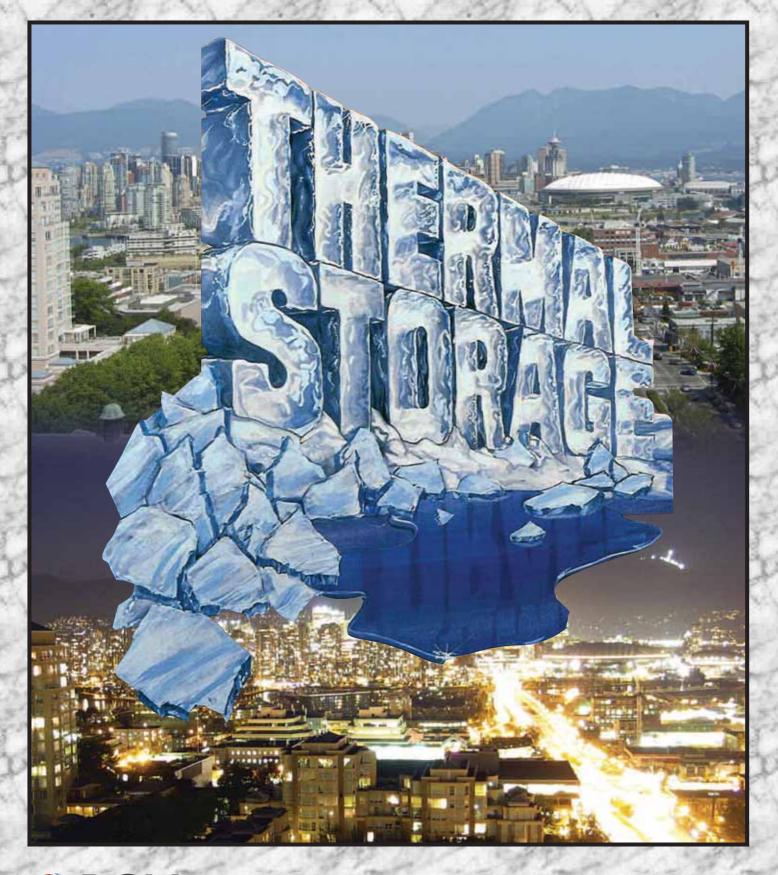
Plusice™ Phase Change Materials



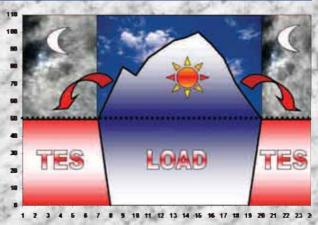
PCM Phase Change Material Products Limited

INNOVATION FOR ENERGY SAVING TECHNOLOGIES

THERMAL ENERGY STORAGE;

Thermal Energy Storage (TES) is the temporary storage of high or low temperature energy for later use. It bridges the gap between energy requirement and energy use. A thermal storage application may involve a 24 hour or alternatively a weekly or seasonal storage cycle depending on the system design requirements. Whilst the output is always thermal, the input energy may be either thermal or electrical.

Phase Change Materials (PCMs) are products that store and release thermal energy during the process of melting & freezing (changing from one phase to another). When such a material freezes, it releases large amounts of energy in the form of latent heat of fusion, or energy of crystallisation. Conversely, when the material is melted, an equal amount of energy is absorbed from the immediate environment as it changes from solid to liquid.



For the majority of the applications, PCM solutions have to be encapsulated in sealed containers. To this end, PCM Products Ltd. have developed many different standard type containers as well as custom-made containers for special applications. These containers can be applied to any water or air based TES systems and can be manufactured using our PlusICE Phase Change Materials (PCM) solutions which have operating temperatures between -40°C (-40°F) and +117 °C (+243 °F).

PRODUCTS;



1) FlatICE Containers:

These containers are constructed of blow moulded HDPE and can be filled with positive or negative temperature PCMs, although high temperature PCMs may be unsuitable due to softening of the plastic. When stacked there is a small gap between each container, allowing either air or water to flow easily over the containers while providing a large PCM surface area for heat transfer.

2) TubeICE:

The PCM-filled HDPE tubular design enables them to be stacked effectively in both rectangular and cylindrical tanks with minimal void space.

3) BallICE:

This technology is only available for use with our positive temperature organic range of PCMs, and involves the PCM being directly incorporated into a plastic or rubber matrix. This is then moulded to produce standard sized balls.



REDUCED RUNNING COST

Load shifting provides reliable operation and lower annual electricity / energy running costs.

REDUCED MACHINERY

Shifting some of the peak load may enable designers to reduce the main machine size.

INCREASED CAPACITY

As a retrofit application, the additional TES load may increase the system output with any additional machinery.

GREEN SOLUTION

Reduced machinery size, energy consumption results in both direct and indirect CO2 $\,$ emission.

QUICK RESPONSE

Custom-made containers offer quicker response in comparison with any other TES systems on the market.

LOWER MAINTENANCE COST

Machinery runs for longer periods without any start / stop and therefore it offers a far more reliable operation.

FLEXIBLE SYSTEM

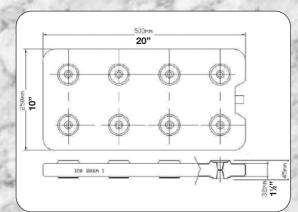
The overall machinery capacity and TES capacity can be exactly matched to system loads.

STAND-BY CAPACITY

In case the main machinery fails, the stored energy can be utilised to handle the system loads, hence, providing a degree of back up facility.

NATURAL ALTERNATIVE TO REDUCE ENERGY

FlatICE[™] FEATURES;



FlatICE custom-made HDPE plastic containers are filled with PlusICE PCM solutions and the filling port fully welded after filling in order to ensure safe and reliable operation.

The design of the container incorporates internal support columns as well as external guide circles so that the containers can be stacked on top of each other forming a self-assembling large heat exchanger within the tank.

The self-stacking concept can be applied for both water and air circuits and the gap between each container provides an ideal flow passage with a large heat exchange surface.

Туре	Temperature	Temperature	(kWh/FlatICE)	Capacity	(Ton-hr/FlatICE)	Capacity	Container Weight	Container Weight
	(C)	(F)		(kWh/m3)		(Ton-hr/US Gallon)	(kg)	(lbs)
S46	46	115	0.318	64	0.090	0.068	6.03	13.30
S32	32	90	0.287	57	0.082	0.062	5.55	12.23
S30	30	86	0.277	55	0.079	0.060	4.96	10.93
S27	27	81	0.310	62	0.088	0.067	5.81	12.82
S25	25	77	0.248	50	0.070	0.053	5.76	12.69
S23	23	73	0.241	48	0.068	0.052	5.78	12.74
S21	21	70	0.234	47	0.067	0.050	5.78	12.74
S19	19	66	0.230	46	0.065	0.050	5.77	12.73
S17	17	63	0.230	46	0.065	0.050	5.80	12.78
S15	15	59	0.224	45	0.064	0.048	5.74	12.65
S13	13	55	0.224	45	0.064	0.048	5.76	12.69
S10	10	50	0.220	44	0.062	0.047	5.59	12.32
S8	8	46	0.219	44	0.062	0.047	5.61	12.36

"PCM Products has a policy of continuous product and product data improvement and reserves the right to change design and specification without notice"

FlatICE[™] TANK DESIGN;

Generally concrete tanks are either built buried below ground level and the top of the tank used as parking or landscape areas or alternatively within the basement area as part of the foundations.

Tanks ideally should be constructed as close as possible to the chiller and load to minimise the pipework and pumping energy penalties. If the system requires a pressurised tank a cylindrical tank can be constructed to accommodate FlatICE containers with minimum by-pass.





FlatICE containers can only be stacked up to a height of 2.6 m (8 ½ ft) and therefore the height of the tank is restricted to around 3m (10 ft) and the foot print of the tank can be adjusted around this limit.

In principle, the longer the tank the larger the temperature difference one can achieve across the tank and the width / length ratios can be adjusted to suit the site requirements.

Furthermore, if the required storage capacity is too large and the design requires multiple tanks, they can be arranged either in parallel or series format to suit the application and available space. Typically the depth of the tank will be 2.6 m (8 $\frac{1}{2}$ ft) inside dimension which corresponds to approx. 65 FlatICE containers high and 150mm (6") of head room above the containers. Therefore, to estimate the approximate rectangular tank size and shape one can use the following formula inline with FlatICE capacity table.



SI Units;

Load (kWh)

----- = Tank Volume (m³) FlatICE Capacity (kWh / m³)

No of FlatICE = 200 x Tank Volume (m³)

Using the ideal aspect ratios of between 1:4~1:6, tank length can be calculated.

IP Units;

Load (Ton-hr)

------ = Tank Volume (USG) FlatICE Capacity (Ton-hr / USG)

No of FlatICE = 0.75 x Tank Volume (USG)

Using the ideal aspect ratios of between 1:4~1:6, tank length can be calculated.



I NATURAL ALTERNATIVE TO REDUCE ENERGY

TubelCE[™] FEATURES:

TubeICE concept is based on custom-made plastic containers filled with our PlusICE Phase Change Materials (PCM) solutions which have operating temperatures between -40°C (-40°F) and +117 °C (+243 °F). They can be stacked in either cylindrical rectangular tanks for atmospheric / pressurized systems for a variety of thermal energy storage applications.

Tubel	CE	PCM
	1,000 mm (39.4")	

TubelCE custom-made HDPE plastic containers are filled with PlusICE PCM solutions and the filling port fully sealed after filling for safe and reliable operation.

The self-stacking concept can be applied for both water and air circuits and the gap between each container provides an ideal

flow passage with a large heat exchange surface with minimal pressure drop.

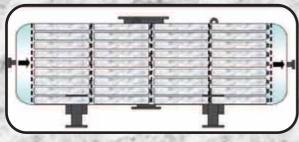
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1	PCM	Phase Change	Phase Change	Weight	Weight	TubeICE	TES Tank	TubeICE	TES Tank
	Туре	Temperature	Temperature	kg/TubelCE	Lb/TubeICE	(kWh/TubeICE)	Capacity	(Ton-hr/TubeICE)	Capacity (Ton-hr/USG)
		(C)	(F)				(kWih/m3)		
	S89	89	192	2.7	6.0	0.124	55	0.035	0.053
	S83	83	181	2.8	6.2	0.119	52	0.034	0.051
1	S72	72	162	2.9	6.4	0.113	50	0.032	0.049
	S58	58	136	2.7	5.9	0.124	55	0.035	0.053
	S50	50	122	2.8	6.2	0.081	36	0.023	0.035
	S46	46	115	2.8	6.2	0.148	65	0.042	0.064
	S44	44	111	2.8	6.2	0.081	36	0.023	0.035
	S34	34	93	3.6	7.9	0.114	50	0.032	0.049
	S32	32	90	2.6	5.7	0.135	59	0.038	0.058
	S30	30	86	2.4	5.2	0.132	58	0.038	0.057
	S27	27	81	2.7	6.0	0.145	64	0.041	0.062
	S25	25	77	2.7	6.0	0.143	63	0.041	0.062
	S23	23	73	2.7	6.0	0.143	63	0.041	0.062
1	S21	22	72	2.7	6.0	0.143	63	0.041	0.062
	S19	19	66	2.7	5.9	0.109	48	0.031	0.047
	S17	17	63	2.7	6.0	0.107	47	0.030	0.046
	S15	15	59	2.7	5.9	0.106	47	0.030	0.046
	S13	13	55	2.7	5.9	0.105	46	0.030	0.045
	S10	10	50	2.6	5.8	0.102	45	0.029	0.044
	S 8	8	46	2.6	5.8	0.102	45	0.029	0.044
	E0	0	32	1.9	4.2	0.177	78	0.050	0.076

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TubelCE[™] Tank Design;

TubeICE TES tanks can be any shape or form to suit site requirements. Tank volumes are calculated based on the required TES capacity and later designed to suit the site layout and restrictions. Tanks can be either atmospheric or pressurised up to 10 Barg (145 Psig). Tanks can be constructed using plastic, steel or concrete and they can be installed in either under- or above ground applications. TubeICE containers can be placed inside the tank using the manhole provided and stacked to form a heat exchange surface between the diffuser plates.

Tanks can be supplied with supply and return headers providing ideal flow conditions within the tank to suit the temperature range and



PCM type, this not only provides ideal heat transfer co-efficiency but also the weight and operational PCM balance can be modified to provide ideal thermal stratification conditions for the tank as a whole. Standard range of both cylindrical and rectangular sectional tanks are available to suit any chilled

water, heat recovery, heating and solar heat recovery applications. The standard cylindrical tanks can be manufactured in diameter to height aspect ratios of up to 1:5. The steel tanks are shipped plain and are generally

insulated on site but plastic tanks can be supplied in 55 mm (2") pre-insulated form as standard.

The sectional and fully internally flanged rectangular tanks are supplied in 1mx0.5m and 1mx1m (3.28'x1.64' and 3.28'x3.28') complete with 55mm (2") thick insulated sections and they are built on site to suit the site layout.



SI Units:

Load (kWh)

- = Tank Volume (m³) TubeICE Capacity (kWh / m³)

No of TubeICE = 440 x Tank Volume (m³)

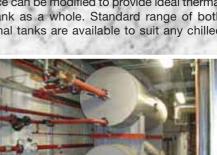
Using the ideal aspect ratios of between 1:4~1:6, tank length can be calculated.

IP Units;

Load (Ton-hr) = Tank Volume (USG) TubeICE Capacity (Ton-hr / USG)

No of TubeICE = 1.5 x Tank Volume (USG)

Using the ideal aspect ratios of between 1:4~1:6, tank length can be calculated.



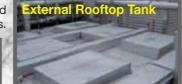
INNOVATION FOR ENERGY SAVING TECHNOLOGIES

FlatICE™ & TubeICE™ TANK APPLICATION;

Generally concrete tanks are either built below ground buried and the top of the tank used as a parking or landscape areas or alternatively within the basement area as part of the

foundations. However, if this can not be achieved or as a Retrofit application, sectional tanks can be manufactured and installed on site either within the basement or roof areas.





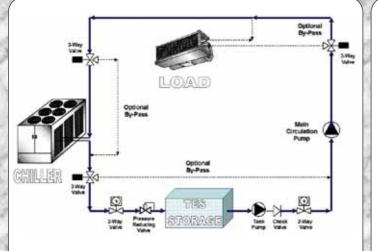
Alternatively, the pressurised tanks can be built to accommodate the containers and buried outside or within the building area. Tanks ideally should be constructed as close as possible to the chiller and load to minimise the pipework and pumping energy penalties.

Furthermore, if the storage capacity is too large and the design requires multiple tanks, they can be arranged either in parallel or series format to suit the application and available space. Typically the depth of the tank will be 2.6 m (8 $\frac{1}{2}$ ft) inside dimension which corresponded to approx. 65 FlatICE containers high and 150mm (6") of head room above the containers.

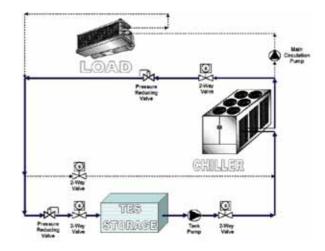




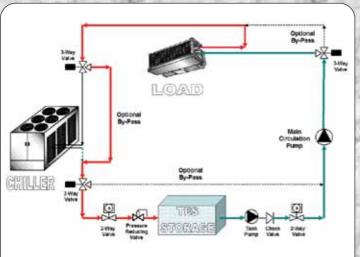
TYPICAL TANK OPERATION;



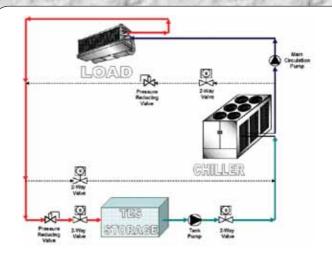
Full Storage Charging Mode



Partial Storage Charging Mode



Full Storage Discharging Mode



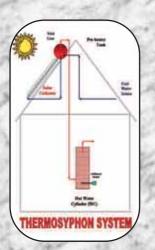
Partial Storage Discharging Mode

WORLD LEADER IN ENERGY SAVING TECHNOLOGIES

BallICE[™] FEATURES;

BallICE rubber PCM ball concept is based on custom-made moulded plastic mixtures containing our organic PlusICE Phase Change Materials (PCM) solutions. Our rubber ball PCM concept is designed for small scale mainly heat storage application such as solar and domestic heating tanks.

In principle, they can be produced in any diameter and incorporating any of our organic PCM solutions but the optimum size of 40mm in diameter using +2°C (36F) and 82°C (180°F) PCM solutions are found to be most attractive options for hot water and heating storage applications respectively.



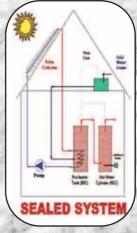
BallICE can be applied for either cylindrical / rectangular tanks for atmospheric / pressurized systems for a variety of thermal energy storage applications.

Balls can be applied for both NEW and RETROFIT applications by simply filling the tank from a 50mm (2") pipe connection when they are either empty or full and as the balls are lighter than water they tend to float and fill the tank volume and the water flows through the balls.









РСМ Туре	Phase Change Temperature (°C)	Phase Change Temperature (°F)	Capacity (kWh/Ball)	TES Tank Capacity (kWh/m3)	Capacity (Ton-hr/Ball)	TES Tank Capacity (Ton-hr/ft3)
A82	82	180	0.019989	20.09	0.0036	0.162
A70	70	158	0.027086	27.22	0.0049	0.219
A62	62	144	0.025428	25.56	0.0046	0.206
A60	60	140	0.024799	24.92	0.0045	0.200
A58	58	136	0.026436	26.57	0.0048	0.214

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SI Units;

Load (kWh)

------ = Tank Volume (m³) BallICE Capacity (kWh / m³)

No of BallICE = 16,500 x Tank Volume (m³)

Standard size balls are in 40mm diameter and weight approx. 30 grams / ball.

IP Units;

Load (Btu)

------ = Tank Volume (USG) BallICE Capacity (Btu / USG)

No of BallICE = 62.4 x Tank Volume (USG)

Standard size balls are in 1½" diameter and weight approx. 0.066 lbs / ball (1.05 oz / ball).

TECHNICAL SUPPORT

PCM Products offers full system design support to assist in proper selection and integration into existing or new installations as part of our customer commitment.

We offer full consultancy on product development on a strict confidentiality basis and the possibility of Licensee options for local manufacturing. Please consult our technical sales team at sales@pcmproducts.net for your specific application or visit our web site www.pcmproducts.net

For additional information contact;

Distributor/Installer Stamp



PlusICE TES-1101