THE LINDE GROUP

User manual.

VAPORMATE® portable electric vaporiser.

Contents.

Important notice.

Warning
Failure to adhere to the operating instructions and guidelines described in this manual may result in serious injury.

Caution
Failure to follow the operating instructions described in this manual may result in damage to the equipment.

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1. Overview.

VAPORMATE® has been developed by Linde as a post-harvest fumigant for use by certified applicators. VAPORMATE is a non-ozone depleting fumigant with a favourable toxicological profile for use on general horticulture as well as commodities impacted by stored product pests. VAPORMATE has flammability properties which meet classification criteria as a flammable gas.

1.1 Introduction

In order to penetrate the product being treated, liquid VAPORMATE must be vaporised before being dispensed into a gas-tight fumigation chamber.

The VAPORMATE Portable Electric Vaporiser (PEV) is an electrically heated, oil bath heat exchanger designed to vaporise VAPORMATE in a controlled way in order to deliver a steady flow of product for fumigation of enclosed spaces such as shipping containers, fumigation tents and process equipment.

The vaporiser has been designed to maintain the VAPORMATE outlet temperature above 55 °C. This is the minimum required temperature to vaporise ethyl formate, the active ingredient in VAPORMATE.

It is a standalone portable unit that has a fully integrated control system complete with over-temperature protection and pressure relief devices. The oil bath is a vacuum-insulated, sealed system that incorporates an expansion chamber. The vacuum insulation maintains an ambient surface temperature while the system is operating at full capacity. Typical oil temperature during normal use is ~110 °C. There should be no need, during normal operation, to replace or top up the oil.

Power is provided via two power cords each supplying 240 V/10 amps to the heating elements. This delivers a total heating power of 4800 W.

The system is supplied complete with inlet and outlet assemblies incorporating temperature gauges, pressure gauge, flow control orifice plate, inlet hose and insulated outlet hose.

The system has been designed and manufactured in accordance with the following Australian standards:

- AS 4041 (2006): Pressure Piping
- AS 3100 (1994): Approval & Test Specification General Requirements for Electrical Equipment
- AS 60335.1 (2011): Household & Similar Electrical Appliances General Safety

This equipment has been subjected to a full pressure test as follows:

- Oil chamber: 600 kPa (6 barg/87 psig)
- Internal coil: 25500 kPa (255 barg/3698 psig)

The vaporiser has stainless steel construction throughout with IP66 rated electrical systems for use in outdoor/wet environments.

1.2 Personal protective equipment

All required safety equipment can be sourced through your local supplier.

Contact your Linde representative for more information.

Mandatory

Advisory

Operators of this equipment must use the recommended personal protective equipment.
As a minimum this must include:

- Full face respirator fitted with Type AX organic vapour cartridge (3M 6000 Series).
  - Linde recommends 3M 6000 Series equipment
- Safety goggles (not required if a full face respirator is used)
- Long sleeved, flameproof shirt & trousers or coveralls
- Safety gloves
- Safety shoes/boots

In addition to the items above, Self-Contained Breathing Apparatus (SCBA) is also required if it is necessary to enter a fumigation chamber before it has been fully ventilated or if there is doubt about the fumigant or oxygen levels inside.

VAPORMATE contains 83.3% CO_2 by weight. As such, any treated areas may have reduced oxygen levels. Organic respirators will protect the user against the effects of inhaling the active ingredient (ethyl formate) but will not protect against reduced oxygen atmospheres.

Hearing protection and hi-visibility safety vests should be available to all personnel as a precautionary measure. The use of this equipment may be necessary depending on site-specific requirements where fumigation activities are undertaken.

Fumigation chambers should be treated as confined spaces. Appropriate confined space entry procedures should be followed by any personnel entering the chamber. This includes, but is not limited to, atmosphere monitoring/analysis for oxygen and fumigant levels using approved, calibrated equipment.

The user should ensure that all work areas are operated in accordance with local Safe Systems of Work. These should include a Permit to Work system where deemed appropriate.

1.3 Minimum operating requirements

Appropriate safety equipment/PPE as described in section 1.4.

Equipment must be used in a well-ventilated area with adequate space for safe access/egress.

Power supplies: 2 x 240 V/10 amp supplies (2400 W per supply).

Fumigant: Sufficient VAPORMATE to meet calculated dosing requirements.

- G Size Cylinder – 31 kg
- FE Size Cylinder – 27 kg
- FSE Size Cylinder – 22 kg
- D Size Cylinder – 6 kg

All hoses/interconnecting pipework must be rated for the maximum operating pressure.

Outlet hoses/pipework should be insulated to maintain product temperature and prevent possible injury to personnel.

Outlet hoses and pipework should be kept as short as possible (less than 5m) to prevent unnecessary heat loss between the vaporiser and the fumigation area.

Where outlet pipework length is excessive, it may be necessary to increase the vaporiser operating temperature in order to maintain the required temperature at the fumigation point.

Do not attempt to open the chamber or remove relief valve/oil plug while the equipment is still hot. Allow the equipment to fully cool to ambient temperatures before undertaking any maintenance or inspection work.

1.4 Performance criteria

VAPORMATE supply pressure: 5000–7000 kPa
(depending on ambient conditions)

VAPORMATE inlet temperature: 0–10 °C
(depending on ambient conditions)

VAPORMATE outlet temperature: 80–100 °C

Start-up zime: 7–10 minutes

Flow rate: Approx. 0.5 kg/min

2. Safety considerations.

2.1 Electrical

Power supplies

The vaporiser has two independent 240V power supplies that must be plugged in to separate sockets in order to accommodate the full load of 20 amps. Each power supply has its own indicator light.

The digital controller is connected to power supply no. 1.

The vaporiser requires both supplies to maintain full power and maximum flow rate.

Prior to conducting electrical inspections or maintenance work, ensure that BOTH power supplies have been removed and the indicator lights are off.

Electrical work should be undertaken by a qualified and authorised electrician. Failure to do so will invalidate any warranty.

Ingress protection

All electrics are protected to IP66 for use in wet conditions or outdoor environments where weather may be a factor.

Hazardous atmospheres

The vaporiser has not been designed or certified for use in hazardous or flammable atmospheres.

2.2 Mechanical

Inlet/outlet connections

Prior to use, check that all inlet/outlet connections are correctly assembled, fully tightened and leak free.

All hose and manifold connections should be leak checked using CO_2 or nitrogen.

Leak tests should be carried out at VAPORMATE cylinder pressure (typically 5000 to 7000 kPa). All mechanical joints should be leak checked using a water-based, non-corrosive leak detection fluid.

Linde recommends the use of VFV or Teepol leak detection fluid. Contact your Linde representative for your nearest stockist.

Gauges

The inlet manifold incorporates a temperature gauge with a range of –50 to +50 °C. This indicates the product temperature being supplied from the cylinder and is dependent on ambient conditions and withdrawal rate.

This is not a calibrated gauge and is for indication only.

It may be necessary to manifold multiple cylinders together where a high withdrawal rate is required. This helps to minimise the effect of cooling through the cylinder valve as the product is withdrawn.

Fig. 1: Vaporiser power supplies

Fig 2: Inlet manifold/temperature gauge

Fig 3: Outlet manifold

Fig 4: Oil chamber relief valve

The outlet manifold incorporates a temperature gauge and a pressure gauge.

- The temperature gauge has a range of 0 to 200 °C and indicates the product temperature leaving the chamber. At stable operating conditions this will typically be 20 to 30 °C below the oil bath temperature.
- The pressure gauge has a range of 0 to 10000 kPa and indicates the back pressure in the system due to the flow restrictor (orifice plate) in the outlet manifold.

These are NOT calibrated gauges and are for indication only.

If the pressure gauge reading starts to increase, it may indicate a blockage or closed valve downstream of the outlet hose.

The pressure gauge incorporates a blow-out back to release pressure in the event of a failure.

Relief valves

The vaporiser is fitted with two different relief devices as follows:

- Oil chamber relief valve – 150 kPa
- Oil chamber plug – 200 kPa

The oil chamber relief valve is located on the right hand side of the vaporiser. It is designed to release excess air pressure generated when the heated oil expands and fills the expansion chamber. The relief valve is fitted with a vent line that extends to the base of the vaporiser and vents at low level in a safe area.

Warning

Do not attempt to remove this relief valve while the unit is still hot. During heating, the expanding oil increases pressure inside the chamber. If the relief valve is removed in this condition, hot oil will be ejected from the chamber under pressure which may result in injury.

The oil chamber plug is located at the back of the vaporiser just below the top plate. It is a friction plug retained by a pair of "O" rings and is designed to "relieve" at approximately 200 kPa to release expanding oil in a controlled manner. The plug has a retention cap which prevents it separating from the vaporiser and becoming a projectile.

If any of the relief valves lift or start to vent, the user should evacuate the area. If it is safe to do so, isolate the source of supply (VAPORMATE cylinders). Safety clothing and a suitable respirator should be worn at all times. Please refer to section 1.2.

Fig 5: Oil chamber plug

2.3 Pressure

General

All gas supply systems are under pressure and should be considered as potentially hazardous to operators. Pressures as low as 100 kPa can present a risk to operators who are not wearing the correct safety equipment.

All systems should be isolated and fully vented before attempting to disconnect hoses and/or couplings.

Pressure gauges can fail or give incorrect readings and, as such, do not provide a guarantee that there is no pressure in a system. In particular, small gauges with a large pressure range may appear to read zero when there is still enough pressure contained to present a hazard.

Safety glasses and hearing protection should be worn at all times when handling pressurised systems.

Product supply assembly (cylinder/hose/manifold)

VAPORMATE is a fumigant containing 16.7% ethyl formate (by weight) in liquid CO_2. The product in the cylinder is stored at the vapour pressure of liquid CO_2. Typical cylinder pressure is 5000 to 6000 kPa but will be dependent on ambient conditions and the level of exposure to direct sunlight.

VAPORMATE is supplied to the vaporiser at cylinder pressure with no pressure reduction regulator. When the system is connected, all downstream equipment will be subjected to the full cylinder pressure.

There are no isolation valves between the cylinder and the vaporiser to trap liquid, gas or pressure in the inlet hose and manifold. Pressure can only be retained in the system if there are customer owned/operated isolation valves downstream of the vaporiser.

It is recommended that NO additional valves should be installed between the cylinder and the vaporiser. The only valve which is required is the isolation valve on the cylinder.

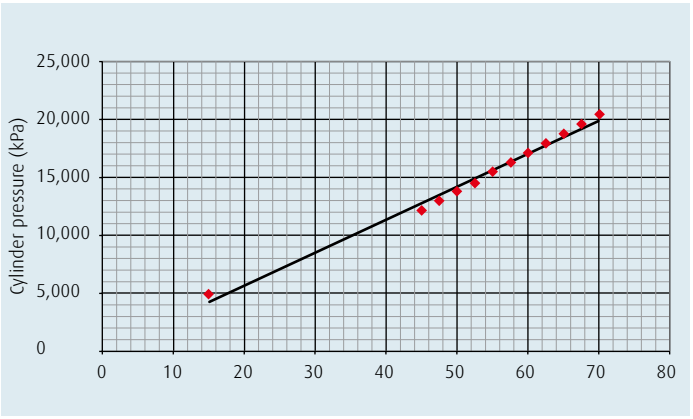


Fig 6: Liquid CO_2 vapour pressure/temperature graph
P (kPa)=2.8526 T(°C)–0.7008, R^2 = 0.9889

Fig. 6 shows the vapour pressure/temperature graph for liquid CO_2. This can be used as a guide to potential cylinder pressure at different ambient conditions.

Outlet manifold/outlet hose

There are no isolation valves between the vaporiser and the customer interface to trap liquid/gas/pressure in the outlet manifold and hose. Pressure can only be retained in the system if there are customer owned/operated isolation valves downstream of the vaporiser.

It is recommended that NO additional valves should be installed between the vaporiser and the fumigation chamber. The only valve which is required is the isolation valve on the cylinder.

2.4 Temperature

Inlet hose & connections

The inlet hose connections may get very cold during use depending on flow rate and ambient temperature. As liquid is withdrawn from the cylinder, it is expanded through the cylinder valve which induces rapid cooling (Joule-Thomson effect). This can lead to very low temperatures and frost forming on the outer surface of the hose.

Appropriate safety gloves should be worn at all times when operating and/or disconnecting the system to protect the user against cold burns. Contact your Linde representative for more information.

Care should be taken when disconnecting the hose as there may still be cold gas or liquid trapped inside which may be released under pressure.

Outlet hose & connections

The outlet hose is fully insulated along its length but will have hot spots at either end where the couplings are fitted. The couplings will get very hot during use and may have a surface temperature in excess of 90 °C.

Appropriate safety gloves should be worn at all times when operating and/or disconnecting the system to protect the user against burns. Contact your Linde representative for more information.

Care should be taken when disconnecting the hose as there may still be hot gas trapped inside which may be released under pressure.

Safety clothing and a suitable respirator should be worn at all times. Please refer to section 1.2. for details of recommended safety equipment.

Fig 7: Insulated outlet hose

Fig 8: Hose end cap/ID plate

Fig 9: Outlet connection/orifice plate position

Vaporiser Body

The vaporiser body is vacuum insulated across most of its surface. The vacuum jacket provides 25 mm of vacuum space between the outer surface and the internal oil bath. Under normal operating conditions the outer surface should remain close to ambient temperature.

The top 50mm of the body (where the outer shell connects to the top plate) is not vacuum insulated. This section is not normally accessed during operation but will have a surface temperature close to that of the oil chamber.

Particular care should be taken when connecting and disconnecting the inlet and outlet manifolds. These may be either very cold or very hot after operation.

Approved safety gloves should be worn at all times when using the system to protect against burns. Contact your Linde representative for more information.

2.5 Manual handling

The vaporiser is a portable device which incorporates lifting handles in the top plate. Due to the weight of the unit (56 kg) it is recommended that a minimum of two people should be available to lift and carry the vaporiser.

Operators should wear protective gloves when carrying/moving the vaporiser.

The vaporiser should be kept upright at all times when in use/storage.

The vaporiser should be kept upright and securely restrained at all times during transport.

Failure to keep the vaporiser upright may result in an oil leak through the oil relief port.

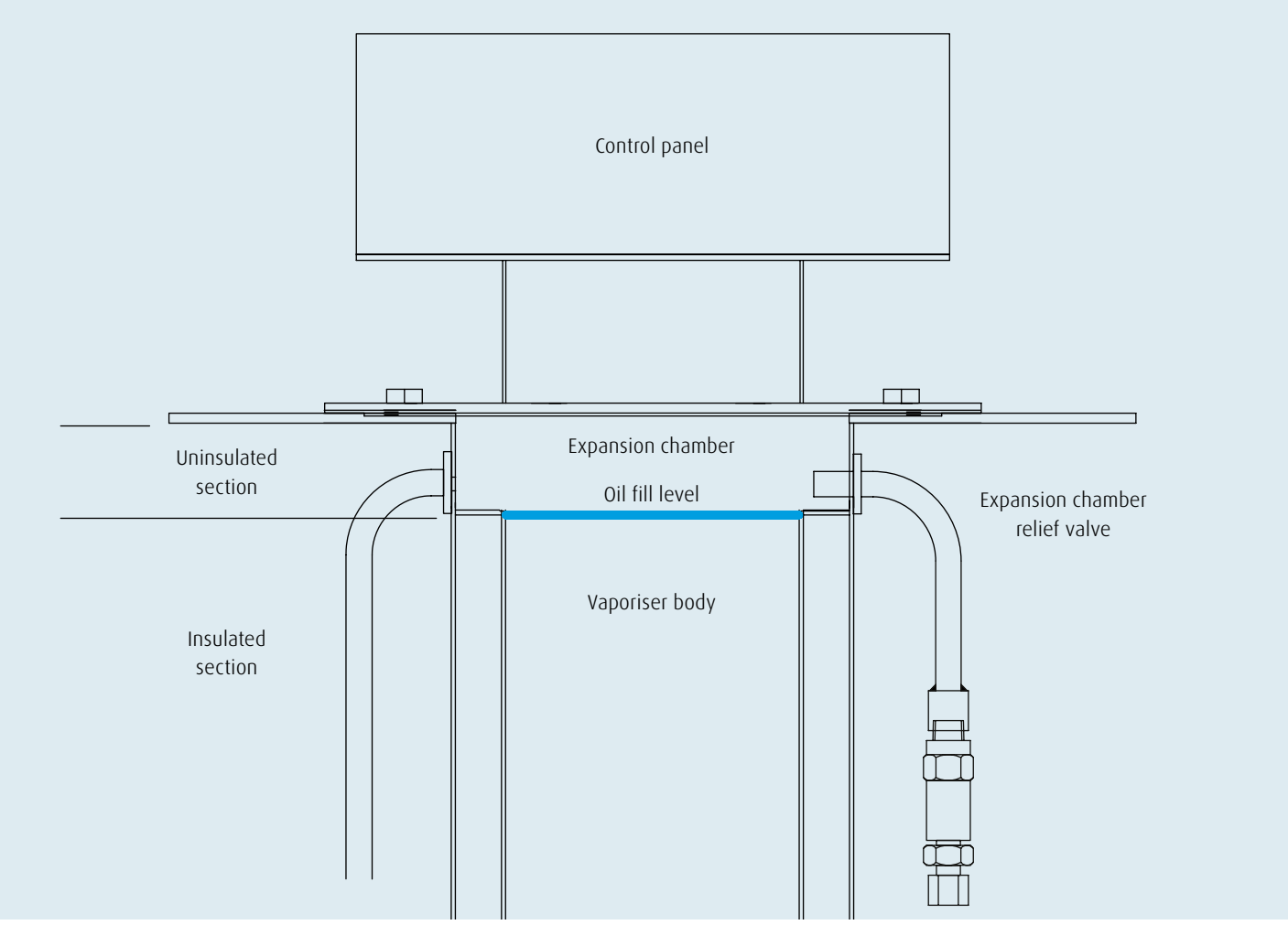


Fig 10: Vacuum insulation diagram

3. Detailed equipment description.

The fully assembled vaporiser comprises the following sub-assemblies:

3.1 Main body assembly

The main body of the vaporiser is a self-contained assembly which houses all of the heating and control components. It is a sealed unit which should only be opened by a Linde technician. The main body assembly comprises:

- Vacuum-insulated oil bath (9.5 litre capacity plus 1.5 litre expansion chamber)
- Pressure relief valve (150 kPa)
- Oil chamber plug (200 kPa)
- Vacuum plug
- Internal 2 stage coil (1/4" inlet 3/8" outlet)
- Heating elements (2 x 2400 W)
- Temperature sensors (1 x control/1 x overload)
- Closing plate/heater mounting assembly

3.2 Inlet manifold

The inlet manifold is a detachable assembly which MUST remain attached to the vaporiser at all times during use and should not be substituted by other components. The manifold comprises:

- VAPORMATE inlet hose (5/32" NB x 2m long/1/4" BSPP(F) connectors)
- 1/4" Swagelok hose connection
- Temperature gauge (–50 °C/+50 °C)

3.3 Outlet manifold

The outlet manifold is a detachable assembly which incorporates outlet instrumentation components. The outlet assembly MUST remain attached to the vaporiser at all times during use and should not be substituted by other components.

The outlet manifold comprises:

- Temperature gauge (0 °C/200 °C)
- Pressure gauge (0–10000 kPa)
- 1/4" Swagelok hose connection
- Orifice plate

This limits the flow rate to approx. 0.5 kg/min to ensure that gas flow does not exceed the vaporiser capacity.

It also helps to limit the off-take rate from the cylinder which minimises the cooling effect of the gas through the cylinder valve.

Insulated outlet hose (1/4" NB x 1.5 m long c/w Swagelok 1/4" connectors)
The hose is foam insulated and protected by an abrasion-resistant sleeve.

The insulation retains heat in the hose and protects operators from potential burn hazards.

Fig 11: Main assembly (front)

1 Control panel 2 Vacuum insulated body 3 Expansion chamber relief valve 4 Gas inlet temperature gauge 5 System pressure gauge 6 Gas outlet temperature gauge
7 Low level relief valve vent line 8 Adjustable feet 9 Base plate

Fig 12: Main assembly (left)

1 Control panel 2 Uninsulated section – hot surface 3 Oil chamber plug 4 Data plate 5 Outlet manifold 6 Vacuum pump port 7 Inlet manifold

Fig 13: Main assembly (right)

1 Control panel 2 Oil chamber plug 3 Outlet manifold 4 Expansion chamber relief valve 5 Vacuum pump port 6 Low level relief valve vent line

3.4 Operator interface panel

The operator interface panel houses the control electrics and temperature overload/safety cut-out circuit. The panel is an IP66 sealed unit which should only be opened by a qualified electrician. The operator interface panel comprises:

1. Power supply cords
2. Power supply indicators
3. Digital controller
4. On/off switch – controller
5. On/off switch – heaters
6. Heating indicator
7. Temperature overload indicator/reset button

Fig 14: Control panel (standby mode)

4. Equipment set-up.

4.1 Vaporiser

The vaporiser is a self-contained unit that is supplied fully assembled excluding the inlet and outlet hoses. The only parts which may need to be removed are the inlet and outlet manifolds. When assembled, these assemblies may be susceptible to damage during transport.

4.2 Inlet manifold

The inlet manifold comprises:
- 1/4" Swagelok hose connection
- Temperature gauge (–50 °C/+50 °C)
- 1/2" Swagelok vaporiser connection

The assembly connects to the main vaporiser body via the 1/2" inlet connection and is supported by a pipe clamp around the body of the manifold.

Ensure that the manifold is securely clamped and the Swagelok connection is tight before attempting to use the vaporiser.

4.3 Outlet manifold

The outlet manifold comprises:
- 1/2" Swagelok vaporiser connection
- Temperature gauge (0 °C/200 °C)
- Pressure gauge (0–10000 kPa)
- 1/4" Swagelok hose connection

The assembly connects to the main vaporiser body via the 1/2" inlet connection and is supported by a pipe clamp around the body of the manifold.

Ensure that the manifold is securely clamped and the Swagelok connection is leak tight before attempting to use the vaporiser.

4.4 Inlet hose

The inlet hose is a 5/32" NB, stainless steel braided high pressure hose that connects the VAPORMATE cylinder directly to the inlet manifold.

There is no regulator required between the cylinder and the hose.

Hose connections:
- Cylinder connection – AS Type 40 Left Hand (5/8" BSP LH/14 TPI)
- Manifold connection – Swagelok 1/4"

iv) The connection with the cylinder is a left hand thread and must be turned in an anti-clockwise direction to tighten.

v) Ensure that all hose connections are leak tight before attempting to use the vaporiser.

4.5 Outlet hose

The outlet hose is an insulated, 1/4" NB, stainless steel braided, high pressure hose. The hose connects the outlet manifold to the customer equipment.

Hose connections:
- Manifold connection – Swagelok 1/4"
- Customer equipment connection – Swagelok 1/4"

Ensure that all hose connections are leak tight before attempting to use the vaporiser.

4.6 VAPORMATE cylinders

VAPORMATE cylinders are connected directly to the inlet hose. One cylinder of VAPORMATE (27 kg) is generally sufficient for most fumigation operations.

For larger operations it may be advisable to manifold multiple cylinders together to ensure a constant flow of product throughout the operation. Please contact your Linde representative for further advice on manifold systems.

VAPORMATE cylinders should be placed on a platform scale in order to monitor dosing by weight.

The cylinder(s) should be adequately restrained by an approved method to prevent them from falling over and potentially causing personal injury or damage to property. Please contact your Linde representative for more information regarding the safe handling of cylinders.

4.7 Leak testing/purging

When the system has been fully assembled, all mechanical connections should be leak tested at normal working pressure (5000–6000 kPa) using an inert gas (pure dry nitrogen).

Test gas should be connected to the system via a suitable regulator to control test pressure accurately.

Inlet/outlet hoses, manifolds and the internal heat exchanger coil have a maximum working pressure of 22000 kPa.

Following successful leak testing, the system may be purged with the test gas to remove any contaminants prior to fumigation.

4.8 Power supplies

The vaporiser is heated by 2 x 2400 W elements (10 amps at 240 V each) and, as such, requires two separate power supplies. The power supplies must be plugged into separate power outlets.

Power boards should not be used as they have a maximum loading of 10–15 amps and plugging both supplies into the same board may cause it to trip out.

The power lights on the main panel light up when the power supplies are connected.

Prior to conducting electrical inspections or maintenance work, ensure that BOTH vaporiser power supplies have been removed and the indicator lights on the operator interface panel are all off.

5. Operation.

5.1 Start-up procedure

Power/Heating
Ensure that both power supplies are connected to independent sockets and that power supply lamps are illuminated on the control panel.

Switch on the digital controller. The LED readout will run through a self-check sequence and then display the current oil bath temperature.

Check operating temperature setting (see section 6.0 for details).

Switch on the heater elements. The rotary switch will light up green and the heating lamp will illuminate to show that the elements are in heat mode.

Monitor the LED readout on the digital controller until the oil bath temperature reaches the set point. In normal operating conditions this should take 7 to 10 minutes.

When the set point is reached, the heaters will switch to standby mode and the heating lamp will go out.

Fig 15: Control panel (heating mode)

Temperature Stabilisation
The temperature on the LED readout will continue to rise due to residual energy in the heater elements. The temperature will peak at ~10 °C above the set point before starting to fall again.

The heaters will switch on when the temperature falls to 0.5 °C below the set point. The temperature will continue to fall until the heaters have reached full power and will bottom out at ~6 °C below the set point.

The oil bath temperature will continue to cycle around the set point by +/–6 °C depending on flow rate and gas inlet temperature.

The vaporiser can be used as soon as the set point is reached. There is no need to wait for complete temperature stabilisation.

5.2 Vaporisation/fumigation

Safety precautions
Ensure the vaporiser has achieved operating temperature and the system is ready to operate.

Check that all necessary downstream valves are open.

Ensure that the space being fumigated (container/chamber/tent) is clear of personnel, air-tight and properly identified and secured against unauthorised access.

Exclusion zones should be identified and marked out using barrier tape.

Exclusion zones should be manned at all times to prevent unauthorised entry.

Hazard warning signs should be posted where necessary.

VAPORMATE supply
Slowly open the VAPORMATE cylinder valve by turning anti-clockwise. The valve may be stiff to turn at first but will free up.

Open the valve fully until the hand wheel stops and then close the valve slightly by about 1/4 of a turn. This ensures that the valve does not stick open during use.

Product will flow through the vaporiser and into the fumigation chamber/customer pipework system.

Flow through the vaporiser is controlled by an orifice plate fitted in the outlet manifold. The plate restricts the flow to approximately 0.5 kg/min. This ensures that flow rate does not exceed the vaporiser capacity and that the product is effectively heated and vaporised.

There is no requirement to add additional valves or flow meters to the system in order to control flow.

Flow rate can be checked/calculated by monitoring the weight of the supply cylinder on a platform scale over time during vaporisation/ fumigation.

The VAPORMATE supply temperature can be monitored via the temperature gauge on the inlet manifold. The temperature will vary depending on ambient conditions and withdrawal rate from the cylinder. Typical inlet temperatures are 4 to 6 °C but can be as low as 0 °C.

The outlet temperature can be monitored via the temperature gauge on the outlet manifold. This will typically be 25°C below the set point. Lower inlet temperatures will result in a lower outlet temperature.

Back pressure in the system during operation can be monitored via the pressure gauge on the outlet manifold. Typically this will be 3200 kPa (464 psi).

When the correct amount of VAPORMATE has been dosed, close the cylinder valve by turning it in a clockwise direction.

After the cylinder valve has been closed, leave the system connected and switched on for a few minutes to allow residual product to disperse.

If there are any downstream valves in the customer system, these should only be closed after product in the vaporiser has been allowed to dissipate. Failure to do so could result in pressure build-up due to the entrapment of expanding gas.

5.3 Shut-down procedure

VAPORMATE supply
- Ensure all residual product has vented from the system.
- Ensure the VAPORMATE cylinder valve is fully closed. (Turn the valve hand wheel clockwise until tight.)

Power/heating
- Switch off the heaters.
- Switch off the digital controller.
- Isolate and unplug the power supplies.

System Purge
During transport, storage and/or long periods of inactivity, there is potential for contaminants to enter hoses and internal pipework of the vaporiser. When used for the first time in these situations, it is recommended that the vaporiser and hoses are purged with nitrogen or CO_2.

Any residual levels of VAPORMATE remaining after use will evaporate and disperse naturally. It is not necessary to purge during normal operation but you may wish to do so if you have any concerns about the product.

Purging Procedure
With inlet/outlet manifolds and hoses connected, the system should be purged with an inert gas (CO_2 or N_2) to remove any traces of VAPORMATE or potential contaminants.

Purge gas should be connected via a suitable regulator to control purge pressure.

Inlet/outlet hoses, manifolds and the internal heat exchanger coil all have a maximum working pressure of 22000 kPa.

Inlet/Outlet Hoses
Vent all gas and isolate system before disconnecting the inlet and outlet hoses.

The VAPORMATE cylinder connection is a left hand thread and must be turned in a clockwise direction to loosen.

Safety Precautions
The inlet manifold and hose may be very cold. Care should be taken when disconnecting the inlet hose and/or manifold.

The outlet manifold will be very hot and will remain hot for some time after the system has been shut down. Care should be taken when disconnecting the outlet hose and/or manifold.

If not vented, the hose may contain some liquid product. This may be pure ethyl formate which has condensed under cooling. Ethyl formate can be irritating to the skin, so chemically resistant gloves should be worn at all times.

If there are isolation valves downstream of the vaporiser there may be some pressure build-up due to trapped liquid/gas which is expanding. Check the pressure gauge on the outlet assembly before attempting to disconnect any hoses or manifolds.

Take care when disconnecting hoses. Connections should be loosened slightly to release any trapped gas. When trapped gas has been released, remove connections completely.

6. Digital controller.

6.1 Introduction

The vaporiser operation is controlled by a digital controller (LAE AC1-5) that is set up to monitor and maintain the temperature within the oil around the pre-determined set point.

The digital controller has been set up to deliver optimum vaporiser performance. As such it should not be necessary to make adjustments to the operating parameters.

The only parameter which may need adjustment is the temperature set point (SP1) which controls the oil bath operating temperature.

If the temperature of the outlet gas is too high for the fumigation process (i.e. possible damage to produce) the operating temperature may be reduced. If in doubt, contact Linde for advice.

The set point can only be adjusted within pre-set limits. SPL is the lower set point limit and SPH is the higher set point limit.

- The lower limit (SPL) has been set at 70°C to ensure that the VAPORMATE is heated above 55°C. This is the vaporisation temperature for ethyl formate.
- The upper limit (SPH) has been set at 130°C to prevent over-heating of the vaporiser and excessive outlet gas temperatures which may damage commodities being fumigated.

The heat transfer oil used in the vaporiser has a flashpoint of 235°C. To prevent ignition, the vaporiser is protected by an overload switch which cuts power to the heaters at 180°C. For this reason it is critical that the maximum temperature limit is not increased from its pre-set value.

6.2 General operation

During normal operation, the display shows the current temperature of the oil bath. (The basic information menu.)

Access Information

To gain access to the information menu press and release the info button 1. Select the data to be displayed using the arrow buttons 2 & 3. Press the info button 1 to display the value. To exit from the menu press the x button 4 or wait for 10 seconds.

Within the information menu, the high temperature (THI) and low temperature (TLO) records can be reset to zero.

Reset THI & TLO values

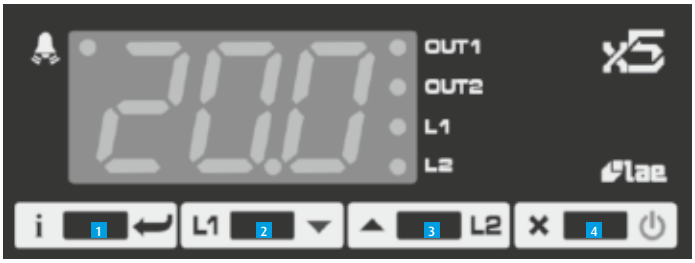
Access the information menu as above. Select THI or TLO using the arrow buttons 2 & 3. Press and hold the info button 1 to view readings. Use the x button 4 button to reset value to zero.

The keypad can be locked to prevent accidental/unauthorised changes to settings.

Lock/Unlock Keypad

Access the information menu as above. Select the keypad lock function (LOC) using the arrow buttons 2 & 3. Press and hold the info button 1. Use the arrow buttons 2 & 3 to select YES or NO. To exit from the menu press the x button 4 or wait for 10 seconds.

Fig 16: Digital controller



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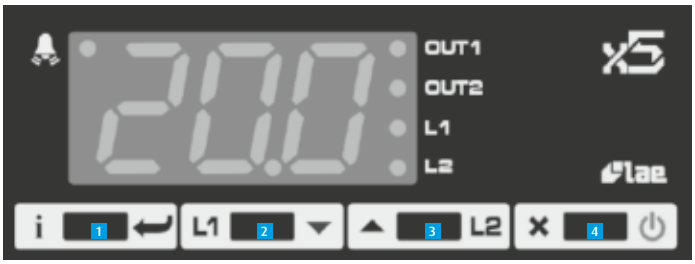


1 Info, 2 Arrow up, 3 Arrow down, 4 X, turn off

6.3 Temperature set point

The temperature set point is the operating temperature for the oil bath. This can be adjusted between pre-set limits to suit the user requirements.

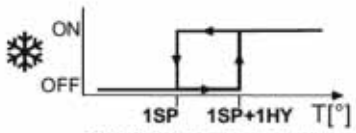
For safety reasons the limits of operation have been set between 70 °C and 130 °C. The lower limits ensure that the VAPORMATE is fully vaporised and the upper limit prevents overheating of the system which could could damage the product.

The gas outlet temperature will typically be 25 °C below the set point.

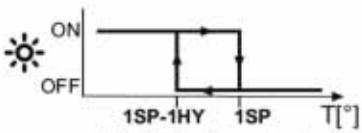
To gain access to the parameter configuration mode, press the x 4 + info 1 buttons together and hold for 5 seconds. When in parameter configuration mode, use arrow buttons 2 & 3 to locate parameter “1SP”. This is the temperature set point parameter. Press and hold the info button 1 to display the current setting. While keeping the info button 1 pressed, use the arrow buttons 2 & 3 to set the desired value. When the info button 1 is released, the newly programmed value is stored. The menu will automatically step forward to the next parameter (1CM). Press the x button 4 to exit configuration mode and return to operating mode. The controller will automatically return to the operating mode if no buttons are pressed for 30 seconds.

6.4 Configuration parameters (Any parameters that show XX in the settings column are not used or required.)

Para		Range	Description	Setting
SCL		1 °C 2 °C °F	Readout scale (see table of input specifications) Caution: Upon changing the SCL value, it is then absolutely necessary to reconfigure the parameters relevant to the absolute and relative temperatures (SPL, SPH, 1SP, 1HY etc.).	2 °C
SPL		–50 °C ... SPH	Minimum limit for 1SP setting. WARNING – do not adjust this setting	70 °C
SPH		SPL ... 150 °C	Minimum limit for 1SP setting. WARNING – do not adjust this setting	130 °C
1SP		SPL ... SPH	Set point (temperature to be maintained in the oil bath) Temperature set point	110°C
1CM		HY/PID	Control mode With 1CM = HY you select hysteresis control mode. Parameters 1HY, 1T0 and 1T1 are used. With 1CM = PID you select 'Proportional Integral Derivative' control mode. Parameters 1PB, 1IT, 1DT, 1AR & 1CT will be used.	HY
1CH		REF/HEA	With 1CH = REF you select refrigerating control mode. With 1CH = HEA you select heating control mode.	HEA
1 CM = HY	1HY	0 ...19.9 °C	OFF/ON thermostat differential. With 1HY = 0 the output is always off.	01
	1T0	0 ... 30 min	Minimum off time After output 1 has been turned off, it remains inactive for 1T0 minutes regardless of the temperature value measured.	00
	1T1	0 ... 30 min	Minimum on time (the following parameter will be IPF) After output 1 has been turned on, it remains active for 1T1 minutes regardless of the temperature value measured.	00
1PF		ON/OFF	Output state in case of probe failure	OFF
OAU			AUX output operation	NON
		NON	NON: Output disabled/always off (The next parameter will be ATM)	
		THR	THR: Output programmed for second thermostat control (The next parameter will be 2SM)	
		AL0	AL0: Contacts open when an alarm condition occurs. (The next parameter will be ATM)	
		AL1	AL1: Contacts close when an alarm condition occurs. (The next parameter will be ATM)	



ON/OFF refrigerating control
(**1CM**=HY, **1CH**=REF)



ON/OFF heating control
(**1CM**=HY, **1CH**=HEA)

Para		Range	Description	Setting
ATM			Alarm threshold management	NON
		NON	NON: All temperature alarms are inhibited. (The next parameter will be SB)	
		ABS	ABS: The values programmed in ALA and AHA represent the real alarm thresholds.	
		REL	REL: The values programmed in ALR and AHR are the alarm differentials referred to as 1SP and 1SP + 1HY.	
ATM = REL	ALR	–12.0 ... 0 °C	Low temperature alarm differential With ALR = 0 the high temperature alarm is excluded.	XX
	AHR	0 ... 12.0 °C	High temperature alarm differential With AHR = 0 the high temperature alarm is excluded.	XX
ATD		0 ... 120 min	Delay before alarm temperature warning	XX
SB		No/Yes	Stand-by button enabling.	NO
INP		0mA/4mA T1/ T2	Sensor input selection (see table of input specifications)	XX
		ST1/ SN4	Available in the models AC1 - 5A, AC1 - 5J & AC1 - 5T only	
OS1		–12.5 ... 12.5 °C	Probe T1 offset	00
TLD		1 ... 30 min	Delay for logging min temperature (TLO) and max temperature (THI)	01
SIM		0 ... 100	Display slowdown	00
ADR		1 ... 255	AC1-5 address for PC communication	01

7. Maintenance.

7.1 General

When in use, the vaporiser is a static piece of equipment which has no moving parts and has minimal maintenance requirements.

The vaporiser is a portable device which may be transported between sites in order to perform fumigation duties. As such, any wear and tear will generally be due to transportation activities and disconnection/ reconnection of inlet/outlet manifolds and hoses.

There is no routine maintenance required by the user other than checking the condition of inlet/outlet connections and checking for leaks before, during and after use.

An annual inspection by Linde is recommended to perform functional tests, check oil level/condition and replace the Viton seal between the main body and the closing plate.

Relief valves and hoses should be replaced at 5-yearly intervals.

There are no user serviceable parts on the vaporiser.

7.2 Maintenance matrix

Interval	Item	Action	By
Each use	Viton seal	Visual inspection oil leaks/air bubbles	User
	Inlet connections	Visual inspection general condition/corrosion/leaks	User
	Outlet connections	Visual inspection general condition/corrosion/leaks	User
	Temperature gauges	Visual inspection general operation/accuracy/leaks	User
	Pressure gauges	Visual inspection general operation/accuracy/leaks	User
	Inlet & outlet manifolds hoses & gauges	Leak check all mechanical connections. Test medium: co_2 or nitrogen. Use approved non-corrosive leak detection fluid (vfv/teepol).	User
Annual	Oil bath	Visual inspection for oil level and/or contamination	Linde
	Viton seal	Replace existing seal with new one before re-assembling closing plate	Linde
	User interface panel	Full functional test	Linde
	Power supplies	Check all electrical connections for security	Linde
5-Yearly	Inlet hose	Portable appliance test/tag	Linde
	Outlet hose	Replace existing	Linde
	Expansion chamber	Replace existing	Linde
	Relief valve	Replace existing (150 kpa)	Linde
	Chamber vacuum	Check vacuum and re-evacuate if required	Linde

8. Troubleshooting guide.

8.1 Vaporiser not heating

Check that both power supplies are plugged in and working.
There should be a green light on the control panel for each power supply.

Check that the digital controller is switched on.
The switch should be turned to the right and the LED readout should be lit.

Check the LED readout on the digital controller.
The LED readout displays the current temperature of the oil bath at all times.

Check the temperature set point.
Please refer to section 6.2 of this manual for detailed instructions.

Check that the heater switch is on.
The switch should be turned to the right and illuminated green.

Check that the amber heating light is on.
The heaters cycle on and off automatically to maintain the set temperature. The amber lights come on during the heat cycle and go off during standby.

Check that the temperature overload safety switch has not tripped out. If the oil bath has exceeded the maximum allowable temperature, the safety cut-out will trip and the red over-temp light will illuminate. Allow the vaporiser to cool down and press the reset button.

If you have checked all of the above and the vaporiser is still not heating, please contact Linde for assistance.

8.2 No gas flow

Check that all VAPORMATE cylinders are full.
Weigh the cylinders and compare with information on the cylinder label. Do not loosen or disconnect any hose connections if you suspect they may be under pressure. If the cylinders contain product but there is no gas flow, contact Linde for further advice.

Check that all VAPORMATE cylinders are connected to the vaporiser.
Check all inlet hose connections.

Check that all VAPORMATE cylinder valves are open.
Turn valve hand wheels anti-clockwise.

Check that any valves downstream of the equipment are open.
Turn valve hand wheels anti-clockwise.

Check system for blockages.
Purge hoses and pipework with nitrogen. Disconnect hoses/manifolds and visually inspect for blockages.

If you have checked all of the above and gas is still not flowing, please contact Linde for assistance.

8.3 Low gas outlet temperature

Check that both power supplies are plugged in and working.
There should be a green light on the control panel for each power supply.

Check that the digital controller is switched on.
The switch should be turned to the right and the LED readout should be lit.

Check the LED readout on the digital controller.
The LED readout displays the current temperature of the oil bath at all times.

Check the temperature set point.
Please refer to section 6.2 of this manual for detailed instructions.

Check that the heater switch is on.
The switch should be turned to the right and illuminated green.

Check that the amber heating light is on.
The heaters cycle on and off automatically to maintain the set temperature.The amber lights come on during the heat cycle and go off during standby.

Check that the temperature overload safety switch has not tripped.
If the oil bath has exceeded the maximum allowable temperature, the safety cut-out will trip and the red over-temp light will illuminate. Allow the vaporiser to cool down and press the reset button.

Check the inlet gas temperature.
If the inlet gas temperature is too low (< −10°C) this will impact the outlet temperature. Gas cools as it is withdrawn from the cylinder and supply temperatures can be affected by ambient conditions. If necessary, manifold several cylinders together to spread the total off-take load and minimise the cooling effect.

If you have checked all of the above and the gas outlet temperature is still low, please contact Linde for assistance.

8.4 High gas outlet temperature

Check the LED readout on the digital controller.
The LED readout displays the current temperature of the oil bath at all times.

Check the temperature set point.
Please refer to section 6.2 of this manual for detailed instructions.

Check that the amber heating light goes out when the set point has been reached.
The heaters cycle on and off automatically to maintain the set temperature. The amber lights come on during the heat cycle and go off during standby.

Check that any valves downstream of the equipment are fully open.
Turn valve hand wheels anti-clockwise. Partially closed valves may restrict the gas flow and lead to a higher than expected heat input from the vaporiser.

Check system for blockages.
Purge hoses and pipework with nitrogen. Disconnect hoses/manifolds and visually inspect for blockages.

If you have checked all of the above and the gas outlet temperature is still high, please contact Linde for assistance.

8.5 Smell of ethyl formate

Ethyl formate has a characteristic rum-like smell that is very noticeable if there are leaks.

Close all VAPORMATE cylinder valves immediately.
Turn all valve hand wheels clockwise until tight.

Vent all excess product from the system to a safe area.

Check all cylinder valves, hoses, manifolds and pipework connections for leaks.
Pressurise the system with an inert gas (nitrogen/CO_2). Test all joints using an approved leak detection fluid. Linde recommends the use of VFV or Teepol leak detection fluid.

Check door seals on fumigation chamber for leaks.
Sniff around the seals using an approved gas monitor. Linde recommends the use of a GFG Microtector II G460 analyser. This device has been tested and approved for use with VAPORMATE and is capable of monitoring both CO_2 and ethyl formate levels simultaneously.

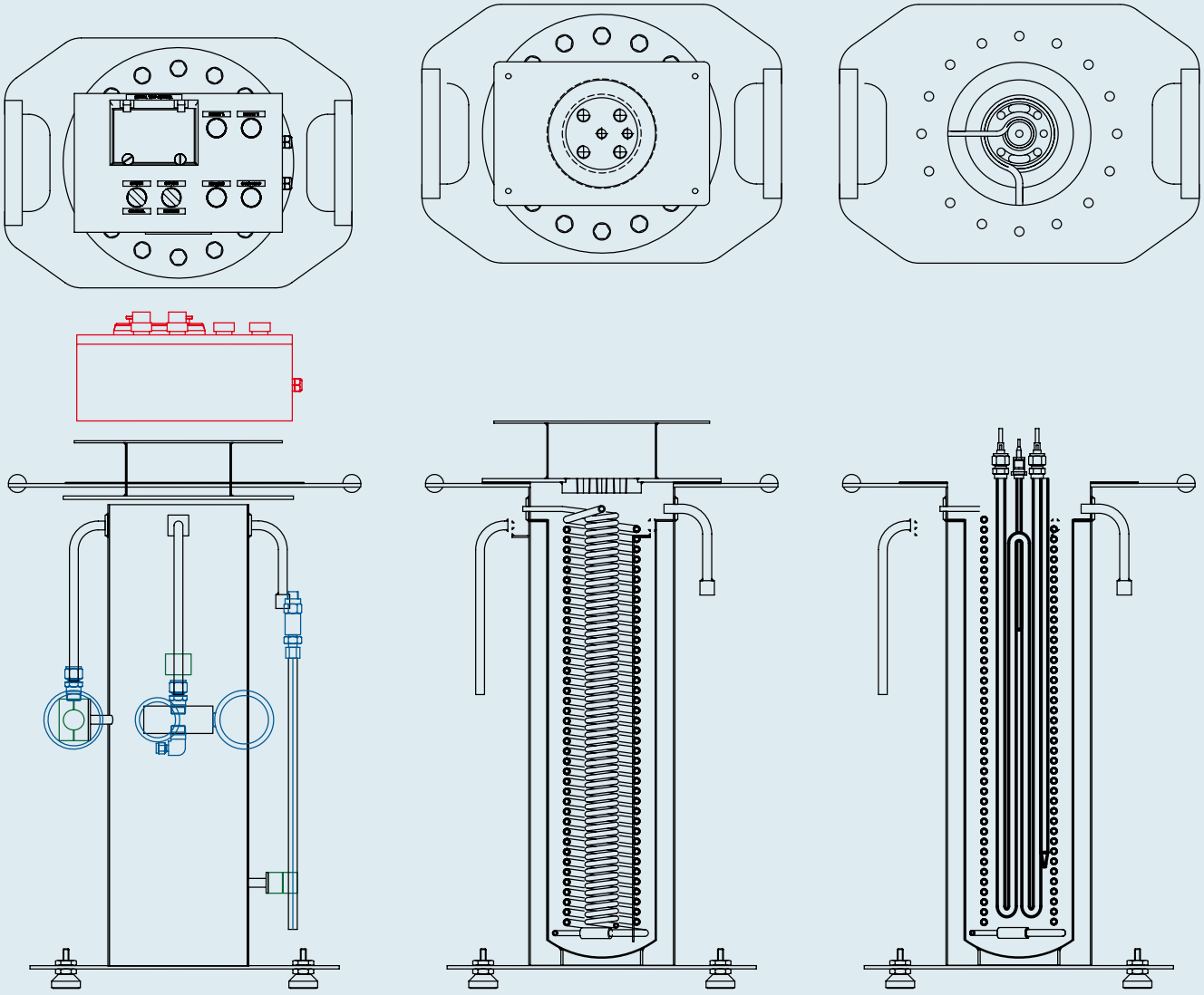
8.6 Vaporiser surface hot

The oil bath is a vacuum-insulated, sealed system. The vacuum insulation maintains an ambient surface temperature while the system is operating at full capacity.

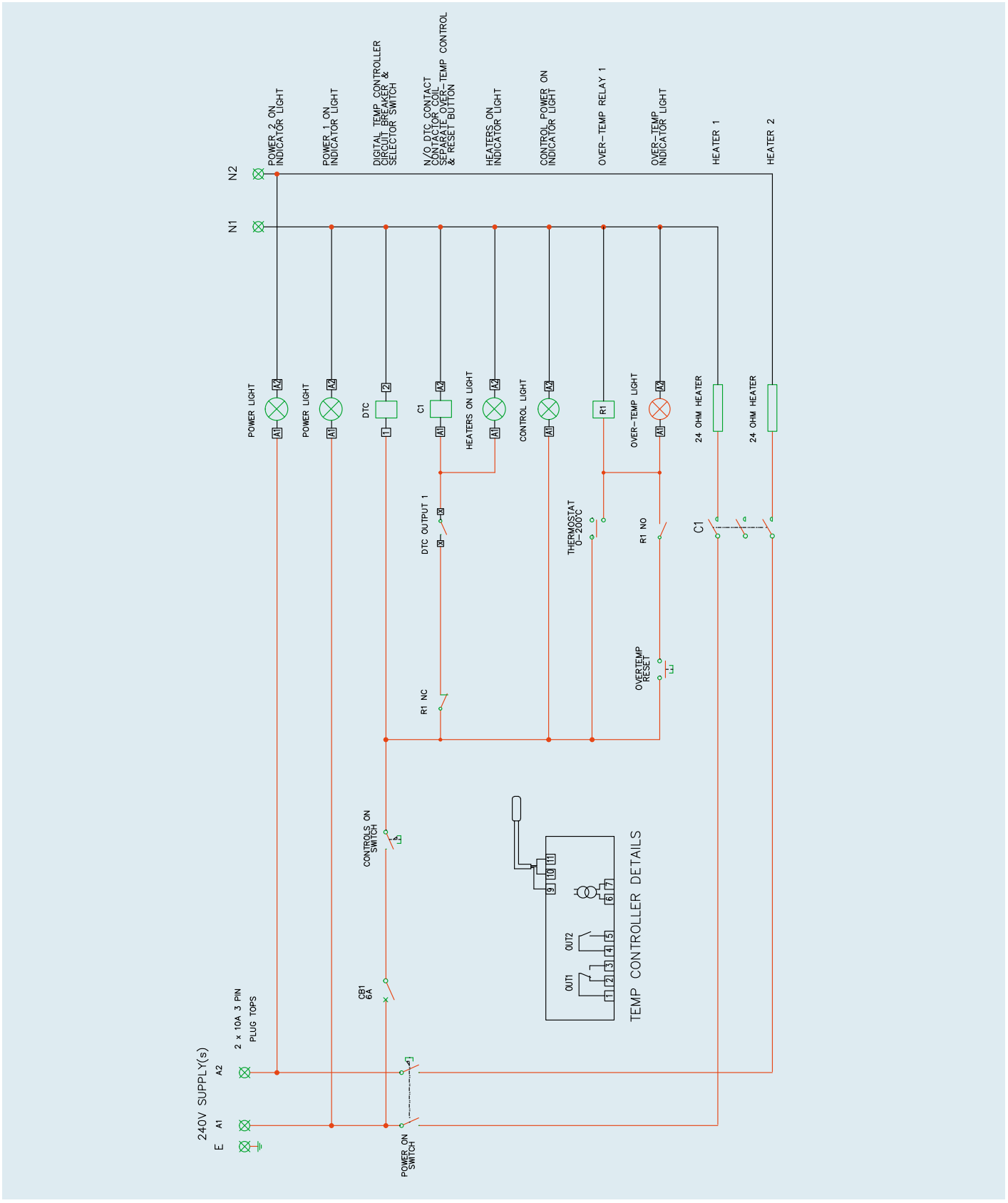
If the surface of the vaporiser is hot to touch this would indicate a poor or failed vacuum. If you suspect the vacuum has failed, please contact Linde for further advice.

9. Drawings.

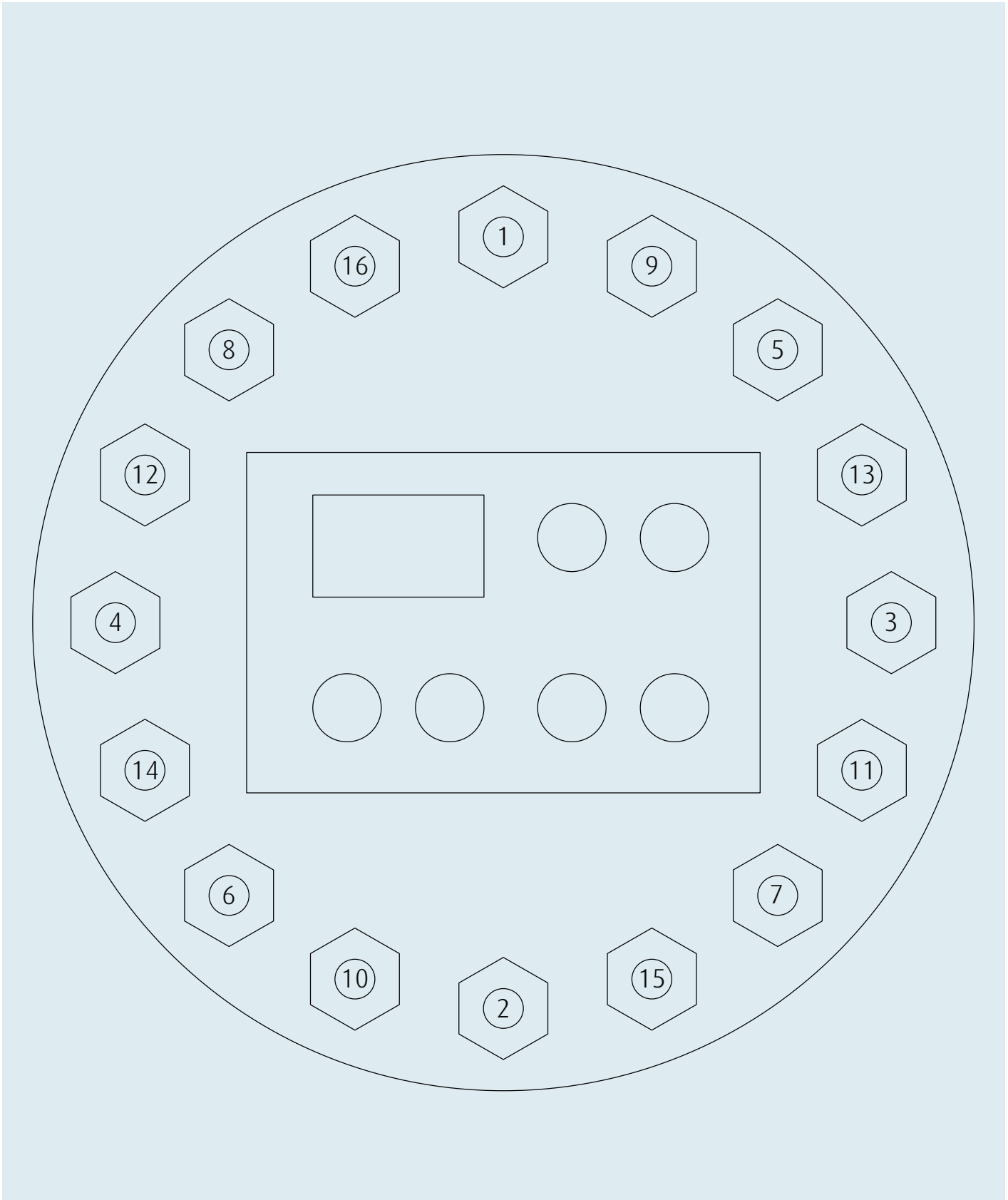
9.1 Mechanical assembly (external & internal)



9.2 Electrical schematic



9.3 Top flange bolt tightening sequence



10. Specification.

10.1 Equipment specification

Oil chamber	Design standard	AS 4041 (2008)
	Water volume	9.50 litres
	Expansion chamber	1.5 litres
	Max. working pressure	500 kPa
	Test pressure	600 kPa
	Design temperature	–50°C/+50°C
Coil	Design standard	AS 4041
	Water volume	0.55 litres
	Max. Working pressure	22000 kPa
	Test pressure	25500 kPa
	Design temperature	–50°C/+150°C
User interface panel	Design standard	AS 3100 (1994)/AS 60335.1 (2011)
	Power supply	2 x 240 V AC
	Current	2 x 10 amps
	Power	2 x 2400 W
	Element power density	21.6 W/in^2
Dimensions	Oil chamber diameter	152 mm OD (6")
	Vacuum jacket diameter	203 mm OD (8")
	Height	950 mm
	Footprint	490 mm x 360 mm
	Weight	55 kg (with oil)

10.2 VAPORMATE specification

	Carbon Dioxide	Ethyl Formate
Molecular weight	44	74.1
Boiling point	–78°C	54°C
Critical temperature	31°C	235°C
Relative density (L)	1.03	0.92
Relative density (V)	1.52	2.6
Vapour pressure	5730 kPa	25.6 kPa
Specific heat capacity	~0.8 J/g°C	~2 J/g°C

The boiling point of VAPORMATE is 54 °C. This is the minimum temperature that needs to be maintained to ensure that the ethyl formate is fully vaporised and the product is delivered as a gas.

11. Product certification and safety sheets.

11.1 Mechanical and electrical certification relating to equipment design, manufacture and testing is supplied separately with the vaporiser.

11.2 Material safety datasheets regarding VAPORMATE are available separately.

For copies of the certification or datasheet please contact your local Linde supplier

Getting ahead through innovation.

With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, it is our task to constantly raise the bar. Traditionally driven by entrepreneurship, we are working steadily on new high-quality products and innovative processes.

Linde offers more. We create added value, clearly discernible competitive advantages and greater profitability. Each concept is tailored specifically to meet our customers' requirements – offering standardised as well as customised solutions. This applies to all industries and all companies regardless of their size.

If you want to keep pace with tomorrow's competition, you need a partner by your side for whom top quality, process optimisation and enhanced productivity are part of daily business. However, we define partnership not merely as being there for you but being with you. After all, joint activities form the core of commercial success.

Linde – ideas become solutions.

For more information about our fumigation solutions and details of current or pending regulatory tests and approvals, visit www.linde-gas.com/fumigants

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