the future of space conditioning

Active Chilled Beams For Healthcare and Patient Rooms

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an FTF Group Company

FRENGER® systems

Contents

Introduction

Chilled Beams are a tried and tested technology (circa 50 years) and over more recent years have further developed for a wide range of applications, especially given the ever increasing awareness for 'Energy Efficient' solutions.

Chilled Beam technology is predominantly used in 'owner occupied' buildings or buildings where the persons paying the energy and/or maintenance bills are influential in the HVAC equipment selection / solution.

One such sector is 'Healthcare'. Frenger have a great deal of awareness of 'Healthcare' applications stemming back some 80 years when Frenger Troughton Young pioneered the supply and installation of Frenger heated ceilings to most if not all hospitals in the UK.

Currently Frenger mainly utilise active chilled beam technology to provide the heating as an integral part of the water driven cooling and fresh (filtered) air ventilation system, with shallow depth constructed active chilled beam (ACB) units that are purposely designed for 'Healthcare' applications.

Detailed below are some of the 'Plus Points' for ACB technology and some 'Project References' for Frenger supplied ACB units for healthcare / hospital applications.

Chilled Beam Technology Plus Points

• Long Life Expectancy (30 Year extended Warranty available) as ACBs have no moving parts, there are no components to wear out or replace.

• Low Maintenance, (only a bi-annual clean is recommended as ACBs have no moving parts, no filters to replace and all access for simple cleaning is from the room side, not the ceiling void).

• Energy Efficient (Typically 22 % lower than top tier Fan Coil Units - see energy study TFS 004 on Feta / HEVAC website for details).

• Optimum in room occupancy Thermal Comfort (compliance to all categories of BS EN ISO7730 'ergonomics of the indoor thermal environment').

• Low noise levels (less than 25 dB sound pressure levels are possible).

• Low Construction Depth (typically 300mm ceiling void is possible, reduced building heights available or more floor levels for same building height in building towers).

• Simple System to Control - soft landings not an issue and system performance is as design (no hidden energy usage as recently discovered with other HVAC equipment not factored into the total energy consumption).

• Best overall 25-year life cycle cost (see BSRIA Blue Book).

Active Chilled Beam Healthcare Projects

Casey Hospital (Monash Health) - Australia

Warnambool Hospital - Victoria, Australia

Walsall Hospital - Walsall, UK

Monash Children's Hospital - Australia

Botswana Academic Hospital - Botswana

Alaska Native Medical Center - USA

Ulster Hospital, Chemotherapy Unit - Belfast, Northern Ireland

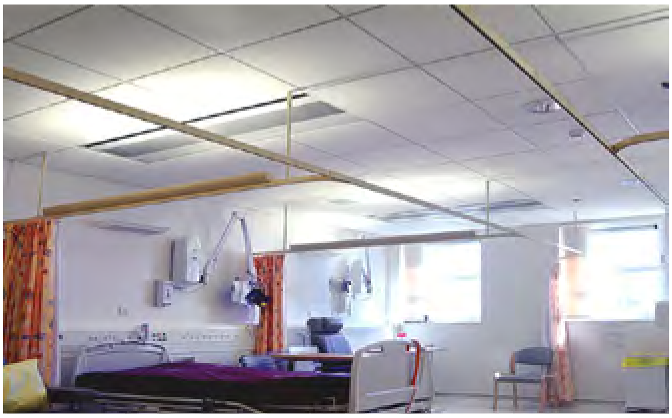
Royal Children's Hospital - Melbourne, Australia

Queens Medical Centre - Nottingham, UK

New Stobhill Hospital - Glasgow, UK

Royal London Hospital - London, UK

Good Hope Hospital - Birmingham, UK



Royal Sussex Hospital - Brighton, UK

Meridian Court - Glasgow, UK

KHUH Hospital - Bahrain

St Bartholomew's Hospital - London, UK

Frimley Park Hospital - Surrey UK

Royal Hobart Hospital - Australia

Other Active Chilled Beam Healthcare Projects Include:

- Great Ormand Street Hospital - London, UK
- South Bucks Hospice – Buckingham, UK
- Gartnavel General Hospital – Glasgow, UK
- Kidderminster Hospital – Kidderminster, UK
- Alder Hey New Research Centre – Liverpool, UK
- Macmillan Hospital – UK
- Kingston Aged Care – Australia
- KSAU Medical Health Science – Riyadh, Saudi Arabia
- Enhanced Bio Bank Medical Research – Saudi Arabia
- The Rehabilitation Centre - Jerusalem, Israel
- St Luke Hospital - UK
- Kent & Canterbury Hospital – UK
- Beatson Oncology – Glasgow, UK
- Glasgow Royal Infirmary, Gynae – UK
- Albury Wogonga Cancer Centre – Wangaratta, Australia
- New Victoria Hospital – Glasgow, UK
- Royal London & St Bart's Hospital – London, UK
- KSAU Medical Health Science – Al Ahsa, Saudi Arabia
- Great Ormand Street Hospital (Phase 2) – London, UK
- Kings College Hospital - London, UK

Reduced Risk of Cross-Contamination

Mechanical filtration at the Air Handling Unit (AHU) can be effective in producing virtually bacteria-free supply (primary) fresh air in hospitals. Viruses and many gases, however, cannot be filtered.

By introducing filtered primary (fresh) air from the AHU to a patient rooms with healthcare Active Chilled Beam (ACB) units, coupled with all recirculated room air via the ACB closed back design and extract air not being reused avoids 'cross contamination' with ceiling voids and/or other patient rooms.

It is best practice to extract air from the corridors to yield a more positive air pressure in the patient room and under pressure in the corridor where old air is extracted.
Dependent upon patient room size / loads, one or more healthcare ACB units (each compact in design and no need for separate grills taking up valuable ceiling space) can keep all fresh and recirculated air within the room space which prevents the conditioned clean air coming into contact with the ceiling void and/or other rooms.

Healthcare ACB units are extremely low maintenance (because of no moving parts and all filters and controls being at the AHU / plant room and / corridors), but even so the healthcare ACB units are fully accessible from the room space below (inspection and cleaning of the coil and induction grille can be performed from the lower face of the ACB unit) without having to remove any ceiling tiles and/or accessing the ceiling void.

Additionally, healthcare ACB units are designed so they operate above dew point, hence avoiding condensation on the fin coil and preventing any need for drip trays as associated with Fan Coil Units (FCU's). Coils that run wet (below dew point) such as FCU's collect dust and dirt and so require special maintenance (treatment of coils and regular dosing of drip trays with chemicals to avoid mould growth etc...) and inspection/replacement of other moving parts.

This simplistic but highly effective design approach is not possible with other systems such FCU unless you have at least three grilles per patient room (one to supply fresh air from the AHU, another for recirculated room air ducted into the FCU and another for the conditioned air supplied from the FCU, all which takes up precious ceiling area and the FCU only serving the one patient room that it is located.

Optimum comfort and IAQ (indoor air quality)

An ACB system will typically control temperature and humidity in the occupied space via the AHU with a constant supply of primary air (minimum fresh-air ventilation requirements are met at all times) and chilled water (above dew point) for sensible loads.

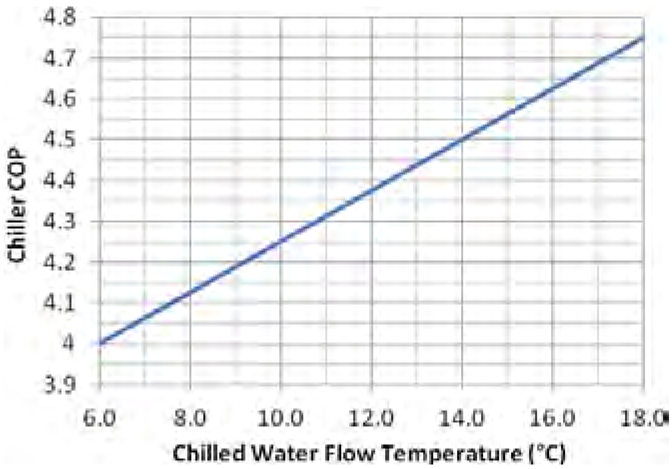
With the elevated chilled water (above dew point) providing the sensible cooling the space temperature is well regulated and thus allows constant-volume delivery of supply fresh filtered air, with comfortable recirculated room air temperatures and low air speeds for compliance to BS EN ISO7730 (ergonomics of the indoor thermal environment).

Air from the ACB's is distributed evenly throughout a space (5:1 induction ratio) in a controlled manner with use of the Coanda effect to entrain conditioned air against the ceiling rather than cold air dumping which is more associated with FCU's given the much colder air off coil temperatures result in denser, less buoyant air.

Lower Energy System

An Active Chilled Beam (ACB) system operates on elevated chilled water supply temperatures (designed to run 'dry' ,above dew point from 14°C to 17°C supply temperature) and have no moving parts (i.e. no fans or motors) which provide a more energy efficient system when compared to a Fan Coil Unit (FCU) system which is typically operated below dew point (wet) on a 6°C or 7°C supply temperature (which also means condensate drip tray is required) and are supplied with individual fans and motors. The Coefficient of Performance (COP) and or EER (Energy Efficiency Ratio) is much higher for Chillers operating on 14/17 degrees (COP / EER is 4.5 standard chiller) when compared to FCU operation on 6/12 flow & return (COP / EER is 4.0) and with ACB units that run dry you can also make use of 'free cooling chillers to drastically increase the COP / EER to an average hourly rate of circa 13.5 for projects based on London weather data.

The total SFP (Specific Fan Power) for an ACB system (in Watts energy used by the AHU for the total system per Ltrs / sec fresh air supplied) is typically much lower than that of a FCU system as ACB units have no fans and additional controls per terminal unit drawing energy all day / every day.



Minimal Maintenance

Chilled Beams have no internal moving parts and have little to no maintenance requirements. However, as large amounts of bedding are used in patient-care areas of hospitals. Lint from this bedding can become airborne, although chilled beams do not usually attract large amounts of lint as the velocity of the recirculated air moving through the fin coil battery heat exchanger element is too low, it still is a good practice to perform routine maintenance on them.

Healthcare chilled-beams offer removable under plates and drop down fin coil heat exchangers battery's to enable for full access to the recirculation air chamber all cleaning of the battery to all 4 sides.

Ordinarily cleaning of the battery for lint is bi annually along with a wipe down of visual surfaces with a damp cloth with mild detergent and/or anti-bacterial cleanser.

Quiet operation

High ambient-noise levels in patient rooms is believed to have negative impacts upon patients, ranging from loss of sleep, elevated blood pressure to extended recovery times. Properly designed ACB systems contribute virtually no detectable noise to occupied spaces, with sound pressure levels which can be below 25 dB. FCU typically create more noise (higher sound pressure) levels, typically 38 dB which can be detrimental to patient recovery / occupancy room comfort.

Turn Down Facility

Unlike other Chilled Beams on the market, Frenger's Active Chilled Beams feature a 'Turn Down' facility as standard, which allows the beams to create a full Coanda effect even at an air pressure even as low as 15 Pa.

Achieving Coanda effect is crucial for maintaining good thermal comfort when rooms are not populated to full design occupancy and reduced fresh air volume is desirable for energy efficiency purposes (reduced air pressure = reduced air volume).

Frenger's Turn Down facility allows rooms to have lowered fresh air supply volume, for example when not required for maximum occupancy, while still maintaining good thermal comfort. This is difficult to achieve with normal active chilled beams and other HVAC items, as usually when the fresh supply air volume is reduced, the supply pressure is reduced below the designed setting as the air introduced into the room from the active chilled beam will no longer produce the desired Coanda effect. The air will stop entraining across the ceiling and instead dump into the occupied space, causing discomfort / draughts.

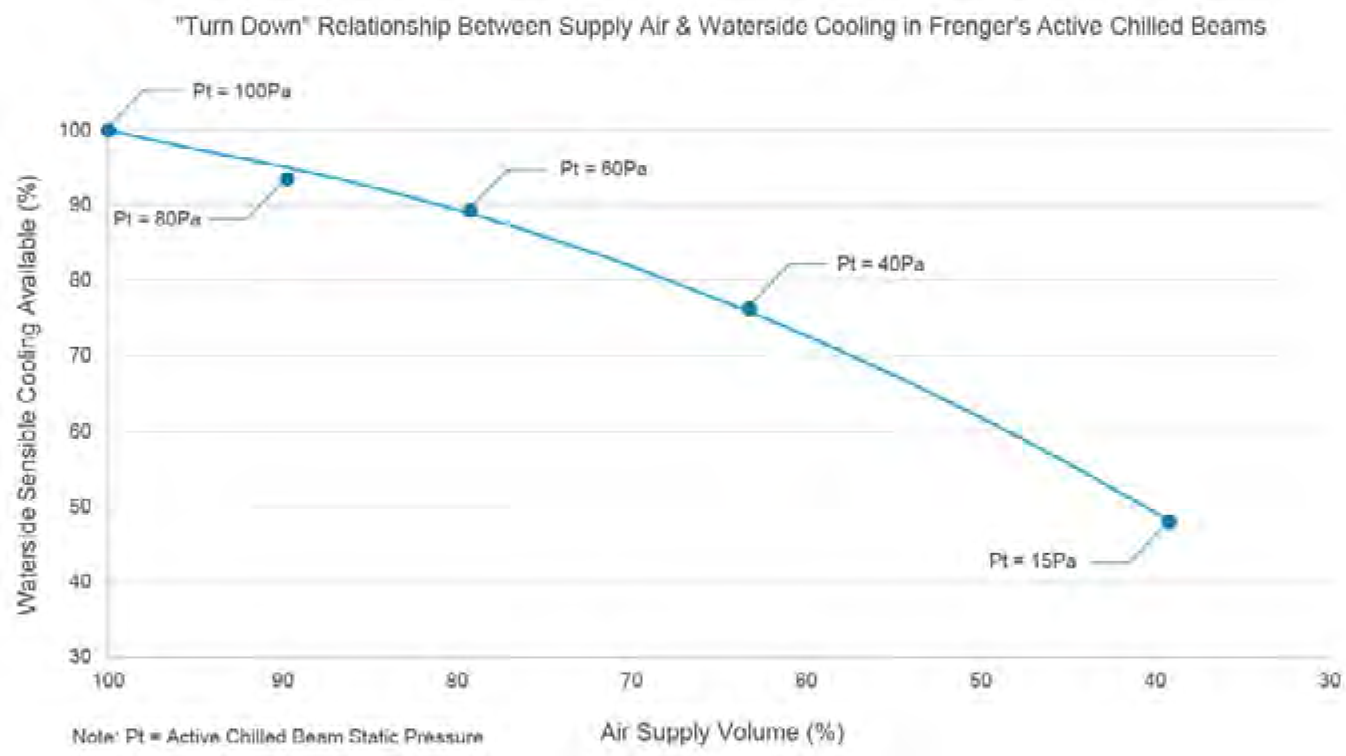
As with all Frenger's products, their ACB's have undergone extensive in-house and third party testing, allowing them to be developed in an optimal way of introducing fresh air to a room without causing draughts or excessive noise.

The ability to 'Turn Down' the fresh air supply pressure, whilst still providing induction and Coanda on discharge maintains, good thermal comfort and allows for a more energy efficient and flexible way of building management. This reduces strain on the HVAC systems, in particular AHU's, therefore lowering running costs and extending the life of the buildings systems.

The graph below shows how the waterside cooling of Frenger's ACB's is reduced during the 'Turn Down' facility, allowing the flexibility to match the requirements relative to the number of occupants in the space.

The Coanda Effect is a phenomenon that causes a moving stream of fluid that comes into contact with a curved surface to follow the curve of the object. In the case of Active Chilled Beams, as air behaves like a fluid, the air will follow the curvature of the air discharge profile allowing it to entrain across the ceiling (or the discharge extrusion on Exposed Chilled Beams and Multi Service Chilled Beams), reducing the air velocities in the occupied zone.

The interaction between the fresh air from the discharge nozzles and air discharge profile on all Frenger's Active Chilled Beams has been designed to give the perfect conditions to allow the Coanda effect to be generated.



Versatile Ceiling Integration

Frenger understands the importance of creating comfortable and energy-efficient healthcare spaces. Their Active Chilled Beams offer a versatile and efficient solution that easily integrates with various ceiling systems, ensuring the optimal climate and air quality for both patients and staff. Explore some of the ceiling systems Frenger's Active Chilled Beams can be effortlessly installed into:

Suspended Ceiling Grid System

Frenger's Active Chilled Beams are designed to complement suspended ceiling systems. This integration allows for a uniform and unobtrusive appearance while efficiently delivering conditioned air. The discreet profile of their beams ensures they blend seamlessly with the suspended ceiling, maintaining the aesthetic integrity of the space.

Plasterboard Ceiling System with Access Hatch

For healthcare environments requiring accessibility and flexibility, Frenger's Active Chilled Beams are the ideal choice. Installing them within a plasterboard ceiling system with an access hatch ensures easy maintenance and adjustments while delivering exceptional thermal comfort. This system is perfect for spaces where periodic inspections or modifications are necessary, without compromising on design and performance.

Custom Ceiling Configurations

Frenger takes pride in tailoring solutions to the specific needs of healthcare facilities. Their Active Chilled Beams can be integrated into custom ceiling configurations, offering endless possibilities for design and functionality. Frenger’s experts can create a solution that aligns with the vision of the project and it's performance requirements.

Eco Healthcare

Frenger's Eco Healthcare active chilled beams are primarily aimed at hospital and healthcare applications. This Healthcare variant of the Eco chilled beam is ideal for these applications, as it has a number of features that allow for deep cleaning and improved maintenance such as, drop down heat exchanger batteries to enable cleaning on all four sides and removable endcaps to allow internal cleaning. The units also come with air vents and drain cocks all accessible from within the room.

Eco Healthcare is 227mm deep as standard and can be increased to **267mm for higher air volumes**.
Eco Healthcare can achieve **1121 watts per meter total cooling** (based on 10∆tk and 25 litrs/sec/m for a beam supplied at 16°C with a 100Pa).

The Eco Healthcare contains a number of **Frenger's Patented performance enhancing features** and as can be expected from the Frenger brand, the Eco Healthcare beam is also designed to be easily tailored to suit the unique parameters of individual project sites, for the optimum product / system efficiencies. This is partly achieved by Frenger's "burst nozzle" arrangement that not only encourages induction, but also reduces noise. Given the size and amount of burst nozzles being appropriately quantified for each project, this provides consistent jet velocities, equal distribution of the air discharge and continuous induction through the entire length of the heat exchanger (battery). There are no dead spots due to plugging back nozzles in the system to suit the amount of open standard nozzles sizes as associated with many competitors' active beams as dead spots and / or reduced jet velocities decrease their cooling capacities / efficiencies.

Frenger's heat exchanger batteries are also fitted with extruded aluminium profiles to not only enhance performance but also provide a continuous clip on facility for the underplate. This arrangement keeps the underplates true and flat for long lengths, even up to 3.6m.

Eco Healthcare is designed with hospital / healthcare environments in mind. The fin coil battery element can easily be lowered to allow cleaning of all four sides. Eco Healthcare units are pre coat finished White, equivalent to RAL 9016 (20% gloss) as standard.

Eco Healthcare is available in any length from 1.2m up to 3.6m in 0.1m increments and is constructed from a combination of zinc coated mild steel for non critical components, extruded aluminium where precision and a high quality robust construction is required.

The air chamber for Eco Healthcare is the largest in Frenger's product range and can accommodate up to 90 ltrs/sec with its 160mm diameter single air inlet connection point.

Eco Healthcare beams have a "closed back", thus meaning that all induced air (recirculated room air) is induced through the underplate within the room space to avoid any need for perimeter flash gaps and / or openings in the ceiling system. This also provides for a better quality of recirculated air as the recirculated air does not mix with any air from the ceiling void. The induction ratio of Eco Healthcare is typically five times that of the supply air (fresh air) rate.

In addition to Eco Healthcare high cooling performance capability in excess of 1000 watts per meter, **Eco Healthcare can operate well and induce at low air volumes, as little as 3 l/s/m and even with a low static pressure of just 40Pa. Likewise Eco Healthcare can handle high air volumes up to 30 l/s/m and up to 120Pa.** Please note however that their high air volumes should be avoided wherever possible and are the absolute maximum and should not ever be exceeded. As a "rule of thumb" 25 ltrs/sec/m from a two way discharge beam is the maximum for occupancy comfort compliance to BS EN 7730.

Eco Healthcare can have integrated heating with separate connections (two pipe connections for cooling and two pipes for heating).

The maximum total supply air for the product is limited to 90 ltrs/sec, which equates to 25 ltrs/sec/m for a 3.6m long beam.

At a glance

- Drop down heat exchange battery for easy cleaning to all four sides of the heat exchanger.
- High output "**1258 W/m**".
- Can accommodate up to 90 ltrs/sec.
- Optimise discharge nozzles sizes and pitch factory set to best suit project requirements.
- Coanda effect is initiated within the beam.
- Discharge veins are concealed within the beam for improved aesthetics.
- **Fan shape distribution for increased occupancy comfort**.
- **Unique fast fixing of removable underplates that prevents any sagging even on long beam lengths of 3.6m**.
- **Various different perforation patterns available for removable underplates**.
- **Multiple manifold variants to enable reduced chilled** (and LTHW, if applicable) **water mass flow rates to be facilitated for increased energy efficiencies**.
- Operates well at "**Low Pressure**" and "**Low Air Volume**" for **increased energy efficiencies**.
- Provides indoor climate **in accordance with BS EN ISO 7730**.

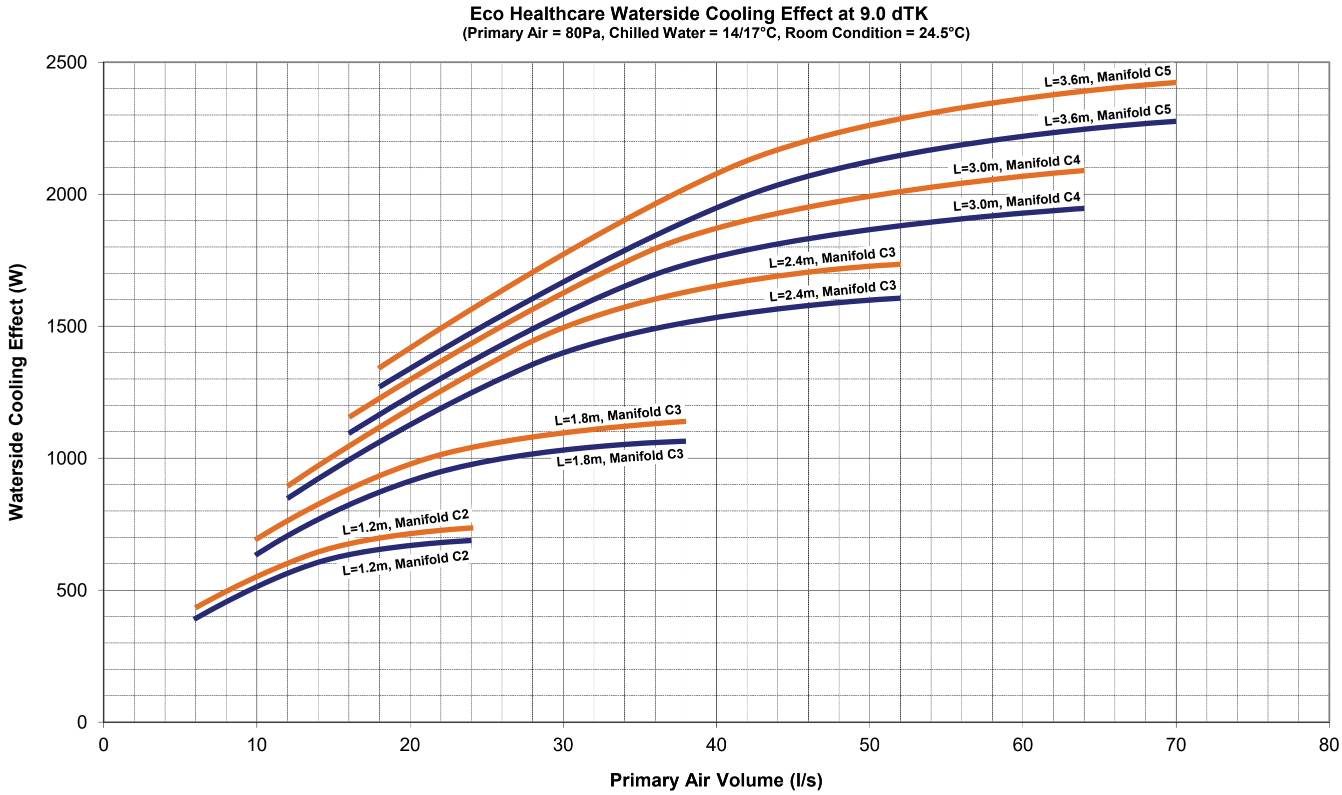
Hygiene

It is important to clean the product to ensure that it looks its best, that it operates at an optimum level, that it will last as long as possible and that it does not present an infection control risk. During development of the Frenger Eco Healthcare chilled beam the ease of cleaning was of the highest priority.

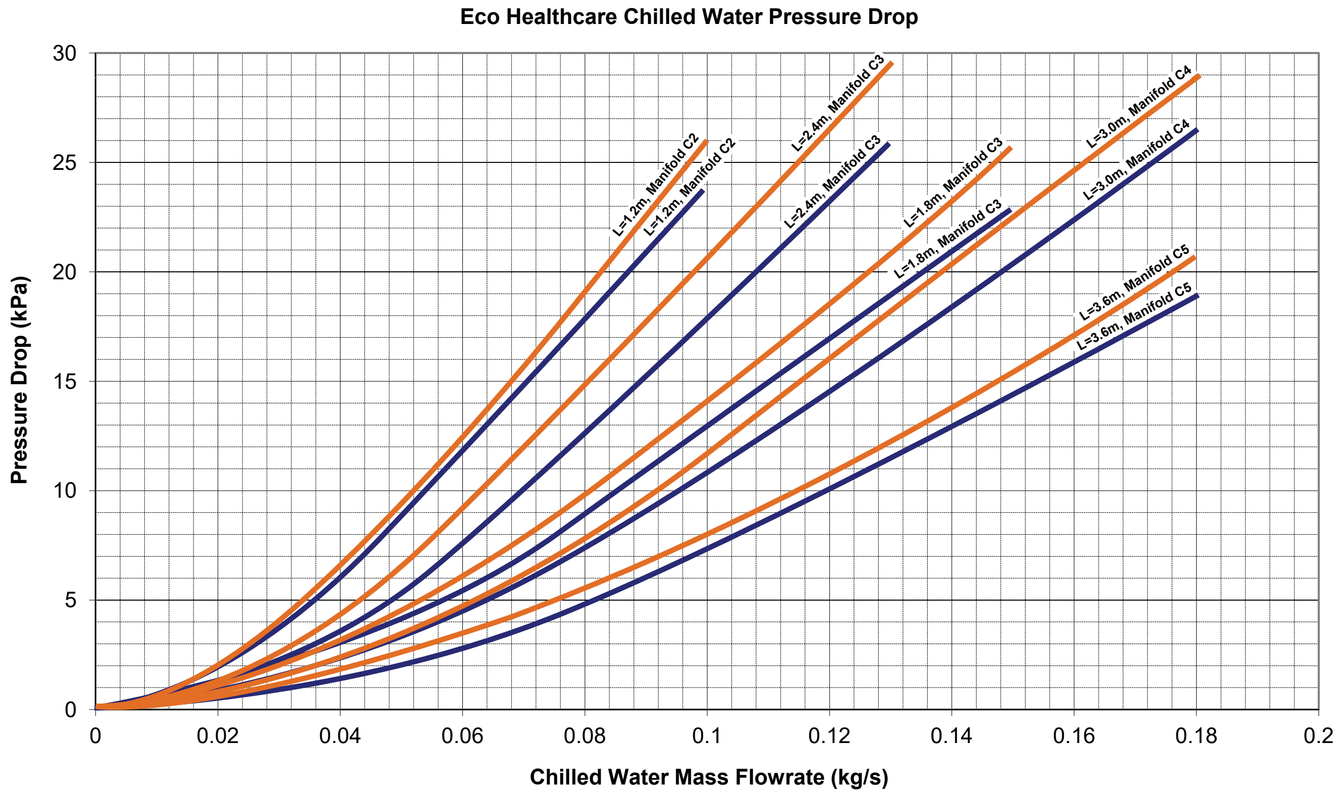
The underplate to the Eco Healthcare is simple to lower or totally remove. The underplate hooks onto a patented extruded aluminium section which is part of the fin coil battery. When “joggled” off the extrusion the underplate can hang on the factory fitted safety cords.

When the underplate is either hanging down on the safety cords or totally removed, the fin coil battery is accessible from below. The fin coil battery can be easily lowered by the removal of four retaining screws (pozi headed screw driver) to enable 60mm clearance behind the fin coil battery and ample clearance to both sides where air passes.

Cooling Performance



Pressure Drop

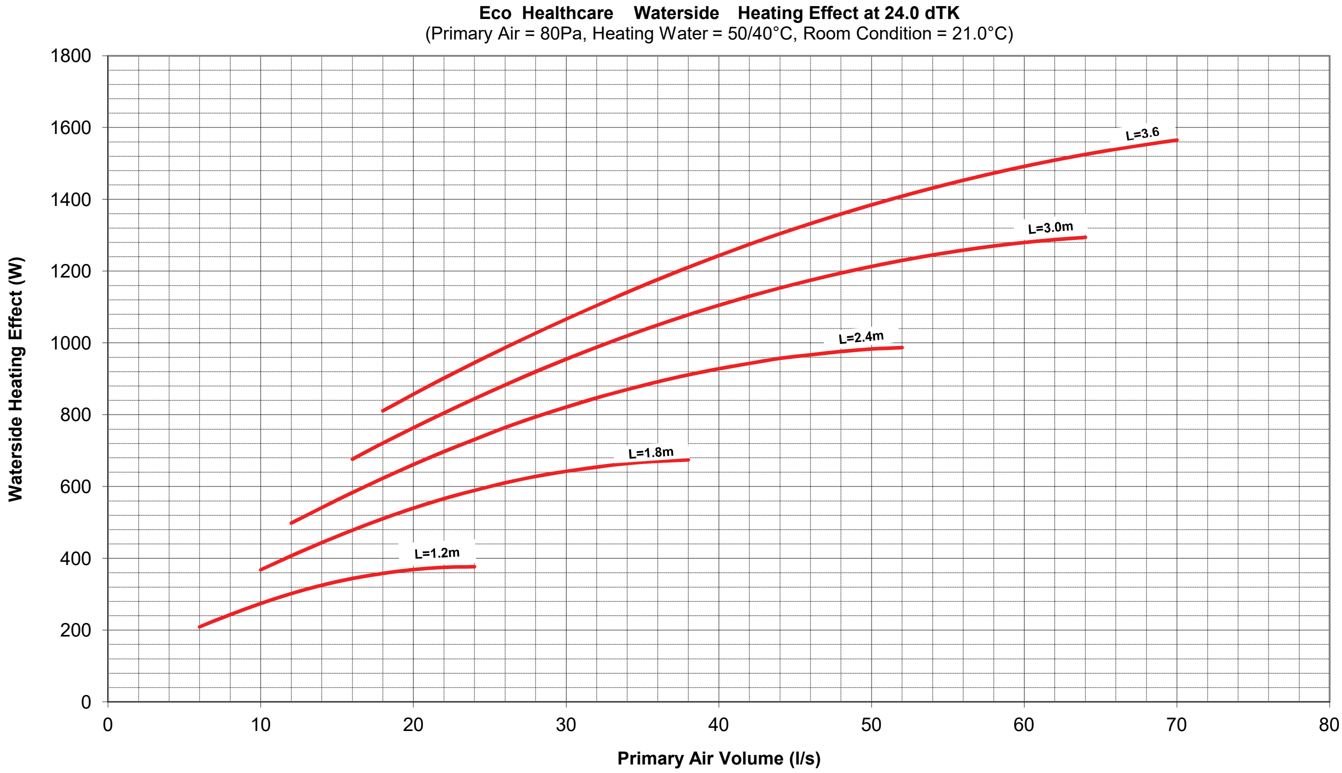


Legend:

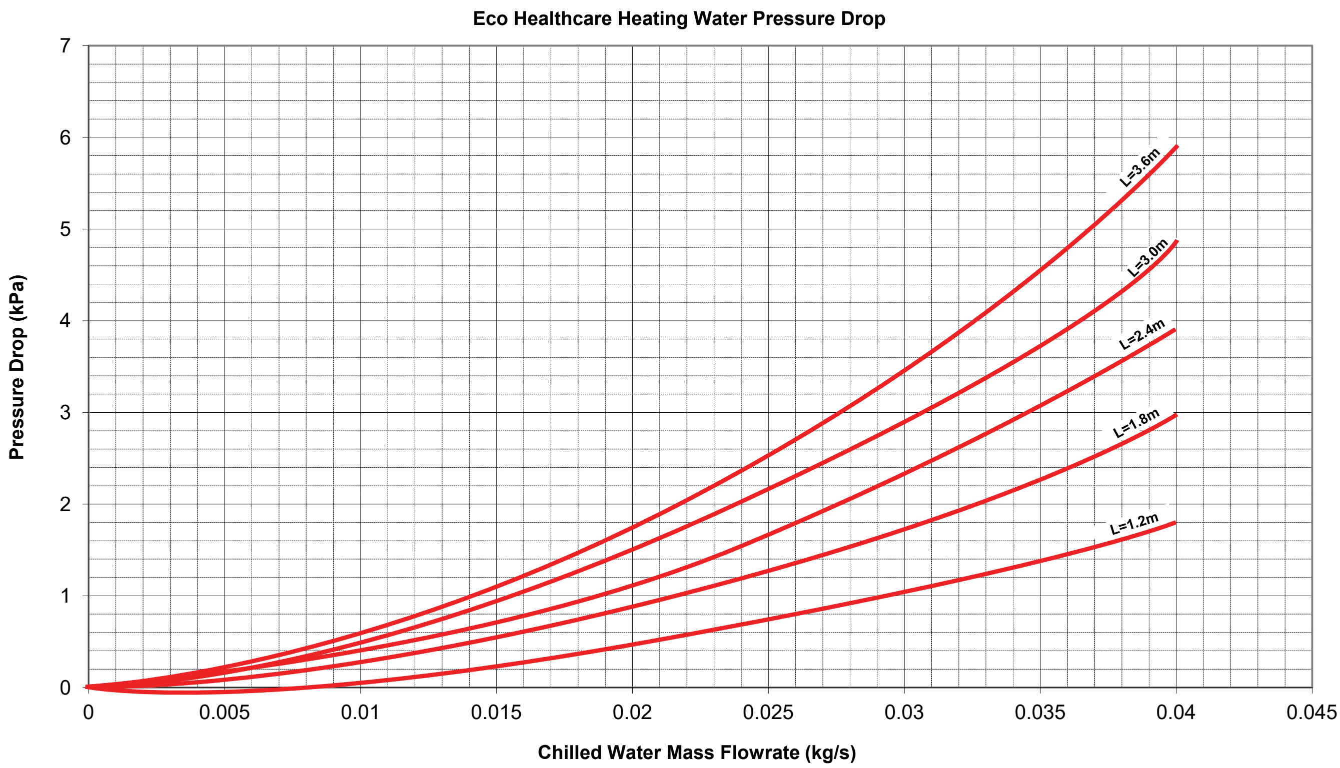
= Cooling Only

= Cooling & Heating

Heating Performance



Pressure Drop



Cooling only at 40Pa Nozzle Pressure

Nozzle Pressure 40 Pa		Water															
Q (l/s)	Eco-H	ΔtK - 7°C				ΔtK - 8°C				ΔtK - 9°C				ΔtK - 10°C			
	L (m)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)
10	1.2	353	0.028	C2	3.6	418	0.033	C2	4.7	482	0.038	C2	6.0	545	0.043	C2	7.5
	1.8	475	0.038	C2	8.9	554	0.044	C2	11.6	636	0.051	C2	14.6	726	0.058	C2	18.1
	2.4	545	0.043	C2	15.1	635	0.051	C2	19.5	673	0.054	C3	7.2	760	0.061	C3	8.9
	3.0	547	0.044	C3	6.3	639	0.051	C3	8.2	731	0.058	C3	10.4	824	0.066	C3	12.8
	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	675	0.054	C2	16.0	716	0.057	C3	5.9	827	0.066	C3	7.6	938	0.075	C3	9.4
	2.4	784	0.062	C3	9.3	917	0.073	C3	12.1	1065	0.085	C3	15.3	1251	0.100	C3	19.2
	3.0	917	0.073	C3	15.2	1084	0.086	C3	19.8	1157	0.092	C4	10.4	1313	0.104	C4	12.8
	3.6	962	0.077	C4	9.1	1120	0.089	C4	11.8	1287	0.102	C4	14.9	1472	0.117	C4	18.4
30	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.4	917	0.073	C3	12.0	1072	0.085	C3	15.7	1240	0.099	C3	19.8	1310	0.104	C4	10.1
	3.0	1052	0.084	C4	8.8	1232	0.098	C4	11.5	1427	0.114	C4	14.5	1659	0.132	C4	18.1
	3.6	1217	0.097	C4	13.5	1442	0.115	C4	17.7	1558	0.124	C5	11.2	1784	0.142	C5	13.9
40	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.0	1156	0.092	C4	10.2	1351	0.108	C4	13.4	1550	0.123	C4	16.9	1674	0.133	C5	10.5
	3.6	1378	0.110	C4	16.5	1530	0.122	C5	10.9	1765	0.141	C5	13.8	2031	0.162	C5	17.1

Flow-adjusted waterside cooling effect table. Cooling circuit Δt = 3°C (Water in-out), nozzle pressure of 40 Pa, 1 x Ø125 air connection.
For green values, a Ø22 manifold connection size is required.
Please refer to Frenger Technical Department for selections not covered within these tables.

Cooling only at 60Pa Nozzle Pressure

Nozzle Pressure 60 Pa		Water															
Q (l/s)	Eco-H	ΔtK - 7°C				ΔtK - 8°C				ΔtK - 9°C				ΔtK - 10°C			
	L (m)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)
10	1.2	383	0.030	C2	4.1	453	0.036	C2	5.4	523	0.042	C2	6.9	593	0.047	C2	8.6
	1.8	501	0.040	C2	9.8	583	0.046	C2	12.7	665	0.053	C2	15.9	754	0.060	C2	19.5
	2.4	582	0.046	C2	16.9	630	0.050	C3	6.4	723	0.058	C3	8.1	814	0.065	C3	10.0
	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	1.2	515	0.041	C2	6.6	609	0.048	C2	8.8	699	0.056	C2	11.3	785	0.063	C2	13.9
	1.8	768	0.061	C2	19.7	813	0.065	C3	7.3	938	0.075	C3	9.3	1065	0.085	C3	11.6
	2.4	848	0.068	C3	10.6	992	0.079	C3	13.8	1148	0.091	C3	17.5	1211	0.096	C4	8.9
	3.0	968	0.077	C3	16.7	1069	0.085	C4	9.0	1222	0.097	C4	11.4	1381	0.110	C4	14.0
	3.6	1014	0.081	C4	10.0	1178	0.094	C4	12.9	1345	0.107	C4	16.2	1524	0.121	C4	19.9
30	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	794	0.063	C3	6.9	936	0.075	C3	9.2	1073	0.085	C3	11.8	1205	0.096	C3	14.5
	2.4	1053	0.084	C3	15.1	1237	0.098	C3	19.8	1328	0.106	C4	10.3	1505	0.120	C4	12.8
	3.0	1168	0.093	C4	10.4	1368	0.109	C4	13.6	1587	0.126	C4	17.3	1695	0.135	C5	10.7
	3.6	1314	0.105	C4	15.4	1551	0.123	C4	20.0	1682	0.134	C5	12.8	1919	0.153	C5	15.8
40	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.4	1143	0.091	C3	17.6	1264	0.101	C4	9.4	1446	0.115	C4	12.0	1624	0.129	C4	14.8
	3.0	1337	0.106	C4	13.0	1563	0.124	C4	17.0	1710	0.136	C5	10.8	1937	0.154	C5	13.4
	3.6	1475	0.117	C5	10.1	1730	0.138	C5	13.3	2003	0.159	C5	16.9	2324	0.185	C5	20.9

Flow-adjusted waterside cooling effect table. Cooling circuit Δt = 3°C (Water in-out), nozzle pressure of 60 Pa, 1 x Ø125 air connection.
For green values, a Ø22 manifold connection size is required.
Please refer to Frenger Technical Department for selections not covered within these tables.

Cooling only at 80Pa Nozzle Pressure

Nozzle Pressure 80 Pa		Water															
Q (l/s)	Eco-H	ΔtK - 7°C				ΔtK - 8°C				ΔtK - 9°C				ΔtK - 10°C			
	L (m)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)
10	1.2	419	0.033	C2	4.7	497	0.040	C2	6.3	573	0.046	C2	8.1	647	0.051	C2	10.0
	1.8	565	0.045	C2	12.0	651	0.052	C2	15.5	735	0.059	C2	19.2	790	0.063	C3	7.1
	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	1.2	542	0.043	C2	7.2	640	0.051	C2	9.6	737	0.059	C2	12.2	839	0.067	C2	15.2
	1.8	743	0.059	C3	6.2	881	0.070	C3	8.3	1016	0.081	C3	10.6	1151	0.092	C3	13.2
	2.4	928	0.074	C3	12.3	1076	0.086	C3	16.0	1173	0.093	C4	8.4	1322	0.105	C4	10.4
	3.0	1061	0.084	C3	19.8	1185	0.094	C4	10.8	1345	0.107	C4	13.6	1505	0.120	C4	16.6
	3.6	1144	0.091	C4	12.3	1317	0.105	C4	15.8	1487	0.118	C4	19.6	1633	0.130	C5	12.5
30	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	835	0.066	C3	7.5	984	0.078	C3	10.0	1134	0.090	C3	12.8	1291	0.103	C3	15.8
	2.4	1129	0.090	C3	17.0	1236	0.098	C4	9.0	1423	0.113	C4	11.5	1615	0.129	C4	14.3
	3.0	1268	0.101	C4	11.9	1478	0.118	C4	15.6	1697	0.135	C4	19.7	1831	0.146	C5	12.3
	3.6	1427	0.114	C4	17.9	1600	0.127	C5	11.8	1823	0.145	C5	14.9	2053	0.163	C5	18.2
40	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.4	1216	0.097	C3	19.1	1329	0.106	C4	10.2	1531	0.122	C4	13.0	1744	0.139	C4	16.2
	3.0	1427	0.114	C4	14.5	1674	0.133	C4	19.0	1823	0.145	C5	12.1	2074	0.165	C5	15.0
	3.6	1598	0.127	C5	11.5	1869	0.149	C5	15.1	2155	0.172	C5	19.2	2482	0.198	C5	23.7

Flow-adjusted waterside cooling effect table. Cooling circuit Δt = 3°C (Water in-out), nozzle pressure of 80 Pa, 1 x Ø125 air connection.
For green values, a Ø22 manifold connection size is required.
Please refer to Frenger Technical Department for selections not covered within these tables.

Cooling only at 100Pa Nozzle Pressure

Nozzle Pressure 100 Pa		Water															
Q (l/s)	Eco-H	ΔtK - 7°C				ΔtK - 8°C				ΔtK - 9°C				ΔtK - 10°C			
	L (m)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)
10	1.2	445	0.035	C2	5.2	527	0.042	C2	6.9	606	0.048	C2	8.9	683	0.054	C2	11.0
	1.8	599	0.048	C2	13.3	690	0.055	C2	17.1	742	0.059	C3	6.3	838	0.067	C3	7.8
	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	1.2	593	0.047	C2	8.3	700	0.056	C2	11.1	806	0.064	C2	14.2	918	0.073	C2	17.6
	1.8	792	0.063	C3	6.9	935	0.074	C3	9.2	1076	0.086	C3	11.7	1217	0.097	C3	14.5
	2.4	981	0.078	C3	13.6	1136	0.090	C3	17.6	1240	0.099	C4	9.3	1396	0.111	C4	11.4
	3.0	1079	0.086	C4	9.1	1253	0.100	C4	11.9	1422	0.113	C4	15.0	1592	0.127	C4	18.2
	3.6	1214	0.097	C4	13.6	1397	0.111	C4	17.5	1550	0.123	C5	11.3	1732	0.138	C5	13.8
30	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	913	0.073	C3	8.7	1075	0.086	C3	11.5	1239	0.099	C3	14.8	1412	0.112	C3	18.3
	2.4	1207	0.096	C3	19.0	1324	0.105	C4	10.1	1522	0.121	C4	12.9	1725	0.137	C4	16.0
	3.0	1342	0.107	C4	13.2	1561	0.124	C4	17.2	1716	0.137	C5	11.0	1935	0.154	C5	13.5
	3.6	1507	0.120	C4	19.6	1691	0.135	C5	13.0	1925	0.153	C5	16.3	2170	0.173	C5	20.0
40	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	955	0.076	C3	9.3	1124	0.089	C3	12.4	1297	0.103	C3	15.9	1488	0.118	C3	19.7
	2.4	1233	0.098	C4	8.9	1451	0.115	C4	11.8	1671	0.133	C4	15.1	1907	0.152	C4	18.7
	3.0	1534	0.122	C4	16.4	1707	0.136	C5	10.7	1963	0.156	C5	13.6	2229	0.177	C5	16.9
	3.6	1693	0.135	C5	12.7	1976	0.157	C5	16.7	2275	0.181	C5	21.1	2620	0.209	C5	26.0

Flow-adjusted waterside cooling effect table. Cooling circuit Δt = 3°C (Water in-out), nozzle pressure of 100 Pa, 1 x Ø125 air connection.
For green values, a Ø22 manifold connection size is required.
Please refer to Frenger Technical Department for selections not covered within these tables.

Cooling & Heating at 40Pa Nozzle Pressure

Nozzle Pressure 40 Pa		Water															
Q (l/s)	Eco-H	ΔtK - 7°C				ΔtK - 8°C				ΔtK - 9°C				ΔtK - 10°C			
	L (m)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)
10	1.2	301	0.024	C2	2.3	359	0.029	C2	3.1	416	0.033	C2	3.9	473	0.038	C2	4.9
	1.8	412	0.033	C2	5.8	482	0.038	C2	7.6	552	0.044	C2	9.6	624	0.050	C2	11.8
	2.4	475	0.038	C2	9.9	552	0.044	C2	12.9	633	0.050	C2	16.2	721	0.057	C2	20.0
	3.0	515	0.041	C2	14.3	599	0.048	C2	18.5	637	0.051	C3	7.2	719	0.057	C3	8.8
	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	584	0.046	C2	10.4	685	0.054	C2	13.6	796	0.063	C2	17.3	812	0.065	C3	6.4
	2.4	680	0.054	C3	6.4	795	0.063	C3	8.3	857	0.068	C3	4.1	1044	0.083	C3	13.0
	3.0	796	0.063	C3	10.5	930	0.074	C3	13.6	1006	0.080	C4	6.8	1137	0.090	C4	8.4
	3.6	884	0.070	C3	15.0	1039	0.083	C3	19.6	1117	0.089	C4	9.8	1264	0.101	C4	12.1
30	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.4	793	0.063	C3	8.2	930	0.074	C3	10.7	1069	0.085	C3	13.6	1216	0.097	C3	16.9
	3.0	975	0.078	C3	14.6	1161	0.092	C3	19.1	1228	0.098	C4	9.5	1399	0.111	C4	11.7
	3.6	1056	0.084	C4	8.9	1235	0.098	C4	11.5	1436	0.114	C4	14.6	1691	0.135	C4	18.3
40	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.0	1067	0.085	C3	17.0	1173	0.093	C4	8.7	1347	0.107	C4	11.1	1523	0.121	C4	13.7
	3.6	1192	0.095	C4	10.8	1399	0.111	C4	14.1	1636	0.130	C4	17.9	1733	0.138	C5	11.1

Flow-adjusted waterside cooling effect table. Cooling circuit Δt = 3°C (Water in-out), nozzle pressure of 40 Pa, 1 x Ø125 air connection.
For green values, a Ø22 manifold connection size is required.
Please refer to Frenger Technical Department for selections not covered within these tables.

Cooling & Heating at 60Pa Nozzle Pressure

Nozzle Pressure 60 Pa		Water															
Q (l/s)	Eco-H	ΔtK - 7°C				ΔtK - 8°C				ΔtK - 9°C				ΔtK - 10°C			
	L (m)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)
10	1.2	325	0.026	C2	2.6	389	0.031	C2	3.5	452	0.036	C2	4.5	514	0.041	C2	5.6
	1.8	435	0.035	C2	6.4	508	0.040	C2	8.3	581	0.046	C2	10.5	654	0.052	C2	12.9
	2.4	509	0.040	C2	11.2	589	0.047	C2	14.4	671	0.053	C2	18.0	710	0.057	C3	6.9
	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	1.2	438	0.035	C2	4.2	524	0.042	C2	5.6	607	0.048	C2	7.3	687	0.055	C2	9.1
	1.8	663	0.053	C2	12.8	780	0.062	C2	16.8	810	0.064	C3	6.3	921	0.073	C3	7.9
	2.4	735	0.059	C3	7.2	860	0.068	C3	9.5	988	0.079	C3	12.0	1126	0.090	C3	14.8
	3.0	843	0.067	C3	11.5	981	0.078	C3	15.0	1130	0.090	C3	18.8	1202	0.096	C4	9.2
	3.6	929	0.074	C3	16.4	1029	0.082	C4	8.5	1175	0.093	C4	10.7	1323	0.105	C4	13.1
30	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	755	0.060	C2	16.2	807	0.064	C3	6.2	933	0.074	C3	8.0	1055	0.084	C3	10.0
	2.4	912	0.073	C3	10.3	1068	0.085	C3	13.6	1232	0.098	C3	17.2	1304	0.104	C4	8.3
	3.0	1083	0.086	C3	17.4	1185	0.094	C4	8.9	1363	0.109	C4	11.3	1556	0.124	C4	14.0
	3.6	1141	0.091	C4	10.1	1333	0.106	C4	13.1	1545	0.123	C4	16.6	1652	0.131	C5	10.3
40	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.4	998	0.079	C3	12.0	1158	0.092	C3	15.8	1317	0.105	C3	19.8	1422	0.113	C4	9.7
	3.0	1157	0.092	C4	8.4	1356	0.108	C4	11.1	1558	0.124	C4	14.1	1774	0.141	C4	17.4
	3.6	1347	0.107	C4	13.2	1587	0.126	C4	17.3	1724	0.137	C5	11.0	1965	0.156	C5	13.6

Flow-adjusted waterside cooling effect table. Cooling circuit Δt = 3°C (Water in-out), nozzle pressure of 60 Pa, 1 x Ø125 air connection.
For green values, a Ø22 manifold connection size is required.
Please refer to Frenger Technical Department for selections not covered within these tables.

Cooling & Heating at 80Pa Nozzle Pressure

Nozzle Pressure 80 Pa		Water															
Q (l/s)	Eco-H	∆tK - 7°C				∆tK - 8°C				∆tK - 9°C				∆tK - 10°C			
	L (m)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)
10	1.2	355	0.028	C2	3.0	426	0.034	C2	4.0	495	0.039	C2	5.2	563	0.045	C2	6.5
	1.8	493	0.039	C2	7.9	573	0.046	C2	10.3	649	0.052	C2	12.8	724	0.058	C2	15.6
	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	1.2	462	0.037	C2	4.6	551	0.044	C2	6.1	638	0.051	C2	7.9	724	0.058	C2	9.9
	1.8	717	0.057	C2	14.6	841	0.067	C2	19.2	878	0.070	C3	7.2	998	0.079	C3	9.0
	2.4	807	0.064	C3	8.4	941	0.075	C3	11.1	1073	0.085	C3	13.9	1208	0.096	C3	17.1
	3.0	933	0.074	C3	13.8	1075	0.086	C3	17.7	1181	0.094	C4	9.0	1324	0.105	C4	11.0
	3.6	1033	0.082	C3	20.0	1160	0.092	C4	10.5	1313	0.104	C4	13.1	1464	0.116	C4	15.9
30	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	802	0.064	C2	17.6	848	0.068	C3	6.8	981	0.078	C3	8.7	1114	0.089	C3	10.8
	2.4	978	0.078	C3	11.6	1146	0.091	C3	15.2	1324	0.105	C3	19.3	1398	0.111	C4	9.3
	3.0	1166	0.093	C3	19.9	1286	0.102	C4	10.2	1473	0.117	C4	12.9	1667	0.133	C4	15.9
	3.6	1249	0.099	C4	11.8	1447	0.115	C4	15.3	1651	0.131	C4	19.1	1793	0.143	C5	12.0
40	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2.4	1051	0.084	C3	13.1	1234	0.098	C3	17.2	1324	0.105	C4	8.5	1503	0.120	C4	10.5
	3.0	1234	0.098	C4	9.4	1448	0.115	C4	12.4	1668	0.133	C4	15.7	1915	0.152	C4	19.5
	3.6	1456	0.116	C4	15.1	1708	0.136	C4	19.7	1863	0.148	C5	12.5	2115	0.168	C5	15.5

Flow-adjusted waterside cooling effect table. Cooling circuit ∆t = 3°C (Water in-out), nozzle pressure of 80 Pa, 1 x Ø125 air connection.
For green values, a Ø22 manifold connection size is required.
Please refer to Frenger Technical Department for selections not covered within these tables.

Cooling & Heating at 100Pa Nozzle Pressure

Nozzle Pressure 100 Pa		Water															
Q (l/s)	Eco-H	∆tK - 7°C				∆tK - 8°C				∆tK - 9°C				∆tK - 10°C			
	L (m)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)	P (w)	p(kg/s)	Manifold	p(kPa)
10	1.2	378	0.030	C2	3.3	452	0.036	C2	4.5	525	0.042	C2	5.7	596	0.047	C2	7.2
	1.8	523	0.042	C2	8.7	607	0.048	C2	11.3	687	0.055	C2	14.2	768	0.061	C2	17.2
	2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	1.2	505	0.040	C2	5.3	602	0.048	C2	7.1	697	0.055	C2	9.2	792	0.063	C2	11.4
	1.8	759	0.060	C2	16.2	805	0.064	C3	6.2	932	0.074	C3	8.0	1057	0.084	C3	9.9
	2.4	854	0.068	C3	9.3	995	0.079	C3	12.2	1133	0.090	C3	15.3	1276	0.102	C3	18.8
	3.0	986	0.078	C3	15.2	1136	0.090	C3	19.5	1249	0.099	C4	9.9	1399	0.111	C4	12.1
	3.6	1062	0.085	C4	8.9	1230	0.098	C4	11.6	1392	0.111	C4	14.5	1555	0.124	C4	17.6
30	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	780	0.062	C3	5.8	927	0.074	C3	7.8	1072	0.085	C3	10.0	1217	0.097	C3	12.5
	2.4	1047	0.083	C3	13.0	1224	0.097	C3	17.0	1319	0.105	C4	8.4	1495	0.119	C4	10.5
	3.0	1164	0.093	C4	8.5	1361	0.108	C4	11.2	1556	0.124	C4	14.2	1760	0.140	C4	17.5
	3.6	1319	0.105	C4	12.9	1527	0.122	C4	16.8	1685	0.134	C5	10.8	1894	0.151	C5	13.2
40	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	816	0.065	C3	6.3	969	0.077	C3	8.4	1120	0.089	C3	10.8	1274	0.101	C3	13.5
	2.4	1148	0.091	C3	15.1	1348	0.107	C3	19.8	1446	0.115	C4	9.8	1642	0.131	C4	12.2
	3.0	1329	0.106	C4	10.6	1557	0.124	C4	14.0	1793	0.143	C4	17.7	1929	0.154	C5	11.0
	3.6	1540	0.123	C4	16.6	1718	0.137	C5	10.9	1969	0.157	C5	13.8	2233	0.178	C5	17.1

Flow-adjusted waterside cooling effect table. Cooling circuit ∆t = 3°C (Water in-out), nozzle pressure of 100 Pa, 1 x Ø125 air connection.
For green values, a Ø22 manifold connection size is required.
Please refer to Frenger Technical Department for selections not covered within these tables.

Heating Selection Tables

Heating at 40Pa Nozzle Pressure

Nozzle Pressure 40 Pa		Water											
Q (l/s)	Eco-H	ΔtK - 15°C			ΔtK - 20°C			ΔtK - 25°C			ΔtK - 30°C		
	L (m)	P (w)	p(kg/s)	p(kPa)	P (w)	p(kg/s)	p(kPa)	P (w)	p(kg/s)	p(kPa)	P (w)	p(kg/s)	p(kPa)
10	1.2	291	0.012	0.5	358	0.012	0.4	442	0.012	0.5	516	0.012	0.5
	1.8	349	0.012	0.7	446	0.012	0.8	546	0.013	0.9	675	0.016	1.2
	2.4	401	0.012	1.0	505	0.012	1.0	652	0.016	1.6	801	0.019	2.3
	3.0	447	0.012	1.3	581	0.014	1.6	747	0.018	2.5	915	0.022	3.6
	3.6	-	-	-	-	-	-	-	-	-	-	-	-
20	1.2	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	456	0.012	0.8	608	0.015	1.0	797	0.019	1.7	986	0.024	2.4
	2.4	528	0.013	1.1	746	0.018	2.0	966	0.023	3.2	1187	0.028	4.5
	3.0	613	0.015	1.8	856	0.020	3.2	1100	0.026	5.0	1343	0.032	7.1
	3.6	684	0.016	2.6	949	0.023	4.6	1214	0.029	7.1	1477	0.035	10.1
30	1.2	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	-	-	-	-	-	-	-	-	-	-	-	-
	2.4	646	0.015	1.6	912	0.022	2.9	1178	0.028	4.5	1438	0.034	6.3
	3.0	766	0.018	2.6	1070	0.026	4.7	1369	0.033	7.3	1663	0.040	10.3
	3.6	862	0.021	3.9	1194	0.029	6.9	1521	0.036	10.6	1843	0.044	14.8
40	1.2	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	-	-	-	-	-	-	-	-	-	-	-	
	2.4	-	-	-	-	-	-	-	-	-	-	-	-
	3.0	871	0.021	3.3	1212	0.029	5.9	1544	0.037	9.0	1871	0.045	12.6
	3.6	1002	0.024	5.1	1380	0.033	8.9	1750	0.042	13.5	-	-	-

Flow-adjusted waterside heating effect table. Heating circuit Δt = 10°C (Water in-out), nozzle pressure of 40 Pa, 1 x Ø125 air connection.

For red values, the flow rate has been adjusted to the recommended minimum flow of 0.012 kg/s.

Heating at 60Pa Nozzle Pressure

Nozzle Pressure 60 Pa		Water											
Q (l/s)	Eco-H	ΔtK - 15°C			ΔtK - 20°C			ΔtK - 25°C			ΔtK - 30°C		
	L (m)	P (w)	p(kg/s)	p(kPa)	P (w)	p(kg/s)	p(kPa)	P (w)	p(kg/s)	p(kPa)	P (w)	p(kg/s)	p(kPa)
10	1.2	298	0.012	0.4	376	0.012	0.4	445	0.012	0.4	548	0.013	0.6
	1.8	362	0.012	0.7	452	0.012	0.7	580	0.014	1.0	718	0.017	1.4
	2.4	428	0.012	1.1	540	0.013	1.1	700	0.017	1.8	862	0.021	2.6
	3.0	-	-	-	-	-	-	-	-	-	-	-	-
	3.6	-	-	-	-	-	-	-	-	-	-	-	-
20	1.2	359	0.012	0.4	448	0.012	0.4	586	0.014	0.6	738	0.018	0.9
	1.8	465	0.012	0.7	649	0.016	1.2	849	0.020	1.9	1048	0.025	2.7
	2.4	561	0.013	1.2	791	0.019	2.2	1023	0.025	3.5	1253	0.030	5.0
	3.0	650	0.016	2.0	908	0.022	3.6	1165	0.028	5.5	1419	0.034	7.8
	3.6	729	0.017	2.9	1011	0.024	5.2	1290	0.031	7.9	1565	0.037	11.1
30	1.2	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	525	0.013	0.8	756	0.018	1.5	990	0.024	2.4	1221	0.029	3.5
	2.4	692	0.017	1.8	975	0.023	3.2	1255	0.030	5.0	1531	0.037	7.1
	3.0	814	0.019	2.9	1133	0.027	5.2	1446	0.035	8.0	1755	0.042	11.3
	3.6	913	0.022	4.3	1261	0.030	7.6	1602	0.038	11.6	1938	0.046	16.2
40	1.2	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	-	-	-	-	-	-	-	-	-	-	-	-
	2.4	765	0.018	2.1	1079	0.026	3.8	1387	0.033	5.9	1688	0.040	8.4
	3.0	934	0.022	3.7	1296	0.031	6.6	1649	0.040	10.1	1999	0.048	14.2
	3.6	1064	0.025	5.7	1462	0.035	9.9	1852	0.044	14.9	-	-	-

Flow-adjusted waterside heating effect table. Heating circuit Δt = 10°C (Water in-out), nozzle pressure of 60 Pa, 1 x Ø125 air connection.

For red values, the flow rate has been adjusted to the recommended minimum flow of 0.012 kg/s.

Heating at 80Pa Nozzle Pressure

Nozzle Pressure 80 Pa		Water											
Q (l/s)	Eco-H	ΔtK - 15°C			ΔtK - 20°C			ΔtK - 25°C			ΔtK - 30°C		
	L (m)	P (w)	p(kg/s)	p(kPa)	P (w)	p(kg/s)	p(kPa)	P (w)	p(kg/s)	p(kPa)	P (w)	p(kg/s)	p(kPa)
10	1.2	316	0.012	0.5	393	0.012	0.5	463	0.012	0.4	580	0.014	0.6
	1.8	379	0.012	0.7	470	0.012	0.7	615	0.015	1.1	763	0.018	1.5
	2.4	-	-	-	-	-	-	-	-	-	-	-	-
	3.0	-	-	-	-	-	-	-	-	-	-	-	-
	3.6	-	-	-	-	-	-	-	-	-	-	-	-
20	1.2	385	0.012	0.4	480	0.012	0.4	642	0.015	0.7	807	0.019	1.1
	1.8	484	0.012	0.7	690	0.017	1.3	901	0.022	2.1	1111	0.027	3.0
	2.4	593	0.014	1.3	836	0.020	2.5	1079	0.026	3.8	1319	0.032	5.4
	3.0	688	0.016	2.2	960	0.023	3.9	1229	0.029	6.1	1493	0.036	8.5
	3.6	774	0.019	3.2	1072	0.026	5.7	1365	0.033	8.8	1651	0.040	12.2
30	1.2	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	573	0.014	0.9	825	0.020	1.8	1079	0.026	2.8	1330	0.032	4.1
	2.4	738	0.018	2.0	1037	0.025	3.6	1334	0.032	5.5	1625	0.039	7.8
	3.0	861	0.021	3.2	1195	0.029	5.8	1523	0.036	8.8	1847	0.044	12.3
	3.6	965	0.023	4.8	1327	0.032	8.3	1682	0.040	12.6	2034	0.049	17.6
40	1.2	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	-	-	-	-	-	-	-	-	-	-	-	-
	2.4	833	0.020	2.4	1174	0.028	4.4	1507	0.036	6.9	1833	0.044	9.7
	3.0	998	0.024	4.2	1381	0.033	7.4	1756	0.042	11.3	-	-	-
	3.6	1126	0.027	6.3	1544	0.037	10.9	1957	0.047	16.5	-	-	

Flow-adjusted waterside heating effect table. Heating circuit Δt = 10°C (Water in-out), nozzle pressure of 80 Pa, 1 x Ø125 air connection.
For red values, the flow rate has been adjusted to the recommended minimum flow of 0.012 kg/s.

Heating at 100Pa Nozzle Pressure

Nozzle Pressure 100 Pa		Water											
Q (l/s)	Eco-H	ΔtK - 15°C			ΔtK - 20°C			ΔtK - 25°C			ΔtK - 30°C		
	L (m)	P (w)	p(kg/s)	p(kPa)	P (w)	p(kg/s)	p(kPa)	P (w)	p(kg/s)	p(kPa)	P (w)	p(kg/s)	p(kPa)
10	1.2	322	0.012	0.5	399	0.012	0.5	473	0.012	0.4	591	0.014	0.6
	1.8	386	0.012	0.7	480	0.012	0.7	629	0.015	1.1	781	0.019	1.6
	2.4	-	-	-	-	-	-	-	-	-	-	-	-
	3.0	-	-	-	-	-	-	-	-	-	-	-	-
	3.6	-	-	-	-	-	-	-	-	-	-	-	-
20	1.2	400	0.012	0.5	507	0.012	0.5	673	0.016	0.8	842	0.020	1.2
	1.8	496	0.012	0.7	705	0.017	1.3	918	0.022	2.1	1130	0.027	3.1
	2.4	605	0.014	1.4	852	0.020	2.5	1099	0.026	4.0	1343	0.032	5.6
	3.0	702	0.017	2.3	981	0.023	4.1	1257	0.030	6.3	1528	0.037	8.9
	3.6	793	0.019	3.4	1101	0.026	6.0	1403	0.034	9.2	1700	0.041	12.9
30	1.2	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	602	0.014	1.0	859	0.021	1.9	1117	0.027	3.0	1371	0.033	4.3
	2.4	756	0.018	2.1	1059	0.025	3.7	1357	0.033	5.7	1651	0.040	8.1
	3.0	877	0.021	3.3	1215	0.029	5.9	1547	0.037	9.1	1875	0.045	12.7
	3.6	982	0.024	4.9	1351	0.032	8.6	1713	0.041	13.0	-	-	-
40	1.2	-	-	-	-	-	-	-	-	-	-	-	-
	1.8	652	0.016	1.2	941	0.023	2.2	1228	0.029	3.6	1509	0.036	5.1
	2.4	866	0.021	2.6	1212	0.029	4.7	1550	0.037	7.2	1881	0.045	10.1
	3.0	1020	0.024	4.4	1406	0.034	7.7	1785	0.043	11.6	-	-	-
	3.6	1146	0.027	6.4	1567	0.038	11.2	1983	0.048	16.8	-	-	-

Flow-adjusted waterside heating effect table. Heating circuit Δt = 10°C (Water in-out), nozzle pressure of 100 Pa, 1 x Ø125 air connection.
For red values, the flow rate has been adjusted to the recommended minimum flow of 0.012 kg/s.

Cooling effect supplied in the ventilation air [W]

1. Start by calculating the required cooling effect that has to be supplied to the room in order to provide a certain temperature.
2. Calculate any cooling effect that is provided by the ventilation.
3. The remaining cooling effect has to be supplied by the beam.

Formula for air cooling effect: $P = m \bullet Cp \bullet \Delta t$

Where:

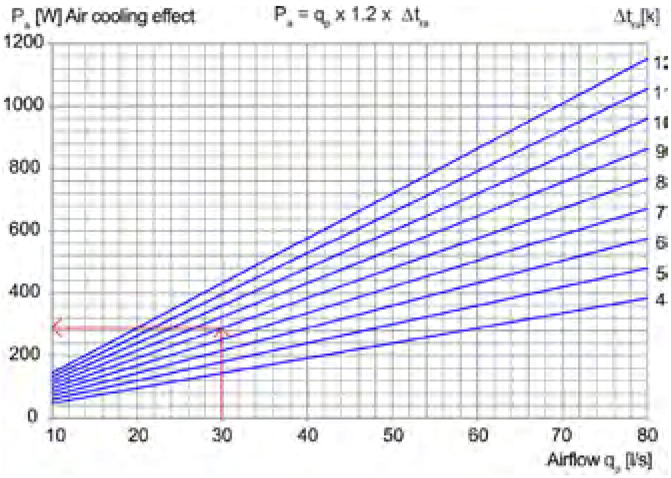
m = mass

Cp = specific heat capacity [J/(kg-K]

qp = air flow [l/s]

Δt = the difference between the temperature of the room and the temperature of the supply air [K].

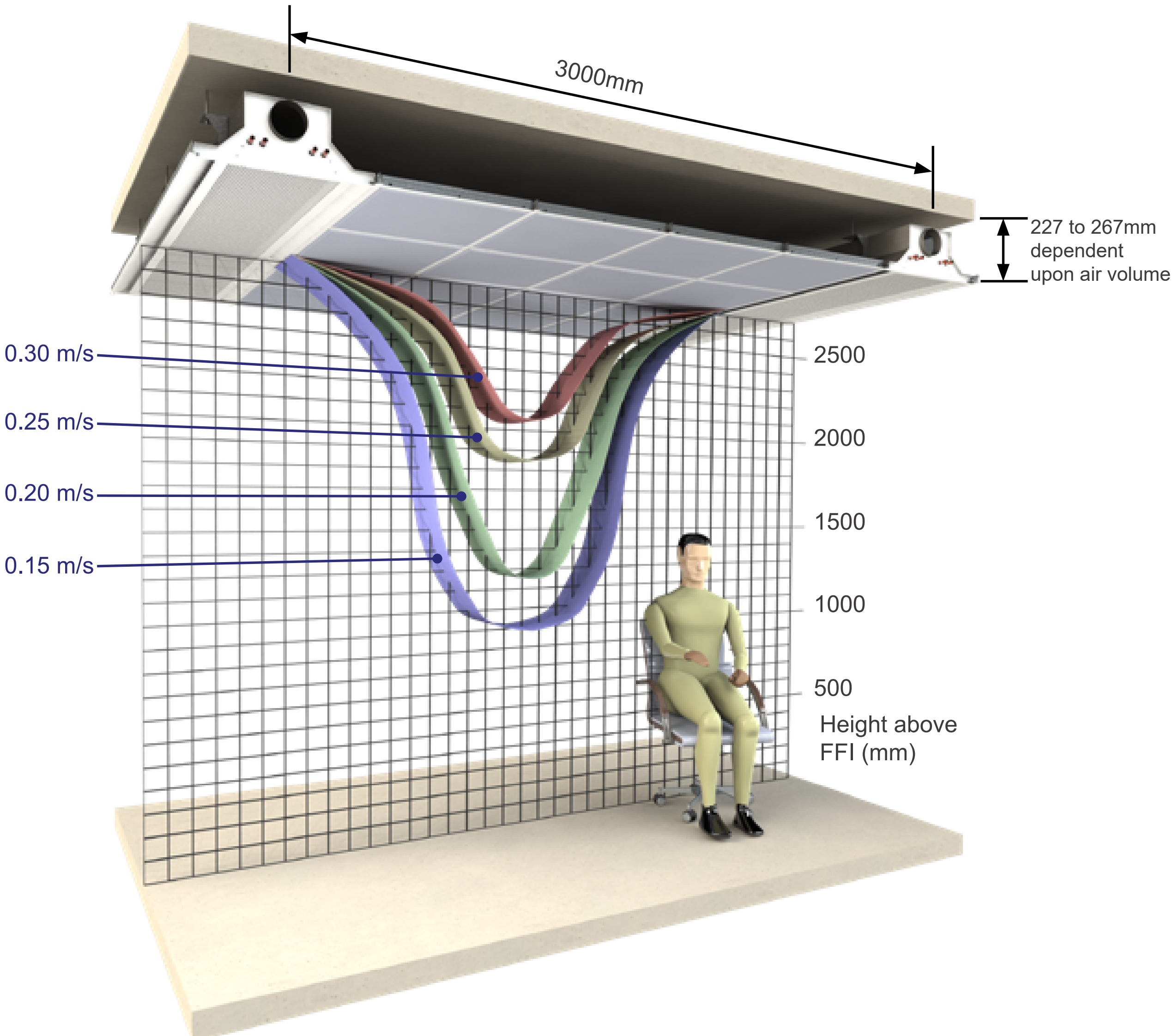
It is usually $m \bullet Cp \approx qp \bullet 1.2$



Air cooling effect as a function of airflow. For example, if the air flow is 30 l/s and the under-temperature of the supply air is Δt_{ra} = 8K, the cooling effect from the graph is 290W.

Scatter Diagram

Fresh Air Volume 22 l / s / Active m @ 80 Pa



Project Specific Testing Facility

The 3 number state-of-the-art Climatic Testing Laboratories at Frenger's technical facility in Derby (UK) have internal dimensions of 6.3m (L) x 5.7m (W) x 3.3m (H) high and includes a thermal wall so that both internal and perimeter zones can be simulated. Project specific testing validates product / solution performance (outputs) and resultant Room Comfort Conditions for compliance category grading in accordance with BS EN ISO 7730. All of Frenger's chilled beams have also been independently tested and certified by Eurovent in terms of product performance (output), as Eurovent can not test for thermal comfort; hence the need for Frenger's own laboratories.

Project Specific Testing

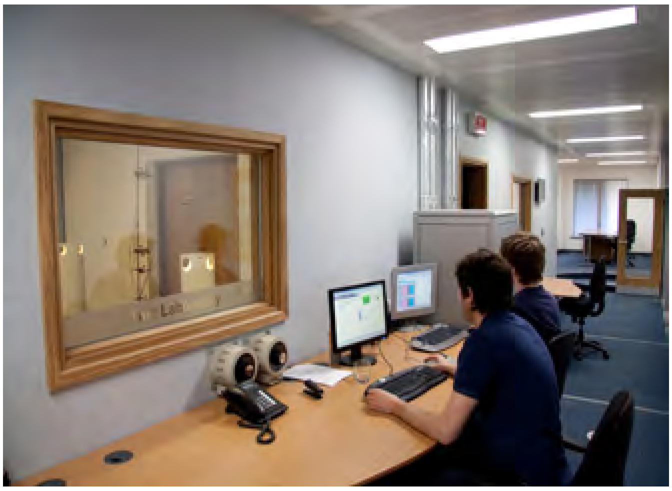
Project specific mock-up testing is a valuable tool which allows the Client to fully assess the proposed system and determine the resulting room occupancy Thermal Comfort conditions. The physical modelling is achieved by installing a full scale representation of a building zone complete with internal & external heat gains (Lighting, Small Power, Occupancy & Solar Gains).

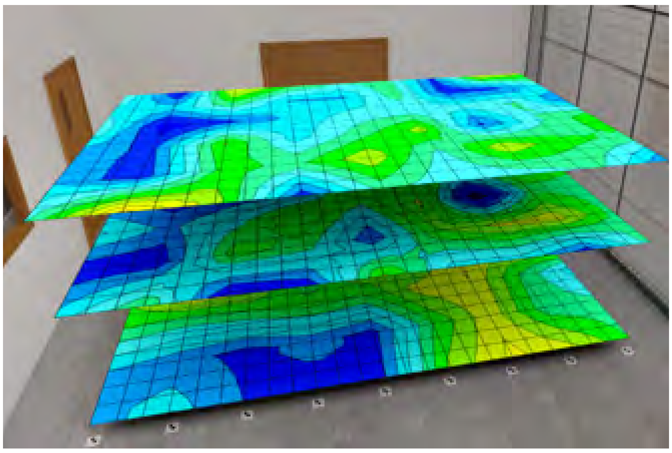
The installed mock-up enables the client to verify the following:

- Product performance under project specific conditions.
- Spatial air temperature distribution.
- Spatial air velocities.
- Experience thermal comfort.
- Project specific aesthetics.
- Experience lighting levels (where relevant).
- Investigate the specific design and allow the system to be optimised.

The project-specific installation and test is normally conducted to verify:

- Product capacity under design conditions.
- Comfort levels - air temperature distribution.
  - thermal stratification.
  - draft risk.
  - radiant temperature analysis.
- Smoke test video illustrating air movement.
- Live Thermal Imaging





Photometric Testing Facility

The in-house Photometric test laboratories at Frenger are used to evaluate the performance of luminaires. To measure the performance, it is necessary to obtain values of light intensity distribution from the luminaire. These light intensity distributions are used to mathematically model the lighting distribution envelope of a particular luminaire. This distribution along with the luminaires efficacy allows for the generation of a digital distribution that is the basis of the usual industry standard electronic file format. In order to assess the efficacy of the luminaire it is a requirement to compare the performance of the luminaire against either a calibrated light source for absolute output or against the “bare” light source for a relative performance ratio.

The industry uses both methods. Generally absolute lumen outputs are used for solid state lighting sources and relative lighting output ratios (LOR) are used for the more traditional sources. Where the LOR method is chosen then published Lamp manufacturer’s data is used to calculate actual lighting levels in a scheme and for LED light source the integration chamber is used to measure LED luminance efficacy.

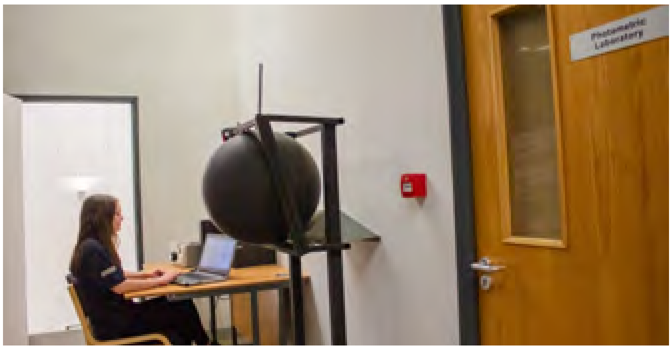
The intensity distribution is obtained by the use of a Goniophotometer to measure the intensity of light emitted from the surface of the fitting at pre-determined angles. The light intensity is measured using either a photometer with a corrective spectral response filter to match the CIE standard observer curves or our spectrometer for LED sources.

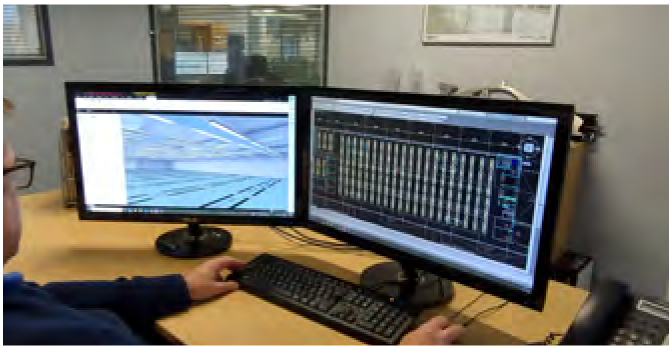
Luminaire outputs are measured using our integrating sphere for smaller luminaires or our large integrator room for large fittings and Multi Service Chilled Beams. For both methods we can use traceable calibrated radiant flux standards for absolute comparisons.

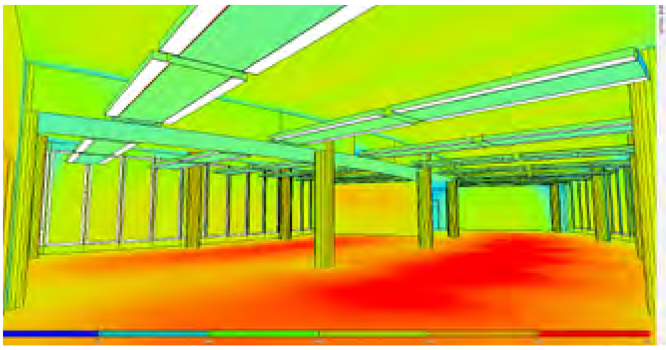
All tests use appropriate equipment to measure and control the characteristics of the luminaire and include air temperature measurements, luminaire supply voltage, luminaire current and power. Thermal characteristics of luminaire components can be recorded during the testing process as required.

A full test report is compiled and supplied in “locked” PDF format. Data is collected and correlated using applicable software and is presented electronically to suit, usually in Eulumdat, CIBSE TM14 or IESN standard file format.

Frenger conduct photometric tests in accordance with CIE 127:2007 and BS EN 13032-1 and sound engineering practice as applicable. During the course of these tests suitable temperature measurements of parts of LED’s can be recorded. These recorded and plotted temperature distributions can be used to provide feedback and help optimise the light output of solid state light source based luminaires which are often found to be sensitive to junction temperatures.







Acoustic Testing Facility

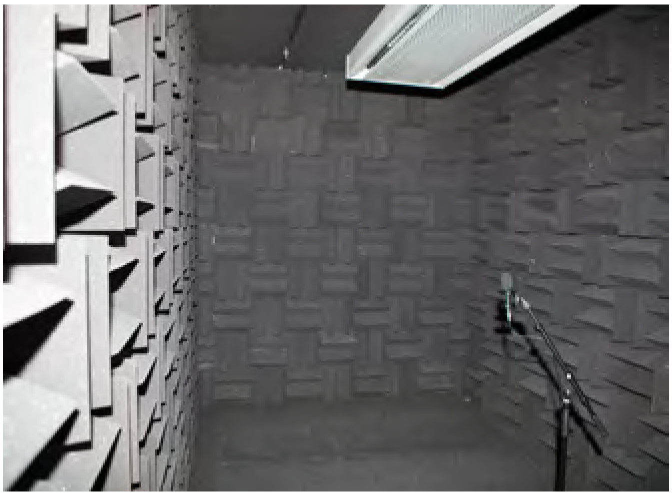
The Acoustic Test Room at Frenger is a hemi-anechoic chamber which utilises sound absorbing acoustic foam material in the shape of wedges to provide an echo free zone for acoustic measurements; the height of the acoustic foam wedge has a direct relationship with the maximum absorption frequency, hence Frenger had the acoustic wedges specifically designed to optimise the sound absorption at the peak frequency normally found with our active chilled beam products.

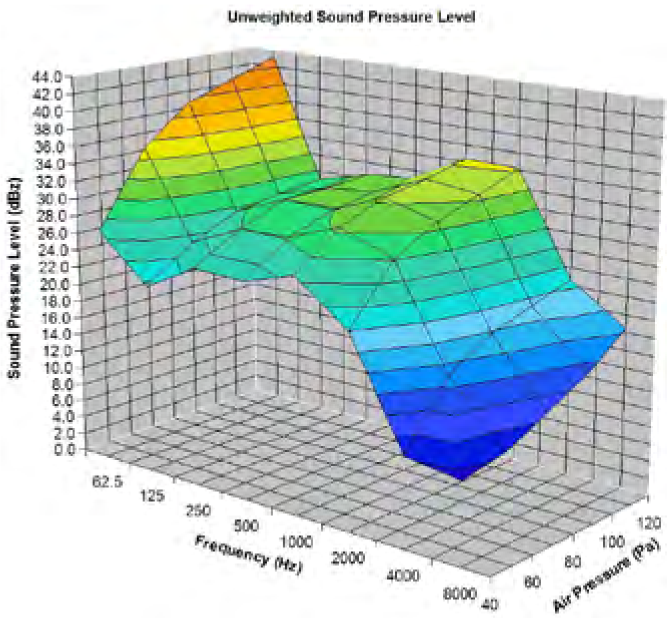
The use of acoustic absorbing material within the test room provides the simulation of a quiet open space without "reflections" which helps to ensure sound measurements from the sound source are accurate, in addition the acoustic material also helps reduce external noise entering the test room meaning that relatively low levels of sound can be accurately measured.

The acoustic facilities allow Frenger to provide express in-house sound evaluation so that all products, even project specific designs can be quickly and easily assessed and optimised.

To ensure accuracy, Frenger only use Class 1 measurement equipment which allows sound level measurements to be taken at 11 different ⅓ octave bands between 16 Hz to 16 kHz, with A, C and Z (un-weighted) simultaneous weightings.

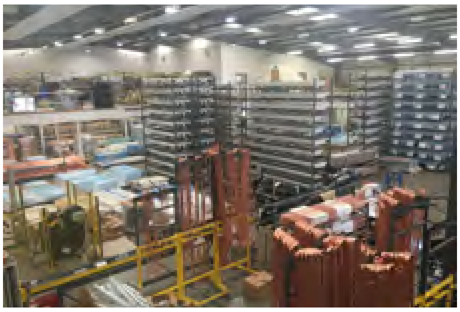
In addition to the above, Frenger also send their new products to specialist third party Acoustic Testing. The results of which are very close and within measurement tolerances to that of Frenger's in-house measurement of sound.





Bespoke Manufacturing

Frenger has the manufacturing capability required to deliver the most complex of bespoke solutions. Facilities include the latest full CNC machine centers, together with a dedicated powder-coat paint plant to paint all of the components of the products and project specific in-house testing laboratories.















Industry Associations

Always mindful of its place within the HEVAC industry, Frenger Systems pride themselves on broad range of trade associations and accreditations. With a clear service, product and environmental ethos across everything they do, Frenger is focused on meeting and consistently surpassing the expectations of its customers. Frenger invest heavily in achieving industry recognised accreditations and as part of ongoing commitment to their customers and continually assess the level of services they provide. Opening up their company to these independent organisations allows Frenger to continually improve their customer service and satisfaction.

As an engaged member of the HEVAC industry, Frenger are actively asked to participate in industry specific discussions and studies. With this in mind Frenger are proud to have achieved and be linked with the following associations:

BSI EN ISO 9001:2015

Frenger Systems are registered by BSI for operating a Quality Management System which complies with the requirements of BS EN 9001:2015.

Eurovent

Frenger Systems participate in the EC programme for Chilled Beams. Check ongoing validity of certificate: www.eurovent-certification.com or www.certiflash.com. The heat exchanger for the Recepto HRU is a Klingenburg Eurovent Certified aluminium static heat exchanger.

Chilled Beam and Ceiling Association

The Chilled Beam and Ceiling Association has been formed by leading companies within the construction industry. The objective of the Association is to promote the use of Chilled Beams and Chilled Ceilings, and encourage best practice in their development and application.

HEVAC Member

HEVAC is the heating and ventilating contractors association. As a HEVAC member Frenger Systems are subject to regular, third party inspection and assessment to ensure their technical and commercial competence.

Federation of Environment Trade Association

The Federation of Environment Trade Association (FETA), of which Frenger Systems is a member of, is the recognised UK body which represents the interests of manufacturers, suppliers, installers and contractors within the heat pump, controls, ventilating, refrigeration & air conditioning industry.

UK Trade & Investment

Frenger Systems are members of both the UK TI (the former Department of Trade and Industry) as well as the Chamber of Commerce for Export Documentation.

Certified CIBSE CPD

Frenger Systems is a CIBSE approved "Continued Professional Development" (CPD) provider. Frenger offers 1 hour lunch time CPD presentations regarding "Chilled Beam Technology", CPD presentations are usually held at Consulting Engineers local practices with lunch provided courtesy of Frenger. Alternatively half or full day Chilled Beam Technology training is available at Frenger's UK Technical Academy in a dedicated training theatre with fully operational BMS system with various different Chilled Beam and Ceiling solutions integrated.

Booking of a CPD Presentation can be requested on Frenger's home page, under the drop down menu headed "Company", then "CPD Booking". Alternatively email sales@frenger.co.uk.

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