potentially hazardous outputs. Safety considerations are related to the power connections and physical mountings.

Electronic and mechanical components housed within the MFI 10 covers are to be serviced by authorized LLOYD INSTRUMENTS' representatives only.

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## 1.0 INTRODUCTION TO MELT FLOW INDEXING

### 1.1 MELT FLOW RATE

The melt flow rate (MFR) of a thermoplastic material is the measured gravimetric flow of the sample extruded through a die following specified conditions of die length, diameter, temperature and pressure. Different standardised conditions of extrusion temperatures and pressures are used for different types of polymer but, for the purpose of comparison, samples of the same type of polymer should be tested under identical conditions.

The MFI Apparatus may be regarded as a rheometer operating at conditions of low shear. Although the shear stresses applied and the resultant shear rates are much lower than those used in the processes, the results obtained do provide a useful indication as to the relative ease with which different materials will flow when processed. Since higher MFR values indicate easier melt flow, a grade of polymer with a high MFR is generally chosen when the process envisaged involves relatively high rates of shear, i.e. injection moulding. MFR is also a measure of the molecular weight of a sample and is indicative of the mechanical strength of a material. Average molecular weight and MFR are indirectly proportional, so that, although a sample of high MFR will process more readily, its melt strength is likely to be low.

### 1.2 OTHER APPLICATIONS OF THE APPARATUS

In addition to determining the MFR, the apparatus can be used to measure other properties of the polymer providing useful knowledge of its behavior. By performing the MFR test under two or more different loads, useful information about the rheological properties of the material can be found. It could be wrongly assumed that two polymer samples with the same MFR will behave in the same way with respect to output (shear rate) when tested under the same conditions. When subjected to the higher pressures (shear stress) required for a moulding or extrusion process, they could perform quite differently. If the samples have different Molecular Weight Distributions (MWD) the increase in the shear rate resulting from an identical increase in shear stress will be different as well. In general, a



*MFI 10 Melt Flow Indexing Machine*

large MWD corresponds with a greater shear sensitivity, i.e. a higher rate of change in shear rate per unit increase in shear stress. A useful measure of the shear stress/shear rate relationship (flow parameter) can be made by measuring the samples MFR at standard load and at a higher load. Increasing the test load (for polyethylene's) from the standard 2.16kg to 21.6kg loads, increases the level of shear rate by factor between 50 and 100:1, depending on the MWD of the sample and the simple arithmetic ratio.  $MFR\ 21.6kg/MFR\ 2.16kg$  gives a measure of the flow parameters.

Depending on the MFRs at 2.16kg load, the value at 21.6kg can be equivalent to shear rates more than 100 secs<sup>-1</sup> coming, possibly, into the range of extrusion processes. The facility also exists to measure flow parameters at different temperatures giving an insight as to the temperature sensitivity of the sample.

The extrudate generated during the test can also be used to determine other useful parameters of the sample. The emerging sample temperature and the die diameter are known and its rate of cooling and ambient temperature gives "controlled" conditions and is therefore repeatable. Two important properties can be measured more conveniently and with greater precision from the Melt Flow Indexer than from commercial processing equipment. These are Die Swell and Draw Down.

### 1.3 DIE SWELL

Die Swell or swelling ratio, is an arithmetic ratio between the diameter of the cooled extrudate at ambient temperature and the diameter of the die. This is an important factor for processes such as pipe extrusion and blow moulding.

### 1.4 DRAW DOWN

Draw Down is the extending of the polymer extrudate by its own weight as the extrudate lengthens. It is, for example, a requirement of a polymer to have good draw characteristics in the blown moulding process so that a good parison is produced.

Because the Die Swell and Draw Down depend on an accurate measurement of the extrudate, it is important that the cross section should be as circular as possible. The most common cause of irregular cross section circularity is draught, causing asymmetric cooling, the equipment should be placed as far away as possible from any draught source.

Process	Desired Characteristic	Molecular Design
Blow Moulding	High Melt Strength	Low MFR
Film Blowing		Broad molecular weight distribution
Thermoforming		
Extrusion	Low Die Swell	Narrow molecular weight distribution
Injection Moulding	Easy Flow	Medium to High MFR
	Moderate Temperatures	Narrow molecular weight distribution
	Rapid Cycles	

## 2.0 THE MFI 10

The Melt Flow Rate apparatus has been designed in accordance with ISO 1133 and ASTM D1238 (Method B requires the Displacement Transducer, AFRT). ISO 1133 now supersedes all European Standards such as DIN 53735 (Germany), NF: 51-106 (France), UNI 5640-74 (Italy) UNE 53098 (Spain). The apparatus is a dead weight extrusion plastometer with a microprocessor controlled melt chamber (the barrel) in which, under standard set conditions, the test sample of polymer is heated and extruded through a die with a known load. All component parts to perform the tests are calibrated within stringent limits required by the above standards.

There are two tests; the manual cut-off (Procedure A) is suitable for materials with an MFR between 0.1 and 25g/10mins or for comparison of filled and unfilled polymers. The automatic method (Procedure B) requires that the melt density either be known or calculated using the "calculate" option in the embedded software. The AFRT automatically allows the flow rate to be measured and is suitable for flow rates between 0.5 and 900g/10mins. (according to ASTM but only 100g/10mins according to ISO 1133).

### 2.1 THE BARREL (OR CYLINDER)

The barrel is a steel cylinder, 50.8mm diameter and 162mm long, through which a smooth, straight hole 9.55mm diameter has been bored and honed. The barrel is encased in a double layer of insulating material and the whole is housed in a sheet metal case.

### 2.2 THE HEATER

The barrel is heated by three cartridge heaters equally spaced around the central bore. Great care is taken to ensure that all our barrel assemblies are produced to close tolerances to give the best heat distribution and temperature stability.

### **2.3 TEMPERATURE CONTROLLER**

The temperature of the barrel is controlled by means of a platinum resistance thermometer (PT100) in conjunction with a micro processor based, three term temperature controller. This enables the operator to select any temperature within a standard range of 40-400°C which will be accurately held to +0.1°C. The selection and adjustment of the barrel temperature forms part of the test set-up which is entered from the console and saved when the machine is switched off.

### **2.4 INDICATING THERMOMETER**

Indicating thermometers used for testing to standardised conditions are calibrated over a range of 4°C in steps of 0.1° C, For example, an indicating thermometer for use at the standard test temperature of 190° C is graduated from 188° C to 192° C.

A standard range of these thermometers is available covering all the standard test temperatures laid down in ISO 1133 and ASTM D1238. Long range thermometers can also be supplied covering the working, range of 100° C to 300°C in three equal, 70° x 1.0°, overlapping ranges, 100 - 170°C, 165 - 235°C and 230 - 300°C.

### **2.5 THE DIE**

Made of tungsten carbide, these conform precisely to standard dimensions; 8mm long, 9.47mm overall diameter, bore diameter 2.095mm. The bore is very highly finished and is tested to tolerances well inside the closest called for in any published standard, particularly with regard to bell-mouthing. The alternative standard die called for in BS 2782 method 105C (as jet B) with a bore diameter of 1.181mm, is also available on request as an extra. Please note that this is no longer called for in the Method 720A which replaces 105C, or in ISO 1133 which replaces the BS Standard, or the ASTM Standard. However it is still in use for polymers with exceptionally high flow rates.

### **2.6 THE DIE PLATE**

The die plate supports the die and is held in place underneath the barrel by three socket head screws. The die plate is a piece of circular steel with three keyhole slots and a larger round hole in the middle into which the ceramic insert is placed. The non-stick PTFE coating assist with cleaning, and a ceramic insert withstands high temperatures and provide a rigid flat surface for the die to sit on. The ceramic insert sits slightly proud of the die plate in contact with the die and bottom of the barrel. This concave underside enables the cut-off knife to cut the extrudate right up to the base of the die.

Insert screws to about half their length so that the die plate may be pushed up to the bottom of the barrel and turned 10° to the engaged position. Do not over tighten the screws; it should be possible to engage and remove the die plate without adjusting the screws and still have a tight fit between the ceramic insert and the bottom of the die.

### **2.7 THE PISTON**

There are two pistons, the standard version for use with weights up to 10 kg and one with guide bush fitted for weights of 10kg and above. The guide bush is a metal tapered collar which slides up and down the shank of the piston and provides extra rigidity with higher loads to prevent vectored loads. The standard piston weighs 100g.

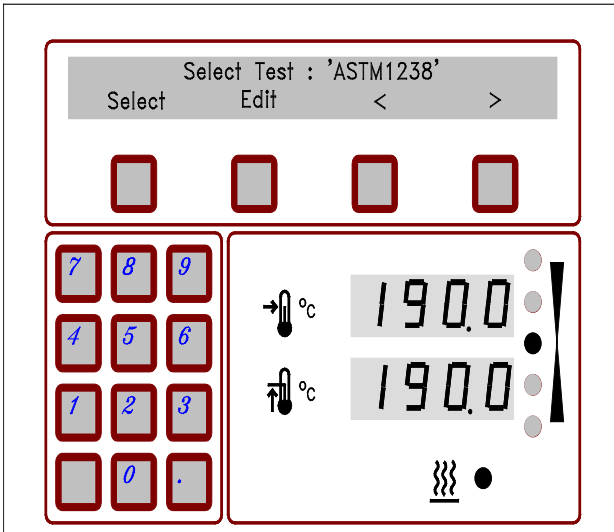
The solid steel piston has a head with a diameter of 9.47mm and a length of 6.35mm. The shank has a diameter of 8.89mm and terminates with a portion of further reduced diameter which is covered by an insulating, heat resistant sleeve. This forms a spigot upon which the loading weights are placed. The purpose of this sleeve is to reduce (as far as practicable) the heat-sink effect of the weights. The loose weights are tared to give the correct total load with the correct piston. Weights purchased with model 6, 7, 8 or later, or since Lloyd Instruments acquired DAVENPORT are tared for use with the heavier pistons.

The shank of the piston is marked with two circumferential grooves so that the upper will be exactly coincident with the top of the cylinder when the face of the piston head is precisely 20mm from the top of the die, whilst the distance between the two grooves themselves is 30mm. The purpose of these grooves is explained later in this manual.

Please note; that in the early stages of the development of the Melt Index method of characterising polymers, HOLLOW pistons weighing only 58g were extensively used.

They were later abandoned as the need for heavier test loads became apparent, since they lacked the necessary mechanical strength. Weights which have been tared for use with the hollow pistons WILL NOT BE CORRECT for use with the later solid pistons. This fact should be considered if you decide to use weights other than those supplied with the apparatus.

## 2.8 CONTROL PANEL



*MFI 10 Control Panel Layout*

This is used to display information and to enter test set-ups. The set temperature and actual temperatures are both displayed at all times. The lower group of green numbers shows the set temperature, while the upper group of red numbers shows the actual barrel temperature. LED's provide quick status indication. The band of five LED's to the right of the temperature displays indicate the temperature relative to the set temperature.

The centre green LED will be lit when the actual temperature is within  $\pm 0.1^\circ\text{C}$  of the set temperature. The amber LED's indicate that the temperature is between  $0.1^\circ\text{C}$  and  $0.5^\circ\text{C}$  from the set temperature and the outer red LED's will be lit when the temperature is more than  $0.5^\circ\text{C}$  from the set temperature.

The alphanumeric LCD provides user instructions and allows easy entry of the test parameters. An audible beeper helps to prompt the operator and provides end of preheat and sample cut-off warning signals.



The numeric keypad is used for entering parameters. The blank key grouped with the numeric keys is used to select calibration mode. The four keys directly under the LCD display a soft keys used to select from the list of options displayed on the second line of the LCD.

More detailed information on setting up tests and displayed messages is given in The MFI 10, Test Set-up section of this manual.

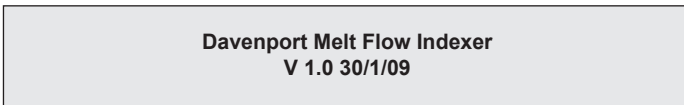
## 2.9 AUTOMATIC FLOW RATE TIMER (Optional Equipment)

This attaches to the side of the MFI and the lead plugs into the 9 way socket on the right hand side of the column. The Automatic flow rate timer derives its power from the MFI. All readings are automatically handled by the MFI. The distance over which a test is performed is programmed as part of the test set-up described in the relevant section of this manual. Standard distances are 2mm and 20mm ISO 1133 and 6.25mm (1/4 inch) and 25.4mm (1 inch) for ASTM D1238.

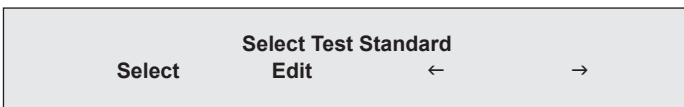
## 2.10 USING THE CONTROL PANEL

The top line of the LCD provides the user with information or instructions. The second line displays messages which are used to define the function of four soft keys located directly under the LCD display. Where messages are displayed on the second row, simply press corresponding key to select the required option.

### 2.11 TEST PROCEDURE



This sign on message is displayed for 3 seconds following power ON. After this time the display will automatically clear and the next message will be displayed. The second line shows the version number of the embedded software and its release date. If the internal EPROM is replaced with a different version number, the new version will be displayed. A change of version will cause the internal working memory to be re-initialised. This will result in the loss of all test set-ups which have previously been saved. Temperature calibration information will not be lost.



This screen is displayed when the user needs to select one of the pre-programmed test set-ups or to define a completely new one. It is also displayed when a test is aborted at any point, allowing the user to select a different test type. The default test set-up is the one which was current when the machine was last switched OFF. The ← and → options scroll through the available test set-ups. The Edit button will allow the user to customise the test set-up. This display will not normally be shown after power ON.

To force this screen to be shown at power ON the appropriate option in the test set-up for the default test must be set. See the section on setting up the test for more information.

Pressing select will advance to the next screen and tell the temperature controller to start heating the barrel to the temperature specified in the selected test set-up.

**No AFRT fitted please connect**  
**Ignore                      Abort**

This screen is only displayed when the test requires an AFRT and none is connected. Connect an AFRT or select Ignore to perform test using cut-off method.

**No weight loading fitted please connect**  
**Ignore                      Abort**

This screen is only displayed when the test requires the weight loader and none is connected. Connect a weight loader or select Ignore to perform test using manual weight loading method.

**Push AFRT to its lowest position**                      **Abort**

If the test uses an AFRT, the MFI needs to know the current AFRT position relative to the barrel. By pushing the AFRT to the bottom of its stroke, a micro switch is activated which provides a reference position for the MFI. This information is only needed if the MFI has been switched OFF. If the AFRT has been disconnected or if the internal working memory has been initialized, it will be necessary to re-calibrate the AFRT. This is a simple procedure which will automatically be invoked when required. Follow the on screen instructions or see the section on AFRT calibration for more details (page 36).

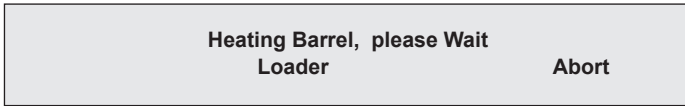
**Moving Weight Loader, please Wait**  
**Stop                      Stop                      Stop                      Stop**

This screen is displayed whenever the weight loader arm is moving. If the test uses the auto weight loader then it must be positioned in its upper position before the test can start. If it is not in the upper position, it will be moved there automatically with the above message displayed.

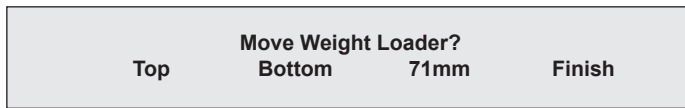
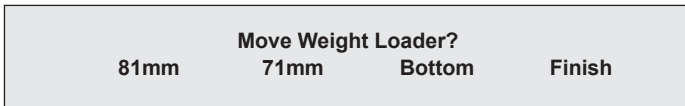
Pressing any option key will stop the weight loader before it reaches the top.



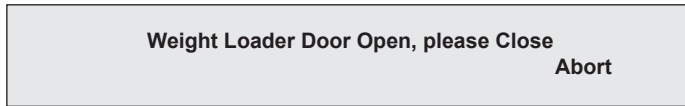
**NOTE:** The Automatic Weight Loader is optional equipment and is not supplied as standard with the MFI10.



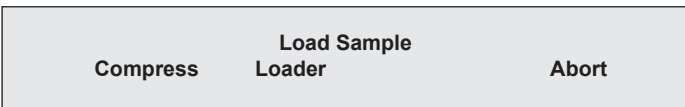
This screen is displayed while the temperature controller is setting the barrel to the required temperature. When the barrel temperature is stable within  $\pm 0.1^{\circ}\text{C}$  for a minimum of 10 seconds, the buzzer is sounded and the next message is displayed. If an auto weight loader is connected to the MFI 10 it can be manoeuvred manually by selecting the Loader key.



When the auto weight loader is to be driven manually, one of the above screens will be displayed. The exact options will depend on the actual position of the weight loader arm. Press Finished to end manual operation of the weight loader. If the weight loader is in the wrong position it will automatically reposition itself before continuing the test.



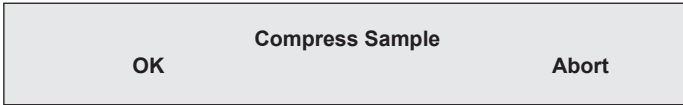
The weight loader arm can only be moved if both doors are closed. If either door is open the above message is displayed.



This screen instructs the operator to start charging the barrel with the sample to be tested. The same sample mass of the test polymer should be loaded every time to improve repeatability of the test, especially in QC situations, Please refer to fig 72. As soon as the charging process has been started the Compress button should be pressed. This starts the preheat timer and displays the next message. Note that the time spent compressing the sample is included in the preheat time.



**NOTE:** While pouring sample into funnel, agitate the funnel slightly from side to side. This will speed loading.



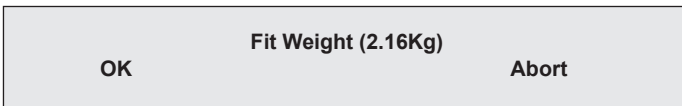
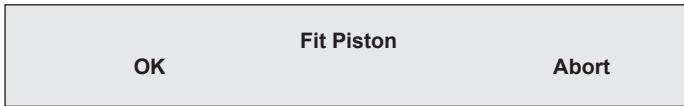
The sample should now be compressed. Press OK when you are satisfied that the sample has been compressed and there are no more air bubbles (Air bubbles create a "popping" sound) This process should be continued for a maximum of one minute. After this time the audible beeper will sound and the next message will be displayed.



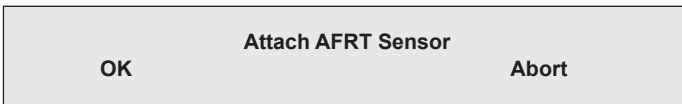
**NOTE:** Compress sample firmly. Do not move the compression tool up and down. This will introduce bubbles and cover the side of the barrel with plastic, causing possible friction between the piston and barrel.



Having compressed the sample, the piston should be fitted with its support. This message will automatically clear after 10 seconds. Two piston supports are provided, one 81mm long for high flow rate polymers (up to 5g/10 mins) and one shorter, 71mm, for low flow rate polymers under 5g/10



mins. When using the auto weight loader, the message reads:  
The weight should now be fitted to the top of the piston. The figure in parenthesis is the weight entered as part of the test set-up and is included here to assist the user. This message will automatically clear after 10 seconds. When using the auto weight loader, the weights will be lowered automatically without showing this message. The auto weight loader will automatically stop when it reaches the pre-set stop position corresponding to a spacer height of either 71mm or 81mm. If neither



option was set during the test set-up the loader arm will continue to its bottom position.

If the selected test requires the use of the AFRT, it should now be attached to the bottom of the weight. If the AFRT is not required, this message will not be displayed. This message will automatically clear after 10 seconds.

**Pre-heating Sample 2:30 (6:00)**  
**Release** **Abort**

The system will now continue preheating the sample for the time set in the test set-up. This would normally be a total of 6 minutes from when the sample is first entered into the barrel. The preheat time elapsed is displayed with the total preheat time shown in parenthesis. If using the auto weight loader, then at the end of the preheat time the auto weight loader arm will be moved to the bottom position. This will release the weights and allow the test to start automatically. By pressing the key marked Release, the weight loader arm can be lowered before the end of the preheat period. The Release option is not displayed if the auto weight loader is not in use.

**Remove Piston Support**  
**OK** **Abort**

If the auto weight loader is not being used, then at the end of the preheat period the piston support should be removed allowing the piston to fall freely. This message will automatically clear after 10 seconds.

**Pre-Heat finished, start test? 6:30**  
**OK** **Abort**

If the manual cut-off method is being used the operator will now be waiting for the lower piston scribe mark to enter the top of the barrel. As soon as this happens the Start key should be pressed and the waste extrudate cut-off at the same time. The time displayed is the total test time commencing from when the sample was first entered into the barrel. The next screen for the cut-off method is shown if the test start time is not reached. If the AFRT is being used, the following message will be displayed instead.

**Pre-Heat finished, awaiting start 6:30**  
**Abort**

When the lower piston scribe mark enters the barrel, the MFI will automatically start to measure the time taken for the AFRT to move through the specified distance.

**Test start time not reached. 6:30**  
**Continue** **Abort**

The test set-up allows the user to enter a minimum time from when the sample is entered into the barrel to when the first measurements should be taken. This message will only be displayed if the minimum time has not been reached. The user has the option to Continue or Abort the test. If Continue is selected before the minimum time is reached, a warning message will be printed if the results are sent to a printer. For most tests the minimum time will be 6 minutes, the same as the preheat time, so this situation should not occur.

**Cut Off Waste** **Abort**

This message is only displayed if the cut off method is being used. It is automatically cleared after 5 seconds.

**Test Start time exceeded**  
**Continue** **Abort**

The test set-up allows the user to enter a maximum time from when the sample is entered into the barrel to when the first measurements should be taken. This message will only be displayed if the maximum time has been exceeded. The user has the option to Continue or Abort the test. If Continue is selected, a warning message will be printed if the results are sent to a printer.

**Cut-Off Time 25 sec (60 Sec)**  
**Last** **Abort**

If the cut off method is being used, this message will be displayed showing the time remaining until the next cut off should be made. The figure in parenthesis is the total cut off time for this test. During the last 2 seconds prior to the cut off 2 short audible beeps will sound followed by a longer beep telling the user to perform the cut off. This sequence of beeps is designed to improve the accuracy of the manual cut off method by reducing user induced error. The beeps may optionally be turned off by using supervisor mode. When the time reaches zero and the cut off beep is sounded, the display shows the following message, telling the user to cut the sample. When the last cut off has been made the operator should press the Last key. All cut offs should be made before the upper scribe mark on the piston enters the barrel. If the AFRT is also being used, the test will end automatically if the upper scribe mark on the piston enters the barrel.



**NOTE:** The Automatic Cut-Off device is optional equipment and is not supplied as standard with the MFI10.

<b>Cut-Off Sample</b>
<b>Continue</b> <span style="float: right;"><b>Abort</b></span>

This message is displayed for 5 seconds. It is then cleared automatically and the previous message is displayed. The Standards both require at least 3 good cut-offs to be made. Cut-offs containing air bubbles should be discarded and the good cut-offs weighed and recorded in the order in which they were cut.

<b>Performing AFRT Test</b>
<b>Abort</b>

If the cut off method is not used, or if the cut off test is finished before the AFRT test, this message will be displayed. This message will automatically be cleared when the AFRT test is finished or when the upper piston scribe mark enters the barrel.

At the end of the test, if the auto weight loader was used, it will be automatically raised to the top position ready to begin a new test.

<b>Sample Weight (g) [ 1 ] 0.234</b>
<b>Finished</b> <span style="margin-left: 100px;"><b>Enter</b></span> <span style="margin-left: 100px;"><b>BkSp</b></span> <span style="float: right;"><b>Abort</b></span>

This screen, displayed if the cut off method was used, allows the user to enter the weight of each cut off. The user can enter the weight to 5 decimal places followed by Enter. The Standards both require the cut-offs to be weighed to 4 decimal places. If the user is re-entering the sample weights after the results have been displayed, the Abort message is replaced by Delete. This allows the user to remove any weights from the calculations.

<b>Cut-off MFR (g/10 min) 1.0525</b>
<b>Re-Weight</b> <span style="margin-left: 100px;"><b>More</b></span> <span style="margin-left: 100px;"><b>Print</b></span> <span style="float: right;"><b>New Test</b></span>

This display shows the melt mass-flow rate (MFR) of the sample tested using the Cut-Off method. If the Cut-Off method was not used, this display is not shown. If the AFRT was also used, the More option is provided for displaying additional results, otherwise this option is not shown.

<b>AFRT MVR (cc/10 min) 1.4700</b>			
<b>Repeat</b>	<b>More</b>	<b>Print</b>	<b>New Test</b>

This display shows the melt volume-flow rate (MVR) of the sample tested using the AFRT method. The More option is provided for displaying additional results.

<b>Melt Density (g/cc) 0.6410</b>			
<b>Repeat</b>	<b>More</b>	<b>Print</b>	<b>New Test</b>

This display shows the Melt Density of the sample tested using a combination of the MFR obtained from the Cut-Off method and the MVR obtained from the AFRT method. If the test set-up does not specify that the melt density is calculated, this display is not shown.

<b>AFRT MFR (g/10 min) 1.0525</b>			
<b>Repeat</b>	<b>More</b>	<b>Print</b>	<b>New Test</b>

This display shows the melt mass-flow rate of the sample tested using the AFRT method. It is calculated using the result for the MVR and the value entered for sample melt density as part of the test set-up. If the AFRT was not used, or if the test set-up specified that the melt density should be calculated, this display is not shown.



**NOTE:** Selecting Repeat from any of the above screens will repeat the test using the same test set-up parameters. More will display the next results screen as applicable for the type of test performed. Print will display the following screen and New Test will enable a different test set-up to be selected or edited.

<b>Select printout options</b>			
<b>Test Setup</b>	<b>Samples</b>	<b>Results</b>	<b>All</b>

This display allows the user to select what information is to be printed. Selecting All will print Test Set-

<b>Abort</b>	<b>Printing ...</b>
--------------	---------------------

up, Samples and Results in one go.

This display is shown while printing is in progress. Pressing Abort will cancel printing.



## 2.12 TEST SETUP

The following series of screens are used to set up the test method. Where Yes/No options are offered, the existing setting is displayed above the left hand key. Where values are to be entered, the previous value is offered as a default and can be selected by pressing Accept which is displayed above the left hand key. As all existing defaults can be selected by pressing the left key, it is a simple matter to edit one part of a test set-up without having to remember all of the other settings. After setting all of the options, they can be saved into non-volatile memory. Up to ten test set-ups can be saved and recalled later. Two Standard Test Set-ups are provided as examples. One uses manual cut-off method, the other uses the AFRT. These can be used as they are or modified to suit individual requirements.

<b>Accept</b>	<b>Enter Password</b>
<b>Change</b>	<b>BkSp</b>

If a user password has been set-up in supervisor mode, then it is necessary to enter the password before the test set-up can be modified. This provides a level of security which enables only supervisors to modify the test set-up. If no password has been set-up, this display is not shown.

<b>OK</b>	<b>English Messages</b>	<b>→</b>
	<b>←</b>	

The language used can be selected and saved as part of the test set-up. This enables each test set-up to use a different language.

<b>Yes</b>	<b>AFRT Used?</b>	<b>No</b>
------------	-------------------	-----------

Selects whether the AFRT is to be used for the test. The AFRT is required to calculate results in accordance with ISO 1133 and ASTM D 1238 Procedure B.

<b>Accept</b>	<b>AFRT Distance (mm) 2.00</b>
<b>Change</b>	<b>BkSp</b>

If an AFRT is to be used, it is necessary to set up the distance over which the AFRT is to be timed. If a single measurement is to be taken, this can be anything up to the full test range of the AFRT, usually 30mm. If multiple readings are to be taken, the total must be less than the AFRT range. The value entered is the distance for each reading. This option is bypassed if the AFRT is not used.

<b>Accept</b>	<b>Number of AFRT readings 5</b>
<b>Change</b>	<b>BkSp</b>

This specifies the number of readings that will be taken at the distance entered in the previous section. ISO 1130 Procedure B specifies that at least three measurements should be taken. This option is bypassed if the AFRT is not used.

<b>Material Melt Density (g/cc) 0.760</b>			
<b>Accept</b>	<b>Change</b>	<b>BkSp</b>	<b>Calculate</b>

This allows the user to enter the melt density for the material to be tested if it is known. This value is used to calculate the melt mass flow rate (MFR) from the melt volume flow rate (MVR) determined from the AFRT test. The density shown is for the standard PE resin used to test all systems prior to shipment! NB; The melt density is NOT the same as the (Solid) density and may be calculated:  $r = m$  divided by  $0.711 \times i$ . Where  $r$  = density in g/cc of the melt at the test temperature and  $m$  = the average mass in grams of the cut-offs and  $i$  = predetermined distance moved by piston. The user may also select Calculate, in which case both AFRT and Cut-Off tests can be performed simultaneously. The melt density is calculated from the results obtained from each type of test. If Calculate is selected, the following option to use Cut-Off method is automatically set to Yes. This option is not offered if the AFRT is not used.

<b>Cut-off method</b>	
<b>Yes</b>	<b>No</b>

Selects whether the Cut-Off method is to be used. If the AFRT is not used, this is automatically set to Yes. It is also set to Yes if The AFRT is used and the option to calculate melt density is chosen. The Cut-Off method is required to calculate results in accordance with ISO 1133 Procedure A and ASTM D1238.

<b>Use Auto Cut-off?</b>	
<b>Yes</b>	<b>No</b>

If the Cut-Off method is to be used and an auto cut-off device has at some time been connected to the MFI the test can be configured to use the auto cut-off device. If Yes is selected, then during a test, when a cut off is due to be made, the auto cut-off device will be automatically triggered.

<b>Allow MFR Spread (%) 15.0</b>		
<b>Accept</b>	<b>Change</b>	<b>BkSp</b>

This sets the maximum MFR spread which is allowed from the Cut-Off test. If the total spread is above the entered value, a warning message is printed with the test results. It is calculated as the difference between the maximum and minimum sample weight divided by the average weight of the samples. Any value in the range 0% to 100% can be entered although ISO 1133 Procedure A specifies that a maximum spread of 15% is allowed. This option is not offered if the Cut-Off method is not used.

	<b>Cut-off time (Secs) 60</b>
<b>Accept</b>	<b>Change BkSp</b>

The Standard specifies the Cut-Off time for each sample according to the flow rate. An audible beeper is sounded each time the set time period expires. The timer will then be reset automatically. Any value in the range 4 seconds to 999 seconds can be entered and will depend on the material being tested and the weight applied. A Cut-Off time should be chosen which gives a Cut-Off length of between 10mm and 20mm for the given sample. This option is not offered if the Cut-Off method is not used.

MFI g/10mins	Extrudate cut-off time intervals (S)
0.1 to 0.5	240 <sup>1</sup>
>0.5 to 1.0	120
>1.0 to 3.5	60
>3.5 to 10	30
>10	5 to 15 <sup>2</sup>



**NOTE:** (1) ISO 1133 Recommends the measurement of MFIs between 0.1g /10mins and 100g/10mins, although ASTM D1238 allows measurements up to 50g/10mins.



**NOTE:** (2) ISO 1133 recommends that all polymers with an MFR greater than 25g/10mins use Procedure B or an automatic cut-off device accurate to less than 0.1 second. This is to ensure adequate repeatability.

	<b>Set Temperature (°C) 190.0</b>
<b>Accept</b>	<b>Change BkSp</b>

Determines the temperature at which the test is to be performed. Any value in the range 40°C to 400°C can be entered.

	<b>Weight used? (Kg) 2.160</b>
<b>Accept</b>	<b>Change BkSp</b>

Allows the user to enter the value of weight which is to be used for the test. The value entered here is used as a prompt when the operator is instructed to fit the weight, thus reducing the likelihood of operator error if multiple weights are available. The weight is also quoted in the test report printed at the end of the test.

<b>Accept</b>	<b>Preheat Time (Mins. Secs) 6.00</b>
	<b>Change      BkSp</b>

Allows entry of any preheat time in the range of 1 minute to 99 minutes in 1 second steps. This is the total time from when the sample is first charged into the barrel to when the first cut-offs can be taken, including the time spent charging the sample. The ISO 1133 Standard recommends 6 - 8 mins.

<b>Accept</b>	<b>Min Test Start Time (Mins. Secs) 6.00</b>
	<b>Change      BkSp</b>

This is the minimum time that must elapse from when the sample is first charged into the barrel to when the first cut-offs can be made or AFRT readings taken. If this minimum time is not reached, a warning message will be displayed on the LCD. The user then has the option of aborting the test or continuing. If to continued within the minimum time a warning message is printed with the test results.

<b>Accept</b>	<b>Max Test Start Time (Mins. Secs) 8.00</b>
	<b>Change      BkSp</b>

This specifies the maximum time which may elapse between first charging the sample and taking the first Cut-Off or AFRT reading. If this time is exceeded, the user has the option of aborting the test. If continued, a warning message is printed with the test results.

<b>Accept</b>	<b>Max Total Test Time (Mins. Secs) 25.00</b>
	<b>Change      BkSp</b>

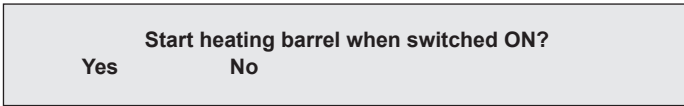
This specifies the maximum total duration for the test. If this time is exceeded, a warning message is printed with the test results.

	<b>Use Weight Loading System?</b>
<b>Yes</b>	<b>No</b>

Asks whether the auto weight loader should be used for the test. The option is only offered if an auto weight loader has at some time been connected to the machine.

	<b>Pause Weight Loading System? 81mm</b>
<b>Accept</b>	<b>71mm      81mm      No Pause</b>

If the auto weight loader is to be used, it can be programmed to pause at a position equivalent to using either a 71mm or a 81mm spacer to support the weights. If the pause option is not required, this can also be selected.

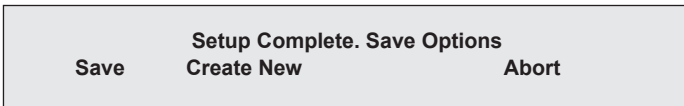


If this option is set to Yes (default setting), the barrel will automatically begin heating as soon as the MFI is switched ON. If it is set to No, at switch ON a screen will display the prompt for the test set-up procedure. The barrel will only be heated when a test set-up has been selected.



This screen allows the user to specify a name for the test set-up. Any name up to ten characters long may be entered. The UP and DOWN arrows are used to change the letter indicated by the underline cursor.

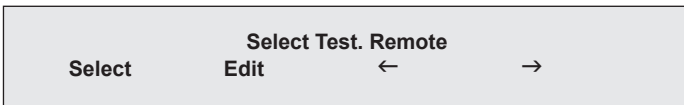
A list of alphanumeric characters and some special symbols is provided. Pressing the RIGHT arrow will advance the cursor to the next letter. After the tenth letter, the cursor is returned to the start of the name. The name entered is the one displayed when selecting the test set-up at the start of a test. Pressing Accept advances to the next screen.



Having programmed all of the test set-up options, they can now be saved into non-volatile memory to be called up later. Selecting Save will overwrite the previous version of this test set-up. Selecting Create New will not overwrite the previous version but will create a copy of it with the changes just made.

### 2.13 REMOTE CONTROL

The MFI 10 can be controlled from a computer using the NEXYGEN MFI software (p/n 40/0734).



This requires Version 1.6 or later of the embedded software. To do this the Remote test setup must be selected. The Remote test setup can be edited by pressing the Edit button, however, only the language option can be changed. The Remote test setup is selected by pressing the Select button. This will display the next screen.

**Cannot connect to remote computer**  
**Abort**

NEXYGEN will start the connection process. If this is not completed the MFI 10 will remain in this state for 10 minutes, after which it will automatically return to the Select Test option. During this time the Abort button will also display the Select Test option. The Calibrate button will start the calibrate mode, for more details of the calibrate mode see the Calibration Mode section of this manual (page 35). When the NEXYGEN has finished the connection process the next screen will be displayed

**Under control of remote computer**

automatically.

When this message is displayed the MFI 10 will be controlled by the NEXYGEN MFI software and will not respond to any local button press.

## 2.14 SUPERVISOR MODE

This mode can be entered when the MFI is switched ON by pressing the first option key followed by the third option key while the Davenport sign on message is displayed. This provides the following list of system configuration options. Many of these options will never need to be changed.

**Enter Password**  
**Accept      Change      BkSp**

If a password has been set-up, then it is necessary to enter the password before the following options can be modified. This provides a level of security which enables only supervisors to modify the configuration. If no password has been set-up, this display is not shown.

**AFRT start pos above die (mm) 50.0**  
**Accept      Change      BkSp**

This screen allows the user to enter the position at which the AFRT test will begin. The figure specifies the distance between the lower edge of the piston head and the top of the die. ISO 1133 specifies that this distance should be 50mm and that is the default setting in our factory. The ASTM

**AFRT end pos above die (mm) 20.0**  
**Accept      Change      BkSp**

Standard requires the piston to be 48mm above the die.

This screen allows the user to enter the position at which the AFRT test will end. The figure specifies the distance between the lower edge of the piston head and the top of the die. ISO 1133 specifies that this distance should be 20mm.

<b>Enable buzzer</b>	
<b>Yes</b>	<b>No</b>

The audible beeper can be switched off by selecting No. This may be useful where several MFI machines are operating in close proximity or the test has been fully automated by addition of the AFRT and the auto weight loading system. Default setting is that the buzzer is enabled.

<b>Cut-off warning Bips?</b>	
<b>Yes</b>	<b>No</b>

This option allows the user to select whether the two short bips which are sounded before a Cut-Off is to be made are to be enabled. Select No if you do not require these bips. Default is bips enabled.

<b>Enable Calibration mode?</b>	
<b>Yes</b>	<b>No</b>

Calibration mode can be entered by pressing the calibration key, ( the blank key at the bottom left hand corner of the numeric key pad), during any part of a test. (not during test set-up). This option allows calibration mode to be disabled. Default setting is with calibration enabled.

<b>Enter new password</b>			
<b>Accept</b>	<b>Change</b>	<b>BkSp</b>	<b>None</b>

If a password already exists, it can be confirmed by pressing Accept. A new password can be entered by pressing Change. If a password is no longer required, selecting None will remove the password. The password may be up to eight characters long and made up using any of the numeric keys on the keypad.

<b>Test new password</b>		
<b>Accept</b>	<b>Change</b>	<b>BkSp</b>

If the password has been changed the user will be prompted to re-enter the password. The password should be typed in exactly as before followed by Enter. If the password has been re-entered correctly, it will be accepted. If the two entries are different, the user will be prompted to enter the password again.

## 2.15 CALIBRATION MODE

Calibration mode can be entered by pressing the calibration key ( the blank key at the bottom left corner of the numeric keypad) from any of the test states. It cannot be entered from the test set-up state. Calibration mode allows calibration of the temperature controller and AFRT. Note that the AFRT must be re-calibrated whenever the internal working memory is cleared. The barrel temperature should only be calibrated when the temperature control loop is active and the barrel temperature is stable. The temperature calibration data is not erased when the internal working memory is erased.



This display allows calibration of the temperature controller. The temperature can be calibrated at any set temperature by placing a calibrated thermometer in the barrel of the MFI. For best results the thermometer should be surrounded by a polymer having similar characteristics to the polymer to be tested. If the system is calibrated again at the same set temperature, the previous calibration value is overwritten. If the system is calibrated at a second set temperature, the calibration value stored at the original set temperature is not affected. To calibrate the temperature at ambient, the set temperature should be adjusted to a value around ambient. Calibration may be performed at a maximum of fifty set temperatures. Pressing +0.1°C or -0.1°C will increment or decrement the displayed actual temperature by 0.1°C. This is only adjusting the displayed value, not the value currently used by the temperature control loop. When the displayed temperature is correct, Follow can be pressed. This will tell the temperature control loop to use the displayed temperature reading for controlling the barrel temperature. This Follow message will change to display Hold. Further pressing of the +0.1°C or -0.1°C keys will change the displayed temperature and force the control loop to adjust the barrel temperature accordingly. Pressing Hold will tell the temperature control loop to maintain the temperature at the last set temperature regardless of further changes to the displayed temperature.

Press OK when the displayed temperature matches the temperature of the calibration thermometer. To exit without changing the calibration data stored, press the calibration key again.



**NOTE:** Load 2g of PE or the polymer you normally test into the barrel. Compress to expel air bubbles. Insert the thermometer holder (a brass cylinder about 8cm long with two vertical sections cut out on either side about 2cm long) Then insert the thermometer to its full length so that the 90° angle piece rests on top of the barrel cover. The brass holder ensures that the thermometer remains vertical and straight. The 90° angle on the thermometer ensures that the thermometer measures at the precise distance above the die orifice. Correct the temperature controller if necessary, after 4 minutes has elapsed and both the thermometer and barrel temperature are stable.



The AFRT uses an optical encoder to measure distance moved. This cannot provide an absolute position so the AFRT uses a micro switch as a reference mark. The micro switch is activated by pushing the AFRT arm to its lowest position. Activation of the micro switch will zero the counter associated with the optical encoder and will automatically be detected by the MFI software. The number displayed in the lower right hand corner of the LCD indicates the AFRT arm position relative to its position when attached to the weight with the piston resting on the die.



<b>Fit die, piston and weight. Attach AFRT</b> <b>OK</b> <span style="float: right;"><b>10.5432</b></span>
---

By assembling the components in a clean condition as instructed, the MFI control software can measure the distance from the reference micro switch to this position.

Press OK to indicate that the system is correctly set-up. Once this has been done, the system control software can determine test start and end positions by moving the AFRT arm down to the micro switch.

## **2.16 STARTUP OPTIONS**

It is possible to force certain actions when the machine is first switched ON by pressing certain keys or sequences of keys while the Davenport sign on screen is displayed.

Internal Working Memory Initialization can be forced by pressing the right hand option key during the Davenport sign on message. This forces all internal working variables to be cleared and will result in the loss of all test set-ups and AFRT calibration. Temperature calibration will not be lost.

Hardware Test Mode can be forced by pressing the left hand option key twice while the sign on message is displayed. This mode is used for testing the internal electronics of the MFI and should only be used by qualified test personnel.

Supervisor Mode can be started by pressing the left hand option key followed by the third option key from the left. See the section THE APPARATUS, Supervisor mode for details of options available in the mode.

System Test Mode can be entered by pressing a sequence of three keys while the Davenport sign on message is displayed. Counting from the left the first key, followed by the third key and then the second key must be pressed in sequence. A special password is required to enter this mode. When this mode has been selected, operation is as normal but no limit is placed on the values which can be entered. This facility is used for testing the barrel over temperature trip which needs to be set at 450°C.

## **2.17 ANCILLARY EQUIPMENT**

All equipment should be kept clean and stowed away after use. The long tools, including the piston, each slot into the holes in the top cap. The small tools should be kept in the drawer in the base of the MFI. The draw contains cut-outs sections for each tool so that the tools do not roll around and get damaged. Missing items are easily identified.

### **2.17.1 CHARGING TOOL**

A non-metallic rod for tamping the test charge in the cylinder.

### **2.17.2 DIE EJECTOR**

A steel rod with a special soft alloy tip to avoid any possibility of damaging the die. Used to push the die up and out of the cylinder.

### **2.17.3 CLEANING TOOL**

For cleaning the bore of the cylinder.

#### **2.17.4 CUT OFF KNIFE**

Designed specially for cutting off the extrudate.

#### **2.17.5 CIRCULAR SPIRIT LEVEL**

Fitted with a thermal insulating foot so that it can be placed on top of a hot barrel without suffering damage. For levelling the apparatus.

#### **2.17.6 DIE BROACH**

For cleaning the bore of the die.

#### **2.17.7 HEXAGON KEY**

For loosening the die plate retaining screws.

#### **2.17.8 TWO PISTON SUPPORT SLEEVES**

For restricting the movement of the piston during the pre-heat period.

One of 71mm length for low flow rate polymers.

One of 81mm length for high flow rate polymers.

#### **2.17.9 THERMOMETER SLEEVE**

Brass cylinder with two vertical cut-outs

Designed to hold the calibration thermometer absolutely straight and make sure the mercury bulb is directly above the die orifice.

#### **2.17.10 DEAD WEIGHT**

Weighing exactly 2.06kg, which together with the piston makes up the most common standard test load of 2.16kg.

#### **2.17.11 CERAMIC INSERTS**



**NOTE:** These should be changed if chipped or polymer has built up.

#### **2.17.12 FUNNEL**

To help loading with the loading of polymer.

There is also a powder funnel available to special order with an extension into the barrel to avoid polymer sticking to the side of the top of the barrel.

#### **2.17.13 DIE PLATES**

PTFE coated to prevent polymer sticking to the 3 key hole slots to ensure quick and simple removal and replacement.

#### **2.17.14 CALIBRATION THERMOMETER**

90° angle, indicating, mercury in glass, 4°C x 0.1°C

#### **2.17.15 BOX OF CLEANING PATCHES**

Used for cleaning the barrel.

## **2.18 ADDITIONAL FEATURES**

With the exception of the test loads, all items required to perform Melt Flow Index tests are housed within the cabinet of the apparatus, thus being a totally stand-alone work station using the minimum amount of bench space. To assist in both the cleaning of the barrel and manual operation, i.e. Cut-Off principle, the automatic flow rate timer sensor unit is able to be swung away from the barrel housing to a park position, thus giving easy access to the barrel entry and die plate. When required, the automatic Flow Rate timer sensor unit is easily returned to its position near the barrel. The apparatus has a built in over-temperature protection relay. If the temperature of the barrel exceeds the pre-set Cut-Off point, the heaters will be disconnected.

## **2.19 ADDITIONAL REQUIREMENTS**

Certain additional equipment is required for use of the apparatus but is not supplied as standard equipment (commonly available in most laboratories). The principle item is an analytical LABORATORY BALANCE capable weighing to 4 decimal places. If you are only using the automatic Procedure B AND the melt density is known, this equipment will not be necessary.

All users will require a top pan balance capable of weighing to 2 decimal places for weighing out the sample charging mass.

A Scotchbrite pad (flat rectangular pan scourer available from most supermarkets) is ideal for polishing the die once the bulk of the polymer has been scraped off with the cut of knife.

### 3.0 INSTALLATION

#### 3.1 UNPACKING

All packing material should be carefully removed from the MFI machine and a careful visual inspection should be made to ensure that there is no obvious transit damage. The following items should be in this package:

Supplied items	Quantity	Part No
This User Manual	1	01/2713
Melt Flow Indexer model 10	1	(depending on order)
Die plate casting	1	737/8
Ceramic die plate insert	2	737/7
Standard die 2.096mm bore	1	338/10
Die broach standard diameter	1	338/101
Standard piston assembly	1	338/45
Weight 2.16kg	1	338/14
Cut-off Knife	1	338/33
Charging tool	1	338/52
Die ejection tool	1	338/54
Cleaning tool	1	338/55
Cleaning patches	1 box	338/132
Filling funnel	1	730/79
Piston support sleeve 71mm	1	338/293
Piston support sleeve 81mm	1	338/294
Die tweezer's	1	92/0404
RS232 lead MFI10 to PC	1	09/0695
Standard thermometer 188-192°C	1	338/104/3
Thermometer sleeve	1	730/62
Circular spirit level	1	338/100
Spanner 16-17mm	1	91/0095
Hex driver 3/32	1	338/50
Adjustable foot assembly	5	02/0443
Cordset 1	(depending on order)	

If there is any damage, or parts missing, please report this to your authorized DAVENPORT representative.

- A Carefully clean all the parts, removing any preservative that may have been applied to protect

them during transit and storage. It is strongly recommended that at this stage the small loose parts should be stored in the wooden tool tray in the base of the MFI in their appropriate recesses. The long tools and piston placed into the pockets located on the top of the unit.

B Choose a suitable site, preferably out of reach of strong draughts, where the apparatus may be set up more or less permanently.

Place the circular spirit level on top of the barrel, raise the two rear corner feet clear of the work surface and level the apparatus as exactly as possible by means of the centre rear foot and two front feet. Once levelled, lower the two rear corner feet to provide stability and lock all feet into place. Do not move the apparatus. If it has to be moved, ensure that the levelling procedure is repeated in the new site.

**NOTE:** IT IS IMPORTANT FOR CORRECT FUNCTION THAT THE APPARATUS SHOULD BE LEVEL.



**NOTE:** It is advisable to check the levelling of the apparatus from time to time, whether it has been moved or not. It is quite in order for this to be done whilst the machine is hot but in this case, take care not to leave the circular spirit level on the hot barrel for any considerable length of time. Despite the insulated base of the level, enough heat will be generated to burst it over a long period of time.



C Loosen the die plate retaining screws and remove the die plate. Clean the cylinder bore thoroughly using the cleaning tool and as many cleaning patches as may be necessary, finish off with a polish using a dry patch.

D Similarly clean the die, paying special attention to the bore which should be polished with a small wooden stick, (a pared down match stick). Drop the cleaned die into the bore. It must fall freely and strike the die plate with a clearly audible click. If this does not happen it indicates that either the die or the bore of the barrel (or both) are not perfectly clean and they should be re-examined and cleaned if necessary.

E The apparatus is supplied with a plug socket and mains lead. Fuses for the apparatus are incorporated into the inlet socket. Power consumption of the apparatus will not exceed 1KW. An auxiliary power outlet is fitted with a IEC socket. A maximum of 1 amp is available at this socket.

We are able to supply suitable connecting leads for this socket to enable other peripherals to be powered directly from the apparatus.

F The temperature controller will start to control the barrel temperature as soon as an electrical supply is connected, unless the test set-up has been customized to disable this feature. This controller is calibrated at the factory to give a controlled temperature between 190 and 230° C to within  $\pm 0.2^\circ$  C. If it is necessary to perform tests at higher temperatures, for example 320 - 400°C it is advisable to set the controller to the desired set point and check the barrel temperature. If an appreciable difference is apparent, one of two procedures can be followed.

1. An offset can be used by setting the set point of the controller to allow for the difference.
2. The controller can be re-calibrated against a known accurate thermometer to give the correct reading at the required set point.

The controller will control to  $\pm 0.1^\circ$  C of any set point.

### 3.2 TEMPERATURE CONTROL

With the apparatus connected to the mains, the temperature controller will start to heat the barrel to set point (factory set to 190°C). The LED below the temperature displays will indicate that a controlled output is being applied to the heaters. The set point on the controller can be changed by means of the keys on the front of the unit. See the section THE MFI 10, Test Procedure of this manual.

The temperature shown on the digital display may be checked, if required, with a mercury in glass thermometer following the procedure below.

- A Insert the thermometer sleeve into the barrel and ensure that it is fully down against the die plate.
- B Insert a thermometer of suitable range into the thermometer sleeve. Any difference can be re-adjusted by re-calibration. See the section THE MFI 10, Calibration Mode of this manual.
- C If ISO R-1133 standard is being followed, the temperature should be checked with the thermometer placed directly into the melt of polymer in the barrel.
- D Calibration adjustments should be performed 4 minutes after the polymer and thermometer are loaded into the barrel and all readings are stable.

### 3.3 CUT-OFF TIMER OPERATION

Although various standard methods are in general agreement, particularly regarding apparatus specifications, they do differ in certain methodological aspects. The test method described below is, in our opinion, the best way to use the apparatus for the most consistent, reproducible and meaningful results, and is supported by prompts on the control panel.

- A Allow the barrel temperature to reach a set point and stabilise for at least half an hour. Insert the die into the barrel. Pre-heat the piston. The LCD will prompt loading when the temperature has re-stabilised. Remove the piston
- B Charge the cylinder with the test sample, introducing it in increments and tamping down each increment with the charging tool to exclude as much air as possible. Complete the charging operation in less than one minute. Preheat time will begin with the charging process.
- C On completion of the charging operation, insert the piston into the barrel and place the piston support sleeve so that the piston is supported by the sleeve acting on the rim, with the base of the sleeve square on the barrel. Two sleeves are provided, the longer for the MFRs greater than one and the shorter for MFRs less than one.
- D Place the appropriate weight on the piston and manually force the test material through the die until the top of the sleeve prevents further travel of the piston into the barrel. DO NOT purge at the end of the pre-heat period.
- E When the pre-heat time has elapsed, remove the sleeve to start the test.

**CAUTION:** The sleeve will be hot.



FWatch the progress of the piston down the barrel. As soon as the lower circumferential ring on the piston enters the barrel, Cut-Off and press the OK button, discard the extrudate and AT THE SAME TIME START THE TIMER for the beginning of the test. If the option AFRT is being used the MFI will start taking readings automatically.

G Cut-off and retain, in order, specimens of the extrudate at a succession of identical time intervals.

The time interval used should be chosen on the basis of the expected MFR of the sample (see table), but whenever possible cut at least 5 samples making quite certain that they are ALL taken when the lower piston ring is INSIDE the barrel and the upper ring is still outside it.

MELT FLOW RATE GRAMS/600 SECS	SAMPLE MASS GRAMS	CUT-OFF INTERVAL SECONDS
0.1 - 0.5	4 - 5	240
0.5 - 1.0	4 - 5	120
1.0 - 3.5	4 - 5	60
3.5 - 10	6 - 8	30
10 - 25	6 - 8	10 - 15

H On completion of the test and after all subsequent tests, clean the piston, die and barrel.

See section OPERATING TECHNIQUES, Cleaning.

#### **4.0 CALCULATIONS AND PRESENTATION OF RESULTS**

- A Weigh each Cut-Off in the order of the extrusion. Discard any that have obvious air bubbles in them.
- B Calculate the average weight of the extrudate samples to three significant figures.
- C Calculate the MFR from the equation:

$$\text{MFR} = 10W/T$$

where:

MFR = Melt Flow Rate in grams per 10 minutes.

W = the average extrudate sample weight.

T = the extrusion time per sample in minutes.

D Report the value thus obtained to two decimal places. When reporting this result always quote the testing conditions used, such as, the temperature, the load and whether the die used was of standard geometry or of some other (see notes on operating techniques).

E If the sample was thermally unstable during the test, the successive extrudate samples will have a continually changing weight. Some materials cross-link, forming high molecular weight groupings and others degrade due to breaks in the chain. With cross linking the MFR tends to become lower and the extrudate samples lighter, whilst with chain breaks the MFR will tend to increase so the samples will become heavier. When a systematic change of mass of this nature is observed, it is most useful to calculate the extent of the weight change. MELT FLOW RATE SPREAD is not only an indication of the thermal instability of the sample, but is also used to indicate the significance of the quoted Melt Flow Rate value.

The MFR Spread is simply the range of extrudate sample weights expressed as a percentage of the average and calculated from this equation:

$$\text{Total MFR Spread (\%)} = \frac{(\text{Max Weight} - \text{Min Weight}) \times 100}{\text{Average Weight}}$$

$$\text{Lower MFR Spread (\%)} = \frac{(\text{Ave Weight} - \text{Min Weight}) \times 100}{\text{Average Weight}}$$

$$\text{Upper MFR Spread (\%)} = \frac{(\text{Max Weight} - \text{Ave Weight}) \times 100}{\text{Average Weight}}$$

Using the control panel numeric keypad individual sample weights can be entered into the MFI. The MFI then calculates and displays the MFR using the equations given above. The MFR and total MFR spread can be sent to the RS232 interface for printing on the optional ticket printer.



## 5.0 OPERATING TECHNIQUES

### 5.1 CUTTING OFF THE EXTRUDATE

For accurate and repeatable results, the cutting off action should be done quickly and neatly. The tip of the Cut-Off knife should pass upwards along front side of the conical hole in the die plate, lightly against the bottom of the die, cutting the extrudate in its passage and continuing down the other side of the conical hole. The neatness of the cut may be gauged from watching the way the next portion is extruded. If the cut has been clean and sharp, the emergent strand will point straight down. If not, there will be a tendency for it to curl, or even stick to one side of the plate hole and emerge in the form of a loop.

Until some practice in cutting off has been gained, it is helpful to smear a little silicone oil around the inside of the conical hole. This will help to prevent miss-cuts from sticking to the inside of the hole. It is also important to avoid allowing the tip of the Cut-Off knife to become hot by holding it in contact with the side of the die plate orifice between cuts, as this will increase the tendency of the extrudate to stick to the Cut-Off knife. Keep the tip of the Cut-Off knife sharp and unmarred.



**NOTE:** DO NOT USE IT AS A SCREWDRIVER.

### 5.2 THE IMPORTANCE OF PISTON GROOVES

The wall pressure in the barrel **INCREASES** as the distance between the piston head and the die **DECREASES**. Unless this distance is standardised for the purpose of measuring the extrudate flow rate, very variable results can be obtained from the same sample. This is particularly true of those materials such as polypropylene which are very pressure sensitive with respect to shear rate. The purpose of the piston grooving, therefore, is to ensure that all samples are taken over substantially the same range of pressures in each case, thereby achieving a significant improvement in the repeatability of the results.

A secondary benefit derived (sometimes erroneously described as the main purpose of the grooving) is that taking samples over a prescribed and limited part of the piston travel also ensures that they are all taken over the same temperature gradients, which will no doubt be advantageous in the case of those melt indexers where there is a pronounced temperature gradient along the barrel length.

### 5.3 FORM OF TEST SAMPLE

The sample under test may be in any form which can be loaded into the barrel. However, it should be noted that certain forms, such as films, powder, fibre or any very small particles, are to be avoided if possible. This is because it is most difficult to exclude air during the charging of such samples. Included air will produce extrudate containing bubbles and may also promote oxidative degradation of the sample.

### 5.4 CLEANING

Immediately after each test, the apparatus must be cleaned. Not only is it easier to clean a machine whilst still hot, but there is less likelihood of the cleaning being forgotten. There is also a real risk of damage in trying to clean hardened polymer from the operating surfaces. It has been found, as a result of experience in the field, that the bulk of cases where there has been apparent malfunction of the apparatus (leading to anomalous results and un-reliability) are due to faulty cleaning, usually over some time, rather than to component failure. In particular, half-hearted cleaning of the barrel and/or the die can easily lead to deposits of pyrolysed polymer, often remarkably difficult to see and recognise, effectively reducing the cross-sectional area and markedly affecting the results. The routine below should be rigorously followed.

A Remove the piston and clean off any polymer adhering to the head, face and particularly the shank, with a cloth. Place the cleaned piston in the housing provided on the apparatus.

B Push the die UP the cylinder bore with the die ejector and out of the top. The die ejector will pass through the hole in the die plate and it is not necessary to remove this. The passage of the die through the barrel will remove the bulk of any polymer remaining after the test.

C Clean the die thoroughly with a cloth and clean the bore with a die broach, polishing with a wooden peg. DO NOT HEAT THE DIE IN A FLAME TO BURN OFF POLYMER.

D Clean the bore of the barrel with the end of the cleaning tool wrapped in a cleaning patch which has first been folded in half. Push the cleaning tool firmly, with a slight rotating motion, down the barrel but DO NOT FORCE so fast that the tool crashes into the die plate below. Slow down towards the bottom of the barrel to prevent damaging the die plate, ceramic insert screws and screw holes. Use as many pieces as necessary to ensure the barrel is thoroughly clean and shiny. A dirty barrel will cause friction between the piston and the barrel wall and give false low results.

E After each series of tests, or batch exchange, give the machine more thorough cleaning removing the die plate and cleaning both sides of it and the bottom of the cylinder, in addition to the routine cleaning process already detailed.

F About every 100 hours use, or once a week for frequent users, remove the die retaining plate and retaining screws and clean thoroughly. Check the ceramic insert for chips and damage. If the insert is damaged or covered in blackened polymer, replace it.

G a) The cylinder is hardened, so the bore may be occasionally cleaned with a patch loaded with a mild metal polish. ON NO ACCOUNT however, use any coarser abrasive material than this.

b) The corrosion resistant barrel is lined with Tungsten Carbide to avoid excessive wear by caustic (e.g. PVC) or abrasive (glass filled) polymers.

H The dies are made of tungsten carbide, and with reasonably careful use, will maintain their accuracy over years of service. Dies with PE will last for years, but should be checked regularly. If PVC or glass filled polymers are used, then the die dimensions should be checked far more often. It should be cleaned, as already described, by means of the die broach and a wooden peg. Suitable plug GO/NO GO gauges are available for checking that the bore diameter is within the correct tolerance. If such a plug gauge is used to check dies in this way, great care must be taken to see that the die is both perfectly clean and COLD. If there is any dirt in the bore there is a possibility that the plug gauge will jam and, if this happens, the die will, in all probability, become damaged or chipped whilst trying to remove it. Similarly, a plug gauge inserted into a hot die will very probably lock due to differential thermal expansion. In this case make no attempt to force it but allow the whole to cool down, then the gauge will become free.



IT IS ABSOLUTELY ESSENTIAL that no die should be used which has any visible imperfection in the bore, particularly any chip, however small, on the edge of the bore opening. The die ejector is tipped with a soft alloy to prevent damage to the dies.

**NOTE:** Never use any die ejector which has lost its tip.

## **5.5 DIFFERENCES IN TEST CONDITIONS**

The standard die is not always considered suitable for use with materials with MFR greater than 25 grams/10 mins. In such cases, a die with a smaller diameter bore, 1.181mm, may be used, (the Jet B of BS2782). It must never be forgotten, however, that it is impossible to make a strict comparison between a result obtained with a different sample and the smaller die. Similar caution must be exercised when considering test temperatures and test loads.

## 6.0 AUTOMATIC FLOW RATE TIMER OPERATION

### 6.1 NOTES OF AUTO FLOW OPERATION

The Auto Flow Rate Timer is calibrated to time the swept volume of a weighted piston travelling through a pre-selected distance, usually 2mm or 25mm.

The Swept Volume of 2mm = 0.142cc

The Swept Volume of 25mm = 1.776cc

The Auto Flow Rate Time recorded on the display is the time taken to extrude either of the above volumes and depends on the Standard being applied. In order to obtain the Melt Flow Rate from this volumetric flow it is necessary to obtain the melt density at the test temperature and load from the material supplier or by integration of Cut-Off time with the use of the Auto Flow Rate Timer.

### 6.2 MELT DENSITY CALCULATION

$$\rho = m / (0.711 \times i)$$

where:

$\rho$  = the density ( $\text{g}/\text{cm}^3$ ) of the melt at the TEST TEMPERATURE.

$m$  = the average mass (g) of the cut-off.

$i$  = the predetermined distance move by the piston



**NOTE:** The melt density is NOT the same as the (solid) density at 23°C usually quoted on the certificate of conformity supplied with the resin.



**NOTE:** The GD6250 "Hostalen" resin with an MFI of 1.0 to 1.1g/10mins is used to test all machines before leaving our factory has a density of 0.947 at 23°C but a melt density of 0.760 at 190°C.

## 7.0 GENERAL MAINTENANCE

Apart from regular, careful cleaning of the working parts as already described, the Melt Flow Rate Apparatus requires little maintenance.

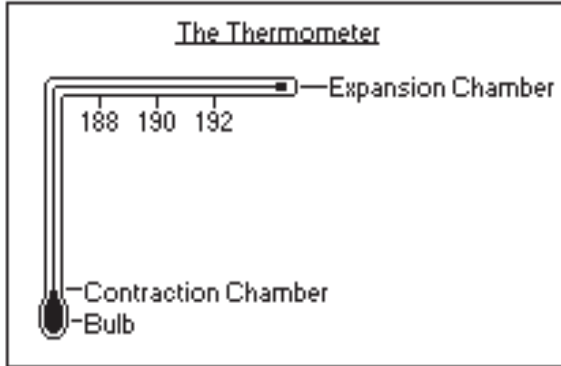
In the rare event of component failure, this should be corrected by replacing the defective unit, e.g. thermometer. If the apparatus is to be taken out of use for any length of time, it should be given a very thorough clean, after which all exposed metal parts should be protected with a light greasing before storing the apparatus in a DRY PLACE and under dust covers.

Under these conditions the Melt Flow Indexer should give many years of trouble free service.

## 8.0 THERMOMETERS

We take care to pack our thermometers so that they will not be damaged in transit. Even though it may still be that, due to vibration, breaks have appeared in the mercury column. These can easily be repaired and MUST be looked for before using the thermometer as, if one exists and is not noticed, a false temperature indication will be given as well as the possibility of the mercury bulb breaking.

### 8.1 REPAIRING BREAKS IN MERCURY COLUMN TYPES OF THERMOMETERS



A break in the mercury column can usually be detected by eye. If it is not it will be seen as soon as it is put into a heated barrel. The mercury will shoot up beyond the maximum temperature very quickly, where as under normal operation the movement of the mercury column will be quite slow. If the mercury does shoot up very quickly, immediately remove it from the barrel and allow to cool down. Then shake the thermometer firmly and decisively, with downward strokes to force the mercury back down into the bulb. Repeat if necessary. If this does not work place in the freezer compartment of a normal domestic refrigerator for about two minutes to retract the mercury into the bulb.

RS Components also supply a cryogenic spray which is much more convenient. DO NOT USE LIQUID NITROGEN, IT IS TOO COLD. DO NOT leave the thermometer in a cold place as this may solidify the mercury. Then the thermometer should be returned to room temperature slowly as rapid warming may burst the bulb owing to the pressure generated in forcing the Mercury through the capillary. Whether to heat or cool depends on the position of the break. Those near the bulb are best rejoined by cooling and visa versa.

### 8.2 THERMOMETERS WITH CONTRACTION AND EXPANSION CHAMBERS

If the detached part of the column is above the contraction chamber, rejoin the expansion chamber by heating as already explained. If there are breaks in the mercury in the contraction chamber, firmly but smoothly swing the thermometer bulb downwards, as when shaking down a clinical thermometer. If this fails, tap the bulb vertically on the palm of the hand. Occasionally a small globule of mercury is left in the neck of the contraction chamber. It can often most easily be reunited by heating the thermometer to drive it some way up the stem and then chilling the bulb. The detached piece will shoot back down the capillary and fly into the contraction chamber.

### 8.3 RED SPIRIT THERMOMETERS

It is not unusual for these to exhibit breaks. If they occur they can be rejoined by freezing the bulb.



**NOTE:** DO NOT ATTEMPT TO REJOIN BY HEATING

#### **8.4 GENERAL CARE OF THERMOMETERS IN USE**

Thermometers must be treated with care. Being made of glass, they are not only mechanically fragile, but also cannot withstand excessive thermal shocks, either by heating or by cooling. It is therefore always better to allow a thermometer to warm up and cool down gradually. If it is necessary to change thermometers during use DO NOT put hot thermometers onto cold conductive surfaces. Try to warm up cold thermometers gradually, rather than plunging them directly into high temperature environments.

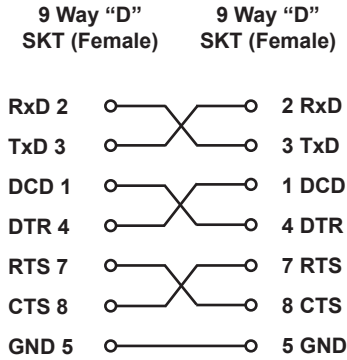
## 9.0 SPECIFICATIONS

MFI Specification	
Temperature Range	40°C to 400°C with 20 minutes warm up time from ambient to 190°C
Temperature Controller	All systems $\pm 0.1^\circ\text{C}$ accuracy
Mounting	All systems are bench mounted
Electrical Supply	MFI 10 & MFI 10/CB, 230V ac +10% 50 - 60Hz, Fuses 5A(T) MFI 10/110 & MFI 10/110/CB, 115V ac +10% 50 - 60Hz, Fuses 10A (T) Maximum power requirement 1 kW. via I.E.C. plug. (CN 1)
Overall Dimensions	Height 600mm, Width 463mm, Depth 404mm
Weight, with standard accessories	Unpacked 32kg (71 lbs) Packed (in wooden crate) 53kg (117 lbs)
Operating Conditions	5°C to 45°C (41°F to 129°F) 0 - 80% RH non condensing. Well ventilated, draught free.
Storage Conditions	-20°C to 55°C, Substantially Dry (-4°F to 131°F)
i/p & o/p Connections	CN1 - I.E.C. Plug, Mains In. CN2 - I.E.C. Socket, Mains Out, 250VA max. CN3 - 9 Pin "D" Plug, RS232 interface. CN4 - 15 Way "D" Socket, Auto Cut Off & Analogue O/P CN5 - 15 Way "D" Socket, Weight Loading System & Analogue. O/P. CN6 - 9 Way "D" Socket, Automatic Flow Rate Timer.
Standards	ISO1133 BS2782: Part 7: Method 720A , ASTM D1238 (Procedures A & B) - Procedure B requires optional Automatic Flow Rate Timer NFT UNE UNI DIN

## 10.0 CONNECTION LEADS

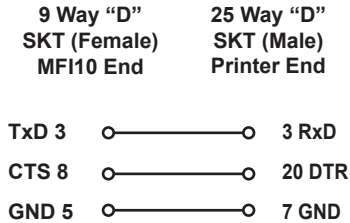
### 10.1 RS232 LEADS

MF110 to PC Lloyd Part No. 09/0695 ( supplied )



Baud rate 4800, 8 bit, 1 Stop bit, No parity

MF110 to Citizen Printer Lloyd Part No. 09/0644 ( optional )



Baud Rate 4800, 8 bit, 1 Stop bit, No parity.



**NOTE:** To maintain EMC compliance ONLY leads supplied by Lloyd Instruments should be used. Check leads for signs of damage regularly. Replace leads that are damaged in any way.





#### International Symbols

##### WEEE Directive

This equipment contains electrical and electronic circuits and should not be directly disposed of in a landfill site.



##### RoHS

This product is RoHS and China RoHS compliant. This symbol indicates the equipment contains some restricted hazardous substances above the recommended level, and may offer potential harm to the environment after 15 years from date of manufacture.

**AMETEK**<sup>®</sup>  
TEST & CALIBRATION INSTRUMENTS

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