

# ICM-WMKR

## Inline Contamination Monitor

### User Guide



Covers All ICM Models

## SAFETY WARNING

Hydraulic systems contain dangerous fluids at high pressures and temperatures. Installation, servicing and adjustment is only to be performed by qualified personnel.

Do not tamper with this device.

# Contents

<b>1</b>	<b>Introduction</b>	<b>6</b>
1.1	Operating Principle	
<b>2</b>	<b>How to Order</b>	<b>8</b>
2.1	Related Products	
2.1.1	ICM-RDU	9
2.1.2	ICM-FC1	9
2.1.3	ICM-USBi	9
<b>3</b>	<b>Speci cation</b>	<b>11</b>
3.1	Performance	
3.2	Hydraulic	
3.3	Environmental	
3.4	Physical	
3.5	Electrical	
3.6	Warranty and Recalibration	
<b>4</b>	<b>Status LED</b>	<b>14</b>
<b>5</b>	<b>Front Panel Operation</b>	<b>16</b>
5.1	Result Display	
5.2	Diagnostics Display	
<b>6</b>	<b>Water Sensor</b>	<b>20</b>
<b>7</b>	<b>Data Logger</b>	<b>22</b>
<b>8</b>	<b>Remote Display Unit Option</b>	<b>23</b>

<b>9</b>	<b>USBi - Optional Computer USB Interface</b>	<b>24</b>
<b>10</b>	<b>Remote Control</b>	<b>25</b>
10.1	Computer Connection	
<b>11</b>	<b>PC Software Operation</b>	<b>28</b>
<b>12</b>	<b>Settings</b>	<b>30</b>
12.1	General	
12.2	Test Number	
12.3	Test Duration	
12.4	Test Format	
12.5	Continuous Testing	
12.6	Alarms	
12.6.1	Alarm LED	33
12.6.2	Alarm Levels	34
12.6.3	Alarm Mode	36
<b>13</b>	<b>Installation</b>	<b>41</b>
13.1	Installation Procedure	
<b>14</b>	<b>Electrical Interface</b>	<b>43</b>
14.1	DC Power	
14.2	Serial Interface	
14.3	Switched Input and Output Signals	
14.4	Start Signal	
14.5	Alarm Outputs	
<b>15</b>	<b>Hydraulic Connection</b>	<b>49</b>
15.1	High or Low Pressure Parallel Connection	
15.2	Low Pressure, O -Line Operation	
15.3	Very Low Flow Systems	
15.4	Flow Rate	

15.4.1	Summary	50
15.4.2	Detailed Calculations	50
15.5	Manual Flow Control	
15.6	Active Flow Control	
<b>16</b>	<b>Fault Finding</b>	<b>55</b>
16.1	LED Flashing / Fault Codes	
16.2	Other Faults	
<b>17</b>	<b>Cycle Time and Flow Rate Considerations</b>	<b>57</b>
<b>18</b>	<b>Modbus Programming</b>	<b>59</b>
18.1	Reading the Result Codes	
<b>A</b>	<b>Measuring Water in Hydraulic and Lubricating Fluids</b>	<b>61</b>
<b>B</b>	<b>ISO 4406 Cleanliness Code System</b>	<b>62</b>
<b>C</b>	<b>NAS 1638 Cleanliness Code System</b>	<b>64</b>
<b>D</b>	<b>Hydraulic System Target Cleanliness Levels</b>	<b>65</b>
<b>E</b>	<b>New ISO Standard Test Dust and its effect on ISO Contamination Control Standards</b>	<b>67</b>
E.1	Calibration	
E.2	New Test Dust Benefits	
E.3	Effect on Industry	
E.4	Correlation between Particle Sizes Obtained using ACFTD (ISO 4402:1991) and NIST (ISO 11171) Calibration Methods	
E.5	Other Standards	

# 1 Introduction

The ICM measures and quantifies the numbers of solid contaminants in Hydraulic, Lubrication and Transmission applications. The ICM is designed to be an accurate instrument for permanently installed applications utilising mineral oil as the operating fluid.

The unit can operate using any of the international standard formats ISO 4406:1999, NAS 1638, AS 4059E and ISO 11218.

The ICM incorporates a serial data connection for comprehensive remote control and monitoring.

The integrated data logger records up to 4000 test results internally, for use where a computer cannot be permanently connected.

Simple switched inputs and alarm outputs are provided as alternative means of controlling the testing and signalling the results. The “full color” front panel led provides a basic indication of the cleanliness level.

The graphical LCD and keypad allow direct local display of the results in any selected format.

The ICM-WMKR also performs a measurement of % saturation of Water in oil (RH), and fluid temperature (°C).

## 1.1 Operating Principle

The instrument uses a light extinction principle whereby a specially collimated precision LED light source shines

through the fluid and lands on a photodiode. When a particle passes through the beam it reduces the amount of light received by the diode, and from this change in condition, the size of the particle can be deduced.

## 2 How to Order

Example: **ICM** - **W** **M** **K** **R** **G1**

Example: **ICM** - **0** **M** **0** **0** **G3**

### **ICM**

*Common Features* – All versions can be controlled by a PC, PLC or the ICM-RDU Remote Display Unit. Included is time-stamped data-logging for around 4000 tests, an integral status LED to indicate fault conditions, RS485 communications and measurement in multiple international standard formats. All units include 3m pre-wired control cable and LPA-View test analysis software. For more details see the product brochure and the Specification (3).

The *base unit* for remotely controlled embedded applications and comes without key-pad and LCD.

### **W**

Adds Water and Temperature Sensing.<sup>1</sup>See 6. “0” if not required.

### **M**

Mineral Oil Fluid Compatibility. Also **N** – **O** shore and selected water based fluids. **S** – Phosphate ester and aggressive fluids.

### **K**

Keypad – Adds graphical LCD and a key-pad. See 5. “0” if not required.

### **R**

Adds settable upper and lower limits for the test results, with two programmable “Alarm” relay outputs<sup>2</sup>. The full

<sup>1</sup> For high frequency pressure pulse applications contact MP Filtri UK Ltd.

<sup>2</sup> This option, together with -K, is also required in order to display detailed particle counts on the LCD. The option also provides a switched start signal input.



colour front panel LED indicator also reflects the test results, indicating if any set limits have been exceeded. See **12.6**. “0” if not required.

**G1**

M16x2 Mini-mess connections (ICM Standard). Also **G3** – 1/4", **G4** – 7/16th UNF.

## 2.1 Related Products

### 2.1.1 ICM-RDU



The ICM-RDU is a separate product that is used to remotely monitor or control an ICM. It is used when the ICM is in a location unsuitable for a display, such as an engine compartment. See **8**.

### 2.1.2 ICM-FC1

A pressure compensated flow control valve suitable for the ICM. This may be needed if the application produces an oil flow that varies outside the working range of the standard unit.

### 2.1.3 ICM-USBi



USB interface adaptor for the ICM. This is a ready-made solution for easily connecting a computer to the ICM. It comprises a USB:RS485 interface with a terminal block pre-wired with the ICM cable. An extra terminal block is provided for any customer wiring to external devices. An external DC adapter can be used to power the complete

system, or if the computer is always connected during use, power can be taken directly from the USB cable.

Full usage instructions are provided in the separate product leaflet.

# 3 Specification

## 3.1 Performance

<b>Technology</b>	Precision LED Based Light Extinction Automatic Optical Particle Counter
<b>Particle Sizing</b>	>4,6,14,21,25,38,50,70 $\mu\text{m(c)}$ to ISO 4406:1999 Standard
<b>Analysis Range</b>	ISO 4406:1999 Code 0 to 25 NAS 1638 Class 00 to 12 AS4059 Rev.E. Table 2 Sizes A-F : 000 to 12 (Lower Limits are Test Time dependent)
<b>Reporting Formats</b>	ISO 4606:1999 NAS 1638 AS 4059E Table 2 AS 4059E Table 1 ISO 11218
<b>Accuracy</b>	$\pm\frac{1}{2}$ ISO code for 4,6,14 $\mu\text{m(c)}$ $\pm 1$ code for 21,25,38,50,70 $\mu\text{m(c)}$
<b>Calibration</b>	Each unit individually calibrated with ISO Medium Test Dust (MTD) based on ISO 11171 (1999), on equipment certified by IFTS.
<b>Test Time</b>	Adjustable 10 - 3600 seconds (factory set to 120s)
<b>Moisture &amp; Temperature Measurement</b>	% saturation (RH) and fluid temperature( $^{\circ}\text{C}$ ) – Mineral Oil Only. See <a href="#">6</a>
<b>Data Storage</b>	Approximately 4000 timestamped tests in the integral ICM memory.

**Keypad & LCD** 6 keys, 128x64 pixels, back-lit graphical display

### 3.2 Hydraulic

**Fluid Compatibility** Mineral oil & petroleum based fluids. Consult MP Filtri UK for other fluids.

**Flow Rate** 20-400 ml/minute

**Viscosity Range** <1000 cSt

**Fluid Temperature** -25 to +85 °C

**Maximum Pressure** 400 bar static. For high frequency pressure pulse applications contact MP Filtri UK

**Differential (Inlet-Outlet) Pressure** Typically 0.5 bar, but see [15.4](#).

**Seal Material** Nitrile (NBR). Contact MP Filtri UK for any fluids that are incompatible with Nitrile seals.

### 3.3 Environmental

**Ambient Temperature** -25 to +55 °C

**IP Rating** IP 65/67 Versatile

**Vibration** TBD

### 3.4 Physical

**Dimensions** 117(H)x142(W)x65(D).

**Fixing Holes** Centers 126mm apart, Diameter 6.9mm (for M6).

**Weight** 1.15kg

### 3.5 Electrical

**Supply Voltage** 9-36V DC

**Supply Current**

12V	24V	36V
150mA	80mA	60mA

**Power** <2.2W

**Consumption**

**Switched Inputs & Outputs** see [14.3](#) for details

### 3.6 Warranty and Recalibration

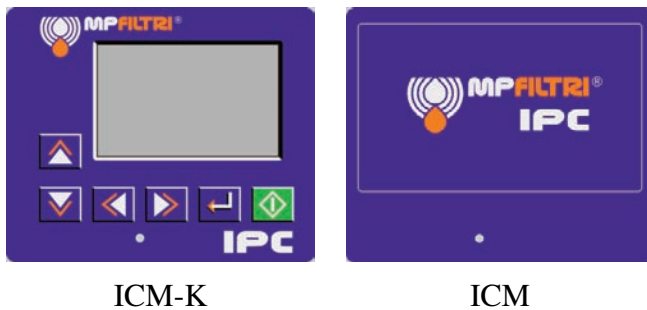
**Warranty** The ICM is guaranteed for 12 months from date of receipt.

**Re-calibration** The ICM is recommended to be should be recalibrated every 12 months. Return to MP Filtri UK for recalibration.

As a policy of continual improvement, MP Filtri UK reserve the right to alter the specification without prior notice.

## 4 Status LED

All ICM versions have a multicolor indicator<sup>3</sup> on the front panel, which is used to indicate the status or alarm state. The alarm thresholds can be set from LPA-View via the serial interface.



**Figure 4.1** Front Panel Versions

- *Green* indicates that the test result passed, i.e. none of the alarm thresholds were exceeded.
- *Yellow* indicates that the lower cleanliness limit was exceeded, but not the upper one.
- *Red* indicates that the upper cleanliness limit was exceeded.
- *Blue* indicates that the upper water content limit was exceeded.

<sup>3</sup> If all these codes seem confusing, please note that a given colour will only ever be seen if the corresponding limit has been specifically set by the user. So for example if a maximum temperature limit has not been set, the violet indication will never be seen. If all that is wanted is a “green or red” light, that can be arranged by simply setting only the cleanliness threshold maximum limit.

- *Red/Blue Alternating* indicates both cleanliness and water content upper limits exceeded.
- *Violet* indicates that the upper temperature limit was exceeded.<sup>4</sup>
- The LED can also indicate various fault codes by turning red and flashing white a number of times, see **16.1**.

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<sup>4</sup> This alarm, *if set*, takes priority over the Contamination and Water alarms. In the event of an over-temperature condition, the LED will turn violet only, whether or not there is also a contamination or water alarm condition. The rationale is that an over-temperature condition could be immediately catastrophic for the hydraulic system.



# 5 Front Panel Operation

## 5.1 Result Display






The ICM-WMKR has a 6 button keypad and a small graphical LCD. This allows the display of the test result (current cleanliness level, with water content and temperature if applicable). The graphical format allows a full display of all codes of the standards supported.

The unit powers up in “Display Mode”. This displays the test result in the selected format. **Figures 5.1** onward show those available.<sup>5</sup> The screenshots on the right are the “detailed” version of the display additionally showing the particle counts and flow rate. The particle sizes and count representation are automatically matched to the selected format.

The operator can switch between the “simple” and “detailed” displays using  and .

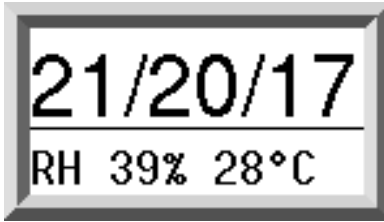
The horizontal line is the progress bar, it grows from left to right as the test progresses. When it reaches the right hand side a new result is generated.

## 5.2 Diagnostics Display

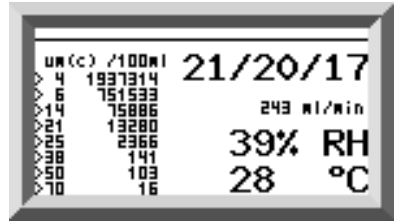
Press  to show the diagnostics display (used when diagnosing problems). Then switch between the diagnostics screens using the  and  buttons.

<sup>5</sup> The selected format is typically set during installation (using LPA-View). The rationale is that each industry or company will have its preferred format, it is not something that an operator should be changing.



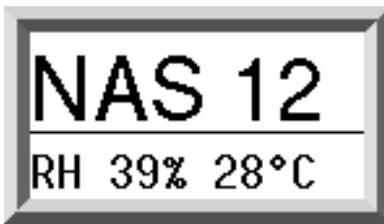


Simple

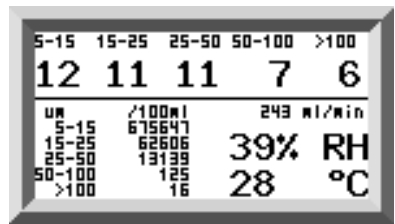


Detailed

Figure 5.1 ISO4406:1999



Simple

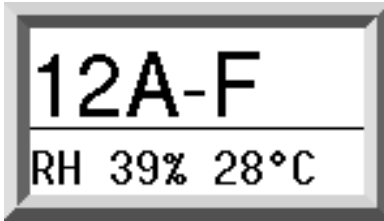


Detailed

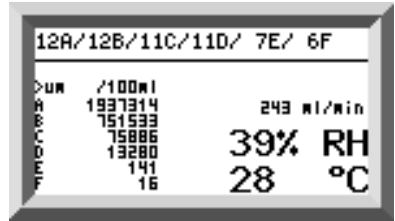
Figure 5.2 NAS1638

*Completion* shows a number from 0 to 1000, indicating the test progress. *FLOW ml/min* provides an approximate indication of flow rate, updated after each test. This can be helpful when installing the unit or checking operation, to ensure that the flow rate is within the limits of the unit. The other items are mainly of use to assist in support when reporting problems.

The second screen shows diagnostics relating to serial communications. *Bridge Transactions* are those between a connected PC and the ICM. *Master Transactions* are internal to the unit, showing communications between the ICM keyboard/display circuit board and the sensor itself.

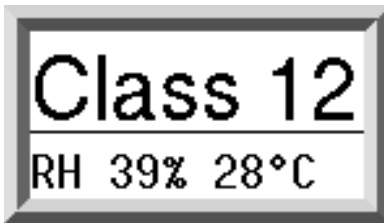


Simple

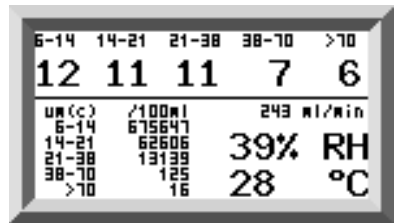


Detailed

Figure 5.3 AS4059E Table 2

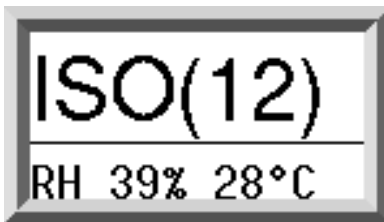


Simple

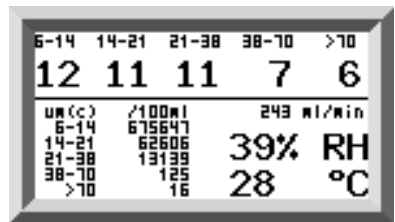


Detailed

Figure 5.4 AS4059E Table 1



Simple



Detailed

Figure 5.5 ISO11218 (Draft)

```
IPC SERIAL NUMBER 1234
COMPLETION        1000
NO NOISE THRESHOLD 221
LED LEVEL         6349
TEMPERATURE       2262
RH                4228
FLOW ml/min       226
KEYMAP            00
IPC-R VERSION     0.7
IPC-R VERSION     0.11
```

General Diagnostics

```
Master Transactions 220
Master Errors      0
Master Baud Rate   0
Master Edge Count  1
Master Last Edge   0
Master Bit Time    3333
Master AutobaudTime 191114
Bridge Transactions 330
Bridge Errors      0
Baud Established
```

Communications

Figure 5.6 Diagnostic Screens

## 6 Water Sensor

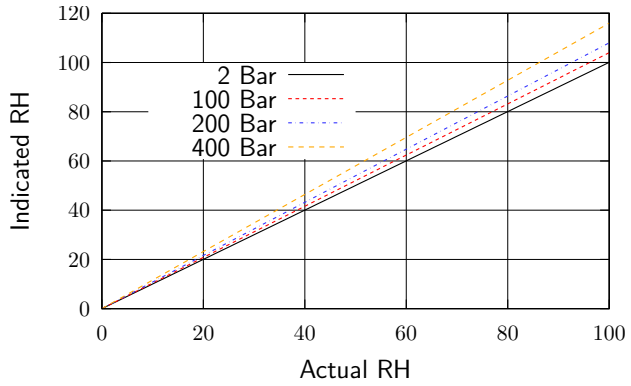
The ICM-WMKR measures water content using a capacitive RH (relative humidity) sensor. The result is expressed as percentage saturation. 100% RH corresponds to the point at which free water exists in the fluid, i.e. the fluid is no longer able to hold the water in a dissolved solution. This is also normally the point at which damage occurs in a hydraulic system, so is an ideal measurement scale that is independent of the fluid characteristics.

The water saturation point (100% RH) is temperature dependent, so the temperature is measured at the same time.<sup>6</sup> This enables results to be compared meaningfully.

The water sensor output is affected by pressure, so the accuracy will be proportionally degraded above 100 bar operating pressure.

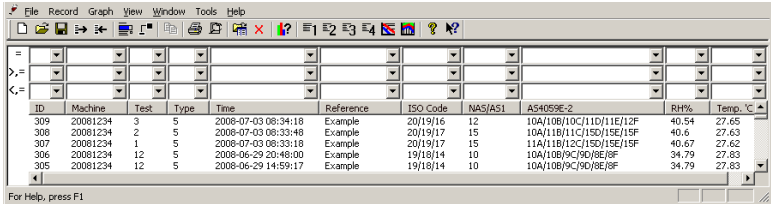
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<sup>6</sup> The temperature measured is that of the fluid passing through the unit. Note this may differ from that of the hydraulic system, depending on flow rate, pipe length and ambient temperature. It is not intended to be an accurate indication of system temperature, but to provide a reference for the RH measurement. Nevertheless experience has shown the temperature measured is within a few degrees of that of the hydraulic system, in most applications.



**Figure 6.1** Water Sensor Response variation with Absolute Pressure

# 7 Data Logger



The screenshot shows the ICM data logger software interface. It features a menu bar (File, Record, Graph, View, Window, Tools, Help) and a toolbar with various icons. Below the toolbar is a grid of dropdown menus for configuring the data logger. The main area displays a table of test results with the following columns: ID, Machine, Test, Type, Time, Reference, ISO Code, NAS/AS1, A54059E-2, RH%, and Tempo. °C.

ID	Machine	Test	Type	Time	Reference	ISO Code	NAS/AS1	A54059E-2	RH%	Tempo. °C
309	20081234	3	5	2008-07-03 08:34:18	Example	20/19/16	12	10A/10B/10C/11D/11E/12F	40.54	27.65
308	20081234	2	5	2008-07-03 08:33:48	Example	20/19/17	15	10A/11B/11C/15D/15E/15F	40.6	27.63
307	20081234	1	5	2008-07-03 08:33:18	Example	20/19/17	15	11A/11B/12C/15D/15E/15F	40.67	27.62
306	20081234	12	5	2008-06-29 20:46:00	Example	19/18/14	10	10A/10B/9C/9D/8E/8F	34.79	27.83
305	20081234	12	5	2008-06-29 14:59:17	Example	19/18/14	10	10A/10B/9C/9D/8E/8F	34.79	27.83

The ICM includes a built-in data logger, which adds the facility to log and timestamp test results locally within an internal memory, even when not connected to a computer.

- Which tests are logged, and when, are determined by the log settings (see [12.5](#)).
- Each log entry is time-stamped and contains the ICM serial number, so that it can be identified later.
- The ICM memory has space for around 4000 log entries. When full, the oldest log entry is overwritten.

See [chapter 11](#) for details of how to download the test log.

## 8 Remote Display Unit Option

The optional ICM-RDU is a separate box that just contains the keypad and display. The sensor itself is mounted remotely in another box. This allows the operator full control of the ICM even where the sensor itself is not easily accessible. The ICM-RDU connects “in between” the incoming supply/serial connections, and the ICM sensor. It is “transparent” to the serial communications. This means that a PLC or LPA-View can operate in the usual way to control the ICM, change settings or download results, without having to unplug the RDU.

The same components are used for the RDU as for the normal ICM -K option, so the same instructions apply for operation. See [chapter 5](#) for more details.

The RDU wiring details are shown in [figure 14.4](#).

## 9 USBi - Optional Computer USB Interface



**Figure 9.1** ICM-USBi: A  
USB Interface Unit for the ICM

This is a ready-made solution for easily connecting a computer to the ICM. It comprises a USB:RS485 interface with a terminal block pre-wired with the ICM cable. An extra terminal block is provided for any customer wiring to external devices. An external DC adapter can be used to power the complete system, or if the computer is always connected during use, power can be taken directly from the USB cable.

Detailed installation and usage instructions are provided in the separate product user guide.



# 10 Remote Control

The ICM can be controlled using the remote control facility included in the LPA-View software package, installed on a PC. Alternatively customers can use their own software running on a PC or PLC.

Since the ICM includes a built-in datalogging memory, operators can make use of the remote control facility in one of two ways:

- **Direct Online Operation**

The particle counter is permanently connected to a computer whilst tests are carried out. The operator can set parameters, type a label and initiate the test. They can then monitor the progress of each test. Each test result is displayed and downloaded into the test database as it is completed.

- **Disconnected Operation**

Here the ICM operates as a stand alone item, performing tests on a schedule or under external command from a control system. If a permanent record of the results is needed, and operator can occasionally connect a computer and use LPA-View to download the accumulated test data.

## 10.1 Computer Connection

The connection is made using an RS485 adaptor connected to the PC. Either a USB:RS485 or a RS232:RS485 converter can be used, depending on the the interface available

on the computer. The ICM-USBi is separately available as a pre-wired solution for USB (all modern laptops and PCs). Make the connection, start LPA-View running and then apply power to the ICM.

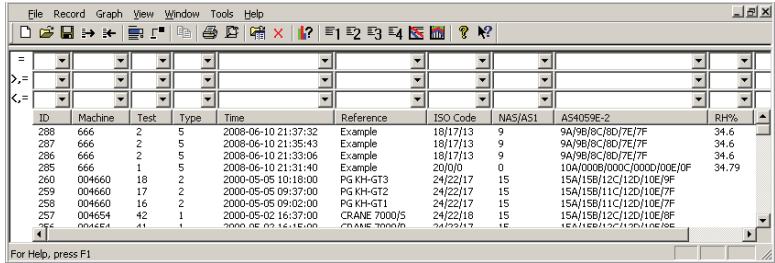


Figure 10.1 LPA-View



To access the Remote Device facility in LPA-View, press the Remote Control button on the toolbar.

The *Connect* dialog will then appear.



Figure 10.2 The Connect Dialog

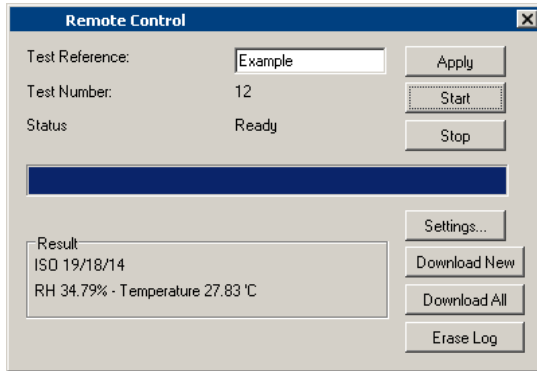
The first time that this is done, the correct communications port (COM port) on the computer has to be selected, as detailed below.

- The program scans the computer for available ports, and puts them in a list to choose from - this list is in the box above the Connect Button. Press the arrow on the right hand side of this box and choose the connection on your computer.

- All working communication ports of the computer are available for selection. Select the one used to connect the ICM, then press OK. If you are unsure which port is correct, try each one in turn. When communication has been established successfully, the remote control dialog will appear. After a successful connection, the COM port will be remembered for next time and will appear preselected in the dialog.

# 11 PC Software Operation

The *Remote Control* dialog allows an operator to manually control the ICM from a PC, using the LPA-View software. It can also be used to download test results that have accumulated during autonomous (disconnected) operation.



**Figure 11.1** The Remote Control Dialog<sup>7</sup>

To perform a test, first optionally edit the *Test Reference* and press *Apply* to set the new value. This is a descriptive label which can be used to identify or group the test later (along with the test number and test time/date). An example would be a machine number or customer name. The *Test Reference* can be up to 15 characters in length.

When connected the ICM *status* should show “Ready”. The operator can then press the *Start* button to begin the test.

<sup>7</sup> Some items may be missing depending on the options fitted to the ICM.

The *progress bar* shows how much of the test has been completed. The test can be abandoned at any time by pressing the *Stop* button. If the *Start* button is pressed during a test, then the current test is abandoned and a new one started.

When the test has finished, the *Result* area will display the contamination level , water content and temperature in the set format.

After a test the *Test Number* is automatically incremented and the *status* of the test is displayed. If the status is *Ready* then the operator can press the *Start* button again to begin a new test. It is also possible to configure the ICM to *automatically* begin another test, after an optional delay. In this case the status will be *Testing* or *Waiting*.

The ICM incorporates a data logger, so previous test results can be downloaded into the test database using the *Download New* and *Download All* buttons. The difference between these is that *Download New* only transfers results that have never been downloaded before. *Download All* transfers all results that are stored in the ICM. *Erase Log* deletes the test results from the memory of the ICM.

When the user has finished operating the ICM the dialog can be dismissed using the *close* control (the “X” at the top right corner of the dialog) or by pressing the *Esc* key.

Pressing the *Settings...* button brings up the *Remote Device Settings* dialog.

# 12 Settings

The ICM can be reconfigured<sup>8</sup> using the *Remote Device Settings* dialog. This is normally done as part of the installation or commissioning process.

After making any changes, pressing the OK button will update the ICM with the new settings. Or press Cancel to leave the settings as they were.

## 12.1 General

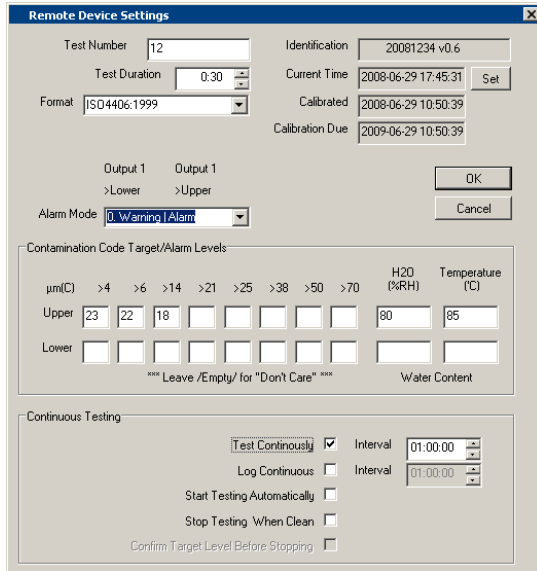
Some general information about the connected ICM unit is available. The *Identification* shows the ICM serial number and software version. The serial number, together with the test timestamp, uniquely identify the test record. These two parameters are the ones used to avoid duplication of test records.

*Current Time* shows the time set on the ICM. It is important that this is correct (for -L data-logging versions) since this is used to timestamp the tests. Pressing the *Set* button automatically synchronises the ICM time to that on the computer.

---

<sup>8</sup> The ICM has been designed to be a very flexible product, so has a wide range of settings and operating modes. However the shipped defaults are suitable for most applications and many users can skip this section. Actual operation is straightforward even when advanced settings are used during initial configuration.

<sup>9</sup> Some items may be missing depending on the options fitted to the ICM.



**Figure 12.1** Remote Device Settings Dialog<sup>9</sup>

The *calibration* area displays the date last *Calibrated* and the next *Calibration Due* date.

## 12.2 Test Number

The *Test Number* can be used to help identify a test within a sequence. However it is automatically reset when the ICM is powered up, so instead simply relying on the timestamp (date and time of test) and test reference is preferred.

## 12.3 Test Duration

The length of the test is controlled by the set *Test Duration*.

The factory set value of 2 minutes is suitable for most applications, but the user is free to set a different value. Shorter times will make the ICM more responsive to short-term fluctuations in contamination level. It will also result in less consistent results for the large particle sizes and clean systems, due to statistical fluctuations in the number of particles counted.

Longer tests will allow more “even” results in very clean systems and for the larger particle sizes, since there will be a larger total number of particles counted during the test. This means that any fluctuations have less of an effect on the test result.

## 12.4 Test Format

Use the selector to choose the preferred display *Format* (ISO, NAS etc). This selection is not just cosmetic since it also determines how the cleanliness alarm targets are to be interpreted, if these are used.

## 12.5 Continuous Testing

In the *Continuous Testing* area are settings which control how the ICM decides when to perform and log a test. Selecting *Test Continuously* makes the ICM automatically repeat the test, according to the specified *Test Interval*. Setting an interval longer than the test duration results in the test being repeated upon each expiry of that interval. For example, setting a *Test Duration* of 1 minute, and a *Test Interval* of 10 minutes, results in a 1 minute test performed every 10 minutes. Setting the interval to a value less than the



Test Duration (for example zero) results in a new test being started immediately a test finishes.

*Start Testing Automatically* sets the ICM to begin a test soon after it is powered up. This is ideal for unattended systems.

*Stop Testing When Clean* is a feature intended for cleaning rigs or “filter trolley” type applications. The ICM continues testing until the fluid is “clean”, at which point an alarm is signalled and testing stops.

*Confirm Target Level Before Stopping* This helps to ensure that a test sequence is not terminated too soon, when there are still a few large particles in the system. When selected, two successive “clean” results are needed before testing halts.

## 12.6 Alarms

The ICM has two switched “alarm” outputs that can be used to signal external equipment in various ways, according to the test results and the alarm settings. There is also a multi-colour front panel light which indicates how the result compares to the set alarm thresholds.

The alarm settings are comprehensive and flexible, allowing the ICM to be used in many different scenarios.

### 12.6.1 Alarm LED

The front panel LED also indicates these alarm states to the operator (see [section 4](#)).

## 12.6.2 Alarm Levels

The various alarm thresholds are set in the *Contamination Code Target / Alarm Levels* area of the dialog.

Contamination Code Target/Alarm Levels										
µm(C)	>4	>6	>14	>21	>25	>38	>50	>70	H2O (%RH)	Temperature (°C)
Upper	23	22	18						80	85
Lower										

\*\*\* Leave /Empty/ for 'Don't Care'\*\*\*  
Water Content

**Figure 12.2** ISO4406:1999 Alarm Levels

Alarms can be set on combinations of cleanliness codes, water content and temperature. The available codes, and their interpretation, vary according to the set test *Format*. For example it is possible to set a threshold of “NAS 11” or “ISO 18/16/15” or “AS4059E 8B-F”, etc.

In general there are upper and lower limits that can be set for the cleanliness level, also for water content and temperature if applicable. An alarm, if enabled, will become active if *any* of the associated (upper/lower) limits are exceeded. However a field is left empty (blank) this is interpreted as a “don t care” setting.

In the example Figure 12.2 the Upper Alarm is exceeded if the  $4\mu\text{m}$  count is greater than ISO code 23, or the  $6\mu\text{m}$  greater than ISO code 22, or the  $14\mu\text{m}$  count greater than code 18, or the water content is greater than 80% RH, or the temperature is greater than  $65^{\circ}\text{C}$ . The lower alarm is never triggered since all the settings are empty.

### 12.6.2.1 ISO4406:1999 Alarm Levels

ISO4406:1999 represents cleanliness using codes for the number of particles greater than 4, 6 and 14  $\mu\text{m}$ . These codes can be used as limits for the alarms by selecting the ISO4406:1999 test *Format* and then entering values as required. As an extension to ISO4406:1999 it is also possible to specify codes for the other measured sizes too. If this is not needed then the entries can be left blank.

### 12.6.2.2 NAS1638 Alarm Levels

Contamination Code Target/Alarm Levels								
Basic Class		Particle Size Ranges ( $\mu\text{m}$ )					H2O (%RH)	Temperature (°C)
Upper	Lower	5-15	15-25	25-50	50-10	100+		
7							80	85

\*\*\* Leave /Empty/ for "Don't Care" \*\*\*

Water Content

NAS 1638 can be used by selecting this as the test *Format*. The headings and boxes for the available settings change appropriately. NAS 1638 represents the overall cleanliness level as a single code, this being the highest of the individual codes generated for each defined particle size. Hence we have the option of setting a limit on this overall contamination class (the *Basic Class*), or we can set individual limits on any combination of the classes for the defined particle size ranges.

### 12.6.2.3 AS4059E Table 2 Alarm Levels

Contamination Code Target/Alarm Levels									
Basic Class		Particle Size Ranges					H2O (%RH)	Temperature (°C)	
Upper	Lower	A	B	C	D	E	F		
7								80	85

\*\*\* Leave /Empty/ for "Don't Care" \*\*\*

Water Content

AS4059E Table 2 uses letters instead of numbers to indicate the particle size range, so the settings are labelled appropriately. The standard specifies ways to represent a cleanliness level using only a subset of the available particle sizes, for example B-F. The user can achieve this by only entering settings for the sizes desired, leaving the others empty. So a limit of AS4059 7B-F could be represented simply by entering a value of 7 for B,C,D,E and F.

### 12.6.2.4 AS4059E Table 1 / ISO11218 Alarm Levels

Contamination Code Target/Alarm Levels		Basic					H2O	Temperature
		µm	5-15	15-25	25-50	50-100	(%RH)	(°C)
		Class µm(C)	6-14	14-21	21-38	38-70	>70	
Upper	<input type="text" value="7"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text" value="80"/>	<input type="text" value="85"/>
Lower	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
*** Leave /Empty/ for "Don't Care" ***								Water Content

These two standards are similar except for terminology and reporting format. The actual numeric sizes and class thresholds are the same.

### 12.6.3 Alarm Mode

Output 1		Output 1
<=Lower		>Upper
Alarm Mode	<input type="text" value="1. Clean   Dirty"/>	
Contamination Code	<input type="text" value="1. Clean   Dirty"/>	
Basic	<input type="text" value="2. Green   Amber-Red"/>	<input type="text" value="50-100 &gt;100"/>
Class	<input type="text" value="3. Particles   Water"/>	<input type="text" value="38-70 &gt;70"/>
Upper	<input type="text" value="4. Continue   Clean"/>	
	<input type="text" value="5. Tested   Clean"/>	
	<input type="text" value="6. Testing   Clean"/>	

Figure 12.3 Alarm Modes

The *Alarm Mode* sets the precise function of the two switched alarm outputs of the ICM.<sup>10</sup> This allows the ICM to be used in a variety of situations. Note that the conditions under which the outputs are turned on are also displayed above the *Alarm Mode* selector, for each setting.

### 12.6.3.1 Alarm Mode 0: Warning-Alarm

	Output 1	Output 2
Turns on When	>Lower	>Upper
Intended Function	Warning	Alarm

This allows the ICM to switch external warning lights or alarms. Output 1 is the “Warning” output, switching on if any of the *Lower* limits are exceeded. Output 2 is the “Alarm” output, behaving similarly for the upper limit.

### 12.6.3.2 Alarm Mode 1: Clean-Dirty

	Output 1	Output 2
Turns on When	≤Lower	>Upper
Intended Function	Clean	Dirty

<sup>10</sup> Note that these outputs are distinct from the front panel LED, and that the set alarm mode does not affect the LED. The set alarm mode determines the function of the two switched outputs only. This setting and this entire section can be ignored if these outputs are unused, i.e. the user has not connected them to anything.

This could be used in a cleaning system that attempts to maintain a cleanliness level by switching a pump on and off.

Output 1 is the “Clean” output, coming on when the result is less than or equal to the lower (“Clean”) limit. This could be used to stop a cleaning pump.

Output 2 is the “Dirty” output, coming on when the result is greater than the upper (“Dirty”) limit. This could be used to start the cleaning pump.

### 12.6.3.3 Alarm Mode 2: Green-Amber-Red

	Output 1	Output 2
Turns on When	<Upper	>Lower
Intended Function	Green	Red

- ● ● This mode encodes the result in such a way that the internal alarm relays can be used to drive an *external remote* 3-colour LED indicator. This is a special type of LED containing both red and green emitters, which could be mounted in a control panel. This external LED will then turn green / amber / red according to the test result – in a similar way to the built-in one. Output 1 (“Green”) is turned on when the result is less than the upper limit. Output 2 (“Red”) is turned on when the result is greater than the lower limit. If the result is in between, both outputs are turned on and the LED colour will be amber (i.e. a mixture of red and green light).

### 12.6.3.4 Alarm Mode 3: Particles-Water

	Output 1	Output 2
Turns on When	Cleanliness>Upper	Water>Upper
Intended Function	Cleanliness Alarm	Water Alarm

This is used when separate alarm outputs are needed for particles (cleanliness) and water content.

### 12.6.3.5 Alarm Mode 4: Continue-Clean

	Output 1	Output 2
Turns on When	>Lower	≤Lower
Intended Function	Continue Testing	Stop Testing / Clean

This is used for a “cleaning” application where a signal is needed to stop testing (for example to stop a pump or signal an external controller).

### 12.6.3.6 Alarm Mode 5: Tested-Clean

	Output 1	Output 2
Turns on When	Test Complete	≤Lower
Intended Function	Test Complete Signal	“Pass” Signal

This is used when controlling tests from a PLC using switched outputs. The PLC gives a start signal, then monitors the “Test Complete” output. If the test has passed it can detect this with the “Pass” signal.

### **12.6.3.7 Alarm Mode 6... Customer Requested Modes**

Other alarm modes will be defined as and when customers request them.



# 13 Installation

Each ICM supplied consists of the following:

- ICM particle counter
- Calibration certificate
- LPA-View CD ROM, software package
- Pre-wired cable

Optional Equipment:

- Circular connector pre-wired with 2 m cable
- ICM-RDU Remote display unit
- 500  $\mu\text{m}$  coarse screen filter
- ICM-FC1 Flow Control Valve
- ICM-USBi USB adaptor with pre-wired ICM cable

## 13.1 Installation Procedure

- Decide on tapping points in hydraulic circuit.
- Fix mechanically
- Connect hoses
- Wire back to junction box
- Check flow in acceptable range. There needs to be a differential pressure placed across the ICM, such that a flow of fluid is generated within the range of the unit.

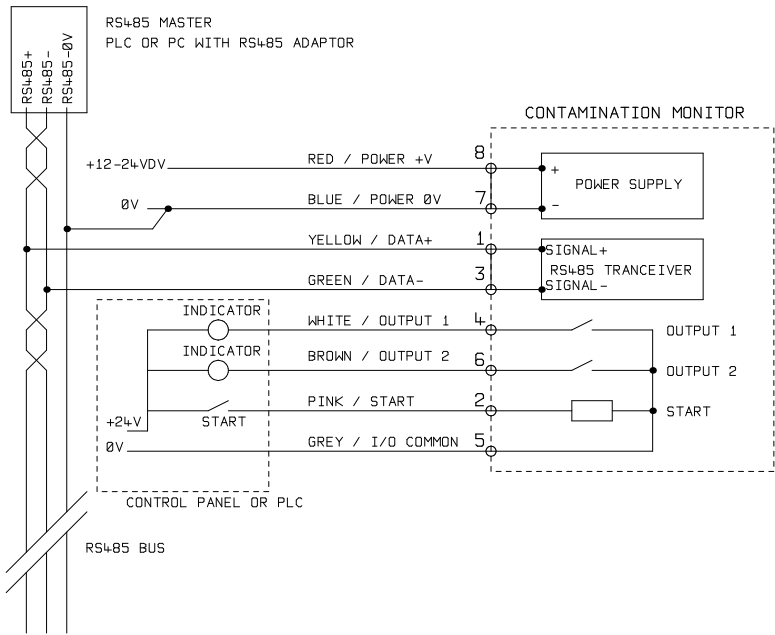
- If there is no suitable differential pressure available, then a flow controller will be needed. One solution is the ICM-FC1 which will accept a pressure from 4-400 bar, admitting a constant flow within the range of the ICM. This should be fitted to the drain side of the ICM (the top fitting).
- Locate the unit mechanically and bolt to desired location using fixing holes provided. The ICM must be in a vertical orientation, with the oil flowing upwards through it.
- Connect hoses.
  - There must be no extra restriction placed in the drain hose. So do not have a pipe going to a restrictor to control flow. Any such restrictor must be mounted directly to the ICM drain fitting.<sup>11</sup>
  - Fluid flow must be from the bottom fitting to the top, following the direction of flow arrow on the product labelling. I.e. the bottom fitting is the inlet and the top fitting is the outlet.
- Fit electrical connector, wire back to a junction box.

---

<sup>11</sup> This is because any length of pipe between the ICM and a downstream restrictor can act as an accumulator. Any pressure pulsations (for example from a pump) in the feed to the ICM are then translated into pulsations in flow rate, sometimes leading to flow reversals in time with the pulsations. If the flow is very low this can sweep the same particle backwards and forwards through the sensing volume multiple times, confusing the results.

# 14 Electrical Interface

Note: The separate ICM-USBi product is available for those wishing to simply plug the ICM into a computer. This section is for those wishing to do their own wiring to the product.



**Figure 14.1** External Wiring Example

In Figure 14.1 an example installation is shown.

## 14.1 DC Power

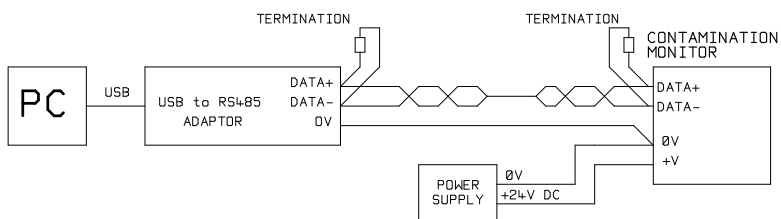
DC power is connected to pins 7 and 8 of the ICM circular connector (Red and Blue if using the pre-wired cable). All the other signals are optional.

Item	Minimum	Maximum
Voltage	9V DC	36V DC
Current		200mA

## 14.2 Serial Interface

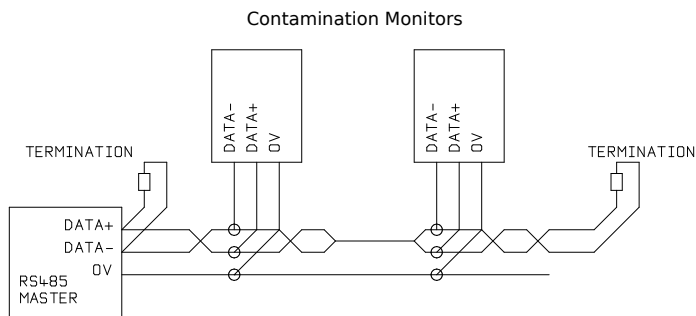
An RS485 interface can optionally be connected to pins 1 and 3 (yellow and green). This can be a PLC running customer software, or a PC with a RS485 adaptor running the supplied LPA-View software. To provide a reference the RS485 0V connection should also be linked to the ICM 0V (as shown on the drawing).

The standard ICM control protocol is Modbus RTU. Modbus is a freely available open standard for industrial control. Adapters are available to interface to other industrial control buses. The standard LPA-View software from MP Filtri UK itself uses Modbus to communicate with the ICM, but it is also possible for customers to implement their own controllers – see [chapter 18](#).



**Figure 14.2** PC Control Example

Figure [14.2](#) shows a single ICM linked to a PC, using a USB-RS485 adaptor. 100 Ohm termination resistors should be fitted as shown for long cables, for example over 10m. Twisted pair wiring should be used for any length over 2m.



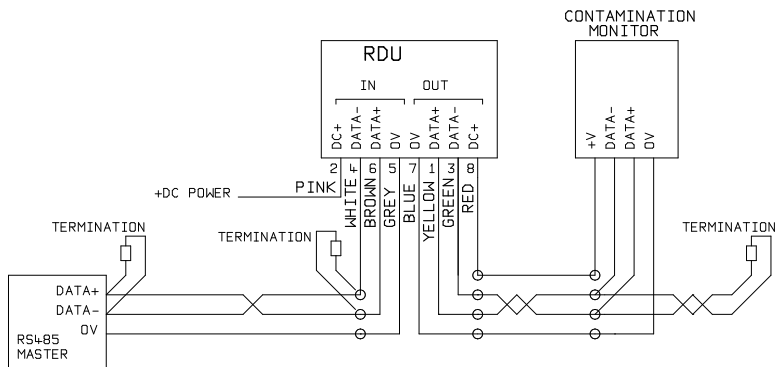
**Figure 14.3** Multi-Drop Network Example

Figure 14.3 shows how to connect two or more ICM devices to a multi-drop RS485 network. Any termination resistors should be fitted to the network cable ends only. Spurs off the main RS485 bus should be kept as short as possible, e.g. below 2m. Normally the pre-wired 2m cable available for the ICM would be used, with a junction box to connect to the RS485 trunk. Either individual DC supplies can be used to power each ICM, or a single supply run through the trunk cable.

Figure 14.4 shows how to connect the ICM-RDU Remote Display Unit. The RDU is used when the ICM location is not convenient for an operator. It can control and monitor a remote ICM, as well as allowing an external controller to be connected to it (for data download, for example).

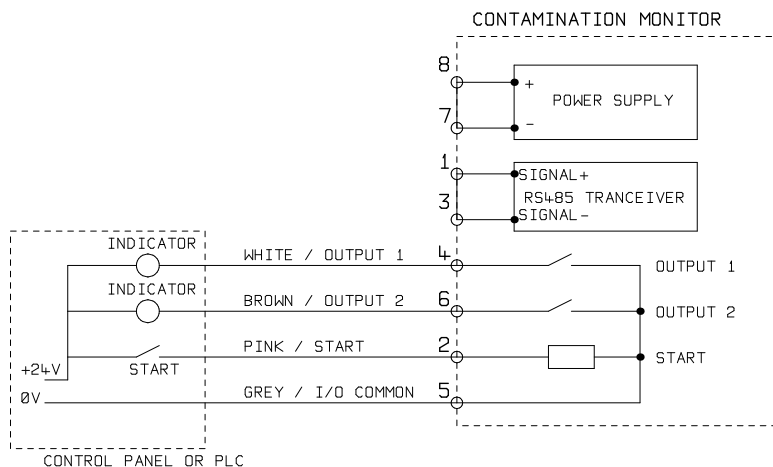
## 14.3 Switched Input and Output Signals

The ICM has one switched input and two switched outputs. These can be used instead of, or in addition to, the RS485



**Figure 14.4** Remote Display Unit Including PC Controller Example

interface for command and control. The RS485 interface is more flexible but requires more software work if LPA-View is not used (e.g. control from a PLC). An alternative is to control the ICM via these switched signals, either from a PLC or using a manual switch and indicators.



**Figure 14.5** Switched I/O Signals

In order to reduce wiring the input and outputs all connect together on one side (see Figure 14.5). However they are optically isolated from the rest of the system so can be used to switch unrelated signals.

## 14.4 Start Signal

The “start signal” is an opto-isolated input that can be used to start a test. This could be from a push button or a PLC output. The input accepts AC or DC signals, typically derived from the DC supply voltage. The exact function of this input is determined by the Test Mode setting (12.5).

Item	Minimum	Maximum
Voltage	9V DC	36V DC
Impedance	10k Ohms	

Other ways to start a test are:

- From the ICM front panel START button, if fitted (-K Keyboard option)
- Via LPA-View or PLC Modbus command
- Periodic automatic testing according to a programmed test mode

## 14.5 Alarm Outputs

These are opto-isolated switches that can be used to signal external indicators, PLC inputs or other equipment (e.g. pump on/o control).

The exact function of these outputs is determined by the Alarm Mode setting (see [12.6.3](#)).

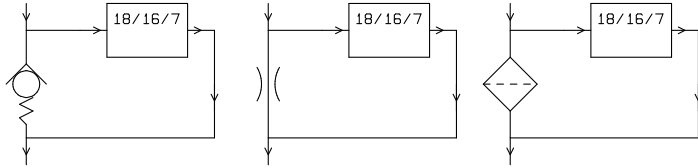
The outputs are “voltage free” contacts that can switch AC or DC signals up to 36V nominal (60V absolute maximum peak voltage).

Item	Minimum	Maximum
Voltage		36V DC
Current		0.5A



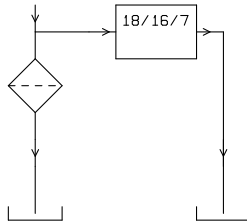
# 15 Hydraulic Connection

## 15.1 High or Low Pressure Parallel Connection



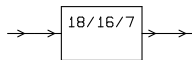
**Figure 15.1** ICM working pressure generated by hydraulic component.

## 15.2 Low Pressure, O -Line Operation



**Figure 15.2** ICM working pressure generated by hydraulic component.

## 15.3 Very Low Flow Systems



**Figure 15.3** Entire system flow rate is within the range of the ICM.

## 15.4 Flow Rate

### 15.4.1 Summary

For the majority of systems, a differential pressure of a few Bar will generate an in-range flow for a ICM connected using two 1.5 meter lengths of Mini-mess hose. The required differential pressure can be obtained by taking advantage of an existing pressure drop within the system. Alternatively one can be created by e.g. inserting a check valve. The ICM can then be connected across this differential pressure source.

### 15.4.2 Detailed Calculations

In general the flow rate of fluid through the ICM needs to be kept within the range of the unit (see hydraulic specification **3.2**). The ICM measures the flow during operation, so this can be used to check that the flow is correct. A flow that is out of range will be indicated by a fault code (see **16.1**). *Results taken with out-of-range flows are not logged.*

The flow is entirely generated by the differential pressure between the ends of the pipes used to connect the ICM. The pressure needed to generate an in-range flow can be estimated by assuming a target flow, and determining the resulting pressure drop across the ICM and connection piping. Use the graph **15.4** to lookup the ICM pressure drop, and manufacturers data to lookup the piping pressure drop at the desired flow. The sum of these two pressures is that needed.

The user connects the ICM between two points in the hydraulic circuit, that have this pressure difference.

In order to use the graph:

- Determine the working viscosity of the fluid, e.g. 30 cSt.
- Decide on a desired flow rate. 200ml/minute is normally used since this is in the middle of the ICM flow range. But 100ml/minute is also suitable and uses less oil.
- Use the graph **15.4** to look up the pressure drop, across the ICM ports, at the this flow rate and viscosity. E.g. at 30cSt and 200ml/minute, this is 0.4 Bar. The maximum and minimum allowed differential pressures can also be determined using the 400ml/min and 20ml/min lines, respectively.
- Determine the additional pressure drop caused by the piping used to connect the ICM. This may be negligible for 1/4 inch piping and over, but is very important for “Mini-mess” hoses. This information can be found in the manufacturers catalogs. In the case of Mini-mess hoses supplied with the ICM, at 30 cSt these have a pressure drop of around 10 Bar per meter per lpm of flow. So a 2m total hose length would add a pressure drop of  $2 \times 10 \times 0.2 = 4$  Bar. (So in this case the pressure-flow relationship is mainly dependent on hose resistance.)
- Add the ICM pressure drop to that of the hoses, e.g.  $4 + 0.4 = 4.4$  Bar.

When the required pressure drop has been found:

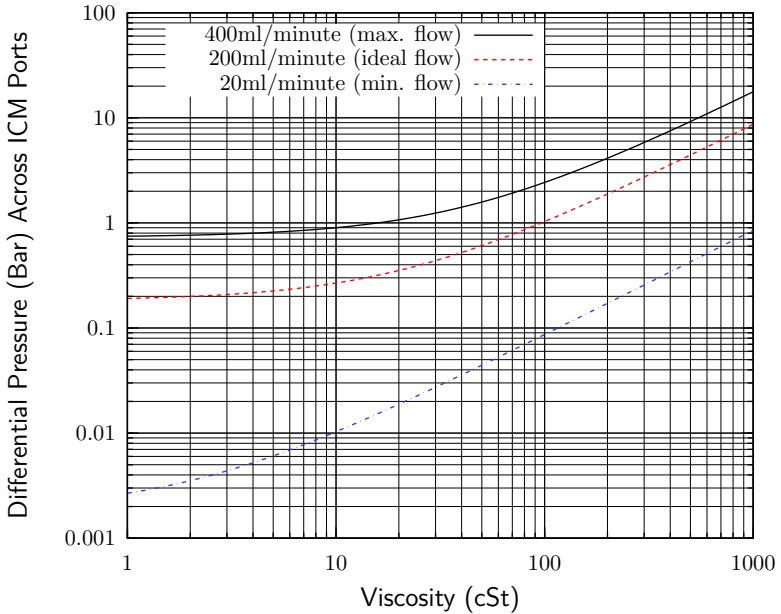
- See the figures at the start of this section for examples of where the ICM could be connected.
- If there is a pair of connections in the hydraulic circuit that operates with a differential pressure near to that calculated, then the ICM can be connected there.
- Alternatively, create the pressure drop by modifying the hydraulic system. For example, insert a check-valve in the circuit with a 4 bar spring.<sup>12</sup> The “component” could also be a filter, a restrictor or even a piece of piping if it has a suitable pressure drop across it.
- If none of these options is feasible, then an active flow controller will likely be needed, see **15.6**.
- Otherwise connect the ICM across the points identified, taking care to maintain an upward flow of oil through the unit (this reduces trapped air).

Of course in a real system the pressure and viscosity will vary with temperature and operating conditions. But since the working flow range of the ICM is very wide, this should not be a problem provided it remains within range. On the graph the area between upper and lower lines represents the usable operating region for the ICM, with the middle line being ideal. The differential pressure and the viscosity can vary from the ideal, provided the system stays within the upper and lower lines. This ensures the flow stays within

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<sup>12</sup> In fact the ICM will work perfectly well at a lower flow, for example 100ml/minute, in which case a 2 Bar check-valve could be used.

the working range of 20 - 400 ml/min. It can be seen that the unit will accommodate a 20:1 variation in either viscosity or differential pressure during operation.



**Figure 15.4** Differential Pressure vs Fluid Viscosity, for various flow rates

## 15.5 Manual Flow Control

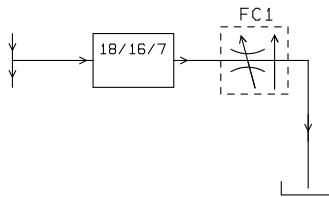
Another possibility is to fit a simple manual flow control (flow restrictor) to the outlet of the ICM.

- This should only be done where the available pressure is less than twice the maximum value calculated. This is because the small orifice size needed to control the flow from a pressure larger than this has a risk of blockage.

- The flow controller must be fitted to the outlet only. If fitted to the inlet it will have a filtering effect.
- The flow controller must be fitted directly to the ICM outlet port.

## 15.6 Active Flow Control

This is only needed for High Pressure, O -Line Operation.



**Figure 15.5** ICM flow actively regulated.

A pressure compensated flow control valve is fitted to the ICM drain outlet. This maintains a constant flow rate even with a varying inlet pressure (provided this pressure stays above a minimum working value). A suitable valve is the ICM-FC1 (see [2.1.2](#)), but other ones can be used too.

# 16 Fault Finding

## 16.1 LED Flashing / Fault Codes

The ICM front panel led indicates a fault by a number of white flashes, with a red background. The number of flashes indicates the fault code:

1. *Optical* - An optical fault could indicate LED failure or blockage of the optical path. Try flushing with Petroleum Ether, or return to MP.
2. *Low Flow* - The ICM estimates the flow by measuring the transition time of the particles. The Low Flow warning indicates that the flow rate is below the minimum recommended level.<sup>13</sup>
3. *High Flow* - The flow rate is above the maximum recommended level. This will degrade the accuracy of the particle counts.

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<sup>13</sup> The unit will still work but may be more susceptible to errors caused by pressure fluctuations. This warning can also come on when there are no particles whatsoever detected, i.e. the fluid is totally “clean”. In this case the correct result e.g. 0/0/0 is still generated.

## 16.2 Other Faults

*Unexpected results obtained from sample*

Check that the Mini-mess hose has been fully connected at both the system and ICM ends

Confirm that the flow through the ICM is within the range of the unit  
High water / aeration levels

*Remote Device dialog not responding to buttons being pressed.*

Check that correct COM port has been selected in the Remote Device dialog  
Disconnect power supply to ICM and then reconnect it

If the ICM has been subjected to excessive contamination and a blockage is suspected, a flush with a suitable solvent may clear the blockage.

The standard ICM is fitted with Nitrile seals, so Petroleum Ether may be used for this purpose, in conjunction with the MP Filtri UK Bottle Sampling Unit.

*DO NOT USE ACETONE*



# 17 Cycle Time and Flow Rate Considerations

The set *Test Duration* is the amount of time for which particle counts are accumulated, before the test result is updated. The default of 120 seconds is likely to be suitable for most applications. However it is possible to set other values.

A shorter time enables the unit to respond more quickly to variations in cleanliness. This may be desired in order to reduce the product test time in a production line situation.

A longer test time enables the unit to average out variations in cleanliness and produce a more stable result. This is especially true for the larger particle sizes. In clean systems there are very few of these, so a large amount of fluid needs to be sampled in order to count a statistically significant number.

Another factor is the flow rate. This can be traded off with cycle time, since a higher flow allows the same amount of fluid to be sampled in a shorter time.

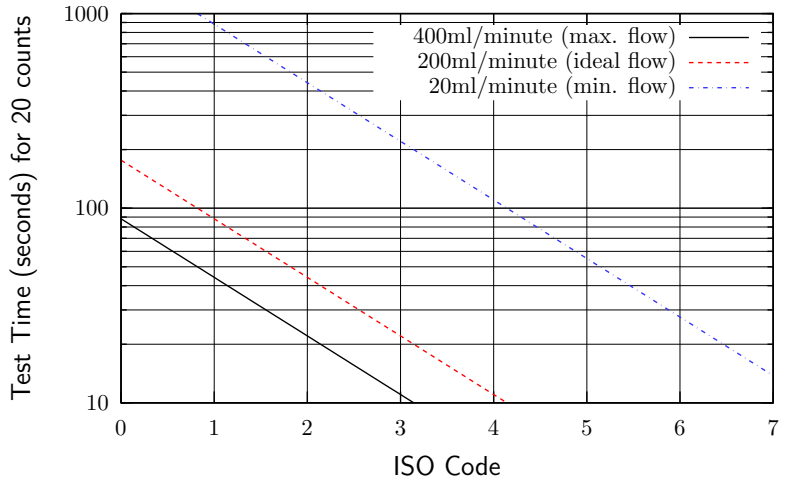
*“Very Clean” Systems* – Longer test times / higher flows needed.

*“Normal” or “Dirty” Systems* – Shorter test times or lower flows are acceptable.

This relationship is shown in **Figure 17.1**.

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<sup>14</sup> This means >20 particles counted as per ISO 4406:1999



**Figure 17.1** Test Time needed for Reliable Indication<sup>14</sup> by ISO code

# 18 Modbus Programming

The ICM can be controlled via commands on its serial (RS485) interface, using the Modbus RTU protocol. It is possible to control every aspect and setting of the ICM, as is done by the MP Filtri UK LPA-View control software. All results and counts are available in all supported formats. One scenario is to use LPA-View to initially configure the ICM, then the customer-written software only has to read the test results. This could be used to integrate the ICM measurements with a general machine control, vehicle control or factory monitoring system.

Customers wishing to implement their own modbus controller software will need to refer to the full ICM Modbus Programming Manual – however a simple example is given here.

## 18.1 Reading the Result Codes

The simplest arrangement is to configure the ICM to test continuously, with a set interval between tests. For example a *Test Duration* of 2 minutes and a *Test Interval* of 10 minutes. The *Start Testing Automatically* selection can be used so that the unit does not require a start signal.

Then, the most recent test results can be read from the appropriate Modbus Registers.

---

Register	Function
56	4 $\mu$ m(C) Result Code
57	6 $\mu$ m(C) Result Code
58	14 $\mu$ m(C) Result Code

---



# Measuring Water in Hydraulic and Lubricating Fluids

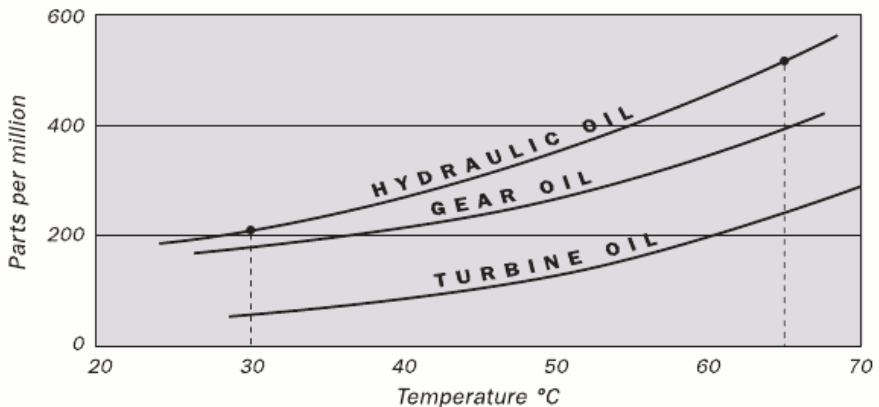
*From North Notts Fluid Power Centre*

In mineral oils and non aqueous fire resistant fluids water is undesirable. Mineral oil usually has a water content of 50-300 ppm which it can support without adverse consequences.

Once the water content exceeds about 500ppm the oil starts to appear hazy. Above this level there is a danger of free water accumulating in the system in areas of low flow. This can lead to corrosion and accelerated wear.

Fire resistant fluids have a natural water content which may be different to mineral oils.

## Typical Water Saturation Levels - For new oils



Examples : Hydraulic oil @ 30°C = 200ppm = 100% saturation  
 Hydraulic oil @ 65°C = 500ppm = 100% saturation

# ISO 4406

## Cleanliness Code System

The International Standards Organization standard ISO 4406 is the preferred method of quoting the number of solid contaminant particles in a sample.

The code is constructed from the combination of three scale numbers selected from the following table.

The *rst* scale number represents the number of particles in a millilitre sample of the fluid that are larger than  $4\ \mu\text{m}(c)$ .

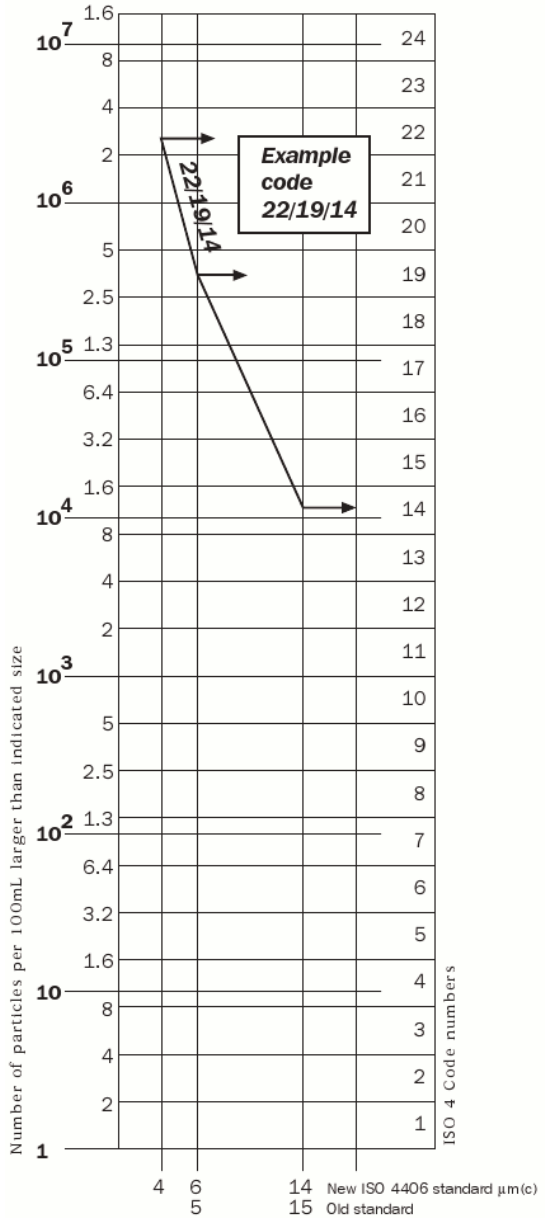
The *second* number represents the number of particles larger than  $6\ \mu\text{m}(c)$ .

The *third* represents the number of particles that are larger than  $14\ \mu\text{m}(c)$ .

Number of Particles per mL		Scale No.
More than	Up to and including	
2.5M	-	> 28
1.3M	2.5M	28
640k	1.3M	27
320k	640k	26
160k	320k	25
80k	160k	24
40k	80k	23
20k	40k	22
10k	20k	21
5000	10k	20
2500	5000	19
1300	2500	18
640	1300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5.0	9
1.3	2.5	8
0.64	1.3	7
0.32	0.64	6
0.16	0.32	5
0.08	0.16	4
0.04	0.08	3
0.02	0.04	2
0.01	0.02	1
0.0	0.01	0

ISO 4406 Allocation of Scale Numbers  
ISO 4406 ...

Microscope counting examines the particles differently to APCs and the code is given with two scale numbers only. These are at 5  $\mu\text{m}$  and 15  $\mu\text{m}$  equivalent to the 6  $\mu\text{m(c)}$  and 14  $\mu\text{m(c)}$  of the APCs.



ISO 4406 Cleanliness Code Chart (with 100ml sample volume)

# NAS 1638 Cleanliness Code System

The NAS system was originally developed in 1964 to define contamination classes for the contamination contained within aircraft components. The application of this standard was extended to industrial hydraulic systems simply because nothing else existed at the time. The coding system defines the maximum numbers permitted of 100ml volume at various size intervals (differential counts) rather than using cumulative counts as in ISO 4406. Although there is no guidance given in the standard on how to quote the levels, most industrial users quote a single code which is the highest recorded in all sizes and this convention is used on the ICM software.

	00	0	1	2	3	4	5	6	7	8	9	10	11	12
<b>5-15</b>	125	250	500	1000	2000	4000	8000	16000	32000	64000	128000	256000	512000	1024000
<b>15-25</b>	22	44	89	178	356	712	1425	2850	5700	11400	22800	45600	91200	182400
<b>25-50</b>	4	8	16	32	63	126	253	506	1012	2025	4050	8100	16200	32400
<b>50-100</b>	1	2	3	6	11	22	45	90	180	360	720	1440	2880	5760
<b>Over 100</b>	0	0	1	1	2	4	8	16	32	64	128	256	512	1024

## CONTAMINATION LEVEL CLASSES

according to NAS 1638 (January 1964).

The contamination classes are defined by a number (from 00 to 12) which indicates the maximum number of particles per 100 ml, counted on a differential basis, in a given size bracket.



# Hydraulic System Target Cleanliness Levels

Where a hydraulic system user has been able to check cleanliness levels over a considerable period, the acceptability, or otherwise, of those levels can be verified. Thus if no failures have occurred, the average level measured may well be one which could be made a bench mark. However, such a level may have to be modified if the conditions change, or if specific contaminant-sensitive components are added to the system. The demand for greater reliability may also necessitate an improved cleanliness level.

The level of acceptability depends on three features:

- the contamination sensitivity of the components
- the operational conditions of the system
- the required reliability and life expectancy

The table shows the recommended filtration level for various hydraulic components, together with typical target system cleanliness levels.

# Appendix D

Components	Recommended Filtration								
	1	2	3	4	5	6	7	8	9
Servo Valves	•			•	•				
Proportional Valves				•	•				
Variable Displacement Pumps					•	•			
Cartridge Valves						•	•	•	
Piston Pumps						•	•	•	
Vane Pumps							•	•	•
Pressure / Flow Rate Control Valves							•	•	•
Solenoid Valves							•	•	•
ISO Code	12/10/7	13/11/8	14/12/9	15/13/10	16/14/11	17/15/12	18/16/13	19/17/14	20/18/15
NAS Code	1	2	3	4	5	6	7	8	9
Absolute Filtration Recommended			3µm			6µm		10µm	>10µm

# **New ISO Standard Test Dust and its effect on ISO Contamination Control Standards**

When General Motors gave advance warning to the International Standards Organization (ISO) that it was intending to stop the production of AC Fine Test Dust (ACFTD), work commenced immediately on finding an improved replacement dust. ACFTD was used extensively within the fluid power and automotive industries for calibrating Automatic Particle Counters (APCs) and for the testing of components.

APCs are used for testing oil filters, and also for contaminant sensitivity testing of hydraulic components. For 25 years, APCs have been the main stay in the measurement of solid particles in hydraulic fluids. The growth in demand for measuring fluid cleanliness in a variety of industrial processes, including fluid power, has resulted in APCs moving from the laboratory environment out into the factory. In fact, they are now a critical part of many production processes. It is therefore essential that the data they provide is both accurate and consistent.

## **Calibration**

ACFTD has been used as an artificial contaminant since the 1960s and its original particles size distribution was determined using an optical microscope. This particle size distribution subsequently formed the basis of ISO 4402, the method for calibrating APCs. Due to the limitations of that method of measurement, the particle size distribution was questioned below about  $5\mu\text{m}$ . It was also not traceable to any

## Appendix E

national standard of measurement - a critical requirement for today's quality management systems.

There was also an absence of formal controls over the distribution of the test dust, and batch-to-batch variability was much greater than is acceptable nowadays.

ISO therefore defined the requirements for the replacement for ACFTD and asked the National Institute of Standards and Technology (NIST) in the USA to produce a standard, traceable reference material. The new dust's particle size distribution has been accurately determined with the aid of modern scanning electron microscope and image analysis techniques.

### **New Test Dust Benefits**

The new ISO Medium Test Dust (ISO MTD) consists of similar materials to the old ACFTD, but to minimize particle counting errors, it is of a slightly coarser grade because ACFTD included too many particles smaller than  $5\mu\text{m}$  which gave problems during testing.

ISO MTD is produced to a standard distribution and stringent quality control procedures, thereby ensuring excellent batch-to-batch repeatability. These procedures, combined with a revised ISO APC calibration method give:

- A traceable and controlled reference test dust with greatly reduced variation in particle size distribution. This gives the traceability required by ISO 9000, QS9000 and similar quality management systems.
- A procedure for determining the performance of APCs so that minimum acceptable levels can be set by the user.

- Improved calibration techniques and procedures.
- More accurate calibration.
- Improved levels of particle count reproducibility with different equipment.
- More accurate and consistent filter test results.

## **E ffect on Industry**

The introduction of ISO MTD has necessitated changes to certain ISO standards.

The standards affected include:

ISO 4402: 1991 Hydraulic fluid power  
Calibration of liquid automatic particle counters.

ISO 4406: 1987 Hydraulic fluid power  
Code for defining the level of contamination by solid particles.

ISO 4572: 1981 Hydraulic fluid power  
Filters  
Multi-pass method for evaluating filtration performance of a filter element.

In order that users are not confused by the changes to these standards, particularly by reference to them in technical literature, ISO is updating 4402 to ISO 11171, and 4572 to ISO 16889.

## Appendix E

Two standards which concern our industry are the ISO 4406 coding system and the new ISO 16889 Multi-pass test. As APCs will henceforth count particles more accurately, there will now be a change in the way sizes are labelled.

In the new ISO 4406, new calibration sizes are used to give the same cleanliness codes as the old calibration sizes of 5 and 15  $\mu\text{m}$ . In this way, there will be no necessity to change any system cleanliness specifications. It is proposed that the cleanliness codes (for APCs) will be formed from three<sup>15</sup> particle counts at 4, 6 and 14  $\mu\text{m}$ , with 6 and 14  $\mu\text{m}$  corresponding very closely to the previous 5 and 15  $\mu\text{m}$  measurements. This will ensure consistency in data reporting.

As the counts derived by microscope counting methods are not affected, the particle sizes used for microscopy will remain unchanged (i.e. at 5 and 15  $\mu\text{m}$ ).

To clarify matters still further, ISO standards written around the new test dust will utilize a new identifier, (c) . Hence  $\mu\text{m}$  sizes according to the new ISO 11171 will be expressed as  $\mu\text{m}(c)$  and Beta ratios according to ISO 16889 will be expressed as Bx(c) , e.g. B5(c) .

However, it must be stressed that the only real effect users will experience will be the improved accuracy in particle counts - there will be no change in the performance of filters, nor in the ISO cleanliness levels that they will achieve.

The following charts shows the correlation between the old ACFTD and the new ISO MTD.

The ICM is calibrated with ISO Medium Test Dust (to ISO 11171). The correlation between particle sizes and the ACFTD (old standard) to the ISOMTD (new standard) is as follows :

---

<sup>15</sup> The option of quoting just two counts of 6 $\mu\text{m}$  and 14 $\mu\text{m}$  for APCs remains.

ACFTD	<1	5	15	25	30	<sup>16</sup> 50	<sup>16</sup> 75	<sup>16</sup> 100
ISO MTD	4	6	14	21	25	38	50	70

---

<sup>16</sup> To be confirmed by NIST

**Correlation between  
Particle Sizes Obtained  
using ACFTD (ISO  
4402:1991) and  
NIST (ISO 11171)  
Calibration Methods**

*This table is only a guideline.  
The exact relationship between  
ACFTD sizes and the NIST sizes  
may vary from instrument to in-  
strument depending on the char-  
acteristics of the particle counter  
and original ACFTD calibration.*

Particle Size Obtained Using	
ACFTD (ISO 4402:1991) $\mu\text{m}$	ISO/NIST MTD (ISO 11171) $\mu\text{m(c)}$
1	4.2
2	4.6
3	5.1
4	5.8
5	6.4
6	7.1
7	7.7
8	8.4
9	9.1
10	9.8
11	10.6
12	11.3
13	12.1
14	12.9
15	13.6
16	14.4
17	15.2
18	15.9
19	16.7
20	17.5
21	18.2
22	19.0
23	19.7
24	20.5
25	21.2
26	22.0
27	22.7
28	23.5
29	24.2
30	24.9
31	25.7
32	26.4
33	27.1
34	27.9
35	28.5
36	29.2
37	29.9
38	30.5
39	31.1
40	31.7



## Other Standards

Although the ISO 4406 standard is being used extensively within the hydraulics industry other standards are occasionally required and a comparison may be requested. The following table gives a very general comparison but often no direct comparison is possible due to the different classes and sizes involved.

ISO 4406	DEF.STD 05/42 [7] <sup>17</sup> Table A	Table B	NAS 1638[5] ISO 11218[6]	SAE 749[8]
13/11/08			2	
14/12/09			3	0
15/13/10			4	1
16/14/09		400F		
16/14/11			5	2
17/15/09	400			
17/15/10		800F		
17/15/12			6	3
18/16/10	800			
18/16/11		1,300F		
18/16/13			7	4
19/17/11	1,300	2000F		
19/17/14			8	5
20/18/12	2,000			
20/18/13		4,400F		
20/18/15			9	6
21/19/13	4,400	6,300F		
21/19/16			10	
22/20/13	6,300			
22/20/17			11	
23/12/14	15,000			
23/21/18			12	
24/22/15	21,000			
25/23/17	100,000			

<sup>17</sup> All section headings indicated with [] are reproduced by kind permission of British Fluid Power Association from BFPA/P5 1999 issue 3 Appendix 44



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