



Installation, Operation & Maintenance Instructions

Combustion Tube Furnaces CFM models

This manual is for the guidance of operators of the above Carbolite products and should be read before the furnace is connected to the electricity supply.

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**Manuals are supplied separately for the furnace controller
(and overtemperature controller when fitted).**

Please read the controller manuals before operating the furnace.

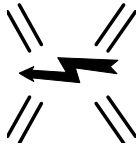


1.0 SYMBOLS & WARNINGS

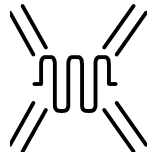
1.1 Switches and Lights



Supply Light: when the furnace is connected to the electrical supply the light in the adjacent switch glows

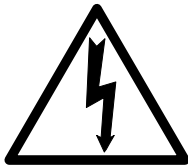


Heat Switch: the switch disconnects power to the heating elements; unless this switch is off there is a danger of electric shock when inserting objects into the furnace



Heat Light: the adjacent light glows or flashes to indicate that power is being supplied to the elements

1.2 Warning Symbols



DANGER of electrical shock— read any warning printed by this symbol.



DANGER – hot surface. Read any warning printed by this symbol.
WARNING: all surfaces of a furnace may be hot.



DANGER – read any warning printed by this symbol.

2.0 **INSTALLATION**

2.1 **Unpacking & Handling**

When unpacking or moving the furnace always lift it by its base. Do not lift it by the end panels or by the internal insulation. Use two people to carry the furnace where possible. Remove any packing material from inside the furnace before use.

2.2 **Siting**

Place the furnace in a well ventilated room, away from other sources of heat, and on a surface which is resistant to accidental spillage of hot materials. Do not mount the furnace on an inflammable surface.

Ensure that there is free space around the furnace. Do not obstruct any of the vents in the control section: they are needed to keep the controls cool.

Ensure that the furnace is placed in such a way that it can be quickly switched off or disconnected from the electrical supply - see below.

2.3 **Setting Up**

The furnace is typically used for sulphur and chlorine test in accordance with BS1016 parts 6 & 7, ASTM D 3177-75; ISO 351 & 609. Please refer to the appropriate documentation. This manual only gives general guidance common to tube furnaces.

Fit any work tube(s) ordered into place.

If a metal work tube is being used in the furnace, ensure that it is earthed, and that it is mounted so as not to touch the furnace ceramic tube or insulation. See the safety warning in section 3.5.

2.4 **Heating Elements (1400°C Models)**

The Silicon Carbide elements are VERY FRAGILE and are packed separately. Fit them according to the instructions in section 5.7.

2.5 Electrical Connections

Connection by a qualified electrician is recommended.

The furnaces covered by this manual require a single-phase A.C. supply with earth (ground). The supply may be Live to Neutral non-reversible, Live to Neutral with reversible plug, or Live to Live.

Check the furnace rating label before connection. The supply voltage should agree with the voltage on the label, and the supply capacity should be sufficient for the amperage on the label.

The supply should be fused at the next size equal to or higher than the amperage on the label. A table of the most common fuse ratings is also given in section 8.1 of this manual. Where a supply cable is present there are internal supply fuses; customer fusing is preferred but not essential.

Furnace with supply cable: either wire directly to an isolator or fit with a line plug.

Furnace without supply cable: a permanent connection to a fused and isolated supply should be made to the internal terminals after temporary removal of the furnace back panel.

Connection by line plug: the plug should be within reach of the operator, and should be quickly removable. Connection to isolating switch: this should operate on both conductors (single phase) or on all live conductors (three phase), and should be within reach of the operator.

Single phase: connect the supply as follows:

| Cable colour | Terminal label | <i>supply type</i> | |
|--------------|----------------|--------------------|------------------------------|
| | | Live-Neutral | Reversible or Live-Live |
| Brown | L | to live | to either power conductor |
| Blue | N | to neutral | to the other power conductor |
| Green/Yellow | PE | to earth (ground) | to earth (ground) |

The supply **MUST** incorporate an earth (ground).

Technical Note (1400°C Models)

The 1400°C models have an electronically controlled power limit. Do not attempt to calculate the Amps from the Wattage. High break capacity fuses should be used. Avoid fast-blow fuses and magnetic trip circuit breakers - consult Carbolite if in doubt.

3.0 OPERATION

The instructions for operating the temperature controller are given in a separate manual.

If the furnace is fitted with a time switch, see also the supplementary manual MS03.

3.1 Operating Cycle

If the furnace has an auxiliary heater, see also section 3.2.

The furnace is fitted with a combined Supply light and Instrument switch. The light is on whenever the furnace is connected to the supply. The switch cuts off power to the control circuit. There is also a Heater switch which can be used to disconnect power to the elements.

Connect the furnace to the electrical supply. The Supply light should glow.

Operate the instrument switch to activate the temperature controller; the **O** position is *off*, the **I** position *on*. The controller becomes illuminated and goes through a short test cycle. Adjust the temperature controller (see controller manual).

Overtemperature option only. If the overtemperature controller has not yet been set as required, set it and activate it according to the instructions in the appropriate manual.

Switch on the Heater switch, located on the instrument panel.

Unless a time switch is fitted and is off, the furnace starts to heat up. The Heat light(s) glow steadily at first and then flash as the furnace approaches the desired temperature or a program setpoint.

Unless a time switch is fitted and is off, the furnace starts to heat up. The Heat light(s) glow steadily at first and then flash as the furnace approaches the desired temperature or a program setpoint.

Overtemperature option only. If the overtemperature trip operates then an indicator in the overtemperature controller flashes, and the heating elements are isolated. Find and correct the cause before resetting the overtemperature controller according the instructions supplied.

To switch off power to the heating elements, use the Heater Switch .

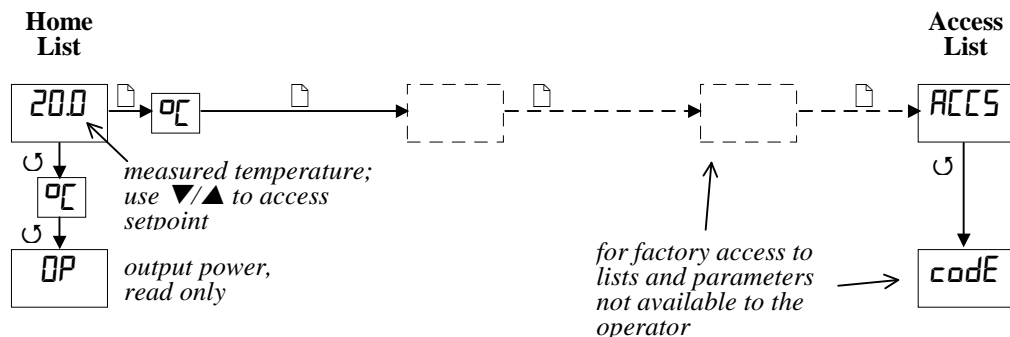
To switch the furnace off, set the Instrument switch to off. If the furnace is to be left off, isolate it the electrical supply.

3.2 Auxiliary heater (if fitted)

The auxiliary heater is controlled by an independent temperature controller, which is affected by the same instrument switch as the main controller. Note that a time switch (if fitted) may not switch off the auxiliary heater, depending on other options ordered.

Set the auxiliary heater's temperature controller after setting the main controller, as given in section.

Auxiliary heater controller navigation diagram:



3.3 General Operating Advice

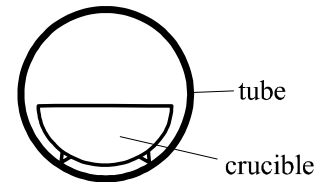
Heating element life is shortened by use at temperatures close to maximum. Do not leave the furnace at high temperature when not required. The maximum temperature is shown on the furnace rating label and on the back page of this manual.

Switch off the Heater switch whenever loading or unloading the furnace - see the safety warning below.

3.4 Tube Life

A work tube may be cracked if workpieces are inserted too quickly or at temperatures below 900°C (when the tube is more brittle). Large pieces should also be heated slowly to ensure that large temperature differences do not arise.


Poor thermal contact should be encouraged between the workpiece and the tube; crucibles or boats should be of low thermal mass and should have feet to reduce the contact with the tube.



avoidance of thermal contact

Avoid metal directly touching the work tube - see the safety warning below.

3.5 Operator Safety

 The ceramic materials used in furnace manufacture become electrically conductive to some extent at high temperatures. **DO NOT** use any conductive tools within the work tube without isolating it.

The work tube is isolated when the Heater switch is OFF. This switch cuts both sides of the circuit directly or, where the rated current exceeds 16 Amps, via a contactor.

3.6 Pressure

Work tubes are not able to accept high internal pressure. When gas seals or similar fittings are in use, the gas pressure should be restricted to a maximum of 0.2 bar (3 psi). A pressure of about half of that should normally be sufficient to achieve the desired flow rate. The customer must ensure that the exhaust path from the tube is not blocked, so that excess pressure does not occur.

4.0 MAINTENANCE

4.1 General Maintenance

No routine maintenance is required other than the occasional replacement of consumable items.

The furnace outer surface may be cleaned with a damp cloth. Do not allow water to enter the interior of the case or chamber. Do not clean with organic solvents.

4.2 Calibration

After prolonged use the controller and/or thermocouple could require recalibration. This would be important for processes which require accurate temperature readings or which use the furnace close to its maximum temperature. A quick check using an independent thermocouple and temperature indicator should be made from time to time to determine whether full calibration is required. Carbolite can supply these items.

Depending on the controller, the controller manual may contain calibration instructions.

4.3 After Sales Service

Carbolite's service division (Thermal Engineering Services) has a team of Service Engineers capable of repair, calibration and preventive maintenance of furnace and oven products at our customers' premises throughout the world. We also sell spares by mail order. A telephone call or fax often enables a fault to be diagnosed and the necessary spare part despatched.

Each furnace has its own record card at Carbolite. In all correspondence please quote the serial number, model type and voltage given on the rating label of the furnace. The serial number and model type are also given on the front of this booklet when supplied with a furnace.

To contact Thermal Engineering Services or Carbolite see the back page of this manual.

4.4 Recommended Spares Kits

Carbolite can supply individual spares, or a kit of the items most likely to be required. Ordering a kit in advance can save time in the event of a breakdown. Each kit comprises one thermocouple, one solid state relay, one heating element or set of elements. For 1400°C models the kits also include element clips and braids. Individual spares are also available.

When ordering spares please quote the model details as requested above.

4.5 Power Limit

In the 1400°C models the furnace control system incorporates electronic power limiting. Power is supplied to the elements in bursts of about 1/3rd second duration. This prevents overheating of the elements. The power limit is programmed into the furnace controller and may be calculated as a percentage as follows:

$$\text{powerlimit} = (100 \times \text{targetpower} \times \text{ohms}) / \text{volts}^2$$

where targetpower is the wattage given on the furnace rating label

ohms is the overall resistance of the combined element circuits (see example)

volts is the voltage across each element circuit (e.g. 240 for a 415/240V supply)

example:

1-phase furnace with 4 elements of 3.6 ohms each in series, running on 220V, with a target power of 2250W:

$$\text{ohms} = 3.6 \times 4 = 14.4$$

$$\text{powerlimit} = (100 \times 2250 \times 14.4) / (220 \times 220) = 67\%$$

A table of power limit settings is given in section 8.2. These are the settings for the furnace with new elements as supplied.

All models. Occasionally the power limit is set to zero to permit demonstration of the controls without the heating elements taking power. The operator may reset it to its standard value or the value that it had before setting to zero.

4.6 Element Aging

Applicable to 1400°C models.

Silicon carbide elements gradually increase in resistance with use: a process known as aging. Their heating power reduces correspondingly. To ensure sufficient power to the furnace it may be necessary to adjust the power limit, and, ultimately, to replace the elements - taking care to readjust the power limit.

If the furnace does not reach temperature, or is slow, measure the element resistances and calculate the required power limit using the method given above. If it exceeds 100%, the elements have too high a resistance and need replacing: check your data and calculations with Carbolite.

See the separate manual supplied for how to adjust the controller. Always record the setting when first making an adjustment. If new elements are fitted, return the adjustments to the original value, or remeasure and recalculate. A table of standard power limits is given in section 8.2.

CFM 14/4: This model has only a small margin for power limit adjustment on 240V. Power limit adjustment should not be necessary.

5.0 REPAIRS & REPLACEMENTS

5.1 Safety Warning – Disconnection from Supply



Always ensure that the furnace is disconnected from the supply before repair work is carried out.

5.2 Safety Note - Refractory Fibrous Insulation



This furnace contains refractory fibres in its thermal insulation. These materials may be in the form of fibre blanket or felt, vacuum formed board or shapes, mineral wool slab or loose fill fibre.

Normal use of the furnace does not result in any significant level of airborne dust from these materials, but much higher levels may be encountered during maintenance or repair.

Whilst there is no evidence of any long term health hazards, we strongly recommend that safety precautions are taken whenever the materials are handled.

Exposure to dust from fibre which has been used at high temperatures may cause respiratory disease.

When handling fibre always use an approved mask, eye protection, gloves and long sleeved clothing.

Avoid breaking up waste material. Dispose of waste fibre in sealed containers.

After handling rinse exposed skin with water before washing gently with soap (not detergent). Wash work clothing separately.

Before commencing any major repairs we recommend reference to the European Ceramic Fibre Industry Association Bulletin No. 11 and the UK Health and Safety Executive Guidance Note EH46.

We can provide further information on request. Alternatively our service division can quote for any repairs to be carried out at your premises or ours.

5.3 Temperature Controller Replacement

201. This controller is fitted to the back of the control panel; in many models this can be separated from the base by removal of two screws.



Before handling the controller: **wear an anti-static wrist strap** or otherwise avoid any possibility of damage to the unit by static electricity.

Refer to the detailed instructions supplied with the replacement controller.

2132, 2416, 2408 etc. Ease apart the two lugs at the side; grip the instrument and withdraw it from its sleeve; push in the replacement.

5.4 Solid-state Relay Replacement

Disconnect the furnace from the supply and remove the end panel at the supply cable end.

Make a note how the wires are connected to the solid state relay, and disconnect them.

Remove the solid state relay from the base panel or aluminium plate.

Replace and reconnect the solid state relay ensuring that the heat-conducting thermal pad is sandwiched between the relay and the base panel or aluminium plate. Alternatively a thin layer of white, heat-conducting silicon paste may be applied between the new relay and the plate.

The new solid state relay contains a built-in MOV which protects it from short periods of excess voltage. If the old relay had a separate disc-shaped "MOV" connected between the high voltage terminals of the old relay, discard the old MOV.

Replace the removed panel.

5.5 Thermocouple Replacement

Disconnect the furnace from the supply, and remove the end panel at the thermocouple end.

Make a note of the thermocouple connections. The negative leg of the thermocouple is marked blue. Compensating cable colour codings are:

| | |
|-----------------|--------------------------|
| <i>negative</i> | <i>positive (type R)</i> |
| white | orange |

Disconnect the thermocouple from its terminal block; retain any porcelain spacers.

Withdraw the thermocouple from its sheath and remove any broken bits of thermocouple.

Re-assemble with a new thermocouple observing the colour coding.

5.6 Element Replacement - 1200°C models



Please see safety note 5.2- wearing a face mask is recommended.

The chamber of this type of furnace contains a tubular refractory muffle around which is wound resistance heating wire. In the event of failure, the whole "wound muffle" assembly must be replaced.

Disconnect the furnace from the electrical supply and remove both furnace end panels.

Make a note of all the wiring connections; see the section above which refers to the thermocouple colour coding.

Unfasten the electrical connections to the inner chamber (brick-box) and remove the thermocouple (see thermocouple replacement instructions). If the connections are secured by hexagonal nuts, two spanners should be used to avoid cracking the porcelain mounting.

Undo any screws, bolts or hook bolts necessary to release the brick-box.

Support the brick box as you withdraw it from the case so it does not fall onto the electrical connections below.

Remove the brick box lid and all insulation, noting how it is assembled and observing the position of the heating element wires (or "tails").

Pull the element tails out of the terminal blocks and remove sufficient insulation to allow access to the heating element. Check and replace damaged insulation.

Fit the new heating element, ensuring that the tails are separated from the element by at least 25 mm of insulation.

Feed the heating element tails through the terminal blocks and tighten the clamping screws using two spanners as before. Cut off excess element tails.

Refit the insulation and refit the lid. Do not use any cement unless supplied by Carbolite, as other types may chemically attack the heating element.

Replace and fasten the brick-box into the furnace case.

Replace the thermocouple and remake the electrical connections. In porcelain and brass terminal blocks the brass connector should be slightly loose in its porcelain support block to allow for expansion.

Replace the panels and reconnect the electrical supply.

Switch the furnace ON and heat to 900°C without interruption, and then soak for 1 hour. Some smoke may be observed during this process, which should be carried out in a well ventilated area.

Check that the furnace is controlling properly to rule out the possibility that previous element failed because of a fault in the control circuit.

If you have any problems with this procedure, please contact our service division.

5.7 Element Fitting and Replacement - 1400°C models

Replacements: read the section on element aging (0). If at any time the power limit has been increased, measure the new element resistances and recalculate the limit.

Disconnect the furnace from the electrical supply.

Remove the furnace end panels to gain access to the element connections.

The elements are expensive and fragile, and can be damaged by contamination: handle them with care and keep them clean.

Replacements only: make a note of the actual braid and cable connections to the elements. Disconnect the clips with the special tool provided (or with finger pressure, depending on the type of clips supplied), lift off the braids and carefully withdraw each element. See fig. 5.

Carefully insert the new elements into the furnace.

Attach the connection braids according to the note made above or to the appropriate diagram, fig. 6. Use the special tool (or finger pressure) to fit the clips. Take care that adjacent clips do not touch each other.

Replace the furnace end guards and connect the furnace to the supply.

If aged elements have been replaced, reset the furnace power limit.

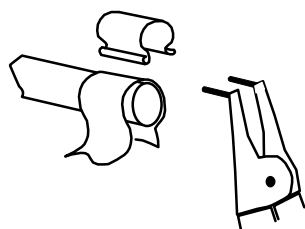


Fig.5. - Use of Clip Tool

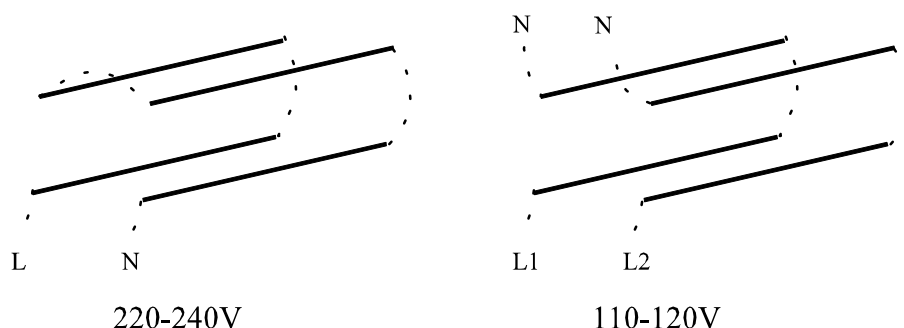


Fig.6. - Element Connections

CFM 14/4: this model has 6 elements in series on 220-240V. On 110-120V these are connected as two sets of 3 elements in series, in which case the L and N connections are at opposite ends of the furnace.

5.8 Fuse Replacement

Fuses are marked on the circuit diagram (section 7.0) with type codes, e.g. F1, F2. A list of the correct fuses is given in section 8.1. *Depending on model and voltage, the different fuse types may or may not be fitted.*

If any fuse has failed, it is advisable for an electrician to check the internal circuits.

Replace any failed fuses with the correct type. For safety reasons do not fit larger capacity fuses without first consulting Carbolite.

The fuses are near the cable entry point, and access is by removal of a panel.

6.0 FAULT ANALYSIS

A. Furnace Does Not Heat Up

- | | | | |
|----|-------------------------------------|--|--|
| 1. | The HEAT light is ON | → The heating element has failed | → Check also that the SSR is working correctly |
| 2. | The HEAT light is OFF | The controller shows a very high temperature or a code such as S.br | → The thermocouple has broken or has a wiring fault |
| | | The controller shows a low temperature | → The door switch(es) (if fitted) may be faulty or need adjustment |
| | | | → The contactor (if fitted) may be faulty |
| | | | → The SSR could be failing to switch on due to internal failure, faulty logic wiring from the controller, or faulty controller |
| | | There are no lights glowing on the controller | → The SUPPLY light is ON → The controller may be faulty or not receiving a supply due to a faulty switch or a wiring fault |
| | | | → The SUPPLY light is OFF → Check the supply fuses and any fuses in the furnace control compartment |

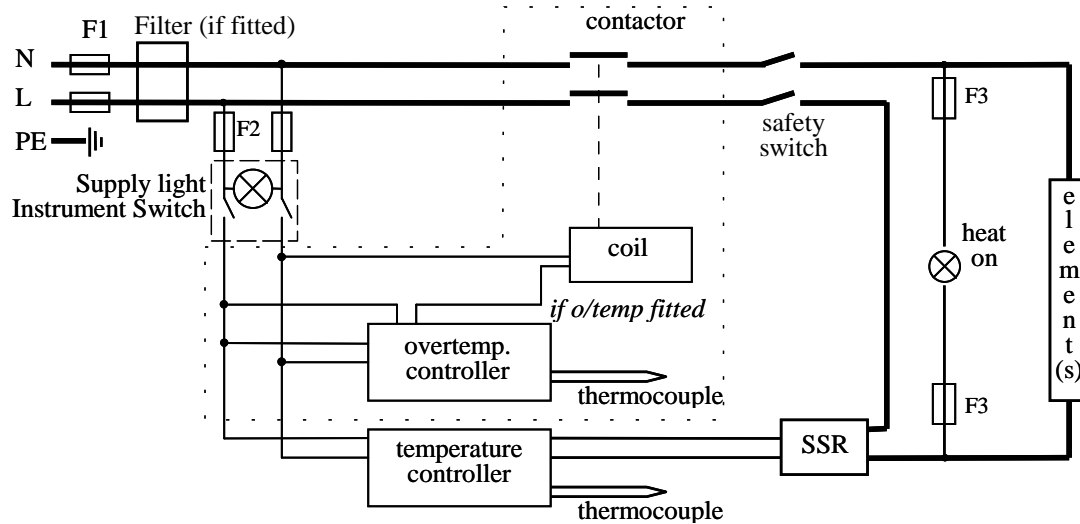
B. Furnace Overheats

- | | | | |
|----|---|---|--|
| 1. | The HEAT light goes OFF with the instrument switch | → The controller shows a very high temperature | → The controller is faulty |
| | | → The controller shows a low temperature | → The thermocouple may have been shorted out or may have been moved out of the heating chamber |
| | | | → The thermocouple may be mounted the wrong way round |
| | | | → The controller may be faulty |
| 2. | The HEAT light does not go off with the instrument switch | → The SSR has failed "ON" | → Check for an accidental wiring fault which could have overloaded the SSR |

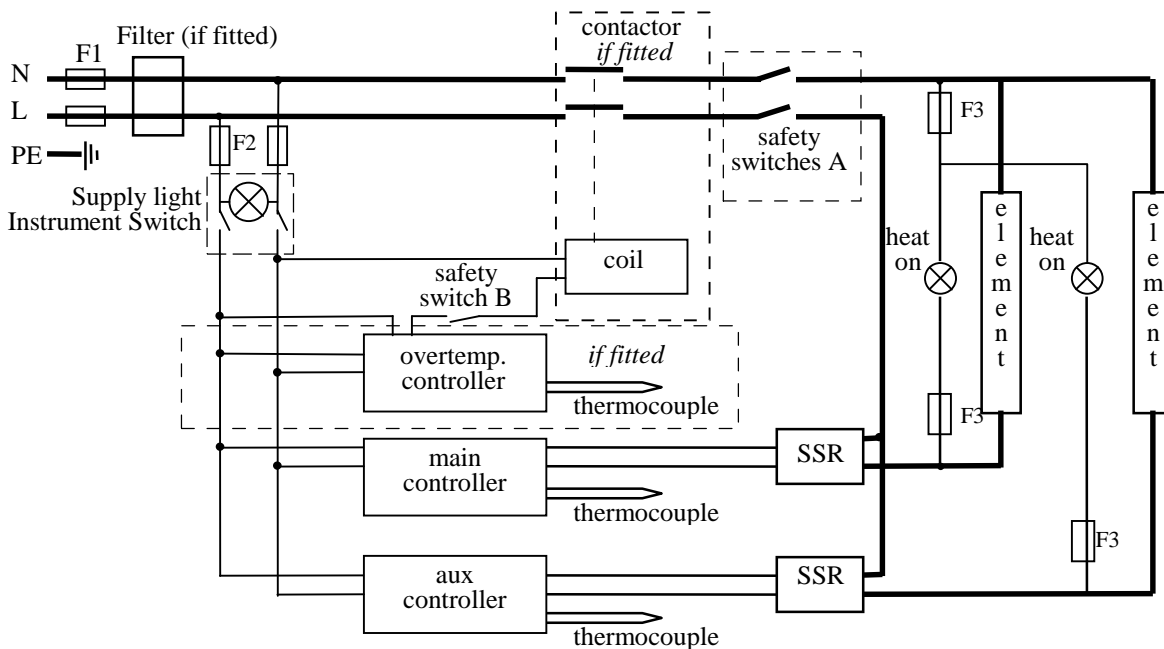
7.0 CIRCUIT DIAGRAMS

Safety switches: where the furnace rating is over 16A, there is a single switch in the contactor coil circuit, and the double switch shown is not present (both examples are shown in 7.2).

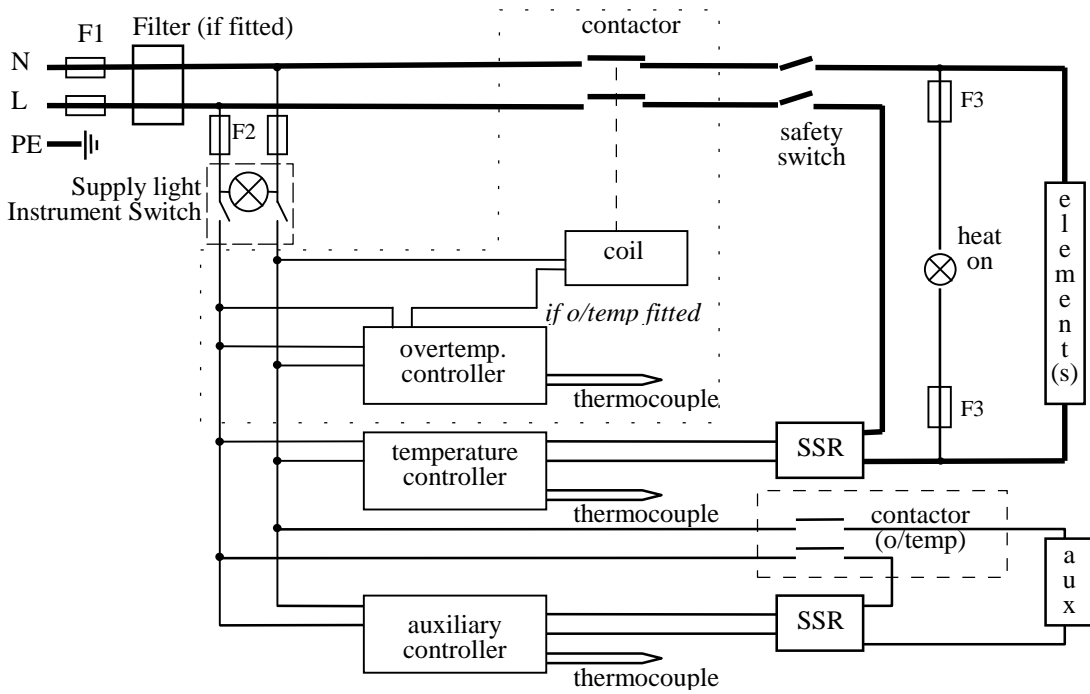
7.1 Single Phase



7.2 1400°C Model with Auxiliary Heater (current models)

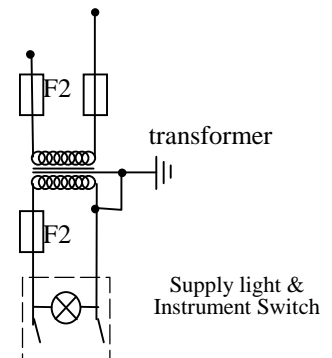


7.3 1400°C Model with Auxiliary Heater (earlier models)



7.4 Higher Voltages

For 254V (or above) an isolating transformer is fitted in the control circuit after the F2 fuses.



8.0 FUSES & POWER SETTINGS

8.1 Fuses

F1-F3: Refer to the circuit diagrams.

| | | | |
|-----------|-------------------------|---|---|
| <i>F1</i> | Internal supply fuses | Fitted if supply cable fitted. Fitted on board to some types of EMC filter. | on-board and up to 16 Amps: 32mm x 6mm type F other: GEC Safeclip |
| <i>F2</i> | Auxiliary circuit fuses | Fitted on board to some types of EMC filter. May be omitted up to 25Amp/phase supply rating. | 2 Amps glass type F On board: 20mm x 5mm Other: 32mm x 6mm |
| <i>F3</i> | Heat Light fuses | May be omitted up to 25 Amp/phase supply rating. | 2 Amps glass type F 32mm x 6mm |
| | Customer fuses | Required if no supply cable fitted. Recommended if cable fitted. | See rating label for amperage; see table below for fuse rating. |

| Model | phases | Volts | Supply Fuse Rating | Volts | Supply Fuse Rating (type) |
|----------------|---------|---------|--------------------|---------|---------------------------|
| CFM 12/1, 12/2 | 1-phase | 220-240 | 5A | 110-120 | 10A |
| CFM 14/1, 14/2 | 1-phase | 220-240 | 15A or 16A | 110-120 | 30A or 32A |
| CFM 14/1 + Aux | 1-phase | 220-240 | 16A | | |
| CFM 14/2 + Aux | 1-phase | 220-240 | 20A | | |
| CFM 14/4 | 1-phase | 220-240 | 20A | 110-120 | 40A |

Note: For technical reasons any internal fuses fitted may have a higher rating than the recommended supply fuses.

8.2 Power Settings

The power limit settings (parameter ΔPH_i) for the 1200°C CFM models are all 100%, with the exception of any units supplied for 254V operation where the limit is 89%.

The power limit settings for the 1400°C models are as follows. The figures represent the maximum percentage of time that controlled power is supplied to the elements. Do not attempt to “improve performance” by setting a value higher than the correct one from the table.

| Model | Volts: | 110V | 120V | 208V | 220V | 230V | 240V | 254V |
|----------|--------|------|------|------|------|------|------|------|
| CFM 14/1 | | 67 | 56 | 89 | 67 | 61 | 56 | 50 |
| CFM 14/2 | | 67 | 56 | 89 | 67 | 61 | 56 | 50 |
| CFM 14/4 | | | | | 100 | 100 | 92 | 82 |

Auxiliary heater models: the power limits for the controllers for the auxiliary heaters have power limits of 100%..

9.0 SPECIFICATIONS

Carbolite reserves the right to change specifications without notice.

9.1 Models Covered by this Manual

| MODEL | Max. Temp. (°C) | Max. Power (kW) | Internal Bore (mm) | Net Weight (kg) |
|---|--------------------|--------------------|-----------------------|--------------------|
| <i>Heated by resistance wire wound on a ceramic former</i> | | | | |
| CFM 12/1 | 1200°C | 1.0 | 1 x 38 | 35 |
| CFM 12/2 | 1200°C | 1.0 | 2 x 38 | 35 |
| <i>Heated by silicon carbide rod elements</i> | | | | |
| CFM 14/1 | 1400°C | 2.8 | 1 x 38 | 35 |
| CFM 14/2 | 1400°C | 2.8 | 2 x 38 | 35 |
| CFM 14/4 | 1400°C | 3.7 | 4 x 38 | |
| <i>The 1400°C models are also available with an auxiliary heater attachment</i> | | | | |

All models are designed to accept 1 or 2 work tubes 25mm internal diameter by 750mm long. The number of tubes is indicated by the model name (--/1 or --/2).

9.2 Environment

The furnaces contain electrical parts and should be stored and used in indoor conditions as follows:

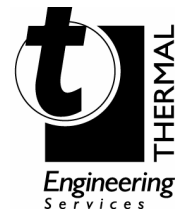
| | |
|--------------------|---|
| temperature: | 5°C - 40°C |
| relative humidity: | maximum 80% up to 31°C decreasing linearly to 50% at 40°C |

The products covered in this manual are only a small part of the wide range of ovens, chamber furnaces and tube furnaces manufactured by Carbolite for laboratory and industrial use. For further details of our standard or custom built products please contact us at the address below, or ask your nearest stockist.

For preventive maintenance, repair and calibration of all Furnace and Oven products, please contact:

Thermal Engineering Services

Telephone: UK: 0845 3308035 Int: +44 1433 623335
Fax: UK: 0845 3308036 Int: +44 1433 623336
Email: service@thermalservice.com



MF10-3.04

18/2/04

CFM

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