
# L60iF
# Large Volume Air Sampler
# Instruction Manual

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Registered in England 06965050 Vat: GB 977 7939 30.

# L60iF Large Volume Air Sampler with Integrated Flow and Volume Display

## INSTRUCTION MANUAL

## Contents




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# 1. Introduction

There is an ever-increasing demand for greater accuracy in the measurement of pollution in the workplace environment. This has forced a review of the traditional methods of air sampling in which the sampler flow rate gently drifts over the sampling period, making exact calculation of sampled volume difficult.

One solution to this problem has been to stabilize the flow rate against variations in power supply and changes in filter restriction as pollution is collected. However, this technique is best suited to low flow personal samplers.

The approach taken in the L60iF is to assume that the precise flow rate is not as important as the exact volume of air sampled, within reasonable limits, because the average flow rate is only used to calculate volume sampled. This approach means that the flow rate requires no stabilization, and will depend on the type of filter medium as well as the collected pollution level, power supply variations and changes in pump performance as it warms up. To ensure that flow rate changes are accurately 'tracked', the average flow is measured over a short interval, typically one second, and the calculated volume of air sampled is added to the previous accumulated total. Use of a very short integrating or averaging interval ensures that flow rate changes are automatically allowed for, because such changes take place over relatively long periods, minutes or even hours.

The prime mover is a Munro Instruments L60 Pump and Motor unit. Over the years, improvements in motor design and manufacture of pump parts have resulted in a much higher pump specification than used to be the case.

Flow rate is derived by measuring the pressure drop across an orifice in the airline. The electronic signal is then manipulated to derive a flow rate, which is both displayed and used for volume calculation.

The unit is controlled using a Vacuum Fluorescent display and four buttons (←, ↑, ↓ and →). The button functions in any mode are shown on the display and allow the operator to run whatever test has been selected by a supervisor. The operator can also display the results of the previous test; the information includes an indication as to how the test ended.

If the power supply to the sampler is interrupted during a test, the test will resume when power is restored (subject to a number of conditions).

In supervisory mode, the type of test required can be set up and other parameters can be checked and changed if required.

The Sampler can be calibrated against a traceable flow meter using a built-in routine.

A comprehensive series of diagnostic displays show the history of the sampler and pump unit plus complete calibration data.

The pump and motor are cooled by a fan, the air drawn into the sampler being filtered at the inlet point.

The outer surfaces of the sampler are simple with the minimum number of corners, recesses and so on. This makes decontamination much easier.

The sampler is also designed for ease of maintenance. The front panel can be removed to allow access for replacement of vanes without removing the pump and motor. The cooling fan is protected by a gauze filter that is easily cleaned and replaced.

## 2. Specification

**Flow rate** Nominal 60 litres per minute. The actual flow depends on the filter medium e.g. filter paper, Maypack filter, etc. Flow will also be affected by the length and size of connections, for example to a duct. Typical flow using a Maypack filter 55 litre/minute.

**Display** Vacuum Fluorescent. Display data is selected by menu keys as follows:

**Operator Mode (See flow chart at rear of manual)**

1. Time/date - opening and default display with option to start programmed test or display result of last test.

When *run test* is selected, appropriate displays indicate the type of test in progress and once it is complete, the results of the test. (The operator can cancel a test in progress at any time by switching off the sampler)

**Supervisory mode (See flow chart at rear of manual)**

The following test modes can be selected for running in operator mode. Once selected they will be available to the operator until changed.

1. Immediate start and stop after selected time.
2. Immediate start and stop when selected volume sampled.
3. Delayed start and stop after selected test period.
4. Delayed start and stop when selected volume sampled.
5. Immediate start and run until manually stopped.

The following parameters can also be viewed and changed if required.

6. Test results - displays results of last 250 tests.
7. Low & high flow alarm - user selected flow rates at which low or high flow alarm is raised and test is aborted.
8. Real time - displays real time for possible correction.
9. Date - displays date for possible correction.
10. Mute the audible alarm.
11. Set Auto resume parameters or turn the feature off.

**Accuracy** Flow and total volume - depends on the accuracy class of the rotameter flow gauge used for calibration. Initial calibration of flow rate will be ±2% of reading. The user can improve on this if required. Accuracy of total measured volume will be similar to that of the flow.

**Display resolution (Volume)**

While the total volume sampled is less than 1000 litre, the display is in litres to one decimal point, for example

**738.3 litres**

When the volume exceeds 1000 litres but is less than 100,000 litres, the decimal place is dropped, for example

**1429 litre or 83445 litres**

When the volume sampled exceeds 100,000 litres, (100 $m^3$) the display changes to cubic metres to one decimal place, for example

**0108.6 cu.m or 0743.9 cu.m**

The maximum value is 9999.9$m^3$. Therefore the sample will stop and the display shows OV after approximately 115 days of continuous sampling.

**The user has the option of displaying $m^3$ at all times or using the *Auto* mode described above.**

**Calibration** The unit can be calibrated using a certified flowmeter, a flow controller (restriction valve) and the inbuilt calibration routine. A fuller temperature calibration can also be undertaken if required.

**Prime air mover** Sliding vane pump (4 vanes)

**Motor type & rating** 1400 rpm induction; permanent capacitor.
220/240V ac 50Hz 0.65A; 110/120V ac 50Hz 1.3A

**Motor protection** Overload cutout trip; rating 2A. Typically cut out operates within 40s if the motor stalls.

**Dimensions** 300 x 152 x 305 mm

**Weight** 14 kg

**Accessories** The following items are available:
Inlet adapters for Maypack or card-mounted filters
Extension hose to allow sampling head to be located up to 2.5m from the sampler.
Anglepoise trolley to support remote sampling head.
A variety of filter papers.
DC/AC Converter to enable the L60iF to operate from a 12V d.c. source in a vehicle. (Current requirement is approximately 15A) *This converter is only recommended for use in a vehicle.*

# 3. Installation and operation

## 3.1 Installation

The L60iF is a portable instrument with a permanently connected mains cable. Unless otherwise marked, it is designed to operate from a 110V 50Hz supply. The power cable uses the standard colour code of

**Live - Brown; Neutral - Blue; Yellow/Green – Earth**

When locating the sampler it is important that the rear of the unit should not be too close to a wall etc., which could impede the free flow of cooling air through the Sampler. No other installation procedure is required.

If the DC/AC converter is to be used, connect the Sampler to the 3-pin socket on the converter. Then connect the 12V input leads securely to a suitable battery.

**NOTE that the operating current is approximately 15A.** For example, a fully charged 12V 85Ahr battery will run the L60iF for about 5 to 5½ hours.

### 3.2 Preparation for sampling

#### 3.2.1 Selection of test routine (Refer to flow charts at rear of manual)

The Sampler will be in Operator mode, if switched on with no buttons pressed.
In operator mode, selecting *Run test* will display the routine set up in Supervisory mode. Selecting *confirm* will run this test. Unless cancelled, the test will then run as described on the display. If an alarm condition causes a test to stop, the results of the test until stoppage can be displayed, and the system can then be returned to the opening menu by pressing *end*.

To change the type of test, Supervisory mode must be entered as follows. With the instrument switched OFF, press and hold the Up **(↑)** and Down **(↓)** keys and switch the unit ON. The following options will then be available by scrolling up or down.

**Test results**

The results of previous tests can be displayed in turn for reference. (The operator can access the most recent test only, in case the results were not noted, or there was a power failure when the operator was not present.). Each result is displayed with a code to indicate how the sample ended. Where a sample has several parts as a result of power failures the separate parts can be viewed labelled **PF** and a summary result is also displayed labelled **FI**.

A sample stored in a single uninterrupted run is labelled **OK**.

## Low and high flow alarms

If for any reason, the flow drops to a very low level, or rises to an abnormally high level it is desirable that the test should be aborted.

### Low flow

Apart from mischievous blocking of the air inlet, the most likely cause of low flow will be excessive loading of the filter following an event that releases large clouds of dust or particles.

The supervisor can select an alarm level a few litre/minute below the working flow for the filter in use. For example, if the flow is normally 64 l/min when the pump is hot, a low flow alarm limit of 60 l/min could be set. The limit can be set down to 20 l/min, if required.

The results of the test up to the time at which the alarm condition occurs will be stored and the code **LF** appended.

### High flow

The high alarm level is not set as an absolute value, because of wide range of flows likely to be encountered in normal operation. For example, the cold airflow may be 5 l/min more than the hot flow, and the flow will also be lower with a high restriction filter.

The high alarm level is set as the *change of flow (increase)* that must occur within a 2 second period during sampling to trigger the alarm. Thus the change always 'rides' on the present flow setting. If for example, the alarm level is set to 5 l/min and the cold flow is 69 l/min, the alarm level will be 74 l/min. If the airflow drops to 65 l/min for any reason, the alarm level will likewise drop to 70 l/min.

Apart from damage to the filter, the most likely cause of a high flow alarm is an extension hose being accidentally detached from the front of the sampler. The results of the test up to the time at which the alarm condition occurs will be stored and the code **HF** appended.

If a limit less than 1 l/min is attempted, the high alarm will be disabled.

### Alarm Sounder

The audible alarm that sounds when a flow failure is recorded can be muted.

**Volume Display**

Volume up to 99.999 $m^3$ can be displayed in litres by setting the volume display to ***Auto***. The alternative is a display in $m^3$ at all times.

**Auto Restart**

The supervisor can select what happens if power is interrupted. The test can stop at that point or resume when power is restored and complete as programmed. The supervisor can select the number of restarts allowed in a particular test (up to 50) and the maximum duration of a power failure (up to 100 hours).

**Real time & date**

These parameters will rarely need to be accessed, unless for example, GMT changes to BST or *vice versa*.

**Test mode**

Five operating modes are available, and once a mode is selected it will be the test that will run whenever the operator selects *Run test*.

**1. Timed test**

This will start as soon as the operator confirms that a test is to be run. It will continue until the selected test duration (e.g. 10 minutes) has elapsed.

**2. Volume test**

This will start as soon as the operator confirms that a test is to be run. It will continue until the selected volume of air (e.g. 600 litres) has been sampled.

**3. Delayed timed test**

This mode will be entered as soon as the operator selects *Run test*. The start time and test duration will be displayed until the operator selects *confirm*. The display will then change to Real time and start time. Sampling will not commence until the preset start time, and will continue for the preset duration unless a low flow alarm condition occurs.

**4. Delayed volume test**

This mode will be entered as soon as the operator selects ***Run test***. The start time and volume to be sampled will be displayed until the operator selects ***confirm***. The display will then change to Real time and start time.

Sampling will not commence until the preset start time, and will continue until the selected volume of air has been sampled, unless a low flow alarm condition occurs.

**5. Open ended test**

This mode will be entered as soon as the operator selects ***Run test*** and then ***confirm*** to start the test.

The test will run until *stop* is selected by the operator. Flow, total volume and elapsed time will be displayed during the test.

### 3.2.2 Selection of filter medium

This will depend on local requirements. For example, if dust and particulate is to be measured by weight (gravimetric sample) pre-weighed filters must be available and should be loaded into the filter holder just before sampling is to start.

If a card mounted or Maypack filter is to be used, the appropriate adapter must be attached to the air sampler.

All media must be handled carefully to avoid loss of particulate and to maintain traceability. Used filters should be analysed as soon as possible.

### 3.2.3 Leaving supervisory mode

To revert to operator mode, switch the sampler off and on again after five seconds.

### 3.3 Taking a sample

3.3.1 At the sampling site, connect the Sampler to power and switch on. Check that the display is illuminated and showing the opening screen (date, time, and two options).

3.3.2 If sampling or a delayed program is to start immediately, fit the chosen filter to the Sampler and then press ***Run test***. Check that details of the chosen test mode are now displayed, and if they are correct, press ***confirm***. Depending on the selected mode, sampling may start, or a countdown to the delayed start time will begin.

3.3.3 If a test finishes while the sampler is unattended or if an alarm condition occurs, sampling will be stopped and the results of the test (litres sampled) will be stored with the appropriate error code. If the ALARM message is displayed, the reason for the stoppage should be investigated before another test is attempted.

3.3.4 If the filter is undamaged at the end of sampling, it should be removed carefully and returned to the container from which it was taken at the start of testing. Record any information required by local rules (weather conditions, date, volume of air sampled etc.).

3.3.5 The filter holder should be cleaned before re-use.

3.3.6 To stop a **Volume** or **Timed** test (overriding the auto resume function), turn power off then on again with ↓ and → keys pressed. Sample will not resume.

### Alarm Codes

Results will be appended by one of the following codes.

OK – Sample completed in a single run without interruption
FI – Summary result showing programmed start time. Sample ended normally
PF – Sample ended by power failure (one or more parts of test)
*If a single run is ended by a power failure that exceeds the interrupt time limit then no FI data is shown, just a single PF data entry.*
LF – Sample ended by low flow alarm (will not resume)
HF – Sample ended by high flow alarm (will not resume)
TL – sample time reached 10,000 hours. Sample ended.
OV – sample volume reached 10,000 $m^3$. Sample ended

## 4. Technical Description

The L60iF is a large volume air sampler with a nominal sampling rate of 60 litres per minute. It uses a standard Munro Instruments Pump and Motor unit to draw air through a 60mm open face filter holder. There is an orifice assembly in the airline between the filter and the pump. The pressure drop across this assembly is accurately measured by a pressure sensor which produces a 10 bit digital output proportional to the pressure drop for direct connection to the control PCB. Airflow is proportional to the square root of pressure drop, and a linearisation curve with four break points is used to perform the necessary square root function. This output is scaled and then used to display and store the airflow rate. Volume sampled is calculated by integrating the flow rate over one second intervals. Thus if the flow rate drifts, the volume measurement remains accurate.

All selection of test routines is carried out using the vacuum luminescent display in conjunction with the four directional push buttons. Software routines configure the display and buttons in either an Operating or a Supervisory mode. The memory that stores the chosen routines etc. is battery backed, the battery having a nominal life of 10 years. There is also a Calibration mode, which is entered in a similar manner to the Supervisory mode, by holding down selected pushbuttons while powering up the unit. The user can calibrate the L60iF against a traceable flow gauge at any time.

A Diagnostic menu gives access to stored parameters and data about the history of the sampler. (First powered date, total run time, calibration date etc.)

Total volume is calculated as the time integral of (Flow × Sampling period). The accuracy of time measurement within the microprocessor is so high that volume measurement is effectively as accurate as the flow measurement.

The interior of the unit is cooled by a fan. The air inlet is filtered to minimize build-up of dust etc. within the case. The filter support also acts as an EMC screen. The air filter should be replaced at regular intervals. Spare packs of five filters are available from Munro Instruments.

Mains and other filtering are included to ensure compliance with current LV and EMC European Directives.

## 5. Maintenance, servicing and fault location

### 5.1 Regular maintenance

5.1.1 Surface cleaning for decontamination will be carried out in accordance with locally issued instructions.

5.1.2 The filter holder should be cleaned after every sampling run.

5.1.3 The air filter at the rear of the instrument should be changed at intervals, six months is recommended initially. For safety,

**Disconnect from the mains and allow the fan to stop before removing the grille.**

The filter elements are easily changed and are very inexpensive, so if the interior of the sampler is found to be accumulating material, the filter should be changed more frequently. Spare filter elements are available from Munro Instruments.

### 5.2 Servicing

5.2.1 The main part of the Sampler requiring regular attention is the pump. The pump blades or vanes wear and should be inspected at least annually and more regularly if the Sampler is in constant use. If servicing is to be carried out locally, a course is available from Munro Instruments on Large Volume Air Sampler maintenance and servicing, which includes stripping down and re-assembly of pumps, checking blade dimensions and making performance measurements. Regular service checks are recommended as good practice and as preventive maintenance, avoiding catastrophic failures.

5.2.2 The Sampler should be re-calibrated annually against a traceable standard flowmeter.

### 5.3 Fault location

5.3.1 If the flow starts to decrease, the pump almost certainly needs cleaning.

5.3.2 If the Sampler stalls for any reason (e.g. dust in the pump) the over current cut out will activate and isolate the motor to avoid over-heating. The unit should be sent for maintenance immediately. The cut out button can be reset once (by pressing it in until it locks) but this should not be repeated if it activates again.

5.3.3 If the display shows an abnormal message, power down and up again. If this does not cure the fault, seek advice from Munro Instruments.

## 6. Re-calibration

The L60iF uses a four point linearisation algorithm to compensate automatically for changes in restriction of different filter media, and for increasing restriction as a filter collects particulate during sampling. The calibration can be checked and corrected by the user providing that a flow meter (rotameter) of suitable accuracy and a means of varying the restriction in the air path are available. Temperature calibration can also be carried out if required. As this will only be affected by long term changes in pump performance, it is recommended that it be only carried out infrequently, say twice a year, or after servicing of the pump.

**Notes on accuracy**

The accuracy of the flow indication of the L60iF will be almost as good, (but not quite) as the flowmeter used to calibrate it. Consider a flow gauge with a full-scale reading of 100 litre/minute, the most likely range for calibrating the L60iF. A typical commercial rotameter flow gauge will have accuracy to VDI/VDE 3513 Class 1.6. In practice this means that the accuracy will be 1.6% at full-scale (100), 1.8% at 65 and 2% at 45 l/min. Thus over the working range of the L60iF, the calibration accuracy will be ±2%.

This accuracy cannot be assumed from a single calibration. For full confidence the calibration would be performed at least three times and readings of the calibrated flow gauge made over the working range of the L60iF. If the errors are small and repeatable, the calibration can be accepted with confidence. Of course, *small* and *repeatable* would need to be defined. For example, if the flow at any chosen calibration point was always within ±0.2 l/min and the difference was less than
0.1 l/min between runs, the error could be considered small and the repeatability acceptable. These figures are illustrative only; the user might finally decide the figures to be used in relation to the work being carried out. If there is not time for more than a single calibration, lower accuracy must be assumed.

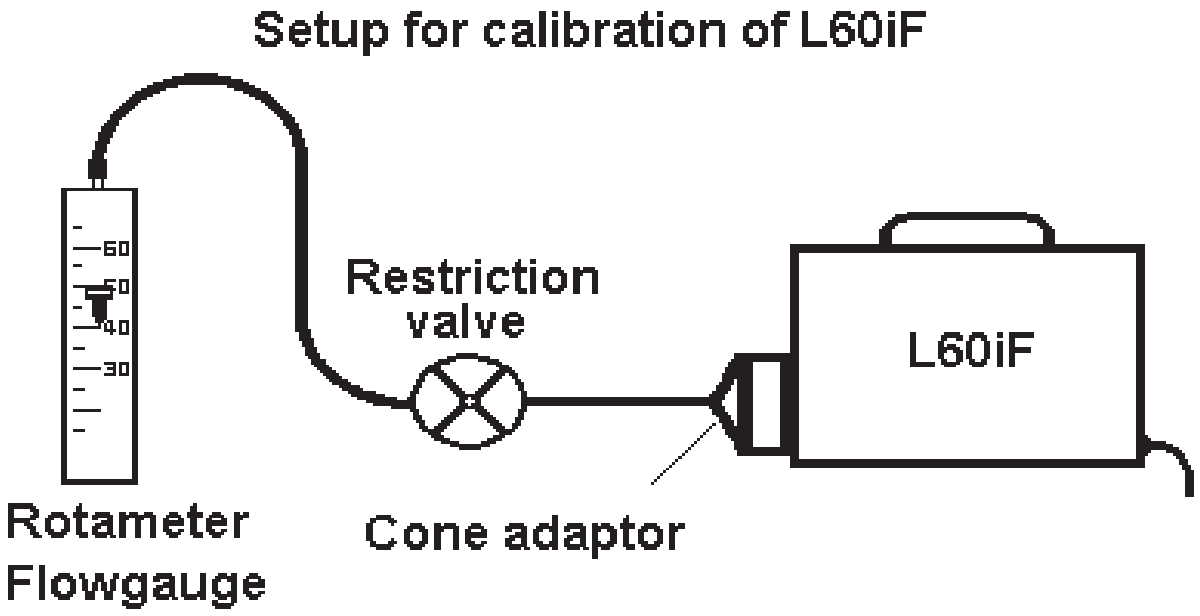
At the other end of the scale, accuracy can be improved by having the rotameter calibrated in a test house, which would provide a correction chart for any part of the scale specified by the user (more calibration points, higher cost!) This higher accuracy would in turn be transferred to the L60iF. Comparison checks could then be made at intervals to ensure that the instrument is maintaining its accuracy. The flow gauge would need to be recalibrated at intervals not greater than 18 months.

Rotameter flow is measured from the top level of the float unless otherwise stated by the manufacturer. To ensure maximum accuracy, read the float at eye level. This will avoid parallax errors. The accuracy of the L60iF is only as good as the flow settings.

## 6.1 Basic re-calibration

Before starting the calibration procedure it is sensible to *check* the calibration against the reference. If no significant difference is shown then the procedure is unnecessary.

As explained earlier, the minimum requirement for recalibration is a flowmeter of known accuracy and a means of adjusting the airflow. These items can be obtained separately and are also fitted to the Munro Instruments Pump Test Stand.




**Calibration set up**

**NOTE If temperature calibration is also being carried out, please refer to paragraph 5.4.2. Note that temperature calibration compensates for changing pump performance during the warm-up period to give maximum accuracy.**

6.1.1. A flow gauge with a maximum flow of 100 litre/minute is recommended. Also required is a cone adapter, which temporarily replaces the normal 60mm filter holder. Unscrew the filter holder and locate the cone adapter in its place using its locking ring.

6.1.2. Connect the flow gauge to the L60iF via the Restriction Valve (see diagram above). Open the valve to offer minimum restriction.

6.1.3. With the L60iF switched OFF, press and hold the right **(→)** and left **(←)** arrows on the front panel while switching on the power. This will force the L60iF into Calibration mode. The motor will start in order to warm it up ready for calibration. Allow the temperature to stabilise (usually around 40°C).

When warm-up is complete, pressing the down **(↓)** button will first stop the motor, enforce a short settling time and then a 10 second averaging value for zero flow.

6.1.4. At the end of the ten second interval, the pump will be turned on automatically and the user invited to adjust the flow for 48 l/min using the restriction valve and reading the flowmeter. When the flow is set, and then press the right arrow **(→)** to start the ten second averaging run.

6.1.5**.** At the end of this ten second interval, the user will be invited to adjust the flow for 53 l/min, again using the restriction valve and reading the flowmeter. When the flow is set and stable press the right arrow **(→)** to start the ten second averaging run.

6.1.6. This routine will be repeated for 58 and 63 litre per minute, after which the flow calibration procedure will be complete, the pump will be switched off. The display will then offer the option of a temperature calibration. In normal circumstances, this should be refused. The L60iF will return to operator mode. See Section 8 if a temperature calibration is to be carried out.

6.1.7. To check the calibration, start the pump, and adjust the valve for various flows as indicated on the flowmeter. Allow a settling time (***30 seconds minimum***) after adjusting the flow, and then note the L60iF reading for each flow to verify that the calibration is correct. Calibration intervals can be every five l/min, or for a more thorough check, every l/min from 45 to 65. Results should be logged for later comparison. If the results are unacceptable, the calibration procedure should be repeated.

**6.2. Procedure for flow and temperature calibration (See NOTE on page 13)**

***Temperature calibration is not necessary as often as standard calibration. It should be carried out about twice a year, or after the pump has been serviced.***

6.2.1. A flow gauge with a maximum flow of 80 to 100 litre/minute is recommended. Also required is a cone adapter, which temporarily replaces the normal 60mm filter holder.

6.2.2. Connect the flow gauge to the L60iF via the Restriction Valve (see diagram above). *Open the valve to offer minimum restriction, this is VERY important*. **This test must be started with the Sampler cold, (i.e. not having been run) and after being in the coolest part of the building overnight or for a couple of hours.**

6.2.3. With the L60iF switched OFF, press and hold the right **(→)** and left **(←)** arrows on the front panel while switching on the power. This will force the L60iF into Calibration mode. The motor will start in order to warm it up ready for calibration. ***A reading of the standard flow gauge must be taken while the pump is still cold and within 30 seconds of switching on. The value must be recorded for later use. This is designated the Cold Flow value.***

The displayed temperature will rise to about 40°C and stabilize. ***When the temperature is stable, warming up is complete. Take another reading of the flow gauge and record it as the Hot Flow value.*** After this, pressing the down **(↓)** button will first stop the motor, then enforce a short settling time and finally a 10 second averaging value for zero flow.

6.2.4. At the end of the ten second interval, the pump will be turned on automatically and the user invited to adjust the flow for 48 l/min using the restriction valve and reading the flowmeter. When the flow is set, press the right arrow **(→)** to start the ten second averaging run.

6.2.5**.** At the end of this ten second interval, the user will be invited to adjust the flow for 53 l/min, again using the restriction valve and reading the flowmeter. When the flow is set, and then press the right arrow **(→)** to start the ten second averaging run.

6.2.6. This routine will be repeated for 58 and 63 litres per minute, after which the flow calibration procedure will be complete and the pump switched off. The display will then offer the option of a temperature calibration, which must be accepted. The display will request the **Cold Flow** and **Hot Flow** readings to be entered in turn. When this has been done, temperature calibration is complete.

6.2.7. To check the calibration, start the pump, and adjust the valve for various flows as indicated on the flowmeter. Allow a short settling time after setting the flow, and then note the L60iF reading for each flow to verify that the calibration is correct.

Calibration intervals can be every five l/min, or for a more thorough check, every l/min from 45 to 65. Results should be logged for later comparison. If the results are unacceptable, the calibration procedure should be repeated.

To check the temperature compensation. Switch the L60iF on ***from cold*** and note the flow gauge and display readings. Check at intervals over an hour as the pump warms up. The two readings may diverge by up to 1.5 litre/minute at switch on but will rapidly converge as the compensation system takes over. Note the readings for future comparison. If a greater error develops, the calibration should be repeated.

## 7.1 Order Codes

| Code | Description |
|---|---|
| NR2050 | L60iF 110V 50Hz version. |
| NR2051 | L60iF 240V 50Hz version. (to special order) |
| RM1142 | UEH2 Universal Extension Hose Assembly |
| 27961ETA | ETA Cutout 110V 2A |
| 20221VAN | Set of four vanes for the L60 Pump |
| NR711 | Test & Calibration Stand, including up to four flow gauges covering the range 5 to 200 l/min, vacuum gauge, restriction valve and extension hose fitted with cone adapter for coupling directly to air sampler. |
| 8224118 | Set of replacement air filters for cooling fan inlet. |

### 7.2 Training Courses

Munro Instruments can offer training courses in air sampler maintenance and calibration, adapted to your exact needs. These can be at our premises or on site, and may be of particular interest to users who cannot easily return samplers to Munro Instruments for servicing and re-calibration. Courses can be at user level, including first line servicing or at a more advanced level, including stripping down and resetting of pumps, testing and recalibration. These skills can form the basis of regular preventive maintenance programmes. Please contact the address on the front of this manual for details of courses.

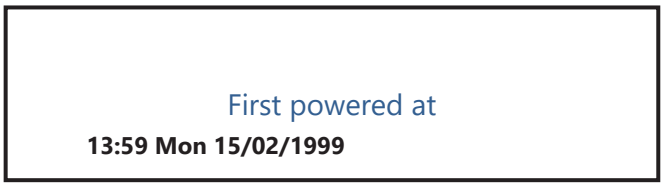
## 8 Diagnostic Mode

Diagnostic information is provided in the L60iF for several purposes:

1. To assist in verification of correct calibration.
2. To provide statistical data of the 'hours run' type.
3. To assist in fault finding.

### 8.1 Accessing Diagnostics Mode

With the L60iF powered down, press and hold the **(↑)** and **(←)** buttons while powering p. An opening screen reading **L60iF Diagnostics** and the version number is briefly displayed, changing to



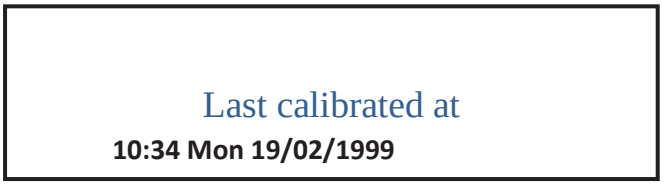

Note that all times, dates and other numerical data in this Appendix are typical. It is always possible to revert to a previous screen using the **(↑)** key.

Press **(↓)** to display

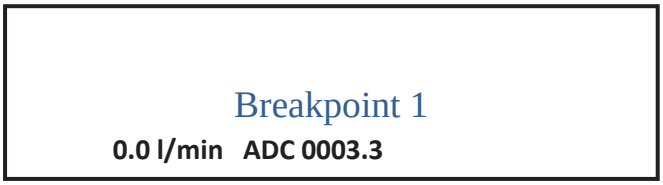

This is a dynamic display; seconds should be incrementing in real time.

Press **(↓)** to display


Press **(↓)** to display




Press **(↓)** to display



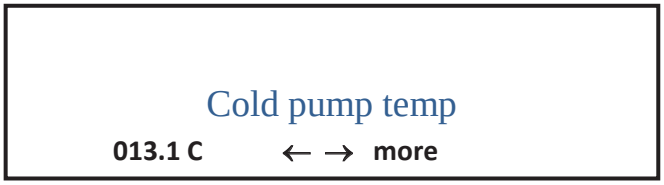
This is the first of five breakpoint values that define the linearising characteristic of the sampler. Linearisation is necessary because the input signal to the microprocessor is proportional to the pressure drop across the orifice in the air flow path. As the true flow is proportional to the square root of the pressure drop, linearisation is used effectively to take the square root of the input signal.

To see the other four Breakpoints, press the **(→)** key four times. Typical readings -

48 l/min ADC 0181.2  53 l/min ADC 0204.5  58 l/min  ADC 0224.6  63 l/min  ADC 0253.8

If these values are plotted they should lie on a shallow curve.

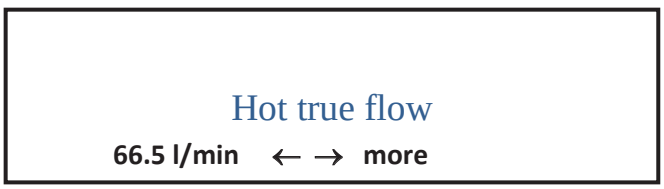
At any time while viewing breakpoints, pressing **(↓)** moves the display to




This is the first of six displays related to temperature calibration. This is used to compensate for potential flow reading errors during the period that the pump is warming up, usually the first 20 to 30 minutes of running. Without compensation, short samples (e.g. 10 minutes) will be recorded inaccurately. (In an 8-hour run the error would be negligible even without compensation.)

As indicated on screen, pressing key **(→)** displays the next data, pressing **(←)** reverts to the previous data. Pressing **(↓)** at any time prepares the instrument for a calibration check.



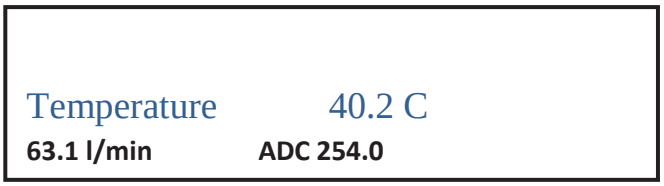




It can be seen from the above typical figures that there is a difference of nearly 4 l/min between true and L60iF measured flow when the pump is cold, and only a small residual difference of 0.3 l/min when the pump is hot. It is this difference that the temperature Compensation addresses, adjusting the correction depending on the pump temperature, which is continuously monitored by a sensor. These data are discussed more fully later.

Press **(↓)** to display


Press **(→)** to run the pump.

The following values are displayed, updated every second. This means that the calculation of flow from ADC and temperature values can be checked. By restricting the flow to one of the set points the corresponding ADC value should be indicated.




An indicated flow rate of 00.0 l/min indicates an invalid calibration.

Press **(↑)** or **(↓)** to stop the pump.

## A1.1 Temperature compensation

The algorithm which generates the correction is

$$\left[\frac{T-Th}{Th-Tc}\right]\times\left(Lc-Lh\right)-\left(Gc-Gh\right)$$

T is the measured temperature of the pump during operation
Tc is the cold temperature (taken at the start of calibration)
Th is the hot temperature (taken after pump has reached running temperature)
Lc is the L60iF reading when the pump is cold (Tc)
Lh is the L60iF reading when the pump is hot (Th)
Gc is the Flow gauge reading when the pump is cold (Tc)
Gh is the Flow Gauge reading when the pump is hot (Th)

For example,

if Tc = 13°C, Th = 44°C, Lc = 74.7, Lh = 66.2, Gc = 71 and Gh = 66.5 l/min

The general equation for correction under these circumstances is

$$\left[\frac{T-44}{44-13}\right]\times\left(74.7-66.2\right)-\left(71-66.5\right)=\frac{T-44}{31}\times 4=\frac{T-44}{7.75}$$

At 44° there is no compensation, and at say, 20°C the compensation is

(20 - 44) / 7.75 = -3 litre/minute.

At 13°C, the compensation is (13 - 44) / 7.75 = -4 litre/minute.

This is what would be expected since at the beginning of the test, when the temperature was 13°C, the true (Flow Gauge) reading was 71 l/min and the L60iF internal reading was 74.7l/min. The small error of 0.3l/min is negligible, and is caused by the assumption that the error is linear with temperature change. The true variation is slightly non-linear. However an error of 0.3 in 71 l/min represents an error of less than 0.4%.

The error falls linearly from -4 to 0 l/min as the temperature rises from 13 to 44°C.

The benefit of this correction is that the readings on the L60iF are correct from power up.

## A1.2 Accuracy of reading

The accuracy attainable with the L60iF depends on a number of factors. In principle, the calibration procedure relies on the flow gauge used to set flow rates during the sequence. It follows that the flow gauge itself must be the best available and also have been calibrated by a Test House having traceable standards.

The temperature calibration uses a highly accurate sensor as the primary temperature reference, whose output is accurate to ±0.5°C.

The L60iF assumes that the error in flow reading is linear with temperature, an assumption justified by tests.

The flow indication is ±0.5 litre/minute over the working range of approximately 50- to 65 litre/minute.

## A1.3 Changing the Eprom

*Warning. These devices are static sensitive; operators should follow the appropriate procedure.*

From time to time as upgrades and updates become available users may be offered the opportunity to modify instrument firmware. This change is made by replacing the Eprom that carries the firmware program.

The procedure will be the same for each upgrade and is described here.

1. Disconnect all power from the unit.
2. Remove the six fixing screws holding the instrument case in position (two either side of the handle, two on each side at the lower edge).
3. Remove the case. The bottom edge should be eased out to facilitate removal.
4. Identify the circuit board and the Eprom mounted on it (position labelled IC6). Drawing 9001-711 is available illustrating this layout.
5. The old Eprom carries a label which shows information as follows

   L60iF Ver 1.02
   0000 372D

These are the version number and checksum.

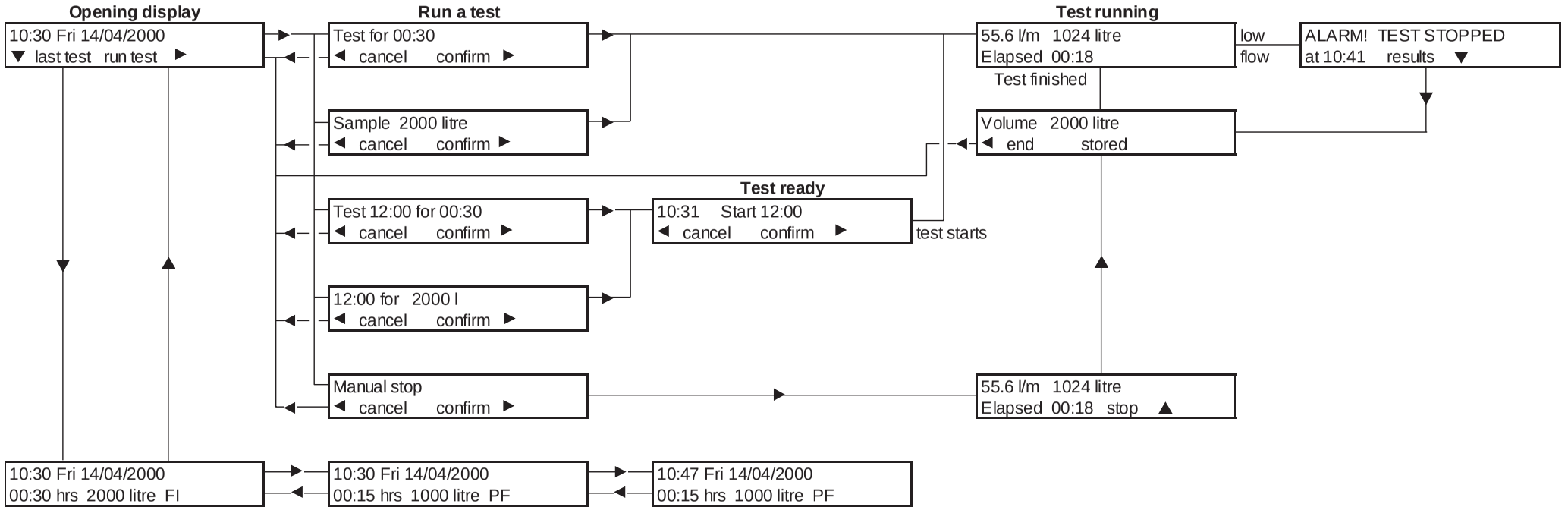
6. Remove this Eprom with an appropriate tool.
7. Ensure that the new Eprom carries the correct label, for example

   L60iF 1.03
   0000 9719

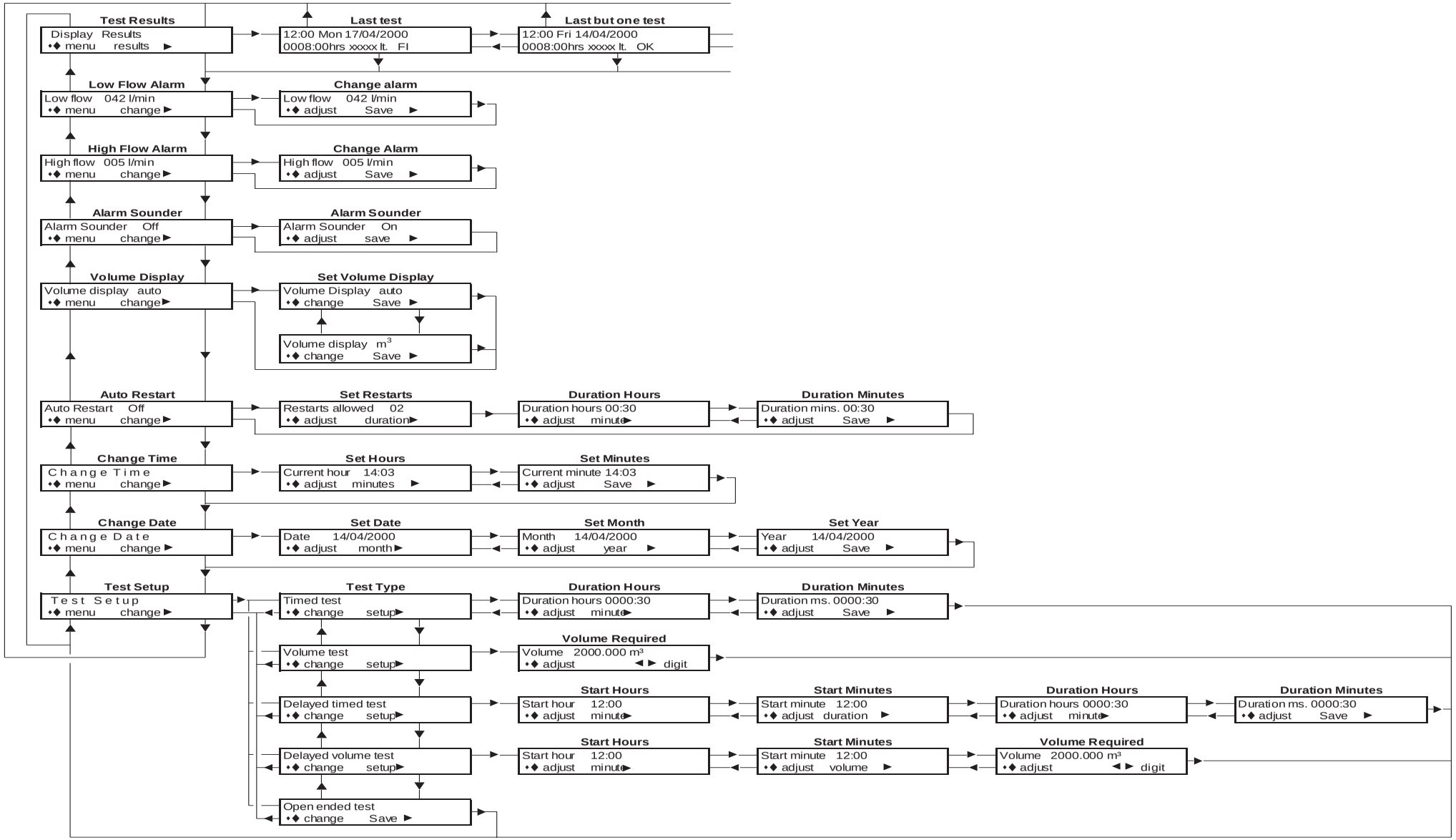
8. Make sure that the pins are in line
9. Insert the Eprom, ensure that the notch is away from the edge of the board and that no pins are bent.
10. Press home firmly.
11. Replace the lid of the case.
12. Apply power. The Version should now read the updated value.

**A2**

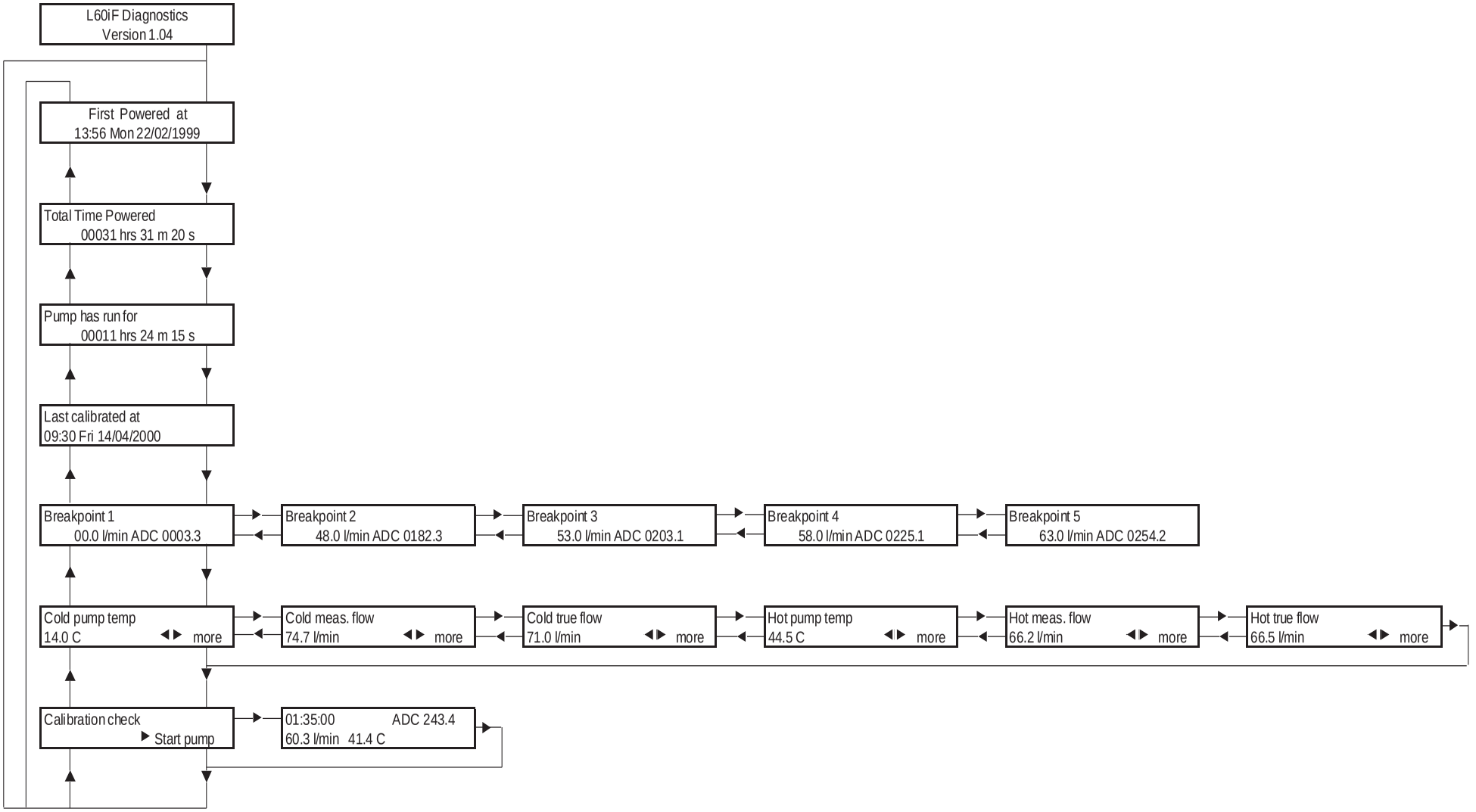
# Operator Menu



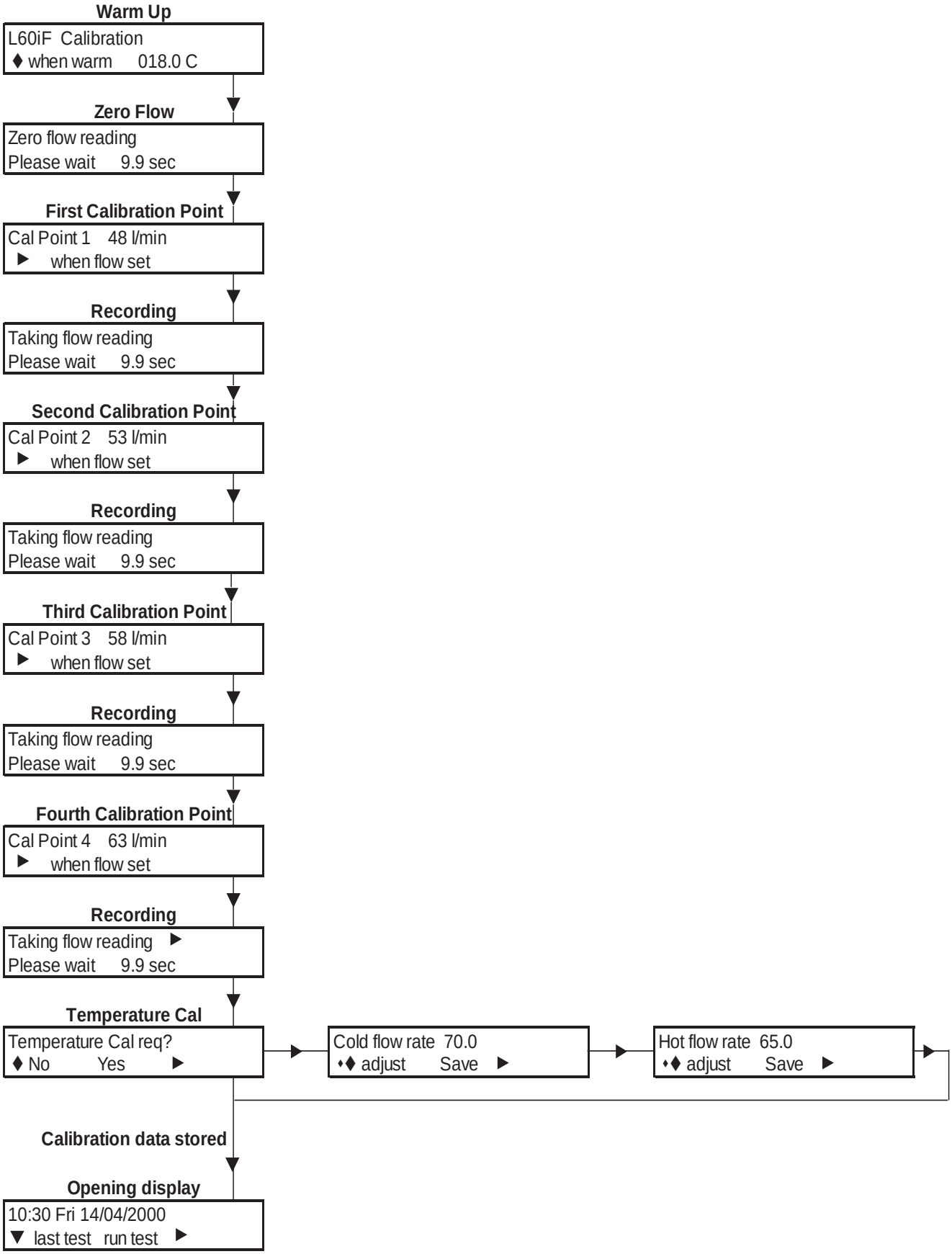
# Supervisor Menu



# Diagnostics Menu



# Calibration Menu



## MODIFICATION RECORD

Issue 2 Various corrections and amendments following discussions with customers.

Issue 3 Anomalies in date display (leap years and Y2K) eliminated.

Issue 4 Diagnostic mode modified to allow calibration parameters to be displayed. Diagnostic mode flow chart added. Operation of High Alarm modified. Scrolling error corrected.

Issue 5 Calibration diagram and following paragraph amended. An inline filter is not now used in calibration. This modification record added.

Issue 6 Amendments reflecting new ownership

Issue 7 Auto Resume. Higher maximum values. Firmware V1.04

Issue 8 Safety warning for fan filter change

Issue 9 Address details updated