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How to select the right industrial chiller

GUIDE

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It is an established fact that industrial chillers are an essential part of manufacturing procedures, especially where production downtime, due to excess heat, is not an option. In recent times there have been major advances and innovations in the design, performance, and efficiency of industrial chiller concepts. The significance of these developments is included in this guide.

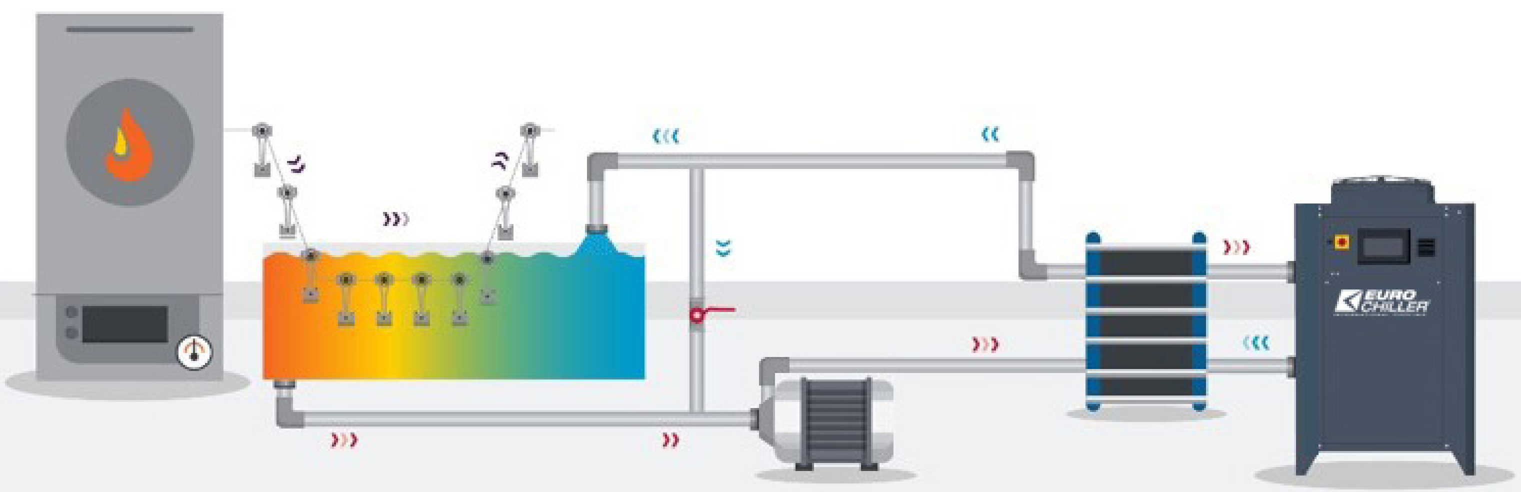
Why the right choice of chiller is important

Among the most compelling reasons for a chiller installation is minimising downtime through the continuous protection it provides in removing heat from valuable and temperature-sensitive process equipment. At the same time, a chiller saves water and associated costs by recirculating and re-using the plant's own water supply.

The cost of cooling water can add up quickly, especially if process equipment is running for several shifts a day. When a chiller is introduced into the system, it can bypass the costs and need for a monitored, municipal water supply and wastewater discharge, and contribute to substantial savings within production budgets. Furthermore, with the latest developments in chiller technology, capital investment payback can be realised over a very short period of the equipment lifetime.

Specifying a chiller installation

When specifying a chiller installation, a working knowledge of chiller performance factors is crucial to obtaining the right product fit. What needs to be determined is: the type of process fluid that will be used; the process cooling temperature; the flow and pressure requirements; the operating environment; ambient temperature; the chiller size needed and the spatial constraints of its location.



Process fluid performance

The main factors to bear in mind when considering the appropriate cooling fluids for a process are their performance characteristics and their equipment compatibility.

The performance of a cooling fluid is based upon its properties at a given temperature. The relevant parameters are specific heat, viscosity, and freezing/boiling points. There is a direct relationship between specific heat and cooling capacity. In order to maintain system integrity and prolong optimum performance, mixing a percentage of ethylene or propylene glycol with water (typically in the 10 to 50% range) is recommended when low or high setpoint temperatures are required.

In terms of compatibility, the potential for corrosion and the early degradation of seals are common failure modes for incorrectly sized systems. That is why the materials of construction and the nature of fluids should be an important consideration, and why inclusion of a corrosion inhibitor in the cooling fluid is recommended.

However, in the latest developments of chiller technology, the storage tank and hydraulic parts of centrifugal pumps are constructed in stainless steel to prevent process water contamination with rust particles, as well as provide higher levels of reliability and temperature control. Similarly, state-of-art, all-aluminium microchannel condensers are designed to provide long life without corrosion and require 30% less refrigerant charge in comparison to other types of heat exchanger.

Cooling fluid temperature

The setpoint temperature will affect the cooling capacity of a chiller. Decreasing the temperature will put more load on the refrigeration system, and vice versa for increasing it. There is a direct relationship between the temperature at which the chiller has been set and its total cooling capacity. Therefore, it is important to review the chiller's published performance data for relevance to the proposed installation.

At the same time, if the chiller is destined for an exposed site, it is equally important to establish the level of freeze protection required, i.e., the coldest leaving fluid temperature of the chiller during operation.

Process flow and pressure requirements

While pump life is a primary consideration when configuring an industrial cooling system, pressure loss across the system and the necessary flow rate must first be determined by the pump size and performance.

Pressure:
An undersized pump will reduce the fluid flow rate through the entire cooling circuit. If the chiller has been equipped with internal pressure relief, the flow will be diverted around the process and back into the chiller. If there is no internal pressure relief, the pump will attempt to provide the necessary pressure and run at what is referred to as dead-head pressure, or limit. When this state occurs, the pump's life can be drastically reduced; liquid ceases to flow and the liquid in the pump becomes hot, eventually vaporising and disrupting the pump's ability to cool leading to excessive wear to bearings, seals, and impellers.

Determining the pressure loss across a system requires siting pressure gauges at the process's inlet and outlet, then applying pump pressure to obtain values at the desired flow rate.

Flow rate:
Inadequate flow through the process will yield inadequate heat transfer so the flow will not remove the heat necessary for safe operation of the process. As the fluid temperature increases beyond the setpoint, the surface/component temperatures also will continue to rise until a steady-state temperature that is greater than the initial setpoint is reached.

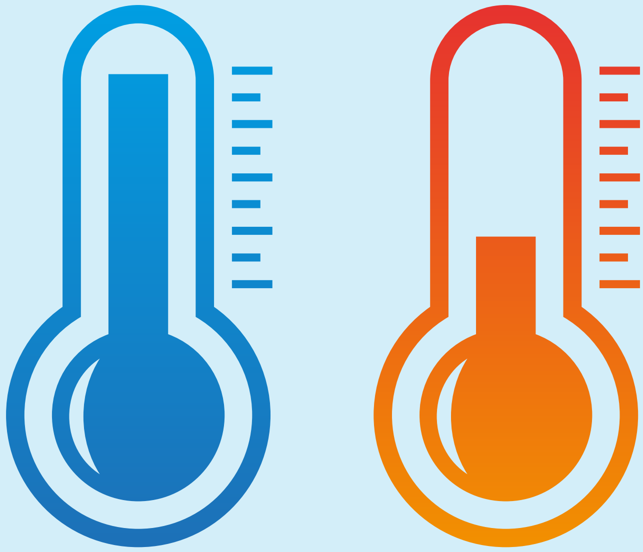
Most chiller systems will detail the pressure and flow requirements. When specifying the necessary heat load removal as part of the design, it is important to account for all hoses, fittings, connections, and elevation changes integral to the system. These ancillary features can significantly increase pressure requirements if not sized appropriately.

Chiller operating environment

Ambient Temperature
An air-cooled chiller's ability to dissipate heat is affected by the ambient temperature. This is because the refrigeration system uses the ambient air/refrigerant temperature gradient to induce heat transfer for the condensation process. A rising ambient air temperature decreases the temperature differential (ΔT) and, subsequently, reduces the total heat transfer.

If the chiller uses a liquid-cooled condenser, high ambient temperatures can still have negative effects on key components such as the compressor, pump, and electronics. These components generate heat during operation, and elevated temperatures will shorten their lifetime. As a guideline, the typical maximum ambient temperature for non-exterior rated chillers is 40°C.

Spatial Constraints
In order to maintain the proper ambient air temperature, it is important to provide adequate air circulation space around the chiller. Without proper airflow, recirculation of an inadequate volume of air rapidly heats it up. This affects chiller performance and potentially can damage the chiller unit.



Why size is important

Selecting a correctly sized chiller is a crucial decision. An undersized chiller will always be a problem – never able to properly cool the process equipment and the process water temperature will not be stable. In contrast, an oversized chiller will never be able to run at its most efficient level and prove more costly to operate.

To determine the correct size of unit for the application it is necessary to know the rate of flow and the heat energy that the process equipment is adding to the cooling medium, i.e., the change in temperature between the inlet and outlet water, expressed as the ΔT.

The formula for calculation purposes is: Heat energy per second (or more commonly known as Power) = mass flow rate × specific heat capacity × change in temperature (ΔT)' The specific heat capacity of the water is nominally expressed as 4.2 kJ / kg K but if it contains a percentage of glycol additives that value is increased to 4.8 kJ / kg. K

Note: 1K = 1°C and the density of water is 1 i.e.,1l of water volume = 1kg of water mass

An example
Here is an example of the formula application to determine the correct kW sized chiller to handle a water flow rate of 2.36 l/s (8.5 m3/hr) with a temperature change of 5°C

Heat Energy per second (kJ/s or kW) = 2.36 l/s (Flow Rate) X 5°C (ΔT) X 4.2 kJ /kg K (Specific Heat Capacity of pure water)

Chiller size required = 49.6 kW

Alternatively, the heat load to be cooled may already be known in which case the formula can be re-arranged to determine the temperature difference (ΔT) that can be attained with different flow rates (achievable with different pump sizes).

There may be other circumstances that can influence size choice. Planning for future plant expansion, exposure to high ambient temperatures, or location at high altitudes, could all lead to the specification of a different size of unit.

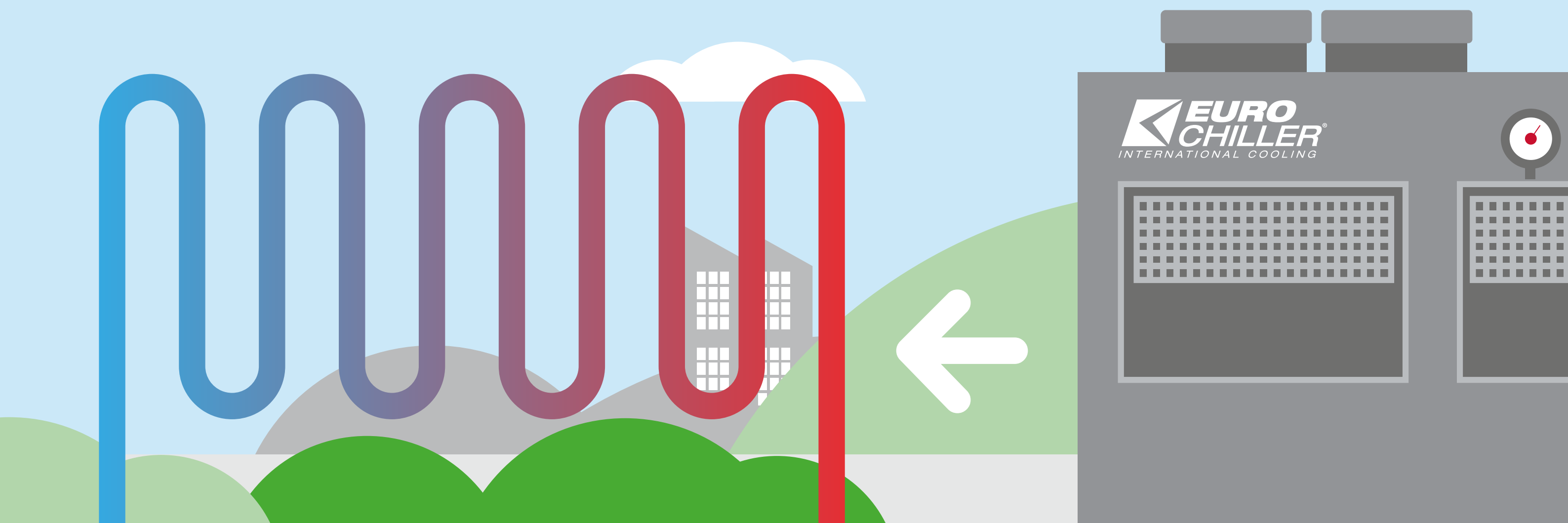
Maintenance, safety and control

In the latest, advanced generation of industrial chillers, ease of maintenance, operational safety, and intelligent control and connectivity are prominent features of their designs.

For example, they are constructed with IP54-rated, sound-attenuated canopies that allow chillers to operate indoors or outdoors, even at ambient temperatures down to -45°C. They are specifically designed for easy access to the installed components – refrigeration systems in the front and the cooling water circulation assembly in the back. Wide canopy doors and intelligent layout reduces maintenance time and allows for easy inspection to prevent breakdowns.

Innovative new models on the market feature a wide range of safety devices, such as flow and level switches, thermal probes, pressure probes, crankcase heating and strainers which allow the chiller to operate securely. Additionally, a fully hermetically sealed refrigeration system prevents refrigerant gas from leaking and requires zero maintenance. The provision of a phase sequence relay ensures no risk of compressor damage in case of incorrect wiring. Note: UK FGAS Regulations do require an annual, and on larger refrigeration systems , bi-annual inspection by a FGAS certifed engineer.

In these new designs, a touch screen controller operates with energy-efficient algorithms, combines all the chiller sensors into one system and issues timely warnings in case of deviation from the operating parameters. Full connectivity is achieved with built-in smart remote monitoring capability on chiller sizes 11 Kw and above. This provides user's machine data, in real time, in a clear format to ensure optimum efficiency.



Conclusion

In general, potential users of an industrial chiller system are advised to take into account the conditions in which the process chiller will be used, and the process for which it will be used. This will help to identify the features most needed in the system.

It is also wise to consider the possibility of expansion in the future. If the amount of heat output by one machine is increased, then the cooling power of the chiller has to be increased accordingly. If there is a variable heat rate, choose the kW rating that can handle the highest heat output.

In summary, taking all of these considerations on board, recognising the important technological advances, and the availability of chiller suppliers who incorporate them in their product offering, all helps in determining the optimal industrial cooling system for any particular application.

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