REPLACE ENERGY THROUGH SMART SYSTEM

FAFCO

MADE SWISS

POWER MANAGEMENT
SOLAR HEATING & HEAT RECOVERY
COOLING & ENERGY STORAGE

ICEBAT

A FAFCO SA registered trade mark

THERMAL ENERGY STORAGE SYSTEMS
(TES)

INTERNAL MELT
EXTERNAL MELT
HYBRID

Technical data

General Presentation

The ICEBAT, an ice storage system developped and marketed by FAFO since the 80's, was originally developed to flatten or shift in time the electrical power needed to cool or chill a process or a building

Its working principle is very simple : to store the cold, a given volume of water is frozen This phase change between water and ice is actually the most powerful mean to store a great cooling energy in a small volume. . To recover this cold, the ice is melted. The efficiency for a load/unload cycle is around 100% thanks to the very good insulation of the tanks.

Our exclusive technology is

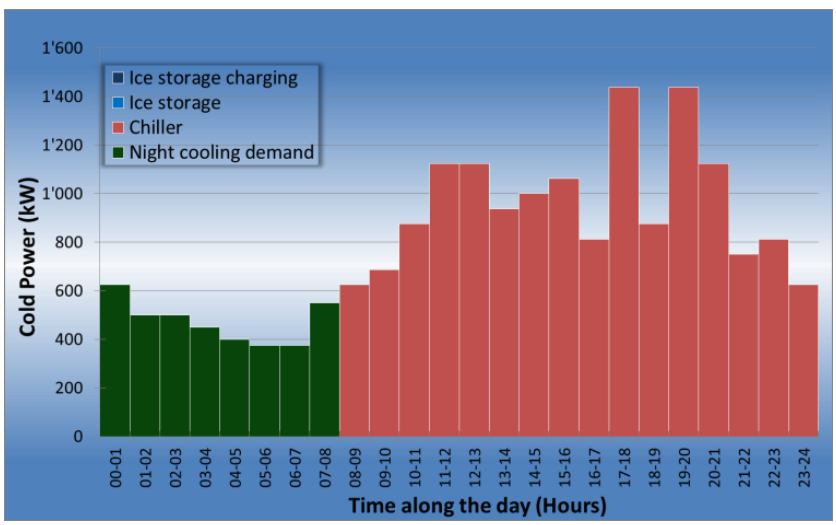
- reliable : suitable for critical applications and emergency systems,
- powerful : applicable for high loads in short time,
- versatile : many configurations and applications,
- flexible : several needs covered by a single system.

Moreover, it features

- a long life time : evaluated over 30 years,
- and a minimal maintenance need in comparison with chillers.

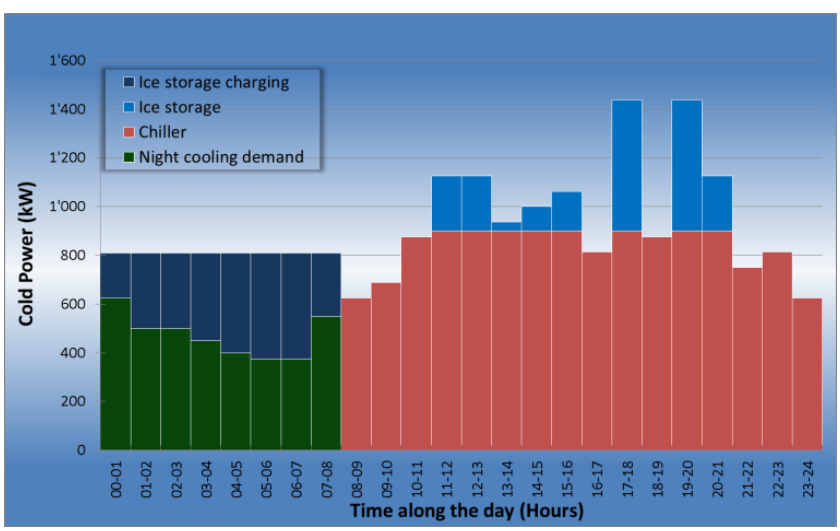
Example: Ice storage for an hospital

***Without ICEBAT**: the cold needs must be fully covered by the chillers.*
Installed power: 1400 kW of cold, i.e. around 450kW on the electric grid.



***With ICEBAT :** The peak loads are covered by the ICEBAT, which delivers its power in accordance with the needs.*
Installed power: 900 kW of cold, i.e. around 300 kW on the electric grid.

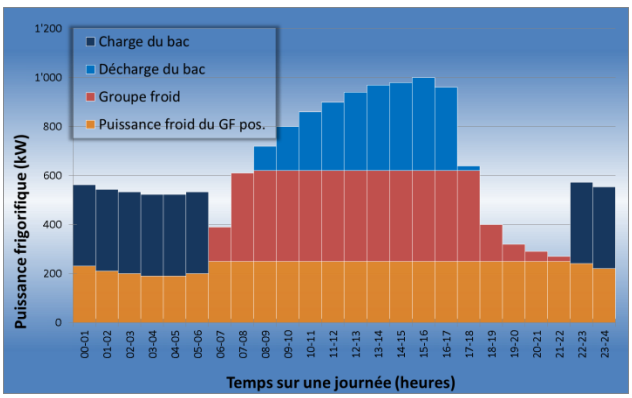
This represents a 30% reduction in the sizing of chillers, cooling tower and electrical panels.



General Presentation

The ICEBAT responds to many problematic in both industry and buildings. Hundreds of variations of the system allow a made-to-measure solution which will generate substantial efficiency on energy consumption, maintenance, operation and even investment. Moreover, the increased reliability and flexibility will give new ways of designing and operating your installation. Depending on the project, the ICEBAT allows:

- 5 to 50% reduction of the installed cooling power
- 5 to 50% reduction of the cooling towers
- 5 to 50% reduction of the electrical infrastructures
- Less stop and go and partial load operation of the chillers
- Cost reduction :
  - ✓ Fix costs : capacity price (kW price), infrastructures, investment, planed maintenance,
  - ✓ Production costs : kWh price, unplanned maintenance and failures, increased efficiency
- Energy efficiency can be increased thanks to lower outside temperatures, and nominal load of the machines, lower ancillaries' consumption (circulation pumps and cooling towers, dry coolers)
- Immediate start with very low electrical power need (circulating pump) and very high cooling power (0°C brine coming out of the system right after start up)
- Reduce refrigerant use through reduced circulating volume and reduced refrigerant piping : a great advantage to lower environmental impact, and administrative burden !



In the design phase, our simulation tool calculates the best sizing for the whole cooling plant : positive chillers (here in orange), negative/positive chillers (dark blue and red), and unloading (light blue) according to the actual building or process needs. The purpose is to cover the needs with minimum costs and maximum flexibility in the system operation.

FAFCO provide either a selection of chiller designed to work with ice storage, or only an ICEBAT compatible with existing chillers. The energy balance is calculated precisely to make sure the system match the requirements.

FAFCO systems feature leading performance and technology :

- Our %-accurate load sensor is the best available technology
- Shortest loading time of the market, even with "high" temperatures (-5°C)
- Most flexible unloading time
- Most powerful unloading system with the hybrid technology : down to 1 hour unloading time
- Online monitoring and remote-control system based on our 30 years experience
- A reference for reliability and life-time
- The most compact system on the market : the highest energy density
- The lowest glycol content on the market
- Very low pressure drop, still allowing for an even distribution of fluids and energy in the system
- Between 0.3% and 2% of daily thermal loss thanks to an optimized insulation, designed for each project
- A measurable Return on Investment ranging from 0 to 7 years on all our projects

Main application fields

Air conditionning

- Housing
  - Hostels
  - barracks
  - Holyday village
- Recreational resorts
  - Theme parks
  - Theater, concert halls
  - Museum
  - pools, gymnasium, stadium
- Professional buildings
  - Office buildings
  - Workshop, cleanroom, manufacturing area
- Commercial buildings
  - Commercial centers
  - Malls
- Special buildings
  - University
  - Exhibition halls
  - multi-purpose rooms
  - Bunkers
  - Subway stations
  - Hospitals

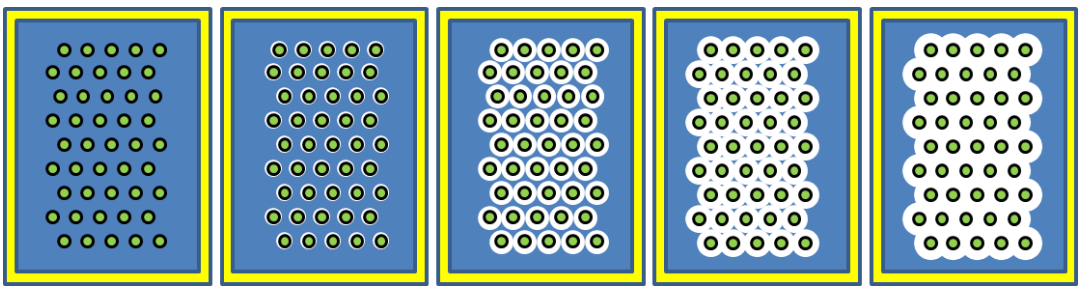
Refrigeration

- Food industry
  - Logistics, storage, conservation
  - Washing, packing
  - Transformation, sterilization, pasteurization
- Pharmaceutical, chemistry, biotechnologies
  - Fabrication
  - Conservation
  - Safety
  - Near zero temperature needs
- Other process
  - Fast decreasing temperature needs
  - Safety
  - Air conditioning + cold for process coupled
  - Near zero temperature needs

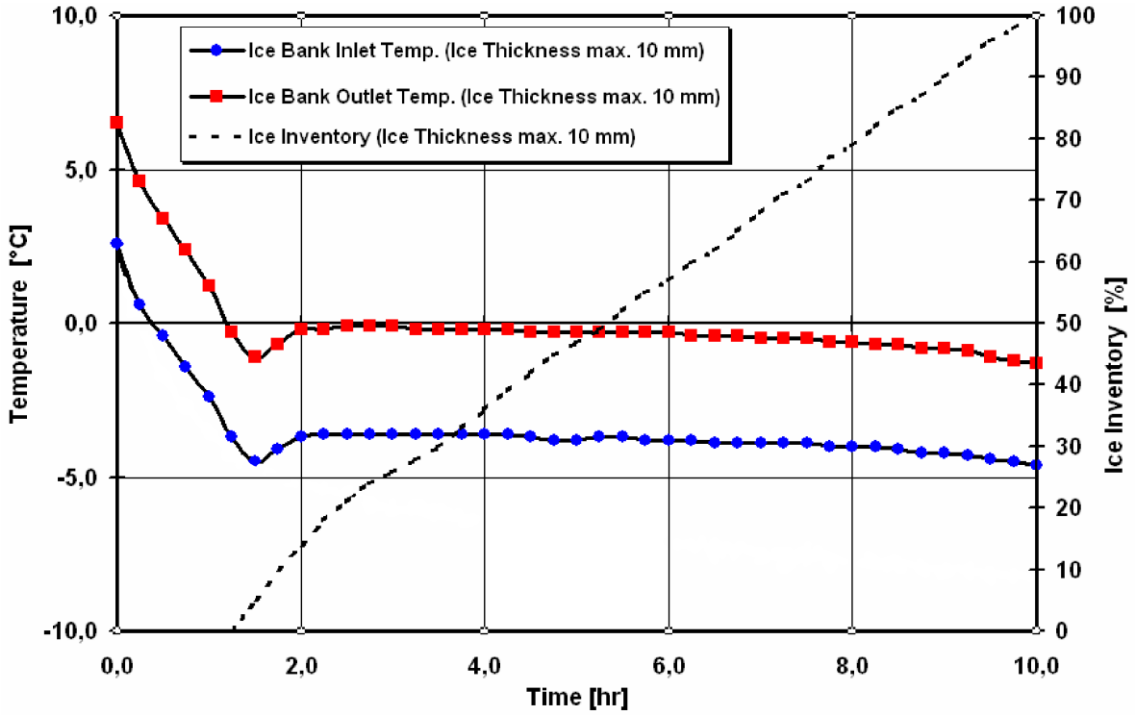
Working Principle
Loading the ice storage

The ice bank stores as ice the cold produced by the chillers. It consists in a large insulated and water tight tank containing district or industrial water in which heat exchangers are immersed. A heat transfer fluid, often a water-glycol brine, flows through the heat exchangers and convey cold between the chillers, the ice bank and the customer site. The water of the tank is then frozen to store the latent cold energy.

During the charge, the glycoled water is conveyed in the ICEBAT at a temperature between -3°C and -7°C in order to freeze the water and eventually create a massive bloc of ice inside the tank



The charge of FAFCO's accumulators is a very stable and homogeneous process. Typically, the glycoled water enters at a stabilized temperature of -5°C and exit at -2°C with a constant flow rate during the whole charge (about 8 hours). The diagram below shows real data for a charge at -4°C. The made to measure conception of our ICEBATs allows to reduce the number of tanks, simplify the connections, the regulation, and avoid the balancing problems linked to several storage modules.

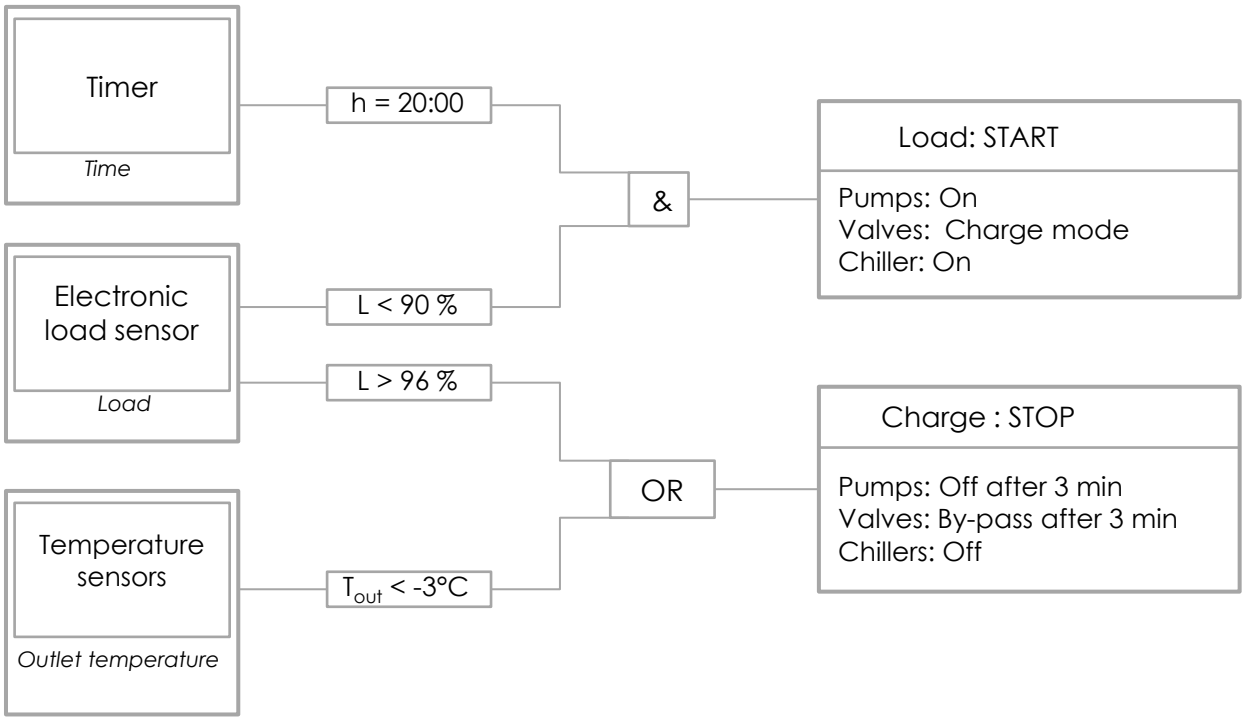


Charging time is usually comprised between 6 and 12 hours depending on chillers cooling power and charging temperature. A typical value for air conditioning applications would be 8/9 hours charging.

The discharge of the tank consists in recovering the cold energy by melting the ice. Several types of ICEBATs are available to match the customer needs (power, temperature, size, etc.)

Working Principle
Discharge mode

Block diagram of the loading process



Regulation is a key point to guarantee an optimized utilization of the ICEBAT. FAFCO always work in cooperation with the client/the operator and gives advices on how to control the system. Based on several parameters such as daily cold needs profile or seasonal variation, the load/unload cycle are thus well handled.

The load is triggered by external and internal parameters.

- External parameters: Timer, electrical tariff from the grid, electrical consumption of the site, chillers availability,
- Internal parameters: Ice level, temperatures, previous load and unload past

The purpose of this regulation diagram is to start charges only on a specific period (low tariff, low needs) and prevent an overload by avoiding frequent restart.

Indeed, the purpose is almost always to load the ICEBAT at 100%. The only regulation parameters to modify are the criteria to determine end of charge.

- Two indicators are used to control the end of the load: the outlet temperature and the ice level sensor. Thus, the chiller will instantaneously stop even if one of the two sensors was out-of-order.
- The chiller will stop at 96% because the sensible energy in the ice and the glycoled water will finish the load, just by running the pumps few minutes more.

Working Principle
Discharge Mode

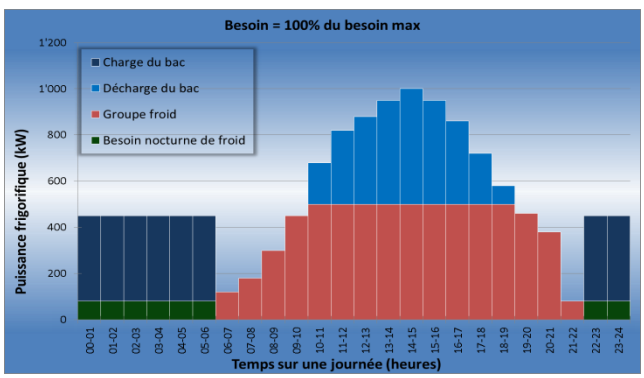
For the discharge, the regulation strategy needs to be adapted for each project, depending on the utilization of the ICEBAT, but also the season.

In general, a storage is designed for the maximal need of the year. In this case, the ICEBAT must be unload sparingly to be sure there will still be ice for the peak of the day.

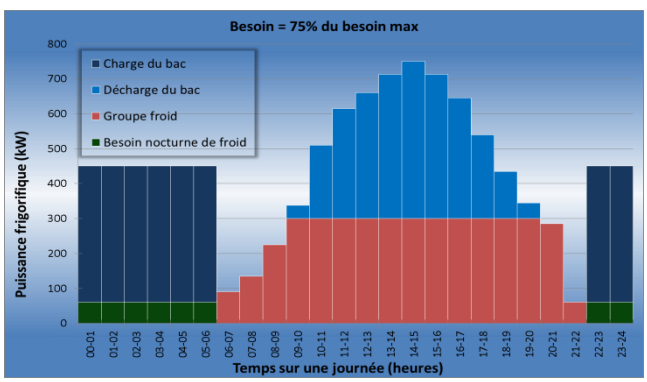
When the needs are smaller, the role of the storage is different: it must not be use only as a complement for the chiller, otherwise it will be very few solicited. Rather, it must be used in priority to benefit from the energy stored (made by night, so cheaper). Thus, it is recommended to reduce the power of the chillers (stopping one chiller, or using variable power chiller) but a constant speed, and to use the storage for the peaks.
The following figures illustrate those points. It represents the repartition of cold production on a full day, for an office building, with a maximum need of 1 000 kW.

Example: Annual evolution of the cold need

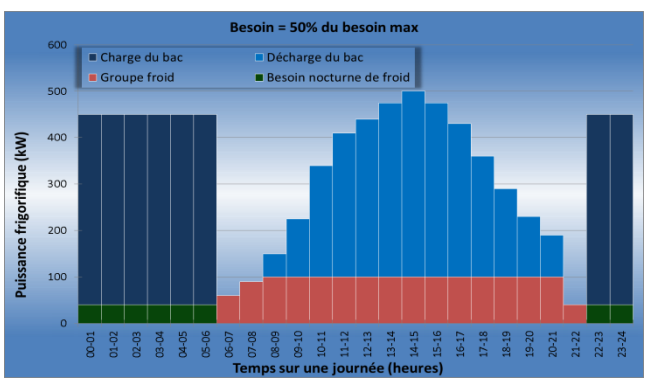
***In summer**: the needs curve is maximal, the storage covers 45% of the power and 30% of the daily load. The night, the chillers load of the ICEBAT (dark blue) and provide the cold for the night needs.*



***At mid-season:** The ICEBAT represents now 55% of the power and 50% of the daily needs. The storage is still used at 100%, so we can benefit a lot from it.*



***In Winter**: We can get into a situation where all the needs are covered by the ICEBAT. In our case, 75% of the needs are provided by the storage. This case is even the more efficient, because of high winter electrical tariffs and low temperature by night.*



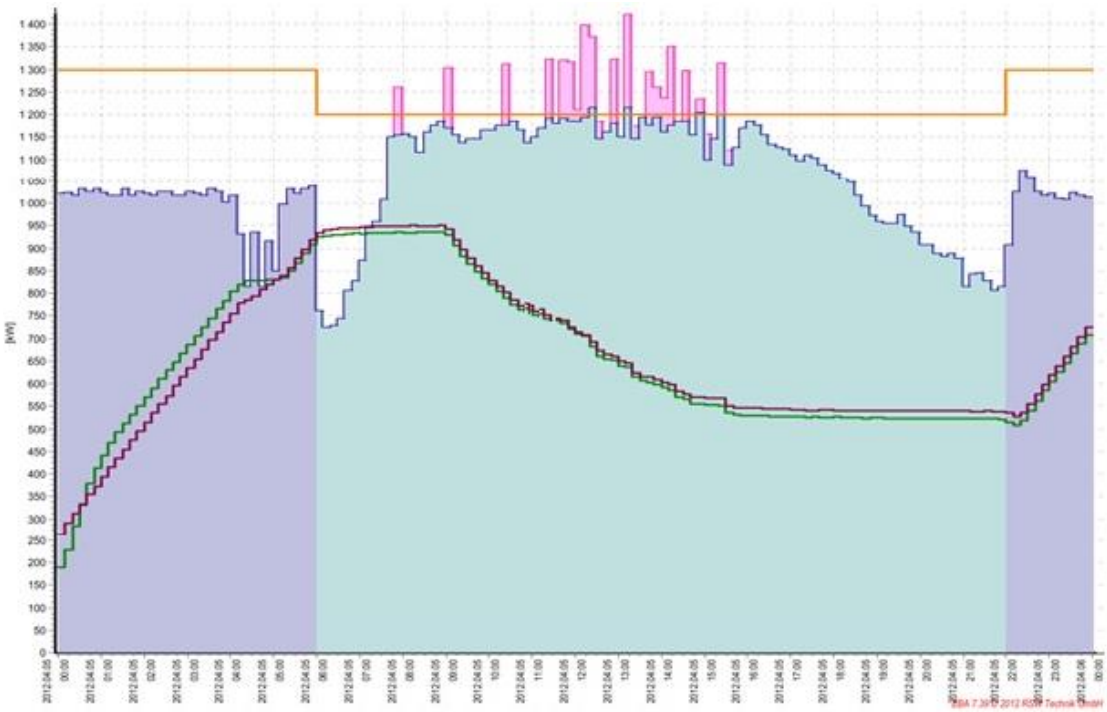
This is only one example for one type of application, but it is important to define for each project the operating conditions in order to create the best discharged strategy.
This is why FAFCO's engineers work in cooperation and early in the project to define together the rules to follow and the adapted uses.

Working Principle
Electronic load sensor

FAFCO ice banks are the only ones on the market to have a real-time monitoring of the load level with 1% accuracy. It includes following devices:
- a visual indicator of load level, graduated from 0 to 100%,
- an electronic level sensor with a 4-20 mA output compatible with your BMS, monitoring and control systems.

If outside, the sensor and indicator are installed in a protected stainless steel box.
The technical data of these components are available on the website www.fafco.ch.

To improve the performance of the plant and optimize continuously your operation, 3 levels of monitoring and control systems are also offered :
- **Level 1 : On-line Monitoring System, in order to have permanent access to your operation data, draw graphs and curves with electrical consumptions, ice level, and tariffs,**
- **Level 2 : On-line and automated control system for electrical load management of the customer site,**
- **Level 3 : Multi-sites control system for power management and energy trading**



Real data from Institut Curie, Paris, France
on a 24h period

Load management through our exclusive RSW system : cooling is performed through the ice bank when power demand exceeds power limit.

Pink bars : shifted or denied power consumption
Orange line : Max. power command, sent through the electrical grid
Purple and green lines : storage level of 2 FAFCO ice storages
Light blue bars : power consumption in high tariff hours, information sent through the electrical grid
Dark blue bars : power consumption during low tariff hours, information sent through the electrical grid

All this information can be shown on a day-to-day basis at your office desk, over a simple internet interface. Different information levels can be defined for the operator on site, his headquarters, the power supplier, and FAFCO for instance.

Design and Sizing

In order to dimensioning the ICEBAT for a specific project, FAFCO engineers examine the daily cold needs (per hour). They determine the optimized power of the chillers on the glycol loop (and the water loop if any) and the storage capacity to reduce investment and operating costs. Daily cycles of load/unload are defined depending on the needs, the temperatures available, and other specific constraints. This dimensioning is done for several scenarios in order to fit any situation (different seasons, electrical tariffs, …)

The following table is an example of our dimensioning. This is for an office building, with a maximum cold need of 570 kW. This analyse leads to a 262 kW chiller and a 1752 kWh ICEBAT. The daily needs can be covered by the chiller an the discharge of the storage.

(puissance minimum de la MF en positif:	262	kW)		
Puissance en positif des GF choisis:	262.3	kW		
(capacité minimum theorique de l'accumulateur:	1'652	kWh)		
Capacité totale des l'accumulateurs choisi:	1752	kWh	Type :	UW 233/4/11
Température d'entrée de l'échangeur à plaques:	4	°C	Nombre:	1
Température de sortie de l'échangeur à plaques:	10	°C		

Temps	Puissance nécessaire totale (kW)	h. charge 1=charge 0=décharge	Puissance froid du GF pos.(kW)	Puissance nécessaire GF+ACCU (kW)	Puissance en froidu GF +/- décharge (kW)	Puissance en froid de l'ACCU décharge (kW)	Puissance en froid neg. du GF charge (kW)	Degré en % de charge de l'ACCU	tranche horaire tarifaire	
h										
00-01	0	1	0	0	0	0	236	33%	1	0.0258
01-02	0	1	0	0	0	0	236	46%	1	0.0258
02-03	0	1	0	0	0	0	236	60%	1	0.0258
03-04	0	1	0	0	0	0	236	73%	1	0.0258
04-05	0	1	0	0	0	0	236	87%	1	0.0258
05-06	0	1	0	0	0	0	236	100%	1	0.0258
06-07	57	0	0	57	57	0	0	100%	2	0.04125
07-08	97	0	0	97	97	0	0	100%	2	0.04125
08-09	114	0	0	114	114	0	0	100%	2	0.04125
09-10	143	0	0	143	143	0	0	100%	2	0.04125
10-11	217	0	0	217	217	0	0	100%	2	0.04125
11-12	285	0	0	285	262	23	0	99%	2	0.04125
12-13	393	0	0	393	262	131	0	91%	2	0.04125
13-14	462	0	0	462	262	200	0	80%	2	0.04125
14-15	553	0	0	553	262	291	0	63%	2	0.04125
15-16	570	0	0	570	262	308	0	46%	2	0.04125
16-17	547	0	0	547	262	285	0	29%	2	0.04125
17-18	462	0	0	462	262	200	0	18%	2	0.04125
18-19	359	0	0	359	262	97	0	13%	2	0.04125
19-20	285	0	0	285	262	23	0	11%	2	0.04125
20-21	359	0	0	359	262	97	0	6%	2	0.04125
21-22	217	0	0	217	217	0	0	6%	2	0.04125
22-23	68	0	0	68	68	0	0	6%	1	0.0258
23-24	0	1	0	0	0	0	236	19%	1	0.0258
Somme (kWh)	5'188		0	5'188	3'536	max : 308 1'652	1'652			

Temps de charge: 7 heures

Construction

The ICEBAT can be built in a metal tank or a concrete tank, in our factory or directly on site, for indoor or outdoor location.

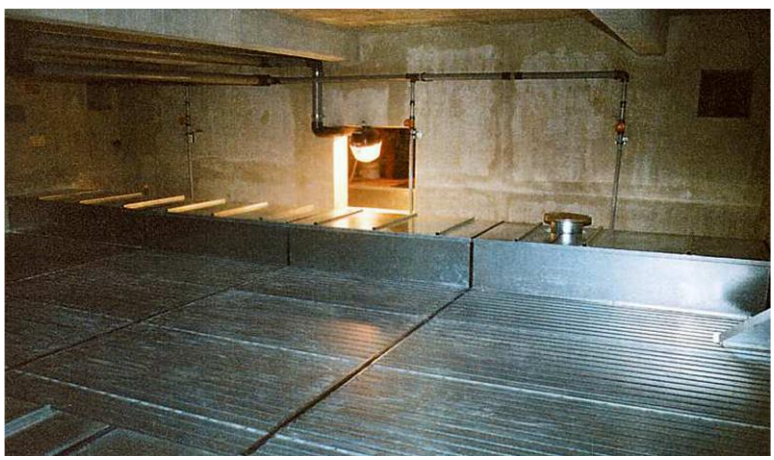
The steel ice bank consists of a rectangular steel tank assembled from trapezoidal steel sheets protected by an acrylic coating and galvanized steel profiles. A vapour barrier is placed between the tank walls and insulation plates to prevent condensation of ambient water vapour.

The ICEBATs in concrete are assembled on site by FAFCO inside a concrete tank provided by the customer.

In both steel and concrete tanks, a thermal insulation of the walls is guaranteed by 50 to 100 mm plates of an insulating material with a lambda lower than 0.040. Water tightness of the container is ensured by a liner of synthetic vulcanized rubber, factory welded according to the actual tank dimensions. It is oxidation-resistant and heat-aging-resistant. The liner back side is reinforced with textile fiber.

Inside the tank, a metallic structure insure the rigidity of a tubing network. This makes a performant heat exchanger between the glycol loop and the water inside the tank. This whole structure, made of galvanized steel is designed on measure for each project, depending on the size of the tank and any mechanical constraints specific to the project.
Many specific insulation parts are also used to make sure every thermal bridge is broken, avoiding every condensation problems on the outside wall of the tank.

In most projects, the top of the ICEBATs are closed and insulated by top cover sandwich panels (40mm thin). These panels are removable to allow maintenance or reparation if necessary. A service trapdoor is also available to allow visual controls. However, in some concrete tanks there is no top cover and it is the whole concrete tank which is insulated (from ground to ceiling).



Construction

FAFCO's ICEBATs are tailor-made products in order to bring the biggest latent capacity for a given volume (L, W, H). For metal tanks, length and width are between 1.5m to 12.0m, and high is between 2.0m and 4.2m. Concrete tanks can have bigger sizes: up to 16m in width and 6.5m in high. This flexibilty is made possible by the use of modules of plastic heat exchangers which can be assembled in our factory on site, depending on the global size of the ICEBAT. One module is 1.3m long, 18cm wide and the high is chosen for each projects.

The ICEBAT has 2 or 4 flange connections:

Internal melt ICEBATs, or ICEBAT UW, have one inlet flange and one outlet flange, connected to the glycol loop (linking the chiller, the ICEBAT and the plate heat exchanger). The same loop of glycoled water is used to charge the storage (glycol loop at negative temperature) and for the discharge (glycol loop heat by the client loop). The glycoled water flows through the FAFCO tubular heat exchangers, but the water in the ICEBAT doesn't quit the tank: its only purpose is to freeze and defreeze around the FAFCO's HX.

Main headers for water loop and glycol loop (inlets)

External melt ICEBATs or ICEBAT XM, have 4 flanges: one inlet for the glycol loop, one outlet for the glycol loop, one inlet for the water loop and one outlet for the water loop. This water loop is used as the cold source by the client, either directly or through an heat exchanger. The charge of the ICEBAT is done by the glycol loop (same as UW), but the discharge is done through the water loop. This water enters the tank at a positive temperature, and melt the ice by flowing around it. Since the extracted water is directly made from melted ice, its temperature is very low (0.5/1°C). In order to increase the heat exchange surface, the FAFCO's heat exchangers are slightly spaced, thereby creating several ice blocks.

Hybrid ICEBATs or ICEBAT HYE, combine the 2 previous systems (UW & XM), i.e. the glycol loop and the water loop. They aslo have 4 flanges (inlet/outlet for glycol and water loops), but the two loops are used during discharge. The FAFCO's heat exchangers are as close as for the UW. The heat exchange surface and global capacity are thus maximized, such as the available power.

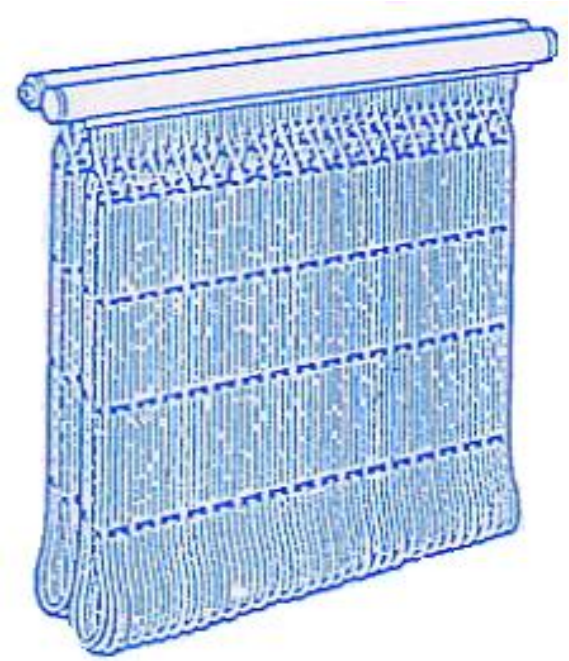
An hybrid tank, installed indoor on a pharmaceutical site. On the bottom we can see the outlet flange for water loop.

Heat Exchangers

FAFCO heat exchangers are designed to provide a large heat transfer surface area : 0.43 m2/kWh of latent heat. The active part of the heat exchanger consists of tubes of 6.5 mm of outer diameter which are produced by extrusion from a polypropylene-based polymer blend. The resulting plastic tube is ultra-stable, its resists to all chemical attacks usually encountered in industry, as well as oxidation and UV. The tubes are welded together using a patented FAFCO technology. This assembly constitutes an exclusive hydraulic distribution system. It ensures that the brine is uniformly distributed throughout the heat exchangers along the whole circuit, thus providing a great heat exchange efficiency and a uniform charging and discharging process. Moreover, this technology has an extremely low pressure drop thanks to the large effective pipe section.

The heat exchangers are manufactured in modules of 1.30m wide. Every modules are welded together to create a line. Depending on the project, the available space, the cooling power needed, the size of the heat exchangers, the number of module per line and the number of lines are defined to meet the customer needs.

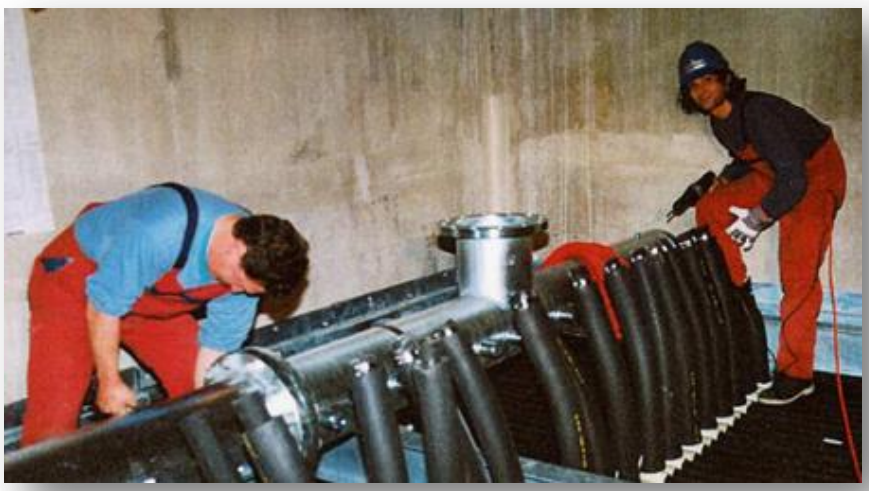
These exchangers lines are held by the metallic structure. They are connected to the main headers with reinforced flexible rubber hoses.



Minimal height:	*1,55 m in standard, 1,00 m if needed*
Maximal height:	*3,12 m in metal tank, 4,20 m in concrete tank*
Maximal number of modules per line:	*8*
Maximal number of lines:	*38 à 80 depending on the type of tank*

The main headers are made of stainless steel 1.4307/304L welded and provided with connecting flanges according to DIN EN ISO. The main headers are also provided with a safety valve and a pressure port.

The heat exchangers loop is equipped with all connections for testing and drainage.



THERMAL ENERGY STORAGE SYSTEMS
(TES)

ICEBAT UW
(Internal melt)

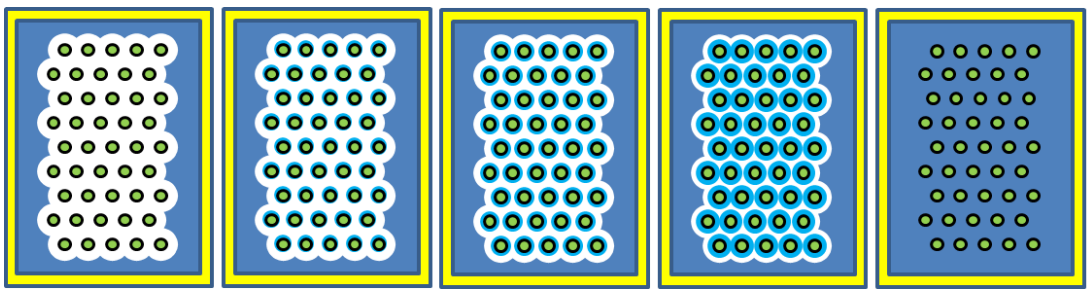
Technical data

WORKING PRINCIPLE : UW ice banks

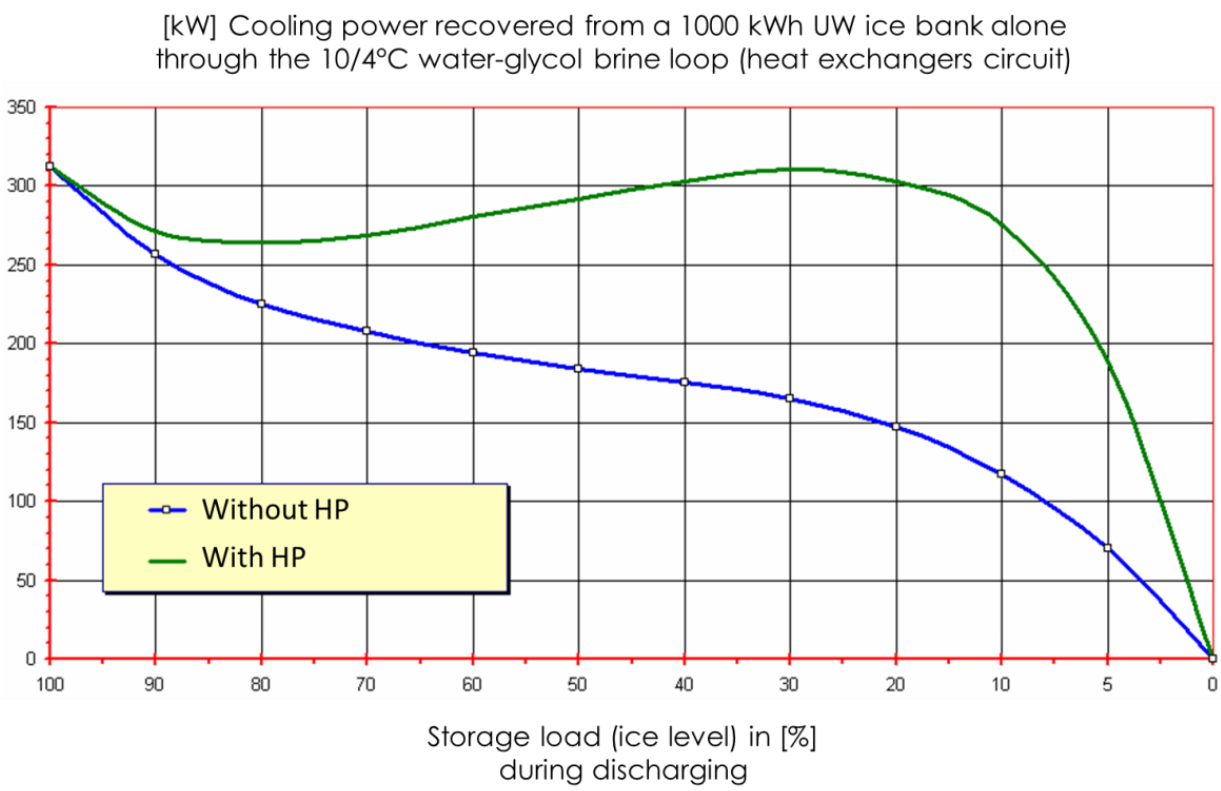
The standard FAFCO UW ice bank is an internal melt system.

For discharging in the internal melt system, the brine flows through the heat exchangers with a positive temperature. It is cooled down as the tubes are surrounded by ice and 0°C water as long as there is ice left in the tank.

This systems gives you an absolute reference for the 0°C and a stable temperature during the whole discharging cycle. The cooling power of the ice bank depends on the ice level in the tank (load level of the storage) because of the thickness of the water layer between the heat exchanger and the ice.

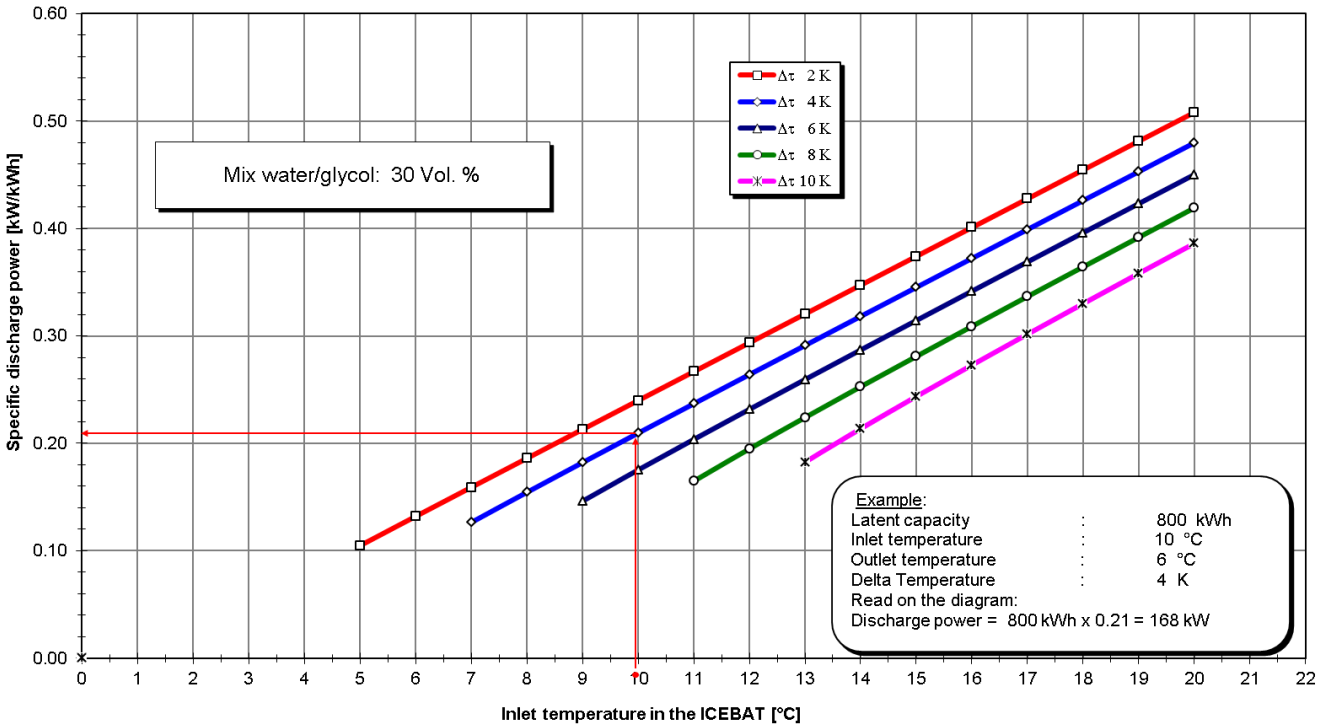


Discharging time can be shorten and recovered cooling power can be enhanced by using our exclusive HP system : air is blown into the tank to enhance water mixing and heat exchange through the water layer between the heat exchangers and the ice block. The HP system increases considerably the cooling power available from the ice storage while the storage load is low (see discharging power curves below).
The ICEBAT is the only ice storage system on the market providing such performance at low load.

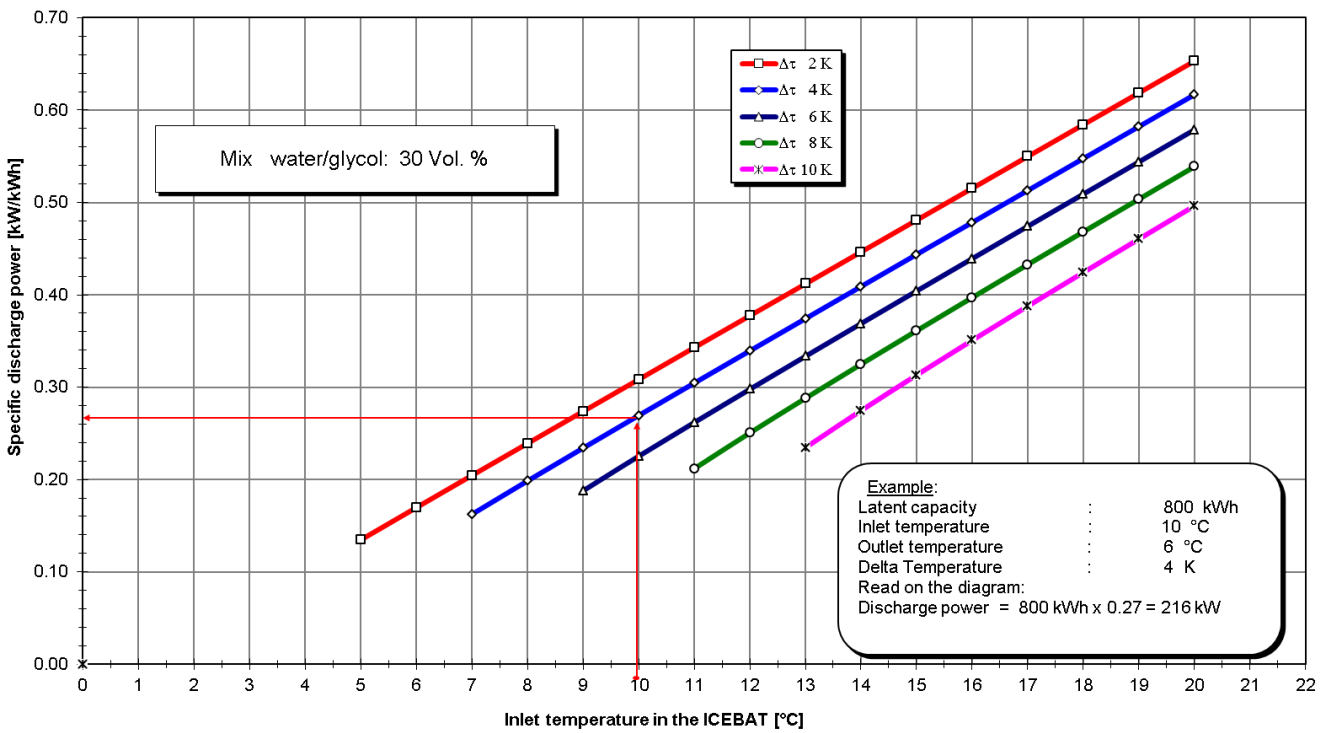


WORKING PRINCIPLE : UW ice banks

Discharge power without air agitation
Ice level : 40% of latent energy



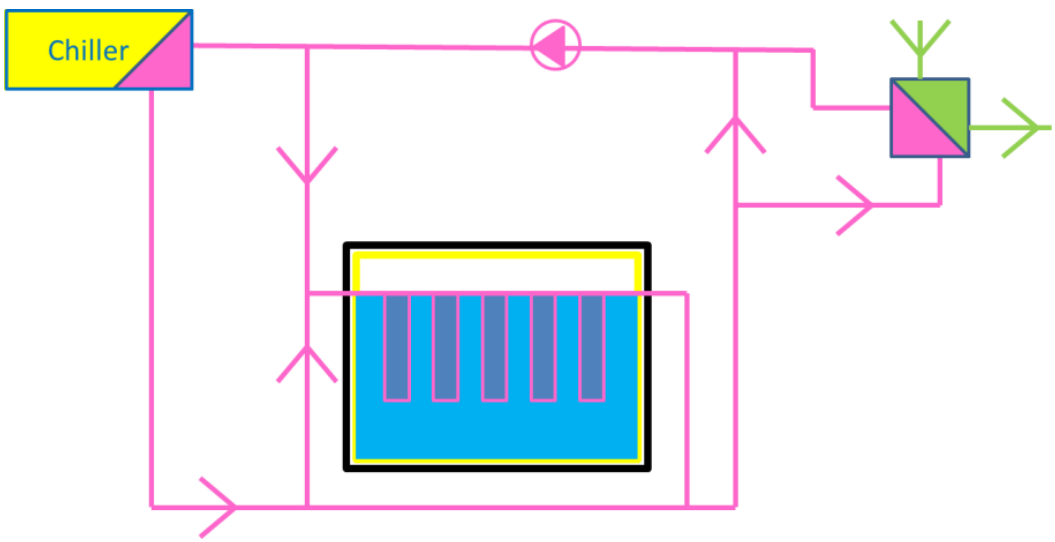
Discharge power without air agitation
Ice level : 80% of latent energy



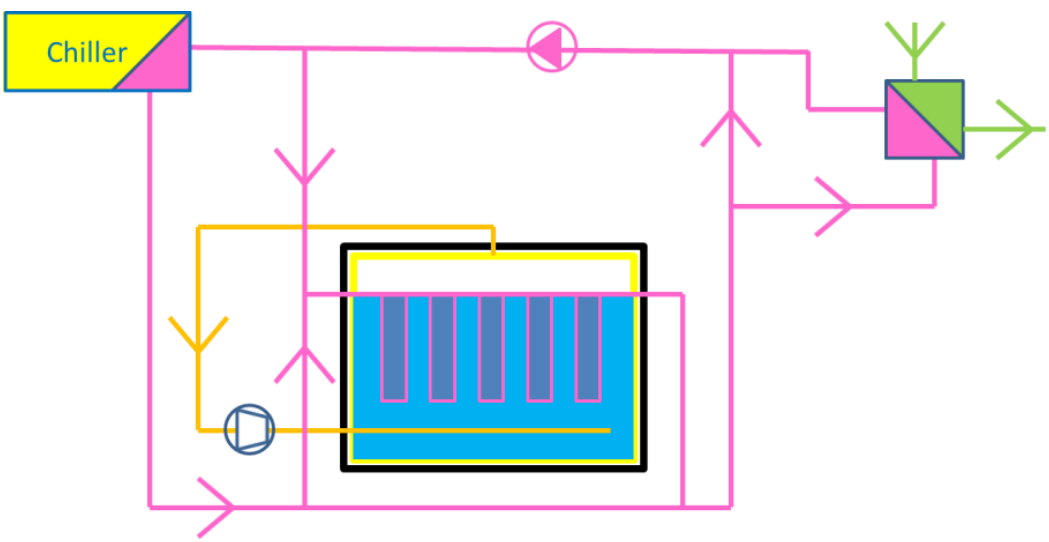
WORKING PRINCIPLE : UW ice banks

One example of hydraulic scheme is presented below for internal melt ICEBAT.

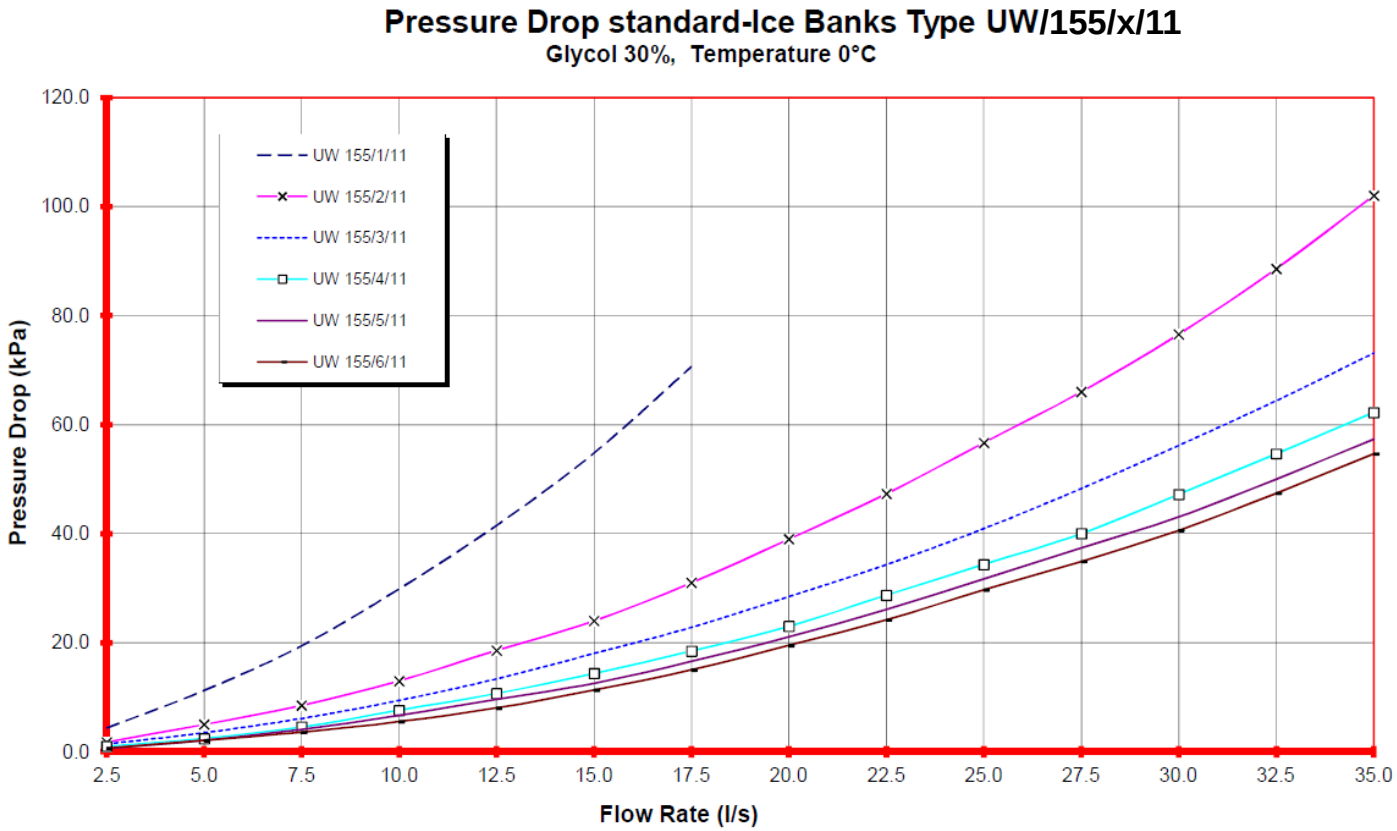
This scheme allows for discharging either in parallel or in series with the chiller. Operating in parallel is used for low pressure drop and high cooling power, while operating in series allows for low temperature. The cooling power is recovered here through a heat exchanger.

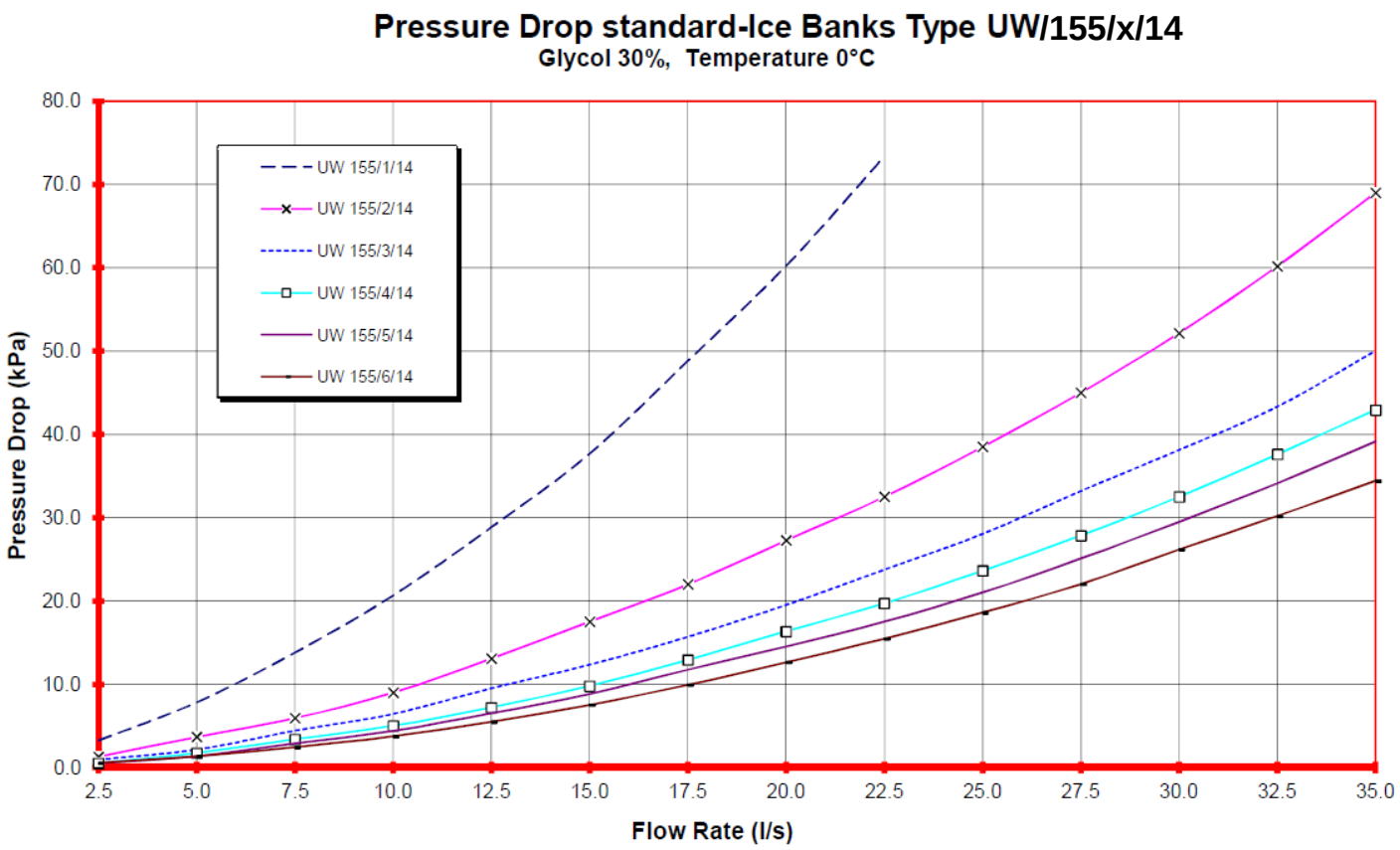


The same scheme is presented below with the High Power HP system and its air loop (in yellow).

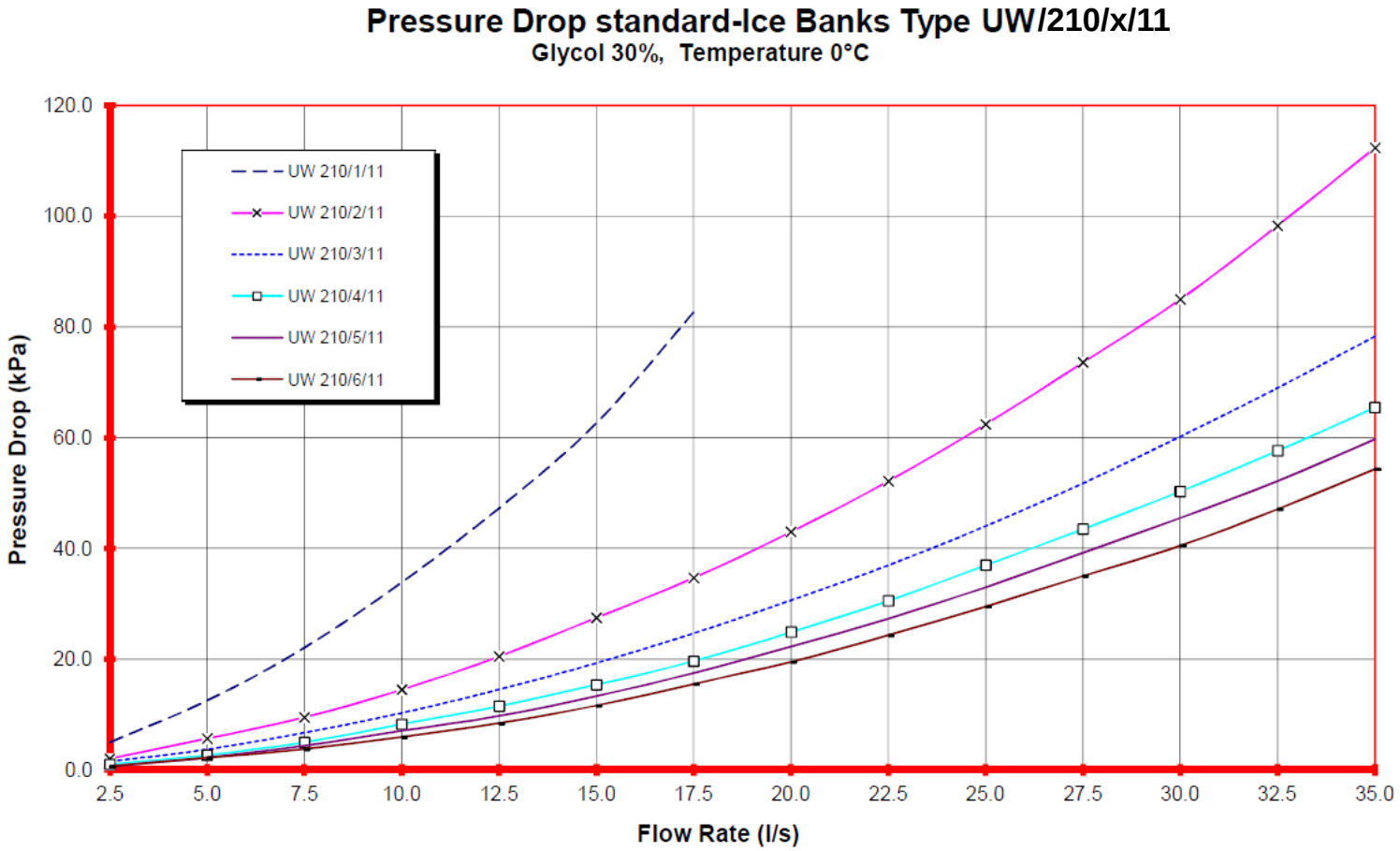


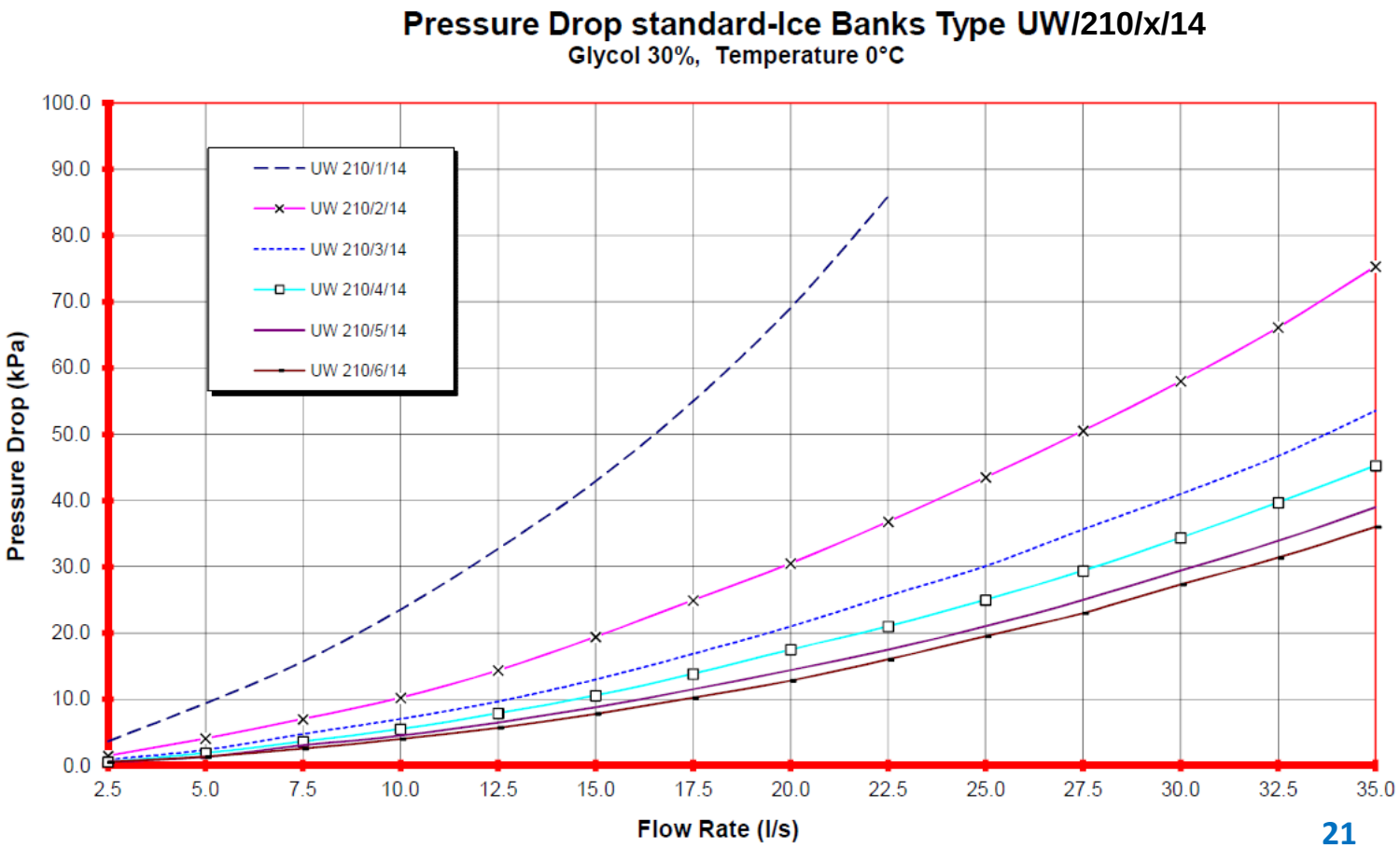
Pressure drop of the UW ice banks





Pressure drop of the UW ice banks





Maximal storage capacity of a FAFCO Ice storage Typ UW 155/…/… (kWh)

Height: 1.55 m		Total height with small ice storage cover: 2'190 mm										Total height with large ice storage cover: 2'370 mm									
Number of rows:		**6**	**7**	**9**	**11**	**12**	**14**	**15**	**17**	**18**	**20**	**21**	**23**	**24**	**26**	**27**	**29**	**30**	**32**	**35**	**38**
Total Width:		1'595	1'870	2'145	2'420	2'695	2'970	3'245	3'520	3'795	4'070	4'345	4'620	4'895	5'170	5'445	5'720	5'995	6'270	6'820	7'370
Number of modules	Total length																				
1	1'870	154	180	232	289	309	368	387	438	464	516	541	593	619	670	696	748	774	825	903	980
1.5	2'695	224	261	336	411	448	523	561	635	673	748	785	860	897	972	1'010	1'084	1'122	1'197	1'309	1'421
2	3'245	309	361	464	579	619	737	774	877	928	1'032	1'083	1'186	1'238	1'341	1'393	1'496	1'548	1'651	1'806	1'960
2.5	4'070	379	442	568	695	758	884	948	1'074	1'137	1'264	1'327	1'453	1'517	1'643	1'706	1'833	1'896	2'022	2'212	2'401
3	4'620	464	541	696	868	928	1'105	1'161	1'315	1'393	1'548	1'625	1'780	1'857	2'012	2'089	2'244	2'322	2'476	2'709	2'941
3.5	5'445	534	623	801	979	1'068	1'246	1'335	1'513	1'602	1'780	1'869	2'047	2'136	2'314	2'403	2'581	2'670	2'848	3'115	3'382
4	5'995	619	722	928	1'158	1'238	1'474	1'548	1'754	1'857	2'064	2'167	2'373	2'476	2'683	2'786	2'992	3'096	3'302	3'612	3'921
4.5	6'820	688	803	1'033	1'262	1'377	1'607	1'722	1'951	2'066	2'296	2'411	2'640	2'755	2'985	3'099	3'329	3'444	3'673	4'018	4'362
5	7'370	774	903	1'161	1'447	1'548	1'842	1'935	2'193	2'322	2'580	2'709	2'967	3'096	3'354	3'483	3'741	3'870	4'128	4'515	4'902
5.5	8'195	843	984	1'265	1'546	1'687	1'968	2'109	2'390	2'530	2'812	2'952	3'234	3'374	3'655	3'796	4'077	4'218	4'499	4'921	5'343
6	8'745	928	1'083	1'393	1'737	1'857	2'211	2'322	2'631	2'786	3'096	3'250	3'560	3'715	4'024	4'179	4'489	4'644	4'953	5'418	5'882
6.5	9'570	998	1'164	1'497	1'830	1'996	2'329	2'496	2'828	2'995	3'328	3'494	3'827	3'993	4'326	4'493	4'825	4'992	5'325	5'824	6'323
7	10'120	1'083	1'264	1'625	1'986	2'167	2'528	2'709	3'070	3'250	3'612	3'792	4'153	4'334	4'695	4'876	5'237	5'418	5'779	6'321	6'862
7.5	10'945	1'153	1'345	1'729	2'114	2'306	2'690	2'883	3'267	3'459	3'844	4'036	4'420	4'613	4'997	5'189	5'574	5'766	6'150	6'727	7'303
8	11'495	1'238	1'444	1'857	2'270	2'476	2'889	3'096	3'508	3'715	4'128	4'334	4'747	4'953	5'366	5'572	5'985	6'192	6'604	7'224	7'843

Maximal storage capacity of a FAFCO Ice storage Typ UW 210/…/… (kWh)

Height: 2.10 m		Total height with small ice storage cover: 2'770 mm										Total height with large ice storage cover: 2'950 mm									
Number of rows:		**6**	**7**	**9**	**11**	**12**	**14**	**15**	**17**	**18**	**20**	**21**	**23**	**24**	**26**	**27**	**29**	**30**	**32**	**35**	**38**
Total Width:		1'595	1'870	2'145	2'420	2'695	2'970	3'245	3'520	3'795	4'070	4'345	4'620	4'895	5'170	5'445	5'720	5'995	6'270	6'820	7'370
Number of modules	Total length																				
1	1'870	214	249	321	393	428	500	535	606	642	714	749	821	856	928	963	1'035	1'071	1'142	1'249	1'356
1.5	2'695	310	362	465	569	621	724	776	880	931	1'035	1'087	1'190	1'242	1'346	1'397	1'501	1'553	1'656	1'811	1'967
2	3'245	428	499	642	785	856	1'000	1'071	1'213	1'285	1'428	1'499	1'642	1'713	1'856	1'927	2'070	2'142	2'284	2'499	2'713
2.5	4'070	524	612	787	962	1'049	1'224	1'312	1'486	1'574	1'749	1'836	2'011	2'099	2'274	2'361	2'536	2'624	2'799	3'061	3'323
3	4'620	642	749	963	1'178	1'285	1'500	1'606	1'820	1'927	2'142	2'249	2'463	2'570	2'784	2'891	3'105	3'213	3'427	3'748	4'069
3.5	5'445	739	862	1'108	1'354	1'478	1'724	1'847	2'093	2'217	2'463	2'586	2'832	2'956	3'202	3'325	3'571	3'695	3'941	4'310	4'680
4	5'995	856	999	1'285	1'571	1'713	2'000	2'142	2'427	2'570	2'856	2'998	3'284	3'427	3'712	3'855	4'141	4'284	4'569	4'998	5'426
4.5	6'820	953	1'112	1'429	1'747	1'906	2'224	2'383	2'700	2'859	3'177	3'336	3'654	3'812	4'130	4'289	4'607	4'766	5'083	5'560	6'037
5	7'370	1'071	1'249	1'606	1'964	2'142	2'500	2'677	3'034	3'213	3'570	3'748	4'105	4'284	4'641	4'819	5'176	5'355	5'712	6'247	6'783
5.5	8'195	1'167	1'361	1'751	2'140	2'334	2'723	2'918	3'307	3'502	3'891	4'085	4'475	4'669	5'058	5'253	5'642	5'837	6'226	6'809	7'393
6	8'745	1'285	1'499	1'927	2'356	2'570	3'000	3'213	3'641	3'855	4'284	4'498	4'926	5'140	5'569	5'783	6'211	6'426	6'854	7'497	8'139
6.5	9'570	1'381	1'611	2'072	2'532	2'763	3'223	3'454	3'914	4'144	4'605	4'835	5'296	5'526	5'987	6'217	6'677	6'908	7'368	8'059	8'750
7	10'120	1'499	1'749	2'249	2'748	2'998	3'500	3'748	4'248	4'498	4'998	5'247	5'747	5'997	6'497	6'747	7'247	7'497	7'996	8'746	9'496
7.5	10'945	1'595	1'861	2'393	2'925	3'191	3'723	3'989	4'521	4'787	5'319	5'585	6'117	6'383	6'915	7'181	7'713	7'979	8'511	9'308	10'106
8	11'495	1'713	1'999	2'570	3'141	3'427	4'000	4'284	4'855	5'140	5'712	5'997	6'568	6'854	7'425	7'711	8'282	8'568	9'139	9'996	10'852

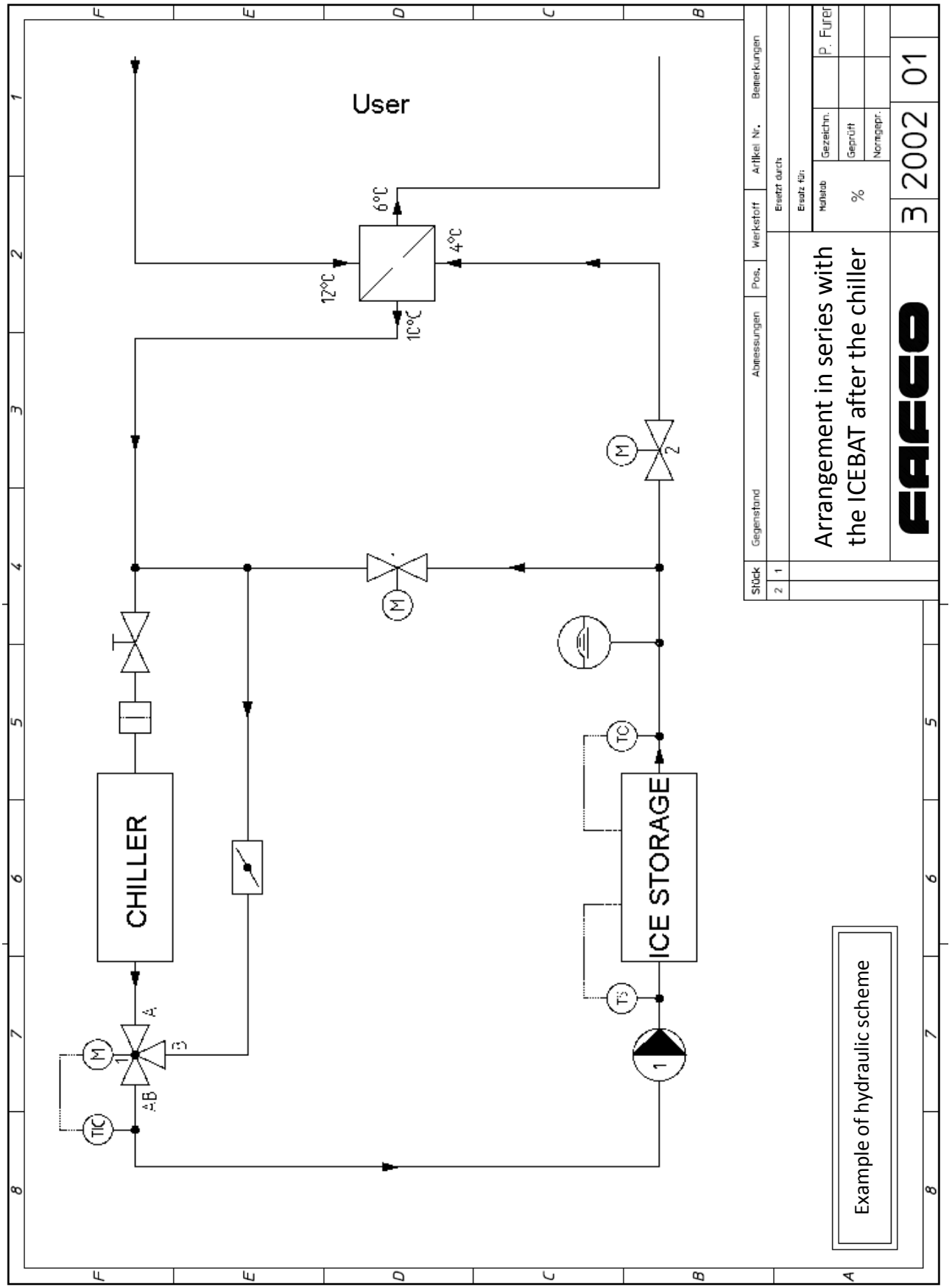
NB : les ICEBAT de ce type munis d'un système HP peuvent être 60 mm plus hauts.

Maximal storage capacity of a FAFCO Ice storage Typ UWH 312/…/… (kWh)

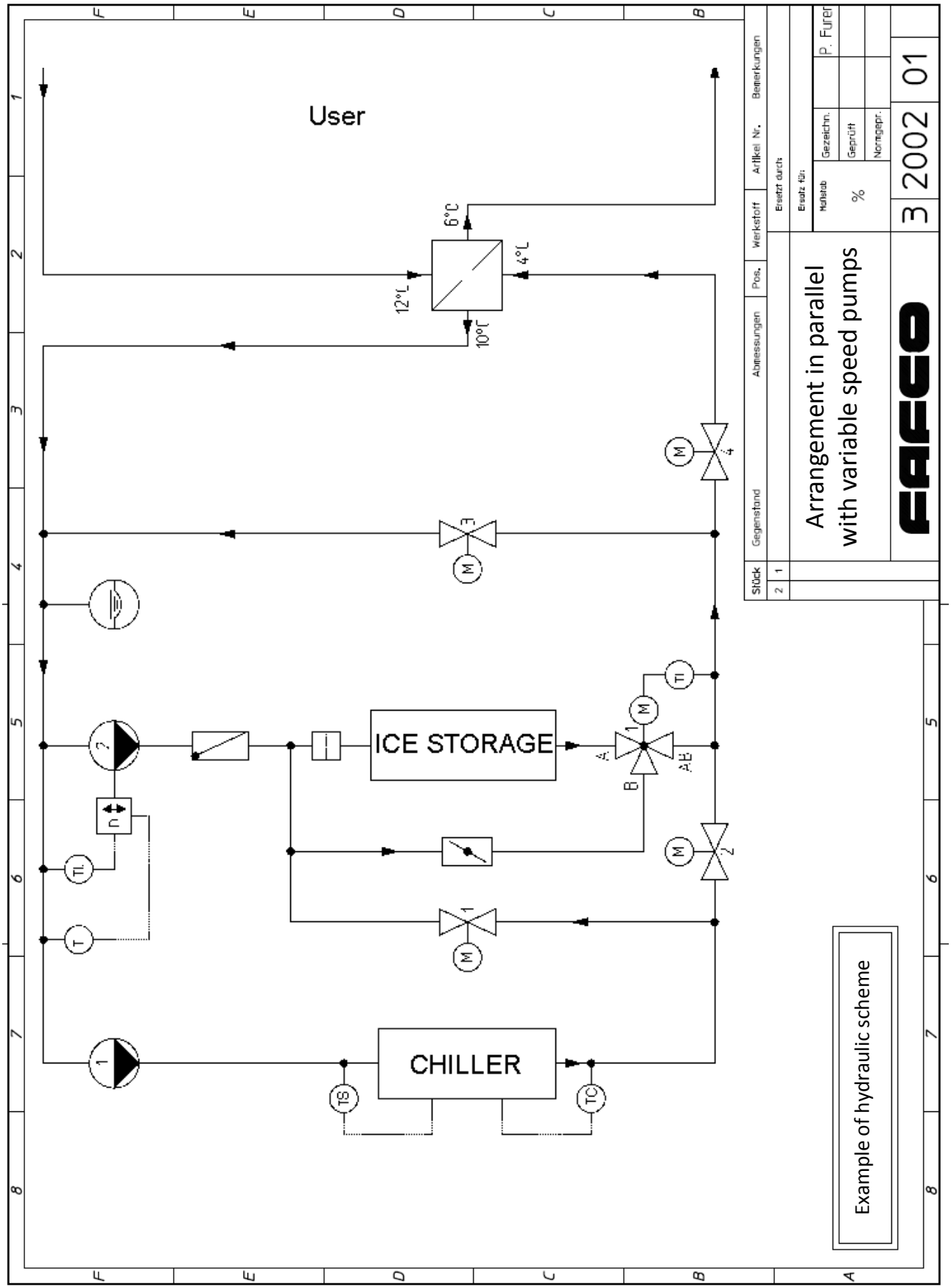
Height: 3.12 m		Total height with small ice storage cover: 3'980 mm												Total height with large ice storage cover: 4'180 mm											
Number of rows:		**5**	**6**	**8**	**9**	**11**	**12**	**13**	**15**	**16**	**18**	**19**	**21**	**23**	**24**	**26**	**27**	**29**	**31**	**33**	**34**	**36**	**37**	**39**	**40**
Total Width:		1'580	1'830	2'080	2'330	2'580	2'830	3'080	3'330	3'580	3'830	4'080	4'330	4'830	5'080	5'330	5'580	5'830	6'330	6'580	6'830	7'080	7'330	7'580	7'830
Number of modules	Total length																								
1	2'080	270	324	432	486	594	648	702	810	864	973	1'027	1'135	1'243	1'297	1'405	1'459	1'567	1'675	1'783	1'838	1'946	2'000	2'108	2'162
1.5	2'830	391	470	627	705	862	940	1'019	1'175	1'254	1'411	1'489	1'646	1'802	1'881	2'038	2'116	2'273	2'430	2'586	2'665	2'822	2'900	3'057	3'135
2	3'580	540	648	864	973	1'189	1'297	1'405	1'621	1'729	1'946	2'054	2'270	2'486	2'594	2'811	2'919	3'135	3'351	3'567	3'676	3'892	4'000	4'216	4'324
2.5	4'330	662	794	1'059	1'192	1'456	1'589	1'721	1'986	2'119	2'384	2'516	2'781	3'046	3'178	3'443	3'576	3'841	4'105	4'370	4'503	4'768	4'900	5'165	5'298
3	4'830	810	973	1'297	1'459	1'783	1'946	2'108	2'432	2'594	2'919	3'081	3'405	3'730	3'892	4'216	4'378	4'703	5'027	5'351	5'514	5'838	6'000	6'325	6'487
3.5	5'580	932	1'119	1'492	1'678	2'051	2'238	2'424	2'797	2'984	3'357	3'543	3'916	4'289	4'476	4'849	5'035	5'408	5'781	6'154	6'341	6'714	6'900	7'273	7'460
4	6'330	1'081	1'297	1'729	1'946	2'378	2'594	2'811	3'243	3'459	3'892	4'108	4'541	4'973	5'189	5'622	5'838	6'270	6'703	7'135	7'352	7'784	8'000	8'433	8'649
4.5	7'080	1'202	1'443	1'924	2'165	2'646	2'886	3'127	3'608	3'849	4'330	4'570	5'051	5'533	5'773	6'254	6'495	6'976	7'457	7'938	8'179	8'660	8'901	9'382	9'622
5	7'580	1'351	1'621	2'162	2'432	2'973	3'243	3'513	4'054	4'324	4'865	5'135	5'676	6'216	6'487	7'027	7'298	7'838	8'379	8'919	9'190	9'730	10'001	10'541	10'812
5.5	8'330	1'473	1'767	2'357	2'651	3'240	3'535	3'830	4'419	4'714	5'303	5'597	6'187	6'776	7'071	7'660	7'955	8'544	9'133	9'722	10'017	10'606	10'901	11'490	11'785
6	9'080	1'621	1'946	2'594	2'919	3'567	3'892	4'216	4'865	5'189	5'838	6'162	6'811	7'460	7'784	8'433	8'757	9'406	10'055	10'703	11'028	11'676	12'001	12'650	12'974
6.5	9'830	1'743	2'092	2'789	3'138	3'835	4'184	4'532	5'230	5'579	6'276	6'625	7'322	8'019	8'368	9'065	9'414	10'112	10'809	11'506	11'855	12'552	12'901	13'598	13'947
7	10'330	1'892	2'270	3'027	3'405	4'162	4'541	4'919	5'676	6'054	6'811	7'189	7'946	8'703	9'082	9'838	10'217	10'974	11'731	12'487	12'866	13'623	14'001	14'758	15'136
7.5	11'080	2'013	2'416	3'222	3'624	4'430	4'833	5'235	6'041	6'444	7'249	7'652	8'457	9'263	9'666	10'471	10'874	11'679	12'485	13'290	13'693	14'499	14'901	15'707	16'110
8	11'830	2'162	2'594	3'459	3'892	4'757	5'189	5'622	6'487	6'919	7'784	8'217	9'082	9'947	10'379	11'244	11'676	12'541	13'406	14'271	14'704	15'569	16'001	16'866	17'299

NB : l'utilisation d'un système HP sur ce type de bac peut en réduire la capacité à hauteur de 2%.

Integration scheme for a ICEBAT type UW
In series



Integration scheme for a ICEBAT type UW
In parallel



THERMAL ENERGY STORAGE SYSTEMS
(TES)

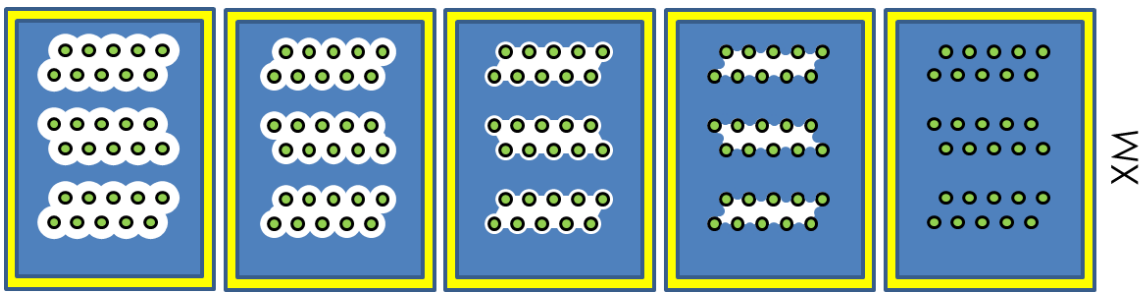
ICEBAT XM
(External melt)

Technical data

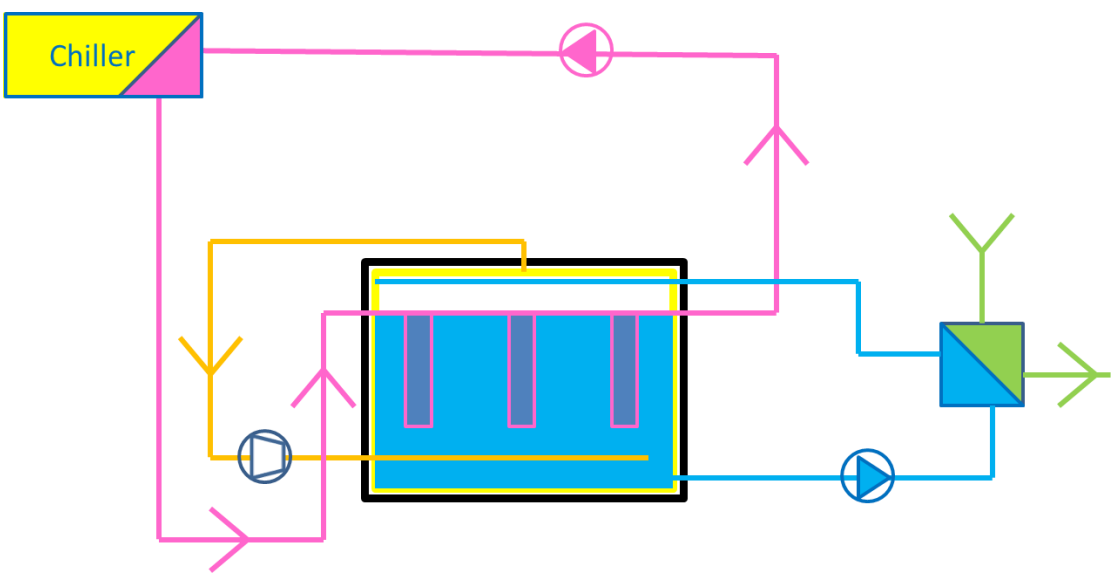
WORKING PRINCIPLE : XM ice banks

The FAFCO XM ice bank is an external melt system.

Pour décharger le système, l'eau liquide stagnant dans le bac autour du bloc de glace est pompée par le bas du bac. Elle cède ses frigories au réseau ou au process, puis est réinjectée dans le bac, sur le dessus du bloc de glace. Cette eau « chaude » circule dans le bac et se refroidit au contact de la glace, en la faisant fondre.



The XM system is always supplied with HP booster to enhance the ice melting : external melting does not provide very high melting surface area, because of the compact ice blocks



Yet, the XM systems is the best solution for some specific applications : using plain water as cooling medium and directly withdrawing it from the ice melting in the tank, it can provide any food processing with very low temperatures without any freezing risk or glycol contamination hazard.

The pressure drop for the water loop in the XM ice banks are equivalent to pressure drop in the glycol loop, because the ducts and pipes are similar in both cases.

Maximal storage capacity of a FAFCO Ice storage Typ XM 155/…/… (kWh)

Height: 1.55 m		Total height with small ice storage cover: 2'420 mm										Total height with large ice storage cover: 2'600 mm									
Number of rows:		**5**	**6**	**7**	**8**	**9**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**19**	**20**	**21**	**22**	**23**	**25**	**27**	**29**
Total Width:		1'595	1'870	2'145	2'420	2'695	2'970	3'245	3'520	3'795	4'070	4'345	4'620	4'895	5'170	5'445	5'720	5'995	6'270	6'820	7'370
	(UW+HYE)	6	7	9	11	12	14	15	17	18	20	21	23	24	26	27	29	30	32	35	38
Number of modules	Total length																				
1	1'870	101	122	142	163	183	224	244	265	285	305	326	346	387	407	428	448	468	509	550	591
1.5	2'695	172	207	242	276	311	380	414	449	484	518	553	587	657	691	726	760	795	864	933	1'002
2	3'245	230	277	323	369	415	508	554	600	646	692	739	785	877	923	969	1'016	1'062	1'154	1'247	1'339
2.5	4'070	301	362	422	483	543	664	724	784	845	905	966	1'026	1'147	1'207	1'267	1'328	1'388	1'509	1'630	1'751
3	4'620	359	431	503	575	647	791	863	935	1'007	1'079	1'151	1'223	1'367	1'439	1'511	1'583	1'655	1'799	1'943	2'087
3.5	5'445	430	517	603	689	775	947	1'034	1'120	1'206	1'292	1'378	1'465	1'637	1'723	1'809	1'895	1'982	2'154	2'326	2'499
4	5'995	488	586	684	782	880	1'075	1'173	1'271	1'369	1'466	1'564	1'662	1'858	1'955	2'053	2'151	2'249	2'444	2'640	2'835
4.5	6'820	559	671	783	895	1'007	1'231	1'343	1'455	1'567	1'679	1'791	1'903	2'127	2'239	2'351	2'463	2'575	2'799	3'023	3'247
5	7'370	617	741	865	988	1'112	1'359	1'483	1'606	1'730	1'853	1'977	2'101	2'348	2'471	2'595	2'718	2'842	3'089	3'336	3'584
5.5	8'195	688	826	964	1'102	1'240	1'515	1'653	1'791	1'928	2'066	2'204	2'342	2'617	2'755	2'893	3'031	3'168	3'444	3'720	3'995
6	8'745	746	896	1'045	1'195	1'344	1'643	1'792	1'942	2'091	2'240	2'390	2'539	2'838	2'987	3'137	3'286	3'435	3'734	4'033	4'332
6.5	9'570	817	981	1'145	1'308	1'472	1'799	1'962	2'126	2'290	2'453	2'617	2'780	3'108	3'271	3'435	3'598	3'762	4'089	4'416	4'743
7	10'120	875	1'051	1'226	1'401	1'576	1'927	2'102	2'277	2'452	2'627	2'803	2'978	3'328	3'503	3'678	3'854	4'029	4'379	4'730	5'080
7.5	10'945	946	1'136	1'325	1'515	1'704	2'083	2'272	2'461	2'651	2'840	3'030	3'219	3'598	3'787	3'976	4'166	4'355	4'734	5'113	5'492
8	11'495	1'004	1'205	1'406	1'607	1'808	2'210	2'411	2'612	2'813	3'014	3'215	3'416	3'818	4'019	4'220	4'421	4'622	5'024	5'426	5'828

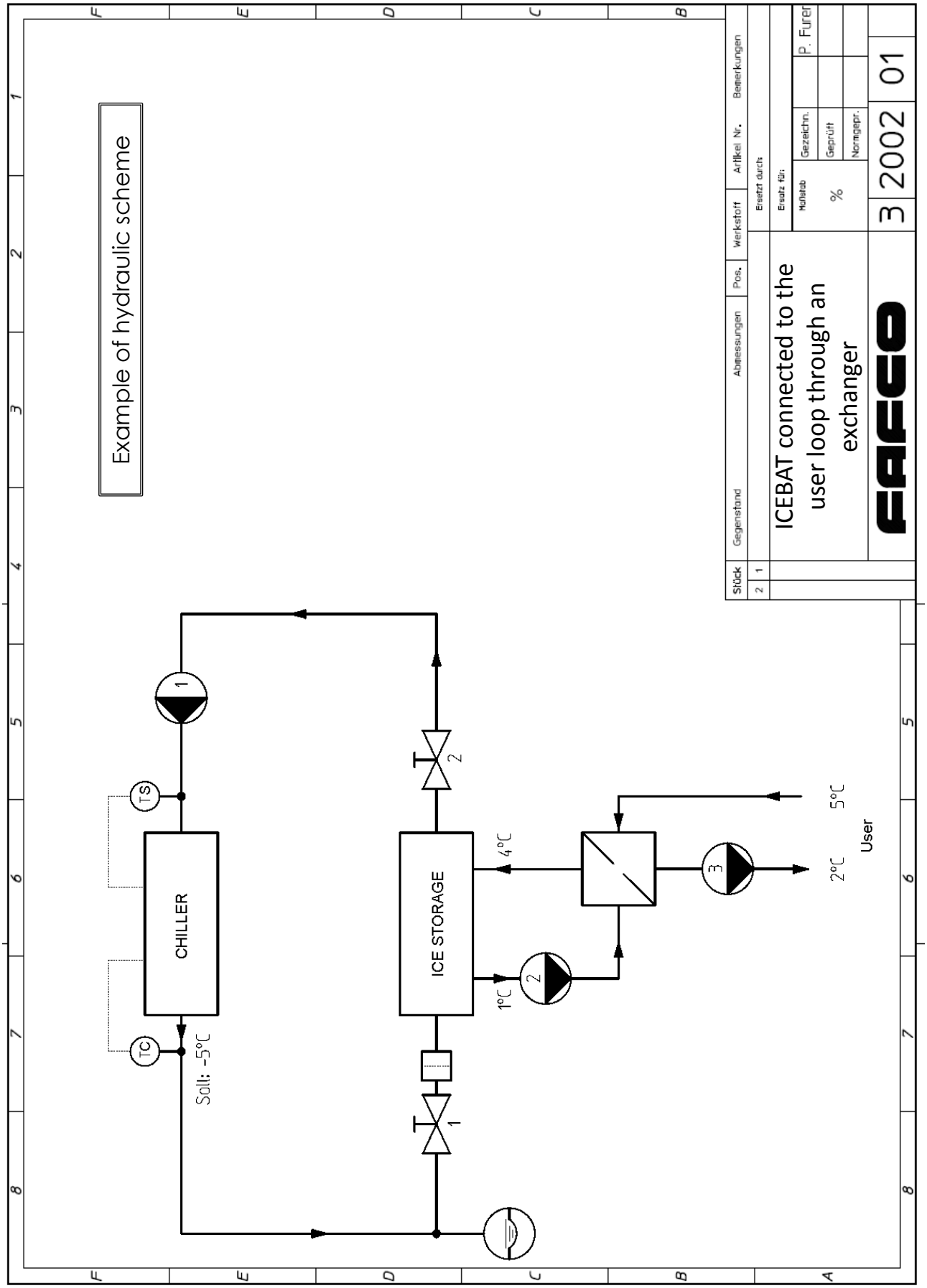
Maximal storage capacity of a FAFCO Ice storage Typ XM 210/…/… (kWh)

Height: 2.10 m		Total height with small ice storage cover: 3'010 mm										Total height with large ice storage cover: 3'190 mm									
Number of rows:		**5**	**6**	**7**	**8**	**9**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**19**	**20**	**21**	**22**	**23**	**25**	**27**	**29**
Total Width:		1'595	1'870	2'145	2'420	2'695	2'970	3'245	3'520	3'795	4'070	4'345	4'620	4'895	5'170	5'445	5'720	5'995	6'270	6'820	7'370
	(UW+HYE)	6	7	9	11	12	14	15	17	18	20	21	23	24	26	27	29	30	32	35	38
Number of modules	Total length																				
1	1'870	146	175	205	234	263	322	351	380	410	439	468	498	556	586	615	644	673	732	791	849
1.5	2'695	244	293	342	391	440	538	587	636	685	733	782	831	929	978	1'027	1'076	1'125	1'223	1'321	1'418
2	3'245	325	390	455	520	585	715	780	845	910	975	1'040	1'105	1'235	1'300	1'365	1'430	1'495	1'625	1'755	1'885
2.5	4'070	423	507	592	677	761	930	1'015	1'100	1'184	1'269	1'354	1'438	1'607	1'692	1'777	1'861	1'946	2'115	2'285	2'454
3	4'620	503	604	704	805	906	1'107	1'208	1'309	1'409	1'510	1'611	1'711	1'913	2'014	2'114	2'215	2'316	2'517	2'718	2'920
3.5	5'445	601	721	842	962	1'082	1'323	1'443	1'564	1'684	1'804	1'925	2'045	2'286	2'406	2'526	2'647	2'767	3'008	3'248	3'489
4	5'995	682	818	954	1'091	1'227	1'500	1'636	1'773	1'909	2'046	2'182	2'318	2'591	2'728	2'864	3'000	3'137	3'410	3'682	3'955
4.5	6'820	780	936	1'092	1'248	1'404	1'716	1'872	2'028	2'184	2'340	2'496	2'652	2'964	3'120	3'276	3'432	3'588	3'900	4'212	4'524
5	7'370	860	1'032	1'204	1'376	1'548	1'893	2'065	2'237	2'409	2'581	2'753	2'925	3'269	3'442	3'614	3'786	3'958	4'302	4'646	4'990
5.5	8'195	958	1'150	1'342	1'533	1'725	2'109	2'300	2'492	2'684	2'875	3'067	3'259	3'642	3'834	4'026	4'218	4'409	4'793	5'176	5'560
6	8'745	1'039	1'246	1'454	1'662	1'870	2'285	2'493	2'701	2'909	3'117	3'324	3'532	3'948	4'156	4'363	4'571	4'779	5'195	5'610	6'026
6.5	9'570	1'137	1'364	1'592	1'819	2'046	2'501	2'729	2'956	3'184	3'411	3'638	3'866	4'321	4'548	4'776	5'003	5'230	5'685	6'140	6'595
7	10'120	1'217	1'461	1'704	1'948	2'191	2'678	2'922	3'165	3'409	3'652	3'896	4'139	4'626	4'870	5'113	5'357	5'600	6'087	6'574	7'061
7.5	10'945	1'315	1'578	1'841	2'105	2'368	2'894	3'157	3'420	3'683	3'946	4'210	4'473	4'999	5'262	5'525	5'788	6'051	6'578	7'104	7'630
8	11'495	1'396	1'675	1'954	2'233	2'512	3'071	3'350	3'629	3'908	4'188	4'467	4'746	5'304	5'584	5'863	6'142	6'421	6'980	7'538	8'096

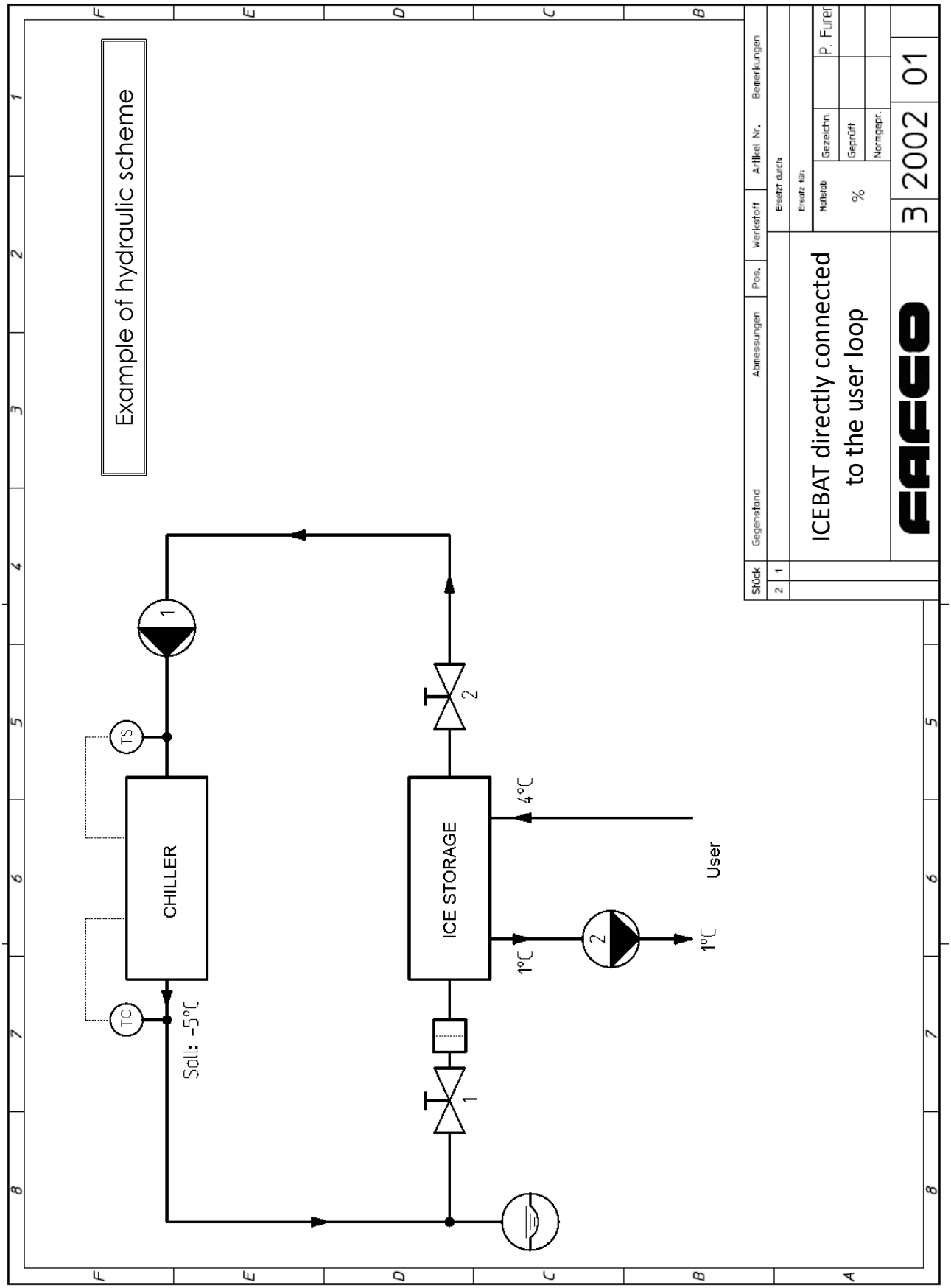
Maximal storage capacity of a FAFCO Ice storage Typ XM-UWH 292/…/… (kWh)

Height: 2.92 m		Total height with small ice storage cover: 3'980 mm												Total height with large ice storage cover: 4'180 mm										
Number of rows:		**4**	**5**	**6**	**7**	**8**	**9**	**10**	**12**	**13**	**14**	**15**	**16**	**18**	**19**	**20**	**21**	**22**	**24**	**25**	**26**	**27**	**29**	**30**	**31**
Total Width:		1'580	1'830	2'080	2'330	2'580	2'830	3'080	3'330	3'580	3'830	4'080	4'330	4'830	5'080	5'330	5'580	5'830	6'330	6'580	6'830	7'080	7'330	7'580	7'830
	(UWH+HYE:)	5	6	8	9	11	12	13	15	16	18	19	21	23	24	26	27	29	31	33	34	36	37	39	40
Number of modules	Total length																								
1	2'080	168	210	253	295	337	379	421	506	548	590	632	674	759	801	843	885	927	1'012	1'054	1'096	1'138	1'222	1'265	1'307
1.5	2'830	279	349	419	489	559	629	699	839	909	979	1'048	1'118	1'258	1'328	1'398	1'468	1'538	1'678	1'748	1'818	1'888	2'027	2'097	2'167
2	3'580	370	463	555	648	741	833	926	1'111	1'204	1'296	1'389	1'482	1'667	1'759	1'852	1'945	2'037	2'223	2'315	2'408	2'501	2'686	2'778	2'871
2.5	4'330	481	601	722	842	963	1'083	1'203	1'444	1'565	1'685	1'805	1'926	2'167	2'287	2'407	2'528	2'648	2'889	3'009	3'130	3'250	3'491	3'611	3'732
3	4'830	572	715	858	1'001	1'144	1'287	1'430	1'717	1'860	2'003	2'146	2'289	2'575	2'718	2'861	3'004	3'147	3'434	3'577	3'720	3'863	4'149	4'292	4'435
3.5	5'580	683	854	1'025	1'195	1'366	1'537	1'708	2'050	2'221	2'391	2'562	2'733	3'075	3'246	3'417	3'587	3'758	4'100	4'271	4'442	4'612	4'954	5'125	5'296
4	6'330	774	967	1'161	1'354	1'548	1'741	1'935	2'322	2'516	2'709	2'903	3'096	3'483	3'677	3'871	4'064	4'258	4'645	4'838	5'032	5'225	5'612	5'806	6'000
4.5	7'080	885	1'106	1'327	1'549	1'770	1'991	2'213	2'655	2'877	3'098	3'319	3'540	3'983	4'204	4'426	4'647	4'868	5'311	5'532	5'754	5'975	6'417	6'639	6'860
5	7'580	976	1'220	1'464	1'708	1'952	2'196	2'440	2'928	3'172	3'416	3'660	3'904	4'392	4'636	4'880	5'124	5'368	5'856	6'100	6'344	6'588	7'076	7'320	7'564
5.5	8'330	1'087	1'358	1'630	1'902	2'174	2'445	2'717	3'261	3'533	3'804	4'076	4'348	4'891	5'163	5'435	5'707	5'978	6'522	6'794	7'066	7'337	7'881	8'153	8'424
6	9'080	1'177	1'472	1'766	2'061	2'355	2'650	2'944	3'533	3'828	4'122	4'417	4'711	5'300	5'594	5'889	6'183	6'478	7'067	7'361	7'656	7'950	8'539	8'834	9'128
6.5	9'830	1'288	1'611	1'933	2'255	2'577	2'900	3'222	3'866	4'188	4'511	4'833	5'155	5'800	6'122	6'444	6'766	7'089	7'733	8'055	8'377	8'700	9'344	9'666	9'989
7	10'330	1'379	1'724	2'069	2'414	2'759	3'104	3'449	4'139	4'484	4'829	5'173	5'518	6'208	6'553	6'898	7'243	7'588	8'278	8'623	8'968	9'313	10'002	10'347	10'692
7.5	11'080	1'490	1'863	2'236	2'608	2'981	3'354	3'726	4'472	4'844	5'217	5'590	5'963	6'708	7'081	7'453	7'826	8'199	8'944	9'317	9'689	10'062	10'808	11'180	11'553
8	11'830	1'581	1'976	2'372	2'767	3'163	3'558	3'953	4'744	5'140	5'535	5'930	6'326	7'117	7'512	7'907	8'303	8'698	9'489	9'884	10'280	10'675	11'466	11'861	12'257

Integration scheme for a ICEBAT type XM Indirect



Integration scheme for a ICEBAT type XM Direct



THERMAL ENERGY STORAGE SYSTEMS (TES)

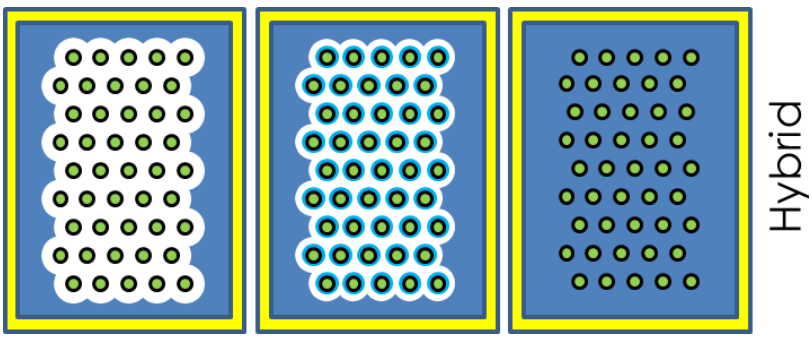
ICEBAT HYE
(Hybrid internal melt – external melt)

Technical data

WORKING PRINCIPLE
ICEBAT type HYE

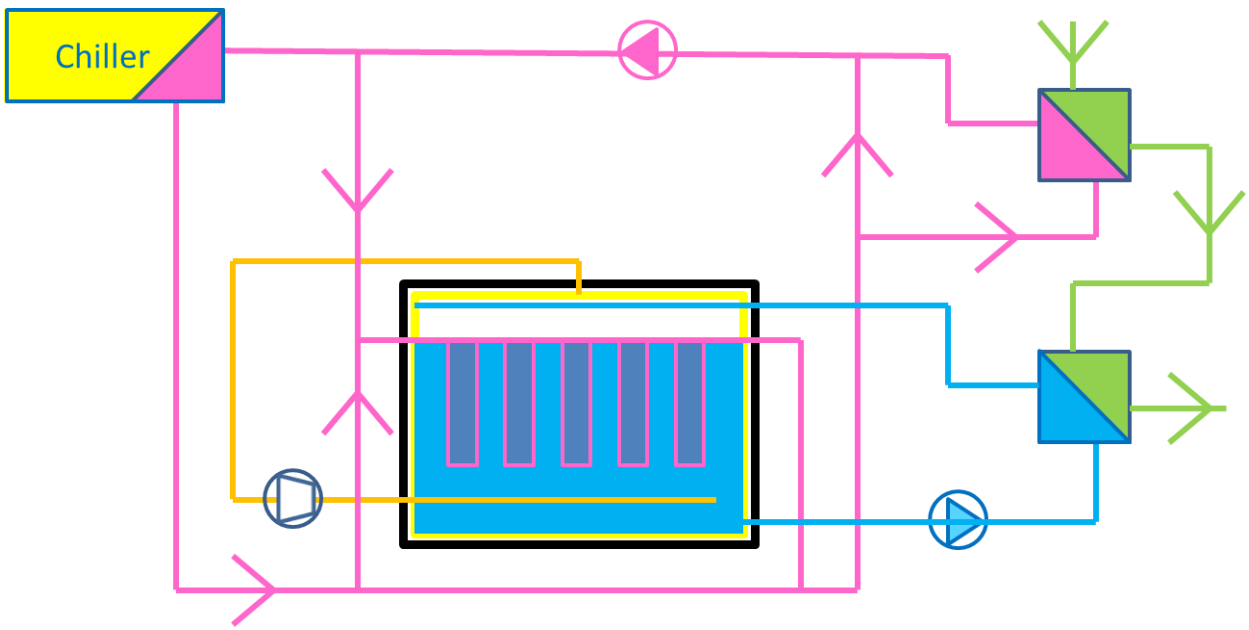
The FAFCO HYE ice bank is a hybrid ice storage system using internal and external melt.

In the FAFCO's exclusive hybrid system, both internal and external loops are operated to obtain a extremely high available cooling power and reach the lowest temperatures



Thanks to these very specific features, the FAFCO hybrid system can be loaded and unloaded simultaneously, hence be used as a huge heat exchanger system with integrated buffer capacity.

It can also be completely unloaded from 100 to 0% in less than one hour. This feature is outstanding for industrial cooling processes, process and building emergency situation, as well as all events and sports infrastructures.



The 2 loops combined with the HP systems offer high flexibility, various integration schemes, low temperature and high cooling power.
The pressure drop for the water loop in the XM ice banks are equivalent to pressure drop in the glycol loop, because the ducts and pipes are similar in both cases.

Capacité de stockage maximale d'un ICEBAT type HYE-UW 155/…/… (kWh)

Hauteur échangeur : 1.55 m

Hauteur totale de l'ICEBAT : 2'420 mm

Hauteur totale de l'ICEBAT : 2'600 mm

Nombre de ligne :		6	7	9	11	12	14	15	17	18	20	21	23	24	26	27	29	30	32	35	38
Largeur totale :		1'595	1'870	2'145	2'420	2'695	2'970	3'245	3'520	3'795	4'070	4'345	4'620	4'895	5'170	5'445	5'720	5'995	6'270	6'820	7'370
Modules	Longueur																				
1	1'870	122	142	183	224	244	285	305	346	367	407	428	468	489	530	550	591	611	652	713	774
1.5	2'695	207	242	311	380	414	484	518	587	622	691	726	795	829	899	933	1'002	1'037	1'106	1'210	1'314
2	3'245	277	323	415	508	554	646	692	785	831	923	969	1'062	1'108	1'200	1'247	1'339	1'385	1'478	1'616	1'755
2.5	4'070	362	422	543	664	724	845	905	1'026	1'086	1'207	1'267	1'388	1'449	1'569	1'630	1'751	1'811	1'932	2'113	2'294
3	4'620	431	503	647	791	863	1'007	1'079	1'223	1'295	1'439	1'511	1'655	1'727	1'871	1'943	2'087	2'159	2'303	2'519	2'735
3.5	5'445	517	603	775	947	1'034	1'206	1'292	1'465	1'551	1'723	1'809	1'982	2'068	2'240	2'326	2'499	2'585	2'757	3'016	3'274
4	5'995	586	684	880	1'075	1'173	1'369	1'466	1'662	1'760	1'955	2'053	2'249	2'346	2'542	2'640	2'835	2'933	3'129	3'422	3'716
4.5	6'820	671	783	1'007	1'231	1'343	1'567	1'679	1'903	2'015	2'239	2'351	2'575	2'687	2'911	3'023	3'247	3'359	3'583	3'919	4'255
5	7'370	741	865	1'112	1'359	1'483	1'730	1'853	2'101	2'224	2'471	2'595	2'842	2'966	3'213	3'336	3'584	3'707	3'954	4'325	4'696
5.5	8'195	826	964	1'240	1'515	1'653	1'928	2'066	2'342	2'480	2'755	2'893	3'168	3'306	3'582	3'720	3'995	4'133	4'408	4'822	5'235
6	8'745	896	1'045	1'344	1'643	1'792	2'091	2'240	2'539	2'689	2'987	3'137	3'435	3'585	3'884	4'033	4'332	4'481	4'780	5'228	5'676
6.5	9'570	981	1'145	1'472	1'799	1'962	2'290	2'453	2'780	2'944	3'271	3'435	3'762	3'925	4'253	4'416	4'743	4'907	5'234	5'725	6'216
7	10'120	1'051	1'226	1'576	1'927	2'102	2'452	2'627	2'978	3'153	3'503	3'678	4'029	4'204	4'554	4'730	5'080	5'255	5'606	6'131	6'657
7.5	10'945	1'136	1'325	1'704	2'083	2'272	2'651	2'840	3'219	3'408	3'787	3'976	4'355	4'545	4'923	5'113	5'492	5'681	6'060	6'628	7'196
8	11'495	1'205	1'406	1'808	2'210	2'411	2'813	3'014	3'416	3'617	4'019	4'220	4'622	4'823	5'225	5'426	5'828	6'029	6'431	7'034	7'637

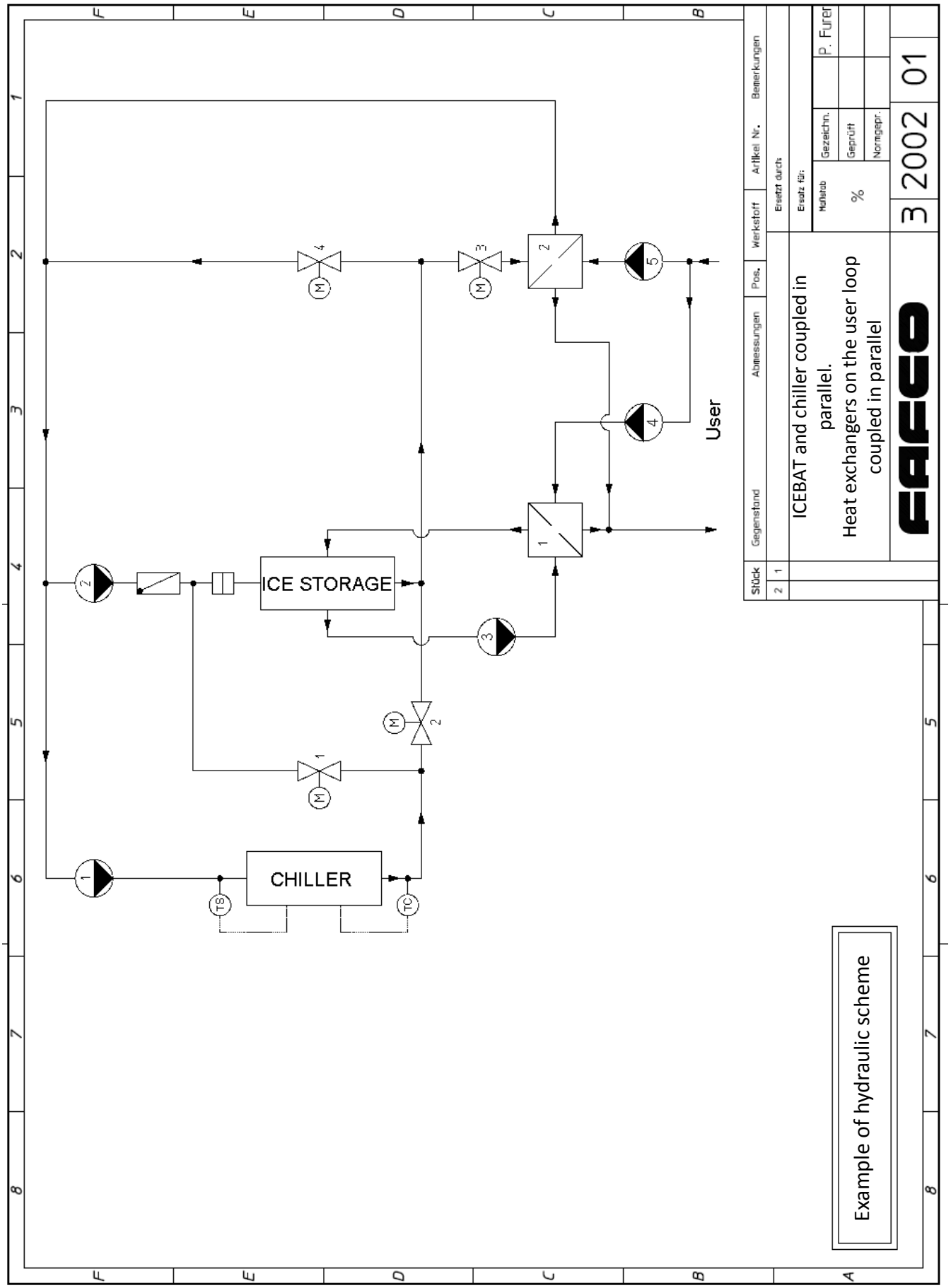
Maximal storage capacity of a FAFCO Ice storage Typ HYE-UW 210/…/… (kWh)

Height: 2.10 m		Total height with small ice storage cover: 3'010 mm										Total height with large ice storage cover: 3'390 mm									
Number of rows:		**6**	**7**	**9**	**11**	**12**	**14**	**15**	**17**	**18**	**20**	**21**	**23**	**24**	**26**	**27**	**29**	**30**	**32**	**35**	**38**
Total Width:		1'595	1'870	2'145	2'420	2'695	2'970	3'245	3'520	3'795	4'070	4'345	4'620	4'895	5'170	5'445	5'720	5'995	6'270	6'820	7'370
Number of modules	Total length																				
1	1'870	175	205	263	322	351	410	439	498	527	586	615	673	703	761	791	849	879	937	1'025	1'113
1.5	2'695	293	342	440	538	587	685	733	831	880	978	1'027	1'125	1'174	1'272	1'321	1'418	1'467	1'565	1'712	1'859
2	3'245	390	455	585	715	780	910	975	1'105	1'170	1'300	1'365	1'495	1'560	1'690	1'755	1'885	1'950	2'080	2'275	2'470
2.5	4'070	507	592	761	930	1'015	1'184	1'269	1'438	1'523	1'692	1'777	1'946	2'031	2'200	2'285	2'454	2'538	2'708	2'962	3'215
3	4'620	604	704	906	1'107	1'208	1'409	1'510	1'711	1'812	2'014	2'114	2'316	2'416	2'618	2'718	2'920	3'021	3'222	3'524	3'826
3.5	5'445	721	842	1'082	1'323	1'443	1'684	1'804	2'045	2'165	2'406	2'526	2'767	2'887	3'128	3'248	3'489	3'609	3'850	4'211	4'572
4	5'995	818	954	1'227	1'500	1'636	1'909	2'046	2'318	2'455	2'728	2'864	3'137	3'273	3'546	3'682	3'955	4'092	4'364	4'774	5'183
4.5	6'820	936	1'092	1'404	1'716	1'872	2'184	2'340	2'652	2'808	3'120	3'276	3'588	3'744	4'056	4'212	4'524	4'680	4'992	5'461	5'929
5	7'370	1'032	1'204	1'548	1'893	2'065	2'409	2'581	2'925	3'097	3'442	3'614	3'958	4'130	4'474	4'646	4'990	5'163	5'507	6'023	6'539
5.5	8'195	1'150	1'342	1'725	2'109	2'300	2'684	2'875	3'259	3'451	3'834	4'026	4'409	4'601	4'984	5'176	5'560	5'751	6'135	6'710	7'285
6	8'745	1'246	1'454	1'870	2'285	2'493	2'909	3'117	3'532	3'740	4'156	4'363	4'779	4'987	5'402	5'610	6'026	6'234	6'649	7'273	7'896
6.5	9'570	1'364	1'592	2'046	2'501	2'729	3'184	3'411	3'866	4'093	4'548	4'776	5'230	5'458	5'913	6'140	6'595	6'822	7'277	7'960	8'642
7	10'120	1'461	1'704	2'191	2'678	2'922	3'409	3'652	4'139	4'383	4'870	5'113	5'600	5'844	6'331	6'574	7'061	7'305	7'792	8'522	9'253
7.5	10'945	1'578	1'841	2'368	2'894	3'157	3'683	3'946	4'473	4'736	5'262	5'525	6'051	6'315	6'841	7'104	7'630	7'893	8'420	9'209	9'998
8	11'495	1'675	1'954	2'512	3'071	3'350	3'908	4'188	4'746	5'025	5'584	5'863	6'421	6'700	7'259	7'538	8'096	8'376	8'934	9'772	10'609

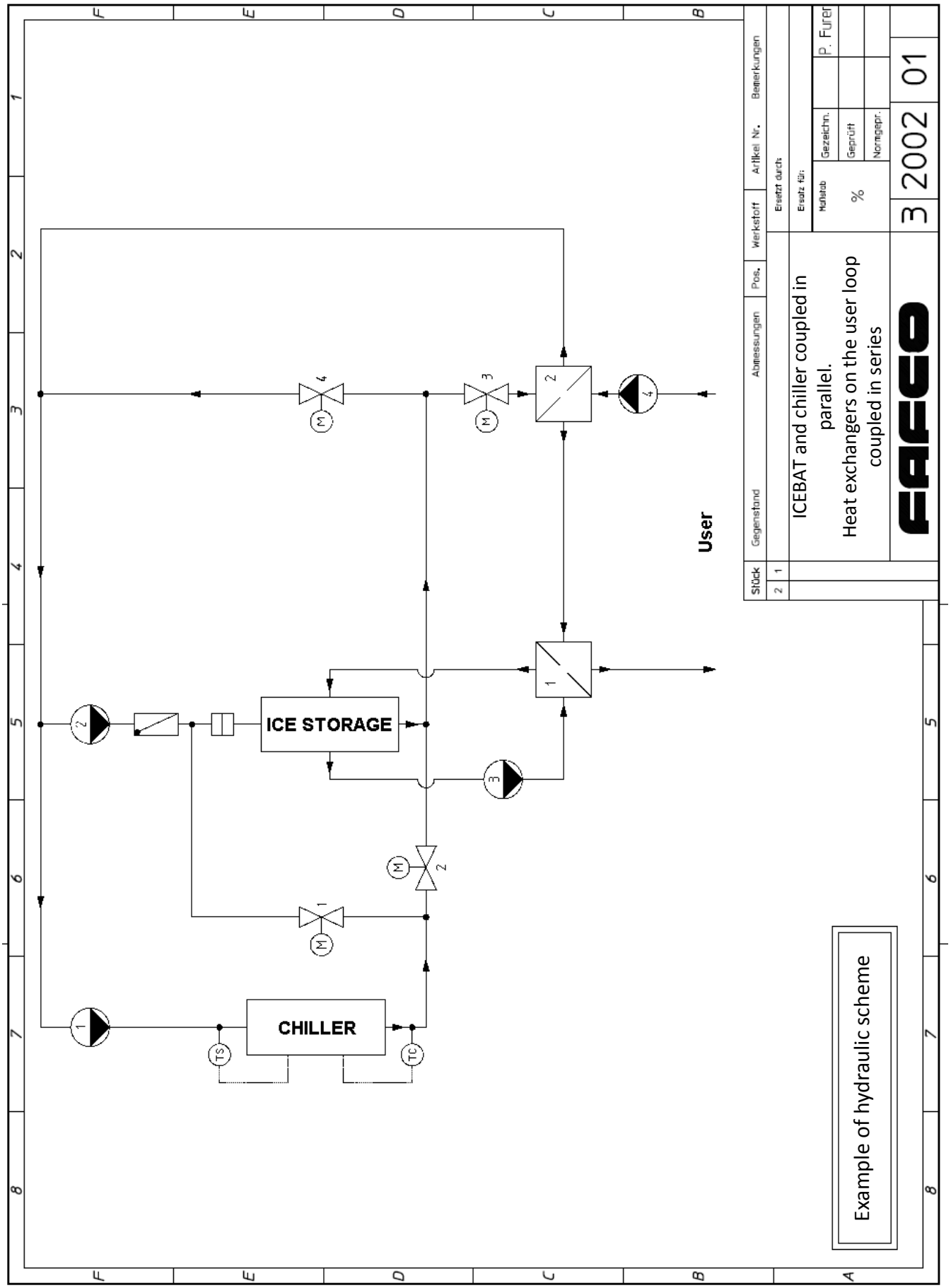
Maximal storage capacity of a FAFCO Ice storage Typ HYE-UWH 292/…/… (kWh)

Height: 2.92 m		Total height with small ice storage cover: 3'980 mm												Total height with large ice storage cover: 4'180 mm											
Number of rows:		**5**	**6**	**8**	**9**	**11**	**12**	**13**	**15**	**16**	**18**	**19**	**21**	**23**	**24**	**26**	**27**	**29**	**31**	**33**	**34**	**36**	**37**	**39**	**40**
Total Width:		1'580	1'830	2'080	2'330	2'580	2'830	3'080	3'330	3'580	3'830	4'080	4'330	4'830	5'080	5'330	5'580	5'830	6'330	6'580	6'830	7'080	7'330	7'580	7'830
Number of modules	Total length																								
1	2'080	210	253	337	379	463	506	548	632	674	759	801	885	969	1'012	1'096	1'138	1'222	1'307	1'391	1'433	1'518	1'560	1'644	1'686
1.5	2'830	349	419	559	629	769	839	909	1'048	1'118	1'258	1'328	1'468	1'608	1'678	1'818	1'888	2'027	2'167	2'307	2'377	2'517	2'587	2'727	2'797
2	3'580	463	555	741	833	1'018	1'111	1'204	1'389	1'482	1'667	1'759	1'945	2'130	2'223	2'408	2'501	2'686	2'871	3'056	3'149	3'334	3'427	3'612	3'705
2.5	4'330	601	722	963	1'083	1'324	1'444	1'565	1'805	1'926	2'167	2'287	2'528	2'768	2'889	3'130	3'250	3'491	3'732	3'972	4'093	4'334	4'454	4'695	4'815
3	4'830	715	858	1'144	1'287	1'573	1'717	1'860	2'146	2'289	2'575	2'718	3'004	3'291	3'434	3'720	3'863	4'149	4'435	4'721	4'865	5'151	5'294	5'580	5'723
3.5	5'580	854	1'025	1'366	1'537	1'879	2'050	2'221	2'562	2'733	3'075	3'246	3'587	3'929	4'100	4'442	4'612	4'954	5'296	5'638	5'808	6'150	6'321	6'663	6'834
4	6'330	967	1'161	1'548	1'741	2'129	2'322	2'516	2'903	3'096	3'483	3'677	4'064	4'451	4'645	5'032	5'225	5'612	6'000	6'387	6'580	6'967	7'161	7'548	7'742
4.5	7'080	1'106	1'327	1'770	1'991	2'434	2'655	2'877	3'319	3'540	3'983	4'204	4'647	5'090	5'311	5'754	5'975	6'417	6'860	7'303	7'524	7'967	8'188	8'631	8'852
5	7'580	1'220	1'464	1'952	2'196	2'684	2'928	3'172	3'660	3'904	4'392	4'636	5'124	5'612	5'856	6'344	6'588	7'076	7'564	8'052	8'296	8'784	9'028	9'516	9'760
5.5	8'330	1'358	1'630	2'174	2'445	2'989	3'261	3'533	4'076	4'348	4'891	5'163	5'707	6'250	6'522	7'066	7'337	7'881	8'424	8'968	9'240	9'783	10'055	10'599	10'870
6	9'080	1'472	1'766	2'355	2'650	3'239	3'533	3'828	4'417	4'711	5'300	5'594	6'183	6'772	7'067	7'656	7'950	8'539	9'128	9'717	10'011	10'600	10'895	11'484	11'778
6.5	9'830	1'611	1'933	2'577	2'900	3'544	3'866	4'188	4'833	5'155	5'800	6'122	6'766	7'411	7'733	8'377	8'700	9'344	9'989	10'633	10'955	11'600	11'922	12'566	12'889
7	10'330	1'724	2'069	2'759	3'104	3'794	4'139	4'484	5'173	5'518	6'208	6'553	7'243	7'933	8'278	8'968	9'313	10'002	10'692	11'382	11'727	12'417	12'762	13'452	13'797
7.5	11'080	1'863	2'236	2'981	3'354	4'099	4'472	4'844	5'590	5'963	6'708	7'081	7'826	8'571	8'944	9'689	10'062	10'808	11'553	12'298	12'671	13'416	13'789	14'534	14'907
8	11'830	1'976	2'372	3'163	3'558	4'349	4'744	5'140	5'930	6'326	7'117	7'512	8'303	9'093	9'489	10'280	10'675	11'466	12'257	13'047	13'443	14'234	14'629	15'420	15'815

Integration scheme for a ICEBAT type HYE
Heat exchangers in parallel



Integration scheme for a ICEBAT type HYE
Heat exchangers in series



THERMAL ENERGY STORAGE SYSTEMS (TES)

Available options for the ICEBAT

Technical Data

Many different options for many different applications

In order to satisfy the biggest range of applications, FAFCO offers a whole range of options to ensure that the ICEBAT's use is optimal in any situation.

Option HP (High Power)

The option HP is an exclusive FAFCO technology available for the ICEBATs UW and by default on the ICEABTs type XM and HYE
The goal is to boost the available power during the discharge. The chart below shows the available power for a standard system and a HP system. This option consist of using an air compressor to inject air into the tank, from the bottom. The air bubbles will rise in the water and create turbulences between the heat exchangers' tubes and the ice, increasing the exchanges and thus the power. It is generally needed for application with an important power need, such as industrial applications, or for buildings with important load at the end of the day (shopping mall).

Air compressor in an concrete ICEBAT(underground)

Option Outdoor

The ICEBAT in its standard version is built for indoor application, but if the project needs it, FAFCO can adapt the design for outdoor installation (parking, roof, etc.). This option include a 2-slope roof over the tank in order to prevent water accumulation and infiltration due to the rain. If the outside temperature can reach 0°C during winter, FAFCO add an external an insulated box on a side of the tank in order to protect the electronic level sensor.
If the HP option is installed, the compressor will also be protected depending on the site.

ICEBAT outdoor in metal with its 2 slope roof and the insulated box to protect the level sensor.

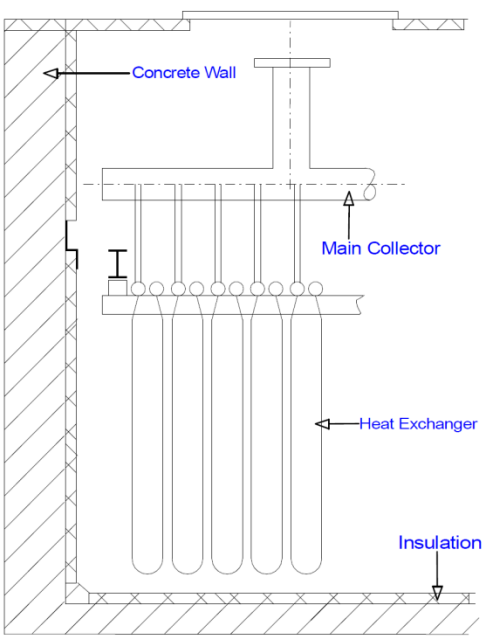
Many different options for many different applications

Option Tropical

When the ICEBAT has to be installed outside in hot climates, FAFCO reinforce the whole insulation of the tank in order to maintain the lowest thermal loss possible (below 1% per day). This reinforcement of insulation can also be needed for indoor installation, if the climate is hot and humid, to prevent any possible condensation on the wall of the tanks.

Option Concrete

This option consist in building a FAFCO storage not in the usual metallic tank, but directly into a concrete tank. If the client has already a concrete tank available, or when it is more simple for him to build one, FAFCO can adapt its design to the dimensions of the tank. If necessary, FAFCO can do the insulation of the tank and the water-tightness. Then, a metallic structure is built in order to support the heat-exchangers.
This option allows the use of higher heat-exchangers than in standard tanks, so the volume can be used more efficiently that way.



Many different options for many different applications

Option Commissioning

In order to guide the customer during his first use of the tank, FAFCO offers to come on site and assist the user for the commissioning. Since ice storage is not a well known technology, the FAFCO expertise gives serenity to the user and ensure the best use of the system. This is the best warranty for smooth operation of the installation. FAFCO's staff will also form the operating staff during this commissioning.

The ICEBAT must be considered an heat exchanger on the glycol loop. It must be isolated with services valves during maintenance on the loop to avoid any particle to get in. The commissioning is also the opportunity to caliber the level sensor and to check the regulation strategy.

Option Maintenance

The FAFCO system is a very simple technology, with no moving parts, so the maintenance need are very low. Moreover, if a problem occur, the reparations are very simple to perform. But if the tank is not used properly, some problems can occurs. Most of the time they are small problems, degrading the performance of the system, but not necessary spotted by the user. That is why FAFCO offers a maintenance contract : once a year, a FAFCO technician comes to verify if the ICEBAT needs some adjustments or reparations.
Besides, FAFCO recommend each 6 years a global maintenance, in order to change preventively some sensible parts.

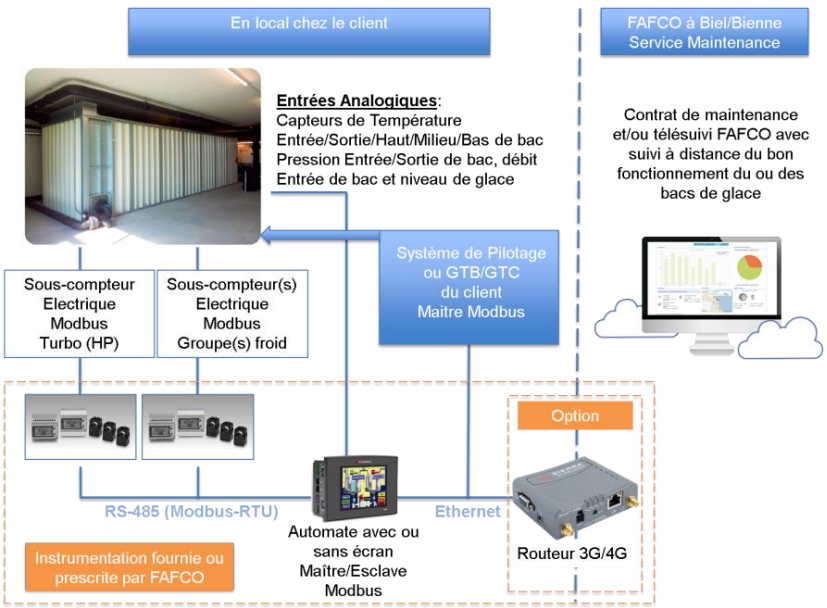
This 30 years old is still running in 2014 on the district cooling of Munich, in Germany.

Those hoses are almost the only components we change in prevention every 7 years.

Many different options for many different applications

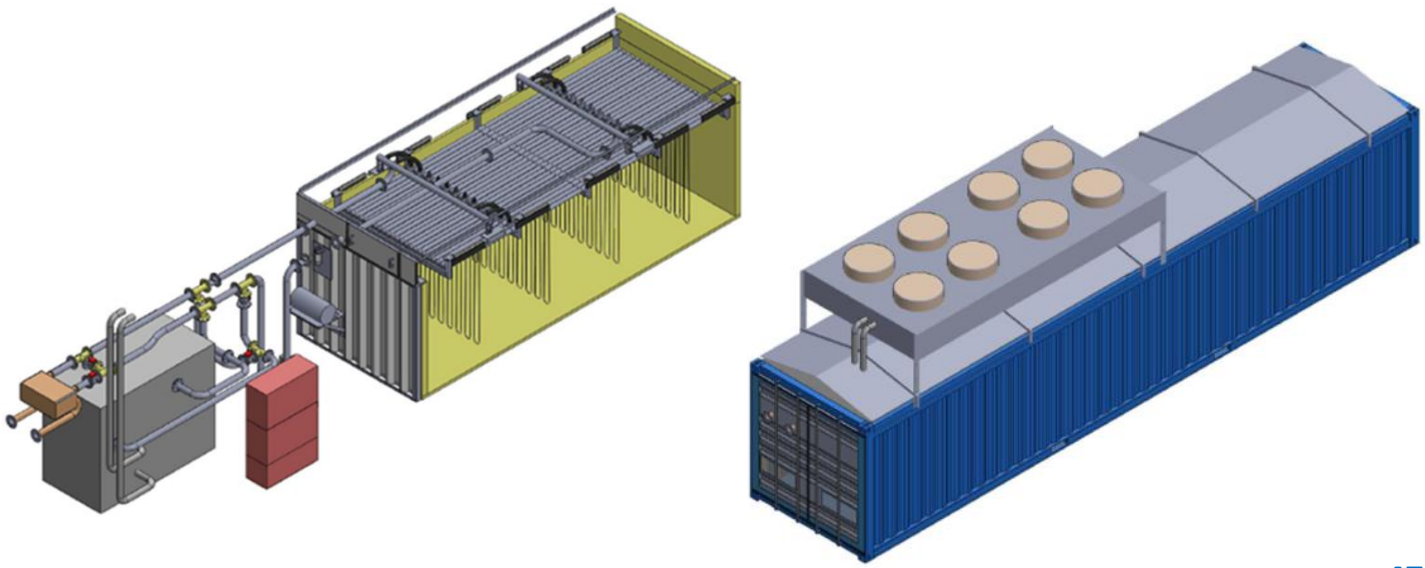
Option Monitoring

FAFCO has established a partnership with the company ALFILEO, specialized in the monitoring technology. Together, they built a dedicated interface for the ice storage monitoring. The users can check on a web platform several data from their installation, such as electric consumption, cold production, storage level, global efficiency, etc. Those data are historised and can be plotted and compared directly from the website. This option helps the user to have a better comprehension of its installation and thus optimize the storage strategy. Moreover, FAFCO has a remote access to those data, and can detect if there is any problem concerning the storage, and thus prevent eventual damages.



Option Container / Plug & Play

FAFCO ice storage systems can be assembled into maritime containers.This product is recommended for rental contract, temporary installation, or on site without technical room for the cold production. The container can include pumps, valves, chillers, dry coolers and regulation to become a complete solution.



THERMAL ENERGY STORAGE SYSTEMS
(TES)

Assembly and Installation

Technical data

Installation : on-site assembly requirements

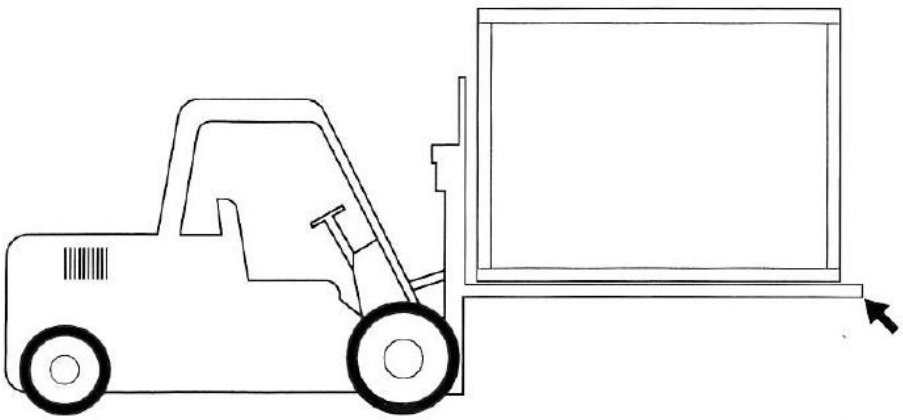
Before start-up of installation on site, following requirements resp. services have to be provided at the final location of the equipment:

- Openings and passage ways of sufficient size for the movement of all materials and components to their final location. The dimensions of largest components are defined case to case;
- Sufficient space for the intermediate storage of materials, ie approx. an area equivalent to 1,5 times that of fully assembled ice tank. A corridor of 2 meters on two successive sides of the assembled tank is also necessary;
- Clean and dry area for the installation and assembly works;
- The available space over the ice bank must be at least 60 cm above the top of the ice bank, free from any structure, ceiling, or piping;
- Supply of electricity 230/400 V, secured, providing at least 3 kW power;
- Fresh water (min. 10 m³/hour) for filling and testing of the installation on site;
- Lighting of the place of installation;
- Crane or other lifting devices for unloading of the trucks on site and transfer of the parts to final position

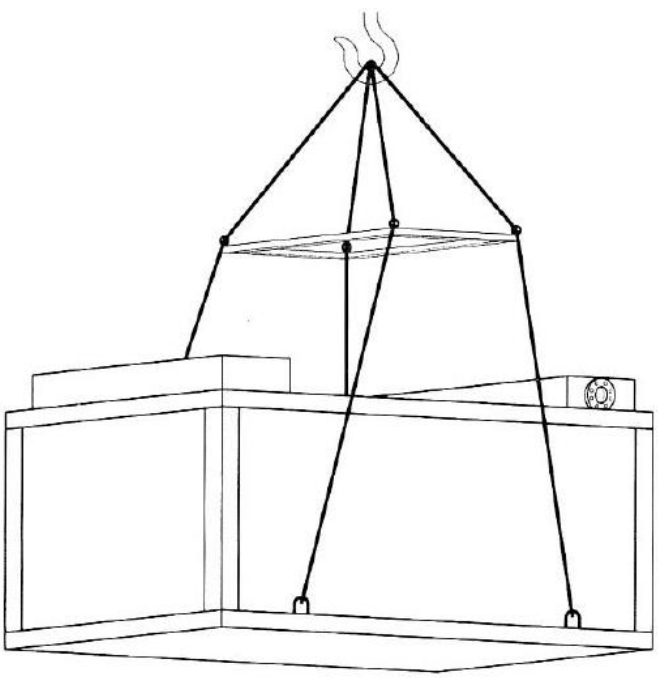
Unloading and Movement to Final Position

If the ice bank is to be moved using a fork-lift truck, take the following precautions:

- The fork-lift truck must be equipped with extended forks that can pass under the **full width** of the tank.
- If the ice bank is to be lifted at its end, the bottom of the tank must be protected with solid cross-pieces.



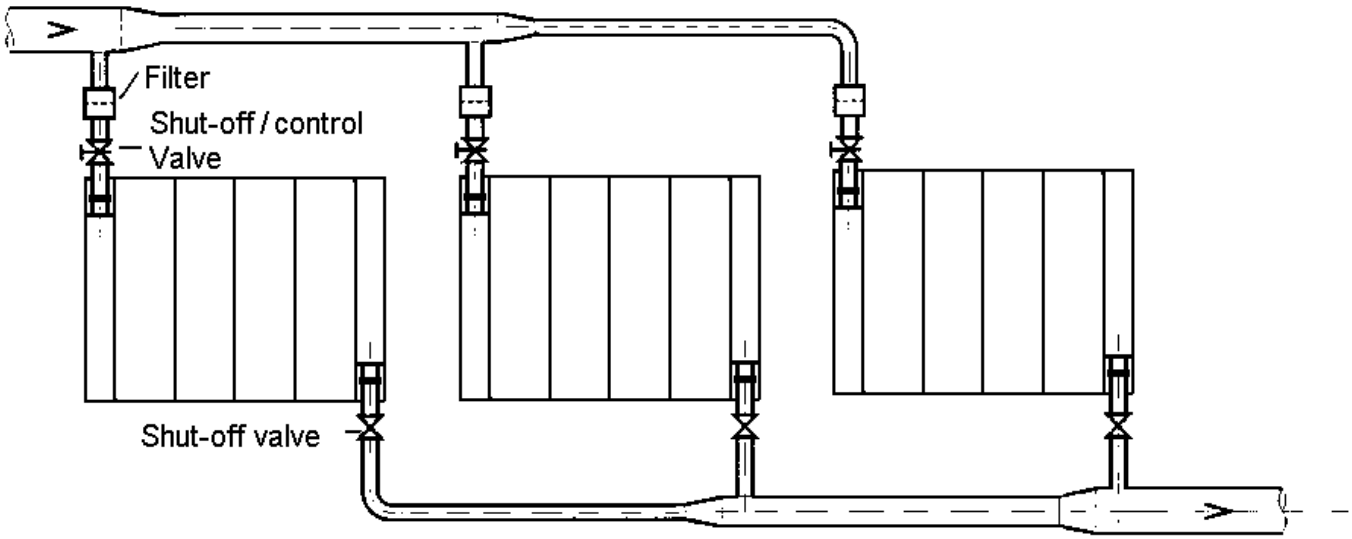
If the movements is by means of a crane, it is absolutely essential, as a function of the tank width and length of cable, to protect the upper part by means of spreader and avoid compression of the tank wall.



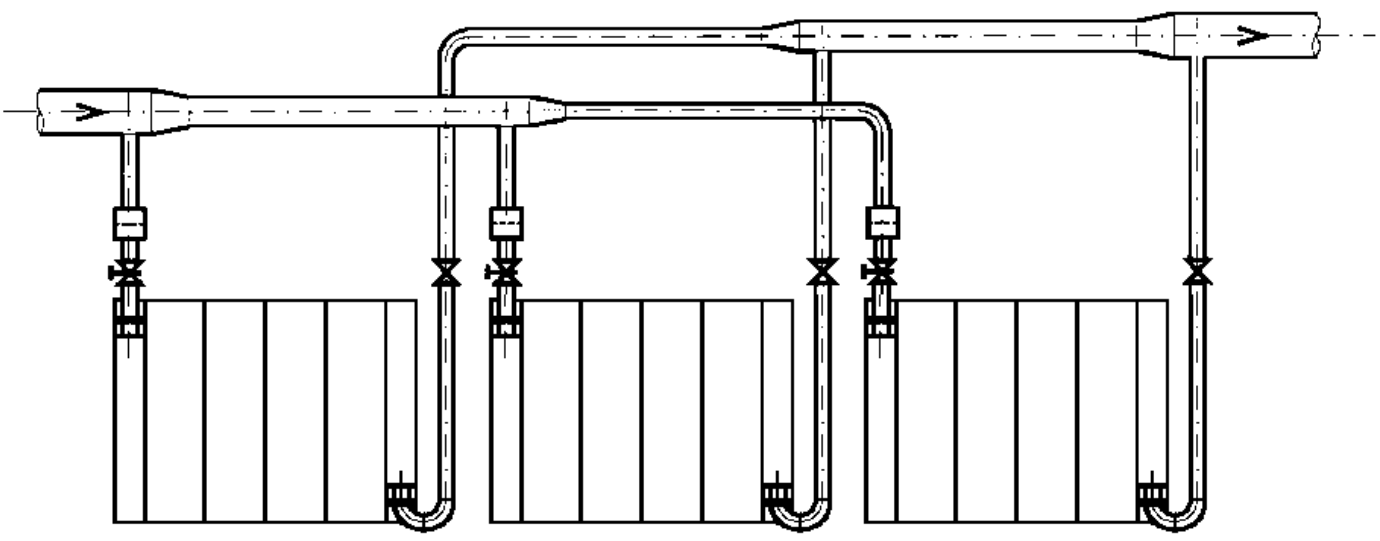
Installation : Ice banks arrangements

If several ICEBATs are necessary to meet the capacity need, they can be connected in parallel. If so, it is important to make sure that the hydraulic is well balanced, in order to have simultaneous charge and discharge in each ICEBAT. Filters are recommended to prevent the FAFCO heat exchangers from being charged with particles. Services valves and balancing valves are also important.

Option 1



Option 2



Installation :
Connection possibilities

In order to make the installation easier for the customer, we can choose the orientation of the flange connections by using following piping bends (PN16):

- Bend 2d / 90°

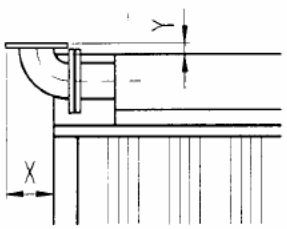
- Bend 2d / 180°

The following table gives the dimensions for each solution.

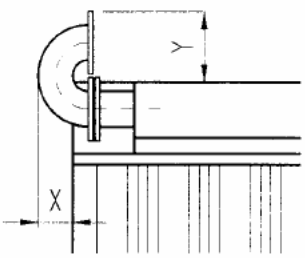
Dimensions (mm):

	DN 125		DN 150	
	90°	180°	90°	180°
X (± 4)	168	108	208	145
Y (± 10)	21	260	54	333
Z (± 10)	16	255	39	318

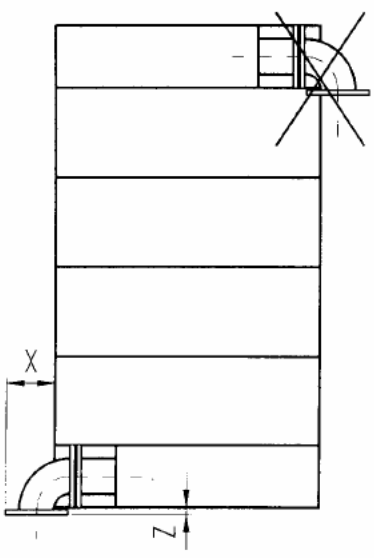
Side view (solution 1)



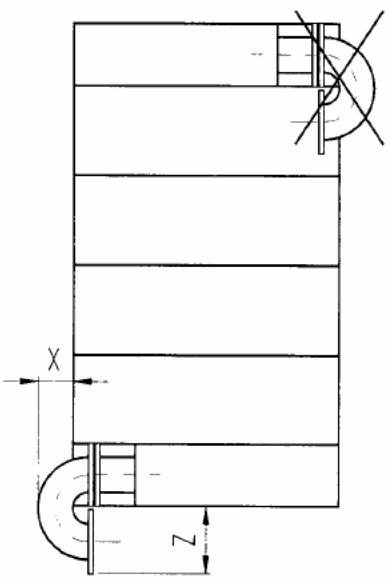
Side view (solution 2)



Top view (solution 1)



Top view (solution 2)



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POWER MANAGEMENT
SOLAR HEATING & HEAT RECOVERY
COOLING & ENERGY STORAGE

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Thermal solar panels
Pool heating solutions
Heat recovery