

Reference Manual
Marine Temperature Calibrator
JOFRA MTC-650 A MKII



Reference Manual

Marine Temperature Calibrator

JOFRA MTC-650 A MKII

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About this manual....

- **The structure of the manual**

This reference manual is aimed at users who are familiar with AMETEK calibrators, as well as those who are not. The manual is divided into 11 sections which describe how to set up, operate, service and maintain the calibrator. The technical specifications are described and accessories may be ordered from the list of accessories.

- **Safety symbols**

This manual contains a number of safety symbols designed to draw your attention to instructions which must be followed when using the instrument, as well as any risks involved.



Warning

Conditions and actions that may compromise the safe use of the instrument and result in considerable personal or material damage.



Caution...

Conditions and actions that may compromise the safe use of the instrument and result in slight personal or material damage.



Note...

Special situations which demand the user's attention.

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1.0 Introduction

Congratulations on your new AMETEK JOFRA MTC Calibrator!

With the AMETEK JOFRA Marine Temperature Calibrator, you have chosen an extremely effective instrument which we hope will live up to all your expectations.

This MTC calibrator is a fast, timesaving, and reliable true industrial temperature calibrator designed for on-site use.

During the past several years, we have acquired extensive knowledge of industrial temperature calibration. This expertise is reflected in our products which are all designed for daily use in an industrial environment. Please note that we would be very interested in hearing from you if you have any ideas or suggestions for changes to our products.

This reference manual applies to the following instrument:

- **JOFRA MTC-650 A MKII – Temperature calibrator**

The calibrator has the following features and functions:

- Wide temperature range
- Fast heating and cooling time as well as a short stabilization time
- Multi-Information colour Display and Function keys
- Useful features such as Set function, Preset mode, Auto Switch Test and Auto Stepping
- IRI – Intelligent Recalibration Information
- Broad range of inserts
- Silent mode operation
- JOFRACAL calibration software
- Protective carrying case with compartments for inserts, cables, manuals, plugs etc.

ISO-9001 certified

AMETEK Denmark A/S was ISO-9001 certified in September 1994 by Bureau Veritas Certification Denmark.

CE-label



Your new temperature calibrator bears the CE label and conforms to the Electromagnetic Compatibility (EMC) Directive 2014/30/EU and the Low Voltage Directive 2014/35/EU and RoHS Recast (RoHS II) Directive 2011/65/EU*.

* MTC-650 A from serial no. xxxxxx-00001

Technical assistance

Please contact the dealer from whom you acquired the instrument if you require technical assistance.

1.1 Warranty

This instrument is warranted against defects in workmanship, material and design for two (2) years from date of delivery to the extent that AMETEK will, at its sole option, repair or replace the instrument or any part thereof which is defective, provided, however, that this warranty shall not apply to instruments subjected to tampering or, abuse, or exposed to highly corrosive conditions.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES WHETHER EXPRESS OR IMPLIED AND AMETEK HEREBY DISCLAIMS ALL OTHER WARRANTIES, INCLUDING, WITHOUT LIMITATION, ANY WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY. AMETEK SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING, BUT NOT LIMITED TO, ANY ANTICIPATED OR LOST PROFITS.

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

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

1.2 Receiving the Marine Temperature Calibrator

When you receive the instrument...

- 1) Unpack and check the calibrator and the accessories carefully.
- 2) Check the parts according to the list shown below.

If any of the parts are missing or damaged, please contact the dealer who sold you the calibrator.

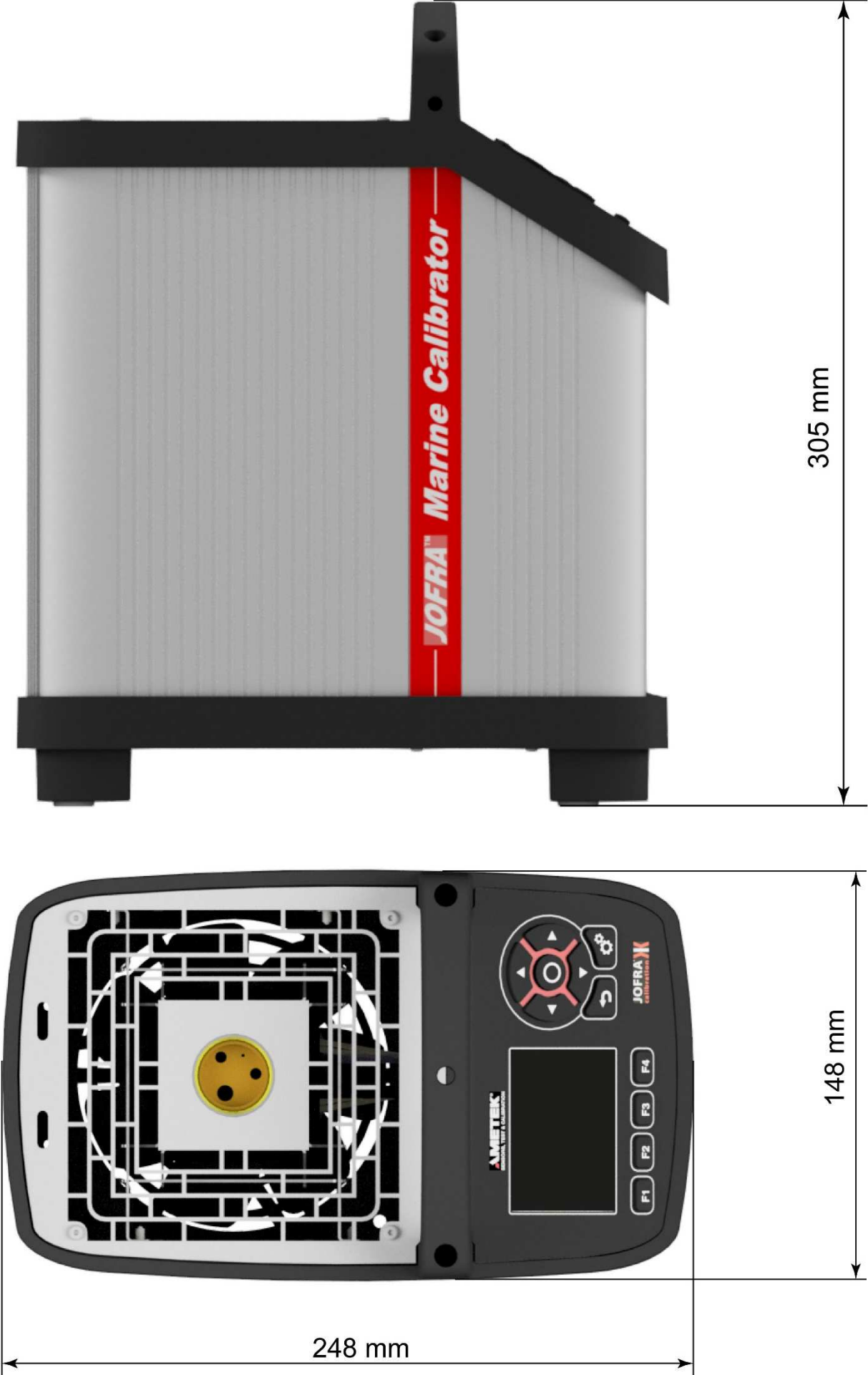
You should receive:

- 1 MTC Calibrator
- 1 USB memory stick containing electronic Reference manual and software package JOFRACAL
- 1 mains cable
- 1 sets of test leads and test clips (black and red)
- Thermal protection shield
- 1 tool for insertion tube
- 1 USB cable
- 1 Calibration certificate (International traceable)



When reordering, please specify the part numbers according to the list of accessories, section 11.0

1.3 Dimensioning drawing



2.0 Safety instructions



Read this manual carefully before using the instrument!

Please follow the instructions and procedures described in this manual. They are designed to allow you to get the most out of your calibrator and avoid any personal injuries and/or damage to the instrument.



Disposal – WEEE Directive

These calibrators contain Electrical and Electronic circuits and must be recycled or disposed of properly (in accordance with the WEEE Directive 2012/19/EU).



Warning

About the use:

- The calibrator **must not** be used for any purposes other than those described in this manual, as protection provided by the calibrator may be impaired and it might cause a hazard.
- The calibrator has been designed for **indoor use only** and is not to be used in wet locations.
- The calibrator is **not to be used in hazardous areas**, where vapour or gas leaks, etc. may constitute a danger of explosion.
- The calibrator is **not** designed for operation in altitudes above 2000 meters.
- The calibrator is a CLASS I product and must be connected to a mains outlet with a protective earth connection. Ensure the ground connection of the calibrator is properly connected to the protective earth before switching on the calibrator. Always use a mains power cable with a mains plug that connects to the protective earth.
- To ensure the connection to protective earth any extension cord used **must** also have a protective earth conductor.
- Only use a mains power cord with a current rating as specified by the calibrator and which is approved for the voltage and plug configuration in your area.
- **Always** make sure to position the power cord and other connected cables in a secure way to prevent the risk of personnel falling.
- To prevent the calibrator from tipping over and causing damage to equipment or systems, please avoid pulling the cables connected to the calibrator.
- Before switching on the calibrator make sure that it is set to the voltage of the mains electricity supply.
- **Always** position the calibrator to enable easy and quick disconnection of the power source (mains inlet socket).
- The calibrator **must** be kept clear within an area of 20 cm on all sides and 1 metre above the calibrator due to fire hazard.
- **Never** use heat transfer fluids such as silicone, oil, paste, etc. in the dry-block calibrators. These fluids may penetrate the calibrator and cause electrical hazard, damage or create poisonous fumes.
- The calibrator **must** be switched off before any attempt to service the instrument is made. There are no user serviceable parts inside the calibrator.
- When cleaning the well or the insertion tube, **REMEMBER** to wear goggles when using compressed air!

- Remember to use appropriate protective equipment or get help when carrying the calibrator (for a longer distance) in order to prevent injuries from dropping the calibrator.

About the frontpanel:

- The connectors, on the front panel of the calibrator, must **NEVER** be connected to a voltage source.
- Thermostats connected to the switch test input must **not** be connected to any other voltage source during a test.

About insertion tubes and insulation plugs:

- **Never** leave hot insertion tubes, which have been removed from the calibrator, unsupervised – they may constitute a fire hazard or personal injury.
If you intend to store the calibrator in the aluminium carrying case after use, you **must** ensure that the instrument has cooled down to a temperature **below 50°C/122°F** before placing it in the carrying case.
- **Never** place a hot insertion tube in the optional carrying case.

About the fuses:

- The fuse box must not be removed from the power control switch until the mains cable has been disconnected.
- The two main fuses must have the specified current and voltage rating and be of the specified type. The use of makeshift fuses and the short-circuiting of fuse holders are prohibited and may cause a hazard.



Caution – Hot surface



This symbol is visible on the grid plate.

- **Do not touch** the grid plate, the well or the insertion tube as the calibrator is heating up – they may be very hot and cause burns.
- **Do not touch** the tip of the sensor when it is removed from the insertion tube/well – it may be very hot and cause burns.
- **Do not touch** the handle of the calibrator during use – it may be very hot and cause burns.
- **Over 50°C/122°F**
If the calibrator has been heated up to temperatures above 50°C/122°F, you must wait until the instrument reaches a temperature **below 50°C/122°F** before you switch it off.
- **Do not** remove the insert from the calibrator before the insert has cooled down to less than 50°C/122°F.



Caution...

About the use:

- **Do not** use the instrument if the internal fan is out of order.
- Before cleaning the calibrator, you **must** switch it off, allow it to cool down and remove all cables.

About the well, insertion tube and grid plate:

- The well and the insertion tube **must** be clean and dry before use.
- **Do not** pour any form of liquids into the well. It might damage the well or cause a hazard.
- Scratches and other damage to the insertion tubes should be avoided by storing the insertion tubes carefully when not in use.
- The insertion tube must **never** be forced into the well. The well could be damaged as a result, and the insertion tube may get stuck.
- **Before** using new insertion tubes for the calibration, the insertion tubes **must** be heated up to maximum temperature 650°C (1202°F) for a period of minimum 30 minutes.
- The insertion tube must **always** be removed from the calibrator after use. The humidity in the air may cause corrosion oxidation on the insertion tube inside the instrument. There is a risk that the insertion tube may get stuck if this is allowed to happen.
- If the calibrator is to be transported, the insertion tube **must** be removed from the well to avoid damage to the instrument.



Note...

The product liability **only** applies if the instrument is subject to a manufacturing defect. This liability becomes void if the user fails to follow the instructions set out in this manual or uses unauthorised spare parts.

3.0 Setting up the calibrator for use

3.1 Preparing the calibrator



Warning

- The calibrator has been designed for **indoor use only** and is not to be used in wet locations.
- The calibrator is **not to be used in hazardous areas**, where vapour or gas leaks, etc. may constitute a danger of explosion.
- The calibrator is **not** designed for operation in altitudes above 2000 meters.
- The calibrator is a CLASS I product and must be connected to a mains outlet with a protective earth connection. Ensure the ground connection of the calibrator is properly connected to the protective earth before switching on the calibrator. Always use a mains power cable with a mains plug that connects to the protective earth.
- To ensure the connection to protective earth any extension cord used **must** also have a protective earth conductor.
- Only use a mains power cord with a current rating as specified by the calibrator and which is approved for the voltage and plug configuration in your area.
- **Always** make sure to position the power cord and other connected cables in a secure way to prevent the risk of personnel falling.
- To prevent the calibrator from tipping over and causing damage to equipment or systems, please avoid pulling the cables connected to the calibrator.
- Before switching on the calibrator make sure that it is set to the voltage of the mains electricity supply.
- **Always** position the calibrator to enable easy and quick disconnection of the power source (mains inlet socket).
- The calibrator **must** be kept clear within an area of 20 cm on all sides and 1 metre above the calibrator due to fire hazard.



Note...

The instrument must **not** be exposed to draughts.

When setting up the calibrator, you must...

- ① Place the calibrator on an even horizontal surface where you intend to use it.



Caution...

Do not use the instrument if the internal fan is out of order.

- ② Ensure a free supply of air to the internal fan located at the bottom of the instrument (pos. 2). The area around the calibrator should be free of draught, dirt, flammable substances etc.
- ③ Check that the fuse size corresponds to the applied voltage on (pos. 3). The fuse is contained in the power control switch (on/off switch (230V/115V)). To check; do as follows (see Fig. 1):

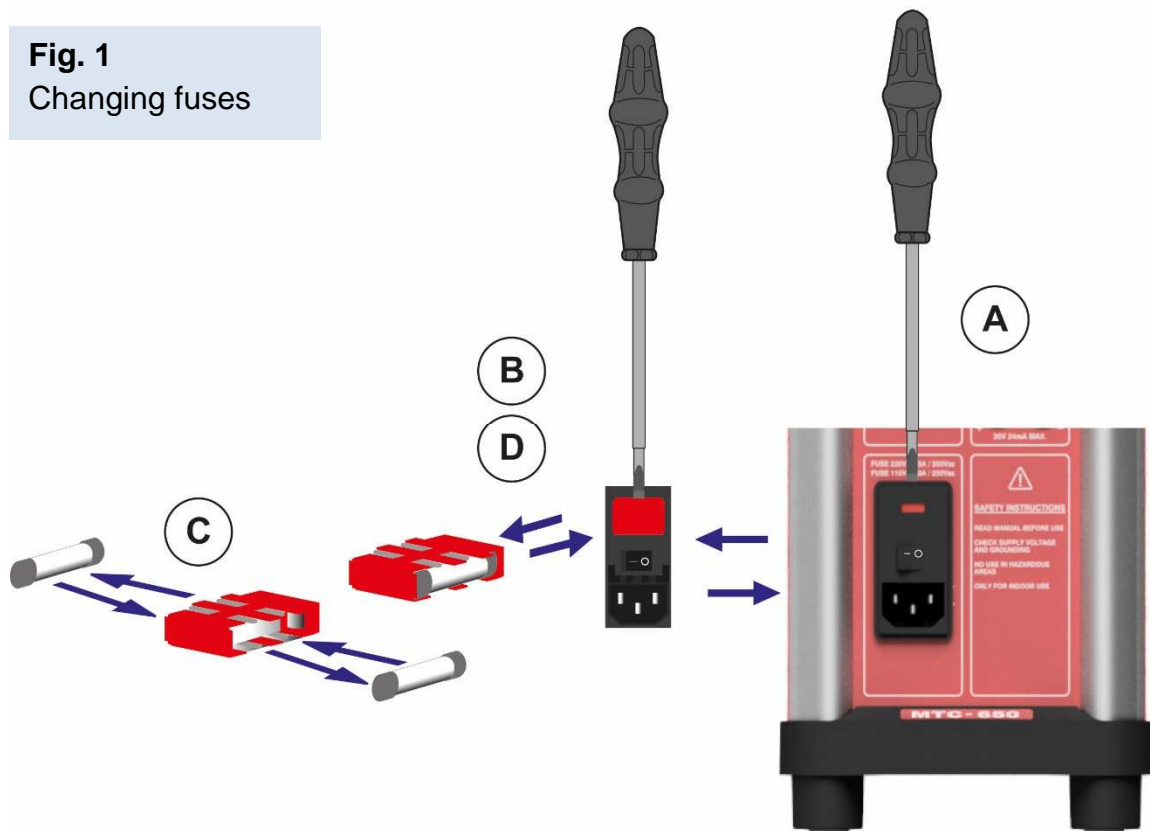




Warning

The two main fuses must have the specified current and voltage rating and be of the specified type. The use of makeshift fuses and the short-circuiting of fuse holders are prohibited and may cause a hazard.

Fig. 1
Changing fuses



- A. Open the fuse box lid using a screwdriver.
- B. Take out the fuse box.
- C. Remove both fuses replacing them with two new fuses. These must be identical and should correspond to the line voltage. See section 11.0.
- D. Slide the fuse box back into place.

- ④ Check that the earth connection for the instrument is present and attach the cable.
- ⑤ Select an insertion tube with the correct bore diameter. See section 3.2 for information on how to select insertion tubes.

The calibrator is now ready for use.

3.2 Choosing an insertion tube



Caution...

To get the best results out of your calibrator, the insertion tube dimensions, tolerance and material are critical. We highly advise using the JOFRA insertion tubes, as they guarantee trouble free operation. Use of other insertion tubes may reduce performance of the calibrator and cause the insertion tube to get stuck.



Caution...

Before using new insertion tubes for the calibration in the MTC-650 instrument the insertion tubes **must** be heated up to maximum temperature 650°C (1202°F) for a period of minimum 30 minutes.

Insertion tubes are selected on the basis of the diameter of the sensor to be calibrated.

Use the table for insertion tubes in section 3.2.1 to find the correct parts number.

Alternatively, you may order an undrilled insertion tube and drill the required hole yourself. The finished dimension should be as follows:

- Sensor diameter $\varnothing d +0.2\text{mm} +0.05 / -0.00\text{mm}$.
- Reference sensor hole $\varnothing 4.2\text{mm} +0.05 / -0.00\text{mm}$.
- When drilling the holes it is important that the distance of the material between the drillings is at least 2mm. If the distance is less than 2 mm the calibration result could be compromised.

3.2.1 Standard insertion tubes



Caution...

To get the best results out of your calibrator, the insertion tube dimensions, tolerance and material are critical. We highly advise using the JOFRA insertion tubes, as they guarantee trouble free operation. Use of other insertion tubes may reduce performance of the calibrator and cause the insertion tube to get stuck.

PARTS NO. FOR STANDARD INSERTION TUBES SINGLE HOLES			
Sensor size	MTC-650	Sensor size	MTC-650
3 mm	129459	Undrilled	129475
4 mm	129460	Undrilled/ref.	129476
5 mm	129461	hole	
6 mm	129462	1/8"	129477
7 mm	129463	3/16"	129478
8 mm	129464	1/4"	129479
9 mm	129465	5/16"	129480
10 mm	129466	3/8"	129481
11 mm	129467	7/16"	129482
12 mm	129468	1/2"	129483
13 mm	129469	9/16"	129484
14 mm	129470	5/8"	129485
15 mm	129471	11/16"	129486
16 mm*	129472	13/16"	129487
18 mm*	129473	3/4"	129488
20 mm*	129474		

PART NO. FOR STANDARD INSERTION TUBES MULTI-HOLES	
MTC-650	
Metric Type 1	
Sensor size 3, 4, 5, 6, 9 mm and 4mm REF	129493
Inch Type 2	
Sensor size 1/8", 3/16", 1/4", 3/8" and 4 mm REF	129494

*Note: Insertion tubes without reference holes.

3.3 Inserting the sensor

Before inserting the sensor and switching on the calibrator, please note the following important warning:



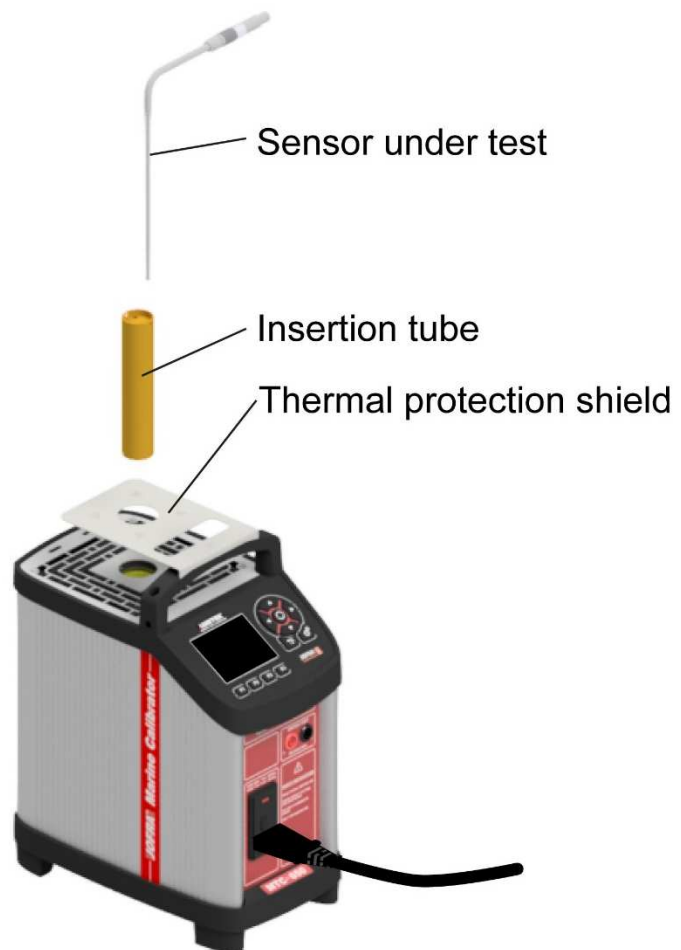
Warning

- **Never** use heat transfer fluids such as silicone, oil, paste, etc. in the dry-block calibrators. These fluids may penetrate the calibrator and cause electrical hazard, damage or create poisonous fumes.
- **Never** try to modify the insulation plugs to make them fit the sensor. Use only insulation plugs supplied by AMETEK Denmark A/S.

Insert the sensor as shown below in fig. 2.

Fig. 2

Inserting sensor and insertion tube



In order to spare the sensor and its connections it is recommended to use a thermal protection shield (129264) at high temperatures.



Caution...

- The well and the insertion tube **must** be clean before use.
- **Do not** pour any form of liquids in the well. It might damage the well.
- Scratches and other damage to the insertion tubes should be avoided by storing the insertion tubes carefully when not in use.
- The insertion tube must **never** be forced into the well. The well could be damaged as a result, and the insertion tube may get stuck.

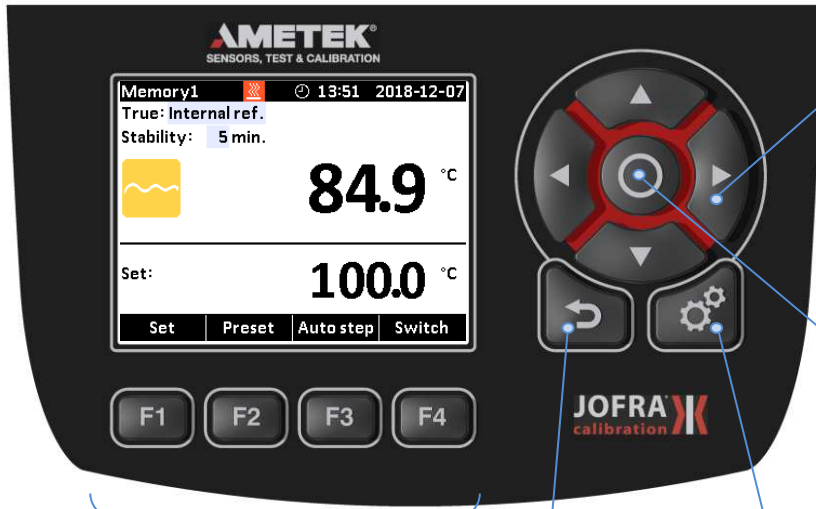


Caution – Hot surface

- **Do not touch** the grid plate, the well or the insertion tube as the calibrator is heating up – they may be very hot and cause burns.
- **Do not touch** the tip of the sensor when it is removed from the insertion tube/well – it may be very hot and cause burns.
- **Do not touch** the handle of the calibrator during use – it may be very hot and cause burns.
- **Do not remove** the insertion tube from the calibrator before the insertion tube has cooled down to less than 50°C/122°F.

4.0 Calibrator Interface

4.1 Keypad - Functions



Arrow Keys
 Serve different functions depending on the mode of operation.
 Navigation mode: Use the four keys to move the cursor in the desired direction.
 Edit mode: The Up and Down Arrow keys scroll through the lists of options. If entering a number, the Left and Right Arrow keys move the cursor one character in the desired direction.

Action key / Enter key
 Action function: Open and close edit fields or a menu button. The action key also accepts the selected option or entered value.

Enter function: Accept selected options or entered values. When a value is entered with the Enter Key the cursor selects the next configurable field in the list.

System menu key
 Press the key to enter the System menu.

Back key
 Press the key to cancel a selection or return to previous menu.

Function keys
F1, F2, F3, F4
 To operate the horizontal menu bar use the Functions keys.

4.2 Display - Functions

Reference sensor info
 Shows the reference sensor selected.

Memory reading
 Shows the current memory selected from the System menu.

Warning/Error symbols. See 4.2.2

Real Time Clock and date display

“Time to stable” Selection
 Shows the selected specified stability criteria and states a time when the stable situation can be achieved.

Process Indicator
 Indicates the status of the current process.

True temperature reading
 Shows the numeric value of the temperature being measured.

Units
 Shows the unit of the current measurement.

Set temperature reading
 Shows the numeric value of the current set temperature selected.

Horizontal menu bar
 Provides you with the relevant menu options that can be selected at the present point. Each option can be selected and activated by pressing the function keys (F1, F2, F3 and F4).




4.2.1 Main screen temperature values

Two temperatures are always displayed:



- TRUE temperature: This is the reference temperature of the calibrator.
- SET temperature: This is the target temperature for the well. SET temperature displays the last value entered. If no value has been entered previously, "---,--" is displayed.

4.2.2 Stability of temperature values



The stability of the TRUE temperature is indicated by the following messages:

-  "Not stable": Indicates that the measured temperature is not yet within the specified stability criteria.
-  Indicates "Time to stable": The temperature changes are within a specified stability criteria and states a time (in minutes and seconds) when the stable situation can be achieved.
-  Indicates that the "stable" situation is achieved and for how long the calibrator has been stable. When the calibrator has been stable for more than 99 minutes, only the stable sign is displayed (time is no longer displayed).



When the instrument is heating up and cooling down indication of this will be shown as following symbols

-  The instrument is heating up.
-  The instrument is cooling down.

Heating and cooling symbols will be displayed in the upper black info bar when:

-  the well temperature is below 5°C.
-  the well temperature is above 45°C.

Warning and error symbols will be displayed in the upper black info bar indicating that action needs to be taken:

-  Warning symbol.
-  Error symbol.

If a warning or an error symbol occurs during operation, a list of alarms will be displayed showing the warning and/or error messages. See section 7.0 – Error messages.

Note...

A warning will always surpass an error, even if the error occurs after the warning.

4.3 Input/Output Connections



Warning

- The input terminals must **NEVER** be connected to voltage exceeding 30V with reference to ground.

Fig. 3

Input and Output

Device

USB 2.0 Device Port, 1 x USB.

Power Control Switch

With a cable connection and On/Off switch. It also contains the main fuse. See section 3.1 for information on how to change the fuse. The text above the Power Control Switch indicates the fuse value.

Switch Test

Connection for thermostat switch test. **Note** that this connection is for voltage free switches.



5.0 Operating the calibrator



Warning



Caution...



Please inspect the Safety Instructions in section 2.0 before using the instrument.

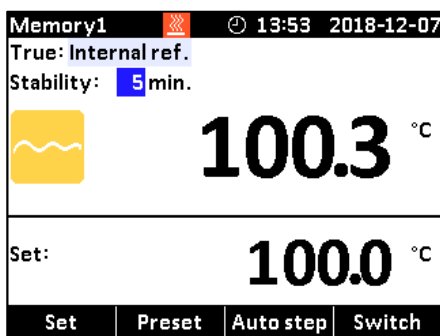
5.1 Operating principle







The calibrator is operated using the Functions keys, the Arrow keys and the Action/Enter key.

1. Press the Functions keys to operate the horizontal menu bar.






2. Press any of the  (Arrow) keys to enter Navigation Mode. Editable fields will be highlighted in blue.
3. Use the  (Arrow) keys to move between the configurable fields within the display. Selected fields will be highlighted in dark blue.

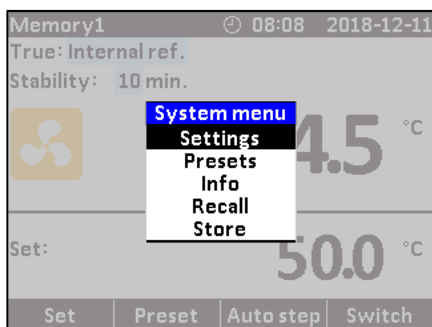


4. Press the  (Enter) key to access the selected field for editing.
5. Use the  (Up) and  (Down) Arrow keys to select a new value.
6. Press the  (Enter) key to accept the new value
7. To exit the Navigation Mode press the  (Back) key. The  (Back) key is also used to cancel a selection or to return to a previous menu.

5.1.1 System menu




The System menu can be accessed at any stage of operation:

1. Press the  (System) key to display the System menu.
2. Use the  (Up) and  (Down) Arrow keys to scroll in the list.




System Settings menu

System Settings	
Min. SET Temp:	0.0 °C
Max. SET Temp:	650.0 °C
Resolution:	0.1 °C
Temperature unit:	°C
Silent mode:	<input checked="" type="checkbox"/>
Date	2018-12-07
Time	13:54
Calibration interval:	12 Months

1. Use the  (Enter) key and the  (Up) and  (Down) Arrow keys to access editable fields, select new values and accept new values.




Note...

- If the current set-temperature is higher than the new max-temperature, you will need to adjust the set-temperature. The instrument will immediately begin to cool (if required) as soon as the new max-temperature is accepted.
- The calibration interval can be set between 1 and 99 months. When the calibration interval is exceeded, a yellow warning symbol  will appear in the upper part of the display.
- If Silent mode is selected, the cooling speed will be reduced.

Presets menu

Preset Temperature Settings	
Preset temperature F1:	50.0 °C
Preset temperature F2:	75.0 °C
Preset temperature F3:	100.0 °C
Preset temperature F4:	150.0 °C

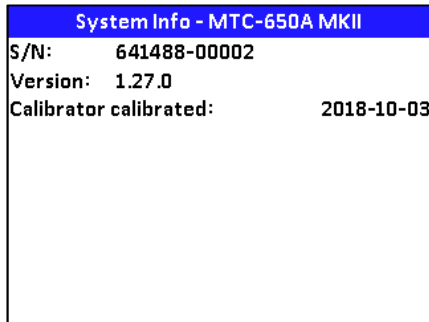
The preset temperatures can be changed manually using the  (Arrows) keys.



Note...

Temperature range is limited by Min. SET Temp. and Max. SET Temp. settings editable in the System Settings menu.

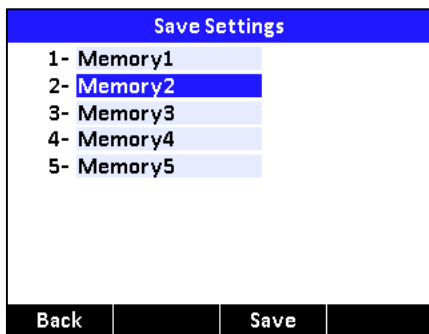
System Info menu



In the System Info menu important information such as serial numbers and calibration dates of the instrument are given.

It is not possible to edit any fields in this menu.

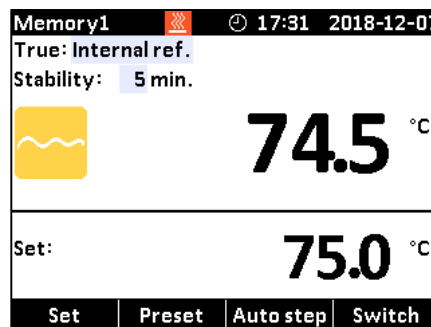
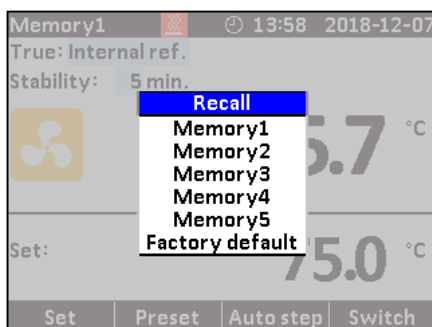
Store menu (Save Settings)




After you have configured the instrument, you can save the setup for future use using the Store function.

1. Use the ▲ (Up) and ▼ (Down) Arrow keys to select the Memory-setup you want to modify, and press **F3** (Save). The new configuration is now saved.
2. You can change the name of the highlighted saved setup by pressing **Enter**, and then using the ▲ (Up) and ▼ (Down) Arrow keys to change the characters. The name is limited to seven (7) characters.
3. Press **F3** to save the new name.

Recall menu



To recall your memory setups select the Recall function.

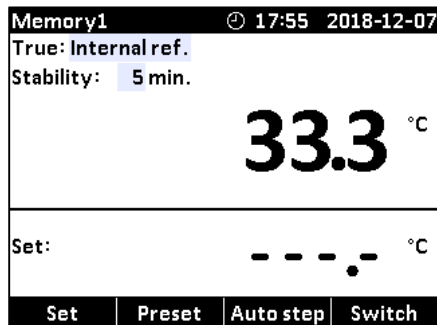
1. Use the ▲ (Up) and ▼ (Down) Arrow keys to scroll in the setup-list.
2. Select the requested setup, and press  (Enter).

The name of the setup will appear in the upper-left corner of the display.

If selecting the Factory default function the active setup will be reset and change to the initial setting.

5.2 Starting the calibrator

Switch on the calibrator using the power control switch (see section 4.3).
A start up screen is displayed and then replaced with the main menu screen:



The functions in the horizontal menu bar are available using the Functions soft keys F1 – F4. For Operating principle – See section 5.1.

5.3 Stability setting

When internal reference is selected the calibrator uses a set of minimum internal stability criteria that shall be met before stability is indicated.



The stability time can be adjusted from the minimum internal stability time (typical 5 min) up to 99 min.

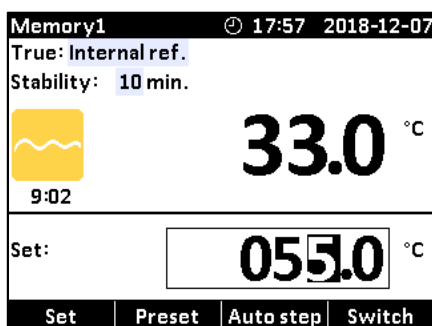
5.4 Selecting the set-temperature

➔ Note...

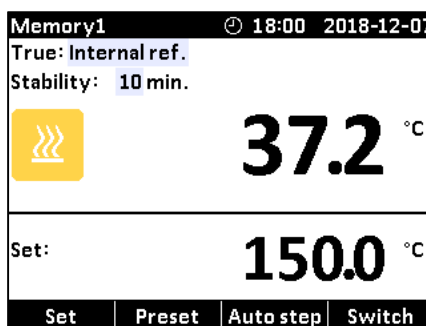
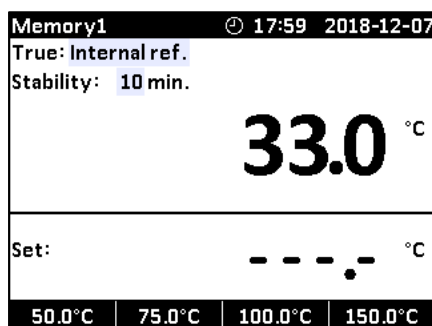
Temperature range is limited by Min. SET Temp. and Max. SET Temp. settings editable in the System Settings menu.

The set-temperature can be entered both manually and by selecting a preset temperature.

1. For manually use press **F1** (Set)
2. Use the  (Arrow) keys to enter the temperature requested.
3. Press  (Enter) to accept the entered temperature.



1. For selecting the preset temperature press **F2** (Preset).
2. Select one of the 4 temperature options available from the menu bar by pressing the correspondent Function key (F1 – F4).
3. The set-temperature is selected, once the Function key has been pressed.

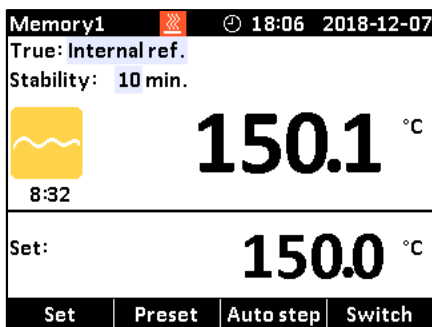



The calibrator will now heat up / cool down.

The starting point is the last chosen set-temperature (even if the instrument has been switched off).

The top display continuously shows the read-temperature and the lower display shows the set-temperature.


In the top display the calibrator will indicate the estimated time in whole minutes until the calibrator will be stable.

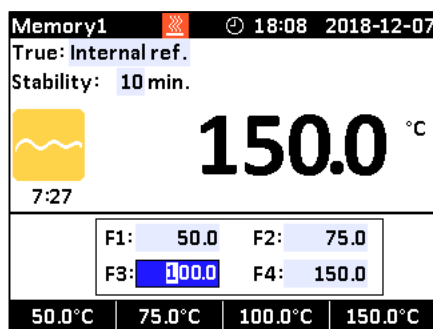
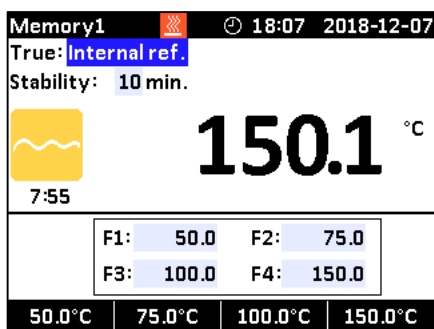







When the calibrator is stable the display will show a green  checkmark symbol and the instrument will emit an audible alarm. The instrument will indicate in minutes and seconds for how long the instrument has been stable.

5.4.1 Editing the preset set-temperature

It is possible to change the preset set temperature to whatever value desired.

1. Press **F2** (Preset).
2. Press one of the  (Arrow) keys and an editable field displaying the preset set temperatures appears.
3. Navigate to the set temperature field using the arrows.

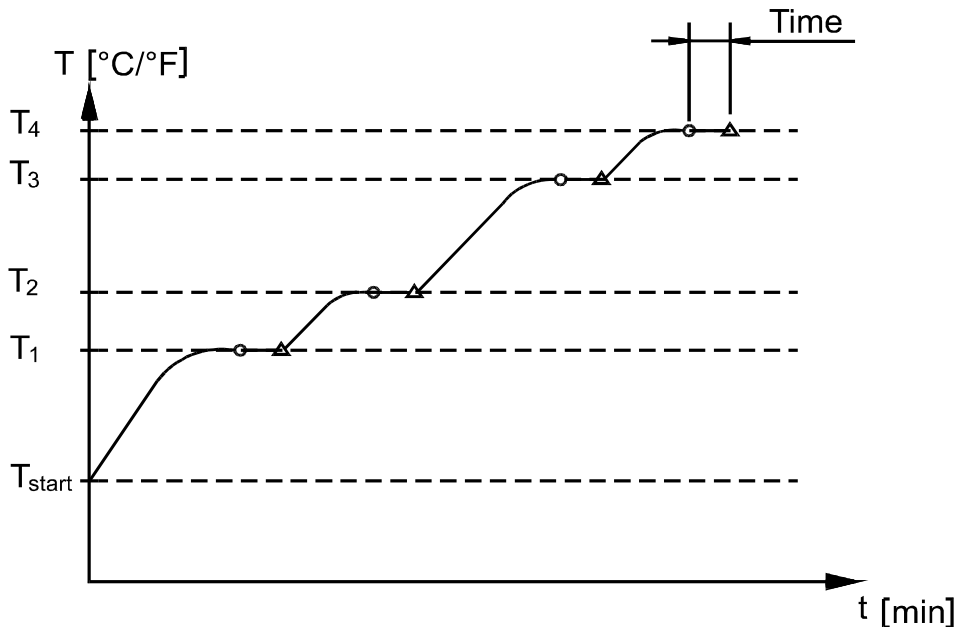


4. Press  (Enter) to access the editable field and use the arrows  (Up) and  (Down) to select a new set value.
5. Press  (Enter) to accept the new set value.
6. Press  (Back) to return to the previous menu.

5.5 Auto Step function

Auto Step is used to step automatically between a range of different calibration temperatures. This is useful when calibrating sensors in places which are hard to reach, and when calibrating sensors for which the output is displayed in a different location.

The function can be illustrated using the following example:



- Calibrator stable
- △ Calibrator starts working towards next temperature

➔ Note...

Temperature range is limited by Min. SET Temp. and Max. SET Temp. settings editable in the System Settings menu.



5.5.1 Running an Auto Step test

1. Press **F3** (Auto Step) to access the Auto Step setup. If you wish to return to the Main screen press **F1** (Main).

Step	Temp.	Step	Temp.	Step	Temp.
1	33.0°C	5	437.0°C	9	400.0°C
2	134.0°C	6	538.0°C	10	342.0°C
3	235.0°C	7	639.0°C	11	243.0°C
4	336.0°C	8	540.0°C	12	44.0°C

Set: 150.0°C Int.ref.: 150.0°C







Main ▶

2. Press one of the  (Arrow) keys to access the editable fields for new values:
 - **No of steps:** the number of temperature steps per direction ($T_1 \rightarrow T_x$) can be set using integers from 2 to 12. You must select minimum 2 steps, maximum 12 steps.
 - **Hold time:** defines the time (in minutes) the temperature is maintained (after it is stable) for each step.
 - **Step values:** must be set within the sensors permitted range.
3. Press  (F4) to start the Auto Step test.



The Auto Step test is now in progress.


While the Auto Step test is in progress, 4 options are available:

- **Stop :** Press  (F1) to stop the Auto Step test. The process will end. Pressing the  (F4) key the process will start again running step 1.
- **Previous :** Press  (F2) to force the test to jump a step backwards to the previous running step regardless of the step's stability.
- **Next :** Press  (F3) to force the test to jump a step forwards to the next running step regardless of the step's stability.
- **Pause :** Press  (F4) to pause the test. Pressing start  (F4) again, the process will continue running from the current step.

5.5.2 The calibrator's Auto Step procedure

- 1) Once the Auto Step test is started, the calibrator starts working towards the given set-temperature. An audible alarm will be emitted once the calibrator is stable.
- 2) The calibrator will wait the specified amount of hold time. The instrument indicates this by counting down the amount of time remaining:
- 3) The calibrator will then go to the next step. The procedure is the same as for the first step. This process will be repeated until the last step has been executed and the function has been completed.
- 4) The measured TRUE temperatures for each step are displayed during operation.

Memory1 18:22 2018-12-07
True: Internal ref.
Stability: 10 min.

 **134.0** °C
0:02

Auto step **134.0** °C
Step 2/12:

■ ◀ ▶ ||

5.6 Switch Test function

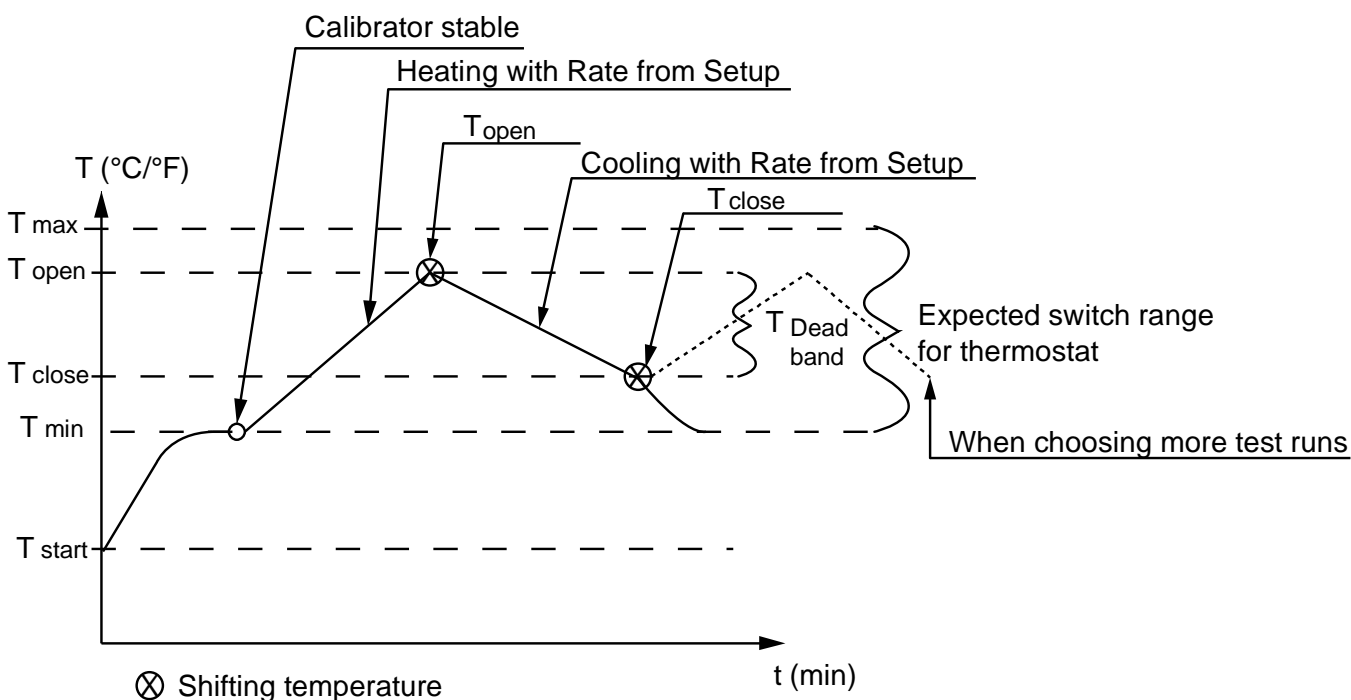
Switch Test automatically locates the switch temperature of a thermostat.

Three parameters are required:

- Start temperature (T_1)
- End temperature (T_2)
- Rate of change in temperature pr. minute (Rate).

Dead band of a thermostat can also be determined here. Where the dead band determines the tolerance between the upper switch temperature and the lower switch temperature of the thermostat.

The function can be illustrated using the following example:



5.6.1 Running a Switch Test

➔ Note...

Before running the Switch Test, make sure that the switch is connected to the Switch Test input.

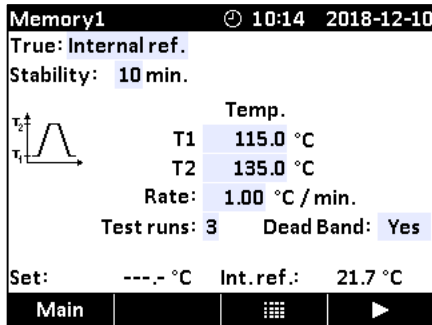


Fig. 4
Switch Test input


➔ Note...

Temperature range is limited by Min. SET Temp. and Max. SET Temp. settings editable in the System Settings menu.

1. Press **F4** (Switch) to access the Switch Test setup. If you wish to return to the Main screen press **F1** (Main).




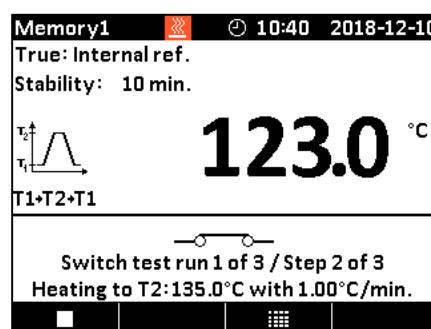
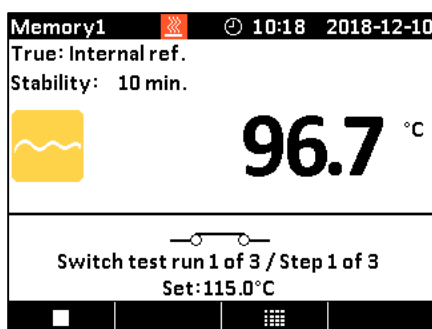
The small graph illustrates the current T_1 , T_2 and dead band selections. Note that T_1 can be greater than T_2 .

2. Press one of the  (Arrow) keys to access the editable fields for new values:
 - T_1 : First set temperature
 - T_2 : Second set temperature
 - **Dead band** : To determine dead band, toggle between "Yes" (a two-way-temperature measurement) and "No" (a one-way-temperature measurement). A dead band result is only measured when dead band is set to "Yes".
 - **Rate** : The permitted range is 0.01 - 10.0°C/min. / 0.02 - 18.0°F/min.
 - **Test runs**: Can be set from 1 to 3 making it possible to run the test more

 **Note...**



the Rate should be set so that the thermostat sensor can follow the temperature in the calibrator's well.


3. Press  (F4) to start the Switch Test.



The Switch test is now in progress.


While the Switch Test is in progress, 2 options are available:

- **Stop** : Press  (F1) to stop the Switch Test. The process will end and the results will be deleted from the results list.
Pressing the  (F4) key the process will start from the beginning heating towards T_1 .

- **Results :** Press  (F3) to display the current Switch Test result. The results change as the test progresses. The results list is also accessible from the Switch Test menu screen.


5.6.2 The calibrator's Switch Test procedure

- 1) Once the Switch Test is started, the calibrator starts working towards T_1 as quickly as possible. The calibrator's temperature changes (heating or cooling) and switch status are shown in the display.
- 2) When T_1 is achieved and the temperature is stable, the text and the graphic in the bottom of the screen will change accordingly.
- 3) The calibrator now starts working towards T_2 at the specified Rate.
- 4) In a normal situation, the thermostat changes state before T_2 is achieved. If T_2 is achieved and the temperature is stable, no results will be displayed.


Memory1  10:21 2018-12-10				
True: Internal ref.				
Stability: 10 min.				
	Test 1	Test 2	Test 3	Avg.
Open:	---	---	---	---
Close:	---	---	---	---
Dead Band:	---	---	---	---
Rate: 1.00 °C / min.				
Switch test run 1 of 3 / Step 1 of 3				
Set:	115.0 °C	Int.ref.:	115.2 °C	
Back				

- 5) When dead band is not selected (single temperature change) (the graphic indicates the choice), the finished switch test result is displayed.

When dead band is selected (two switch changes), the calibrator starts working towards T_1 at the specified Rate.

- 6) Normally, the thermostat changes state before T_1 is achieved. If T_1 is reached and the temperature is stable, no results will be displayed.
- 7) The finished switch test results are displayed in the results list by pressing  (F3).

The results show the temperature when the thermostat has closed and the temperature when it has opened – whichever comes first. The difference between these 2 temperatures is calculated as the dead band.

Memory1  11:22 2018-12-10				
True: Internal ref.				
Stability: 10 min.				
	Test 1	Test 2	Test 3	Avg.
Open:	128.8	128.3	128.2	128.4
Close:	122.1	122.0	122.0	122.0
Dead Band:	6.7	6.3	6.2	6.40
Rate: 1.00 °C / min.				
Switch test run 3 of 3 / Step 1 of 3				
Set:	115.0 °C	Int.ref.:	121.9 °C	
Back				

6.0 Storing and transporting the calibrator



Caution...

The following guidelines should always be observed when storing and transporting the calibrator. This will ensure that the instrument and the sensor remain in good working order.



Warning

- The calibrator **must** be switched off before any attempt to service the instrument is made. There are no user serviceable parts inside the calibrator.
- Remember to use appropriate protective equipment or get help when carrying the calibrator (for a longer distance) in order to prevent injuries from dropping the calibrator.

The following routine must be observed **before the insertion tube is removed** and the instrument switched off:



Over 50°C/122°F

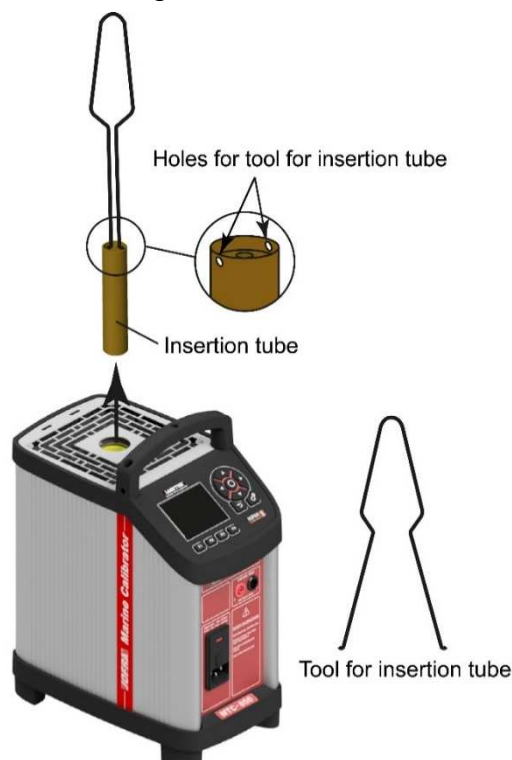
If the calibrator has been heated up to temperatures above 50°C/122°F, you must wait until the instrument reaches a temperature **below 50°C/122°F** before you switch it off.

1. Switch off the calibrator using the power control switch.

Note that the calibration procedure may be interrupted at any time using the power control switch. Switching off the calibrator during the calibration process will not damage either the instrument or the sensor.

2. Remove the insertion tube from the calibrator using the tool for insertion tube supplied with the instrument as shown in fig. 5.

Fig. 5
Removing the insertion tube





Caution – Hot surface

Do not remove the insert from the calibrator before the insert has cooled down to less than 50°C/122°F



Caution...

- The insertion tube must **always** be removed from the calibrator after use.
The humidity in the air may cause corrosion oxidation on the insertion tube inside the instrument. There is a risk that the insertion tube may get stuck if this is allowed to happen.
- If the calibrator is to be transported long distances, the insertion tube **must** be removed from the well to avoid damage to the instrument.

Warning



- **Never** leave hot insertion tubes which have been removed from the calibrator unsupervised – they may constitute a fire hazard or personal injury.
If you intend to store the calibrator in the optional aluminium carrying case after use, you **must** ensure that the instrument has cooled to a temperature **below 50°C/122°F** before placing it in the carrying case.
- **Never** place a hot insertion tube in the optional carrying case.
- **Do not** touch the well or insertion tube when these are deep frozen – they might create frostbite.

7.0 Error messages (List of alarms)



Warning

The calibrator **must** be switched off before any attempt to service the instrument is made. There are no user serviceable parts inside the calibrator.

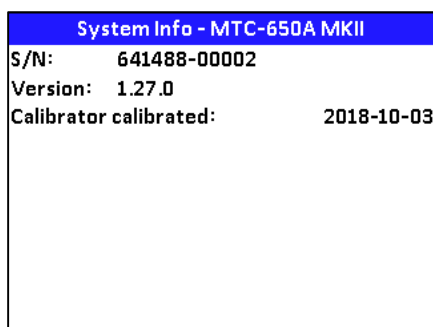




Note...

AMETEK Denmark's liability ceases if:

- parts are replaced/repaired using spare parts which are not identical to those recommended by the manufacturer.
- non-original parts are used in any way when operating the instrument.
AMETEK Denmark's liability is restricted to errors which originated from the factory.

If the calibrator detects an error during operation, the instrument will terminate all functions and display a list of alarms. Make a note of the error message and contact your distributor or AMETEK Denmark's service department.



1. Press  (Left) to access the System Info display for status information on the instrument.
2. Press  (Right) to return to the list of alarms.



Note...

Errors that are critical to safety and the calibrator remain on the list of alarms until the instrument is switched off and on again.

The following alarms can occur:

Error message:

Solution:



Wrong mains frequency
Please enter code to proceed

Contact your local distributor in order to obtain a special pin code.



Mains frequency cannot be measured

Please report the error to your local distributor or to AMETEK Denmark's service department.



Temperature cut off error




















Please report the error to your local distributor or to AMETEK Denmark's service department.



Heater 1-2 error

Please report the error to your local distributor or to AMETEK Denmark's service department.

Error message:**Solution:**

 Heater 3-4 error	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Temperature control error	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Ambient temperature too high	Cool down instrument. Check that ambient temperature is within specified values. Check fan inlet. If the error still occurs, please report the error to your local distributor or to AMETEK Denmark's service department.
 Well temperature too high	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Watchdog reset has occurred	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Software reset has occurred	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Calibrator calibration date has been exceeded	The instrument needs to be calibrated. Please return the instrument to AMETEK Denmark's service department or to your national laboratory.
 Communication error, RTC	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Communication error, safety DAC	Please report the error to your local distributor or to AMETEK Denmark's service department.
 EEPROM read/write error	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Calibrator coefficients have not been set	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Default configuration loaded Model number has to be set	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Default configuration loaded	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Wrong PCB according to configured variant	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Illegal hardware version	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Fan speed too low	Please check that the fan is not blocked
 Extension board not connected	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Internal RTD excitation current too low	Please report the error to your local distributor or to AMETEK Denmark's service department.
 Internal RTD excitation current too high	Please report the error to your local distributor or to AMETEK Denmark's service department.

Error message:**Solution:**

Internal ref. temperature too high

Internal reference temperature has measured a value outside the temperature calibrator temperature range. Please report the error to your local distributor or to AMETEK Denmark's service department.



Internal ref. temperature too low

Internal reference temperature has measured a value outside the temperature calibrator temperature range. Please report the error to your local distributor or to AMETEK Denmark's service department.



Safety sensor temperature too high

Temperature protection sensor has measured a value outside the temperature calibrator temperature range. Please report the error to your local distributor or to AMETEK Denmark's service department.



Safety sensor temperature too low

Temperature protection sensor has measured a value outside the temperature calibrator temperature range. Please report the error to your local distributor or to AMETEK Denmark's service department.



Temperature sensor error

Please report the error to your local distributor or to AMETEK Denmark's service department.



Heater 1 error

Please report the error to your local distributor or to AMETEK Denmark's service department.



Heater 2 error

Please report the error to your local distributor or to AMETEK Denmark's service department.



Heater 3 error

Please report the error to your local distributor or to AMETEK Denmark's service department.



Heater 4 error

Please report the error to your local distributor or to AMETEK Denmark's service department.



Safety circuit activated by well temp.

Information after "Well temperature too high" error. Will remain active until a new SET-temperature is activated.



Safety circuit activated by ambient temp.

Information after "Ambient temperature too high" error. Will remain active until a new SET-temperature is activated.



Safety circuit activated

Information when the temperature safety circuit is triggered. Will remain active until a new SET-temperature is activated.

8.0 Returning the calibrator for service

When returning the calibrator to the manufacturer for service, please enclose a fully completed service information form. Simply copy/print out the form on the following page and fill in the required information.

The calibrator should be returned in the original packing.

Furthermore please follow the guidelines for transportation described in section 6.0 – Storing and transporting the calibrator.

Service info

Customer data:

Date:

Customer name and address: _____

Attention and dept.: _____

Fax no./phone no.: _____

Your order no.: _____

Delivery address: _____

Distributor name: _____

Instrument data:

Model and serial no.: _____

Warranty claimed Yes: _____ No: _____ Original invoice no.: _____

Temp. calibration	Sensor input	Service request:	This instrument is sent for (please check off):
<input type="checkbox"/>	<input type="checkbox"/>	___ Calibration as left	___ Check
<input type="checkbox"/>	<input type="checkbox"/>	___ Calibration as found and as left	___ Service
<input type="checkbox"/>	<input type="checkbox"/>	___ Accredited calibration as left	___ Repair
<input type="checkbox"/>	<input type="checkbox"/>	___ Accredited calibration as found and as left.	

Diagnosis data/cause for return:

Diagnosis/fault description: _____

Special requests: _____

Safety precautions: if the product has been exposed to any hazardous substances, it must be thoroughly decontaminated before it is returned to AMETEK Denmark A/S. Details of the hazardous substances and any precautions to be taken must be enclosed.

9.0 Maintenance

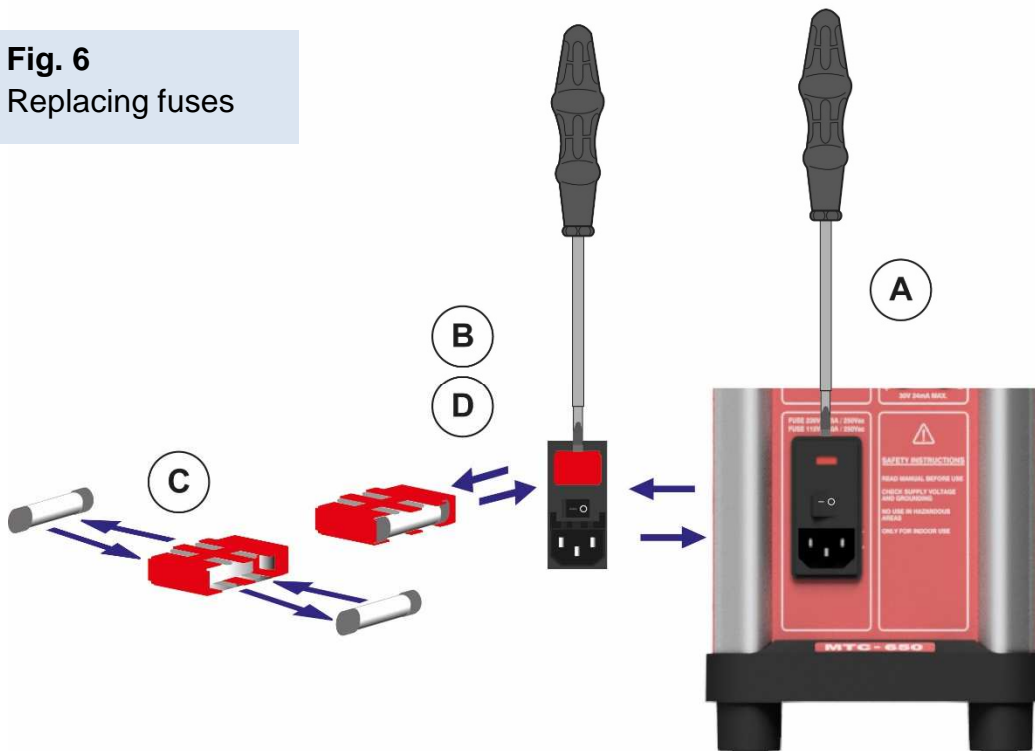
9.1 Replacing the main fuses



Warning

- The calibrator **must** be switched off before any attempt to service the instrument is made. There are no user serviceable parts inside the calibrator.
- The fuse box **must not** be removed from the power control switch until the mains cable has been disconnected.
- The two main fuses must have the specified current and voltage rating and be of the specified type. The use of makeshift fuses and the short-circuiting of fuse holders are prohibited and may cause a hazard.



Fig. 6
Replacing fuses

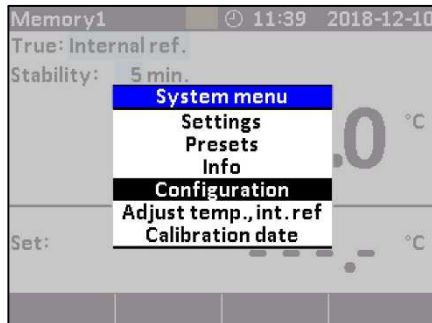


- Locate the main fuses in the fuse box in the power control switch and check the voltage of the power control switch (on/off switch (230V/115V)). If the voltage of the power control switch differs from the line voltage, you must adjust the voltage of the power control switch.
- Open the lid of the fuse box using a screwdriver and remove the fuse box.
- Replace the fuses. The fuses must be identical and should correspond to the line voltage.
 - 115V: 10AF/250V = 60B302
 - 230V: 5AF/250V = 127573If the fuses blow immediately after you have replaced them, the calibrator should be returned to the manufacturer for service.
- Slide the fuse box into place with the correct voltage turning upwards.

9.2 Maintenance mode

The user can change the configuration of the instrument by accessing the Maintenance mode.

1. Press  (Enter) while switching on the calibrator using the ON/OFF switch.
2. Wait a few seconds and press the  (System) key to access the Maintenance System menu.




From the Maintenance System menu you can access the System Settings, the System Info, the Configuration and the Calibration date. You are also presented to a selection of adjustment options. The editable possibilities in the System Settings and the System Info are the same as described in section 5.1.1.

Configuration

If the system is locked on a specific main frequency it is possible to change this frequency.

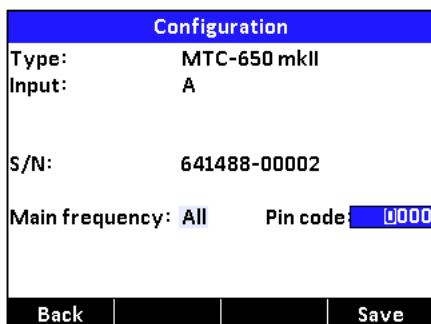
The alarm list will be displayed with the following text:



 Wrong mains frequency

Note...

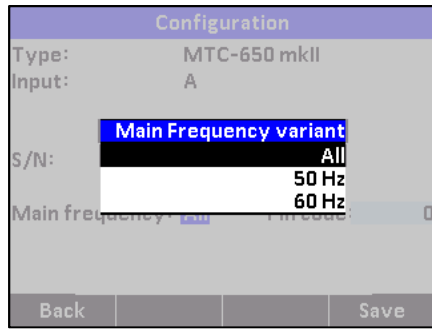
In order to change the main frequency a pin code is needed. Please contact your local distributor to obtain your special pin code.

1. Select the Configuration mode.



2. Type in the pin code obtained from the distributor using the  (Up) and  (Down) keys. The pin code must consist of 4 digits.

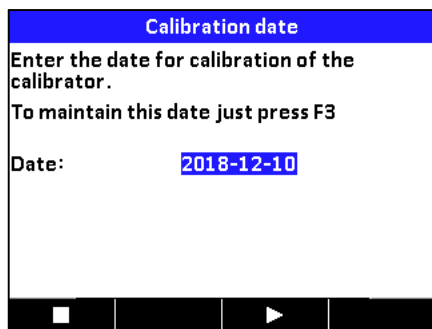
3. Select a new main frequency from the Main Frequency variant list



4. Press **F4** (Save) to save the configuration set up.

Calibration date

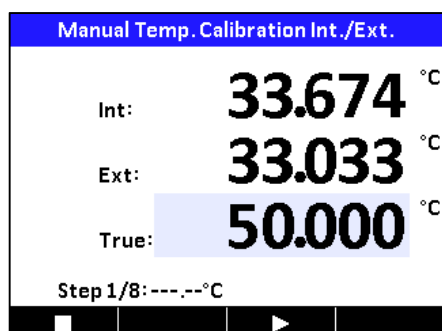
1. Select the Calibration date mode.







2. Use the ▲ (Up) and ▼ (Down) keys to enter a new date.
3. Press Ⓞ (Enter) to accept the new date.
4. Press ▶ (F3) to continue to the next screen setup.
5. Continue pressing the ▶ (Continue) key until the process is completed.

Adjusting temperature, internal reference

1. Place the reference sensor in the calibrator.
2. Select the Adjust temp., mode for the wanted adjustment procedure.
3. Press Ⓞ (Enter) and the calibrator starts heating up/cooling down to reach the first calibration temperature.
4. When the calibrator is stable an audible alarm will be emitted.
5. Type in the reference temperature found using the reference thermometer. Use the ▲ (Up) and ▼ (Down) keys to type in the value.



6. Press  (Enter) to accept the value.
7. Press  Continue (F3) to activate the heating up/cooling down process and wait for the stability indication.
8. Once the temperature is stable, press  Continue (F3) again.
9. Continue pressing the  (Continue) key until the adjusting process is completed.
10. When the temperature has been adjusted a new calibration date must be typed in. The calibrator automatically asks for a new date.

Adjustment temperature Calibration Steps
MTC-650
50°C, 200°C, 350°C, 500°C, 650°C

9.3 Cleaning



Caution...

- Before cleaning the calibrator, you **must** switch it off, allow it to cool down and remove all cables.
- The insertion tube must **always** be removed from the calibrator after use.
The humidity in the air may cause corrosion oxidation on the insertion tube inside the instrument. There is a risk that the insertion tube may get stuck if this is allowed to happen.



Caution – Hot surface

Do not remove the insert from the calibrator before the insert has cooled down to less than 50°C/122°F



Warning

- **Never** leave hot insertion tubes that have been removed from the calibrator unsupervised – they may constitute a fire hazard or personal injury.
If you intend to store the calibrator in the optional aluminium carrying case after use, you **must** ensure that the instrument has cooled to a temperature **below 50°C/122°F** before placing it in the carrying case.
- **Do not** touch the well or insertion tube when these are deep frozen – they can create frostbite.

Users should/must carry out the following cleaning procedures as and when required:

- **The exterior of the instrument** – Clean using water or isopropyl alcohol and a soft cloth. The cloth should be wrung out hard to avoid any water penetrating the calibrator and causing damage.
The keyboard may be cleaned using isopropyl alcohol when heavily soiled.

- **The insertion tube** - Must **always** be clean and should be regularly wiped using a soft, lint-free, dry cloth.
You must ensure there are no textile fibres on the insertion tube when it is inserted in the well. The fibres may adhere to the well and damage it.

To prevent this from happening, the insertion tube must be dried. This is done by heating up the calibrator to min. 100°C/212°F until all water left has evaporated.
Remove the insulation plug while heating up.

It is very important that humidity in the insertion tube is removed to prevent corrosion and frost expansion damages.
- **The well** - Must **always** be clean.
Dust and textile fibres should be removed from the well using e.g. compressed air.



Warning

REMEMBER! Wear goggles when using compressed air!

9.4 Adjusting and calibrating the instrument

You are advised to return the calibrator to AMETEK Denmark A/S or another accredited laboratory at least once a year for calibration.

10.0 Technical specifications

All specifications are given with an ambient temperature of 23°C/73.4°F ± 3°C/5.4°F

MECHANICAL SPECIFICATIONS

MTC-650 A MKII

Dimensions l × w × h	248 x 148 x 305 mm / 9.76 x 5.83 x 12.01 inch
Weight	6.1 kg / 13.4 lbs (without insertion tube)
Bore diameter/depth of well	Ø26 mm / 120 mm – ø1.02 inch / 4.72 inch
Weight non-drilled insertion tube	510 g / 18.0 oz

POWER SUPPLY

Line voltage/frequency	90-127VAC / 180-254VAC 47-63 Hz
Power consumption	1150 VA max.
Type of connection	IEC320

COMMUNICATION INTERFACES

Type of connections	USB type B
---------------------	------------

ENVIRONMENT

Ambient operating temperature range	0-50°C / 32-122°F
Storage temperature range	-20-50°C / -4-122°F
Humidity range	5-90% RH, non-condensing
Protection class	IP10
Altitude	0-2000 m

READOUT SPECIFICATIONS

Resolution	1 / 0.1 / 0.01
Temperature units	°C / °F / K

THERMAL SPECIFICATIONS

MTC-650 A MKII

Maximum temperature	650°C / 1202°F
Minimum temperature	55°C / 131°F @ ambient temperature 50°C / 122°F 28°C / 82°F @ ambient temperature 23°C / 73.4°F 5°C / 41°F @ ambient temperature 0°C / 32°F
Temperature coefficient	±0.03°C/°C (0-20°C and 26-50°C) / ±0.054°F/°F (32-68°F and 79-122°F)
Stability	±0.1°C/ ±0.18°F
Total accuracy	Internal reference:
(1 year)	±0.9°C / 1.62°F @ 28°C / 82.4°F to 200°C / 392°F
(3 years)	±1.8°C / 3.24°F @ 200°C / 392°F to 400°C / 752°F
Heating time incl. insertion tube	23°C / 73.4°F to 650°C / 1202°F : 18 min.
Time to stability	8 min.

Cooling time incl. insertion tube	650°C / 1202°F to 100°C / 212°F:	39 min. (52 min. silent mode)
	100°C / 212°F to 50°C / 122°F:	18 min. (26 min. silent mode)

STANDARDS

The following standards are observed according to the EMC-Directive 2014/30/EU

EN 61326-1: 2013:

Electrical equipment for measurement, control and laboratory use – EMC requirements

Part 1: General requirements

Emmision: Class B - equipment suitable for use in domestic establishment and in establishments directly connected to low voltage power supply network which supplies buildings used for domestic purposes.

Immunity: Table 2 - Immunity test requirements for equipment intended to be used in an industrial electromagnetic environment.

The following standards are observed according to the low voltage-directive 2014/35/EU

EN61010-1:2010 :

Safety requirements for electrical equipment for measurement, control and laboratory use, part 1: General requirement

EN61010-2-030:2010 :

Safety requirements for electrical equipment for measurement, control and laboratory use, part 2-030: Particular requirements for testing and measuring circuits

11.0 List of accessories

All parts listed in the list of accessories can be obtained from the factory through our dealers.

Please contact your dealer for assistance if you require parts which do not appear on the list.

List of accessories

Accessories	Part no.
Fuse 115V: 10AF/250V	60B302
Fuse 230V: 5AF/250V	127573
Rugged carrying case	129244
Electrical ref. manual +JOFRACAL PC software	124915
Tool for insertion tube	60F170
Thermal protection shield	129264
Mains cable, 115V, US, type B	60F135
Mains cable, 240V, UK, type C	60F136
Mains cable, 220V, South Africa, type D	60F137
Mains cable, 220V, Italy, type E	60F138
Mains cable, 240V, Australia, type F	60F139
Mains cable, 230V, Europe, type A	60F140
Mains cable, 230V, Denmark, type G	60F141
Mains cable, 220V, Switzerland, type H	60F142
Mains cable, 230V, Israel, type I	60F143
USB cable	127278
Set of test cables	104203
Cleaning brush, 4 mm	122832
Cleaning brush, 6 mm	60F174
Cleaning brush, 8 mm	122822
Insulation tube 100 mm x \varnothing 25 mm	65-F100
Insulation tube 400 mm x \varnothing 25 mm	65-F105
Support rod set	129539
Sensor grip	125067
Fixture for sensor grip	125066

AMETEK Sensors, Test & Calibration

A business unit of AMETEK Measurement & Calibration Technologies Division offering the following industry leading brands for test and calibration instrumentation.

JOFRA Calibration Instruments

Temperature Calibrators

Portable dry-block calibrators, precision thermometers and liquid baths. Temperature sensors for industrial and marine use.

Pressure Calibrators

Convenient electronic systems ranging from -25 mbar to 1000 bar - fully temperature-compensated for problem-free and accurate field use.

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M&G Deadweight Testers & Pumps

Pneumatic floating-ball or hydraulic piston deadweight testers with accuracies to 0.015% of reading. Pressure generators delivering up to 1,000 bar.

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Digital pressure gauges and calibrators that are accurate, easy-to-use and reliable. Designed for use in the harshest environments; most products carry an IS, IP67 and DNV rating.

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Material testing machines and software that guarantees expert materials testing solutions. Also covering Texture Analysers to perform rapid, general food testing and detailed texture analysis on a diverse range of foods and cosmetics.

Davenport Polymer Test Equipment

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