Heat Pump DCT-1
Operation & Maintenance Manual

Dalrada
TECHNOLOGY GROUP

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This Manual Must be Read and Understood before Operating the Carbon Dioxide Heat Pump.

Failure to read this manual completely and understand it may result in serious or fatal injuries and damage to facilities.

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This manual is designed to support the safe and efficient operation of the Carbon Dioxide Heat Pump. It forms an integral part of the machine installation and must be always kept accessible to all operating personnel.

Before performing any tasks involving the equipment, operators are required to read and fully understand the contents of this manual. Strict adherence to all safety instructions and operational guidelines provided herein is essential for ensuring safe and reliable use.

All local and national safety regulations must also be observed without exception.

Note on Illustrations

Illustrations included in this manual are generic and intended to offer a general overview. Actual machine layouts may differ. Such variations do not constitute grounds for warranty claims or other liabilities.

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The information contained in this manual has been prepared in accordance with applicable standards and regulations, and with the expertise of qualified professionals in the field. Every effort has been made to ensure the accuracy and completeness of the content.

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- Improper or unintended use of the machine.
- Unauthorized modifications or alterations to the equipment.
- Use of parts or components not approved by the manufacturer.

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1. Overview

DCT-1 heat pumps are self-contained, modular units in a standard enclosure, equipped with an electrical panel and PLC controls, featuring an HMI operator panel on the front and all process connections located at the rear.

All DCT-1 heat pumps use carbon dioxide as the refrigerant fluid in a closed system.

The heating and cooling loads are connected via secondary heat transfer fluids, usually water or Glycol mix. Irrespective of operating temperatures a Dalrada ONE is not designed to raise steam, and the secondary system must be operated at a suitable pressure to maintain the liquid state.

The DCT-1 M2000 has a capacity of up to 150 kW heating and 105 kw cooling from 45 kW electrical input.

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2. Warranty

Warranty terms are defined in the manufacturer's General Conditions of Business and the specific contract established with the operating company. These documents outline the scope, duration, and limitations of the warranty coverage.

3. Safety

This chapter provides an insight into the critical safety issues to be considered for the protection of personnel and others as well as safe and trouble-free operation of the Heat Pump. Failure to observe the instruction and safety notes of this manual may result in accidents and/or damage to the equipment.

3.1. Improper Use

Warning.

Danger from Improper use.

- Never operate the Heat Pump with different heat transfer fluids, refrigerants and/or lubricants than specified in the manufacturer's specifications and documents (including this manual).
- Never use the Heat Pump to cool or heat combustible or explosive media.
- Never use the Heat Pump to cool or heat food directly.

3.2. Basic Hazards

The following sections show risks common to Heat Pumps and other cooling machinery as determined by Risk Assessment. To minimize health hazards and to avoid dangerous situations, the safety information and instructions in the manufacturer's documentation (including this manual) must be observed.

3.3. Hazards

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3.3.1. Slips, Trips & Falls

Slips, Trips & Falls due to liquid spills and trailing cables or hoses.

Personnel should be aware that there may be trailing cables pipes and hoses in the workplace. Signs should be placed to warn of this hazard. Spillages of oil and other liquids may occur during filling and due to leakages.

- Remove spills immediately and dispose of in an approved manner.
- Personnel should wear anti-slip footwear.
- Warning signs should be placed in an appropriate location to warn of the hazard.

Slips, trips, and falls can result in serious injury.

3.3.2. Fans

Rotating Parts.

Risk of injury from moving or rotating parts.

- During operation, do not reach into or manage the moving fan blades.
- Do not open covers or maintenance hatches during operation.
- Observe the slow-down time. Before opening covers to conduct maintenance, make sure that all parts have stopped moving.
- Ensure that the fan blades are not accessible during operation.
- Before working on moving fan parts, shut down the system and take precautions to prevent accidental start-up. Follow the operating company's lock out-tag out procedures.

Wait until all parts have stopped moving.
Rotating parts within the fan may cause serious injuries.

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3.3.3. Electric Shock

Danger to life from electric power.

- In the event of damage to the insulation of any electrical parts, switch off the power supply immediately and arrange for repairs.
- Never bypass or disable fuses. When changing fuses, observe the correct ratings. Keep moisture away from live parts. Moisture may result in a short circuit and/or injury or death.
- Before conducting any work on the electrical system and before any maintenance, cleaning, or repair work, ensure that the electrical system is completely disconnected from the power supply, take steps to prevent it being switched on again. Use LOTO to prevent accidental reactivation.

Contact with live parts poses an immediate danger to life due to electrocution. Damage to insulation or individual components may be life-threatening.

3.3.4. Chemical Substances

Chemical Substances.

Refrigerant gases: CO2 R744
Warning: Risk of Suffocation and Frostbite

Carbon dioxide (CO2) presents serious hazards that are often underestimated. While CO2 is classified as non-toxic and non-flammable in safety data sheets, this does not mean it is harmless. A CO2 leak can be life-threatening.

Risk of Suffocation: At high concentrations, CO2 displaces oxygen in the air, creating a significant risk of asphyxiation—particularly in enclosed or poorly ventilated areas. This can occur without warning and may be fatal.

Risk of Severe Frostbite: Contact with liquefied or solid CO2 can cause severe frostbite injuries to skin or eyes due to its extremely low temperatures.

Important: Never assume CO2 is safe simply because it is labeled non-toxic. Always follow safety procedures, wear appropriate PPE, and ensure proper ventilation and leak detection systems are in place.

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As CO2 levels increase above 2% in air, you may feel drowsy, at 3% the gas has a narcotic effect, blood pressure rises & hearing may become impaired. When levels reach 5% difficulties in breathing will be experienced & as CO2 levels rise above 5% unconsciousness will occur.

This is particularly of concern to plant operators & service personnel who may be changing oil, overhauling compressors at low level, whereby unconsciousness arises without any forewarning apart from a feeling of drowsiness.

- The location of the heat pump should be of sufficient size to provide adequate air flow and should comply with the detailed requirements given in section 8 of this manual.
- In some circumstances a CO2 detector is required to be installed with an alarm external to the space, see section 8.
- Never attempt to force open the cooling circuit. Only personnel trained in the use of CO2 should work on the cooling system.
- Wear safety gloves and safety goggles with side protection during work or other activities in the vicinity of the system.
- Avoid damaging the piping.
- Avoid skin and eye contact.

In case of a leak:

- Provide sufficient ventilation with fresh air.
- Consult with the manufacturer's service staff and arrange for proper disposal.
- Follow the instructions on personal protective equipment and clothing as specified in the fluid manufacturer's Material Safety Data Sheet (MSDS).
- Leaking liquid or gas in high concentration may cause unconsciousness or inability to move and can lead to suffocation.
- Avoid skin contact with the compressor oil. It is not corrosive but can cause skin irritation. Check the MSDS sheet. Any leaking CO2 gas WILL have oil in it.

3.3.5. Manual Handling

Operators should not attempt to lift or carry any component which is heavier than they can manage. Always ask for assistance or use mechanical means.

3.3.6. Liquid Under High Pressure

Accidental escape of Hydraulic fluid as JET.

Risk of serious injury or loss of life from liquid jets existing under high pressure.

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- Keep people away from the danger zone. In the event of accidental contact with the liquid jet, administer first aid and seek medical attention immediately.
- Immediately initiate an EMERGENCY STOP. If necessary, take further steps to reduce the pressure and halt the liquid jet.
- Prevent the Heat Pump from starting up. Follow the operating company's lockout-tag out procedures.
- Remove any spilled liquid in a suitable manner and dispose of appropriately.
- Repair defective components before resuming operation of the Heat Pump.
- Never let body parts or objects come in contact with the liquid jet.

3.3.7. Pressure Vessels

DANGER Pressure Vessels.

Do not tamper with pressure relief valves.

- Only conduct work on systems with a pressure vessel after the pressure has been completely relieved and depressurization has been verified.
- Keep heat sources away from pressure vessels.
- Prevent the Heat Pump from starting up. Follow the operating company's lockout-tag out procedures.

Contact with live parts poses an immediate danger to life due to electrocution. Damage to insulation or individual components may be life-threatening.

3.3.8. Gases Under High Pressure

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Pressurized Components.

Before starting work on these components, observe the following:

- Defective components exposed to pressure during operation must be replaced immediately by an appropriate specialist. If improperly managed, pressurized components may move in an uncontrolled manner, causing severe injury or death.

If pressurized components are improperly managed or defective, liquid may exit under high pressure, causing severe injury or death.

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3.3.9. Hot & Cold Burns

Hot & Cold Temperature.

Risk of injury due to hot and cold surfaces.

- When working, always wear temperature protective work clothing and thermal safety gloves.
- Insulate all flanges and pipes to avoid injuries and thermal loss.
- Before conducting any work, make sure that the surfaces have reached an ambient temperature.
- Flange and piping surfaces may heat up or cool down substantially during operation.
- Skin contact with hot surfaces can cause severe skin burns.
- Skin contact with cold surfaces can cause severe frostbite.

3.3.10. Fire

Fire Extinguisher.

Risk of injury due to insufficient or improper fire-fighting equipment and lack of training in its use.

- Ensure that fire extinguishers are available that are suited to the fire class in question.
- Ensure that extinguishers are functional and certified.
- Refill fire extinguishers after each activation.
- Always use qualified fire extinguisher service personnel. In the event of use, follow the safety and operating instructions provided on the extinguisher.

In the event of fire, if the fire extinguisher is not operational, or is not suited to the specific fire class, serious injuries, or death, in addition to significant property damage may result.

Flammable Component:

- Plastic insulation of electric cables.
- Other plastic components.
- Other flammable components may be present in the Heat Pump.
- Compressor oil.

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3.3.11 Oil

- A gas or oil leak while the system is idle can be hazardous to personnel. Appropriate PPE must be worn at all times when working around the system.
- A gas leak while running will also result in either very cold gas/oil mixture or a very hot oil/gas mixture.
- A leak in the oiler system may result in high pressure oil shooting out.

3.4. Personnel Requirements

3.4.1. Trained Personnel

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Electrical or mechanical maintenance should be performed by trained technicians as required by local law.

Risk of injury if personnel are not qualified for the task in hand.

- If unqualified personnel perform work on the system or are in the system's danger zone, hazards may arise which can cause serious injuries and substantial property damage.
- The following is advice for the minimum qualification of personnel in distinct functions.
- It is the operating company's responsibility to ensure the adequacy of personnel qualifications for all tasks performed with and/or on the Heat Pump.
- Therefore, all work must only be conducted by appropriately qualified personnel.
- Unqualified personnel must be kept away from danger zones.

General Personnel Qualification

- Only personnel who are qualified, competent, and capable of performing their tasks safely and reliably shall operate the equipment. Individuals under the influence of alcohol, drugs, or medication that may impair judgment or reaction time are strictly prohibited from operating or interacting with the equipment.
- All operating personnel must be able to understand the language in which this manual is written to ensure safe and correct use of the equipment.

Electrical Specialist

- The electrical specialist must be certified in accordance with all applicable national, state, and local requirements.

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- Additionally, the specialist must be specifically trained for the work environment in which they are assigned and must have thorough knowledge of applicable standards, procedures, and safety practices.
- The electrical specialist is also well-versed in accident prevention regulations and requirements to ensure safe and compliant operation at all times.

Refrigeration Specialist

- A refrigeration specialist is a qualified individual who, through appropriate training, knowledge, and experience as well as familiarity with applicable regulations, is authorized to work on refrigeration systems and identify and avoid potential hazards.
- The refrigeration specialist must be certified in accordance with all relevant national, state, and local requirements.
- They must also be knowledgeable in emission prevention, and the proper operation of industrial refrigeration equipment.
- In addition, the refrigeration specialist must be specifically trained for the work environment in which they are employed and be familiar with all applicable standards, procedures, and safety protocols.
- They must also be well-versed in accident prevention regulations to ensure the safe and compliant handling of refrigeration systems.

Trained Person

A trained person has been trained by the operating company to understand his/her task and has been familiarized with potential dangers and their avoidance.

Trained Specialist

A trained specialist, due to his/her training, knowledge, experience as well as familiarity with applicable rules and regulations, can perform the required tasks and to recognize and avoid potential dangers.

3.4.2. Unauthorized Persons

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Unauthorized Personnel.

Risk to life for unauthorized persons due to hazards in danger and working zones.

- Unauthorized persons must be kept away from the danger and working zone.
- If in doubt, address the persons in question and ask them to leave the danger and work zone.

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- Cease work while unauthorized persons are in the danger and working zone.

Unauthorized persons who do not meet the requirements described herein will not be familiar with the dangers in the work zone. Therefore, unauthorized persons face the risk of serious or fatal injury.

3.4.3. Training

Personnel must be trained regularly by the operating company and training records should be kept.

The following table shows the format of a typical training record.

Date	*Trainer's Name*	*Training Topic*	*Trainee's Name*	*Signature*

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3.5. Personal Protective Equipment (PPE)

Personal protective equipment (PPE) is essential for safeguarding personnel from hazards that may pose risks to health and life during operation, maintenance, or service work.

The specific PPE required for each task is indicated in the relevant chapters of this manual. In addition, the operating company may enforce further PPE requirements based on internal safety policies, job-specific risks, or regulatory obligations.

Personnel must always comply with posted safety signage in the work area, which indicates mandatory protective equipment.

(Personal Protective Equipment) PPE may include:

- Safety helmets
- Protective eye wear or face shields
- Hearing protection
- Insulated or cut-resistant gloves
- Protective footwear
- Flame-retardant or chemical-resistant clothing
- Respiratory protection (when applicable)

All PPE must be properly maintained, fit for use, and worn as intended to ensure effective protection.

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Chemical resistant Protective Gloves.

Chemical-resistant protective gloves are intended to protect your hands from cold, heat, abrasion and toxic chemicals.

.

Protective Clothing.

Protective clothing fits tightly and tears easily. Sleeves are tight and the clothing has no loose parts. The protective clothing primarily protects from moving parts.

.

Safety Goggles.

Safety goggles are intended to protect your eyes from flying components and splashes of liquid.

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3.6. Sign and Symbols

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Illegible Sign.

Risk of injury due to damage and/or illegible signs.

Over time, stickers and sign plates can get dirty or otherwise become illegible.

This can lead to a warning and/or important operating instructions, being missed potentially causing a dangerous situation.

- Keep all safety, warning- and operation-related signs in a good legible condition.
- Replace damaged stickers and sign plates immediately.

Pictograms and signs located on optional components are not listed. Please consult the operating instructions of the manufacturer.

The following signs and symbols are used in the work area of the Heat Pump.

They apply specifically to the particular location where they are placed:

3.6.1. Mandatory Signs

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Observe the Operating Instruction.

Do not operate the Heat Pump before reading and understanding the operating instructions.

3.6.2. Warning Signs

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WARNING High Voltage.

In a work area with this sign, only electric specialists may work. Unauthorized persons may not be present in this area and may not open covers and/or doors with that designation.

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WARNING Cold Surface.

Warning of dangerously cold surfaces. Specific danger of severe frostbite is present for hands, feet, and eyes. Wear appropriate protective gear.

WARNING Hot Surface.

Warning of dangerously hot surfaces. Specific danger of severe burns is present for hands, feet, and eyes. Wear appropriate protective gear.

3.6.3. Safety Signs

WARNING Arc Flash and Shock Hazard.

Danger of severe injury or death due to electric shock.

Follow requirements in HSG85** for safe work practices and appropriate PPE. Failure to comply can result in death or injury.

WARNING Electric Shock.

Danger of severe injury or death due to electric shock.

Make sure that all electric sources are disconnected and locked out. Wear appropriate protective gear.

3.7. Safety Device

WARNING Do Not Operate.

Danger to life from non-functional safety devices.

- Check that all safety devices are fully functional and correctly installed before starting work.
- Never disable or bypass safety devices.
- Ensure that all safety devices are always accessible.

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If safety devices are not functioning or are disabled, there is a danger of serious injury or death.

3.7. 1. Location of Safety Devices

The following show the locations of emergency stop and electrical Isolator on the Heat Pump:

The heat pump contains 5 pressure relief valves, 3 on the CO2 circuit, 1 on the hot water, and 1 on the cold-water circuit. These are located withing the process equipment section of the machine. Refer to the P&ID for further information.

3.7.2. Description of Safety Devices Installed

Uncontrolled Power Up.

Danger to life from uncontrolled power-up of the Heat Pump.

- After the emergency stop has been activated, the reason for the activation must be eliminated before the Heat Pump is powered up again.

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All safety devices must be in place and functioning.

- Unlock the emergency stop only when danger no longer exists.

3.7.2.1. Emergency Stop

- Uncontrolled power up of the Heat Pump may result in serious injury or death. By pushing the emergency stop, the VFD and Compressor are powered down immediately.
- The PLC/HMI and low voltage circuits after 10 seconds.
- The emergency stop must be unlocked by turning it before the Heat Pump can be powered up again.

3.7.2.2. Electric Isolator

When the service panel isolator is in the 'ON 'position, the panel cannot be opened. When the power is switched off a padlock may be applied to prevent power from being switched back on by accident. However, once the door is opened, the power can be manually switched on for maintenance procedures. Prior to this taking place, an electrical Permit to Work must be obtained from the person in charge and all personnel must have signed off on the relevant risk assessments.

3.7.2.3. Pressure Relief

- The pressure relief valves will release excess pressure from the system in the event the system over pressurizes. The pressure reliefs are the last line of Defense for over pressurization. The DCT-1 is designed to provide warnings and shut down before the system reaches the pressure relief settings.
- The enclosure side panels should be kept in place during operation to prevent injury from vented gas/liquid should a relief valve operate.
- The valve must not be tampered with under any circumstances.

3.8. Secure the Heat Pump Against Power-Up

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DANGER to life due to unauthorized power-up.

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- While the Heat Pump is undergoing maintenance work, the machine should be secured against accidental power-up, using the company's lockout policy and procedures.
- The lockout should be kept in place until all parties are satisfied that it is safe to apply power.
- Before power-up, ensure that all safety devices are in place and functioning.
- All personnel should stand at a safe distance before power is applied. Sounds a bit dramatic and unnecessary, remove.
- Always follow the lockout/power-up steps below.

Unauthorized or mismanaged power up of the Heat Pump could result in serious injury or fatality.

Always follow the lockout/power-up steps below:

1. Inform the person responsible for the Heat Pump of the work to be carried out.
2. Turn the machine control switch to "OFF".
3. Disconnect the main power using the isolation switch at front of machine.
4. Follow the lockout/tagout procedure to secure against power-up and file record of procedure using appropriate form.
5. On completion of task, inform responsible person. Ensure that the area is clear of personnel.
6. Ensure that all safety devices are in place and functioning.
7. Complete the record of lockout procedure prior to removing lockout/tagout.
8. Power-up, if safe to do so.

3.9. Environmental Protection

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Environmental Hazard.

Notice Environmental Hazards due to the improper handling of substances harmful to the environment.

- Follow the advice in the following sections when handling and/or disposing of environmentally hazardous substances.
- If environmentally hazardous substances are released accidentally, take immediate and appropriate actions to minimize the impact to the environment. If in doubt, or if required by law, contact the local authority for advice and instructions.

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3.10. Responsibilities of the Operating Company

Operating Company.

The operating company (the company responsible for operation of the Heat Pump) uses the Heat Pump in a commercial environment and carries all liability for protection of personnel and third parties.

Responsibilities of the Operating Company.

The Heat Pump is used in a commercial environment. The operating company therefore is legally responsible for the protection and safety of employees and others affected by this operation.

In addition to the safety advice and instructions in the manufacturer's documentation (including this manual), federal, state, and local safety and environmental requirements must be followed.

In particular, the following need to be observed:

- The operating company must familiarize itself with all legal requirements regarding workers' and environmental protection. They must perform risk and hazard analyses for the specific location and operation of the Heat Pump. Work Instructions and procedures must address any concerns raised by this analysis.
- The operating company must install additional filters and strainers if they cannot guarantee the purity of the heat transfer fluid.
- The operating company must inform their personnel of any hazardous properties of the refrigerants coolants and lubricants used.
- During the entire life cycle of the Heat Pump, the operating company must make sure that all procedures and work instructions meet all legal requirements and are kept up to date.
- The operating company must clearly define responsibilities for installation, operation, maintenance, repair, and cleaning of the Heat Pump.
- The operating company must ensure that all personnel working with and/or on the Heat Pump have read and understood this manual. In addition, the personnel must be trained and informed about inherent and potential hazards at regular intervals.
- The operating company must provide the required personal protective equipment (PPE) and must enforce its use.
- In addition, the operating company is responsible for ensuring that the Heat Pump is fully functional and safe to use.
- The operating company must ensure that maintenance intervals, as specified by the manufacturer, are complied with.
- The operating company must make sure that all safety devices are checked regularly for completeness and function.

The foregoing shall not be considered an exhaustive list of responsibilities of the operating company, and the operating company shall observe all other responsibilities applicable by operation of law, the other transaction documents, and industry standards.

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4. Technical Data

The unit is suitable For Outdoor Use and can only installed in a location not accessible to the general public.

4.1. Capacity Range

The DCT-1 M2002 series heat pump covers a heating capacity range from 70 kW to 150kW depending on demand.

The cooling capacity range is 50kW to 105kW.

4.2. Operating Limits

The heat pump may be operated only within the Operating Limits.

Operation Limits Table			
Parameter	**Units**	**Min.**	**Max.**
Hot Water Temperature - Outlet	°F (c)	-	185 (85)
Hot Water Temperature - Inlet	°F (c)	-	104 (40)
Cold Water Temperature - Outlet	°F (c)	23 (-5)	104 (40)
Cold Water Temperature - Inlet	°F (c)	32 (0)	104 (40)
Hot Water Operating Pressure	Psig (bar)	14.5 (1)	72.5 (5)
Cold Water Operating Pressure	Psig (bar)	14.5 (1)	72.5 (5)
Hot Water Flow rate	gpm (lpm)	4 (15)	-
Cold Water Flow rate	Gpm (lpm)	21 (80)	-
Hot Water Max Pressure Drop	Psig (bar)	-	29 (2)
Cold Water Max Pressure Drop	Psig (bar)	-	29 (2)

[1 bar = 100kPa]

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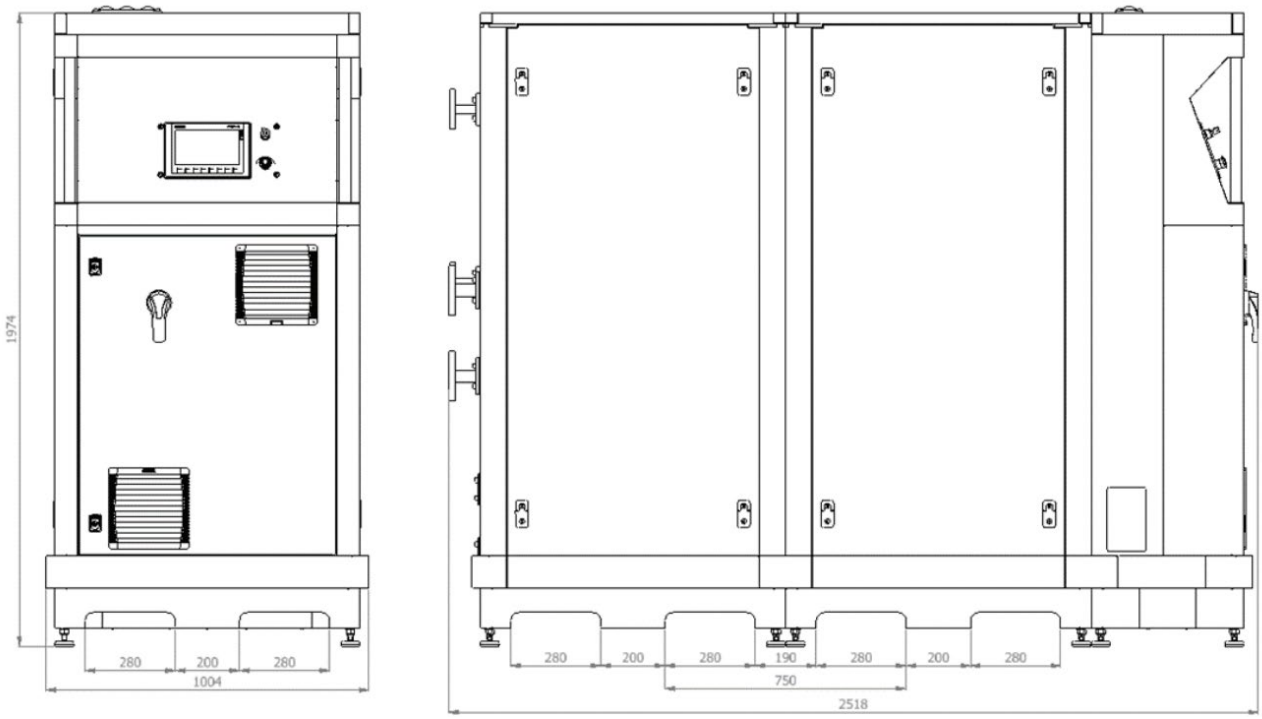
4.3. Dimensions, Weights & Lifting

4.3.1 Dimensions

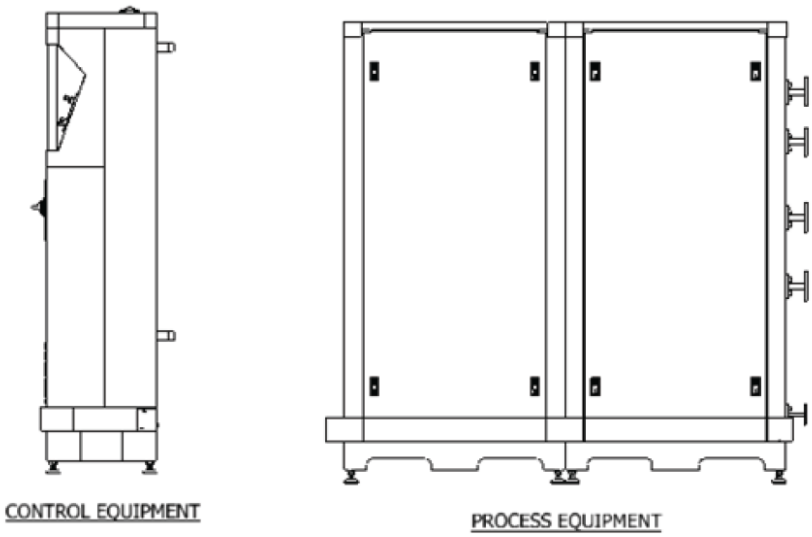
The DCT-1 Dimension when fully assembled are as follows:



4.3.2. Weights

The unit can be split into two main sections - the control equipment and the process equipment.

- Control Equipment weight: 220 kg /485 Lbs
- Process equipment weigh: 1250kg / 2755 Lbs
- Complete Machine weight: 1490 / 3284 Lbs



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4.3.3. Lifting

Important:

The complete assembled DCT-1 cannot be lifted without the control equipment being separated from the process equipment. The only exception to the above is if the assembled unit is on a dedicated lifting platform.

Important:

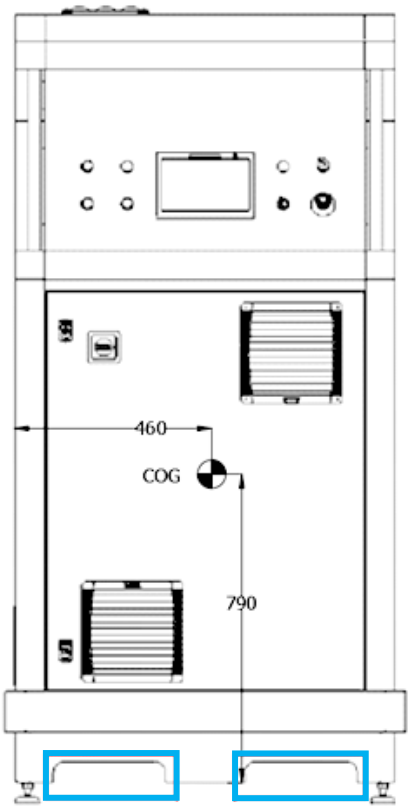
The control and process equipment are not to be lifted by any means from the roof or any other part of their structure other than the dedicated lifting points shown below.

Important:

The personnel undertaking any lifting operation must create their own lifting plan and risk assessment for the lifts they undertake. The information below only demonstrates the methods the equipment can be lifted by without damaging it. If a lifting operation is undertaken in a method not described below, the equipment warranty will be voided.

Control Equipment Lifting points

The control equipment has two dedicated lifting pockets in its base. These can be utilized by a forklift or can be used for lifting beams.



Dedicated Lifting Pockets

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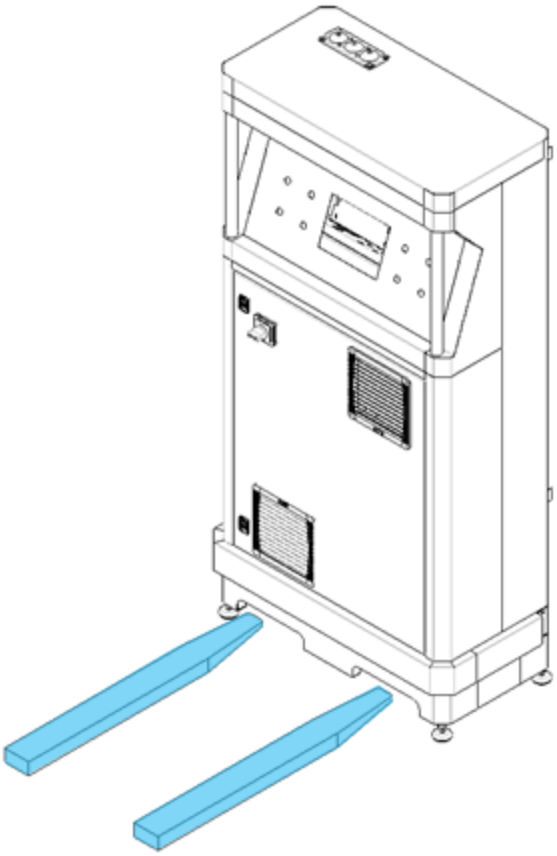
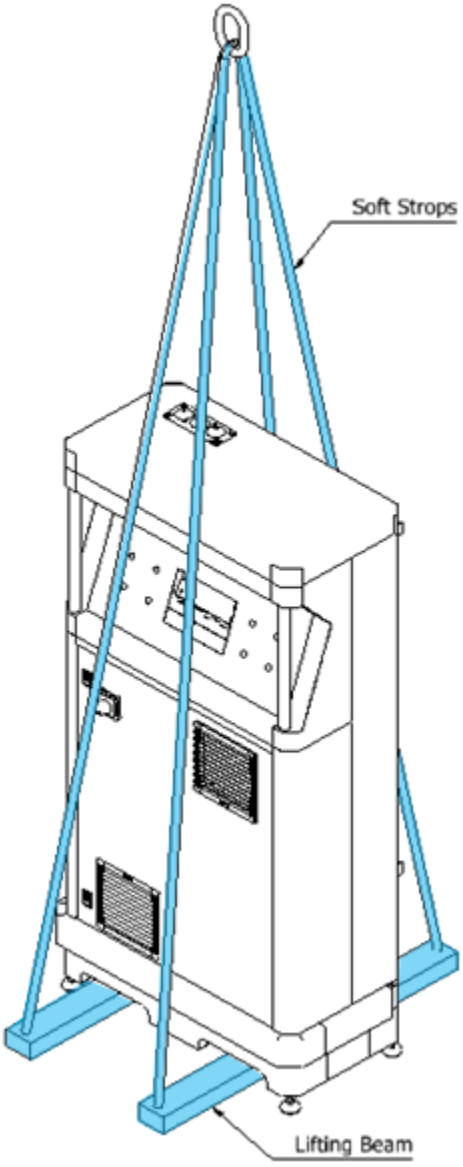
Methods of lifting control equipment.

The control equipment has two dedicated lifting pockets in its base. These can be utilized by a forklift or can be used for lifting beams.

As shown in the diagram at the side the forklift utilizes the dedicated lifting pockets for its forks.





As shown in the diagram to the side when lifting with a crane. Lifting beams and soft strops are to be used. It is the responsibility of personal conducting the lift to ensure the load is stable and the strops do not cause any crushing.

Process Equipment Lifting points.

The Process equipment has four dedicated lifting pockets in its base. These can be utilized by a forklift or by a crane.

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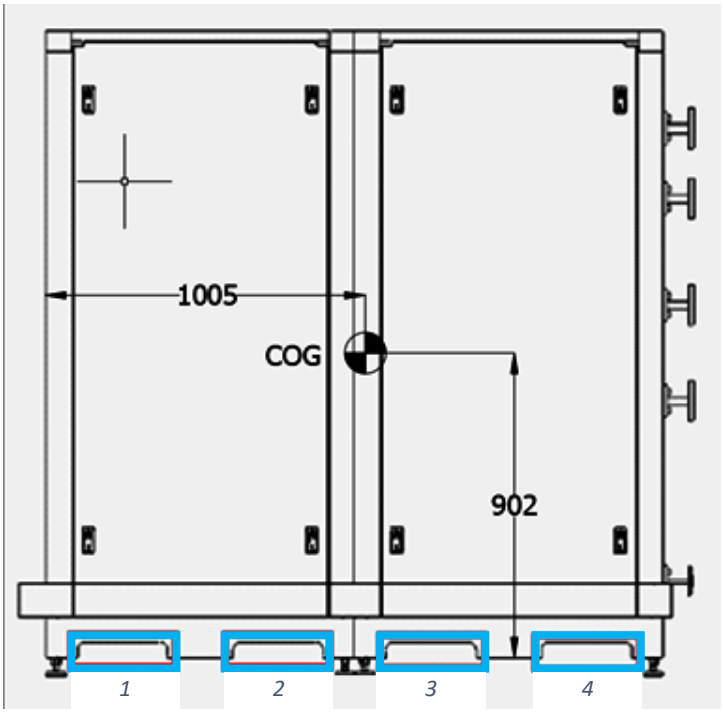
The Centre of gravity of the process equipment is in the X and Z axis below. The COG in the Y axis is central.

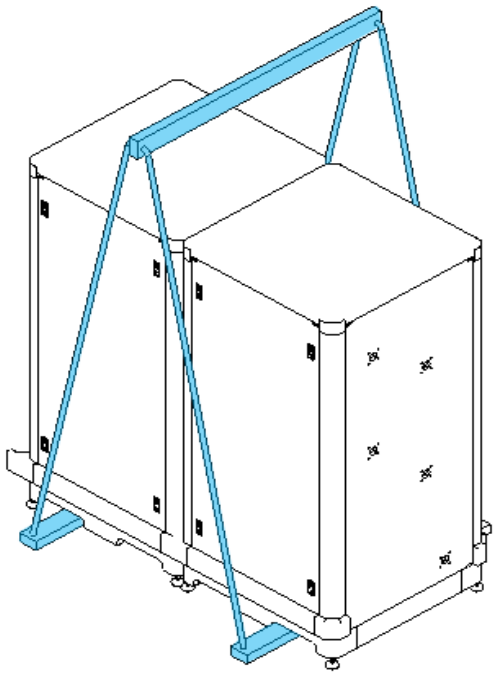
Four Prong Adaptor



Dedicated Lifting Points

General lifting with a fork lift will utilize a four prong adaptor allowing the fork lifter to lift from all four lifting points. See example of four prong adaptor to the left.

For short lifts the adaptor is not required, and the process equipment can be lifted via lifting points 2 and 3. It is advised to ensure if lifting in this manner that it is for short periods of time and the fork lifter is traveling along smooth ground.



As shown in the diagram below when lifting with a crane. Lifting beams and soft strops are to be used.

It is the responsibility of personnel conducting the lift to ensure the load is stable and the strops do not cause any crushing.

When lifting with a crane lifting point 1 and 4 are to be utilized.

.

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4.4. Refrigerant, Oil & Sound Levels

4.4.1. Refrigerant Levels

Final R744 weight may depend on usage. (More weight for colder use)	
Refrigerant	**Weight**
Carbon Dioxide R744 lb(kg)	42lb (19) to 50lb (23)

4.4.2. Oil Levels

Oil	Component	Volume
PAG 68	Compressor g(L)	0.66 (2.5)
PAG 68	Oil Reservoir g(L)	1.59 (6)
PAG 68	Complete System g(L)	2.25 (8.5)

The Oil Reservoir should not be allowed to drop below the lower sight glass. Standard operating levels should have oil visible on the middle sight glass but can vary in use. 6 Liters will fill the oil reservoir to the middle sight glass but may drop below.

4.4.3. Sound Levels

Sound Pressure Level at distance of 1m (dB,A)
< 85

4.5. Water Connections

The Water connections for the Hot Water flow & return, Cold Water flow & return and Hot water drain are situated at the rear of the machine and are of a flange type connection.

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Two terms, flow and return are used to describe the direction of flow at the connection.

- Flow – Refers to the direction of flow from the Heat Pump out to the Process/Application.
- Return – Refers to the direction of flow from the Process/Application to the Heat Pump.

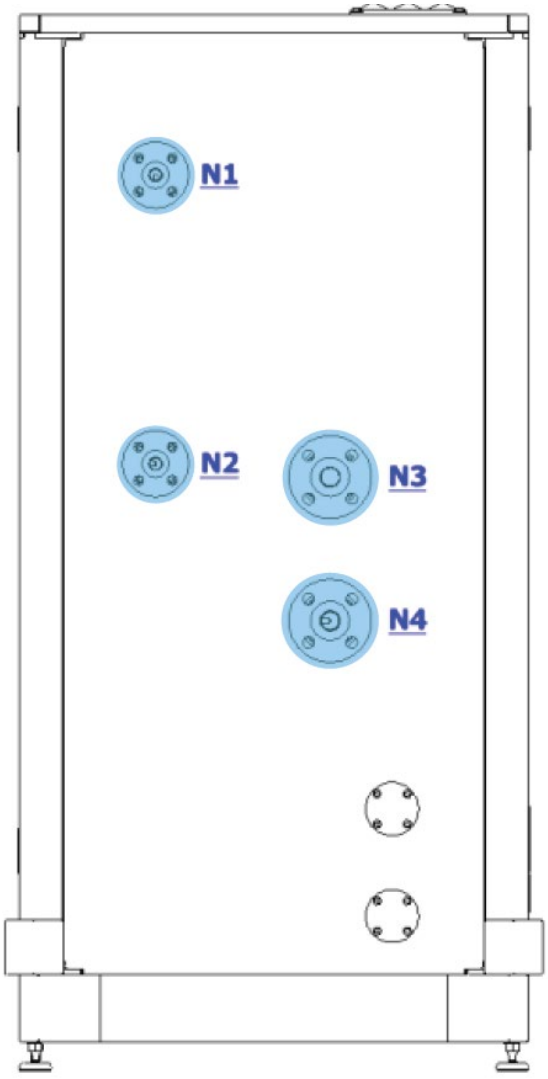
Connection	Description	Standard	Type	Sizes
N1	Hot Water Flow	ANSI B16.5	Class 300	1”
N2	Hot Water Return	ANSI B16.5	Class 300	1”
N3	Cold Water Return	ANSI B16.5	Class 300	1.5”
N4	Cold Water Flow	ANSI B16.5	Class 300	1.5”

IMPORTANT:

If the cold water circuit is to be incorporated into a closed loop circuit additional protection will be required including an expansion vessel and the use of antifreeze.

IMPORTANT:

The water supply to the DCT-1 should be of good quality free of suspended solids.



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4.6. Electrical Data.

Parameter US (EU)	Value	Unit
Voltage	480(400)	V
Frequency	60(50)	Hz
Number of phases	3P+PE	
Maximum Circuit Ampacity	80()	A
Minimum Over-Current Protection	100()	A
SCCR	10()	kA
Current, max	60()	A
Power, max	46.1	kW
RLA	100	A
LRA	323	A

PLC interrogation of VFD parameter registers. For display on HMI and use in performance and efficiency calculations. PLC reset of errors on VFD.

Objects/Parameters

VFD Power (kW), VFD Power (hp), VFD Motor Voltage (V), VFD Frequency (Hz), VFD Motor Current (A), VFD Motor Torque (Nm), VFD Motor Speed (RPM), VFD kWh, VFD Operating Hours, VFD Running Hours VFD Status Word with Alarms. VFD Reset Signal on the Control Word.

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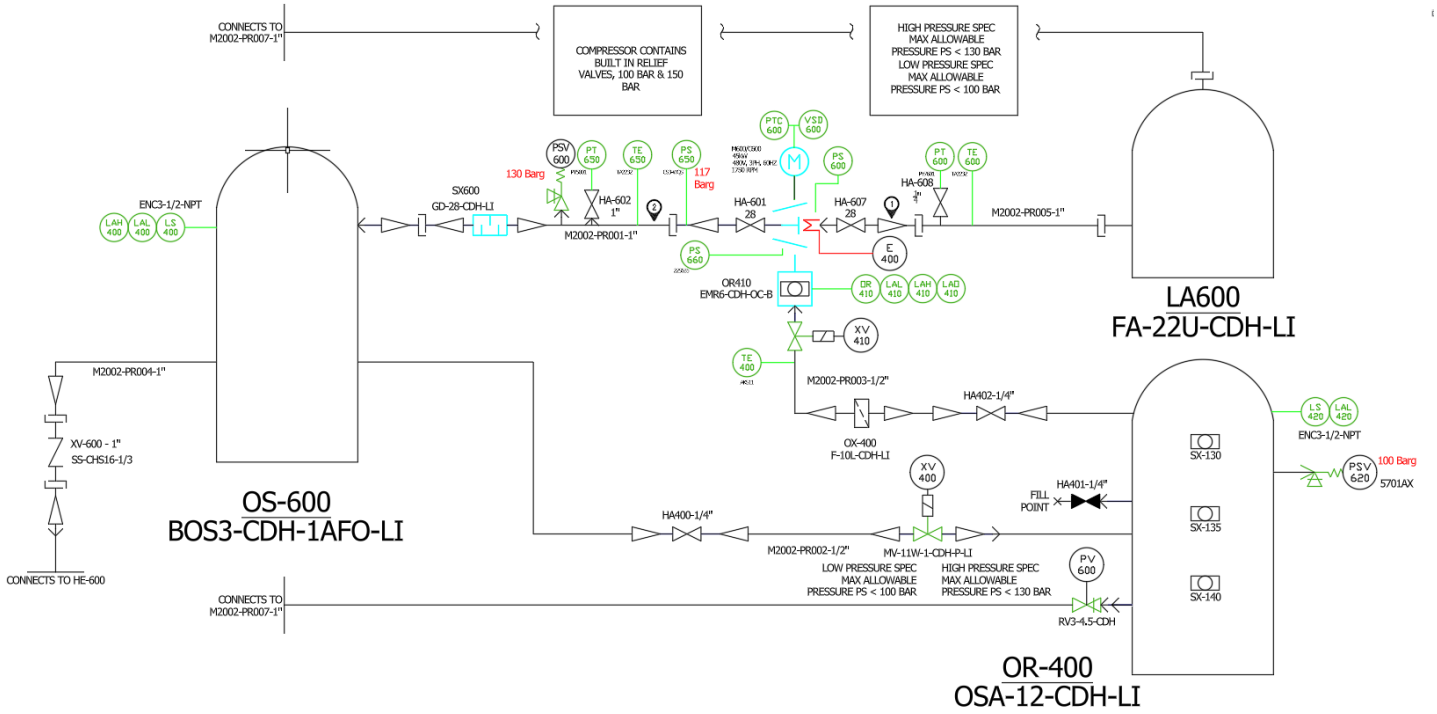
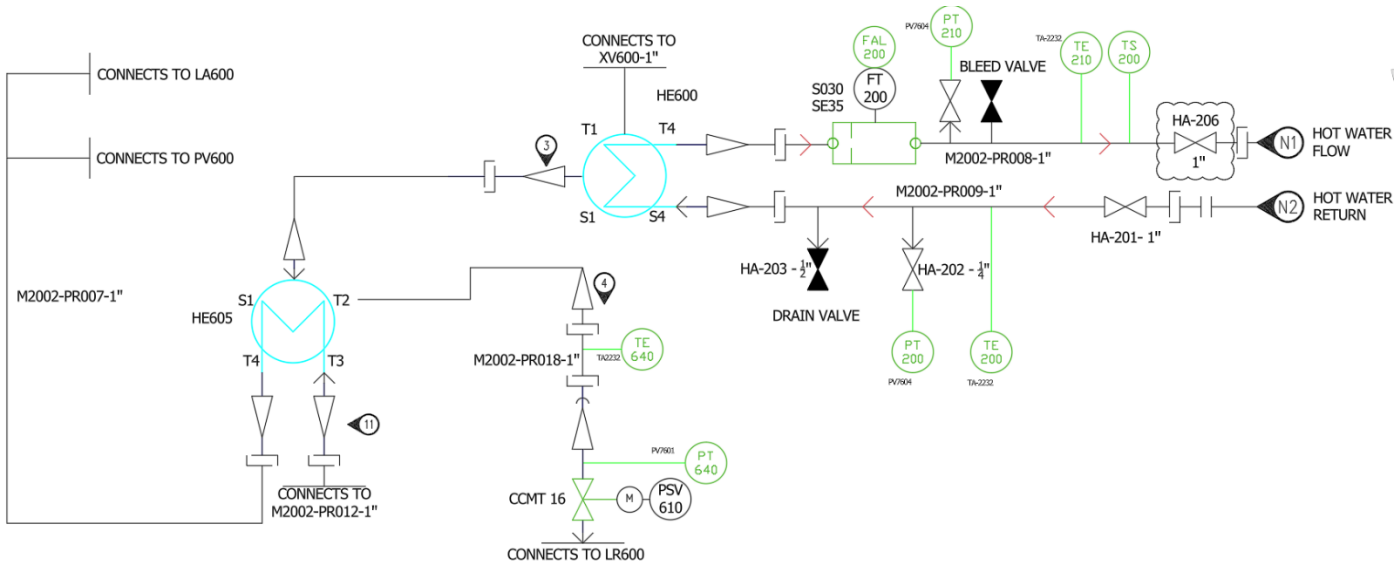
Compression PID



Hot Water PID



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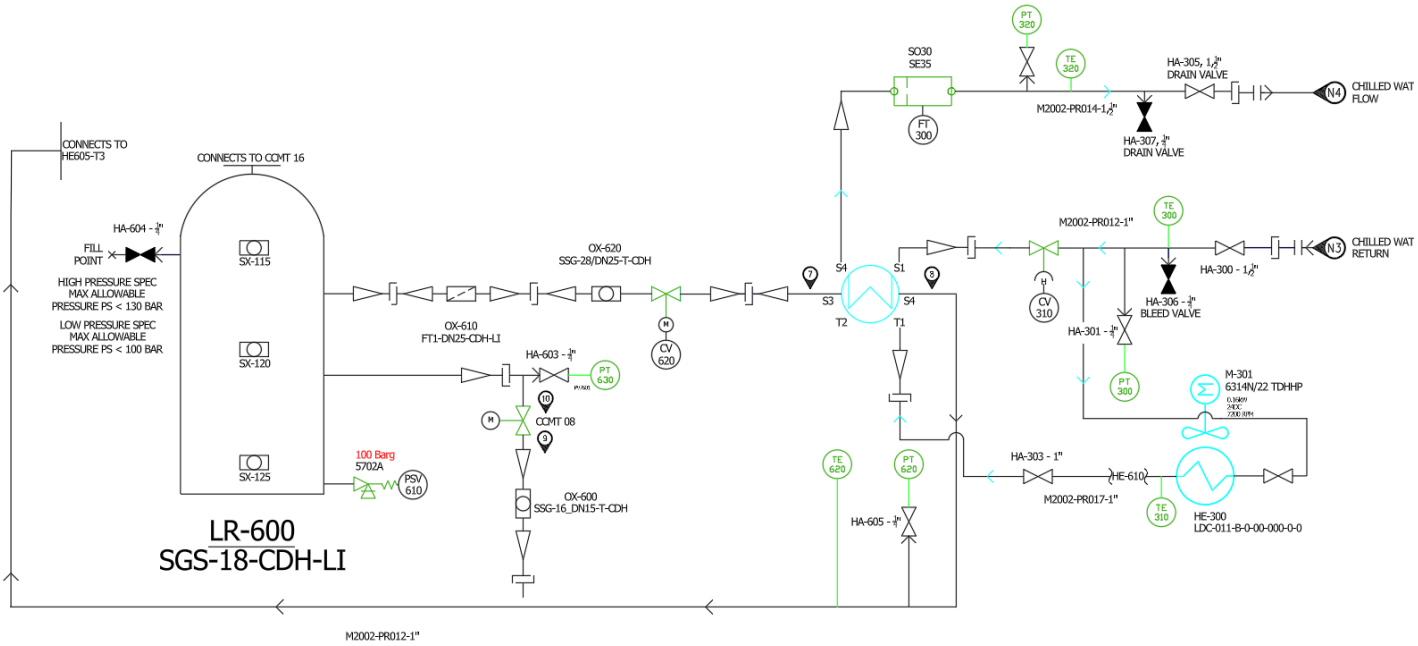
Cold Water PID



P&ID Tag	Description
C-610	ELECTRICAL REGULATING VALVE
C-600, C-620	ELECTRICAL REGULATING VALVE
HA-205, HA-306	ACCESS VALVE ¼" NPT – ¼" SAE WITH SCHRADER & CAP
CV-310	2/2 WAY ANGLE SEAT VALVE, MANUAL OPERATED, DN25
PSV-610	¾" NPT, 1450 PSI Pressure Relief
LS-420	HIGH/LOW LEVEL CONTROL SENSOR
OX-400	FILTER STRAINER
LA-600	SUCTION LINE ACCUMULATOR
OX-610	FILTER DRIER
SX-600	DISCHARGE LINE MUFFLER
OR-400, SX-130, SX-135, SX-140	OIL RESERVOIRS
PV-600	DIFFERENTIAL PRESSURE CHECK VALVE
HA-400, HA-402	1/4" NPT FEMALE- NEEDLE VALVE

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HA-202, HA-204, HA-301, HA-304, HA-401, HA-602, HA-603, HA-604, HA-605, HA-606, HA-608	1/4” NPT MALE FEMALE NEEDLE VALVE
OX-600	DN16 SIGHT GLASS ADAPTOR
OX-620	SIGHT GLASS ADAPTER
XV-600	1” CHECK VALVE 0.03BAR SPRING
HA-206	1/2” ASME BPE BALL VALVE - TYPE SN
FT-200, FT-300	INLINE SENSOR FITTING, 1,1/2” BPE
FT-200	INLINE SENSOR FITTING, 1” BPE
HA-201, HA-206, HA-302, HA-303	1” ASME BPE BALL VALVE -
HA-300, HA-305	1,1/2” BPE TUBE BALL VALVE
FT-300	INLINE SENSOR FITTING, 1,1/2” BPE
TE-200, TE-210, TE-300, TE-320, TE-600, TE-620, TE-640, TE-650	TEMPERATURE TRANSMITTER, -50-200°C, IO-LINK
C-600, PSV-630, PSV-640	CO2 SEMI-HERMETIC COMPRESSOR
HE-610	HEAT EXCHANGER HE610
HE-600	HEAT EXCHANGER – HE600
HE-605	HEAT EXCHANGER – HE605
OR-410, XV-410	OIL LEVEL REGULATOR
OS-600	HIGH PERFORMANCE OIL SEPARATOR
XV-400	1/4" BSPP 24V DC SOLENOID VALVE UL CERTIFIED
LR-600, SX-115, SX-120, SX-125	18L LIQUID RECEIVER
PS-600	PRESSURE SWITCH, 1/4" BSP FEMALE, 0-160 BAR
PSV-600	1/2" NPT PRESSURE RELIEF VALVE - 1885 PSI SET - ASME
PSV-620	1/2" NPT PRESSURE RELIEF VALVE - 1450 PSI SET - ASME
PS-660	PRESSURE TRANSMITTER, 0-3625 PSI, -40-257°F, 4-20MA

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PS-650	PRESSURE SWITCH, 1566 PSI SWITCH, AUTOMATIC RESET
TS-200	1/2" DISC TYPE THERMOSTAT SWITCH, MANUAL RESET, NC, 194°F, QUICK CONNECT
PT-600, PT-620, PT-640, PT-650	PRESSURE SWITCH WITH IO-LINK, 0-250 BAR
PT-200, PT-210, PT-300, PT-320	PRESSURE SWITCH WITH IO-LINK, 0-10 BAR
TE-310, TE-400	STRAP ON TEMPERATURE SENSOR

5. Machine Description

The DCT-1 consists of 5 main sections. The mechanical frame, CO2 & Oil circuit, heating circuit, cooling circuit and the control system.

5.1. Mechanical Frame

5.2. CO2 & Oil Circuit

The DCT-1 operates a trans-critical heat pump circuit with R744 (carbon dioxide) refrigerant. At the high operating pressures of R744 systems the carbon dioxide is above its critical point and behaves as a supercritical fluid in the high-pressure part of the circuit. Hence the heat output is not accompanied by a phase change and the heat exchanger is designated a gas cooler rather than a condenser.

The process is driven by a reciprocating compressor C600 with four cylinders. The compressed gas passes through a muffler SX600 for pulsation damping to an oil separator OS600.

As is standard for refrigeration systems the compressor lubricating oil mixes with the refrigerant and is separated out in the oil separator. When oil is detected in the separator by an optical switch the solenoid valve XV400 opens to discharge oil into the oil receiver OR400. The oil receiver is maintained at just above the compressor inlet

pressure by the pressure reducing valve PV600. When the compressor oil level switch OR410 calls for oil the solenoid valve XV410 opens and oil flows through filter OX400 into the compressor.

After the oil separator the hot supercritical carbon dioxide passes to the main gas cooler HE600 where its heat is transferred to a recirculating heat transfer fluid, normally water at slightly elevated pressure. This is followed by a small economizer HE605 which adds a small preheat to the recirculating gas before it reaches the compressor inlet.

The refrigerant pressure is reduced in two stages. In the first stage control valve CV600 drops the pressure below the critical point so that the supercritical fluid returns to the liquid state and is

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collected in the liquid receiver LR600. There is a filter OX610 on the receiver outlet followed by expansion valve CV620 which drops the pressure further such that the liquid absorbs heat in the evaporator HE610 and becomes a gas. The recirculating heat transfer fluid in the evaporator is normally a solution of glycol in water. There is a hot gas bypass from the liquid receiver and at times of low load control valve CV610 opens to allow gas to bypass the evaporator.

Gas from the evaporator passes through the economizer HE605 and suction line accumulator LA100 and returns to the compressor inlet.

5.3. Heating Circuit

Heat output is to a hot water system maintained at elevated pressure to avoid vaporization or boiling. An External Pump will circulates water through the gas cooler HE600 via flanged connection on the back of the DCT-1 enclosure.

5.4. Cooling Circuit

The cooling output is to a water or water/glycol system. In standard installations this connects into a larger site-wide system via the flanged connections on the back of the DCT-1 enclosure.

5.5. System Safety

The DCT-1 has a number of safety measures incorporated to prevent harm to the machine and personnel.

These measures take the form of independent relief valves, an integrated control system and an independent control safety circuit.

These three safety measures provide the following levels of safety.

- **Integrated control system**
  The integrated controls takes all the feedback from the flow, pressure and temperature switches. The system then operates with predefined logic to control the system within set parameters. These parameters are defined in the Limits and trip Matrix. The defined logic is designed to put the machine into a safe position if the operation goes out of normal operation.
- **Control safety circuit**
  The safety circuit allows for direct intervention that will supersede the integrated control system. This intervention comes from an E-stop, Pressure switches, Temperature switches and Breaker position.

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- **Pressure Reliefs**
  The pressure reliefs are the last line of defense. If all other safety systems fail, the reliefs will allow for the discharge of the working medium to prevent over pressurization.

6. Operation and Controls

6.1. Operating Principles

The control system is comprised of a PLC, I/O expansion module, stepper motor control module and HMI. The PLC has a control logic software program installed which governs how the inputs and outputs on the PLC and expansion module function. This software program ensures the system operates as required by monitoring sensors and operating control relays in response to the condition of the system.

Information from the PLC is fed to the HMI so that it can be displayed in an easily digestible format.

During normal operation the system will seek to maintain an operator defined set point at either the hot or cold water outlet, depending on the mode selected on the home screen.

Minimal user interaction is required, other than starting and stopping of the unit via the home screen. The operator may also be required to use the emergency stop and reset controls in the case of an emergency or system shutdown; and the local / remote controls should a remote control system be installed.

The system uses a series of control valves and a VFD, all operating on independent PID loops in order to achieve the desired output whilst maintaining optimal operating conditions.

Each valve PID loop is referenced to a specific pressure transmitter which acts as the control sensor. Control valves will respond to changes in system load in order to maintain required operating pressures in specific parts of the system. Valve response is defined by the values for proportional, integral and derivative which are set to known good values during factory acceptance tests.

The PID loop for the VFD is referenced to the temperature probe at the hot or cold water outlet which acts as the control sensor dependent on the selected mode.

The VFD will increase or decrease frequency in order to achieve a stable outlet temperature set by the operator. VFD frequency response is defined by the values for proportional, integral and derivative which are set to known good values during factory acceptance tests.

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6.2. User Interface

1. **HMI.**
   Provides system information and access to various system controls and parameters. Navigation is via eight programmed function keys at the bottom of the screen.

2. **Local / Remote Selector.**
   Selects the mode of operation if the option to install a remote HMI has been implemented.

3. **E-Stop.**
   Emergency stop button. Will stop the unit and remove all mains power to all prime movers, leaving the HMI and low voltage instruments connected. To reset the button is released by turning the button and then the system can be reset using the button on the Home screen. The emergency stop circuit can also be connected externally if required.

6.3. HMI Operation and Navigation

The HMI is navigated using a set of 8 function keys that are programmed as:

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- System
- Settings
- Alarms
- Graph
- Service
- Home
- Previous
- Next

Selecting the Home key will give a detailed overview of the inputs, outputs and operating parameters.

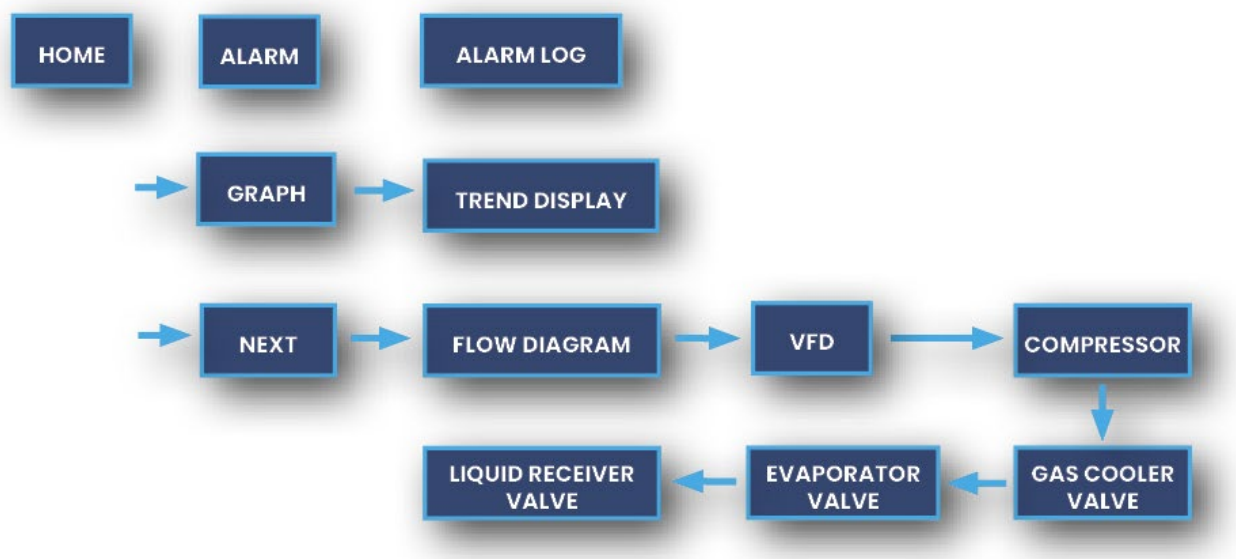
Next and Previous will move through the screens as indicated in the screen map below.

The Alarm key brings up an alarm log.

The Graph tab brings up a screen with a plot for tracing the status of various components and parameters over longer periods of time.

The System, Settings and Service menus contain various menus for setup of the system and may only be accessed by installers or supervisors with the correct login credentials.

6.4. Screen Map



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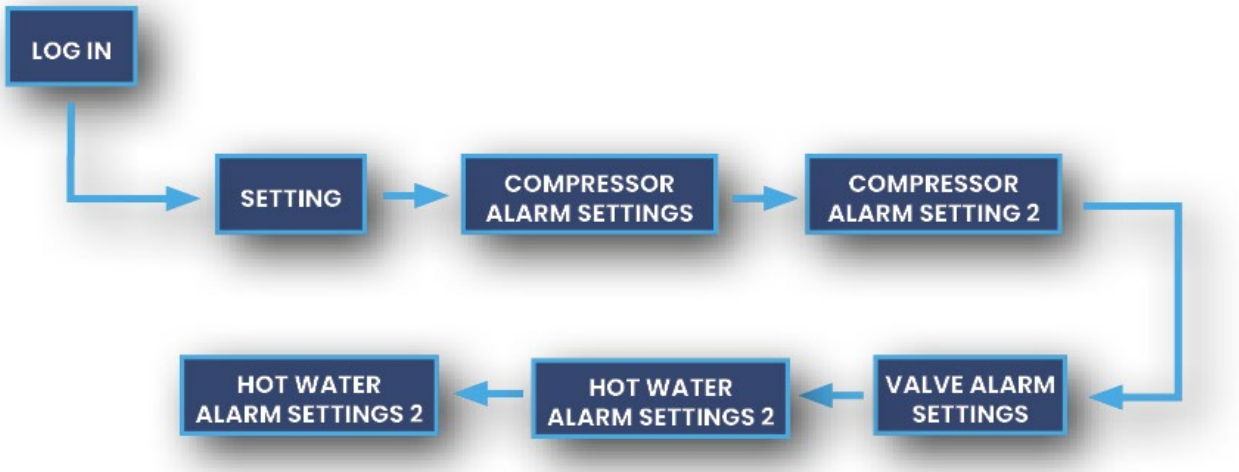
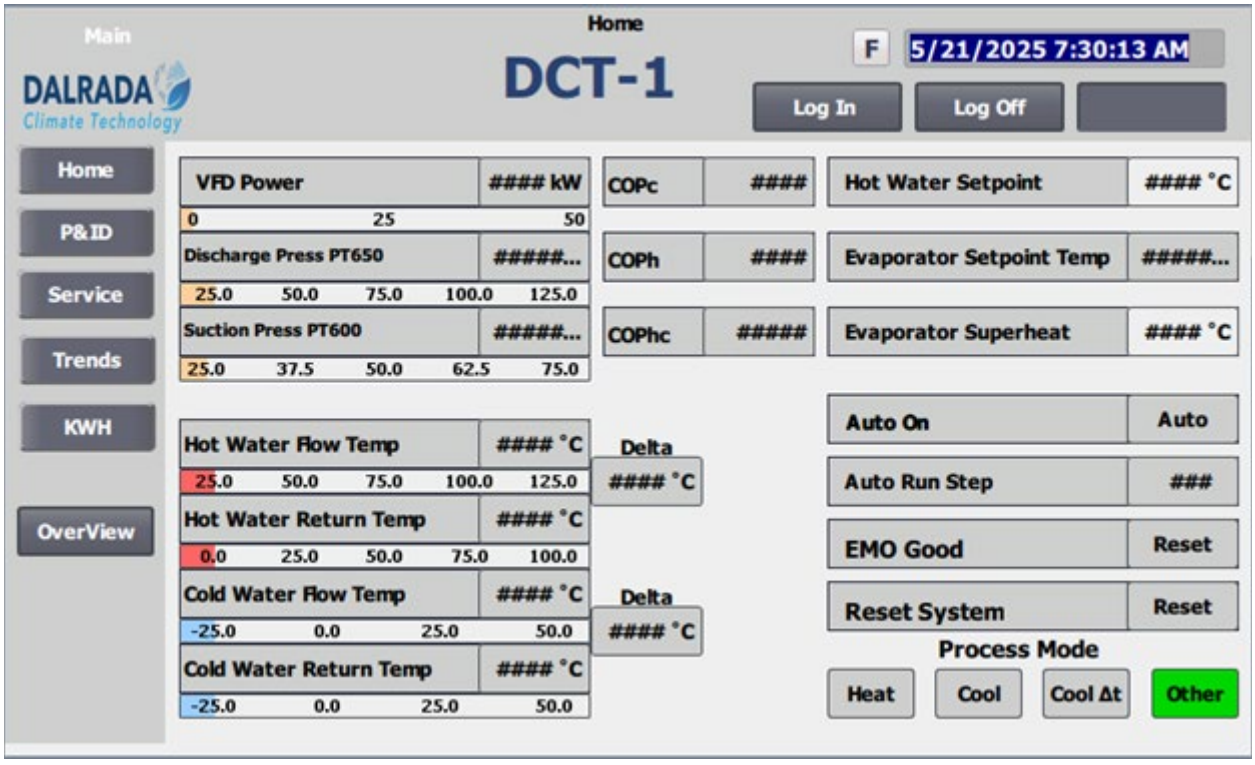


6.4.1. Home Page



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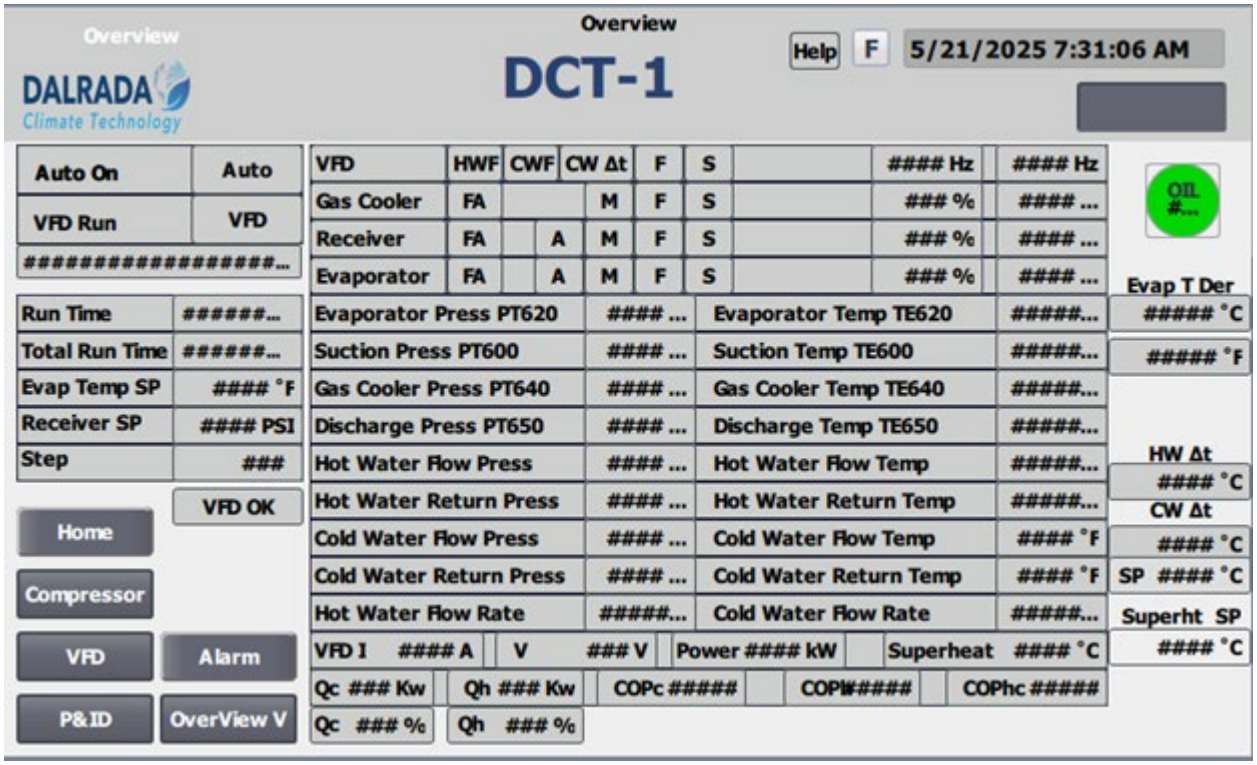
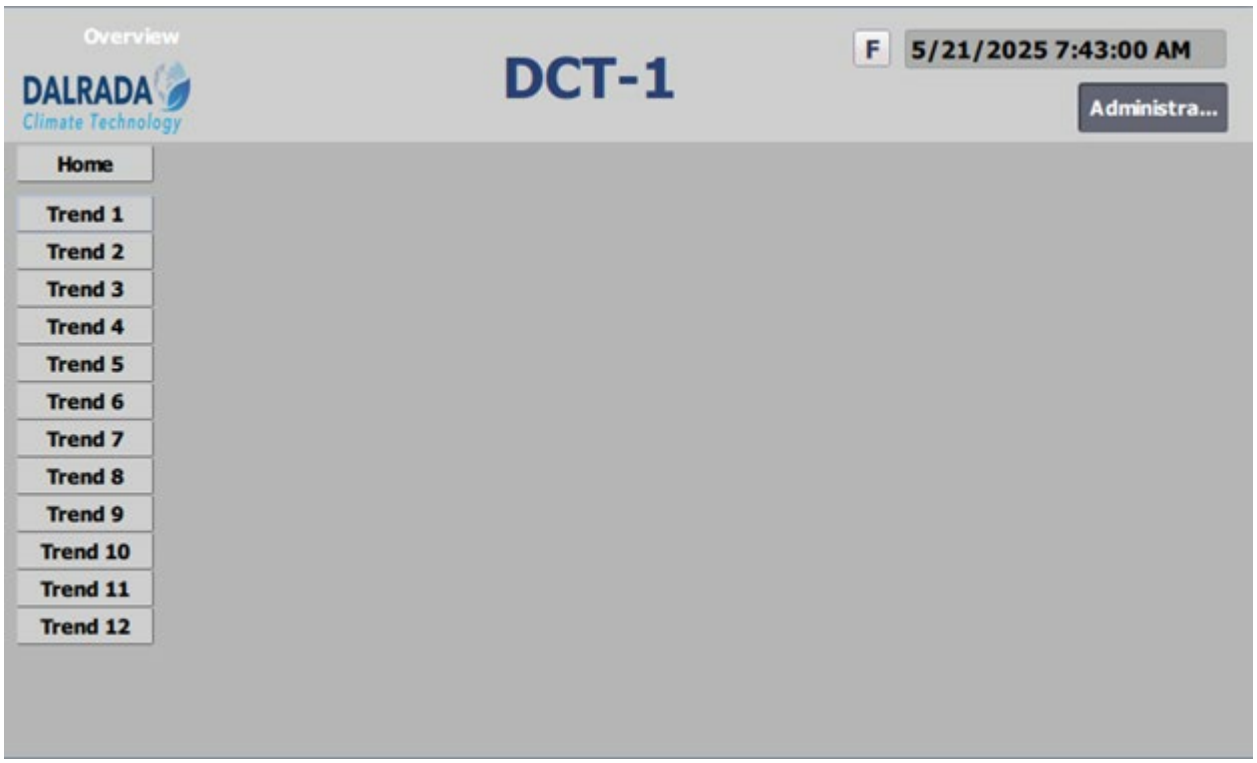
6.4.2. Overview





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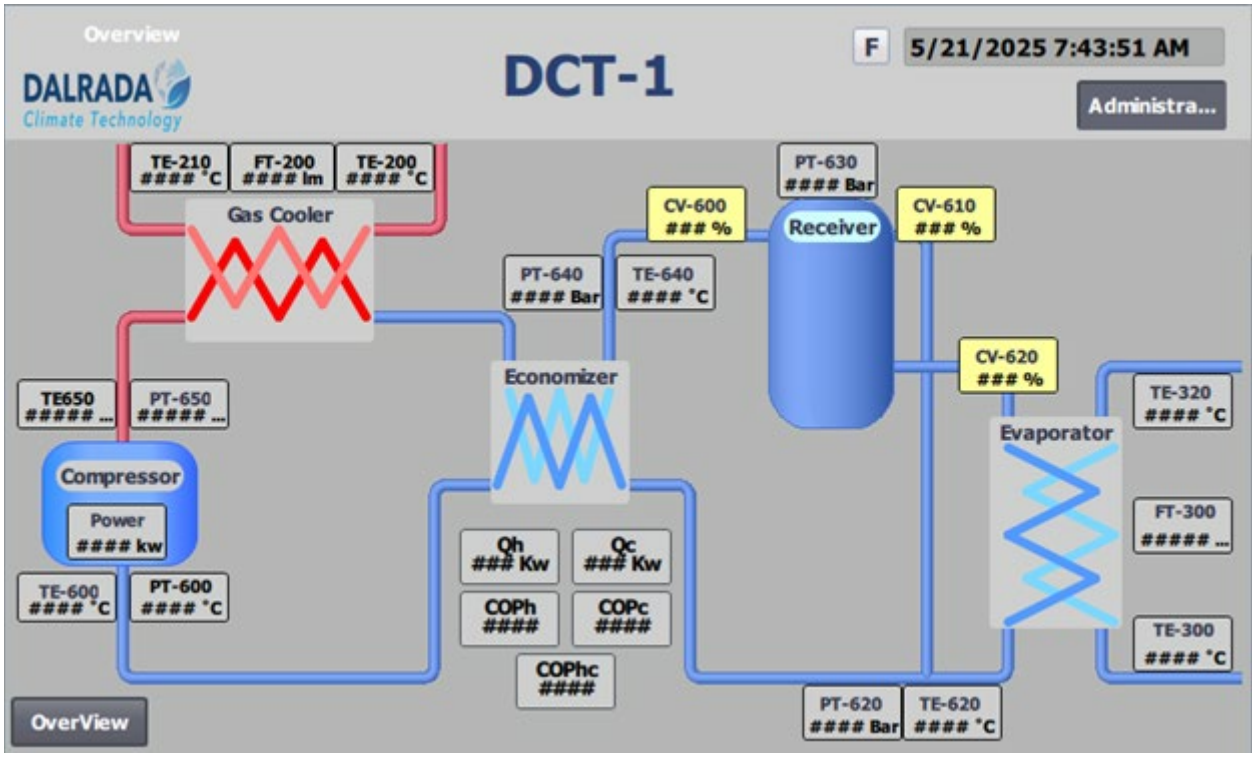
The home page will be the first screen to display after the system has been through its boot up process. All the main operator controls and information are available on this screen.

The Compressor Available lamp will be lit when all preconditions are met including emergency stop reset, alarms cleared and flow in both hot and cold water circuits. Pressing the Start button will initiate the start-up sequence and the unit will operate to bring the water outlet temperature to the set point.

The operator can adjust the set point of the system to the desired outlet temperature using the System Set point slider.

A Supervisor or Service Engineer may sign in on the Home screen providing access to the mode selector and to the System, Settings and Service screens.

6.4.3. Flow Diagram



This screen provides a diagrammatically representation of the process.

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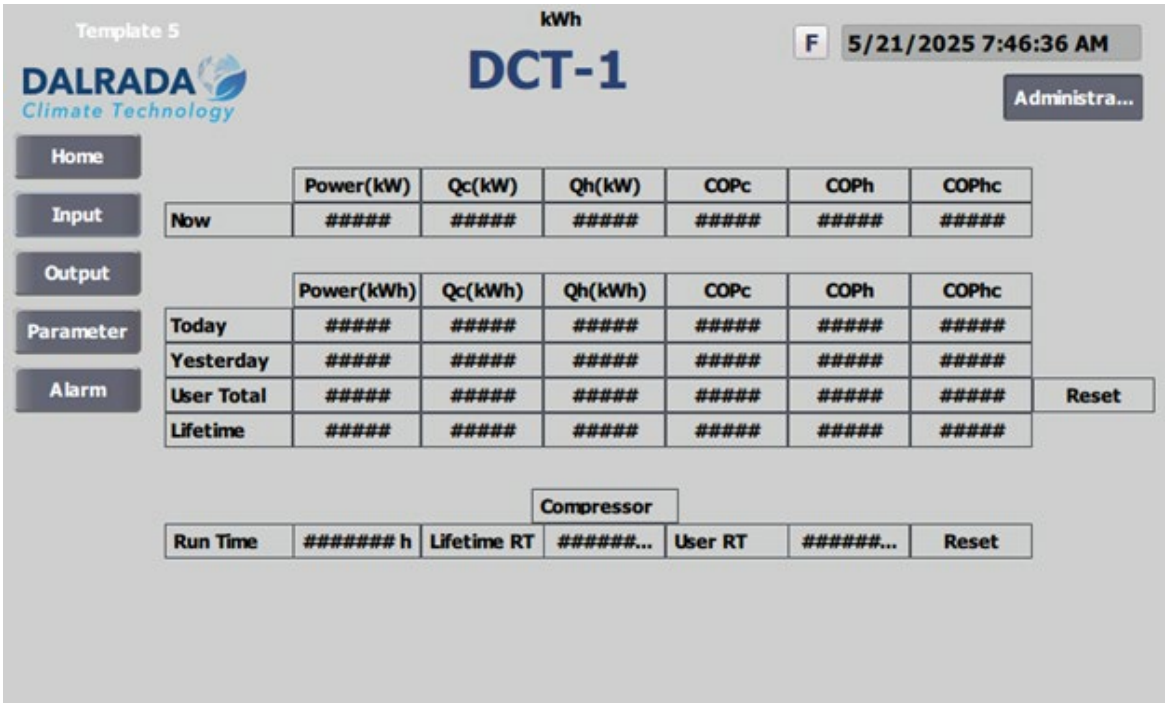
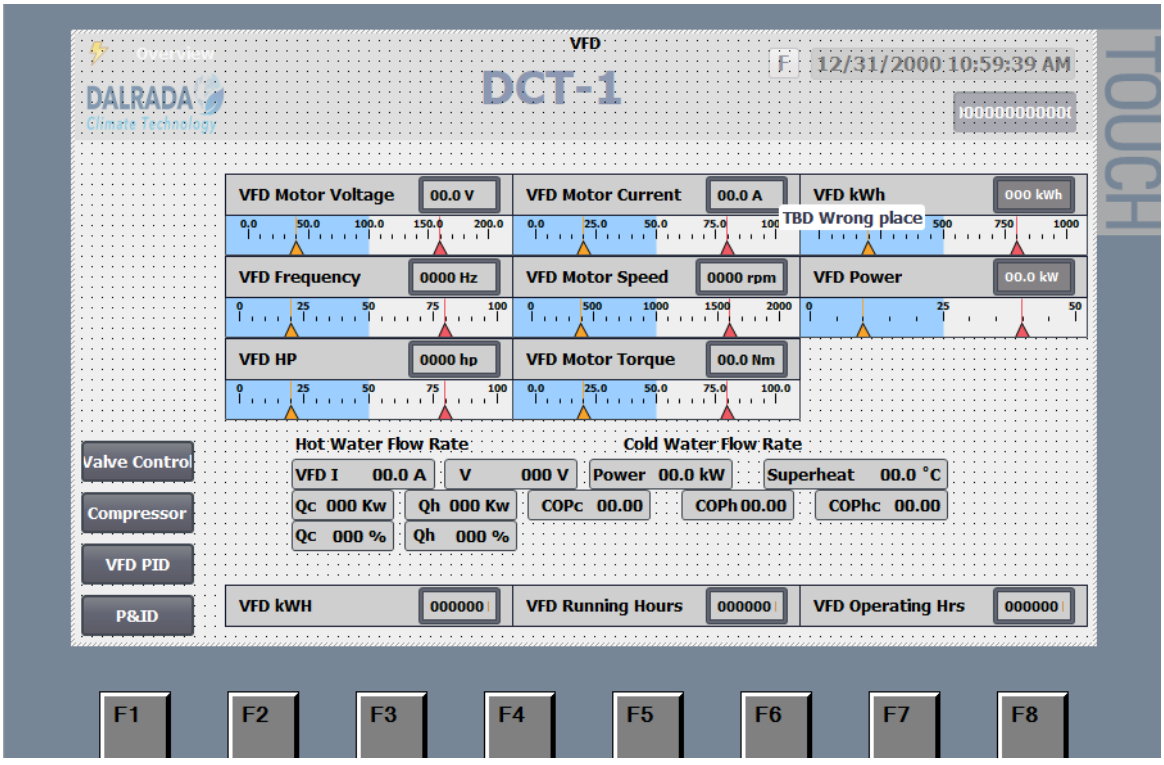
6.4.4. kWh



6.4.5. VFD



This screen provides information from the compressor

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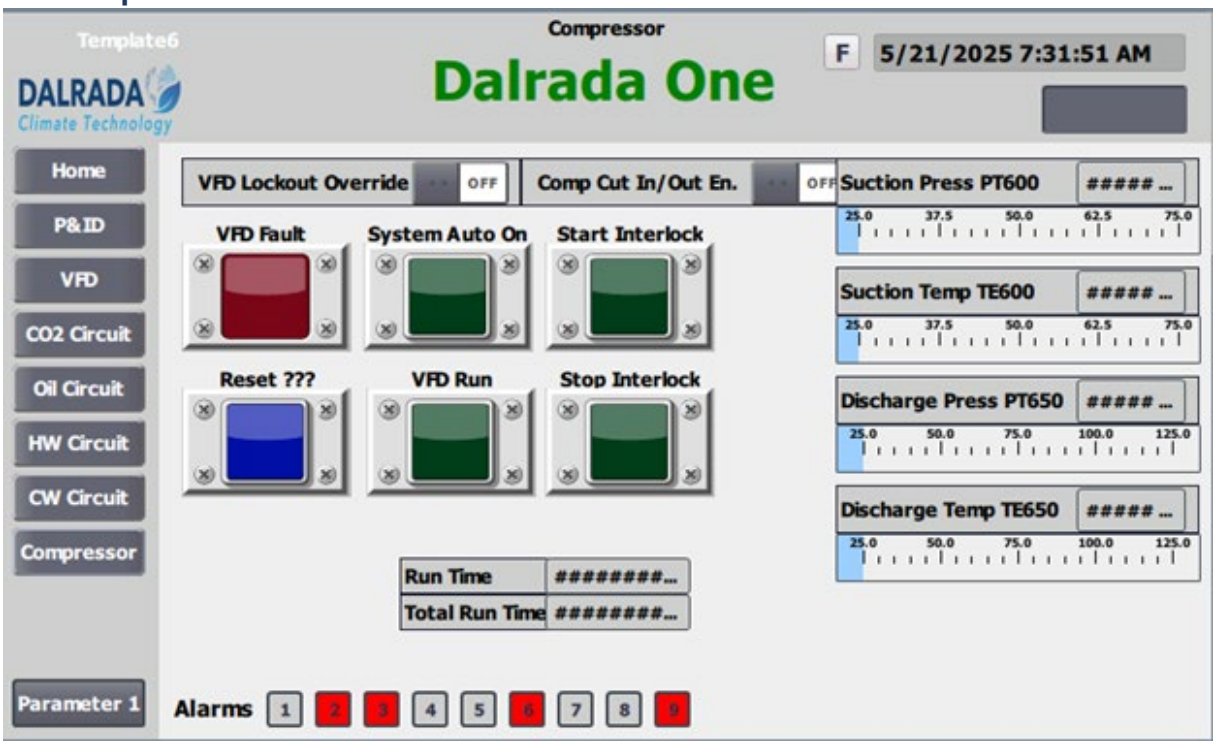
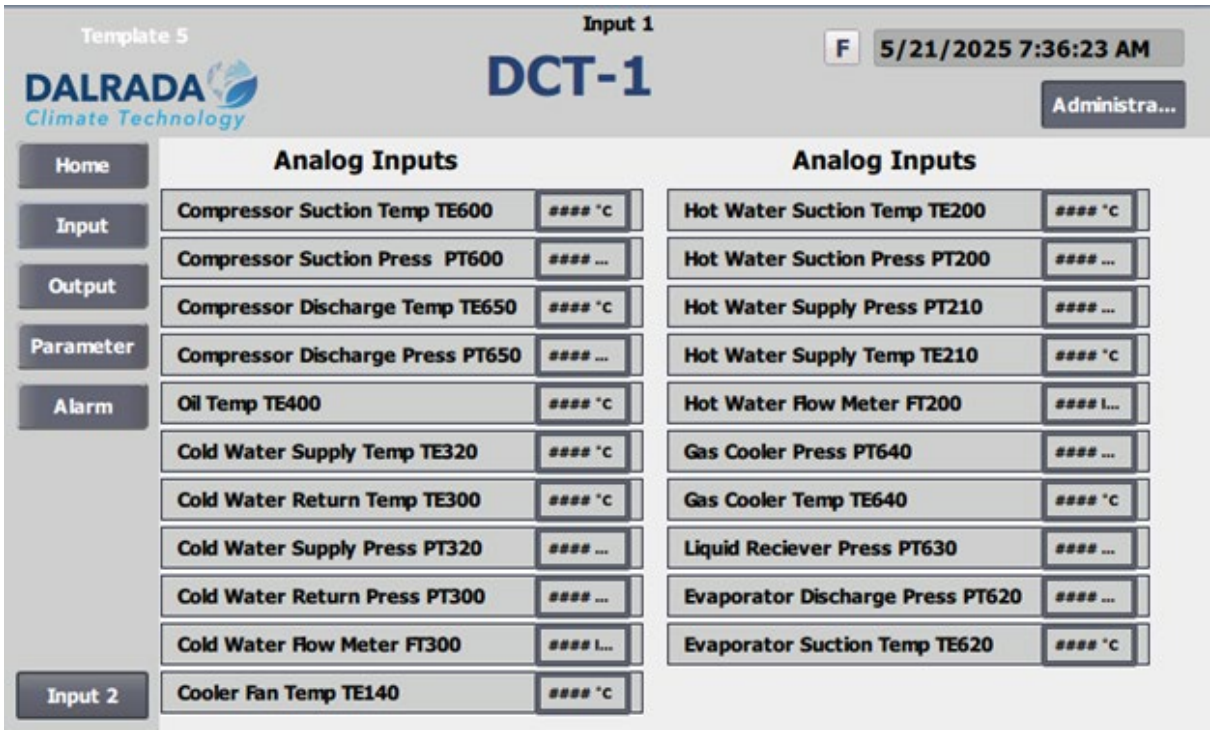
6.4.6. Compressor



This screen provides operating information on the compressor.

Input 1



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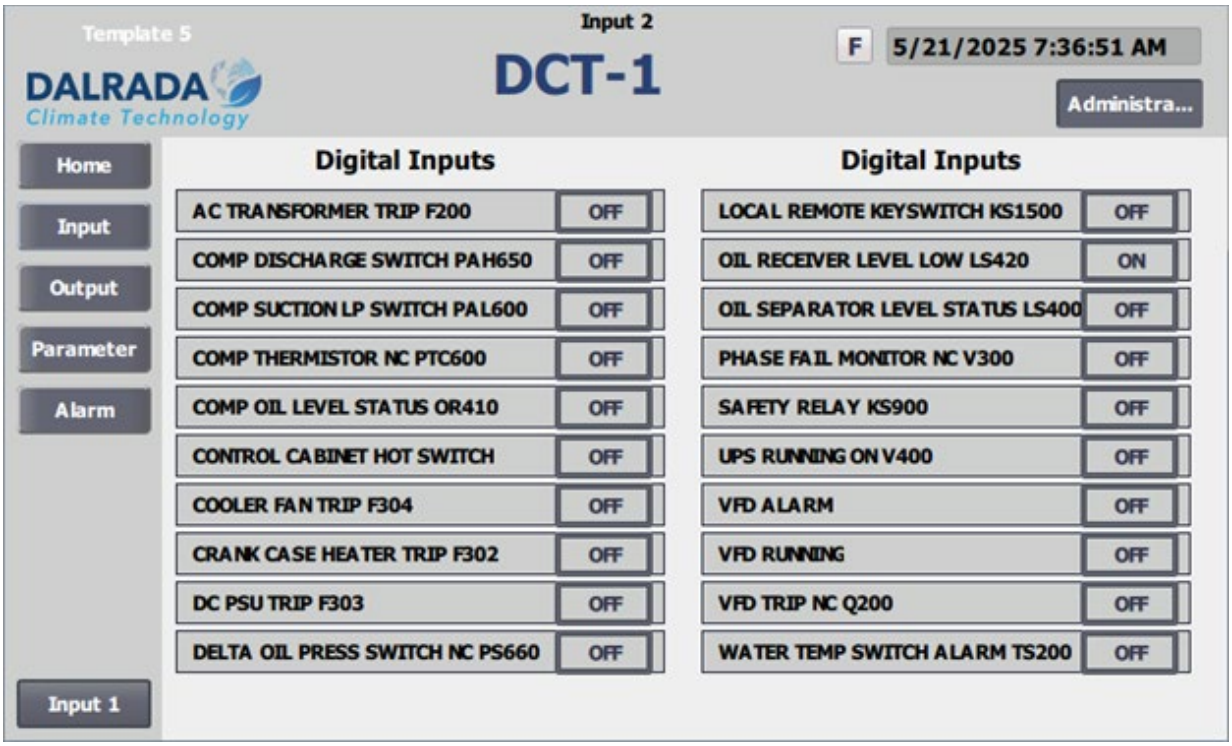
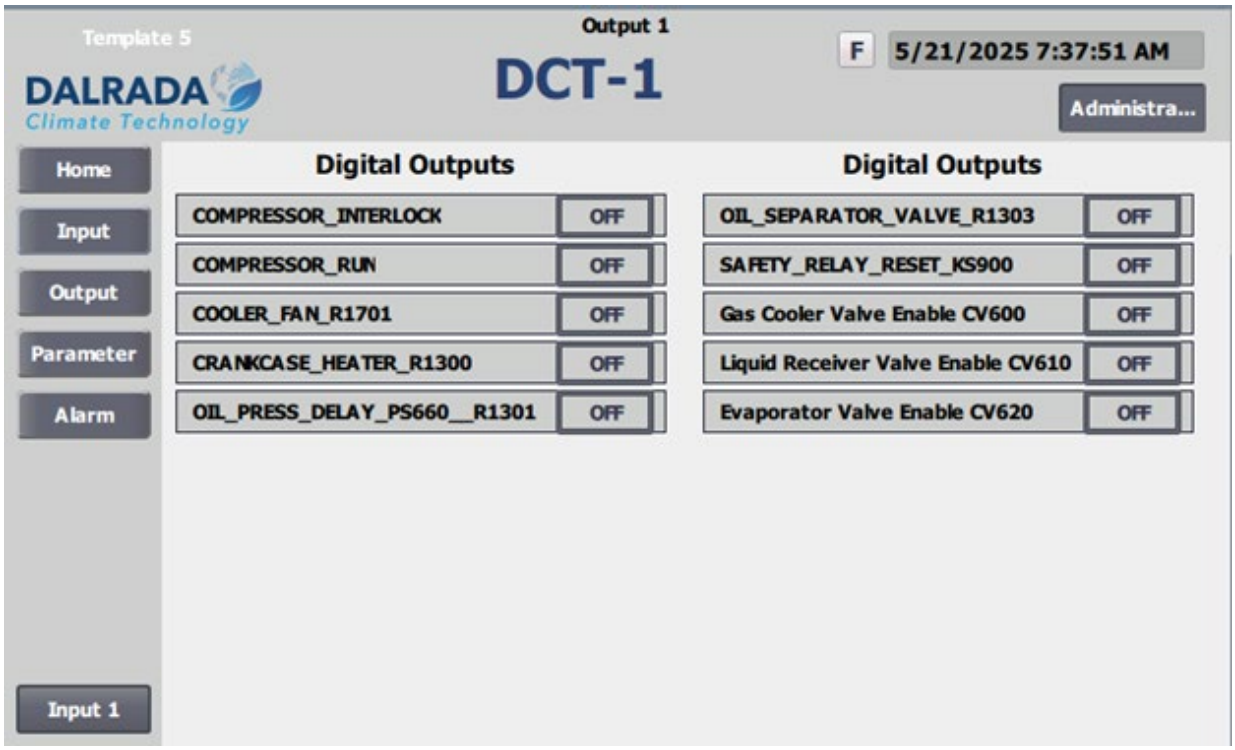
Input 2



Output 1



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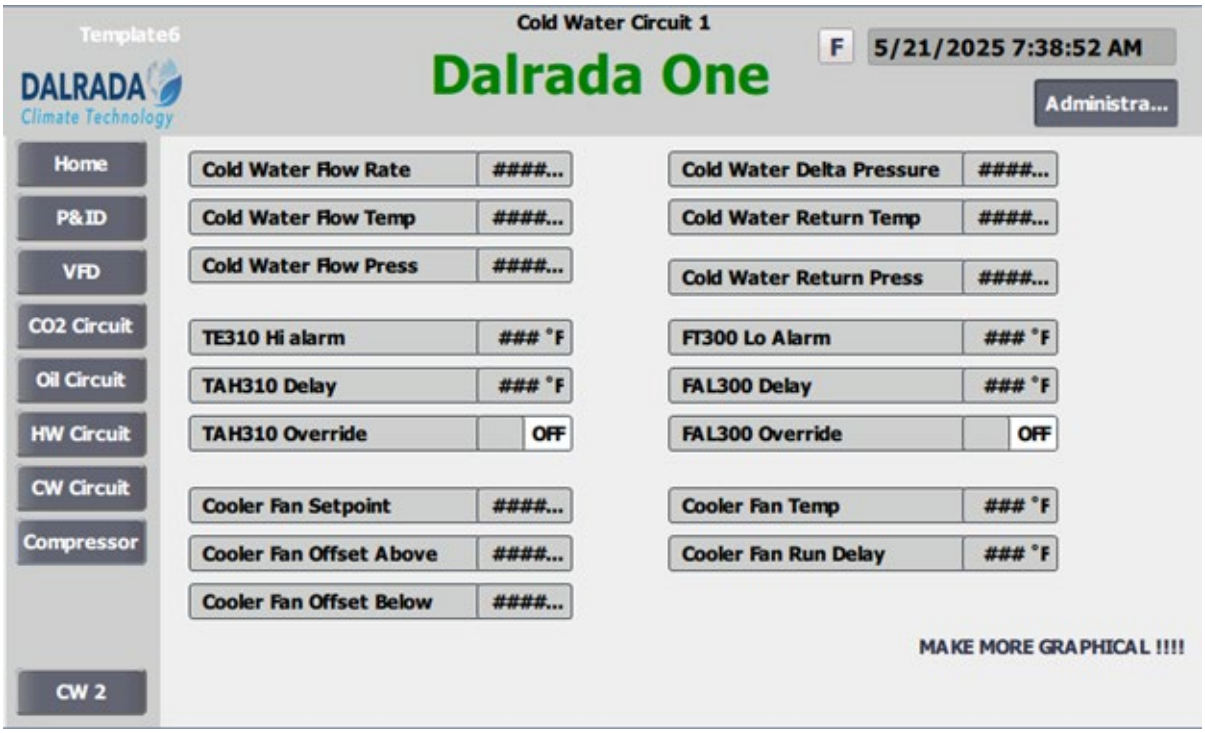
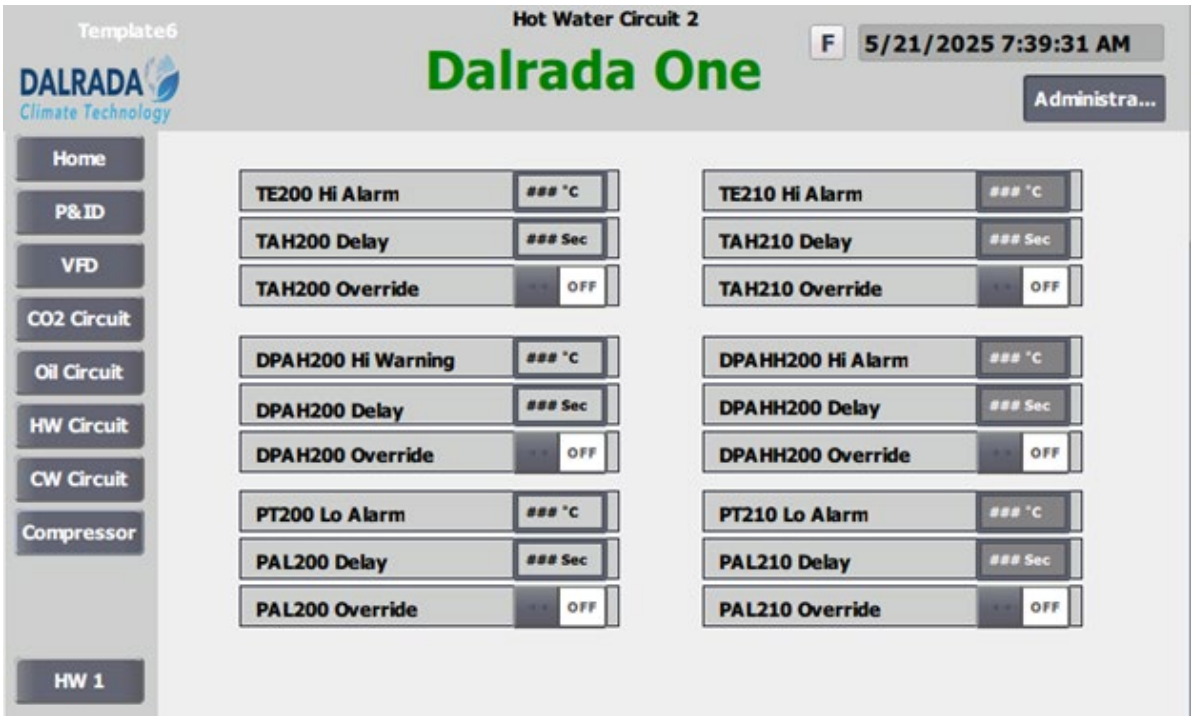
Cold Water Circuit 1



Hot Water Circuit 2



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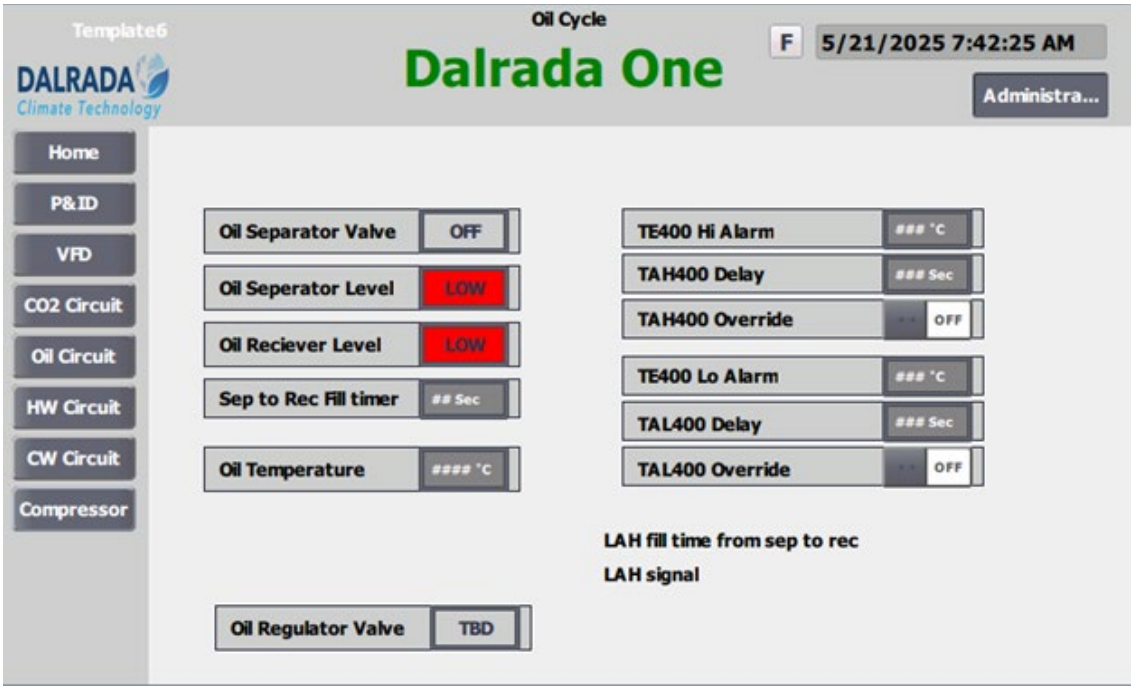
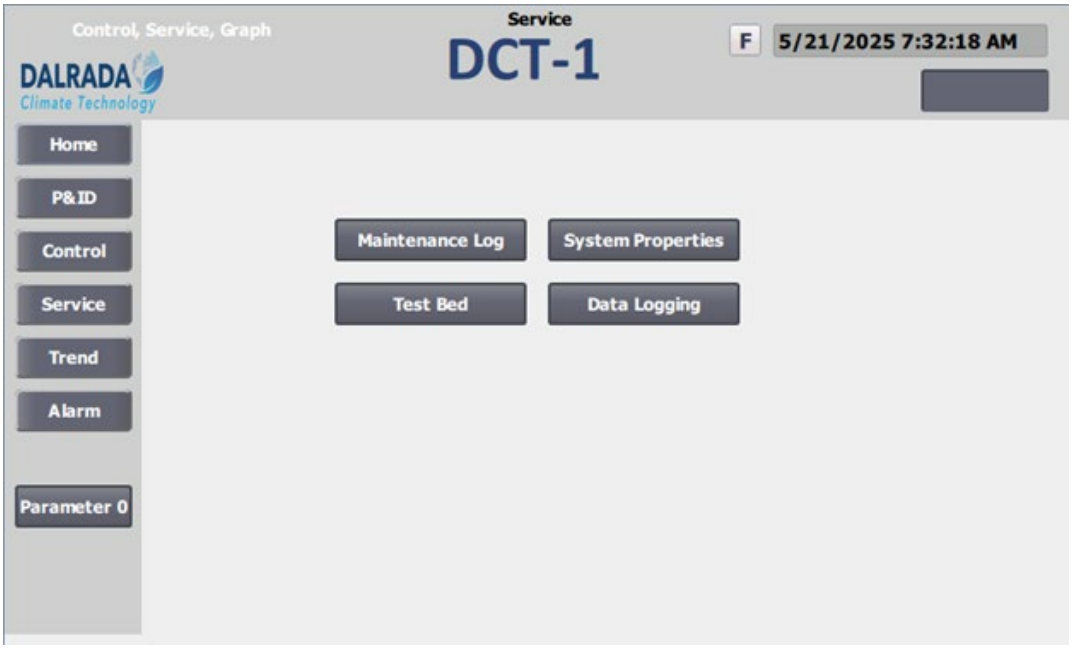
Oil Cycle



6.4.7. Graph



This screen provides graphical trend information.
The operator can navigate using the touchscreen buttons provided.

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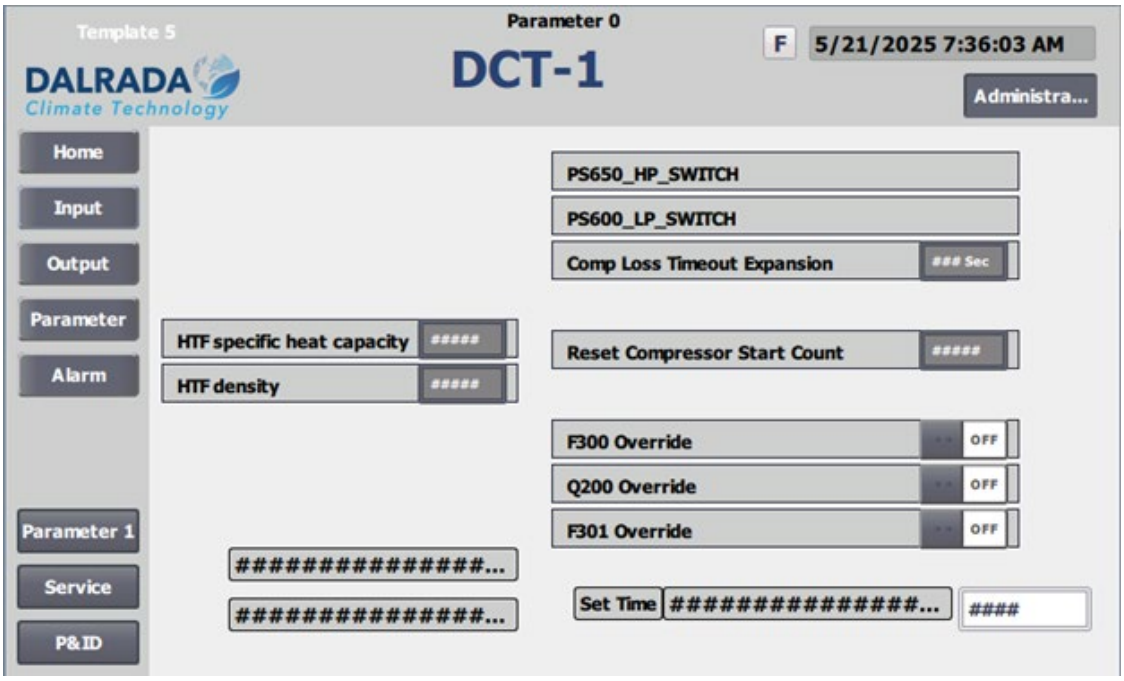

6.4.8. Alarm Log

This screen provides the alarm log for the unit.

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6.5. Operation

6.5.1. Power up Sequence

Step	Operation	Requirement
1	Power up the unit	Switch on the incoming supply to the unit.
2	Power up the control panel	Turn the main isolator on the front panel to the ON position.
3	Allow the PLC & HMI to boot	System powers on. HMI & PLC go through boot process. HMI will read “Connecting” followed by “Security Negotiation” before displaying the home screen.
4	Reset the system	Press the reset push button on the HMI to bring the system into standby.

6.5.2. Emergency Stop Sequence

Step	Operation	Requirement
1	Power down the control panel	Turn the main isolator switch on the front panel to the OFF position.
2	Power down the unit	Switch off the incoming supply to the unit.

6.5.3. Power Down Sequence

Step	Operation	Requirement
1	Push the emergency stop switch on the front console (or remotely, if connected)	Audible alarm sounder. Red LED on HMI and alarm message. Fault lamp flashing and reset lamp lit.
2	Disengage the emergency stop switch on the front console (or remotely, if connected). Press the reset button on the HMI.	Control valves zero and revert to initial positions. System in standby mode.

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Before the unit is powered up after an Emergency Stop, make sure that:

- The root cause(s) of the emergency has/have been eliminated.
- All Safety features are present and in working order.
- No hazards to people are present.
- Unlock the emergency stop only when danger no longer exists.

6.5.4. Heat Pump Start Stop sequence

Step	Operation	Requirement
1	Power up the unit and bring to standby mode.	Switch on the incoming supply. Turn on the main isolator and allow system to boot. Press the reset button.
2	Ensure all preconditions are met: • Emergency stop disengaged and reset. • No alarms. Flow in both water circuits.	Enable the compressor
3	Press the “start” pushbutton on the Home screen.	Compressor starts after control valve initialization has been confirmed.
4	Allow the heat pump to run.	
5	Press the “stop” pushbutton on the Home screen.	After a short sequence, compressor stops.

6.5.5. Water Temp Control

Step	Operation	Requirement
1	Use the slider on the home screen to adjust the water outlet temperature set point	The VFD will adjust output via PID loop in order to achieve the desired output temperature.
2	Select either hot water temperature control, cold water temperature control or cold water delta T control.	

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7. Delivery of Heat Pump

7.1. Safety Notices for Transportation

Damage due to improper transportation

- Be careful when unloading the Heat Pump and/or transporting it within the plant. Pay attention to the symbols and instructions on the packaging.
- Use only the marked attachment points shown in section 4.3.3.

Improper transportation can result in substantial material damage as well as severe injury or death.

Improperly loaded packages can tip and fall of the transportation vehicle.

7.2. Inspection for Shipping Damage

Upon delivery, check the delivered packages for completeness and transportation damage. Use the packing list as reference.

If there is visible damage to the exterior of the packaging, proceed as follows.

- Accept delivery only conditionally.
- Record the damage on the transport company's delivery documentation.
- File a damage claim with the shipper. Inform the manufacturer.

The delivery terms are generally ex-works (EXW); therefore in that case, damage claims must be initiated by the operating company to the freight company.

7.3. Packing

About the Packaging

The combined gross weight of the packaged unit is about 2100 kg.

- Box 1 – 1800 kg
- Box 2 – 300 kg

The packaging consists of a wooden crate for the unit and one of more pallets for supplies and accessories.

The wooden crate's dimensions are approximately:

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- Box 1 – 2200 mm (long) by 1120 (wide) by 2070 (high)
- Box 2 – 1120 mm (long) by 400 (wide) by 2070 (high)

The packaging protects the unit from mechanical and environmental damage and therefore should not be removed until the unit is to be installed at its final location.

Handling of Packaging Material.

Packaging materials must be disposed of in compliance with Federal, State and Local regulations.

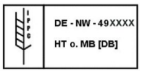
Danger to the environment due to incorrect disposal

- Protect the environment by using proper disposal methods!
- Packaging materials are valuable and may be recycled.
- Improper disposal may be harmful for the environment.

Packaging materials are valuable raw materials and, in many cases, can continue to be used or can be properly processed and recycled. Incorrect disposal of packaging materials may pose risks to the environment.

7.4. Symbols on the Packaging

The following symbols are used on the packaging and must be considered during transportation and storage.

Symbol	Description	Purpose
	Umbrella and Rain	Indicates the package should never get wet or be stored in damp areas
	Upward Arrows	Indicates the position the package should be in while being shipped. “This way up”
	Fragile	Indicates the contents of the package are fragile and care is required when handling.
	International Standard for Phytosanitary Measures	Indicates the treatment wood materials have gone through. Which allows wood materials to be exported.

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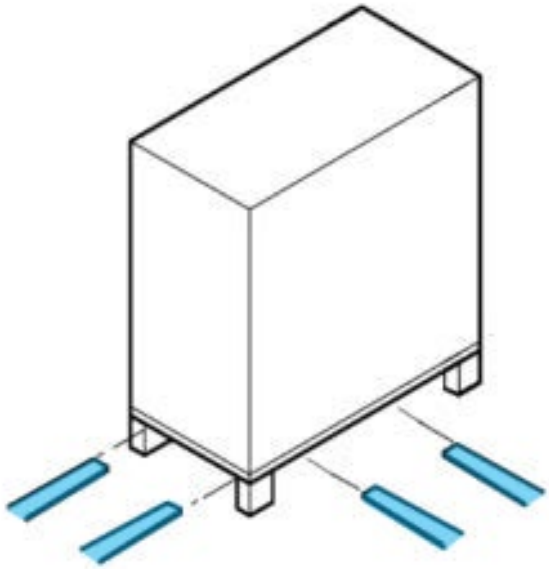
7.5. Transportation

Transportation by Forklift

For transportation of the packaged unit by forklift the following conditions must be met:

- The forklift must be rated for the weight of the packaged unit.
- The fork length must be at least 1200 mm (47“).
- The forklift driver must be qualified.
- Use ratchet straps to secure the unit to the forklift uprights.

Transportation of the Unpackaged Unit.



Transportation by Forklift.

For transportation of the unpackaged unit by forklift the following conditions must be met:

- **The forklift driver must be qualified.**
- The forklift must be rated for the weight of the unit.
- The fork length must be at least 1200mm (47“) to suit the lifting instruction in section 4.3.3 for pick-up from either side.
- The unit may be lifted from either side. The forks should be spaced as far apart as possible and must be positioned to mate with the lifting pockets.
- For lifting from either side, the forks must exit on the opposite side by at least 100mm (4“).
- In all cases secure the unit to the forklift uprights using ratchet straps or similar taking care not to damage the unit housing.

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7.6. Storage

When storing the packaged Heat Pump make sure that the following conditions are met:

- Do not store outside of a building.
- Store in a dry and dust free environment.
- Do not expose to aggressive media.
- Protect from direct sun light.
- Avoid mechanical shocks and vibration.
- Storage temperature between 14 °F and 95 °F.
- No exposure to moisture or water. Relative humidity max. 60 %.
- For storage over periods longer than 3 months, the condition of all parts of the packaging must be checked regularly.

Additional storage requirements may be shown on the packaging and must be followed.

8. Installation Requirements

The DCT-1 should be installed in compliance with the requirements of the Authority Having Jurisdiction (AHJ) for the location, including the requirements of ASHRAE Standard 15 - Safety Requirements For Refrigeration Systems.

9. Installation and Start-Up

Installation must be carried out according to the manufacture's instructions and by competent personnel. The installation must be verified by the manufacturer before start-up. Start up must be performed by a specialist trained and authorized by the manufacture. The commissioning records must be filled in at the completion of installation and start up.

9.1. Safety

For safety information retaining to Installation refer to section 3 and be aware of applicable safety regulations.

9.2.Prerequisites for installation

Before installation refer to section 8 to ensure the location of the installation is suitable.

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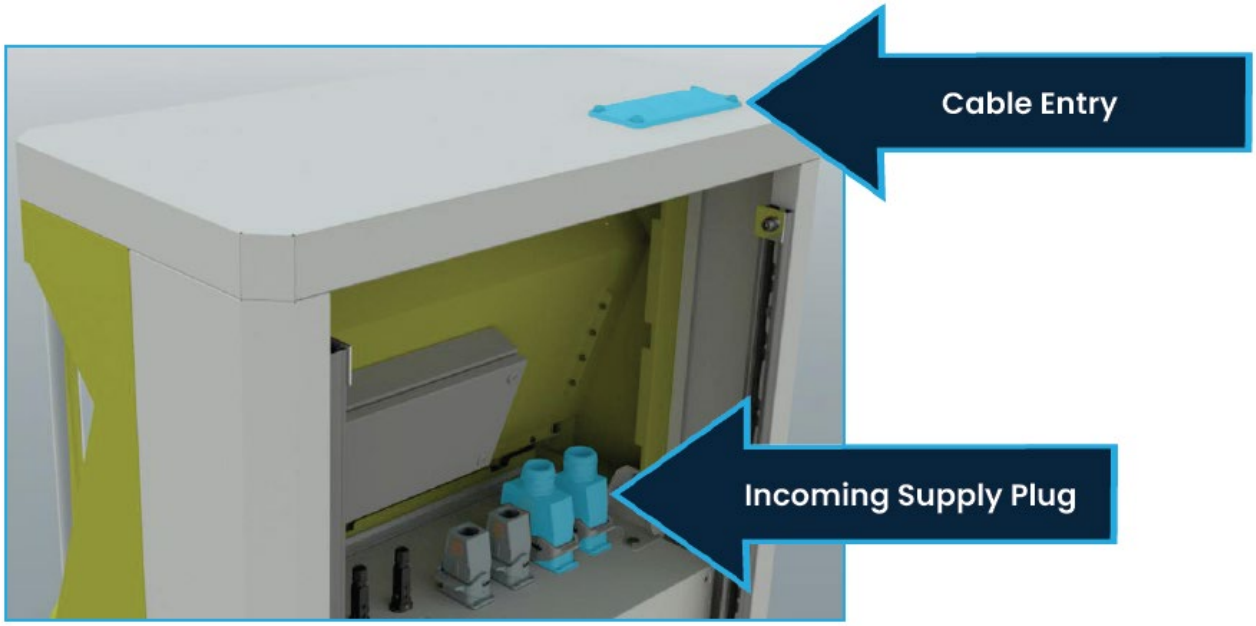
The following requirements are required from the site to allow correct operation of the system when installed:

- Hot and Cold circuit connecting pipes must be equal or larger than the nominal size of the unit's connections.
- In the plant's pipe installation, a bleed valve should be installed at the highest point of the installation, and a drain valve should be installed at the lowest point for the hot and cold circuits.
- Electrical connections must be suitably sized an according to the manufacturer's wiring diagram.
- The electrical supply cables must enter bulkhead plate via the roof of the electrical console.

9.3. Electrical Installation.

A standard single AC supply source with 3Phase+Neutral+PE, 480V 60Hz, required as single source electricity to power up the heat pump. The recommended source supply cable is shielded or armored 4C+PE (four core + PE). The conductor cross section of 25 mm² the required for the supply cable selected accordance to the rated current according to applicable USA regulations.

On installation of the incoming power supply cable this cable is required to be fed into the roof of the control equipment section of the Heat Pump. This is to be done via the cable entry provided. The cable is then to be terminated in the Incoming supply Harting Plug.



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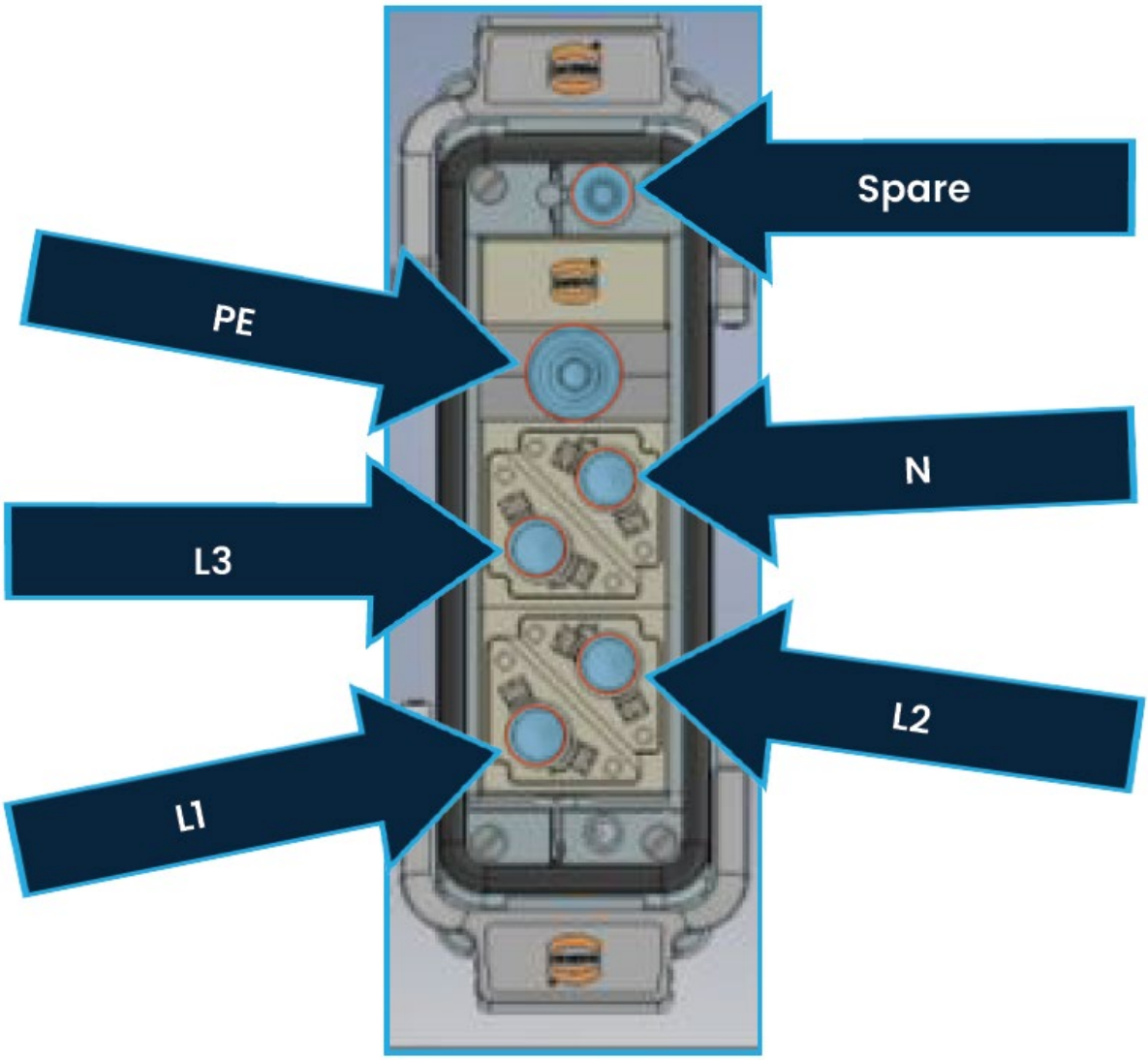
Below shows the cable configuration within the socket on the electrical enclosure for the incoming supply. The view is of the socket attached to the enclosure looking down on the disconnected connection from outside of the enclosure.



9.4. Mechanical installation.

The DCT-1 is designed to stand on its own without any further fastening or securing providing the requirements in section 8.4 are met.

The DCT-1 has feet with adjustable height to allow for any undulation in the floor.

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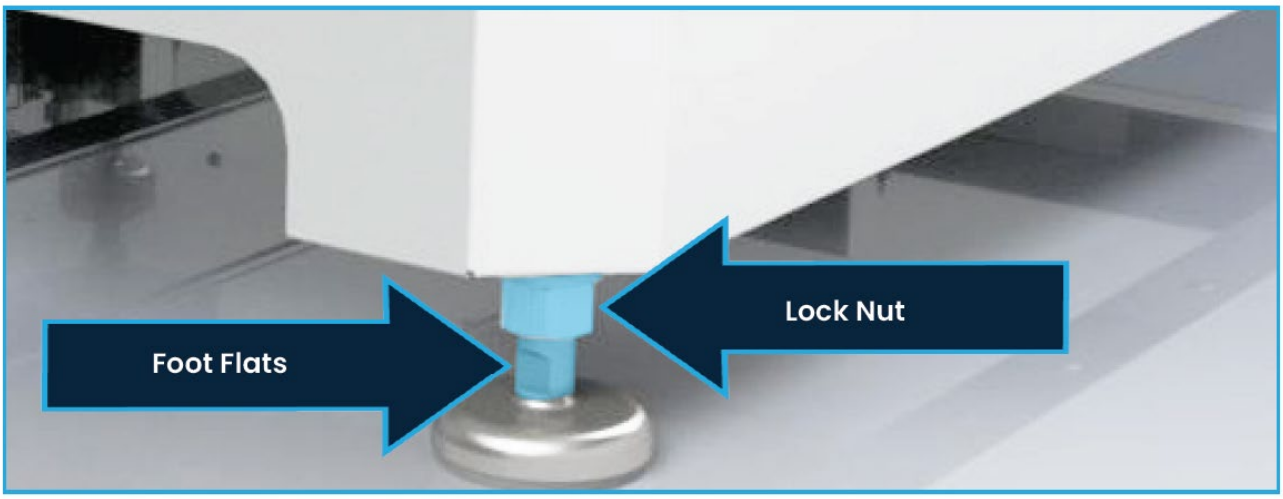
These are to be adjusted on site to ensure the machine is level. To adjust the feet height firstly slacken the locking nut then turn the foot via the flats on the foot shaft. Once adjusted to the desired height tighten the lock nut up.



The DCT-1 process connection requires the hot and cold connection to be made with the process. The drain connection for the hot water circuit may be connected too to allow the hot water circuit to be drained to a specific place. This is at the discretion of the customer.

For details of the hot and cold water connection refer to section 4.5. The connections to the hot and cold can be made with a solid pipe connection, but best practice would be to have a flexible connection between the machine and the process pipework. This can take the form of a hose or compensator bellows.

The flange connection requires an appropriate gasket suitable for the flange sizes and working temperatures of the fluid. The flange connection will also require the following bolts.

Flange Connection	Bolt Sizes	Grade of Bolts
1” Class 300	• M16 x 65 – Bolts • 5/8” UNC x 2.5” – Bolts • M16 x 75 – Studs • 5/8” UNC x 3” – Studs	Grade 8.8
1,½” Class 300	• M20 x 75 – Bolts • 3/4” UNC x 3” – Bolts • M20 x 90 – Studs • 3/4” UNC x 3.5” – Studs	Grade 8.8

The DCT-1 requires to be charged with gas and oil. Typically, systems will be shipped with oil and a minimum charge of CO2 equating to a max of 1 bar. The system is to be charged and filled with oil according to section 10.2 and 10.5 if required.

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9.5. Pre-Start up checks

Check	Description
1	Cable termination tightness.
2	Cable termination pull test.
3	Voltage check for AC & DC.
4	Protection Earth cable connection to main control and machine.
5	Ensure plug connection between heat pump process equipment and controls are correct and secure.
6	Ensure power is on to the machine and the HMI is visible and responding.
7	Check oil levels on the compressor and oil receiver.
8	Ensure the CO2 pressure corresponds to pressure after filling.
9	Ensure all valves are in the correct position.
10	Ensure the process can accept the output from the DCT-1
11	Ensure the water lines have been bled of air.
12	Ensure the process is providing flow to the hot & cold water circuit.
13	Ensure the electrical control valves are in the correct position for starting.
14	There will be under pressure and temperature alarms when not running.

9.6. Initial Start up

Before start-up, make sure that the following conditions are met:

- Verify that the installation has been performed according to the manufacturer's instructions, including the instructions in this manual.
- No persons, other than the start-up personnel, should be present.
- No persons must be in any hazardous area.
- Proper safety equipment and clothing must be used for all work performed on the Heat Pump.

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Check	Description
1	Ensure all pre-start checks have been done as detailed in section 9.5.
2	Install service gauges to the suction and discharge of the compressor.
3	If power is not on put it on by following the Power up Sequence in section 6.5.1
4	Ensure the system healthy lamp is on and the machine is reset.
5	Ensure that there is flow on both the hot and cold water circuits and no alarms are present.
6	Set the control location to local.
7	Before starting the compressor ensure the service gauges are visible and the personnel monitoring them has immediate access to the Emergency stop.
8	Start the compressor by following the Compressor Start Stop Sequence in section 6.5.4
9	Observe operation and ensure functionality is correct.

If operation is correct and the installation and commissioning engineer is satisfied with the install and performance. Remove the service gauges and complete the commission record.

Refrigerant at rest after first fill	Pressure (bar)	Temperature (°C)

Commissioning Engineer to sign to show completion of commissioning	Name	Signature	Date

10. Maintenance

This section provides guides, records and requirements for maintenance.

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10.1. Safety

For safety information retaining to Maintenance refer to section 3 and be aware of applicable safety regulations.

10.2. Filling with CO2

All CO2 entering the system must be weighed and recorded in section 10.4 It is the participants of this activity responsibility to ensure all equipment used in the filling process is fit for purpose, used correctly and appropriate risk assessments are in place.

Good records must be kept of the gas weight in order to know how much gas is in the system. Filling from zero is the only way to know the actual weight. Gas weight can be added. If gas is released from the system then the actual weight becomes unknown and can only be estimated. The pressure in the system is not an indicator of weight of CO2.

STEP 1

Step 1 is to connect the vapor CO2 via valve HA-604 on the liquid receiver. Ensure control valves CV-600 and CV-620 are open in the start up position. Ensure HA-601 and HA-607 on the compressor are fully open isolating the service port and allowing flow to the compressor.

STEP 2

Install service gauge set to valve HA-607 on the compressor and crack the valve HA-607 to open the service port but still allow flow to the compressor.

STEP 3

Open valve HA-604 and then slowly allow vapor CO2 to enter the system. The goal of this step is to raise the pressure in the system so that when the main high pressure bottle of CO2 is connected the pressure drop is not so high to prevent dry ice forming and inhibiting the filling. There is not exact amount of CO2 required at this stage but the pressure should be raised more than 100 psi.

STEP 4

Close valve HA-604 and swap the vapor bottle over to the liquid bottle of CO2. Open HA-604 and slowly open the bottle allow CO2 to enter the system. Monitor the weight of CO2 that has entered the system. This value will slow then stop rising as the bottle and the system start to balance. Once progress of achieving the required mass of CO2 is slow move on to step 5.

STEP 5

Close Valve HA-604. Remove the CO2 bottle and connect to the service gauge set. Run the compressor. This will have the effect of reducing the pressure on the suction side of the system allowing the bottle to provide more CO2. It may be required to get a new bottle if the required mass of CO2 is not reached.

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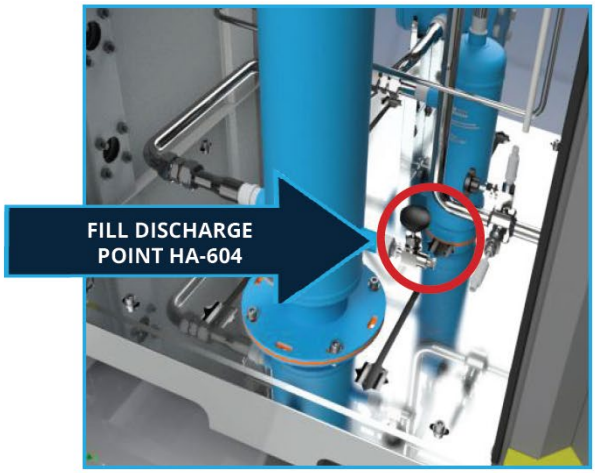
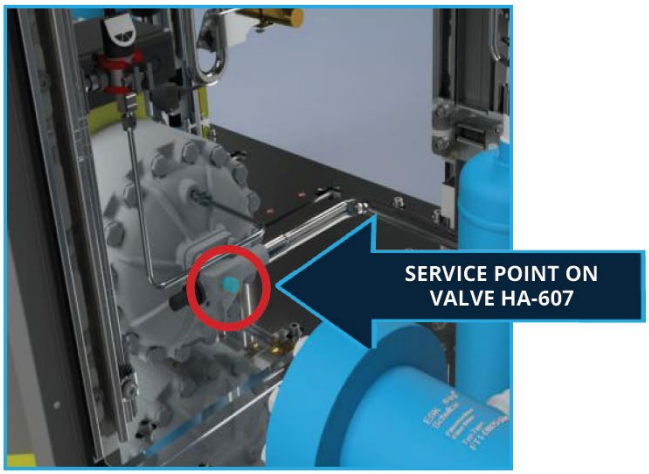
STEP 6

Once desired mass of CO2 is reached isolate bottles and fully open HA607 and remove service set.





Initial total required refrigerant is 35.7 lb to 50 lb.

During this procedure the operation of the compressor shall be monitored, and details recorded of all its mechanical and electrical operating parameters. It shall be shut off if any signs of abnormal operation are seen or heard. Extra care shall be taken until there is an adequate charge of carbon dioxide in the system as the compressor could be operating outside its normal range of temperatures and pressures. The system shall not be left unattended during the charging process.

Carbon dioxide containers should be disconnected as soon as charging is completed.

10.3. Discharging CO2

CO2 removal shall be carried out by competent persons. CO2 refrigerant need not be recovered but any release to atmosphere shall be done in a safe manner. If, for any reason, it is decided to recover carbon dioxide refrigerant the refrigerant shall be recovered into a recovery cylinder dedicated for carbon dioxide Be aware that any CO2 recovered will have oil suspended in it. Containers provided for the supply of new refrigerant shall not be employed as containers for used refrigerant without the prior written consent of their owners since this may lead to contamination of the containers. These containers are not designed to accept CO2 as they have dip tubes.

The hazardous waste regulations apply to all recovered refrigerant transferred from site.

It is recommended to discharge gas via valve HA-604 (ref section 4.8). Attention must be taken when discharging to the location and surroundings. If in an indoor environment it will generally always be required to direct the discharge gas outside. Refer to section 8 for further information.

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10.4. CO2 Inventory Record

The quantity of CO2 within the system is required to be logged along with the reasons for filling and removing gas. The table below is to be used to keep record of the CO2 in the system.

Machine Serial No.				
Source of Gas	**Gas Added (kg)**	**Gas Removed (kg)**	**Reason for Addition / Subtraction**	**Date / Time**

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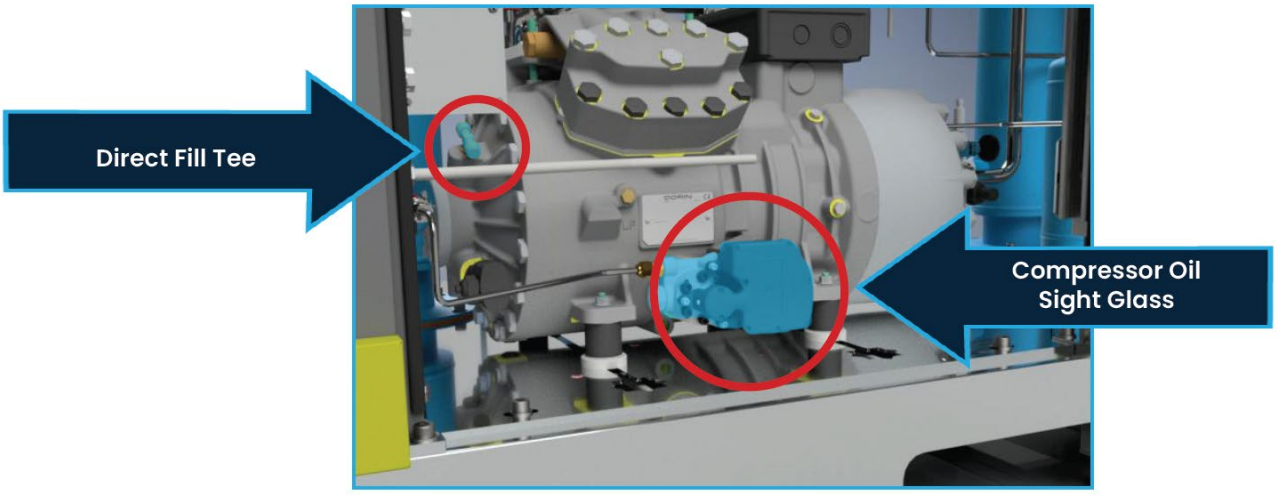
10.5. Filling with oil

The system requires two sections to be filled with oil when filling. The compressor and the oil receiver require to have a visible level of oil. The volume and type of oil required for both sections is detailed in section 4.4.2.

The compressor can be filled directly or via the oil receiver. When filling directly utilize the tee piece on the compressor oil pump. One of the runs of the tee has a Schrader valve to allow filling without degassing the system. The other is just a blanked connection therefore care must be taken when taking the caps off the tee. There is a noticeable difference between the blanking cap and the Schrader cap. The schrader cap is of noticeably lighter duty.



If the compressor oil level is to be filled via the oil receiver firstly the oil receiver must be filled. To enable filling from the receiver valve XV-410 must be manually opened with the use of a permanent magnet. The fill process can be slow if there is no refrigerant in the system. The compressor is considered adequately full once the level is above the 1/3 height on the sight glass. Ensure when filling to not over fill. The sight glass should never be full.

The receiver is filled via valve HA-401 (ref Section 4.8) which has a ¼" NPT female connection. If filling the receiver when a refrigerant charge is present it may be very difficult to fill due to having to work against the refrigerant charge. The receiver can be isolated at valve HA-400 and HA-402. Once the receiver is isolated the refrigerant in the receiver then can be vented via HA-401 which will ease the filling process. Important not to let out all the refrigerant from the receiver and refer to section 10.3 for discharging gas.

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10.6. Draining Oil

Draining oil from the system should only be done when there is no pressurized refrigerant in the system.

The compressor can be drained via the sump plug on the side of the compressor.

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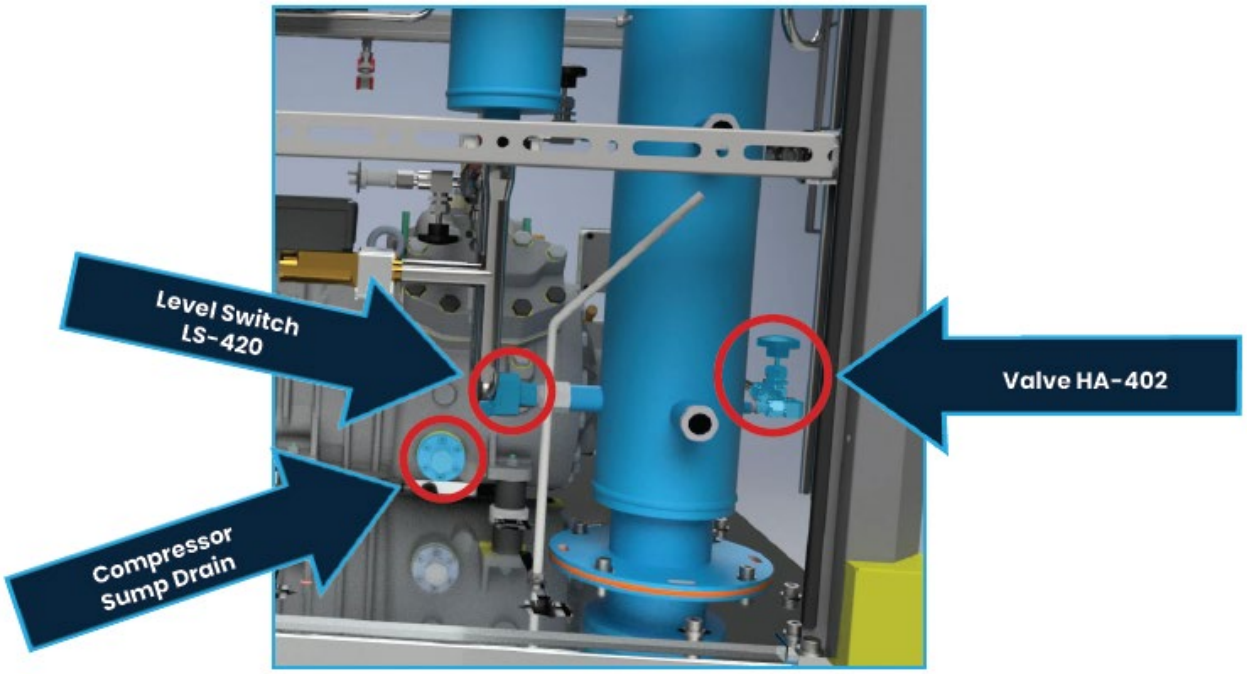

The receiver can either be drained with the removal of level switch LS-420 or via Valve HA-402 once the oil filter OX-400 is removed. Note there will always be a small quantity of oil left in the receiver when draining this way.

When draining oil all oil must be collected and disposed of correctly in a safe manner. See local regulation for disposal requirements. Be aware of any risk the oil in use may have by referring to the MSD for the that oil.

Machine Serial No.				
Oil Type / Brand	**Oil Added (L)**	**Oil Removed (L)**	**Reason for Addition / Subtraction**	**Date / Time**

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10.7. Maintenance Schedule

DCT-1 is designed to require minimal user maintenance. The owner of the machine is required undertake regular level and performance checks out lined in the Routine inspection column of the maintenance schedule.

The units should be subject to a full-service shutdown at least annually with replacement of refrigerant and compressor oil, filter cleaning/replacement, relief valves testing/replacement and recommissioning. This process is detailed in the Major inspection column of the schedule and is required to be undertaken by the manufacture.

The following schedule outlines inspection task and recommended intervals for undertaking these. The inspection tasks are considered preventive maintenance and will ensure safe and trouble-free operation.

Item	Major Inspection	Routine Inspection	Schedule including Rectifying faults as necessary
System	Annually	Weekly	Check for correct refrigerant charge including liquid levels.
		Weekly	Check and record operating pressures and temperatures and compare with commission log and CO2 inventory record for significant deviations.
		Monthly	Leak test system with CO2 Gas sniffer.

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		Weekly	Check oil levels on the oil receiver sight glass. Record oil added or removed.
		Quarterly	Examine all control and isolating valve for full/free travel, check for leakage.
			Replace oil separator coalescence filter element.
			Replace oil filter.
			Replace CO2 filter drier element.
Pipework	Annually	Weekly	Check for undue Vibration, rectify as necessary.
		Quarterly	Inspect for damaged insulation, rectify as necessary.
		Quarterly	Inspect for evidence of leaks at joint locations, rectify as necessary.
		Quarterly	Inspect pipework for corrosion, rectify as necessary.
Compressor	Annually	Weekly	Inspect for evidence of oil leakage.
		Weekly	Check oil levels on compressor sight glass.
		Monthly	Check joints and connections for tightness.
		Quarterly	Check and ensure correct operation of crankcase heater.
		Quarterly	Check condition of anti-vibration mounting & holding down bolts.
		Quarterly	Examine for undue noise, vibration or overheating.
			Change oil or as recommended by manufacture.
		Annually	Sample oil ensure cleanliness is high and water content is low.
			Check starting sequence.
Valves	Annually	Quarterly	Inspect for evidence of leakage.

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Pressure Switches	Annually		Check settings and operation.
Relief device indicator	Annually	Weekly	Check if over pressurization has occurred.
Relief device indicator	Annually	Quarterly	Check that venting is clear and directed to a safe location.
Electrical Control Panel	Annually	Quarterly	Visually check condition, including signs of overheating, of all components. Repair or replace as necessary.
			Check tightness of all terminals.
Electrical enclosures	Annually	Annually	Check integrity to seals of components.
Cable running Process equipment section	Annually	Quarterly	Check for damage and ensure they are secure and not touching any surfaces subject non ambient temperatures.
CO2 Relief valves venting to atmosphere		Quarterly	Visual inspection of device.
	Annually		Replace or, as stated in PSSR writing scheme of examination.
	Every 5 Years		Replace.

11. Faults

In the following chapter, Symptoms of malfunction of the Heat Pump are described as well as potential causes allowing effective trouble shooting of issues. If the frequency of faults and/or malfunctions increases, shorten the maintenance intervals accordingly.

For questions regarding problems that cannot be solved using the information below, contact the manufacturer.

11.1. Safety

For safety information retaining to trouble shooting faults refer to section 3 and be aware of applicable safety regulations.

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11.2. Fault Indications

The control system will indicate when it recognizes a fault, or the system has entered into a fault condition.

The indication is show on the Fault Indication Lamp and on the HMI if applicable. See “user interface” section for further information.

The system has three states of fault named OP1, OP2 & OP3. These states represent the condition the system will be put into if a fault is detected. The different states have been devised to react appropriately depending on the fault. As some faults may only merit a warning where other require the machine to shut down. Further information can be found in the Alarm & Trip List.

11.2.1. Shut down & Warning Sequences

When a fault is detected, the system will be run one of the two sequences to put the system into a fault state.

OP.1

- Compressor OFF.
- Control Valves Reset.
- HMI Screen Alarm + Audible Sounder.
- Flashing System Fault Lamp Front Console.

OP.2

- HMI Screen Alarm + LED + Audible Sounder.
- System remains Operational.

11.2.2. Alarm list and Potential cause

The alarm list below lists all the potential alarms that can come from a DCT-1 and details potential cause of to allow for fault finding. It is essential that if an alarm is trigged that the cause of the alarm is dealt with before resuming operations.

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Alarm Tag	Alarm Description	Warning Sequence	Potential Causes
S900	Emergency Stop activated	OP1	E-Stop engaged
PAL660	Compressor Oil Pump Delta Pressure	OP1	Cold Oil Temperature
			Low Oil Level
TAHH620	Compressor Thermistor	OP1	Compressor motor over heating
PALL 600	Suction Low Pressure	OP1	Loss of refrigerant
			Abnormal operating conditions
PAHH650	Discharge High Pressure	OP1	High levels of superheat
			Over filled with refrigerant
			Undesired restriction upstream
LAL420	Low Level Oil in Oil Receiver	OP2	Oil has been passed into the system past the oil separator
			Oil has leaked from the system
VFD FAULT	Error with the VFD	OP1	Failure of the VFD
F301	Crank Case Heater MCB Trip	OP2	Crank Case heater failure
F200	AC Control Supply MCB Trip	OP1	Power surge
F304	Extractor Fan MCB Trip	OP2	Locked rotor on Fan
VAL300	Incoming Power Phase Fail	OP1	Blown Fuse or Tripped circuit breaker up stream of the machine
Q200	Compressor Trip	OP1	Compressor Electrical issue
LAL410	Compressor Oil Level Low	OP1	Oil leak
			Low oil in oil receiver
			Faulty Oil regulator
LAH400	Oil Separator Low level	OP2	No either being separated or no oil transferred from the compressor

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Alarm Tag	Alarm Description	Warning Sequence	Potential Causes
LAH400	Oil Separator High level	OP1	Faulty solenoid Valve on receiver
F302	Cooler Fan DC Trip	OP2	Electrical Fault on the Fan
F303	DC Supply Trip	OP2	Electrical Fault with DC supply
FL200	Hot Water Low Flow	OP1	No supply coming from Process
			Isolation valve closed
			Blocked heat exchanger
FAL300	Cold Water Low Flow	OP1	No supply coming from Process
			Isolation valve closed
			Blocked heat exchanger
TAH2100	Electrical Enclosure High Temperature	OP2	Enclosure Fan failure
			Operating in too High an ambient temperature
TAH650	High Compressor Discharge Temperature	OP1	Excessive superheat returning to the compressor
TAH210	High Temperature Hot Water	OP2	Low Flow on Hot water system
			Excessive superheat returning to the compressor
TAH300	High Return Temperature on Cold Water	OP2	Error in application process
TAH320	High Return Temperature on Cold Water	OP2	System capacity reached
			Cold Return Temp too high
TAH200	High Hot Water return Temperature	OP1	Error in application process
TAH640	High Gas Cooler Exit Temperature	OP1	Gas cooler performance deteriorated
			High hot water return temperatures

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TAL400	Low Compressor Oil temperature	OP1	Crank case not working
			Excessively cold ambient temperatures
TAH400	High Compressor Oil Temperature	OP1	Excessively high discharge gas temperature
			Crank case heater operating when undesired
TAL600	Low Compressor Suction Temperature	OP1	Evaporating at to low a pressure
			Low flow on the cold water circuit
			Low flow on the cold water circuit
PAL300	Low Cold Water Return Pressure	OP1	Error in application process
DPAH300	High Delta Pressure over Evaporator	OP2	Restriction to flow through the heat exchanger
DPAHH300	High Delta Pressure over Evaporator	OP1	Excessive restriction to flow through the heat exchanger
DPAH200	High Delta Pressure over Gas Cooler	OP2	Restriction to flow through the heat exchanger
DPAHH200	High Delta Pressure over Gas Cooler	OP1	Excessive restriction to flow through the heat exchanger
PAL200	Low Hot Water Return Pressure	OP1	Error in application process
PAH640	High Gas Cooler Pressure	OP2	Control valve CV600 not controlling pressure correctly
PAL620	Low Evaporator Discharge Pressure	OP1	Control valve CV600 not controlling pressure correctly
PAH630	High Liquid Receiver Pressure	OP1	Control valve CV600 not controlling pressure correctly
PAL600	Low Compressor Suction Pressure	OP1	Control valve CV600 not controlling pressure correctly
PAH650	High Compressor Discharge Pressure	OP1	Control valve CV600 not controlling pressure correctly
			Obstruction in Oil Separator

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11.3. Fault Symptoms, Potential Causes

Component	Symptom	Potential Causes
Overall System	**Loss of Performance**	Loss of CO2
		Low flow on the Hot and Cold circuits
		Control Overrides are initiated
		Heat Exchangers efficiency reduction
		Hot water circuit return returning too hot
		Compressor not operating correctly
Overall System	**Will not Star**	Incoming power supply is off
		Isolator on control console is off
		Emergency stop is active
		Key switch not in the position for the controls in uses
		Variable Speed Drive in fault
		PLC communication Loss
		Safety Circuit engaged, caused by either breaker, phase error, high/low CO2 pressure & E-Stop
		Hot water pump will not start
		Oil level too low or high
		Low pressure on CO2 circuit

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Component	Symptom	Potential Causes
		Fault on oil sensor
		No flow on hot or cold circuits
Overall System	Cutting out Repeatedly	Loss of Phase
		Control setting for cut in and cut out engaged
		Control overrides engaged
		Control override settings not appropriate
Overall System	False Alarms	Faulty Sensor
		Bad electrical contacts
Overall System	Electrical Cabinet over heating	Excessive electrical Load
		Cable wear
Overall System	Formation of Ice	Low cooling water flow
		CV-120 operating incorrectly
		Lack of anti-freeze in cooling medium
Overall System	Production of Steam	Low hot water flow
		CV-100 operating incorrectly
		VFD operating incorrectly

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Component	Symptom	Potential Causes
Compressor	Over Heating	Lack of Oil
		Bad electrical contacts
		Internal compressor fault
		CV-100, CV-120 operating incorrectly
		VFD operating incorrectly
		Loss of phase
		Hot gas returning to compressor suction
Compressor	Excessive Noise & Vibration	Internal damage
		Anti-vibration pads damaged
		Lack of or excessive Oil
		Liquid returning to compressor
		Not secured correctly
Compressor	Not Starting	Motor is burnt out
		Lack of power
		Mechanically locked
Pump	Low Flow	Internal damage
		Supply restricted
		Incorrect rotation direction

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Component	Symptom	Potential Causes
Pump	Excessive Noise & Vibration	Internal damage
		Not secured correctly
		Supply restricted
Pump	Not Starting	Motor is burnt out
		Lack of power
		Mechanically locked
Air blast Cooler	Excessive Noise & Vibration	Damage to fan
		Not secured correctly
Air blast Cooler	Low Efficiency	Radiator blocked externally or internally
		Fan not operating
Air blast Cooler	Not Starting	Motor is burnt out
		Lack of power
		Mechanically locked

11.5. Start-Up After Problem Correction

Improper start-up can result in serious injury or loss of life!

Do not start up the Heat Pump if the problem that caused the fault has not been eliminated.

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After the problem that caused the fault has been eliminated, the following steps are to be taken to start up the Heat Pump:

- Make sure that the emergency stop is deactivated.
- Make sure that no persons are present in areas that present hazards.
- Start-up according to instructions in section 6 “Operation and Controls“.

12. Dismantling and Disposal

When the Heat Pump has reached the end of its useful life, it must be dismantled and disposed of in an environmentally friendly manner.

- Improper dismantling can result in danger of serious injury or loss of life!
- Have the dismantling performed exclusively by specialists of the manufacturer.
- When re-locating the Heat Pump, consult the manufacturer.

12.1. Safety

For safety information retaining to dismantling refer to section 3 and be aware of applicable safety regulations.

12.2. Dismantling

The system must be in a position where it will not present any hazards to personnel or to the environment before dismantling.

To ensure the system will not present any hazards there should be no pressure in the heating, cooling, refrigerant, and oil circuit. The afore mention circuit should all be drained or vented. The system should be isolated and disconnected from electrical and data sources.

Ensure all applicable laws and regulations are compiled too when venting and draining gases and liquids. Recycle as appropriate.

Professionally clean all components and assemblies and disassemble them as appropriate. Observe all applicable laws and regulations regarding workers’ safety and environmental protection.

12.3. Disposal

If a return agreement with the manufacturer has been entered into with the operator, return the complete Heat Pump. Take appropriate precautions to avoid leaks during transportation. Otherwise recycle supplies, components, and assemblies as appropriate.

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13. Spare Parts List

Type	Name	Part Number	Description
Oil Filter / Level	Oil Separator Filter	FK3-25 FEP-90-250-56-SO	Coalescing filter element
	Filter Drier Solid Core		Filter Drier Solid Core
	Supply Fuse	LPJ-125SP	CLASS J FUSE, TIME DELAY, 125A
	Non Latching Relay	G2RV-SR500 DC24	24V DC NON LATCHING, 6A SWITCHING
	Non Latching Relay	RIBRL1C-NS	24VDC NON LATCHING, 10A SPDT 10-30VAC/DC
	Safety Relay	SENTRY SSR10	24VDC, SINGLE/DUAL CHANNEL 3NO+1NC
Fuses/Relays	Fuse	FNQ-R-7-1/2	7.5A TIME DELAY FUSE
	MCB	M9F22206	MULTI9-C60SP-2P-10A-C-CURVE
	Fuse	LP-CC-10	10A TIME DELAY FUSE
	Fuse	M9F22202	MULTI9-C60SP-2P-2A-C-CURVE
	Relay	20.21.8.230.0000	LATCHING MODULAR STEP RELAY, 16A SWITCH
	Communication Module	CM 1241 RS422/485 - 6ES7241-1CH32-0XB0 S7-1200, CPU 1215C	PLC communication module
PLC/CPU	CPU	DC/DC/DC - 6ES7215-1AG40-0XB0	Central Processing Unit
	Signal Module	SM 1232 AA - 6ES7232-4HD32-0XB0	Analogue Signal Output Module
	Signal Module	SM 1223 DC/DC - 6ES7223-1BL32-0XB0	Digital Signal Output Module

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