CIBSE JOURNAL
CPD SPECIAL

FORWARD THINKING

The 2018 directory of organisations offering CIBSE-approved CPDs

COMPUTATIONAL FLUID DYNAMICS

DIRECT EVAPORATIVE COOLING FOR COMFORT APPLICATIONS

TWO-STAGE HEAT EXCHANGERS IN HEAT NETWORKS

Modular
Gas Detection.

EDUCATION

GAS DETECTION

COMMERCIAL KITCHENS

- Event logging
- Peak and time waited monitoring
- Service plans available including detector exchange
- Multiple relay options for BMS or alarm signalling
- Status and alarm logging
- Highly adaptable
- 10 Year panel warranty

AGDSelite features

AGDSelite has been designed to be a modular gas detection system and can accept multiple gas detectors. With the addition of extender panels to the system, this can achieve the monitoring of up to 32 detectors of different gas types.

For more information on this product and many more, visit: **medem.co.uk/products**

We have gas detection solutions for, but not limited too:

Battery Stores/Charging Rooms, Car Parks and Breweries with the capability of Hydrogen, CO, CO_2 and Oxygen detection.

Visit the website to view the full range of available gas detectors or just give us a call to discuss your requirements.

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build it,
back it up.

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Editorial
Editor: Alex Smith
Tel: 01223 378034
Email: asmith@cibsejournal.com
Deputy editor: Liza Young
Tel: 01223 378048
Email: lyoung@cibsejournal.com
Technical editor: Tim Dwyer
Designer: James Baldwin

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1 Cambridge Technopark, Newmarket Road, Cambridge CB5 8PE.

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Advertisement sales
Display and sponsorship
Jim Folley
jim.folley@redactive.co.uk
Tel: +44 (0) 20 7324 2786
Products & services
Callum Nagle
callum.nagle@redactive.co.uk
Tel: +44 (0) 20 7880 6217
Recruitment advertising
Chloe Lawrence
chloe.lawrence@redactive.co.uk
Tel: +44 (0) 20 7324 2777
Advertising production
Jane Easterman
jane.easterman@redactive.co.uk
Tel: +44 (0) 20 7880 6248

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Giving you the edge

Welcome to our CPD Directory supplement, featuring the full list of the 218 companies in the CIBSE CPD Directory, plus three additional CPD modules.

The companies listed in the directory all offer courses that have been reviewed and assessed by CIBSE to ensure the technical content they provide is of a high standard. They span the full range of specialisms encompassed within the building services sphere, and offer members a valuable resource with which to maintain their continuing professional development (CPD).

Undertaking CPD is a fundamental part of being a professional engineer. Chartered engineers make a commitment to maintain their competence through CPD, and to record that development. The professional engineering institutions – CIBSE among them – undertake annual random samples of registrants' CPD records and give appropriate feedback.

New guidance from the Engineering Council means the recording of CPD will be mandatory for registered engineers and technicians from January 2019. Professionally active registrants who persistently do not respond to, or engage with, requests for CPD records from a licensed member risk removal from the Engineering Council register.

CPD shouldn't be a chore. This is a valuable part of professional development and ensures your knowledge and skills are kept up to date as you progress through your career. In today's uncertain economic climate, it can also put you ahead of the competition when seeking contracts or new employment, by helping you to prove your credentials.

CIBSE, as a professional engineering body that exists to give members and the public first-class knowledge and information, offers a diverse range of opportunities to maintain CPD.

Training events cover areas such as electrical services, facilities management, fire safety, lighting and project management, and digital engineering, to name but a few, many of which are also available as in-house courses.

CIBSE has seen uptake of its online learning courses increase over the past year. This distance learning reduces the number of hours that engineers are required to spend out of the office or off site. We also offer webinars to complement technical publications, giving engineers content through a host of channels. To view the full list of courses go to **www.cibse.org/training**

CIBSE Journal can also support you with your CPD, with the regular monthly modules – three of which you'll find within this supplement – as well as sponsored webinars, which are available on demand at **www.cibsejournal.com**

For more information about CIBSE, please visit **www.cibse.org**

CARILYN BURMAN director of membership

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CIBSE's complete CPD course directory

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Application of simple evaporative cooling as a means of reducing dry-bulb temperature

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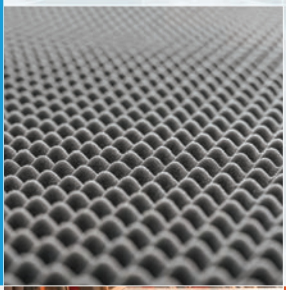
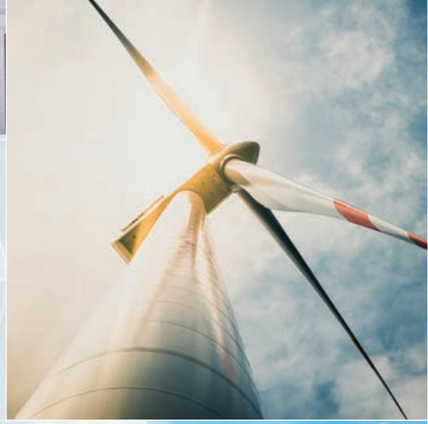
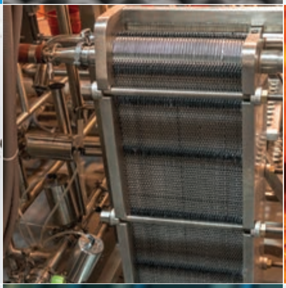
Drivers and methods to enable wide temperature differentials in heat networks

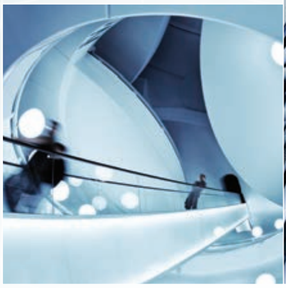
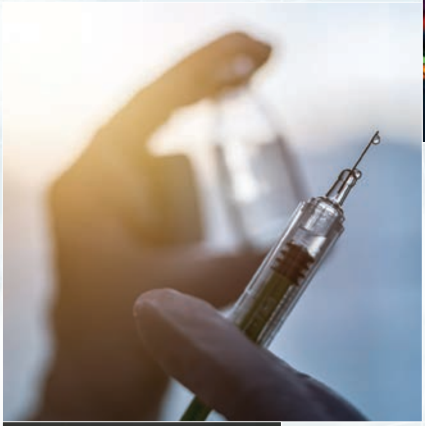
CPD

CIBSE Journal has more than 100 CPD modules available to complete at **www.cibsejournal.com** Our website makes it easier than ever to continue your professional learning online.






CIBSE CPD DIRECTORY

This directory lists all the accredited organisations offering modules on a range of areas, including electrical, fire, lighting and sustainability

All the CPD courses in this directory have been approved by CIBSE. They are reviewed and assessed to ensure that the technical content is of a high standard and offers valuable CPD to delegates.

The directory of CPD course providers has been compiled to assist members of the Institution in identifying courses suitable for their CPD needs. It embraces many different areas suitable for CPD, and is updated continually to incorporate new entries and revisions.

Members of CIBSE are required by the Code of Professional Conduct to maintain their professional competence, but this should also apply to any professional working in the industry.

The directory will help you find suitable CPDs to assist with your ongoing career development.

For guidance on what constitutes different CPD activities, and how to go about recording your continuing professional development, visit **www.cibse.org/cpd**


A-B DIRECTORY

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
A1 Flue Systems www.a1flues.co.uk			■										■				
Access Control Technology (ACT) www.act.eu					■												
ACV UK www.acv-uk.com													■				
ADEY Professional Heating Solutions www.adey.com									■				■				
Aermec UK www.aermec.co.uk		■							■				■				
Airflow Developments			■	■							■		■		■		■

AIRFLOW

Phone: 01494 525252
Web: www.airflow.com
Email: info@airflow.com

Ventilation pioneer Airflow Developments offers an on-demand, CIBSE-approved CPD seminar titled Understanding Mechanical Ventilation with Heat Recovery (MVHR) for Commercial Applications. It explains the key aspects to consider when designing any commercial building.

By the end of the CPD seminar, you will understand:
- The importance of ventilation in improving indoor air quality
- How MVHR works and its applications
- The reasons for choosing MVHR as your ventilation system
- Current Building Regulations and legislation concerning ventilation, MVHR and new-build commercial premises
- The different types of heat exchangers available within commercial MVHR systems
- How MVHR can reduce the energy bills of a building

Its CIBSE-approved CPD seminars are popular, and slots fill up fast. So contact Airflow today to arrange a free seminar, at a location and a time that is convenient for you.

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Altecnic www.altecnic.co.uk			■	■									■				
Aluline Group www.alulinegms.com													■		■		■
AMG Systems www.amgsystems.com			■														
Andrews Water Heaters www.andrewswaterheaters.co.uk													■				
Anolis Lighting www.anolislighting.com											■						
Armacell UK www.armacell.com		■	■	■									■		■		■
Atex www.atex.ie											■						
BACnet Interest Group Europe www.big-eu.org																	■

B-C DIRECTORY

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
BBC Fire Protection www.bbcfire.co.uk								■									
Beckhoff Automation beckhoff.co.uk/building			■								■						
BEG (UK) www.beg-luxomat.com											■						
Belimo Automation UK www.belimo.co.uk								■					■				■
Biddle Air Systems www.biddle-air.co.uk		■	■										■				
Blue Diamond Pumps bluediamondpumps.com		■															
Bold Communications www.boldcommunications.co.uk																■	
BPC Energy www.bpc-ups.com											■						
Brightwater Environmental www.bwater.eu															■		
Bronz-Glow UK www.bronz-glow.co.uk		■											■				■
Brugg Pipesystems www.bruggpipesystems.co.uk															■		
BT Cables British Cables Company www.btcables.com			■														
Building Controls Industry Association www.bcia.co.uk		■								■			■				
Caice Acoustic Air Movement www.caice.co.uk		■	■										■				■
Calor Gas www.calor.co.uk													■				■
Calor Gas Northern Ireland www.calorgas.ie													■				■
Capitoline www.capitoline.org			■										■				■
Carel UK www.careluk.com													■				
Carlo Gavazzi UK www.carlogavazzi.co.uk			■	■	■	■											
Cassian Compliance www.cassiancompliance.co.uk															■		
Chargemaster chargemasterplc.com			■										■				
Colt International www.coltinfo.co.uk								■					■				

C-E DIRECTORY

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Complete Ventilation Solutions www.completeventsolutions.co.uk				■									■				
Condair (JS Humidifiers) www.condair.co.uk													■				
Continu www.continu-ups.com			■														
Cool Designs www.cdlweb.info		■	■										■				
Coolair www.mix-ind.com													■				
Crane www.cranebsu.com													■				
DC Professional Development www.dc-professional.com		■	■			■		■			■		■		■		■
DAB Pumps uk.dabpumps.com													■				
Daikin UK www.daikin.co.uk/cpd		■											■				
Daikin Applied (UK) www.daikinapplied.uk		■							■				■				
Danfoss www.heating.danfoss.com						■											
DEIF UK www.deif.co.uk			■														
Delmatic www.delmatic.com			■								■						
DencoHappel UK www.dencohappel.com		■											■				
Designplan Lighting www.designplan.co.uk											■						
Dextra Group dextragroup.co.uk			■								■						
Dimplex www.dimplexrenewables.co.uk			■										■				■
Distech Controls www.distech-controls.com															■		
DMS Metering Solutions www.dmsltd.com						■											
Durapipe UK www.durapipe.co.uk		■	■										■				
Dutypoint www.dutypoint.com													■		■		
Eastman www.eastman.com		■											■				■

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E-G DIRECTORY

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
EBM-Papst UK www.ebmpapst.com			■	■					■				■				
Elco UK www.elco.co.uk			■										■				■
Elta Fans www.eltagroup.co.uk				■				■	■				■				
Emergi-Lite Safety Systems www.emergi-lite.co.uk			■					■			■						
Emmeti UK emmeti.co.uk														■			
Enocean Alliance www.enocean-alliance.org			■	■		■					■		■				
Envirotec www.envirotec.co.uk													■				
Euro-Diesel (UK) www.euro-diesel.com			■														
Evinox Energy www.evinoxenergy.co.uk									■				■				
Excel Networking Solutions www.excel-networking.com			■														
Ewo www.ewo.com											■						
Fire Safety Training Group www.fstg.org.uk			■								■						
Firemac www.firemac.com								■									
Firesafe Fire Rated Ductwork www.firesafeductwork.co.uk								■									
Flamco www.flamco.co.uk													■				
Fratelli Pettinaroli www.pettinaroli.com															■		
Frenger Systems www.frenger.co.uk		■									■		■				
Frese www.frese.co.uk/en-GB					■												
Fujitsu Air Conditioners www.fujitsu-general.com/uk			■														■
Furse www.furse.com											■						
General Environmental Services www.ges-water.co.uk															■		
George Fischer www.gfps.com/uk													■				

G-H DIRECTORY

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Giacomini UK uk.giacomini.com													■				
Global Water Solutions www.globalwatersolutions.com														■			
Grinstead Consulting Engineers www.grinsteadce.co.uk															■		
Gripple www.gripple.com													■				
Halton Foodservice www.halton.com/foodservice													■				
Hamworthy Heating									■				■				■

Hamworthy

■ **Tel: 01202 662500**
Email: enquiries@hamworthy-heating.com
Web: www.hamworthy-heating.com

Hamworthy Heating is a leading British commercial boiler manufacturer that supplies energy-efficient commercial heating, hot water and renewable solutions for commercial buildings of all shapes and sizes across the UK.

Since introducing the concept of modular boilers in the 1960s, we have continued to be at the forefront of the commercial heating market.

We are committed to sharing our industry knowledge and best practice with our customers. All our presenters have years of experience in the HVAC industry, with relevant professional qualifications.

We offer the following CIBSE-accredited CPD courses:
- Best practice heating and hot-water plant refurbishment
- Energy saving in commercial heating and hot water
- Domestic hot water (DHW) best practice (3 modules)
- New boilers on old systems – hydraulic separation

These courses are beneficial for anyone wishing to understand the latest industry developments and discover new ways to add value, performance and efficiency to your commercial heating and hot-water projects.

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Heatrae Sadia www.heatraesadia.com									■								
Helvar www.helvar.com											■						
Herz Valves UK www.herzvalves.com				■		■							■				
Hevasure www.hevasure.com									■								
Hitachi Air Conditioning Europe www.hitachi.com		■											■				
Hochiki Europe (UK) www.hochikieurope.com			■					■			■						
Honeywell Energy and Environmental Solutions www.honeywell.com			■								■				■		
Humidity Solutions www.humiditysolutions.co.uk													■				

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H-L DIRECTORY

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Hygromatik UK www.hygromatik.co.uk													■				
Itron Metering Solutions UK www.itron.com													■				
IV Produkt www.ivprodukt.com													■				
Jaeggi Hybrid Technology www.jaeggi-hybrid.ch		■		■									■				■
Jaga Heating Products www.jaga.co.uk													■				
Jeremias UK jeremias-fluesystems.co.uk													■		■		
Johnson Controls Building Efficiency UK www.johnsoncontrols.com/en_gb			■										■				
JS Air Curtains www.jsaircurtains.com													■				
Kelvion www.kelvion.com													■				
Kingfisher Lighting www.kingfisherlighting.com											■						
Kingspan Environmental www.kingspanenviro.com													■				■
Kingspan Industrial Insulation www.kingspaninsulation.co.uk			■	■									■				■
KNX UK www.knxuk.org											■						
KSB www.ksb.com															■		
LG Electronics, Air Conditioning and Energy Solutions partner.lge.com/uk/index.lge		■											■				
Lifescience Products www.lifescience.co.uk															■		
Lindab Comfort Division (UK) www.lindab.co.uk													■				
Lochinvar www.lochinvar.ltd.uk													■		■		■
Logstor UK www.logstor.com									■								■
Low Energy Consultancy www.lowenergyconsultancy.co.uk									■								
LPA Lighting www.lpa-lighting.com											■						
Luxonic Lighting www.luxonic.co.uk											■						

M-P DIRECTORY

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Maincor www.maincor.co.uk																	■
Mansfield Pollard & Co www.mansfieldpollard.co.uk		■	■														
Marflow Hydronics www.marflowhydronics.co.uk/events													■				
Mark Eire www.markgroup.eu			■										■				
Marley Plumbing & Drainage www.marleypd.co.uk													■				
Medem UK www.medem.co.uk													■				
Mennekes Electric www.mennekes.co.uk			■														
Mikrofill Systems www.mikrofill.com													■				
Mitsubishi Electric Hydronics & IT Cooling Systems www.climaveneta.com		■	■	■									■				■
Mobotix www.mobotix.com			■														
Monodraught www.monodraught.com											■		■				
Munters www.munters.co.uk		■											■				
Nalco www.nalco.com													■		■		
Nordeon Group www.wila.com											■						
Nortek Global HVAC (UK) www.nortekhvac.com									■								
North Building Technologies www.northbt.com					■												
Nuaire www.nuaire.co.uk													■				
Oventrop UK www.oventrop.co.uk													■		■		
Otter Vacuum Systems www.ottervacuum.co.uk													■				■
Operational Intelligence www.dc-oi.com			■	■									■				■
P4 (P4 Fastel) www.p4fastel.co.uk			■					■					■				
Panasonic UK Heating & Cooling www.aircon.panasonic.eu/GB_en													■				

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P-R DIRECTORY

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Parker Hannifin www.parkertransair.com/Transair_ecom/Accueil.do													■				
Paxton Access www.paxtonspecifier.co.uk			■										■				
Pegler Yorkshire Group www.pegleryorkshire.co.uk													■				
Pentair Thermal Management www.pentairthermal.co.uk													■				
PH Water Technologies www.phwatertechnologies.co.uk														■	■		
Plasma Clean www.plasma-clean.com									■				■				
Price TWA www.pricetwa.co.uk													■				
Prihoda UK www.prihoda.co.uk																	■
Priva UK (Building Intelligence) www.priva.co.uk					■												
Prolojik www.prolojik.com											■						
RCM Products www.rcmproducts.co.uk													■				
Reflex Winklemann www.reflex.co.uk													■				
Rehau www.rehau.com/gb-en													■				
Reliance Worldwide Corporation (UK) www.rwc.co.uk			■												■		■
Remeha Commercial www.remeha.co.uk													■				■
Rettig (UK) www.rettigicc.com									■								
Riello www.rielloburners.co.uk					■								■				■

R-S DIRECTORY

Company	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Rittal www.rittal.co.uk			■	■	■				■				■				

■ **Braithwell Way, Hellaby Industrial Estate, Hellaby Rotherham, S Yorks S66 8QY**
Web: www.rittal.co.uk
Email: information@rittal.co.uk

Rittal manufactures a range of products that form 'Rittal: the system'. This has been designed to offer clients a complete solution, including modular enclosures, power distribution and climate-control systems, which are rapidly becoming the industry's first choice for protecting critical equipment. Its vast range of high-quality, cutting-edge products can be supplied individually or as complete systems, or adapted to meet the most complex and diverse client needs in the infrastructure, manufacturing, engineering and IT sectors.

Rittal is committed to CPD and has created a series of accredited seminars to keep you up to date with the latest industry and IT infrastructure requirements.

- Building a data centre in the perfect storm
- Challenging 'The Edge' – Internet of Things
- Open Compute Project and Open19 Project
- Cloud computing and software-defined data centres
- Data centre energy efficiency
- Energy-efficient cooling
- An introduction to IEC 61439
- Enclosures – equipment protection

Rittal's technical personnel can visit your offices to give a presentation – lasting about one hour – on an agreed topic(s). Alternatively, you can come to its fully equipped demonstration centres in Rotherham and at Canary Wharf, London.

Company	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Rochester Midland Corporation www.rmcorpltd.co.uk			■										■		■		
Roth UK www.roth-uk.com									■					■			
S&S Northern www.snsnorthern.com			■										■				
Safegard Systems www.safegard.ie								■	■								
SAV Systems www.sav-systems.com									■			■					
Schako www.schako.co.uk		■															
School of Architecture, Building & Civil Engineering Loughborough University www.bispa.org													■				
Securiton www.securiton.ch/en/home.html								■									
Sentinel Performance Solutions www.sentinelprotects.com													■				

S-T DIRECTORY

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Shenton Group www.shentongroup.co.uk			■														■
Siemens Building Technologies www.siemens.co.uk/buildingtechnologies					■			■									
SIG Performance Technology www.sigpt.co.uk/fusi	■																
Smith Brothers Stores www.sbs.co.uk													■				
SMS Environmental www.sms-environmental.co.uk															■		■
Socomec www.socomec.com						■											
Socotec www.socotec.co.uk																	■
Sodeca Fans UK www.sodeca.com							■	■									
Solray www.solray.co.uk									■								
Sontay www.sontay.com			■			■							■				■
Spirax Sarco www.spiraxsarco.com						■							■				
Stelrad www.stelrad.com													■				
Stokvis Industrial Boilers International www.stokvisboilers.com													■				
Strategic Media Asia www.stmedia-asia.com		■	■										■				
Stulz UK www.stulz.co.uk					■				■								
Swegon Air Management swegonair.co.uk									■								
SWEP International www.swep.net													■				
Systemair www.systemair.co.uk													■				■
Tamlite Lighting www.tamlite.co.uk											■						
Thorlux Lighting www.thorlux.com											■						
Trane UK www.trane.com/Index.aspx													■				

T-U DIRECTORY

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Tridonic UK											■						

TRIDONIC

■ **Phone: 01256 374303**
Email: Richard.raeburn@tridonic.com
Web: www.tridonic.com

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Tridonic's CPD modules include:
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	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Tyco Building Services Products UK www.tfppemea.com/en/emea/pages/default.aspx								■									
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- Stand-alone v modular UPS
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- Producing a technical specification
- Emergency Lighting
- Battery systems – sizing/containment/isolation
- UPS systems topology/architecture
- Fault clearance, neutral earth referencing, sizing a UPS

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Unitrunk (UK) www.unitrunk.co.uk			■														
Uponor UK www.uponor.co.uk													■		■		

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U-X DIRECTORY

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
UTC Fire & Security www.utcfssecurityproducts.co.uk			■														
Valves Instruments Plus www.vip-ltd.co.uk													■				
Vectaire www.vectaire.co.uk		■							■								
Vector Air & Water www.vector-airandwater.co.uk															■		
Vertiv www.vertivco.com/en-emea			■								■						
Vexo International (UK) www.vexoint.com															■		
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Viking www.viking-emea.com								■									
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Vipond Fire Protection www.vipondfire.co.uk								■									
Wagner UK www.wagner-uk.com								■									
Warmup www.warmup.co.uk			■										■				
Waterloo Air Products www.waterloo.co.uk		■							■				■				
Wavin www.wavin.co.uk				■											■		
Weidmuller www.weidmuller.co.uk			■	■		■					■		■				■
Wieland Electric www.wielandmetalynx.co.uk			■										■				
Wilo UK www.wilo.co.uk			■										■				
Wolf en.wolf-heiztechnik.de				■					■				■				
Wolter Asia www.wolter.com.hk/HongKong/en/index.asp		■							■				■				■
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Xtralis (UK) www.xtralis.com			■					■									

X-Z DIRECTORY

	Acoustic flooring	Air conditioning	Electrical	Energy efficiency	Energy management & controls	Energy metering	Fans	Fire	HVAC solutions	Lifts & transportation	Lighting	Low carbon solutions	Mechanical	Pipework	Public health	Security	Sustainability
Xylem Water Solutions UK www.lowara.co.uk				■					■								
Yanmar Europe www.yanmarenergysystems.eu		■															
Zehnder www.zehnder.co.uk				■									■				
Ziehl-Abegg UK www.ziehl-abegg.com/en		■	■		■								■				■
Zumtobel Group www.zumtobel.com/gb-en/index.html											■						

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Evaporative cooling that does exactly what it says on the aluminium.


The modular design of Colt's CoolStream STAR range means we can customise a system to meet your needs now – and in the future.


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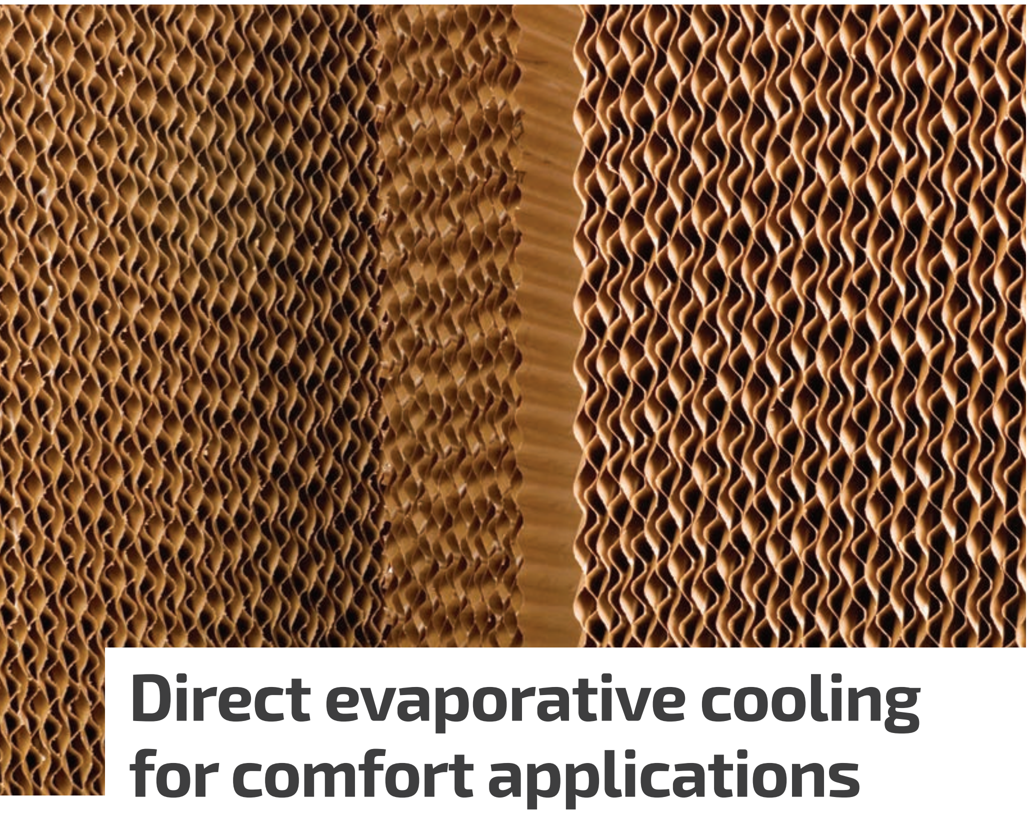

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Direct evaporative cooling for comfort applications

This module explores the application of simple evaporative cooling as a means of reducing dry-bulb temperature

Overheating in buildings can not only cause discomfort and potential health problems, but also adversely affect productivity. There are many applications where the key requirement in the occupied space is to maintain an acceptable dry-bulb temperature, but where a complete air conditioning system employing active refrigeration systems may not be the most appropriate solution. This article will consider the application of simple evaporative cooling (otherwise known as 'adiabatic' cooling) as a means of reducing the dry-bulb temperature.

In buildings, this reduction can be effected through the evaporation of water, in a similar way as the human body evaporates sweat to maintain body temperature[1] as part of the thermoregulatory system. The application of evaporative cooling has been used in and around buildings for millennia – for example, in Iranian (Persian) buildings with integrated evaporative cooling and stack ventilation systems, as shown in Figure 1.

Evaporating water can give a cooling effect equivalent to its latent heat of evaporation of approximately 2,450kJ·kg^{-1} at temperatures used in building environmental applications. The heat to evaporate the water – supplying the water with sufficient energy to break the bonds between adjacent molecules – is provided by the sensible heat in the air (that is, flowing adjacent to the wetted surface), so reducing the air dry-bulb temperature. So, for example, by evaporating 1kg of water in an hour (0.28g·s^{-1}) there is potentially a cooling effect of about 2,450kJ·h^{-1}, or approximately 0.68kW, that would be sufficient potentially to sensibly cool 0.050m^3·s^{-1} of air by more than 10K.

The driving force for evaporative cooling is the difference between the actual vapour pressure in the air and the saturated vapour pressure at the water temperature. The process includes both heat and mass transfer. The 'Lewis number' (see p20) for water vapour in air is such that, even where the flow is not turbulent, 'adiabatic' evaporation may be simply shown as a constant wet-bulb temperature process. In the adiabatic evaporation of water vapour in air,

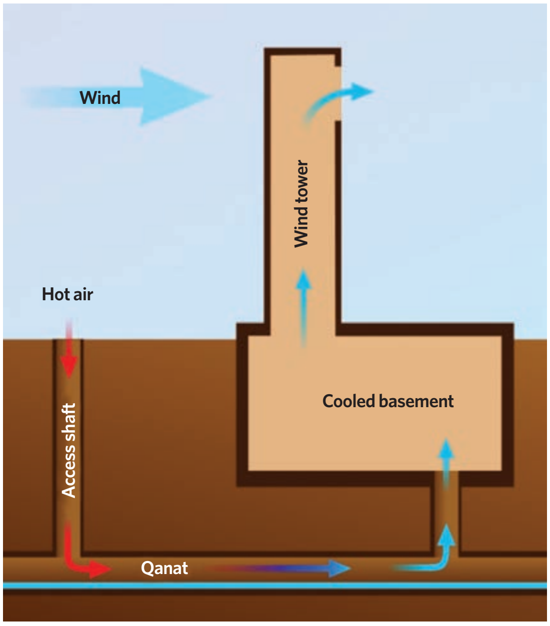

Figure 1: Example of an Iranian building cooled by a qanat and wind tower. Wind passing across the wind tower creates a negative pressure on the leeward side, so drawing air through the system. The evaporative cooling process takes place as the warm dry air passes across the water within the qanat. The cool air flows into the basement of the building, so cooling the building. (Source: Samuel Bailey – commons.wikimedia.org/wiki/File:Qanat_wind_tower.svg)

there is no overall change in energy – the process is more fully explained in ASHRAE Fundamentals[2] and by Peter Jones.[3] This is not only practically useful when describing the process, but also means that it can be readily illustrated on a psychrometric chart, as in Figure 2.

»

So, the opportunity to evaporatively cool the air can be conveniently expressed in terms of the difference between the air dry-bulb temperature and wet-bulb temperature (known as the 'wet-bulb depression'). The effectiveness of the evaporative cooler is typically expressed as

$\eta = (\theta_B - \theta_A)/(\theta_A - \theta_{wb})$ where θ_A and θ_B are the inlet and outlet air dry-bulb temperatures and θ_{wb} is the air wet-bulb temperature. Evaporative systems can be up to 98% effective,[4] although commercial evaporative coolers are more likely to be 80% to 90% effective. At the point where the wet-bulb temperature and the dry-bulb temperature are equal (at the adiabatic saturation temperature), there is no opportunity for a net movement of water molecules from a wetted surface into the air and so no further evaporative cooling is possible. This means that the greatest potential for evaporative cooling is in hot/dry climates. However, the key indicator is the difference between the dry- and wet-bulb temperatures. So, referring to the example summer design temperatures in Table 1, there is likely to be an opportunity for simple evaporative comfort cooling in all these locations (although Hong Kong will have very limited potential).

The two principal applications of evaporative cooling are direct and indirect evaporative cooling. When employing direct evaporative cooling, outdoor air is drawn through a continuously wetted element made of cellulose paper (as shown in Figure 2), plastic or metal, typically available in depths of 50mm to 150mm. The element can be mounted in a ventilator (as shown in Figure 3), with a pump that circulates water from the sump to the distribution system located at the top of the unit, where it is able to flow by gravity, wetting the element and with the excess passing back into the sump, which is automatically supplemented by wholesome water.

As the water evaporates off the medium, the flowing air cools sensibly, while the air moisture content and dewpoint temperature increase so that the air leaving the evaporative cooler will have a high relative humidity. The effectiveness will be influenced by the depth of the medium and the air velocity. The resistance of the cooling

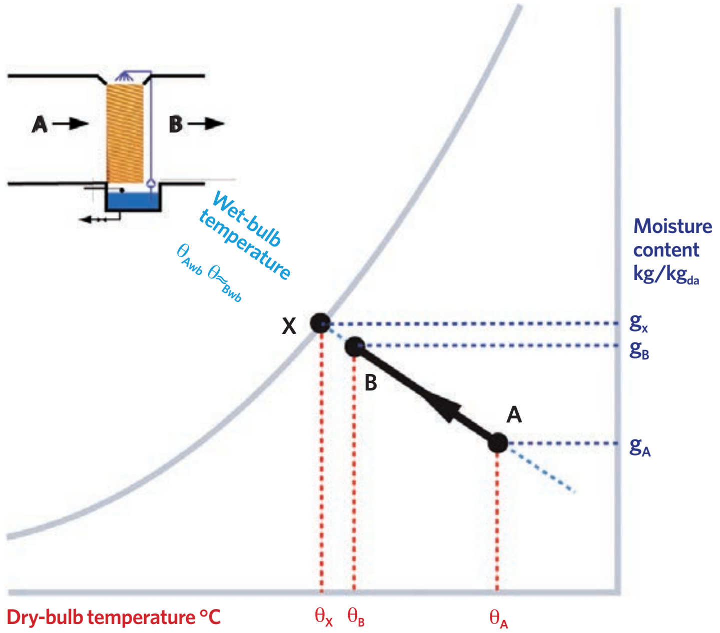

Figure 2: The psychrometric process for evaporative cooling

THE LEWIS NUMBER

Dimensionless values have been empirically established for heat and mass transfer processes.

The Schmidt number, Sc = ν/D, is used when considering diffusion of mass (in this case, water vapour) into a flowing fluid (air) and is the ratio of momentum diffusivity (also known as kinematic viscosity) and mass diffusivity (approximately 0.65 for water diffusion into air at 25°C).

The Prandtl number, Pr = ν/α, indicates how fast the thermal diffusion takes place in comparison to momentum diffusion (approximately 0.73 for air at 25°C).

The Lewis number, Le = α/D, the ratio of thermal diffusivity to mass diffusivity (that is, the rates of thermal propagation to vapour propagation), can be determined from the readily available tabulated values Sc/Pr.

ν is the kinematic viscosity ($m^2 \cdot s^{-1}$), which is also known as momentum diffusivity – that is, how well momentum transfers through a fluid (= μ/ρ)

D is the mass diffusivity, of water vapour in air ($m^2 \cdot s^{-1}$) – a measure of how quickly water molecules will diffuse into the air. For example, at 25°C this will have a value of approximately $2.4 \times 10^{-5} m^2 \cdot s^{-1}$

μ is the dynamic viscosity of the fluid (Pa·s) – a measure of the shear force required to allow adjacent molecular 'layers' to move away from each other; for air at 25°C, this equals 1.84×10^{-5} Pa·s

ρ is the density of the fluid ($kg \cdot m^{-3}$) – for air at 25°C, this equals $1.18 kg \cdot m^{-3}$

α is the thermal diffusivity, given by $\lambda/\rho C_p$ ($m^2 \cdot s^{-1}$) – provides the rate that heat will move through a material; for air at 25°C, this is $2.141 \times 10^{-5} m^2 \cdot s^{-1}$

λ is thermal conductivity ($W \cdot m^{-1} \cdot K^{-1}$) – for air at 25°C, this equals $2.55 \times 10^{-2} W \cdot m^{-1} \cdot K^{-1}$

C_p is specific heat ($J \cdot kg^{-1} \cdot K^{-1}$) – for air at 25°C, this equals $1.007 \times 10^3 J \cdot kg^{-1} \cdot K^{-1}$

So, for example, at 25°C, the Lewis number can be obtained from $\alpha/D = 2.141 \times 10^{-5}/2.4 \times 10^{-5} m^2 \cdot s^{-1} = 0.9$, or from Sc/Pr = 0.65/0.73 = 0.9

Location	0.4%		1.0%		2%	
	Dry-bulb °C	Wet-bulb °C	Dry-bulb °C	Wet-bulb °C	Dry-bulb °C	Wet-bulb °C
Dubai	42.9	23.6	41.4	24.0	40.2	24.3
Edinburgh	22.2	16.6	20.7	15.9	19.0	15.0
London	28.2	18.6	26.2	17.7	24.4	17.0
Hong Kong	33.9	26.5	33.1	26.3	32.2	26.1
Rome	31.1	22.2	30.0	22.6	29.1	22.6

Table 1: Cooling design conditions for a selection of locations (Source: CIBSE Guide A 2015, Chapter 2 appendices)

PSYCHROMETRIC CHART

For a refresher on the application of the psychrometric chart and the associated air processes, see the CPD modules 3, 7 and 9 at www.cibsejournal.com/cpd/year/2009/

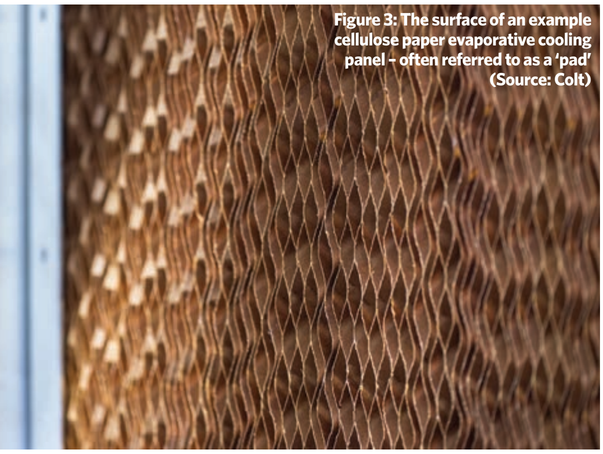

Figure 3: The surface of an example cellulose paper evaporative cooling panel – often referred to as a 'pad' (Source: Colt)

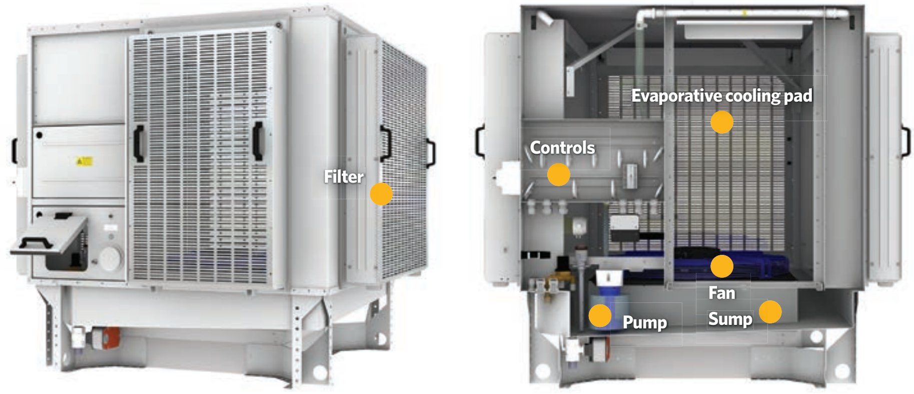

Figure 4: Section view of evaporative cooling ventilation unit (Source: Colt)

medium to airflow will also be determined by the air velocity and the thickness of the material, and can be as low as 20Pa for velocities in the order of $1.5 m \cdot s^{-1}$, so the required air power requirement is relatively low. This power (watts) can be determined from pressure drop (Pa) x airflow rate ($m^3 \cdot s^{-1}$). The other direct operational cost is the wholesome mains water that in the UK costs approximately £2 per m^3.

The cooled, high percentage saturation air can then be directly introduced into the occupied space through a ventilation unit (such as in the one in Figure 4). In this case, the supplied cooled fresh air mixes with the room air, moderating the room air dry-bulb temperature and increasing the room air moisture content.

The introduction of the high humidity air from the evaporative cooler will tend to increase the space humidity. Fortunately, in terms of human comfort, high relative humidity can still be acceptable as long as the dry-bulb temperature is within a reasonable range. CIBSE Guide A[5] indicates that 70% saturation is acceptable. When calculating the predicted mean vote (PMV) for comfort, a higher humidity has a modest effect, and BS EN ISO7730[6] suggests that a 10% increase in humidity is felt to be as warm as a 0.3K rise in the operative (comfort) temperature. (At higher temperatures and activities, the influence is greater.)

When using wet surfaces in ventilation systems, risks from mould, bacteria and – specifically – legionella are always a concern. BSRIA[7] notes that to avoid a buildup of solids in the sump, some or all of the circulating water should be periodically drawn off and replaced with fresh water. The low water temperature in the sump is unlikely to propagate bacteria; however, if they do become established, they are very unlikely to be transferred into the air stream – as long as the air velocity remains below the point at which aerosols are generated.

Where it is important that the space humidity is not increased, or possibly where less wholesome water is available to supply the evaporative cooling, an indirect evaporative cooler may be used. This type of system (as discussed in the *CIBSE Journal* CPD in March 2017) will provide drier cool air but will consume much more water, be more complex, larger and heavier, and demand more fan power. There are more complex further enhancements (such as the Maisotsenko cycle, as discussed by Hammond in the March 2018 *CIBSE Journal*) that can extend the operating range and effectiveness of evaporative cooling devices.

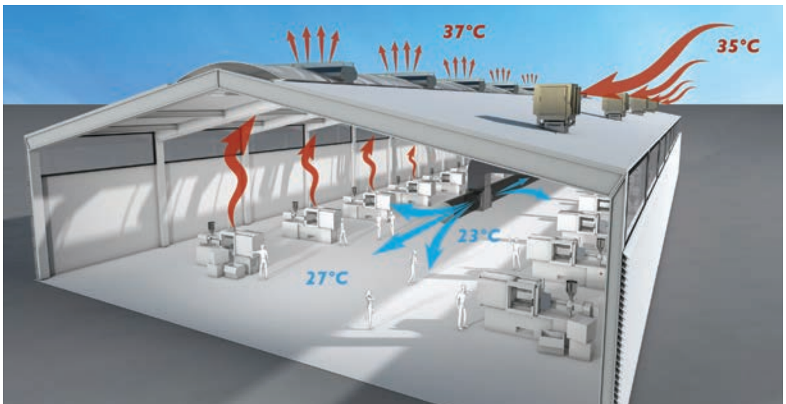

Figure 5: An example application (showing dry-bulb temperatures) of applying high-level direct evaporative ventilation units (Source: Colt)

When using simple ventilators with integrated direct – or indirect – evaporative coolers to supply the cooled outdoor air, the warmer, more humid, vitiated air needs to be removed from the space. This would typically be removed at high level by means of natural ventilators or, where this is not possible, using exhaust fans. The ventilators supply outdoor air and are typically available with heating elements for tempering the supply air temperatures when cooling is not required. During colder periods, where freezing outside conditions would be expected, the evaporative coolers would not be used, and would have been drained down and isolated as part of a winterisation process.

Where higher-humidity indoor air is unacceptable, it may be better to use an indirect method of evaporative cooling.

There will be a limit to the amount of cooling that may be supplied in simple direct or indirect evaporative systems and, of course, these systems cannot provide any dehumidification. Proper access and maintenance are important to ensure that any filtration is in good order and that the evaporative media and water distribution system are kept in a healthy state.

There are significant benefits in the simplicity of the systems, making them less costly to install and operate compared with full air conditioning, but at a more limited capability. Since the working fluid is water, it avoids the handling – and environmental concerns – of more complex chemical refrigerants. As the external temperature increases, so does the potential cooling effect, which contrasts with a traditional vapour compression refrigeration system in which the performance drops with increasing outside temperature. Practically, most European and non-tropical locations are worthy of investigation for evaporative cooling technology.

Turn to page 22 for further reading and references. »

Module 135

November 2018

1. **Approximately how much sensible cooling effect is provided by evaporating 1kg of water per hour?**

☐ A 0.050kW
☐ B 0.68kW
☐ C 1kW
☐ D 3.6kW
☐ E 2,450kW

2. **Which of the locations identified in Table 1 offers the greatest potential cooling power from evaporative cooling?**

☐ A Dubai
☐ B Edinburgh
☐ C London
☐ D Hong Kong
☐ E Rome

3. **If an evaporative pad has a pressure drop of 25Pa with an airflow rate of $0.2m^3 \cdot s^{-1}$, what basic fan power is required to move the air through?**

☐ A 0.2W
☐ B 0.25W
☐ C 2.5W
☐ D 5W
☐ E 50W

4. **If the humidity in a space was increased from 50% to 65% and the operative temperature was originally 25°C, what is the likely typical subjective temperature felt by occupants?**

☐ A Between 23°C and 24°C
☐ B Between 24°C and 25°C
☐ C No change, so 25°C
☐ D Between 25°C and 26°C
☐ E Between 26°C and 27°C

5. **In the example illustrated in Figure 5, what is the difference in the dry-bulb temperature between the inlet of the ventilation unit and the factory floor?**

☐ A 2K
☐ B 8K
☐ C 10K
☐ D 12K
☐ E 14K

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References:

1 Havenith, G et al, *Evaporative cooling: effective latent heat of evaporation in relation to evaporation distance from the skin*, J Appl Physiol 114: 778-785, 2013.
2 *ASHRAE Fundamentals 2017 Handbook*, pp 6.9-6.10, ASHRAE 2017.
3 Jones, WP, *Air Conditioning Engineering*, Section 3, Routledge, 2000.
4 *2016 ASHRAE Handbook – HVAC Systems and Equipment*, Chapter 8 Section 4.
5 CIBSE Guide A, *Environmental design*, Sect. 1.3.1.3, CIBSE 2015.
6 BS EN ISO 7730:2005 *Ergonomics of the thermal environment Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria*, BSI 2005.
7 BSRIA BG 8/2004 *Free cooling systems*, BSRIA 2004.

RINNAI CPDs

CONTINUOUS FLOW HOT WATER HEATING UNITS & SYSTEMS

AN APPRECIATION AND COMPARISON

Rinnai is a major global player in the manufacture and innovation of hot water heating units for all commercial, light industrial and larger residential sites. The company produces a range of CPDs which cover the technical aspects and details of high efficiency condensing hot water heating units which are claimed to be the most cost effective and best value products of their type and kind on the market. In the following pages we will outline what the four Rinnai CPDs can bring to your knowledge of hot water to solve the problem of providing usable, safe hot water provision to any given or specified site - they are –

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July 2014

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Focus is given to functionality, major components, systems operation, sizing of large systems and comparative studies of alternative water heating solutions.

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Continuous flow also offers greater flexibility of design of a hot water heating system – the units can be manifolded/cascaded and do not require the space or plant room installation that other types need to operate. Installation costs are much lower. This is reflected in the Whole of Life Costing of a continuous flow system. This is shown below.

Typical applications include many local authority or central government institution; sports & leisure centres; MoD sites; hotels; care homes; commercial kitchens; schools; hospitals; restaurants.

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Direct fired cylinders	heavy, difficult to handle, requires plant room
Indirect calorifiers	finite amount stored, requires large plant room
Plate Heat Exchangers	prone to blockages, requires regular maintenance needing shut down

PRICE COMPARISON TO OTHER TYPES OF HOT WATER DELIVERY

School Kitchen, Essex

2 Deep Kitchen Sinks, 2 Wash Hand Basins & Spray Wand requiring

450 Litres/hr at peak demand

	Direct Fired Option	Continuous Flow Option
List Price	£3,044	£1,621
Saving	**£1,423**	

Golf Club, Reigate, Surrey

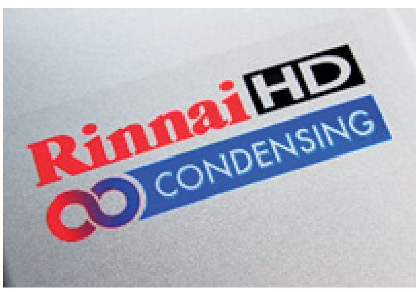
8 Showers, 12 Wash Hand Basins & Kitchen requiring 650 Litres/hr at peak demand

	Direct Fired Option	Continuous Flow Option 2 Modules
List price	£5,154	£3,242
Saving	**£1,912**	

Luxury 5 Star hotel, Central London

120 Rooms - 10,000 Litres /hr required

	Direct Fired Option 4 Modules + 1,200 l store	Continuous Flow Option 9 Modules + 1,000 l store
List Price	£43,152	£26,511
Saving	**£16,641**	



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CONTINUOUS FLOW HOT WATER UNITS AND SYSTEMS – AN APPRECIATION

This CPD is aimed at showing candidates where continuous flow is positioned in the available range of DHW systems for commercial applications. The word 'Continuous' is defined as being 'uninterrupted in time, sequence or extent' and that is exactly what is delivered by continuous flow units and systems. Continuous flow technology provides a constant flow of hot water instantly at the precise temperature required.The CPD makes comparisons between continuous flow and -

- Hot water cylinders which heat and store for use on demand
- Gas / LPG/ oil fired appliances which can be floor and wall hung
- Back-boiler
- Systems boiler with integral primary expansion
- Combi-boilers can also be employed for DHW

The course will contrast and compare the principles of traditional DHW with the principles of continuous flow. It will be specific on the following topics:

- How the Rinnai Infinity range of water heaters operate
- Range of standard efficiency water heaters
- When the use of stored hot water is an efficient mode of supply to a site
- The range of condensing water heaters
- Rinnai Infinity low NOx technology
- Flueing configurations
- Temperature control
- System design
- Benefits of modular system sequencing
- BMS control options

This CPD is designed to give a full overview of the principles and functionality of continuous flow hot water heating units and systems so that performance and delivery of user comfort, cost and energy efficiencies are maximised.

For more details on RINNAI products visit

www.rinnaiuk.com

FOR MORE INFORMATION AND PERSONAL ATTENTION ON THE WHOLE RANGE OF RINNAI CPDs PLEASE CONTACT
Steve Richards
Sales Consultant - National Key Accounts

Mobile: 07947 820 765
HQ 01928 531 765
London Office 0203 903 9030
E-mail: steverichards@rinnaiuk.com
My personalised area:
rinnaiuk.com/resources/region-hub/
www.rinnaiuk.com

CONTINUOUS FLOW - SYSTEM DESIGN EXCELLENCE

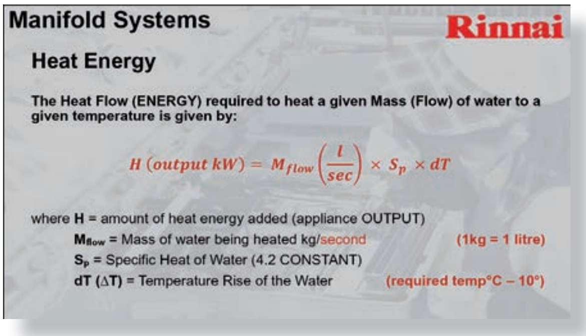
This Rinnai CPD gives an in-depth explanation into the design parameters of a continuous flow hot water system.

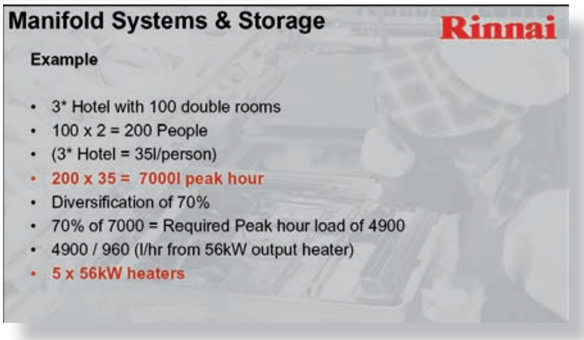
The course comprehensively covers the following critical design considerations;

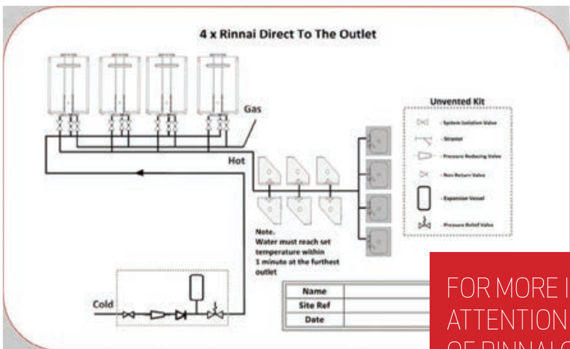
- heat energy and how it is used in the sizing of a commercial hot water delivery system
- what applications are suited to it
- how to size a semi-storage system

The course also covers other important design factors such as the system components that must be fitted to satisfy G3 requirements. It also delves into basic hydraulics and gives an understanding of ACOP L8 whilst explaining the benefits of continuous flow in designing best practice for legionella prevention.

As a continuous flow water heater always deliver TEMPERATURE that is set on water heater we can determine the flow rate exactly that the Water Heater will deliver.







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Steve Richards
Sales Consultant - National Key Accounts

Mobile: 07947 820 765
HQ 01928 531 765
London Office 0203 903 9030
E-mail: steverichards@rinnaiuk.com
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RINNAI CPDs - ACOP L8

This gives guidance for the control of legionella bacteria for Hot & Cold water systems (We are looking at DHW ONLY)

Understanding ACOP L8 and Hot water design

This course is aimed at Installers, Contractors, Maintenance Personnel and Designers. The course seeks to give a basic understanding of L8 and how it affects DHW systems. This course will cover the use of low temperature systems, as well as the use of Rinnai pure controls for pasteurisation.

The course will delve into ACOP L8 and how continuous flow water heaters can help design out proliferation risks, including flow and return, utilisation of close temperature control as a means of limiting bacteria growth and control technologies.

ACOP L8 - PREVENTATIVE MEASURES

- Good system design
- Avoid dead legs (capped ends)
- Cleanliness of system (Hard water areas system should be treated)
- Temperature control
- Ensure water is kept moving frequently
- L8 2.72 'In hard water areas, softening of the cold water supply to the hot water distribution system should be considered'
- This to reduce the risk of scale build up within pipework and its deposit within the base of calorifiers

TO REDUCE RISK

- Where cold water comes direct from wholesome mains
- Where daily water usage is inevitable & sufficient to turn over the entire system
- Where hot water is fed from instantaneous heaters or low storage volume water heaters (supplying outlets at 50°C) 1

For more details on RINNAI products visit

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L8 and Continuous Flow

- Where water is fed from an instantaneous heater
- System at 60°C, 90% of bacteria killed within 2 minutes
- Minimum temperature from heat exchanger 60°C
- Water Heater Temperature Accurate ± 1°C
- Low water volume
- Full turn over in volume

Continuous Flow Systems HELP to Alleviate Risk of Legionella

Auto Pasteurisation Remote Control System

Heaters accurate ± 1°C

To have a system at low temperature a control regime is required

- Biocides
- Chlorine Dioxide
- Copper & Silver Ionisation
- UV Light

Importance of temperature as a control measure

- Above 70°C kills almost instantly
- At 60°C, 90% killed within 2 minutes
- System that runs at safe temperature during day
- Pasteurises when building unoccupied
- Returns to safe temperature prior to occupancy

Continuous Flow Systems Allow for Fully Functional Automatic THERMAL PASTEURISATION

Rinnai

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Accessible computational fluid dynamics for building services applications

This module explores the use of CFD in providing building systems manufacturers, designers and operators with intelligence on the performance of building components

Experimental modelling of fluid flow and heat transfer in full-scale HVAC components is likely to be challenging and costly, particularly if the exercise is to examine a novel design, or installation detail, that is still in development. Unfortunately, physical-scale models – whether larger or smaller than real life – will disproportionately alter the heat and mass transfer, so are unlikely to provide a simple practical option. However, as computational fluid dynamics (CFD) becomes more accessible, it can offer a convenient tool for systems manufacturers, designers and operators to explore and assess the performance of building systems and components.

In the recent past, CFD was the realm of the dedicated expert, researcher or student, but the advent of open-source and free-to-access packages, as well as cloud-based systems, has created an environment where CFD can be readily evaluated as a regular addition to the building professional's toolkit.

Considering fluids at a microscopic scale, the individual molecules and their associated physical properties – such as temperature, density and velocity – will vary continuously as they move as part of the fluid. CFD takes a higher-level viewpoint that considers blocks, cells or elements of the fluid (which will contain many molecules) and takes averaged values of the individual molecular parameters. So, unlike the somewhat chaotic molecular components, it offers an opportunity to examine the ordered trend of transition and interaction as the focus shifts from one element to its neighbour. The incremental changes between one element and the next will be due to some driving force – such as temperature, pressure difference, viscous forces and gravity. By using the certainty that the whole system will conserve energy, mass and momentum, the interactions between the elements can be evaluated using fluid dynamics.

If this was a matter of examining a single parameter (such as velocity) for a couple of discrete elements in two dimensions – which might be analogous to the collision of two smooth ceramic balls rolling on a polished table top – then it would be possible to examine this analytically, using equations to get a single 'exact' solution. However, the challenge soon becomes too complex for simple analytical methods when considering numerous elements while examining multiple parameters in two or three dimensions.
In terms of the dynamics of fluids, the Navier-Stokes equations give a set of partial differential equations used to combine the conservation principles and the viscous forces in fluids to mathematically model a flow. Concurrently, heat transfer within the fluid – used to determine temperatures and heat flow – is examined in accordance with the conservation of energy. These methods have been evolved assuming an infinitesimal element of fluid, and by developing sets of differential equations that can be simultaneously solved to determine the required set of parameters associated with the flow of the fluid.

Although there are a few, very simple, laminar flows for which these equations can be solved analytically, CFD software employing numerical (iterative, trial and error) methods are typically used to converge on an 'exact' solution (see 'The

»

exact solution' box). Many numerical methods have been developed to provide the closest approximations with the least calculation effort, and have been implemented in commercially available CFD software packages.

When setting out to undertake a CFD analysis, pre-processing includes 'cleaning up' the building model and converting it into a compatible format so that the geometry may be used by the CFD software in preparation for creating a suitable 'mesh'. When considering a complex continuum of fluid flow – such as water inside a pipe, or cooled air from a fan coil blowing into a room – the process is far more doable (see the 'Deconstructing the complex into the doable' box) when the domain is broken into smaller elements and the velocity, momentum and temperature (and other parameters as needed) are considered in terms of the conditions at the inlet face(s) and outlet face(s) of each element (in two or three dimensions), with no requirement for knowing the detail of what happens within the element.

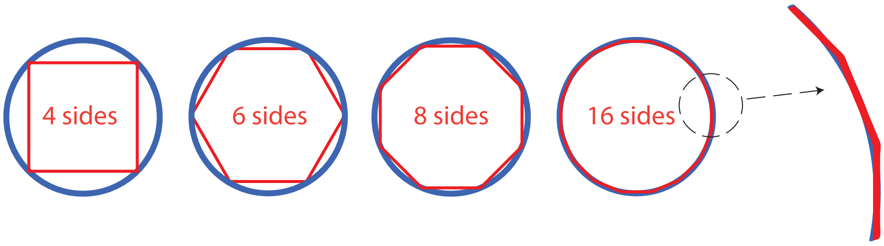
To analyse and solve the series of partial differential equations that describe the changes across a space, such as a room or an air duct, a contiguous virtual mesh is defined with varying sizes of polygons that completely fit the space. For example, in 2D these might be triangles or quadrangles, and in 3D tetrahedrons, hexahedrons, pyramids and wedges. Zones where there is likely to be a greater rate of parameter change would be broken into smaller elements to provide the finer granularity – for example, adjacent to a boundary formed by a heating coil, or to resolve the smallest flow eddies in an air stream. Where there is likely to be less active change – for example, on the centreline of a straight duct – larger mesh elements would be used. This is to optimise the number of calculations where each mesh element will represent an individual solution of the equation that, when combined for the whole network, results in a solution for the entire mesh. Solving the complete problem without dividing it into smaller pieces can be impossible because of the complexity in the modelled domain, such as holes, corners, curves and angles. Many of the CFD software packages include (or can be linked with) automated and, more recently, dynamically adaptive, mesh generation.

The numerical approach is employed to solve iteratively across the mesh until the method converges on a solution that practically coincides with the boundary conditions. Boundary conditions are set for a specific set of elements, such as those representing the walls in a room, the coil surface in a heat exchanger, and the velocity and pressures of air streams, which must be physically true to obtain a CFD solution that is properly constrained in the real domain. Missing, incomplete or incorrect boundary conditions will probably prevent a CFD solution. Thermal models can be linked to CFD packages to allow the dynamic variation of boundary conditions resulting from both the CFD output and changes in the building system itself. The solver will approach a solution by the reduction of errors from the previous iterations, with differences between the previous two iteration values providing the error. If the absolute error is descending, the software is said to be converging towards a stable solution where eventually the computed and physical boundary parameters will be practically consistent.

For example, if considering air distribution in a room with air supplied from a diffuser, the velocity of the air leaving the diffuser is a boundary, as is the velocity at a wall surface (that is, zero velocity for air passing through a wall). Accounting for all the boundary conditions, the CFD solver will apply the simultaneous set of describing equations so that after numerous iterations there will be (almost exactly) zero velocity at the wall surface.

THE 'EXACT' SOLUTION

The required exactness of a solution will be project-dependent. In this analogous illustration, the simulation of the visual appearance of the real blue circle by the n-sided regular red polygon has less error (or deviation) as n increases. An increased number of sides requires more calculation work and time, and at some value of n the error is deemed so small that the simulation is considered acceptable; that, in this case, may be when n=16. However, if the image is magnified, to gain greater insight at a particular point, the error may then be unacceptable, so requiring another iteration of the process.



DECONSTRUCTING THE COMPLEX INTO THE DOABLE

To solve a complex, commonplace non-CFD problem, such as creating a building, it is standard to divide it into sections (form, structure, engineering services, and so on) and then further subdivide each of these – an example in engineering services might be internal environment -> heating -> emitter sizing, and so on – until the scale of the challenge makes it possible to solve each element. Then the individual solutions are integrated to make the whole – the building project having been broken into an interconnected mesh of tasks that are interdependent. The effort required to deliver the solutions for each individual element will not necessarily have any direct relationship to the physical size of the space under investigation.

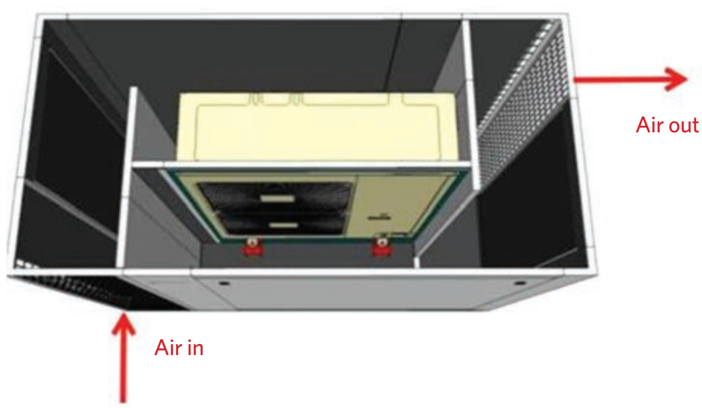
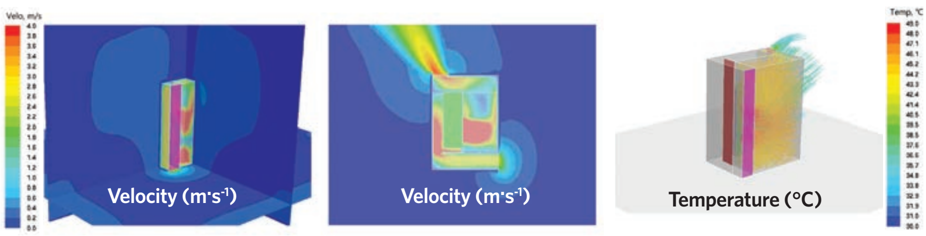


Figure 1: Top view of acoustic enclosure for VRF unit, with top horizontal panel removed (Source: LG)

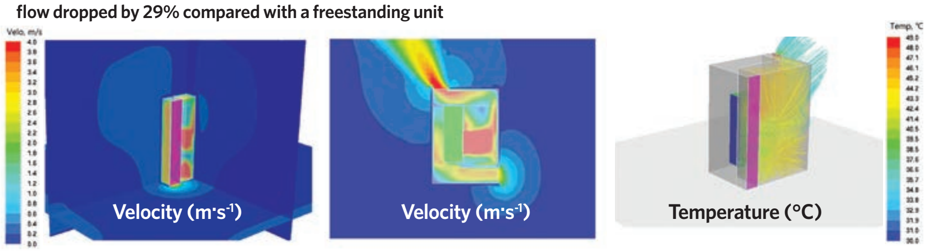
An informed initial guess at where to start from (for example, temperature, velocity and so on) can provide an accelerated route to a solution. As with everyday tasks, it is normally quicker if experience, rule of thumb, a template or an inspired guess sets the appropriate starting point (or condition). Otherwise, it can take longer to converge on the most appropriate solution if starting with a 'blank piece of paper'. Conversely, if the estimated first condition is wildly inaccurate, then the challenge may be exacerbated in the same way as the apocryphal lost traveller who, when asking a local resident for directions, is told: 'If I were going there, I would not start from here.' Informed input can be provided with the integrated output of other simulation tools. The CFD software will use one or more turbulence models to most effectively model the system when accounting for flow regimes (such as high-velocity, rotating or separating flows) and boundary characteristics. For example, so called 'low Reynolds number models' are used to effectively solve where there are swift changes in the values of parameters close to walls, but these require very high mesh resolutions and so come with a high computational cost.

Traditionally, CFD software employed simple text-based input. This allows extreme control of the input data, as well as benefiting from explicitly knowing what data have been entered. The development of graphical input interfaces – as well as visual output – has enabled access to CFD for those who are not experts in the CFD code. Although, inevitably, this can produce poorly defined models and practically meaningless output, it does allow a wider group of users to develop skills and become accomplished in the application of CFD as a means of exploring their engineering solutions. There are also computer-aided design packages that link directly to, or are integrated with, CFD solvers (with meshing) that may lack the flexibility to examine more specialist applications but provide a potentially swifter path to CFD solutions. The industry-leading CFD packages include sophisticated pre- and post-processors, as well as a variety of solvers – the combination of mathematical formulae and solution methodology – and turbulence models.

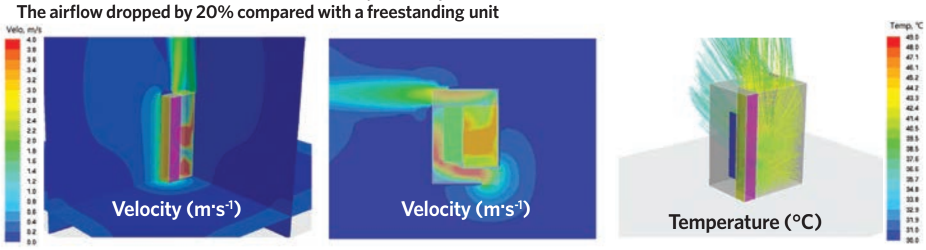
Case A – Original case design. The airflow dropped by 38% compared with a freestanding unit



Case B – Inlet perforated panel (on left side) removed. The air flow dropped by 29% compared with a freestanding unit



Case C – Inlet and outlet areas doubled with top outlet opened. The airflow dropped by 20% compared with a freestanding unit



Case D – Inlet areas doubled with top outlet opened and side outlet closed. The airflow dropped by 25% compared with a freestanding unit

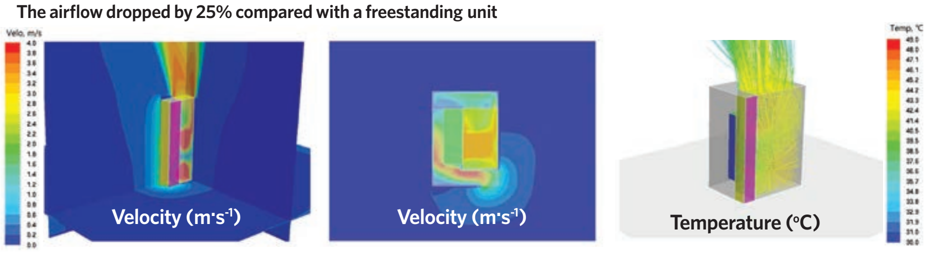


Figure 2: CFD analysis of acoustic enclosure for external VRF unit (Source: LG)

Example CFD application

Individual acoustic enclosures were required for a set of outdoor units of a variable refrigerant flow (VRF) system. The inlet and discharge sections of the specific enclosure (as shown in Figure 1) needed optimisation to reduce the emitted noise levels while having minimum effect on the VRF performance. Key control parameters were that the unit must not exceed an operating temperature of 48°C at the heat exchanger, and that the configuration should minimise the short-circuiting of air between the discharge and the inlet. The CFD package allowed for the assessment of the acoustic environment, as well as air temperatures and velocities, so enabling the optimisation and subsequent satisfactory installation of the enclosure.

The output from the analysis is shown in Figure 2. The temperatures and flowrates from the CFD were used to establish the resulting effect on the performance of the VRF units. (This could require an iterative process in itself, as an alteration in the heat transfer in the VRF unit may alter its coil temperature, which would have created one of the boundary conditions for the CFD.) Since there are multiple units mounted together in a line, Case D was selected as the solution, as the air was discharged at the top – this reduced the effectiveness of the VRF unit by 9%. For individually mounted units, Case C might be the preferred option (with a 7% reduction in effectiveness).

The cost of CFD is relatively low compared with the cost of the personnel that will use it and, particularly in commercial applications, the total cost of ownership must include the costs of setup and interfacing. The increased sophistication, usability and intelligence in pre- and post-processing – together with the plethora of free online learning resources – offers great opportunities for many building systems professionals to, at least, become more familiar with the application of CFD.

Turn to page 32 for further reading. »

» Module 136

November 2018

1. **What is the name of the set of equations that is typically applied for fluid dynamic analysis, as explored in this article?**

☐ A Archimedes

☐ B Bernoulli

☐ C Euler

☐ D Lagrange

☐ E Navier-Stokes

2. **In the explanation of exactness, what value of n was proposed as acceptable for the unmagnified circle?**

☐ A 4

☐ B 6

☐ C 8

☐ D 16

☐ E 32

3. **Which of these is least likely to be suitable as a mesh element volume?**

☐ A Hexahedron

☐ B Pyramid

☐ C Sphere

☐ D Tetrahedron

☐ E Wedge

4. **Which of these is most likely to be derived definitively from the physical parameters of the domain under investigation?**

☐ A Boundary conditions

☐ B Initial conditions

☐ C Mesh element shape

☐ D Solver type

☐ E Turbulence model

5. **In the example CFD application, which arrangement created an airflow reduction of 20% compared with the freestanding unit?**

☐ A Case A

☐ B Case B

☐ C Case C

☐ D Case D

☐ E None of them

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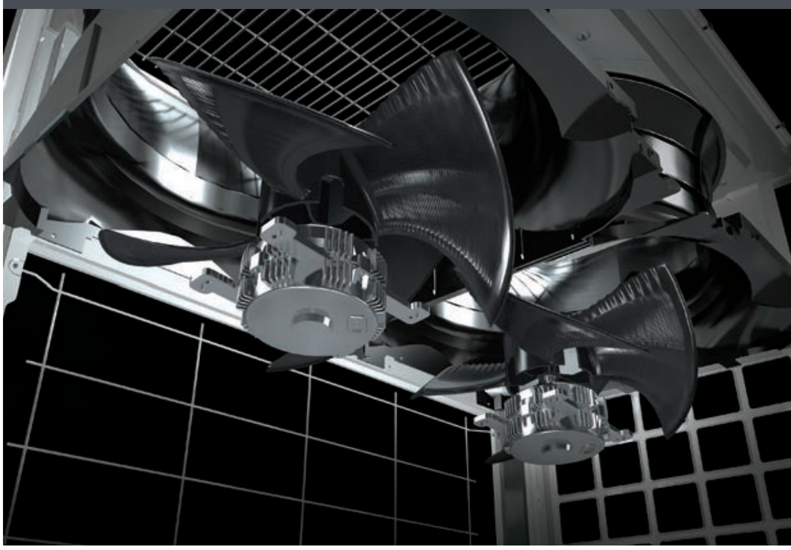
Further reading:

There are many sources of information available. The following will give a good introduction to CFD: What is CFD? – **bit.ly/2RdmA7f**

And this free EdX online course could take you towards being a CFD practitioner: ENGR2000X – A Hands-on Introduction to Engineering Simulations.



The widest range of brazed plate heat exchangers

SWEP offers the largest brazed plate heat exchangers with capacities up to 10MW. Our gasket-free heat exchangers have low maintenance costs and an optimal LCC (Life Cycle Cost).

With significantly lower weight and compact design, they require about 50% less floor space than traditional solutions. The units can easily be transported through a standard doorway. And if you need higher capacity, simply add more units.

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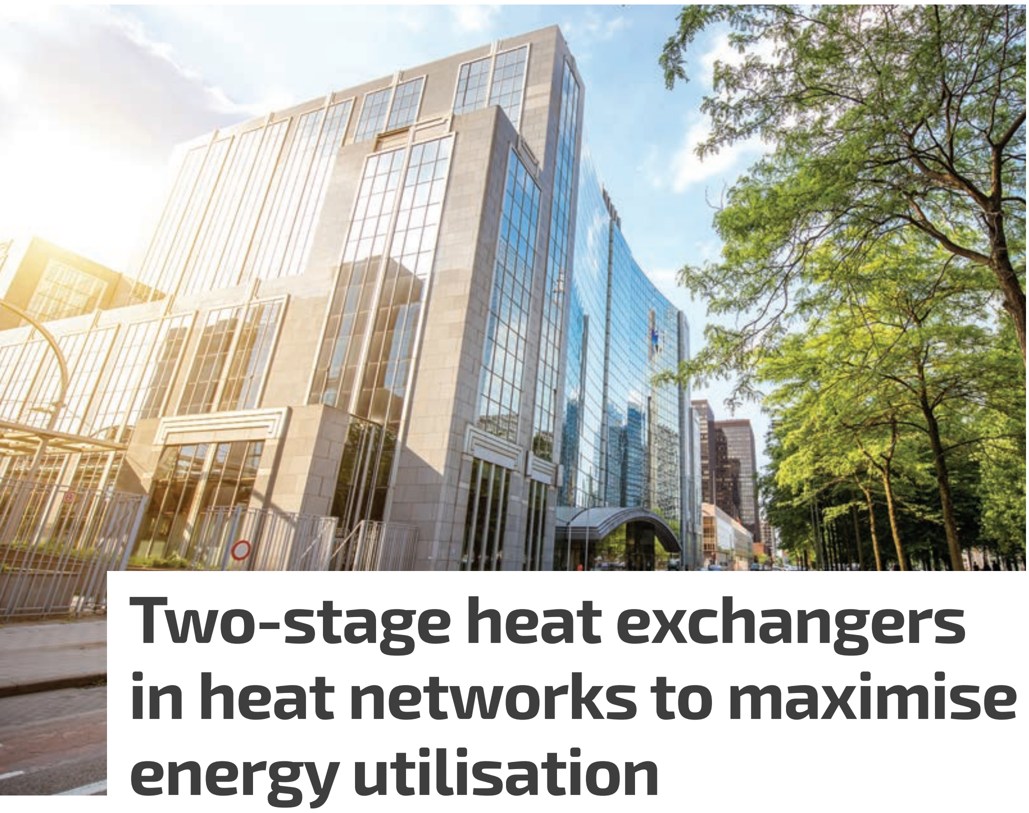

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Two-stage heat exchangers in heat networks to maximise energy utilisation

This module looks at the drivers and methods to enable wide temperature differentials in heat networks

A key aspect of district heating systems is to maximise the use of heat available from the circulated water. Essentially, this means that the return water temperatures should be as low as practicable. This will largely be determined by the type, magnitude and design of attached systems, but can also be influenced significantly by the arrangement of substation heat exchangers.

The amount of heat extracted from water distributed around heat networks will impact on pumping power and heat-generation performance. This will affect both the capital and operating costs. For example, Figure 1 (taken from the *London Heat Network Manual*[1]) indicates the impact of network temperature differential on the cost of associated pipework systems. The temperatures selected are also likely to affect the efficiency of the heat source – particularly for heat pumps and steam-turbine extraction – and the volume of any thermal stores. Even if the heat supplied to the heat network is produced from fuels that are carbon dioxide (CO_2) neutral, the power used for pumps and fans, and its production, contributes to CO_2 emissions. Reduced costs are in the best interest of both the supplier and the consumer, so it is important that the district heating distribution network is holistically designed, operated and maintained for economic and environmental reasons.

The requirements for each application will need careful assessment, not only with a view to optimising the network temperatures, but also to determine any otherwise unexpected impact on the effectiveness of individual consumer systems. As many new heat networks will supply existing buildings and subsystems, the flow and return temperatures required to satisfy the original heating and hot-water systems at peak load will need to be assessed. This would generally require not only metered information, but also a properly informed site inspection to collect numerical data and explore opportunities to meet demand with (typically, at least) reduced return temperatures – and, hence, lower average system temperatures. Inevitably, in many cases, this necessitates multiple inspections, as there may be seasonal or varying occupational demands – particularly in multi-tenanted buildings, as individual end-user heat demands may not be immediately obvious.

The network temperatures should be planned to take account of these demand variations, if appropriate, by varying supply flowrates. (It may be more challenging to identify 'seasonal' requirements where there is a need to satisfy any commercial/industrial processes.) Network losses will

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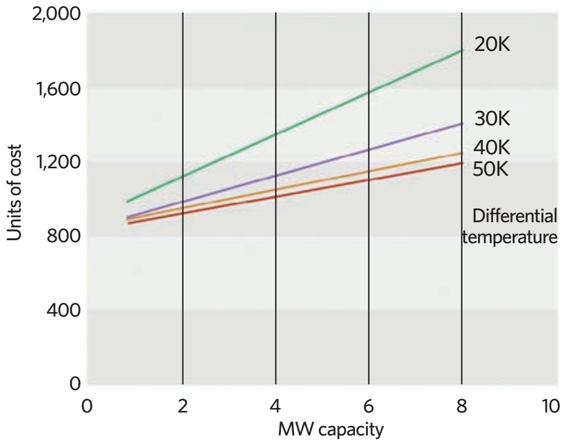

Figure 1: Indicative relationship between cost of pipework infrastructure and differential temperature on a system[1]

be significantly influenced by both the temperature profile and the flowrates.

The current version of the CIBSE/ADE publication CP1 *Heat Networks: Code of Practice for the UK* recommends that the 'targeted difference between flow and return temperatures on the primary heat network under peak demand conditions shall be greater than 30K for supply to new buildings and greater than 25K for existing buildings (where feasible), to reduce the capital costs of the network, unless a detailed analysis of life-cycle costs and performance shows otherwise'. By comparison, in Sweden – where heat networks are long-established – the requirements for system temperatures are rather more demanding; networks for residential applications require supply temperatures of 65°C,[2] with the return water temperature (dependent on the final consumer hot-water system) of between 22°C and 25°C. This sets a standard for at least a 40K difference between flow and return temperatures on the primary heat network.

It is important that delivering useful economic heat safely and reliably to consumers is not obfuscated by an over-zealous desire to reduce heat network costs. There may be demands – such as legionella control, thermal performance of materials, legacy comfort systems and processes – that are particularly sensitive to flow, return or average water temperatures.

Many district heating schemes operate at temperatures and pressures that are compatible with typical building services. In this case, consumers' heating systems can be connected directly to the district scheme, with the same water that flows in the district network flowing through consumers' heating circuits.[3] However, where there is a desire to decouple the consumer systems from the heat network – or where the network flow temperatures are higher than those required in the consumer systems – thermal substations are used to provide a reduction in temperature (and pressure) so that the network heat can be safely used in the building. The substation typically consists of a plate heat exchanger that acts as a pressure break between the district network and consumer system. The heat exchanger often forms part of a metering station – with flow-control valves, isolation valves and a heat meter – that acts as the demarcation point between the district scheme and consumer systems.[3]

Substations in heat network installations are typically arranged in either a parallel or a two-stage arrangement. A parallel connection, as visualised in Figure 2, uses separate heat exchangers for space heating and domestic hot-water systems, and the water from the primary (heat network) is cooled only once, in a traditional parallel system. In a two-stage arrangement, as in Figure 3, the return flow from the radiator heat exchanger is mixed with the flow from the after-heater. The mixed flow enters a third heat exchanger, the preheater, the principal purpose of which is to preheat the cold water before it enters the after-heater – hence why it is referred to as a two-stage system.

The proportions of heat used for preheating and final heating are determined in such a way as to make the most efficient use of the heat (exergy). If the building has a significant demand for hot water, this arrangement will typically result in a lower return temperature than would be the case from a parallel connection. The two-stage arrangement may be combined into a single brazed plate heat exchanger, as shown in Figure 4, that would look similar to Figure 5 when installed on site. This would provide the heart of a substation supplying the load for a residential or commercial building – replacing the traditional boiler and calorifier. The November 2017 *CIBSE Journal* CPD has further details of brazed plate heat exchangers.

The network return water in a typical parallel design is 40°C, whereas simulations and observations have reportedly indicated anything between 40°C and 20°C for a two-stage design – partly depending on heat load, but mostly on how much domestic hot water is being consumed.

Example applications

Typical heat network based on a collection of real applications

An example installation based on real applications was modelled[4] to determine the comparative performance for parallel and two-stage substations while meeting the same building loads. The results are shown in Table 1.

This indicates an opportunity for significant reductions in return temperatures and flowrates. In this case, a reduction in return temperature of 5K is predicted to also reduce distribution losses by approximately 4%.

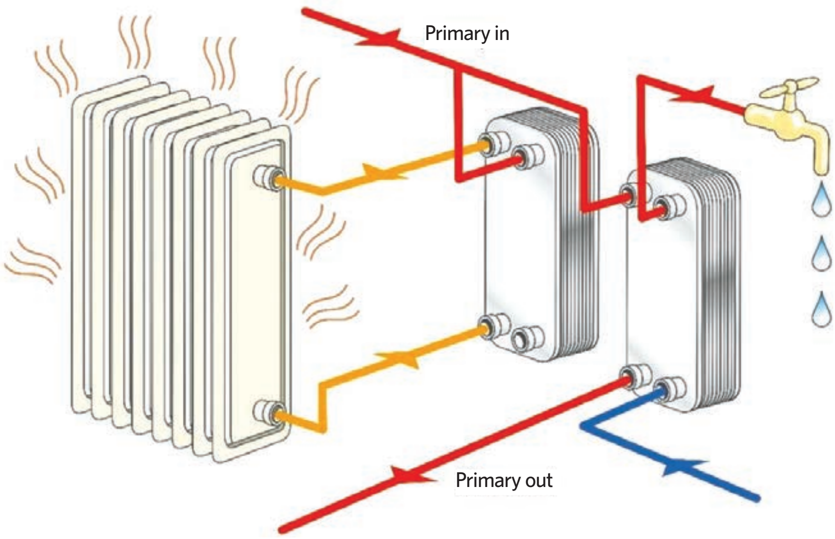

Figure 2: Simplified visualisation of the connection of parallel-connected consumer systems to the heat network primary flow (Source: Swep)

	Parallel	Two-stage	Difference
Winter primary return temperature	48.3°C	41.6°C	-6.7K
Summer primary return temperature	42.5°C	37.3°C	-5.2K
Winter primary flowrate	$37.85 L \cdot s^{-1}$	$28.04 L \cdot s^{-1}$	-35%
Summer primary flowrate	$21.92 L \cdot s^{-1}$	$17.60 L \cdot s^{-1}$	-24%
Investment	£11,524	£13,490	+14.6%

Table 1: Example of greater temperature difference for traditional parallel, compared with two-stage, substation

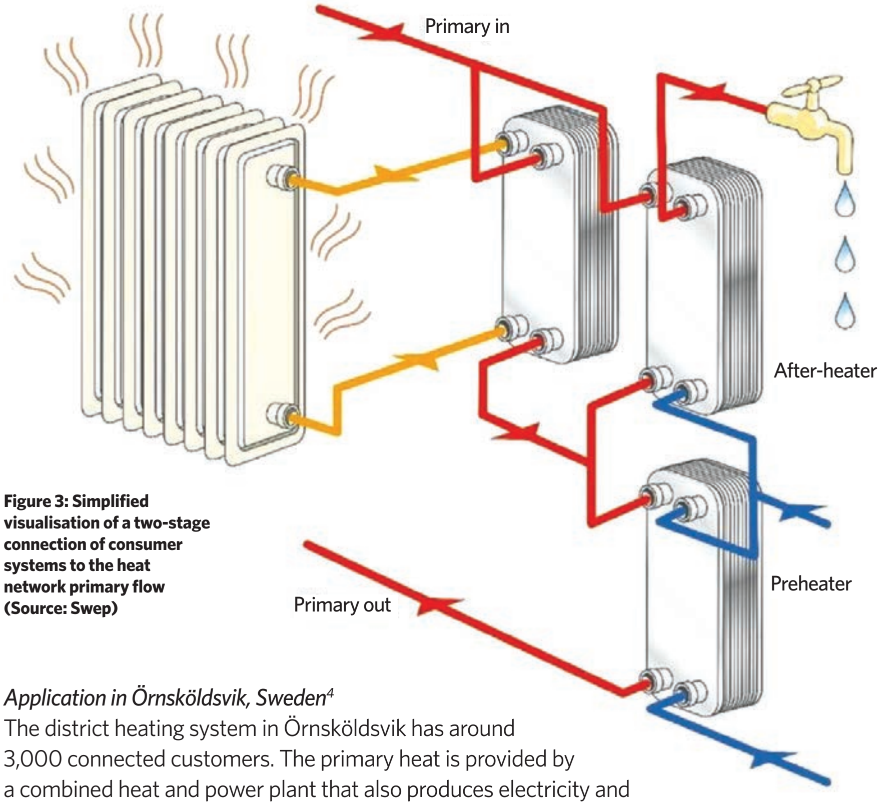

Figure 3: Simplified visualisation of a two-stage connection of consumer systems to the heat network primary flow (Source: Swep)

Figure 5: An example of an installed brazed plate heat exchanger (Source: Swep)

Application in Örnsköldsvik, Sweden[4]

The district heating system in Örnsköldsvik has around 3,000 connected customers. The primary heat is provided by a combined heat and power plant that also produces electricity and industrial steam. For the energy service company (ESCo), as the supplier of district heat, a lower return temperature means that more energy can be recovered in flue gas condensation. This will also reduce the flowrates in the district heating system, and so the pump power and the distribution losses are reduced. The potential impact of a reduced return temperature has been calculated, based on operating data from 2012, and shows that a reduction of the return temperature of 1K represents an annual saving of £76,500. The ambition for the ESCo (Övik Energi) is a flow-to-heat ratio value of $20m^3 \cdot MWh^{-1}$ during the coldest months. To achieve this will mean that the consumers should have an average network temperature differential of 44K. 'Unnecessary consumption' describes how much extra water the district heating substations will consume compared with a substation that has reached the company's target. In this application, a connected sawmill is the customer with the highest unnecessary consumption and is, therefore, also the customer that contributes most to an increase in the return temperature. Had the sawmill reached the temperature differential of 44K, the overall network return temperature would have been reduced by 0.6K.

However, it is not only the major customers that affect the return temperature. The four small residential substations with the worst performance contribute a 0.2K increase to the return temperature. For the period under investigation, a total of 36 substations had a temperature differential of 20K. If all these 36 had the desired 44K differential, the return temperature would drop by 1.1K, which would deliver an estimated annual saving of around £85,000 per year.

As it is the customers' substations that determine the return water temperatures, the ESCo is developing a project with its customers to increase the efficiency of the district heating substations. Other measures to improve network performance include investigating the performance and effect of any bypasses in the distribution network, as well as examining the operation and performance of any connected heat sources.

In practice, it is the customers' facilities that have been identified[4] as increasing the return temperature most significantly across a year. Unsurprisingly, investigations show that customer facilities with high energy use and hot water consumption affect the return temperature most. The temperature differential in the network would improve by several degrees if those facilities were to function optimally. For example, if the facility with the highest over-consumption in January had reached a temperature differential of 50K, the overall return temperature could have been reduced by around 2K and delivered increased operational savings.

So the greater temperature differential and reduced return temperature in the district heating system can lead to an increased efficiency in the network and lower costs for the ESCo – and the consumer.

To estimate a return on investment, a project-dependent 'ball park' estimate used by a supplier[4] indicates that the annual operational saving is in the order of £0.10 per system MWh for each 1K reduction in temperature. To improve utilisation of the heat, consumers may well need encouraging and incentivising to make improvements in their secondary circuits, so that a two-stage system may be successfully employed to deliver low return temperatures.

Consumers typically lack knowledge of how their systems affect the overall efficiency of the network. So, as well as educating them, flow-based fees can be used so that they understand the importance of making improvements.

■ With thanks to Christer Frennfelt, SWEP, for core technical content.

■ Turn to page 38 for references.

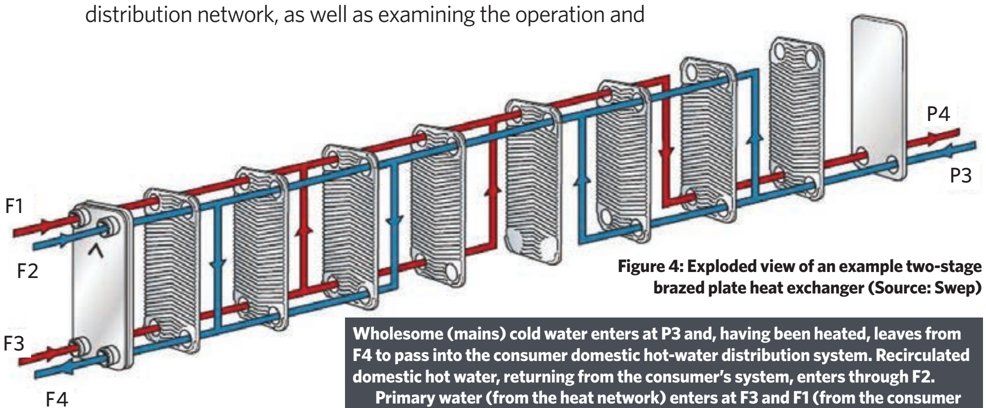

Figure 4: Exploded view of an example two-stage brazed plate heat exchanger (Source: Swep)

Wholesome (mains) cold water enters at P3 and, having been heated, leaves from F4 to pass into the consumer domestic hot-water distribution system. Recirculated domestic hot water, returning from the consumer's system, enters through F2.
Primary water (from the heat network) enters at F3 and F1 (from the consumer radiator/heating circuit) and returns to the heat network through P4.

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Module 137

November 2018

1. For a 4MW heat network, what is the infrastructure cost suggested in Figure 1 of using a 50K temperature differential compared with using 20K?

- ☐ A 0.1 times cost of 20K infrastructure pipework
- ☐ B 0.25 times cost of 20K infrastructure pipework
- ☐ C 0.5 times cost of 20K infrastructure pipework
- ☐ D 0.75 times cost of 20K infrastructure pipework
- ☐ E 0.9 times cost of 20K infrastructure pipework

2. What is the approximate value of the required minimum temperature difference in Sweden for networks serving residential applications?

- ☐ A 25K
- ☐ B 30K
- ☐ C 40K
- ☐ D 50K
- ☐ E 60K

3. Which of these residential applications is most likely to provide the most effective use of heat from a two-stage arrangement in the heat network substation?

- ☐ A Building with large and constant heating load but no domestic hot-water requirement
- ☐ B Building with large heating load and small continuous domestic hot-water demand
- ☐ C Building with large heating load and moderate or large continuous domestic hot-water demand
- ☐ D Building with large heating load and large but intermittent domestic hot-water demand
- ☐ E Building with large heating load and small intermittent domestic hot-water demand

4. Where does the primary flow from the heat network enter the heat exchanger in Figure 4?

- ☐ A F1
- ☐ B F2
- ☐ C F3
- ☐ D F4
- ☐ E P3

5. In the Örnsköldsvik example, what was the calculated annual energy cost saving for each 1K reduction in return water temperature?

- ☐ A £36,500
- ☐ B £46,500
- ☐ C £56,500
- ☐ D £66,500
- ☐ E £76,500

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References:

1 London Heat Network Manual, Greater London Authority, 2014.

2 *District Heating Substations – Design and Installation – Technical regulations F:101*, The Swedish District Heating Association, 2008.

3 **www.ukdea.org.uk/en/substations.html** – accessed 15 September 2018.

4 Swep internal document.

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