EcoChill Nxt

Direct Fired Vapor Absorption Chiller

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Company Profile

Thermax is an engineering major providing energy-environment solutions, systems and products in global markets. The US $ 490 million Thermax is featured in the Forbes List of 'Best Under a Billion' Companies in the Asia Pacific. It offers business - to - business solutions to industrial and commercial establishments in the areas of heating, cooling, captive power, water treatment, air pollution control, waste management & resource recovery, and chemicals. It supports a wide spectrum of industry in over 50 countries in South East Asia and Japan, Africa and Middle East, CIS countries, USA, South America and Europe.
In the energy business, Thermax executes projects in the areas of process heat, captive power and waste heat recovery. The company also offers a range of boilers and thermal oil heaters, energy efficient chillers and customized products such as waste heat and exhaust gas boilers. Thermax's integrated expertise in energy has helped it to offer its customers Combined Heating Power and Cooling (CHPC) projects.

Thermax offers industry its expertise over a hundred fuels - oil, gas and a wide variety of solid fuels including biomass. Through diverse installations in several countries, it has also developed reliable project management capabilities.

Leveraging its leadership position in electricity saving vapour absorption technology, Thermax offers process industries and commercial establishments like hotels, shopping malls and offices vapor absorption machines a boon in power-starved areas. These eco-friendly, energy efficient equipments have found prestigious customers such as BBC, Mercedes Benz, Audi, Bosch, Panasonic, and Henry Ford Museum.

In the environment area, Thermax offers waste management expertise for solid, liquid and air pollution. Thermax provides solutions from pre-treatment to waste water treatment and chemical conditioning of water for boiler and cooling water systems. Water recycling is a thrust area for Thermax. Hi-grade ion exchange resins from Thermax have found niche customers in the US and Japanese markets.

Thermax has an extensive international marketing network. Headquartered in Pune (Western India), Thermax's 17 international offices are located in South East Asia, Middle East, Africa, Russia, UK and the US. Its overseas subsidiaries - Thermax Europe Ltd (UK) and Thermax Inc (USA) play a significant role in business development. The Thermax group's manufacturing facilities spread over 14 plants, measuring a covered area of over 700,000 sq. ft, are ISO 9001, ISO 14001 and OHSAS 18001 accredited. Thermax manufactures to international standards like ASME, BS, DIN, and GOST. Lloyds, Bureau Veritas, SGS, and TUV have inspected the facilities.

Thermax's business is inspired by the conviction that 'Improving your business is our business.'

Introduction

Refrigeration is a process of extracting heat from a low temperature medium and transferring it to a high temperature heat sink. Refrigeration maintains the temperature of the heat source below that of its surroundings while transferring the extracted heat to a heat sink. This operation finds applications in many industries ranging from process, engineering, manufacturing, medical, dairy and confectionery, to beverage, hospitality, education and commercial establishments.

Absorption chillers, instead of using electricity (high grade energy), use heat as energy source which is low grade energy. The energy source may be gas or oil, or hot water, or it may be waste heat as in exhaust gas from an engine and steam. Thermax offers a wide range of solutions for each of these sources of energy, representing a major advance in Absorption Chilling Technology. EcoChill Nxt Vapour Absorption Chillers derive energy from gas (Natural gas, LPG, CNG), light oil (HSD, naphtha, SKO) or medium oil (LDO, FO) to provide the desired chilling-heating effect. The Direct Fired

EcoChill Nxt Chillers and Heaters are available from 100 - 1110 USRT and can achieve chilled water temperature down to 38^{O}F.

The EcoChill Nxt Series product range represents a culmination of Thermax's global expertise in energy and environment, continuous innovation through focused Research and Development, world-class manufacturing capabilities, efficient and responsive service and a deep commitment to quality and reliability. Testimony to this is provided by over 2500 installations in the last 15 years across 40 countries, appreciation from our customers and several prestigious awards and honors.

Salient features of EcoChill Nxt

- **Series flow** In series flow cycle, maximum concentration and maximum temperature do not occur simultaneously in any generator. In other cycles, maximum concentration and maximum temperature occur simultaneously in the High Temperature Generator (HTG). Corrosion rates depend on concentration and temperature. However, when highest concentration and temperature occur simultaneously, corrosion potential increases exponentially. The table below gives approximate values of concentration and temperature in High Temperature Generator (HTG) and Low Temperature Generator (LTG) for various cycles.

Cycle	High Temperature Generator		Low Temperature Generator	
	Concentration (%)	Temperature (^{0}F)	Concentration (%)	Temperature (^{0}F)
Series flow	61	< 320	64	<212
Para flow	64 or more	> 320	61- 62	< 212
Reverse flow	64 or more	>320	61- 62	< 212

Thus, due to series flow cycle, the corrosion rate is the least in Thermax chillers.

- **Concentration display and measurement:** Concentration in absorption chiller is analogous to current in electric motor. Motor meets higher load by drawing more current. Similarly, absorption chiller meets higher load by attaining higher concentration. However, when motor draws current more than it's rated limits, it may burn. Similarly, in an absorption chiller, if concentration increases beyond rated value, the chiller crystallizes. Hence, continuously knowing

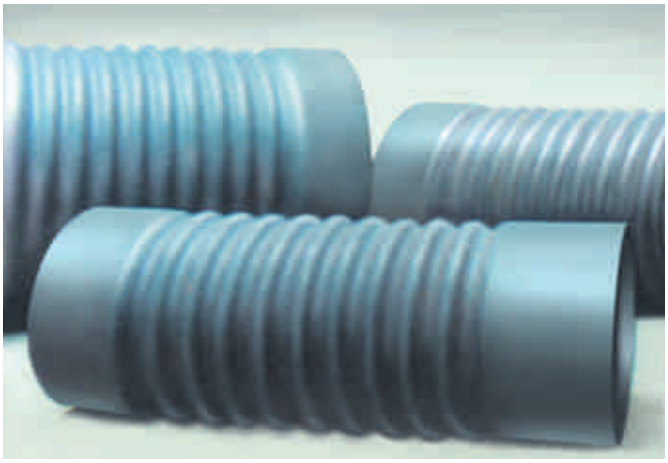
the Lithium Bromide concentration is as important as knowing the current drawn by motor. Thermax has developed and offers a unique technology to determine the **concentration, which is continuously displayed on the PLC.**

- **Crystallization protection:** Due to the unique feature of determining concentration and knowing temperature of Lithium Bromide coming out from Low Temperature Heat Exchanger (LTHE), an **intelligent PLC** constantly **monitors the distance from crystallization line.** If this distance is reduced below 18 ^{0}F, the PLC proactively takes suitable measures to restore it to 18 ^{0}F. In other chillers, crystallization prevention measures are taken after inception of crystallization. However, due to advanced technology and intelligent panel, Thermax chillers take suitable measures before Lithium Bromide approaches crystallization.

- **Low Cooling Water Supply Temperature without crystallization:** Due to sophisticated crystallization protection, Thermax absorption chillers can work at rated capacity even with cooling water supply temperature of 50 ^{0}F while most of the other manufacturers require cooling water supply temperature of 68 ^{0}F or above.

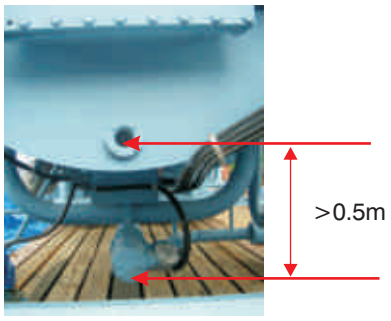
- **Multi-fuel capability:** The generator design is such that the chiller can handle gaseous fuels as well as liquid fuels.

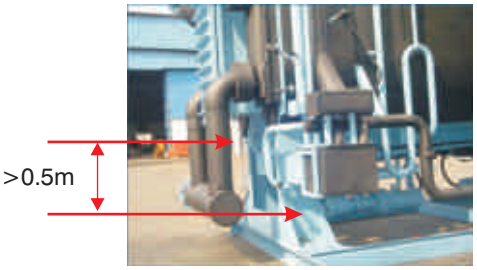
- In the Direct-fired chiller, furnace is welded to the chiller frame. When the chiller is started and reaches its capacity, the furnace metal temperature increases. Such increase in temperature is likely to cause expansion in the furnace length. Since structural members restrict the furnace, compressional stresses are developed in the furnace body and in the members supporting the furnace. For lower models, furnace length is small. Therefore, forces restricting expansion are small and hence stresses are low so that they can be easily borne by steel. However, for higher models (frame size 60 and above), even though stresses developed in the furnace body are less than the ultimate tensile stress, over a period of time, parts can buckle under fatigue. To increase reliability and to ensure longer life, furnace of all models with frame size 60 and above, is corrugated type. Corrugated furnace acts like a bellow that neither generates nor passes on the stresses to other structural members.



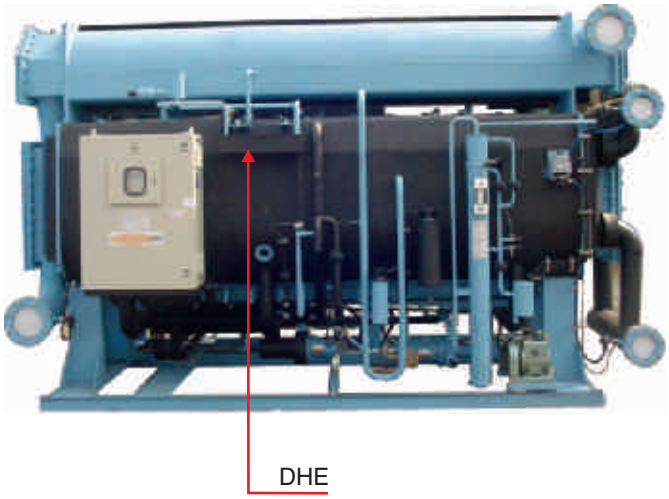
Corrugated furnace

- **Long Life:** For a capital equipment like Absorption Chiller, life expectancy is 20 years. Thermax Absorption Chillers are carefully **designed for long life**. For example, for **maintaining the required pump NPSH**, height of the chiller is never compromised. If NPSH is not maintained, life of the pump will be reduced. After many years of service, some parts like heat exchangers, pumps may require repair/replacement. During the repair/replacement, minimum cutting should be required so that exposure of the chiller internals to air will be limited thereby arresting corrosion. Hence, all **parts are deliberately kept accessible** for increased life of the chiller. If chiller is made over compact, initially some space advantage can be derived but such advantage will be lost to life reduction later.



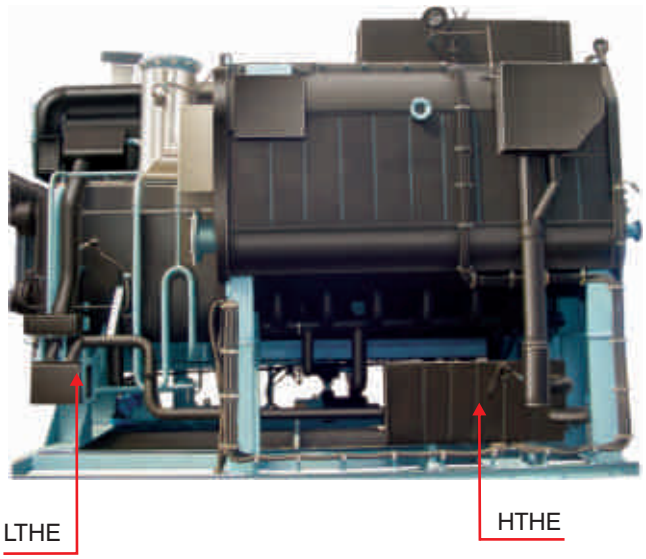


NPSH (R) maintained



Easy access to all parts of the chiller

Adjoining pictures (front and rear side of chiller) show easy access to Low Temperature Heat Exchanger (LTHE), Drain Heat Exchanger (DHE), and High Temperature Heat Exchanger (HTHE).

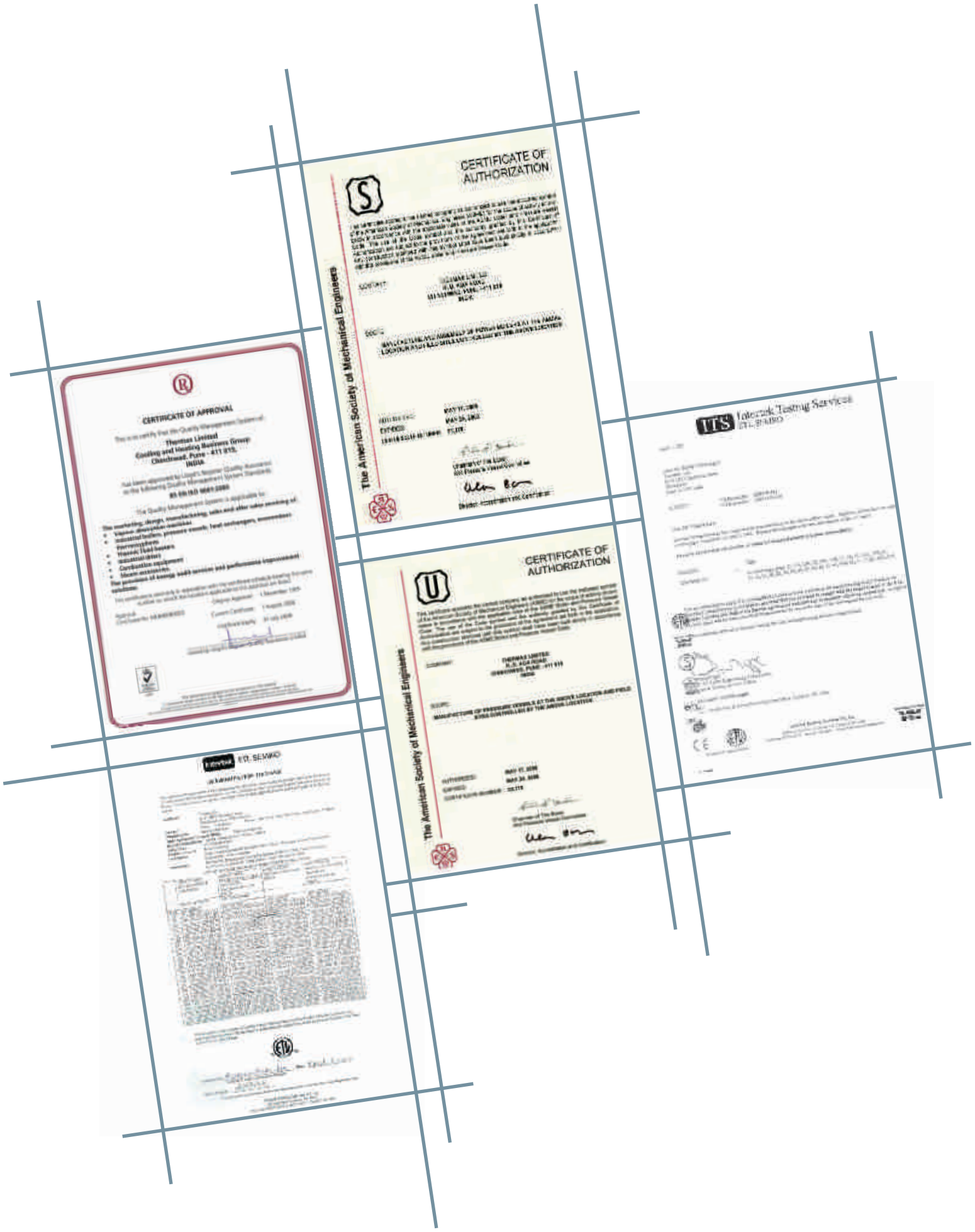


- **Isolation valves** are provided on the pumps, facilitating on-line pump maintenance without any loss of vacuum in the system due to the exposure to air.
- **Double protection,** in terms of differential pressure switch and flow switch, is provided for freeze protection.
- **Choices for part load operation:** User can select a chiller with modulating type burner or staged burner.
- **Thermally efficient cycle:** Efficient heat utilization within the system reduces energy consumption and improves overall system efficiency.
- **Gravity feed system:** Gravity feed of refrigerant and absorbent enhances heat transfer efficiency and overcomes the problems of wear and tear and clogging of nozzles, which use pressurized spraying techniques.
- **PLC based control** panel, user-friendly interface and data-logging system ensure easy and smooth operations. Branded PLC enhances reliability of the chiller.
- **Effective corrosion inhibitors:** The corrosion inhibitor minimizes the rate of copper and ferrous metal corrosion on the solution side of the unit. The corrosion inhibitor used - Lithium Molybdate - is non-toxic and does not generate ammonia, thus protecting the copper tubes in the chiller. Use of Lithium Molybdate is more effective than conventionally used corrosion inhibitors.
- Factory mounted **on-line purging system** maintains low vacuum in the shell and ensures consistent performance. Any non-condensable gas, generated inside the chiller during operation, is purged continuously into the storage tank, thus eliminating the need for a replaceable palladium cell. Moreover, as peak concentration and temperature do not occur simultaneously, corrosion rates are low, thereby enabling a small purge tank.
- **Rupture disc** is provided for protection against generation of high pressure inside the chiller.
- **Constructional features,** such as side exit nozzles, provide ease of maintenance and ensure lower downtime. Hinged absorber and condenser headers provide easy access to the tube bundle, eliminating the need for heavy lifting arrangements. Crossover piping is factory installed, to avoid work at site.
- **Optional features** include VFD control for part load conditions, standby canned motor pumps, flameproof construction, high pressure headers,

online bearing monitoring, special tube material for Evaporator, Absorber and Condenser, depending on the available water quality, multi-sectional shipment and 'Factory Performance Test'.

- **Service:** A global network, powered by over 100 highly trained service personnel, ensures quick response and delivers the right solution to customers. Also on offer are value-added services such as 'e-reach' - remote access for chillers, preventive maintenance contracts, operations and manning and localized customer training programs.

Certificates


CERTIFICATE OF AUTHORIZATION
The American Society of Mechanical Engineers
CERTIFICATE OF AUTHORIZATION
The American Society of Mechanical Engineers
TTS Tolerark Testing Services

Working Principle

The boiling point of water is directly proportional to pressure. At atmospheric pressure, water boils at 212°F. At a lower pressure, it boils at a lower temperature. At 0.24 inch Hg absolute pressure, the boiling point of water is 39°F.

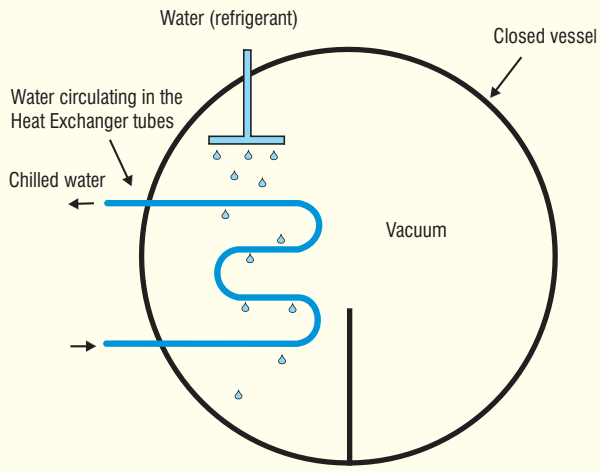
To change water from liquid to vapor it has to be heated. The water absorbs the applied heat and its temperature starts rising, until it reaches the boiling point. At boiling point, the temperature remains constant but liquid water vaporizes. The heat required to change the phase of a liquid to vapor is called the 'Latent heat of Vaporization'. Similarly the heat rejected by the vapors during condensation is called the 'Latent Heat of Condensation'.

For the LiBr - water system, the absorption varies directly in proportion with the solution concentration and inversely with the solution temperature. Lithium Bromide (LiBr) is a water soluble chemical, and LiBr - water solution (used as refrigerant) has an inherent property to absorb water due to its chemical affinity.

Also, there is a large difference between vapor pressure of LiBr and water. This means that when the LiBr water solution is heated, the water will vaporize but the LiBr will stay in the solution and become more concentrated.

Absorption Cycle Overview:

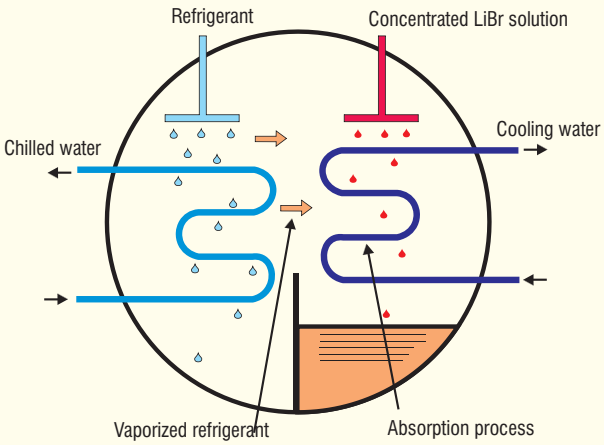
1



When maintained at high vacuum, water will boil and flash cool itself.

Absorption systems use heat energy to produce a refrigerating effect. In these systems the refrigerant, i.e. water, absorbs heat at a low temperature and low pressure during evaporation and releases heat at a high temperature and high pressure during condensation.

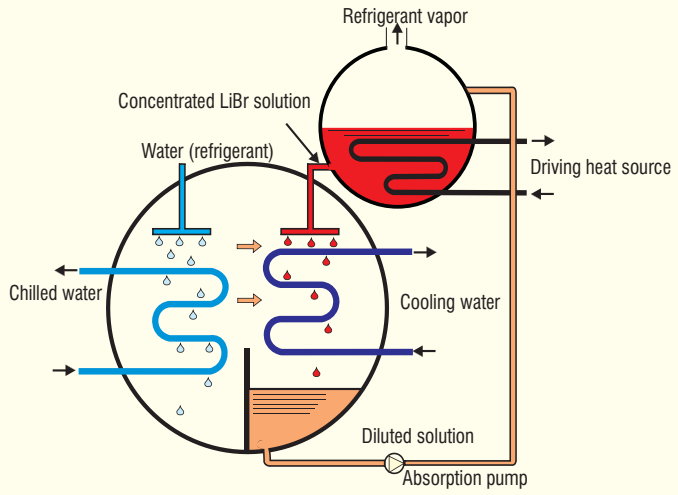
2



Concentrated Lthium Bromide solution has affinity towards water. The solutionAbsorbs vaporized refrigerant water.

LiBr solution, which acts as the absorbent, is used to absorb the vaporized refrigerant. The evaporation of the refrigerant takes place at a low pressure.

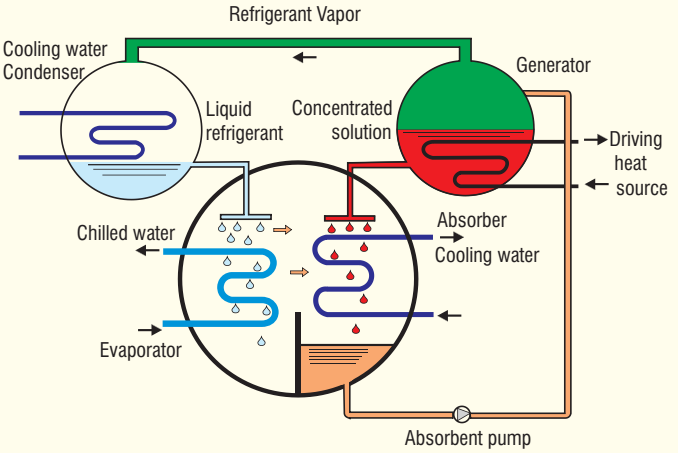
3



As Lithium Bromide becomes dilute it loses its capacity to absorb water vapor. It thus needs to be reconcentrated using a heat source.

The dilute solution, which contains the absorbed refrigerant vapor, is heated at a higher pressure.

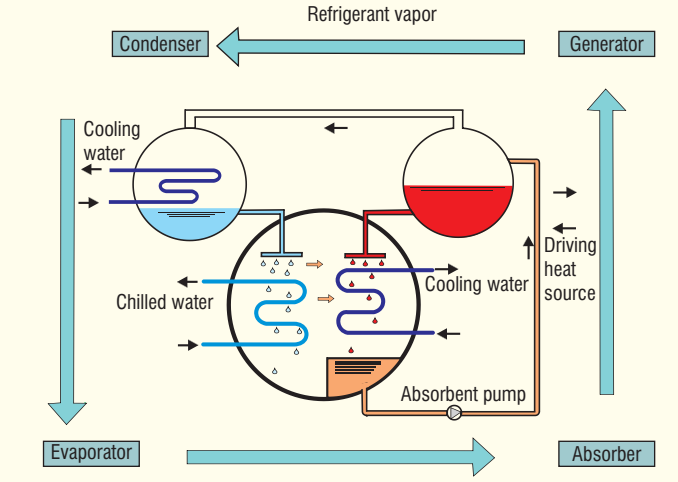
4



This heat causes the solution to release the absorbed refrigerant in vapor form. This vapor is cooled in a separate chamber to become liquid refrigerant.

This leads to the vaporization of the refrigerant and thus the solution is restored to its original concentration. The cycle keeps repeating itself to give the desired chilling effect. In a double effect absorption chiller, the latent heat of condensation, contained in the vaporized refrigerant, is used in a second stage generator to enhance the efficiency of the cycle.

5



The basic operation cycle of the single effect vapor absorption chiller.

The refrigerant goes through a series of processes to complete the refrigerating cycle. These are namely evaporation, absorption, pressurization, vaporization, condensation, throttling and expansion. During this cycle, the refrigerant absorbs heat from a low temperature heat source and releases it to a high temperature sink.

Design Philosophy

The design philosophy of Thermax Absorption Chillers is based on three important factors viz. reliability, energy consumption and ease of maintenance.

Reliability: While designing absorption chillers, two major problems have to be considered viz. corrosion and crystallization. Since corrosion is caused by temperature, concentration and leakages of Lithium Bromide, Thermax has carefully selected Series Flow Cycle (after manufacturing Series Flow, Parallel Flow and Reverse Flow Chillers) so that the highest temperature of Lithium Bromide is limited to less than 320°F and maximum concentration is limited to 64 %. A detailed comparison as tabulated on page 5 coupled with the features like Crystallization Protection and Concentration measurement and display, clearly shows that Thermax Chillers are reliable compared to the other Chillers.

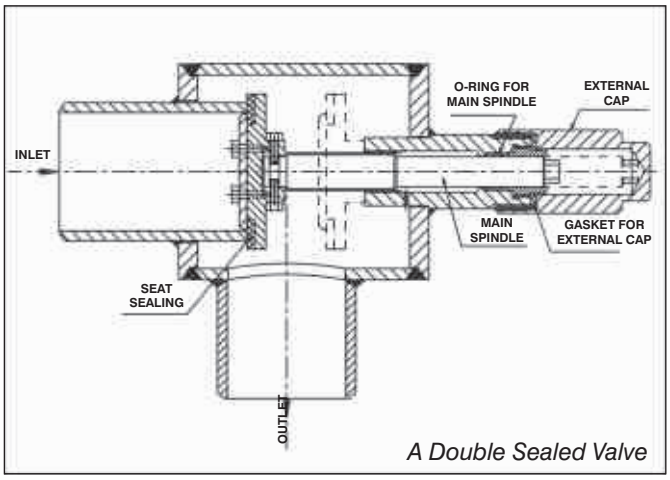
In the series flow cycle, crystallization can occur only in the Low Temperature Heat Exchanger, whereas in other cycles it can happen in both, the High Temperature Heat Exchangers and Low Temperature Heat Exchangers. It was discovered during the research, that the time taken to de-crystallize High Temperature Heat Exchanger was 10 times more than that taken to de-crystallize the Low Temperature Heat Exchanger. To eliminate the possibility of crystallization in the Low Temperature Heat Exchanger, ***the distance of state point from crystallization curve is continuously monitored***, and if the distance is less than the prescribed value, crystallization control takes over and performs suitable actions to prevent crystallization.

The normal method of sensing the high concentration from generator temperature has a flaw - it fails to work when it is most required. It is a well-known fact that the possibility of crystallization is more when the cooling water temperatures are low. At low cooling water temperatures, the generator pressure lowers and the boiling point curve shifts down. Thus, when the cooling water temperatures are low, the boiling temperature of Lithium Bromide does not reach the high temperature set point and becomes ineffective protection, even if high concentration is reached. When cooling water temperatures are normal, it works well but the possibility of crystallization is far less. Monitoring the distance from the crystallization line eliminates such flaws, enabling Thermax to design chillers which can even work at 50°F cooling water temperature.

Coefficient of Performance (COP): Today, Thermax chillers offer one of the best COPs.

Ease of maintenance: This is an important aspect of our design philosophy. Even after 5 years of use, absorption chillers require some ***small*** maintenance. So, if ease of maintenance is ignored in the design philosophy, this small maintenance can turn into ***big*** maintenance. In addition to the design features listed on pages 5 and 6, illustrated below are some more design features in Thermax chillers that play a role in making maintenance easy

- **Double sealed valves:** All isolating valves and service valves have a double seal. More importantly, the outer seal has no moving parts.
- **Use of branded components:** The Thermax philosophy makes it mandatory to use branded components. Some examples are PLC and Low Temperature Heat Exchangers. This is because while Thermax conducts exhaustive reliability tests on self made components, it still cannot match the years of research and experience put in by internationally reputed PLC or Plate Heat Exchanger manufacturers.



A Double Sealed Valve

- **Canned Motor Pump :** In Thermax Absorption Chillers, these pumps are in bolted construction (except for 20 frame, small chillers) so that if required, bearing and filters can be cleaned after few years of operation. In case of welded pumps, replacement of the entire pump is the only solution.

Bolted CANNED Motor Pump

Welded CANNED Motor Pump

What is a Canned Motor Pump?

CANNED motor pump is some times misinterpreted as a pump similar to hermetically sealed compressor of a window air-conditioner.

CANNED motor pump is a single unit of a pump and a motor, and has no shaft seal. Shaft seal is a moving joint and cannot pass through stringent helium leak test.

In the CANNED motor pump, the pumped liquid is used for cooling motor as well as lubrication of bearings. Hence, the pumped liquid enters the motor section, and in order to keep the liquid away from the motor coil and the rotor, the motor coil and the rotor are sealed with CANS, which are thin metal cylinders.

Bolted canned motor pump, bit costly though, offer advantage like replacement of parts, which may be needed after many years of service. Only non-moving parts are bolted and hence they offer excellent leak proof properties while offering maintainability simultaneously.

Refrigeration Cycle

The Direct Fired Vapor Absorption chiller functions in one of the following modes: Cooling mode, Heating mode or in both modes simultaneously.

Cooling Mode

Evaporator

The Evaporator consists of a tube bundle, an outer shell, distribution trays and a refrigerant pan.

A refrigerant pump is used to circulate the refrigerant from the refrigerant pan to the distribution trays. From these trays, the refrigerant falls on to the evaporator tubes.

The evaporator shell pressure is maintained at ~ 0.24 inch Hg (a). At this low pressure, the refrigerant evaporates at a low temperature of ~39°F (for its evaporation, the refrigerant extracts the required heat from the water which is circulated through the evaporator tubes). As a result, the water in the tubes becomes chilled.

Absorber

The Absorber consists of a tube bundle, an outer shell (common with the Evaporator) and distribution trays.

The Low Temperature Generator is housed in the upper shell, just above the Absorber. From the Low Temperature Generator, a concentrated absorbent solution is fed into the distribution trays, which fall on to the absorber tubes.

On the other hand, the vaporized refrigerant from the Evaporator is absorbed by the concentrated absorbent, leading to its dilution. Due to this absorption, the vacuum in the shell is maintained at a low pressure, leading to the desired chilled water temperature. During this process 'Heat of Dilution' is generated. This heat is removed by the cooling water circulating through the absorber tubes. As the absorbent solution loses its heat to the cooling water, it is able to absorb more refrigerant vapor, and gets further diluted. This diluted absorbent gets collected at the bottom of the shell.

Heat Exchangers

The dilute absorbent is pumped into the High Temperature Generator by the absorbent pump.

A part of it first passes through the Drain Heat Exchanger, where it absorbs heat from the condensed refrigerant in the Low Temperature Generator.

Low Temperature Heat Exchangers

The remaining absorbent passes through the Low Temperature Heat Exchanger, where it absorbs heat from the concentrated absorbent.

Both these dilute solutions mix at the inlet of the High Temperature Heat Exchanger. During its flow through the High Temperature Heat Exchanger, this dilute solution absorbs heat from the intermediate absorbent solution. The solution then enters the High Temperature Generator.

The Heat Exchangers heat the cool absorbent solution before its entry into the High Temperature Generator for regeneration. This reduces the heat input required in the High Temperature Generator, thereby increasing the efficiency of the cycle.

High Temperature Generator (HTG)

The High Temperature Generator consists of a furnace, with a shell and tube arrangement on top.

Heat is supplied to the HTG by fuel combustion. As a result, hot flue gases pass through the HTG tubes and

the dilute absorbent surrounding these tubes gets heated. The temperature of the solution keeps on increasing till it reaches its boiling point and the absorbed refrigerant boils out of the solution. The solution concentration increases and it (the increased concentration) is referred to as the intermediate concentration. The vaporized refrigerant generated passes through the Eliminators and goes to the tube side of the Low Temperature Generator.

Low Temperature Generator (LTG) and Condenser

The Low Temperature Generator and condenser tube bundle are enclosed in the upper shell with an insulation plate separating the two. The vaporized refrigerant flows into the LTG tubes. It heats the intermediate absorbent outside and in the process gets condensed. This condensed refrigerant flows to the Condenser through the Drain Heat Exchanger.

On the other hand, the refrigerant, vaporized in the Low Temperature Generator, passes through the Eliminators to the Condenser. Cooling water circulates inside the condenser tubes. The refrigerant vapor condenses on the outside of the condenser tubes and collects at the bottom of the Condenser.

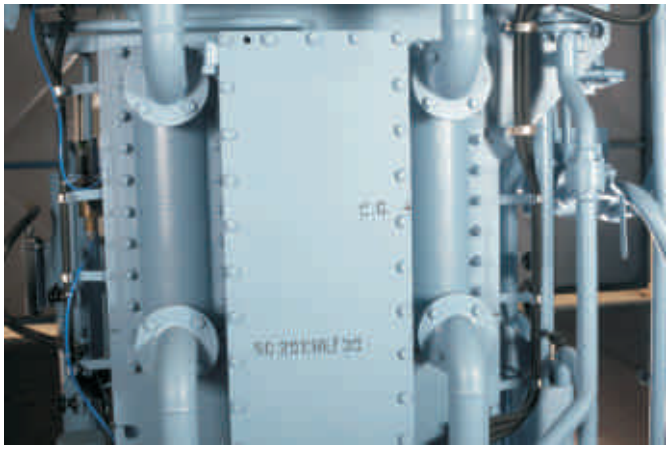
Finally, the condensed refrigerant from the LTG and the condenser mix, and flow into the Evaporator. The absorbent, now concentrated in the LTG, flows to the Absorber to begin a new absorbent cycle.

The LTG and the Condenser

Heating Mode

Evaporator

In heating mode, the hot water flows inside the evaporator tubes. Also, the refrigerant vapors from the



Side-by-side Evaporator and Absorber

High Temperature Generator pass directly to the Evaporator through the changeover valve and condense on the outside of the evaporator tubes. In turn, the water flowing inside the evaporator tubes gets heated. The condensed refrigerant gets collected at the Evaporator bottom and eventually overflows into the Absorber. To enable overflowing, the refrigerant pump is kept switched off.

Absorber

Concentrated absorbent solution, from the High Temperature Generator flows into the Absorber through another changeover valve, kept open in the heating mode. This concentrated absorbent mixes with the overflowing refrigerant from the Evaporator and gets diluted.

High Temperature Generator (HTG)

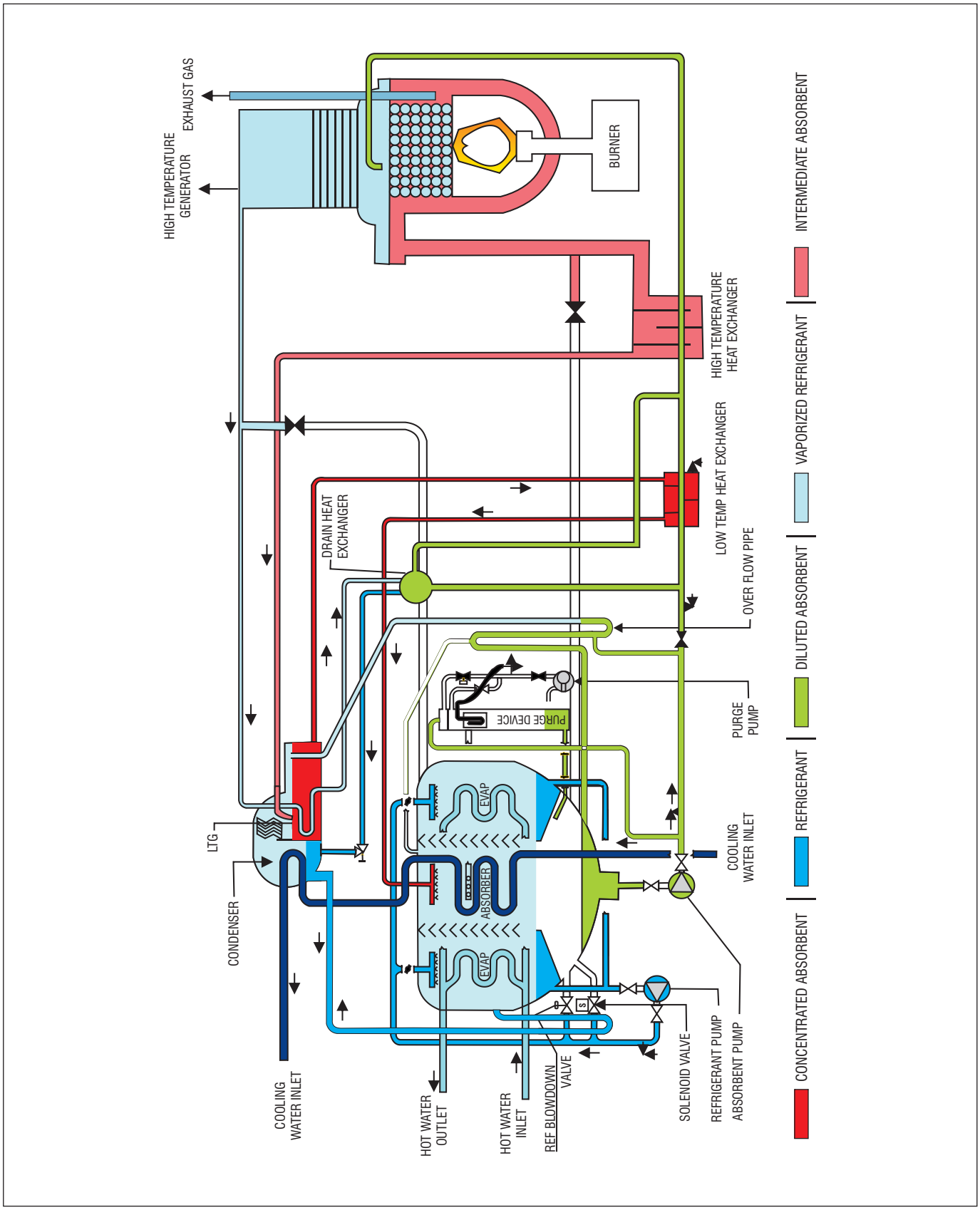
The High Temperature Generator consists of a furnace, with a shell & tube arrangement on the top of it.

Heat is supplied to the HTG by combustion of fuel. The hot flue gases pass through the HTG tubes. The dilute absorbent surrounding these tubes gets heated. The temperature of the solution increases until it reaches its boiling point. The absorbed refrigerant boils out of the solution. The solution concentration increases. This concentrated absorbent flows into the Absorber. The vaporized refrigerant passes through the Eliminators and goes to the Evaporator.

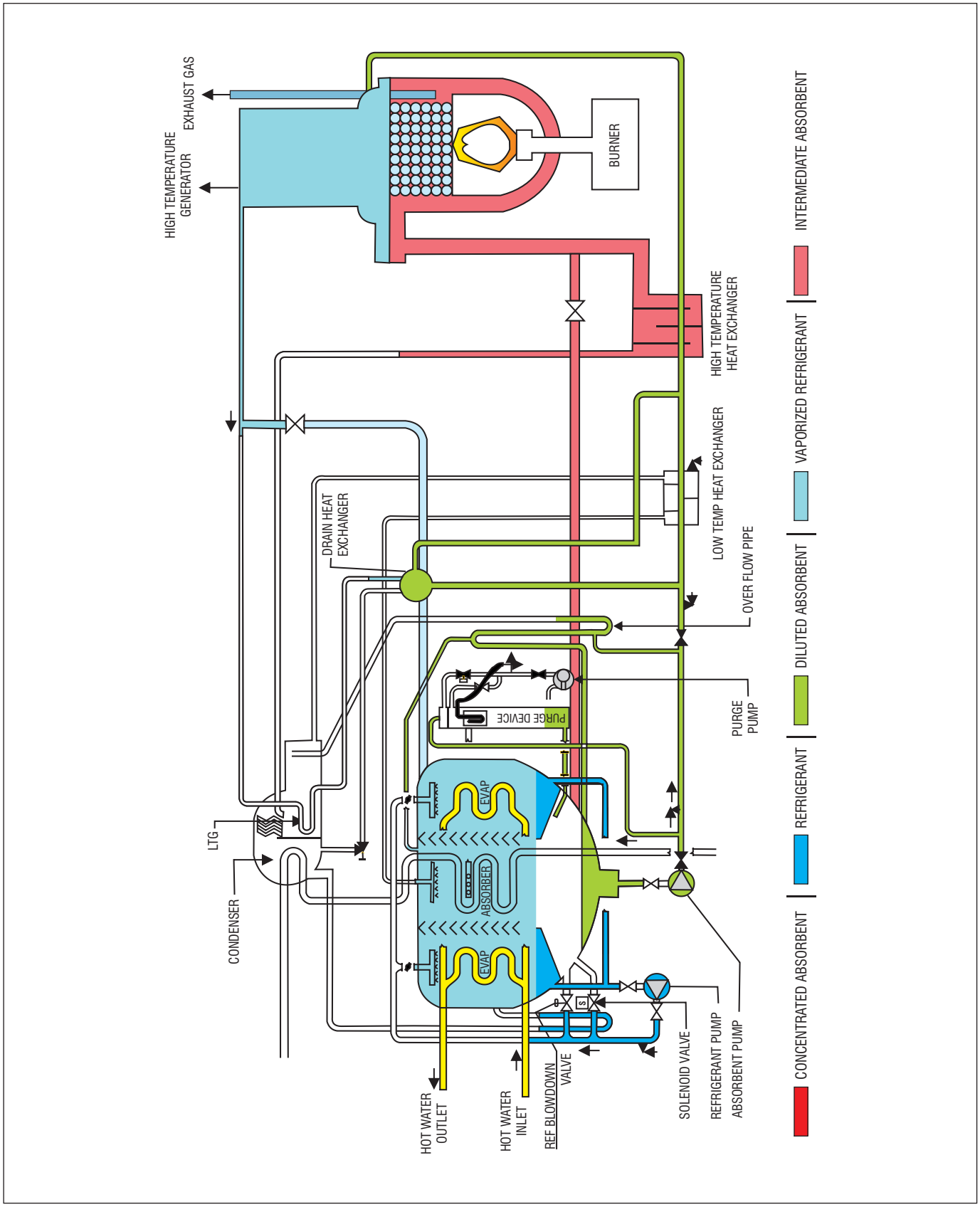
In heating mode, the refrigerant vapors from the High Temperature Generator flow directly to the Evaporator through the changeover valve.

Cooling water does not flow through the Absorber and the Condenser, during this mode.

Cooling Cycle



Heating Cycle



Constructional Features And Mechanical Design Considerations

EcoChill Nxt chiller can be designed to conform to the codes and standards given below. Whenever no specific standard is applicable, the design is according to good and proven engineering standards.

■ ISO 9001:2000 ■ ISO 14001 ■ ETL ■ CE ■ PED
■ TUV ■ DNV ■ ASME ■ OHSAS 18001

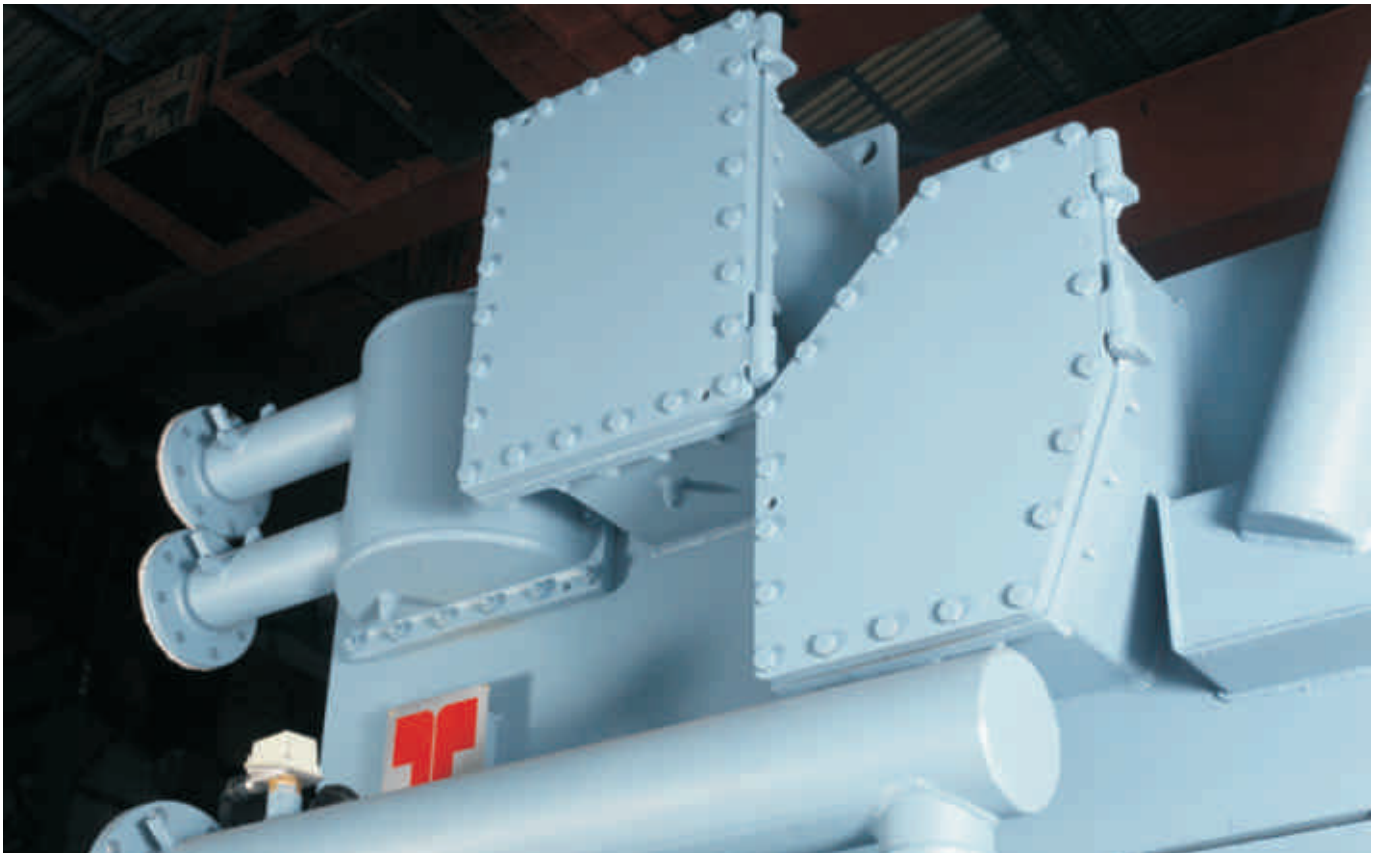
The lower shell with a sight glass

The lower shell houses two shell and tube heat exchangers: the Absorber and Evaporator. This shell is fabricated from formed carbon steel plates with fusion welded seams. Carbon steel tube sheets are drilled and reamed to accommodate absorber and evaporator tubes, and the tube ends are expanded to ensure no leakages between the shell and tube side. The support plates inside the shell are also fabricated from carbon steel plates. Enhanced copper tubes are used in the Absorber and Evaporator. Maximum working pressure is 114 psi (g). Gravity feed spraying technology is applied to spray the solution in the Absorber and Evaporator. The solution in the spraying tubes sprays downward to ensure good film thickness and better heat transfer. The Absorber and Evaporator are separated by an Eliminator that prevents the carryover of LiBr from Absorber to Evaporator, while allowing the water vapor from Evaporator to cross over to the Absorber. The lower shell is mounted on the base frame.

The upper shell houses a Low Temperature Generator and a Condenser. This shell is also fabricated from carbon steel plates. Smooth copper tubes are used in the Condenser and finned carbon steel tubes in the Low Temperature Generator. An Eliminator separates the Low Temperature Generator and Condenser. This Eliminator prevents the carryover of LiBr from the Low Temperature Generator to the Condenser. The upper shell rests on the lower shell. A rupture disk is provided for protection against high pressure.

The High Temperature Generator is a shell and Tube Heat Exchanger with carbon steel tubes located on top of a furnace. The shell is fabricated from carbon steel. Hot gases, generated through oil/ gas combustion, provide heat to the absorbent and are vented through the exhaust gas duct.

The Burner is of forced draft type with cast aluminum housing. If required, it is capable of operating on both liquid and gaseous fuels. For ease of service, the burner swings open laterally. In addition, a removable cover allows access to the serviceable components. It incorporates a self-regulating differential combustion air pressure switch and a burner flange safety interlock switch. A sight glass is provided to enable flame viewing. The combustion air fan is statically and dynamically balanced. Air intake consists of multiple aluminum vanes on the suction side for combustion air regulation. This combustion air can also be adjusted to suit the firing rate. The combustion head consists of stainless steel alloy flame tubes and a stainless steel alloy diffuser assembly. Whenever required, the fuel changeover is simple and does not re-adjustments. The 3-phase TEFC blower



Marine type headers

motor is fully compatible for use with a variable frequency drive.

By utilizing the heat within the system, the Regenerative Heat Exchangers increase the efficiency of the cycle. Marine type water boxes are provided with the Absorber and Condenser. These boxes enable easy tube cleaning and replacement. The drain and vent connections attached to these boxes are of great help while removing the cooling water hold-up when the chiller has not been in use for a long time.

The absorbent and refrigerant pumps are canned motor type and are factory mounted. The motor is directly coupled with the pump. Isolation valves are welded at the inlet and outlet, enabling easy maintenance of pumps without loss of vacuum. All valves, for adjusting solution, are fully welded to prevent leakage of air into the unit.

Non-condensable gases are removed from the chiller chiller by operating the vacuum pump and by opening the manual purge valves. Service valves are provided for N_2 charging, for sampling, and for connecting the Manometer.

Purge System

Supply List And Scope Of Work

Sr. No.	Description	Remarks
A	**Lower Shell**	
1.	Evaporator	Common Shell and Tube sheets, separate water boxes
2.	Absorber	
3.	Base Frame	
B	**Upper Shell**	
4.	Low Temperature Generator	Common Shell and Tube sheets, separate water boxes
5.	Condenser	
C	**High Temperature Generator with Burner Assembly**	High Temperature Generator with combustion chamber and burner assembly.
D	**Heat Exchangers**	
6.	Low Temperature Heat Exchanger	Plate Heat Exchanger
7.	High Temperature Heat Exchanger	Plate Heat Exchanger
8.	Drain Heat Exchanger	Plate Heat Exchanger
E	**Pumps and Motors**	
9.	Absorbent Pump and Motor	Canned Motor Pump Set
10.	Refrigerant Pump and Motor	Canned Motor Pump Set
11.	Purge Pump and Motor	Vacuum Pump
F	**Purge System**	For Separation of Non-condensable gases from absorbent and its storage.
G	**Piping**	Inter-connecting Piping
H	**Instrumentation**	Control Panel, Field Instruments, Cabling.
I	**Electricals**	Starters, Circuit breakers, Wiring within battery limits.
J	**Documents**	Operation and Maintenance Manual, Packing List.

Distribution of Scope of Work - Manufacturing, Transportation and Installation

Item/ Activity	Thermax	Customer	Remarks
Chiller			
Chiller Manufacture with accessories	✓		Refer to Supply List.
Burner	✓		Supplied by Thermax specified vendor.
Testing			
Factory Testing	✓		Thermax Optional Feature.
On-site Erection		✓	
Supervision of Commissioning	✓	✓	Customer to assist, Thermax Representative will supervise the commissioning.
Transportation			
Loading at Thermax Factory	✓		
Factory to Port	✓		
Port in India to port of destination*		✓	
Port to Job-site		✓	
Unloading at Job-site		✓	
Storage at Job-site		✓	If required.
Construction and Installation			
Handling at Job-site		✓	Rigging, Shifting to actual location.
Civil foundation		✓	
Piping outside battery limits		✓	Refer to Supply List.
Butterfly valve in the cooling water line		✓	If required. (Refer to Safety Functions under Instrumentation and Safety Features.)
Chiller insulation*		✓	
Piping insulation outside battery limits		✓	Refer to Supply List.
Electrical connections outside Battery limits		✓	Refer to Supply List.
Assembly and on-site connections		✓	For (a) Burner and (b) Multi-Sectional Shipment (Optional).
Operation and Maintenance			
Training of Customers' Operators during commissioning (maximum period of 7 days)	✓		
Operation		✓	

NOTE: * indicates that the scope of supply can also be included by Thermax, as an option.

Utility Requirements

Chilled/ Hot Water: The chiller's design ensures in delivering the desired cooling capacity. The chilled water flow rate to the chiller is kept constant. Hence its capacity is proportional to the difference in the temperatures of the inlet and the outlet chilled water.

Cooling Water: Cooling water is used to remove heat of absorption and condensation. The chiller can be designed to suit the rated cooling water temperature of 75 - 97°F.

Energy Source: The chiller is designed for fuel flexibility. The liquid and gaseous fuels that can be used are Light Oil, SKO (Superior Kerosene Oil), Natural Gas, CNG and other gaseous fuels.

Air: Compressed air is required for the pneumatic operation of the control valve. The supplied air should be moisture free and the required pressure is 100 psi(g).

Electricity: The power supply to the chiller shall be strictly as per the voltage and frequency rating given on chiller nameplate.

To avoid scaling and corrosion, we recommend maintaining water quality as given in the instructions. If the water quality at the installation site is different, the chiller can be designed to adjust to it.

Chilled Water and Cooling Water Treatment

Water treatment of the chilled and cooling water is important to get desired chiller performance and for its long life.

If the water quality is bad, it shows scaling and/or corrosion tendency. As a result, sludge and scale can adhere to the inside of the tubes. This impedes heat transfer between the chilled water and refrigerant and between the cooling water and LiBr solution. Consequently, there can be an increase in the respective temperatures of the LiBr solution and the condensed refrigerant, leading to an increase in the fuel consumption and thus hampering the capacity and efficiency of the chiller. In cases of prolonged corrosion, the tubes will require maintenance or, in some cases, they may even have to be replaced.

As the cooling water circuit is open, the salts get concentrated due to evaporation taking place in the cooling tower. This can be adjusted by controlling cooling water blow-down and make-up. Moreover, exposure to sunlight favors biological growth. Slime is more detrimental to heat transfer than scale. Dosing biocides during cooling water treatment can minimize these adverse effects.

Unlike the cooling water circuit, which is always open, the chilled water circuit may be open or closed. Due to the lower temperature, chilled water circulating in an open circuit does not have severe consequences. Soft water is recommended for use in this circuit.

JIS recommends the following water quality for copper tubes:

Sr. No.	Description	Unit	Specifications	
			Chilled Water	Make-up Water
1	pH at 77°F		6.5 - 8.5	6.5 - 8.5
2	Electrical Conductivity (max.)	μs/cm	500	200
3	M Alkalinity (max.)	ppm	100	50
4	Total hardness (max.)	mg $CaCO_3$/lit	100	50
5	Chloride ion (max.)	mg Cl/lit	100	50
6	Sulphate ion (max.)	mg SO_4/lit	100	50
7	Total Iron (max.)	mg Fe/lit	1	0.3
8	Sulphide ion	mg S/lit	Not detected	
9	Ammonium ion (max.)	mg NH_4/lit	0.5	0.2
10	Silica ion (max.)	mg SiO_2/lit	50	30
11	Free carbonic acid (max.)	mg $CaCO_3$/lit	10	-
12	Turbidity	NTU	10	5
13	BOD/ COD (max.)	mg/lit	160	160

Sr. No.	Description	Unit	Specifications	
			Cooling Water	Make-up Water
1	pH at 77°F		6.5 - 8.5	6.5 - 8.0
2	Electrical Conductivity (max.)	μs/cm	800	200
3	M Alkalinity (max.)	ppm	100	50
4	Total hardness (max.)	mg $CaCO_3$/lit	200	50
5	Chloride ion (max.)	mg Cl/lit	200	50
6	Sulphate ion (max.)	mg SO_4/lit	200	50
7	Total Iron (max.)	mg Fe/lit	1	0.3
8	Sulphide ion	mg S/lit	Not detected	
9	Ammonium ion (max.)	mg NH_4/lit	1	0.2
10	Silica ion (max.)	mg SiO_2/lit	50	30
11	Suspended solids (max.)	mg/lit	20	5
12	Turbidity	NTU	20	5
13	BOD / COD (max.)	mg/lit	160	160

Selection Criteria And Procedure

Selection Criteria

The following factors govern model selection:

Energy Source Parameters: Energy source can be either natural gas or light oil (containing less than 1% sulfur). Required gas pressure is 65 mbar. Both modulating and Hi-Low burners are available for the machines; 3-stage burners can also be offered as an option. Fuel consumption given is based on standard natural gas and oil HHV. However, for different gas / oil, fuel consumption will be proportional to the ratio of LHV.

Chilled and cooling water temperature: Capacity of the chiller varies based on chilled water outlet temperature and cooling water inlet temperature. The chiller is capable of delivering higher than its rated capacity if chilled water temperature is higher than the rated temperature or cooling water temperature is lower than the rated temperature. Conversely, the chiller capacity is likely to be reduced if chilled water temperature is lower and cooling water temperature is higher than their respective rated temperatures. Thermax has designed and installed chillers for chilled water temperatures ranging from 38°F to 70°F and cooling water temperatures varying from 50°F to 97°F.

Chilled and cooling water circuit pressure: Thermax's standard product range is designed for a maximum pressure of 114 psi (g) in the chilled and cooling water circuits. Thermax also offers special design for higher pressures.

Size: If there are constraints relating to the transportation of the chiller or machine room access, Thermax offers the option of multi-sectional shipment. Typically, this can be in three sections viz. lower shell, upper shell and High Temperature Generator. These sections can be assembled at the installation site by just welding a few connections.

Optional features: These include tube material of construction, frequency drive for double effect absorbent pumps, flame proof construction, claded tube sheets and special electronics and instrumentation.

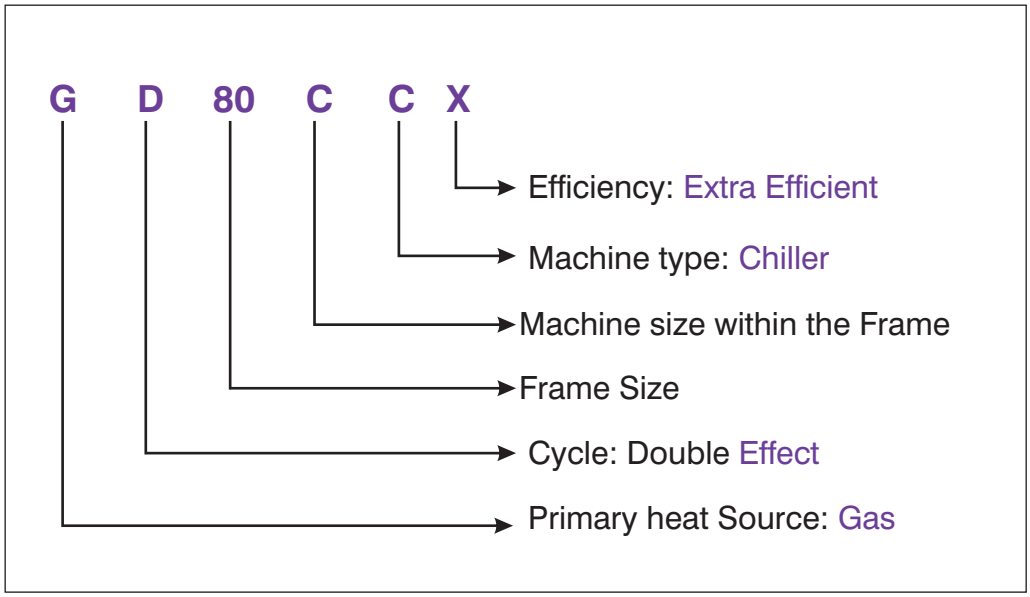
Selection Procedure

Absorption is a complex phenomenon involving heat and mass transfer. The chiller consists of multiple interlinked heat exchangers. In such a complex mechanism, deration factors and two-dimensional graphs can lead only to approximation. At Thermax, every selection is done with the help of a computer program that does detailed heat and mass transfer calculations for each heat exchanger and accurately determines performance of the chiller. When using media other than water or for non-standard fouling factors, the selection considers appropriate properties to evaluate overall heat transfer coefficient. The program facilitates optimization of the energy / fuel consumption, the chilled and the cooling water flow rates and the pressure drops.

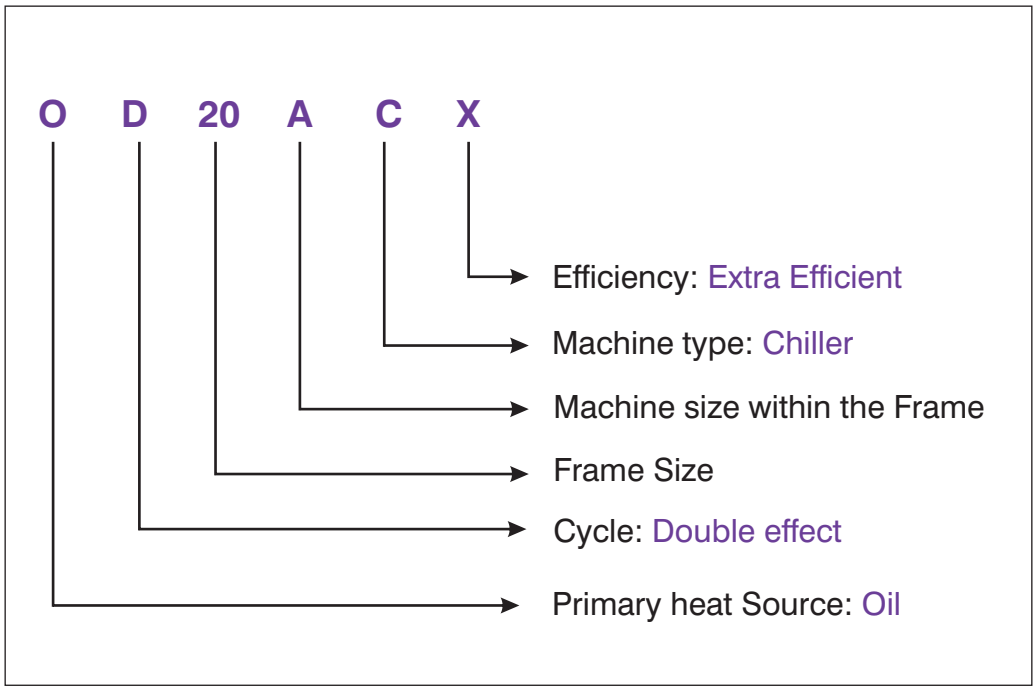
The following document provides performance data and the dimensional data for all the standard models.

Thermax Nomenclature And The EcoChill Nxt Product Basket

GD80CCX



OD20ACX



Performance Data

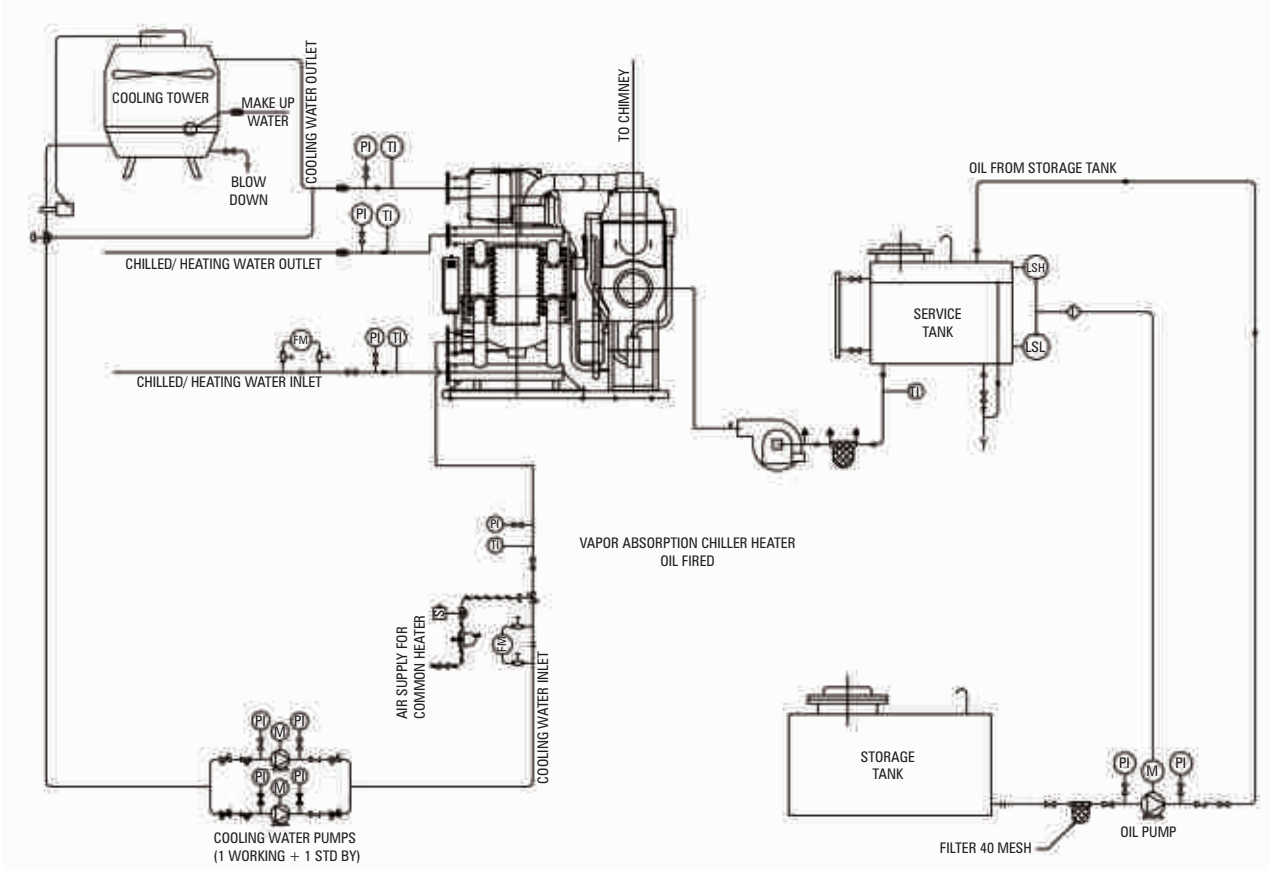
Model Number		UNITS	GD 20A CX OD 20A CX	GD 20B CX OD 20B CX	GD 20C CX OD 20C CX	GD 20D CX OD 20D CX	GD 30A CX OD 30A CX	GD 30B CX OD 30B CX	GD 30C CX OD 30C CX	GD 40A CX OD 40A CX	GD 40B CX OD 40B CX	GD 40C CX OD 40C CX	GD 50A CX OD 50A CX	GD 50B CX OD 50B CX	GD 60A CX OD 60A CX	GD 60B CX OD 60B CX	GD 60C CX OD 60C CX	GD 60D CX OD 60D CX	GD 70A CX OD 70A CX	GD 70B CX GD 70B CX
Cooling Capacity		TR	111	130	162	192	241	272	321	360	408	452	505	560	636	709	802	890	993	1107
Heating Capacity		MBH	978.6	1131.5	1437.3	1681.9	2107.7	2371.2	2799.3	3161.6	3556.8	3952.0	4413.0	4907.0	5532.8	6158.5	7014.7	7772.2	8628.5	9616.5
Chilled Water Circuit	Flow rate	GPM	268.7	314.7	392.2	464.8	583.4	658.5	777.1	871.5	987.7	1094.2	1222.5	1355.6	1539.6	1716.3	1941.5	2154.5	2403.8	2679.8
	No. of passes (Evaporator)	#	3	3	2	2	2	2	2	2	2	2	2	2	3	3	2	2	2	2
	Friction loss	ftWC	13.1	15.4	15.7	19.4	15.1	16.7	25.6	21.3	22.3	24.0	21.7	22.0	22.0	22.6	14.4	15.4	14.8	16.1
	Connection Diameter	inchNB	4				6			6			8		10				10	
Cooling Water Circuit	Flow rate	GPM	488.7	572.4	713.3	845.4	1061.1	1197.6	1391.3	1563.0	1774.4	1990.1	2183.8	2426.0	2800.2	3121.6	3531.1	3918.6	3975.8	4887.2
	Outlet Temp	°F	94.28	94.28	94.28	94.28	94.28	94.28	94.46	94.46	94.46	94.28	94.46	94.46	94.28	94.28	94.28	94.28	95.18	94.28
	No. of passes (absorber)	#	3	3	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	1
	No. of passes (condensor)	#	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Friction loss	ftWC	12.8	12.5	14.8	15.1	14.8	15.1	22.3	21.0	21.3	22.6	22.6	24.0	25.3	25.9	17.7	18.7	36.7	19.7
	Connection Diameter	inchNB	6				8			10			10		12				14	
Fuel Circuit	Fuel Consumption (Cooling)	MBH	1137.9	1315.7	1671.3	1955.7	2450.8	2757.2	3255.0	3676.3	4135.8	4595.3	5131.4	5705.8	6433.4	7161.0	8156.7	9037.5	10033.1	11181.9
	Oil Consumption (Cooling)	GPH	8.23	9.51	12.08	14.14	17.72	19.94	23.54	26.58	29.91	33.23	37.10	41.26	46.52	51.78	58.98	65.35	72.55	80.86
	Fuel Consumption (Heating)	MBH	1137.9	1315.7	1671.3	1955.7	2450.8	2757.2	3255.0	3676.3	4135.8	4595.3	5131.4	5705.8	6433.4	7161.0	8156.7	9037.5	10033.1	11181.9
Overall Dimen-sions	Length	inch	116.1		155.9		162.6		187.4	191.3			198.8		261.4		310.2		305.9	
	Width	inch	101.2		99.2		110.6		113.4	124.8			134.3		145.3		152.0		160.2	
	Height	inch	106.3		105.9		111.4			118.9			131.9		135.0		137.0		155.5	
Max. Shipping Weight		x 1000 lb	13.2	13.7	16.3	17.0	22.0	22.5	25.1	30.4	31.3	32.6	38.1	39.0	56.7	59.1	67.9	71.7	82.2	85.1
Operating Weight		x 1000 lb	14.3	15.0	17.9	18.5	24.5	24.9	27.8	34.0	35.1	36.6	42.3	43.4	63.5	66.6	75.8	80.0	93.0	96.6
Clearance for Tube Removal		inch	94.5		147.8		150.2		161.4	161.4			161.4		209.4		258.3		258.3	
Electric Supply	Absorbent Pump Motor Rating	kW (A)	1.1(3.4)		2.2(6)					3(8)			3.7(11)		5.5(14)				6.6(17)	
	Refrigerant Pump Motor Rating	kW (A)	0.3(1.4)														1.5(5)			
	Purge Pump Motor Rating	kW (A)	0.75(1.8)																	
	Burner	kW (A)	0.6(1.2)	0.8(1.7)	1.4(2.8)		2.1(4.2)			2.6(5.1)	5.5(9.1)		5.5(9.1)		9(17.5)				14(26)	
	Burner Type		HI / LOW (MODULATING BURNER AVAILABLE ON REQUEST)																	
	Total Electric Input	kVA	6.6	7.0	9.6		10.6			12.7	15.6		17.7		25.9		28.5		36.8	
	Power Supply		460 V(±10%), 60 Hz (±5%), 3 Phase+N																	
Exhaust Gas Duct Size			6		8		8		10	10			12		12				16	

NOTE:

- Chilled water inlet / outlet temperature = 54 / 44 °F
- Cooling water inlet temperature = 85°F
- In Heating mode, Hot water inlet / outlet temperature = 132.8 / 140 °F
- Minimum Cooling water inlet temperature is 50°F
- G.C.V. for Oil = 138296 BTU/gal
- Control panel Electric Input = 1kVA
- Maximum Allowable pressure in chilled / cooling water system =113.78 psi(g)
- Ambient condition shall be between 41 to 113°F
- All Water Nozzle connections to suit ASME B16.5 Class 150
- Technical specification is based on ARI 560 : 2000

Typical P & I Diagrams

Light Oil Fired



LEGEND

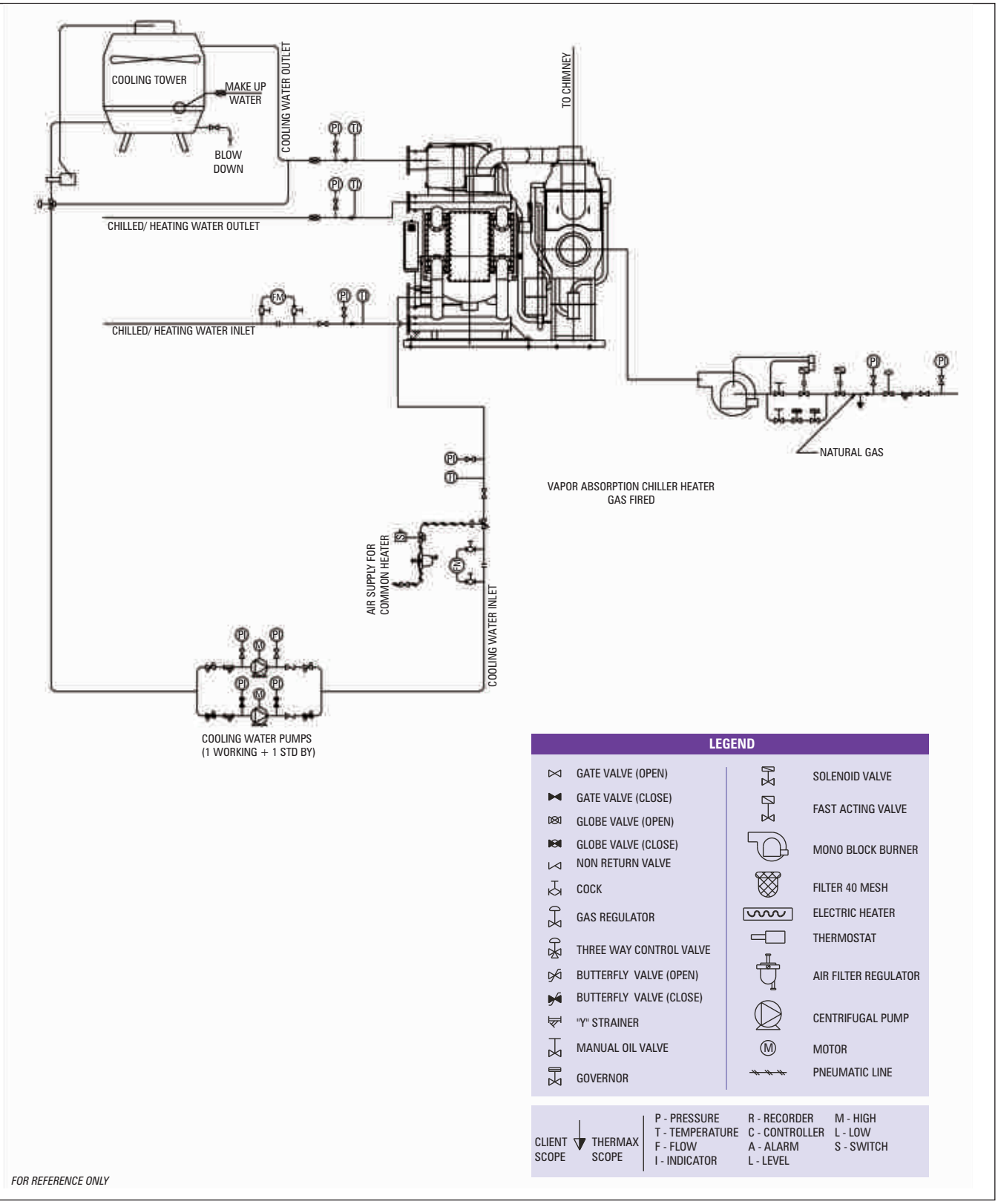
- GATE VALVE (OPEN)
- GATE VALVE (CLOSE)
- GLOBE VALVE (OPEN)
- GLOBE VALVE (CLOSE)
- NON RETURN VALVE
- COCK
- GAS REGULATOR
- THREE WAY CONTROL VALVE
- BUTTERFLY VALVE (OPEN)
- BUTTERFLY VALVE (CLOSE)
- "Y" STRAINER
- MANUAL OIL VALVE
- GOVERNOR
- SOLENOLD VALVE
- FAST ACTING VALVE
- MONO BLOCK BURNER
- FILTER 40 MESH
- ELECTRIC HEATER
- THERMOSTAT
- AIR FILTER REGULATOR
- CENTRIFUGAL PUMP
- MOTOR
- PNEUMATIC LINE

CLIENT SCOPE / THERMAX SCOPE

P - PRESSURE, T - TEMPERATURE, F - FLOW, I - INDICATOR
R - RECORDER, C - CONTROLLER, A - ALARM, L - LEVEL
M - HIGH, L - LOW, S - SWITCH

FOR REFERENCE ONLY

Gas Fired



LEGEND

- GATE VALVE (OPEN)
- GATE VALVE (CLOSE)
- GLOBE VALVE (OPEN)
- GLOBE VALVE (CLOSE)
- NON RETURN VALVE
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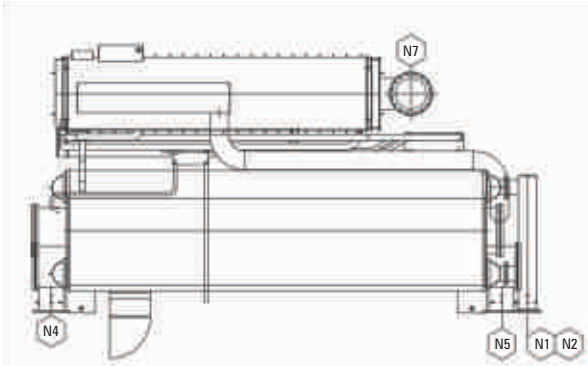
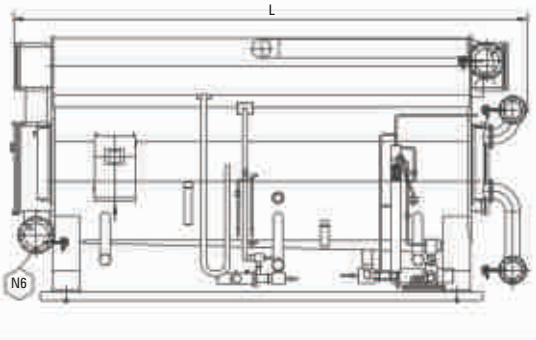
F - FLOW	A - ALARM	S - SWITCH
I - INDICATOR	L - LEVEL	

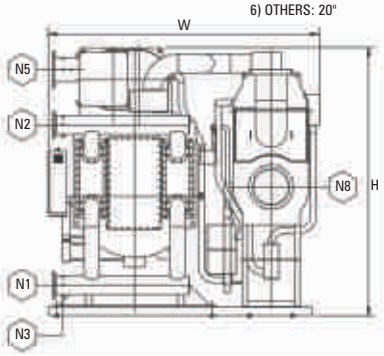
FOR REFERENCE ONLY

General Arrangement Drawing

Typical General Arrangement Drawing







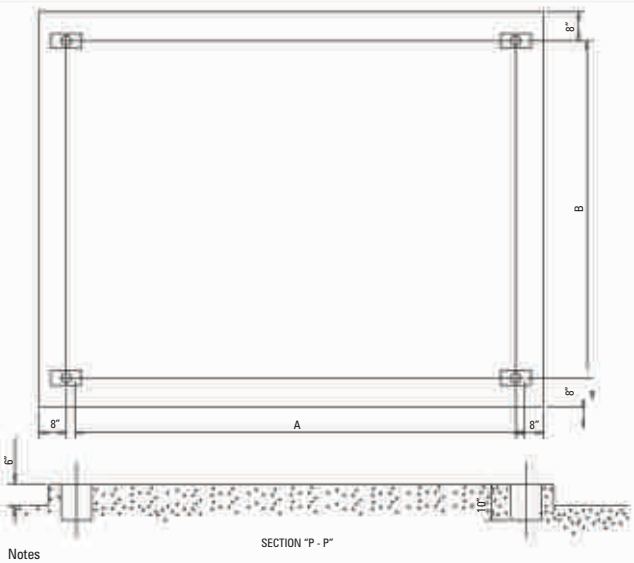
NOZZLE SIZE	NOZZLE FL. RATING	DESCRIPTION	QTY.
N1 as per model	ASA 150	Chilled/ Hot water Inlet	1
N2 as per model	ASA 150	Chilled/ Hot water outlet	1
N3 as per model	-	Chilled/ Hot water drain plugged	1
N4 as per model	ASA 150	Cooling water inlet	1
N5 as per model	ASA 150	Cooling water outlet	1
N6 as per model	-	Cooling water drain plugged	1
N7 as per model	ASA 150	Exhaust gas outlet	1
N8 as per model	-	Fuel inlet	1

NOTES
1) ● INDICATES THE POSITION OF ANCHOR BOLTS
2) ↑ INDICATES THE POSITION OF THE POWER SUPPLY CONNECTION ON THE CONTROL PANEL
3) MINE INSTALLATION CLEARANCE (Min-inches)
4) CONTROL PANEL SIDE : 47.5"
5) TOP: 8"
6) OTHERS: 20"

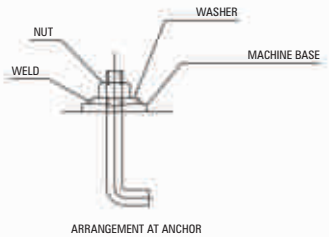
For reference only

Foundation Drawing

Typical Foundation Drawing



SECTION "P - P"



ARRANGEMENT AT ANCHOR

Notes
1. There should be a drain ditch around the foundation.
2. The floor surface should be made as water proof for ease of maintenance work.
3. Finish the foundation work horizontally flat & smooth at the horizontal grade of about 1/1000.
4. The foundation shall be designed to suit the soil conditions & other design considerations at site.

MODEL NO.	A Inches	B Inches	W Inches	Wt 1000xlbs
GD/ OD 20A/20B CX/HX/CE/HE	91	85	8.7	17
GD/ OD 20C/20D CX/HX/CE/HE	127.4	79.8	8.7	20.3
GD/ OD 30A/30B CX/HX/CE/HE	125.8	89.6	10.6	26.9
GD/ OD 30C CX/HX/CE/HE	149.8	93.1	10.6	26.7
GD/ OD 40A/B/C CX/HX/CE/HE	149.4	102.2	10.6	38.1
GD/ OD 50A/50B CX/HX/CE/HE	149.8	112.8	10.6	46.3
GD/ OD 60A/60B CX/HX/CE/HE	197.7	119.5	10.6	70.5
GD/ OD 60C/60D CX/HX/CE/HE	246.3	126.4	10.6	83.7
GD/ OD 70A/70B CX/HX/CE/HE	247.1	141.6	10.6	105.7

Instrumentation And Safety Features

Control Logic

The control panel includes the following components:

- Programmable Logic Controller (PLC)
- Panel view operator interface
- Power circuit for pumps
- Panel mounted instruments

The total heat extracted from the chilled water defines the cooling capacity of a chiller. The chilled water inlet flow-rate is kept constant. Hence the cooling capacity is proportional to the difference in the temperatures of the chilled water at inlet and outlet.

Load changes are reflected in the rise or fall of the temperature of the inlet chilled water. The outlet chilled water temperature varies with the inlet chilled water temperature. An RTD sensor notes this change in temperature. This temperature signal is fed to the PLC. An inbuilt software PID control loop processes this signal with respect to the chilled water set point. A control output signal of 4 to 20 mA is sent to the burner for modulation.

The burner controller converts the 4 to 20 mA electrical

signal into a firing control signal, which controls the position of the burner modulation. As the load increases, the burner firing also increases, and vice-versa, thus regulates the quantity of fuel entering the burner.

In High - Low type of burner, an RTD sensor in the chilled water outlet notes the change in temperature. This signal is fed to the PLC which then sends it to the burner control panel as Control output (Digital Signal, Potential free) in terms of either HI or LOW. This signal controls the output of the burner. As the temperature of the chilled water outlet drops below the set point value, the burner is fired in Low flame and if it continues to drop and reaches set point minus preset value, the Burner is switched OFF. Depending on the load conditions, the chilled water temperature at the outlet starts rising, and as it crosses the control range, (set value in the PLC), the burner is switched ON, to control the temperature.

Safeties

Safety devices are provided to protect the chiller from reaching abnormal conditions, to safeguard it from damage, and to ensure continued availability.

Safety devices are:

- Chiller mounted safeties, located on the chiller
- Panel mounted safeties, in the control panel, and
- Field interlocks passing signals from the field to the chiller

Chiller mounted

- Chilled/ hot water flow switch
  Paddle type device mounted on the chilled water outlet nozzle
- Chilled/ hot water Differential Pressure (DP) switch
  Connected to the inlet and outlet chilled water nozzles
- Refrigerant level electrodes
  Mounted in the refrigerant level box
- Generator level electrodes
  Mounted in the high temperature generator level box
- Absorber level electrodes
  Mounted in the absorbent level box
- Auto blow down solenoid valve
  Mounted on refrigerant pump outlet tapping to absorber.
- Temperature sensors mounted at various locations to display temperatures.
- Furnace temperature sensor.
- Generator Pressure switch.
- Furnace pressure switch.

Panel Mounted

- Generator level controller
- Refrigerant level controller
- Absorbent level controller
- Absorbent pump overload relay / AC Drive
- Refrigerant pump overload relay
- Purge pump overload relay

Field interlocks

- Cooling tower start/ stop permissive contacts
- Cooling water pump/ shut off valve - permissive
- Chilled/ hot water pump - permissive.

Safety Functions

The safety functions of the chiller protect it against abnormal conditions. The various safety functions

Antifreeze protection: To prevent the chilled water from freezing in the evaporator tubes, the safety functions stop the chiller like:

- **H-cut** (for heating mode): Sometimes the load may fall sharply, due to which hot water temperature starts rising. When the hot water temperature rises above hot water out set point plus H cut differential set point, the burner is switched off. The H - Cut is set from the Heat mode control loop screen. This safety prevents further temperature rise in hot water. The burner will start firing at minimum firing after hot water outlet temperature goes below the hot water out temperature plus H - Cut differential minus the hysteresis.
- **L-cut:** If the chilled water outlet temperature drops below the L-cut set point, the refrigerant pump is switched off, stopping the burner immediately. This safety prevents any further temperature drop in the chilled water. As the chilled water outlet temperature rises above the L-cut set point plus the hysterisis set point, the refrigerant pump restarts, which in turn restarts the burner, depending on the PID controller.
- **Antifreeze:** If the chilled water outlet temperature drops below the internal antifreeze set point, the chiller trips and the 'TOTAL SHUTDOWN' alarm sequence is carried out. The alarm should be reset only after the chilled water outlet temperature rises above the internal antifreeze set point plus the hysterisis set point.
- **Chilled/ hot water pump interlock:** Chilled water flow is a prerequisite for chiller operation. A potential free contact is to be wired from the chilled water pump motor starter to the chiller panel to sense chilled water pump ON/ OFF/ TRIP status. The chiller starts only when the chilled water pump is ON. If the chilled water pump stops/ trips during operation, the 'TOTAL SHUTDOWN' alarm sequence is carried out.
- **Cooling water pump interlock:** Cooling water flow should be stopped immediately when the chilled water flow stops in the chiller. So the cooling water pump should be started through the start permissive of cooling water pump.
- **Chilled/ hot water flow switch:** If the chilled water flow drops below 50% of the rated value, the chiller trips and the 'TOTAL SHUTDOWN' alarm sequence is carried out.
- **Chilled/ hot water differential pressure switch:** If the differential pressure across the chilled water inlet and outlet lines drops below the rated value, the chiller trips and the 'TOTAL SHUTDOWN' alarm sequence is carried out.

- **Generator pressure switch:** If the generator pressure increases above 29.9 inch Hg, chiller trips and 'DILUTION CYCLE' alarm sequence is carried out.
- **Butterfly control valve in cooling water line:** If all the cooling water pumps can be stopped electrically when the differential pressure switch or flow switch shows less or no flow in chilled water, automatically operated butterfly valve is not required. However, when such arrangement can not be ensured, auto butterfly valve needs to be provided by the customer to stop the cooling water based on differential pressure switch / flow switch signal.
- **Crystallization prevention:** If the concentrated absorbent solution, while returning to the Absorber from the Low Temperature Generator is excessively cooled, it crystallizes in the Low Temperature Heat Exchanger, affecting the chiller operation. Crystallization occurs, either, when the concentration of the absorbent (related to its temperature) becomes too high or its temperature drops excessively. The following safety functions prevent the chiller from crystallizing:
- **Burner modulation on crystallization prevention safety:** The strong solution concentration and the crystallization temperature corresponding to that concentration are calculated in the PLC. The PLC always tries to maintain the pre-set safe distance between the crystallization temperature and strong solution temperature of low temperature heat exchanger outlet. If the distance is less than the pre-set safe distance, the PLC switches on/ off or modulates the burner so that the strong solution will never reach crystallization zone.
- **Absorber level safety:** Minor crystallization in the chiller can result in low absorber level. When the absorber level falls below 25% of the sight glass, the blow-down solenoid valve opens. It closes when the absorber level goes above the 50% level of the sight glass. The opening of the blow-down solenoid valve allows the flow of refrigerant from refrigerant pump to absorber. Burner modulation opens only when the absorber level reaches the 50% level of the sight glass. Adequate level ensures dilute solution supply to generator thus preventing crystallization.
- **HTG high temperature safety:** If the HTG temperature exceeds the HTG high temperature set point of 320°F, the 'DILUTION CYCLE' alarm sequence is carried out. The chiller goes into the dilution cycle immediately. The HTG high temperature alarm cannot be reset until the HTG temperature drops below the set point minus the hysterisis set value of 9°F.
- **HTG high pressure safety:** If the HTG pressure exceeds the HTG pressure switch setting, the 'DILUTION CYCLE' alarm sequence is carried out and the chiller goes into the dilution cycle immediately. The HTG high-pressure alarm cannot be reset until the HTG pressure drops below the HTG pressure switch setting.
- **Stack high temperature safety:** If the stack temperature exceeds the stack high temperature set point of 482°F, the 'DILUTION CYCLE' alarm sequence is carried out and the chiller goes into the dilution cycle immediately. Stack high temperature alarm cannot be reset until the stack temperature drops below the set point minus the hysterisis set value 9°F.
- **Cooling water low temperature safety:** If the cooling water inlet temperature drops below the cooling water low temperature set point, the 'DILUTION CYCLE' alarm sequence is carried out. The chiller goes into the dilution cycle immediately. The alarm cannot be reset until the cooling water inlet temperature rises above the cooling water low temperature set point plus hysterisis set value.
- **HTG Vapor saturation temperature high:** If the HTG vapor saturation temperature exceeds the high HTG vapor temperature set point, the 'DILUTION CYCLE' alarm sequence is carried out and the chiller goes into the Dilution Cycle immediately. The alarm cannot be reset until the HTG vapor temperature goes below the HTG vapor temperature trip set point minus the set hysterisis value.
- **Furnace pressure switch:** If the furnace pressure exceeds the set point, the 'DILUTION CYCLE' alarm sequence is carried out and the chiller goes in to Dilution cycle. The alarm can only be reset when the when the furnace pressure goes bellow the furnace pressure switch set point minus the set hysteresis valve.
- **Furnace outlet temperature high:** If the furnace outlet temperature exceeds the furnace temperature set point, the 'DILUTION CYCLE' alarm sequence is carried out and the chiller goes in to Dilution cycle. The alarm can only be reset only when the furnace temperature goes bellow the Furnace Temperature Trip set point minus the hysterisis value.

Cavitation protection of refrigerant pump:

The refrigerant pump starts to cavitate, when the refrigerant level in the evaporator pan falls below the set level. To ensure minimum acceptable suction pressure, the refrigerant level is not allowed to fall below a certain level by means of three level electrodes and a level relay.

The three electrodes are mounted in the refrigerant level box assembly present on the lower shell. The pump starts when the level reaches the electrode that is smallest in length. It stops when the level goes below the longest electrode. When the level goes below the intermediate electrode, a delay of 20 seconds is provided before the pump can be switches off automatically.

Cavitation protection of the absorbent pump:

The absorbent pump starts to cavitate when the absorbent level in the absorber sump falls excessively. To prevent the excess absorbent from being pumped out of the absorber sump, the absorbent level in the HTG is not allowed to rise above a certain level. This is done by means of three level electrodes, and a level relay.

The three electrodes are mounted on the high temperature generator level box. The absorbent level is to be maintained below the smallest electrode. The longest electrode acts as the reference electrode. When the level reaches the smallest electrode, the pump stops after a delay of 5 seconds. The pump restarts when the level goes below the intermediate electrode.

Motor protection

- Absorbent pump overload relay: If the absorbent-pump motor draws more than its rated current, the overload relay trips. The 'TOTAL SHUTDOWN' alarm sequence is carried out. The alarm cannot be reset until the absorbent pump overload relay (inside the control panel) is manually reset.
- Refrigerant pump overload relay: If the refrigerant pump motor draws more than its rated current, the overload relay trips and the 'DILUTION CYCLE' alarm sequence is carried out. The alarm cannot be reset until the refrigerant pump overload relay (inside the control panel) is reset manually.
- Purge pump overload relay: If the purge pump motor draws more than its rated current, the overload relay trips. The alarm cannot be reset until the purge pump overload relay (inside the control panel) is reset manually.

Burner trip: If the burner trips frequently just before firing, then there is a possibility of fuel leakage into the furnace without getting burnt. The leaked fuel will get collected at the bottom of the furnace and it can get instantaneously burnt (causing an explosion) when the burner fires subsequently. This has to be prevented by all means. The following safety function prevents this hazard.
If the burner trips for more than 3 times within the pre-set period in the PLC, say within 10 minutes, then the chiller invariably goes into 'DILUTION CYCLE' alarm sequence with an alarm 'check for fuel leakage in the furnace'. Until the alarm is reset, the chiller cannot be re-started.

Machine Room Layout Considerations

Location: Unlike conventional electric chillers, absorption chillers are characterized by their silent operation and simpler foundation. Owing to this, they can be located in basements or on terraces of buildings; the location being ultimately decided by space availability and ease of installation and maintenance.

Room Size: The machine room size should be decided according to the dimensions of the chiller. A provision of minimum 3.3 ft clearance space should be made on all sides of the chiller. In addition, provision for tube removal space should be made on either side of the chiller. A clearance of 3.95 ft is recommended on the panel side of the chiller and 0.7 ft is recommended on the top of the chiller. For more details please refer to the Dimensional Data given in this document.

Ambient Temperature: Temperature in the machine room should be in the range of 4°F to 113°F.

Humidity: The humidity inside the chiller room should be less than 85%. High humidity can result in corrosion and failure of electrical equipment. The chiller room should be adequately ventilated.

Drainage: All the discharge pipes and overflow pipes should be routed to the drains. The drains should be covered. The slope of the drainage system should be such that there is no accumulation of water. In case the chiller room is built in the basement, a water tank and pump is required for proper drainage.

Piping Guidelines

Fuel (oil/ gas) piping should be designed and installed to meet the prescribed safety standards. Pipe sizing should be as per the required flow rates.

- For oil-fired systems, the fuel tank should be equipped with safety devices such as firetrap, level controls and vent, drain connections. The fuel tank should not be exposed to rain. Filters should be installed at the inlet and outlet of the fuel tank. Depending on the elevation of the fuel tank with respect to the burner, a day tank may be required.
- For gas-fired systems, the piping design pressure should be higher than the working pressure. The piping should be equipped with a stop valve, safety devices, vent, drain and sampling connections. It should have minimum pressure drop and should be tested for leaks.
- In the connecting lines, the field instruments should be installed adjacent to the chiller. Design and routing of the piping should provide easy access to the field instruments for effective maintenance.
- The crossover piping from the absorber to the condenser is a standard feature of Thermax absorption chiller.
- The piping should be adequately supported to prevent any strain on the chiller nozzles and connecting flanges.
- Check whether the air-vent valves, drain valves and the pressure gauges are provided on the chilled water, cooling water, fuel and drain piping. The drain connections should be at the lowest point, whereas the air-vents should be at the highest point on the piping.
- The inlet chilled water line, hot water line and the inlet cooling water line to the chiller should be flushed clean, before connecting these to the chiller.
- Check the connective direction of the chilled water and the cooling water piping.
- Check the valve positions on the chilled water piping, cooling water piping, fuel and drain piping.
- Make sure that strainers are provided in the water circuits.
- If cooling water pump is not dedicated to individual chiller, auto-operated butterfly valve is necessary in the cooling water circuit.

Electrical Guidelines

- All field wiring should be in accordance with applicable codes.
- Use Copper conductors only.
- All wiring should be checked regularly for any damage and all terminal connections tested for tightness.
- The power supply specifications should match those on the unit nameplate. Voltage must be within 15% of nameplate value.

- For minimum circuit ampacity and maximum fuse size, see the unit nameplate.
- Wiring to the chiller control panel should be proper.
- Proper wiring should be provided from the chiller control panel to the control valve.
- Proper interlocking of chilled water and cooling water with the chiller control panel should be provided.

Insulation Guidelines

- Use adhesive agents, iron wires and bounds to mount insulation material. These should not be fixed/ mounted using tapping screws or rivets.
- Use non-combustible insulation material. This could be wool or polystyrene foam in case of cold surfaces, and glass wool in case of hot surfaces.
- The insulation should not cover the cap of the damper, sight glass, handle of the refrigerant lowdown valve, refrigerant pump motor, refrigerant level electrode box cover, HTG level electrode level box cover and the service valves.
- For effective in-tube cleaning, the evaporator header should be removable.
- To assist in-tube inspection, the HTG headers should be removable.
- In addition to this, following components should also have removable insulation:
  - Chilled water flow switch
  - Chilled water freeze protection thermostat
  - Chilled water temperature sensor

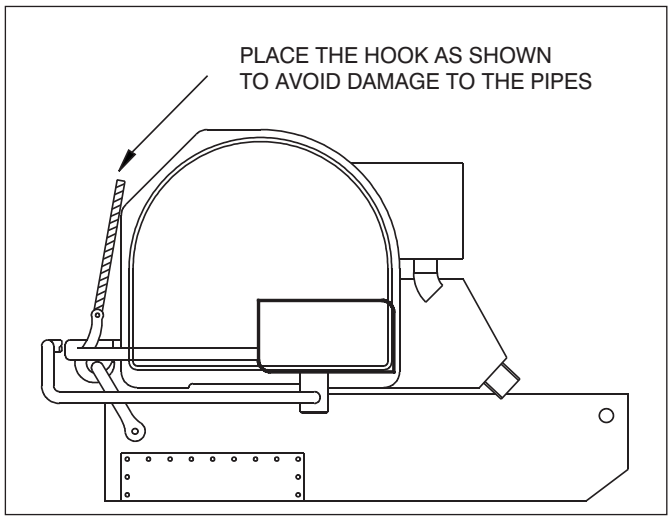
Flue Gas Duct Guidelines

- The flue gas duct and chimney should be designed and installed to comply with prescribed specification and safety standards.
- The flue gas duct and chimney should be designed so that the outlet pressure is slightly negative. The outlet pressure can be maintained by using dampers in the flue gas duct, especially when multiple chillers are connected to the same chimney.
- Sharp bends and other fittings causing back pressure should be avoided. The chimney height should be based on the sharp bends and the horizontal length of the duct.
- The machine room should have adequate ventilation for sufficient burner make-up air and for effective flue gas removal. The machine room pressure should never fall below the flue gas outlet pressure. The chimney location should depend on the atmospheric conditions and the position of the cooling tower and vents.
- Soot should be removed from the system. Heat resistant material should be used for its construction. Ducts should be properly insulated. The chimney should have lightning arresters with proper earthing connections. It should have effective protection from rain, wind and snow. Expansion joints should be provided to limit thermal stresses.

Site Unloading And Installation

Unloading instructions

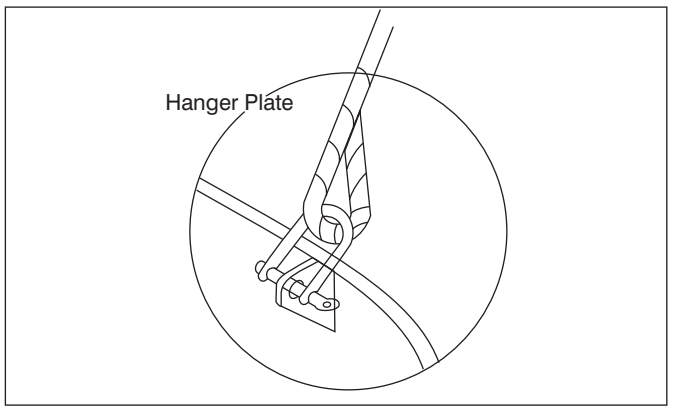
- For unloading purposes, use the lifting shackles provided on the chiller. Rigging from any other point on the chiller can damage the unit and cause personal injury.
- Use proper sized hooks/ slings and approved methods for lifting the chiller.
- Lift the chiller simultaneously from all four corners, while keeping the unit level with the ground.
- Proper care should be taken while hooking up the shackles near the pipes. (Refer figure)
- Every care should be taken to prevent damage to interconnecting pipes, control panel and chiller mounted panel.



Unloading & Installation of Machine (Single piece)

As a standard feature, the chiller is shipped as a single piece. All piping should be adequately supported and fitted to prevent any strain on nozzles and connecting flanges. During installation, sizes of cooling and chilled water lines should match with those of the connecting nozzles. Their inlet connections should be flushed clean, and the electrical wiring should be verified. The sketch shown below indicates the unloading of a single piece chiller.

Note: This is only a diagrammatic representation of the general appearance of the chiller. The actual chiller may be different than what has been shown here.



Rigging and shifting to the foundation

To avoid any damage, the chiller should be rigged with care to its ultimate location. A plate should be placed beneath the saddles of the chiller and castors or rollers placed below this plate. The chiller should be pulled gradually from one side using a winch. The wire rope used for pulling should be tied to the saddle.

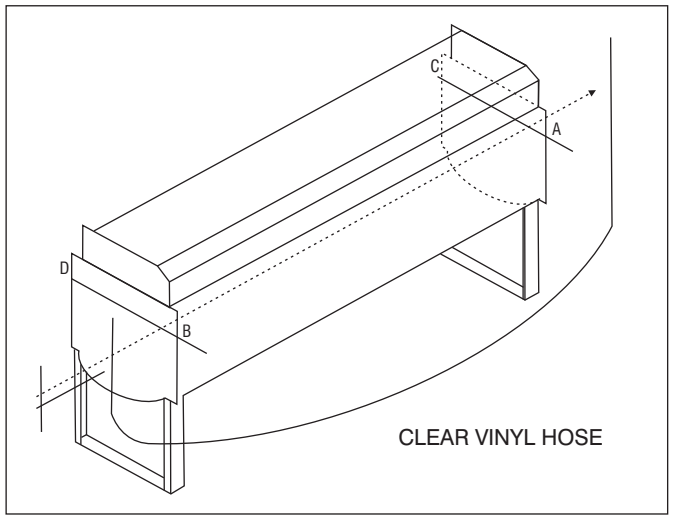
Leveling of chiller

Before hooking up the chiller to the external piping, it is very important to level it based on the procedure given below. Proper leveling of the chiller is essential to achieve the rated capacity of the unit. Allowable tolerance (both lengthwise and side-wise) is less than or equal to 1/16 inch per 5 ft.

There are four leveling checkpoints provided on the heater. Labeled as A, B, C and D in the figure below, these check points are designated by three punch marks on the tube sheet or shell of the lower shell of the chiller.

Procedure for leveling

Fill a clear vinyl hose (diameter of the hose 3/8”) with water, ensuring that there are no air bubbles in it. Using point 'A' as reference point, measure the difference in the water level at the other points (i.e. B, C and D).



A	B	C	D
0 inch	inch	inch	inch

Leveling calculations are as shown below:

$$\frac{A-B}{L}=\frac{C-D}{L} \qquad \frac{A-D}{L}=\frac{B-C}{L} \qquad \frac{A-C}{W}=\frac{B-D}{W}$$

Where L= Length of the heater
W= Width of the heater

In case the tolerance is not met, it can be achieved by inserting a metal shim between the chiller frame and foundation. Metal shim size could be 2” width X 3” length, whereas the thickness of the shims should be in the range of 0.024” to 0.354”.

After making adjustments, confirm the leveling of the machine by taking a new set of readings.

Procedure for grouting

After leveling the chiller, it is required to be grouted before the external piping can be connected to it.

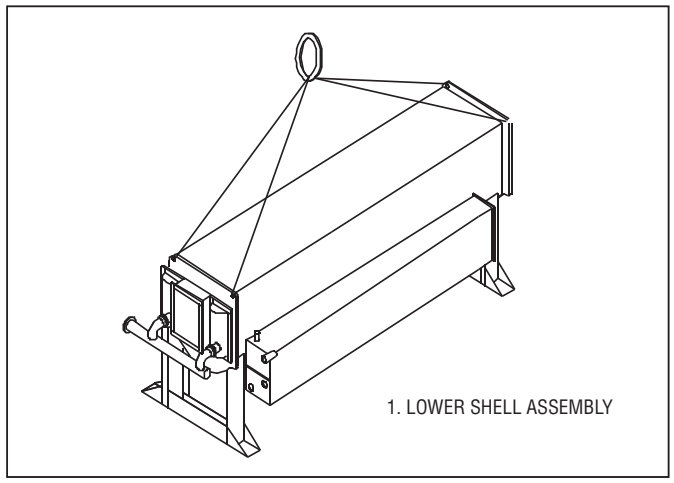
This is done by fixing the anchor bolts, by welding washer to the chiller frame and by tightening the bolts.

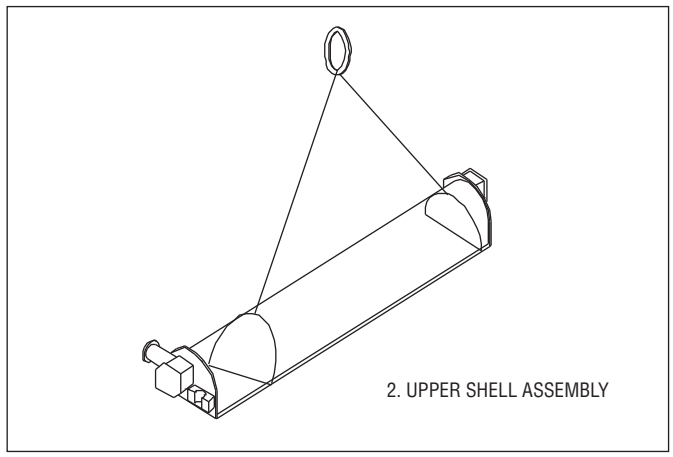
Storage of the unit

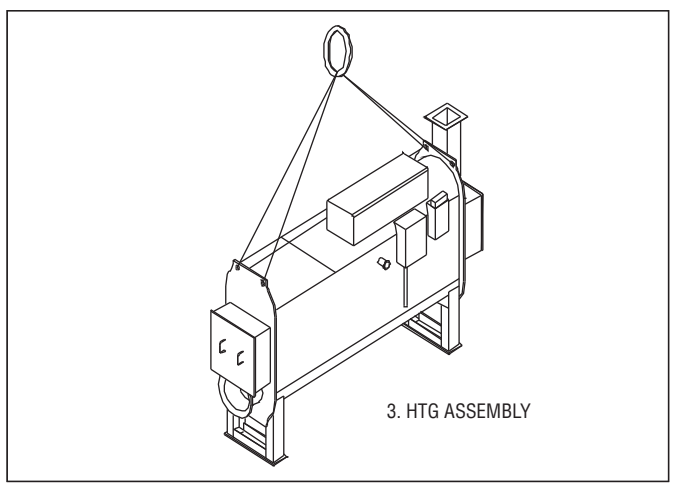
In case the unit is not to be installed immediately, it should be kept covered until its installation. It is recommended to keep the chiller indoors during this period to prevent any damage to it. Nitrogen should not be removed from the heater unit. All the accessories supplied along with the unit should be kept in the same place.

Optional Multi-sectional Shipment

The chiller can be shipped in three sections viz. the lower shell assembly, upper shell assembly and the HTG assembly. This is done when there are indications that the chiller's dimensions as a single piece may cause rigging problems (particularly for retrofit jobs).







Notes

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