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SEMINAR 35 - Introduction to the ASHRAE/REHVA Chilled Beam Design Guide

Energy Analysis and Total Cost of Ownership

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Learning Objectives

- Understand how an active chilled beam functions.
- Understand design considerations when determining whether a project is a good active chilled beam candidate.
- Understand how to operate chilled beam systems in North American climates.
- Understand condensation risks and control strategies to prevent condensation.
- Understand how beam systems can reduce building energy consumption, maintenance and replacement costs.
- Understand the difference between active and passive beams.

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Agenda for Session

- Energy analysis of beam systems,
- Total cost of ownership (TCO),
  - Capital expenditure, CAPEX
  - Operating expenses, OPEX
- Real life examples.

Energy Analysis

- Use of dynamic building energy simulation software,
- Fully know and understand the technology to be simulated,
- Deeply know and understand the calculation method used in the software,

Energy Analysis

- Specific features that may reduce energy consumption,
  - Higher CWT (13– 17ºC) (55-63ºF)
  - Lower HWT (32 – 45ºC) (90-113ºF),
  - Water to transport thermal energy,
  - Absence of excessive uncontrolled dehumidification,
  - Energy efficient room air distribution,
- Specific features that may increase energy consumption,
  - Low CWT temperature differential (Delta T ~ 2ºC)

Energy Analysis

- Use of higher CWT (13– 17ºC) (55-63ºF) opportunities;
  - Dedicated chillers (high EER temperature program),
  - Water free-cooling (without compressors) using,
    - Cooling tower,
    - Dry-cooler,
    - Geothermal sources,
  - Increase of CW deltaT in the chillers.

Energy Analysis

- Use of lower HWT (32º– 45ºC) (90-113ºF) opportunities;
  - Condensation boiler,
  - Heat pump (high COP temperature program),
  - Reclaim heat (example; from Data Center cooling),
  - Geothermal sources,

Energy Analysis

- Use of water to transport thermal energy;

description	symbol	cooling with water	cooling with air	units	formula/source
density	ρ	8.350	0.075	lb/gal ; lb/cft	
specific heat	cp	1.0	0.24	BTU / lb.ºF	
delta T	∆T	4.0	20	ºF	current value
cooling per (gpm, cfm)	cap	2,004	22	BTU/h	ρ . cp . ∆T x 60
flow per 3412 BTU/h cooling	q	0.5	46	gpm ; cfm	1 / cap
fan/pump pressure	P	67	6.0	ft water ; in water	current value
fan/pump efficiency (global)	η	0.55	0.55	-	current value
fan/pump power per 1000 BTU cooling	**E**	**0.015**	**0.080**	**hp**	q . P / (conv.factor x η)

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Adds 20% to the sensible cooling load

Energy Analysis

- Use of water to transport thermal energy;

description	symbol	cooling with water	cooling with air	units	formula/source
density	ρ	1.000	1,2	kg/m3	
specific heat	cp	4,2	1,0	kJ/kg.K	
delta T	ΔT	2	10	K	current value
cooling per (l/s)	cap	8,4	0,012	kW	ρ . cp . ΔT / 1000
flow per kW cooling	q	0,12	83,33	l/s	1 / cap
fan/pump pressure	P	200	1,5	kPa	current value
fan/pump efficiency (global)	η	0,55	0,55	-	current value
fan/pump power per kW cooling	**E**	**43**	**227**	**W / kWclg**	q . P / η

Energy Analysis

- Minimization of latent cooling;
  - In systems using condensing zone coils (wet), dehumidification is often excessive. Dehumidification at the zone coil is usually uncontrolled and increases when the coil surface temperature decreases
  - In beam systems, zone coils are dry and dehumidification is performed at the AHU in a controlled manner.

Energy Analysis

- Building simulation model;
  - Make sure all the features are accounted for in the calculation,
  - No building simulation software includes all the possible variations that may occur in an hvac design,
  - Frequently, “workarounds” are necessary to simulate specific features of hvac systems/equipments,
  - Input must be carefully reviewed bearing in mind the software’s calculation methodology,
  - Output must be carefully analysed; ***“assume the simulation is wrong until proven right”***

Capital Expenditures (Capex)

- Installation costs,
  - Detailed comparison with alternative systems,
- Replacement costs,
  - 20 years lifetime for beams,
- Other costs,
  - Not directly related to the HVAC system

Capital Expenditures (Capex)

- Opportunities for other costs reduction,
  - Reduced floor-to-floor height,
  - Relatively small mechanical rooms,
  - Deletion of architectural ceiling,
  - Integrated services (multi-service beam),

Operating Expenditure (Opex)

- Energy costs,
  - Opportunities related to the use of Beam Systems,
- Maintenance costs,
  - Opportunities related to the use of Beam Systems,

Maintenance Costs

- Features that reduce maintenance costs;
  - No fans&motors,
  - No filters,
  - Dry coils,
  - No condensate drain pans,
  - No condensate drain piping,
  - Centralized location of all equipments that require maintenance.

Maintenance Costs

- Typical maintenance routines,
  - Coil cleaning (time interval from 3 to 5 years)
    - Dry cleaning with vacuum equipment,
    - Removal of suspended ceiling not necessary,
    - Elevation equipment not necessary
  - Control system operation checked (annually)

Real life examples

Distrito C Telefonica (Telephone Company HQ)

Location: Madrid

Climate: Hot and Dry

Area: 366.700 sq.m (3.947.125 sq.ft)

System: water cooled chillers / closed circuit cooling towers / two pipes active beams / perimeter heating.

- **Dedicated Chillers to the beam CW circuit**
- **Cooling Towers can directly supply the beam CW circuit**

Building Completed in 2008

Real life examples

<u>Adeslas Hospital</u>

Location: Granada

Climate: Hot and Dry

Area: 17.650 m2 (189.983 sq ft)

System: air cooled heat pump with HR / ground source heat pump / closed circuit cooling towers / patient rooms; two pipes active beams + perimeter heating

- **Ground source heat pump for the cooling and heating functions**

Currently in the construction phase.

Questions?

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