ADVANCED COOLING TECHNOLOGIES

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SYSTEM-LEVEL THERMAL SOLUTIONS FOR MILITARY GRADE TECHNOLOGIES

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SPEAKERS

ADVANCED COOLING TECHNOLOGIES

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Cutting edge thermal solutions for all Military environments

Technologies to manage high heat loads for Space applications

Custom Environmental Control Systems for Extreme Conditions

Patented innovations in electronics cooling for diverse market use

Founded in 2003

- Over 200 Employees
- Over 140,000ft^2 / 13,000m^2
- ISO 9001:2015 & AS9100D Certified
- Awards
  - Numerous Military & Aerospace Product Innovation Awards
  - U.S. SBA Tibbetts Awards
  - Patents and Scientific Publications

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AGENDA

- System Level Requirements
- ECU's
- Glycol Coolers and Chillers
- P2P
- PCM
- System Controls
- ACT Capabilities
- Q&A

SYSTEM-LEVEL THERMAL SOLUTIONS

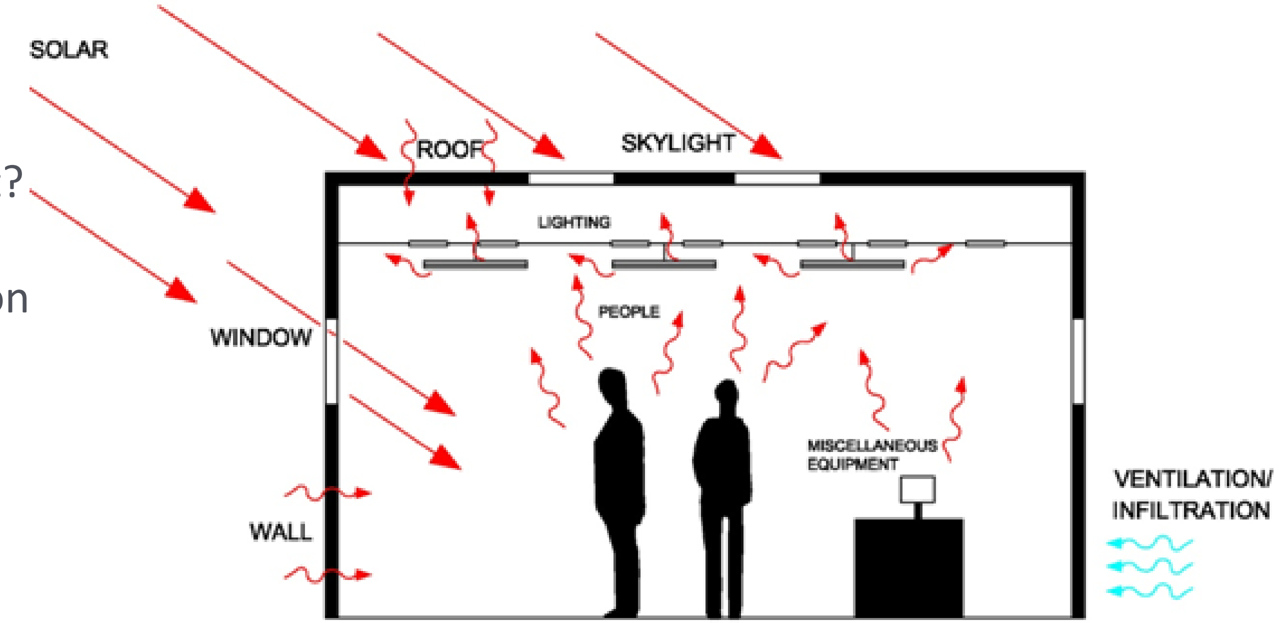
- System-Level Thermal solutions refer to equipment and accessories utilized to reject the heat generated by system components to the exterior environment – primarily the ambient

Ambient design conditions

- -50F to 140F ambient air temperatures
- 0 ft to 10,000 ft elevation
- In some cases chilled water infrastructure may be the exterior environment
    - Shipboard chilled water
    - Facility chilled water

SYSTEM-LEVEL THERMAL SOLUTIONS

- Design Criteria - What are the heat sources?
  - Electronics (sensible) – Continuous or Transient?
  - Occupants (sensible and latent)
  - Envelope conduction and exterior solar radiation (sensible)
  - Outdoor air (sensible and latent)
    - Pressurization (keeps interior clean)
    - Ventilation for Occupants



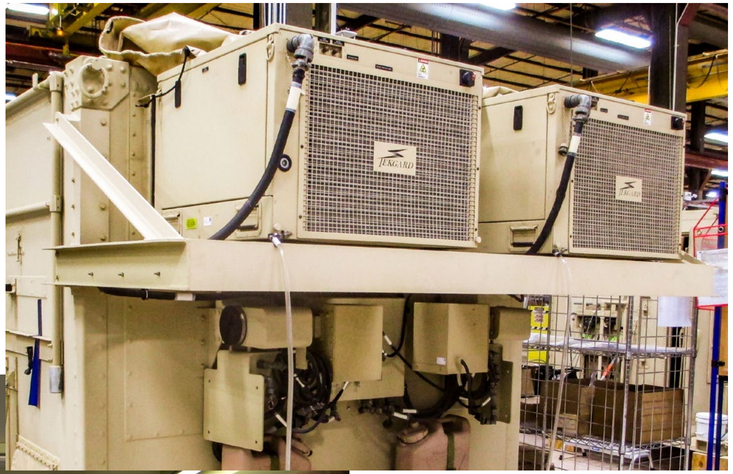
- What are the acceptable conditions?
  - **Electronics** – Entering air maximum temperature
  - **Occupants** – 60-80F air temperature
  - Relative Humidity below 60%
    - Adding humidity requires maintenance of a water source

ENVIRONMENTAL CONTROL UNITS

- Environmental Control Units (ECUs)
  - Air Conditioner built for Military environments
  - Provides conditioned air to an enclosed space
  - Mounted to hard wall shelters
  - Connected by flex ducts to hard or soft wall shelter

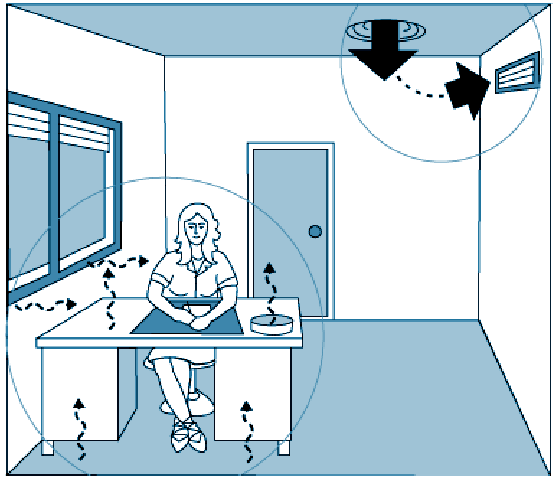
ENVIRONMENTAL CONTROL UNITS

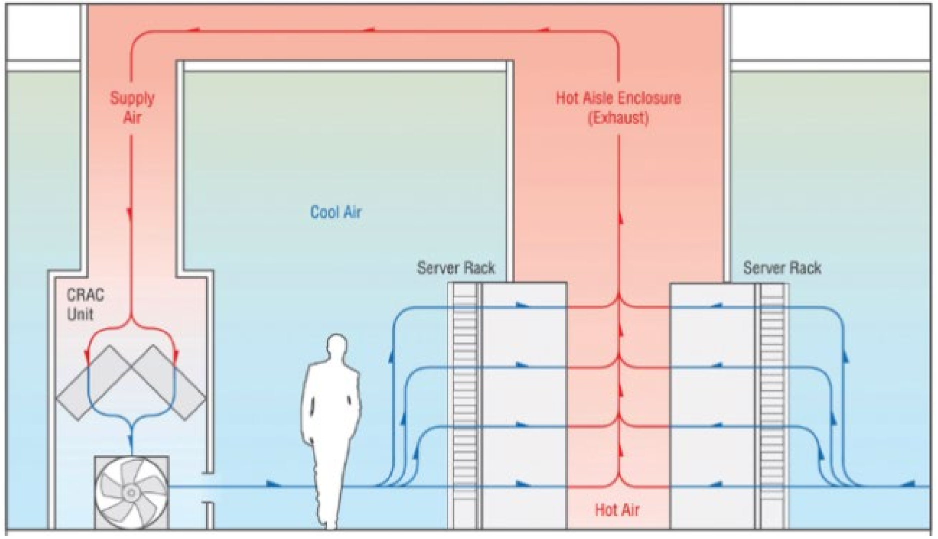
- Environmental Control Units (ECUs)
  - Good way to introduce outdoor air, can be mixed with return air and conditioned before being introduced to the enclosed space
  - Can be 100% outdoor air in case of flight line cooling



ECU – DESIGN CONSIDERATIONS

- Air Systems are easily applied in pairs for capacity or redundancy
  - Backdraft dampers on ECU supply connections to limit bypass air through systems in stand-by
  - Redundant systems used on un-manned and/or mission critical systems
- Capacity is affected by:
  - Ambient temperature – Increase in ambient temp = Decrease in capacity
  - Return air conditions (Temperature, Humidity, Airflow rate) – more/warmer return air = Increase in capacity
    - Sensible vs. Latent Cooling
- Airflow pattern in the space
  - Short Cycling, Well Mixed, or Managed?



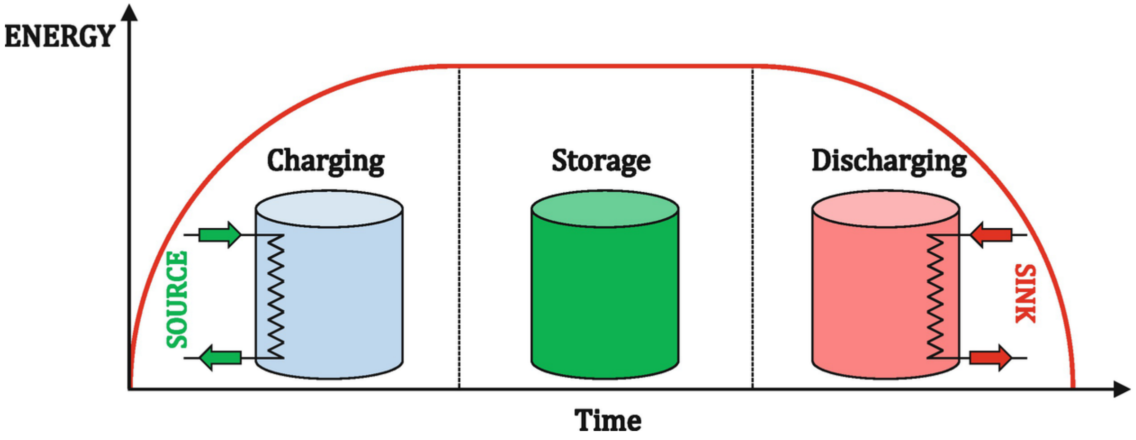


GLYCOL COOLERS AND CHILLERS

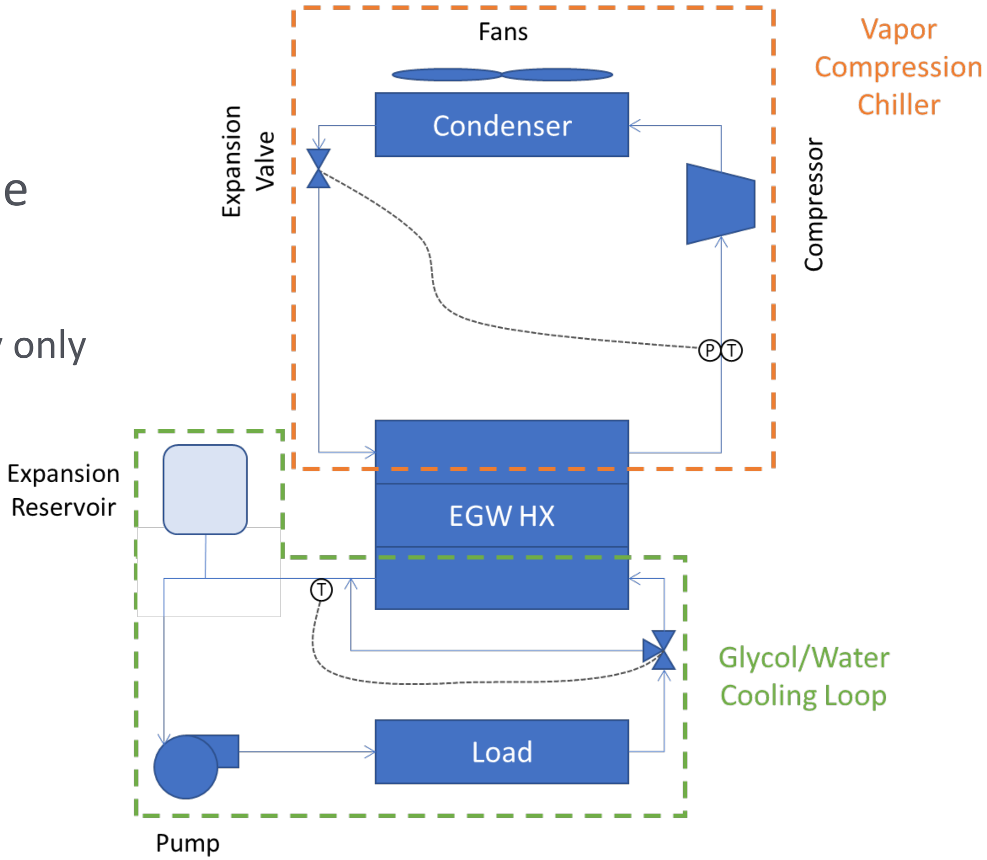
- Glycol Coolers – LTA (Liquid-to-Air)
  - Provide cooling liquid (glycol/water) at some temperature above ambient
  - Good for electronics that can tolerate above ambient conditions
- Chiller
  - Provide cooling liquid (glycol/water) at some fixed supply temperature, lower than max ambient temperature
  - Good for electronics that require below max ambient temperatures
  - Good for electronics that benefit from stable temperatures, that don't fluctuate with ambient conditions

GLYCOL COOLERS AND CHILLERS DESIGN CONSIDERATIONS

- Requires coolant heat sinks at electronic components
- Requires glycol loop piping and fittings that don't leak
- If system is modular, quick-disconnects are needed
- Weight of the glycol system
- A glycol storage tank or PCM (Phase Change Material) can be used for thermal storage
  - Minimize equipment peak power draw when loads are intermittent
  - Great application for Directed Energy Weapons where peak load may only be present for a few minutes per hour



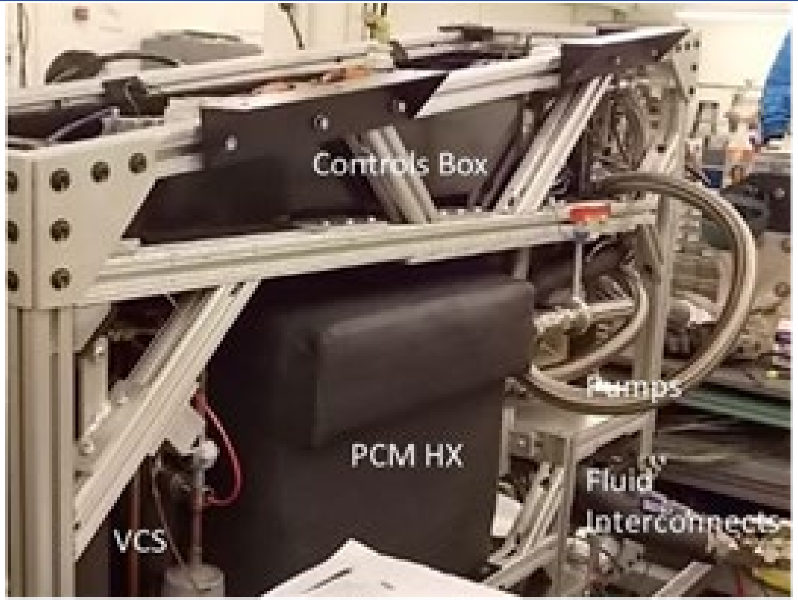
Dincer I., Ezan M.A. (2018) Thermal Energy Storage Methods. In: Heat Storage: A Unique Solution For Energy Systems. Green Energy and Technology. Springer, Cham. https://doi.org/10.1007/978-3-319-91893-8_3

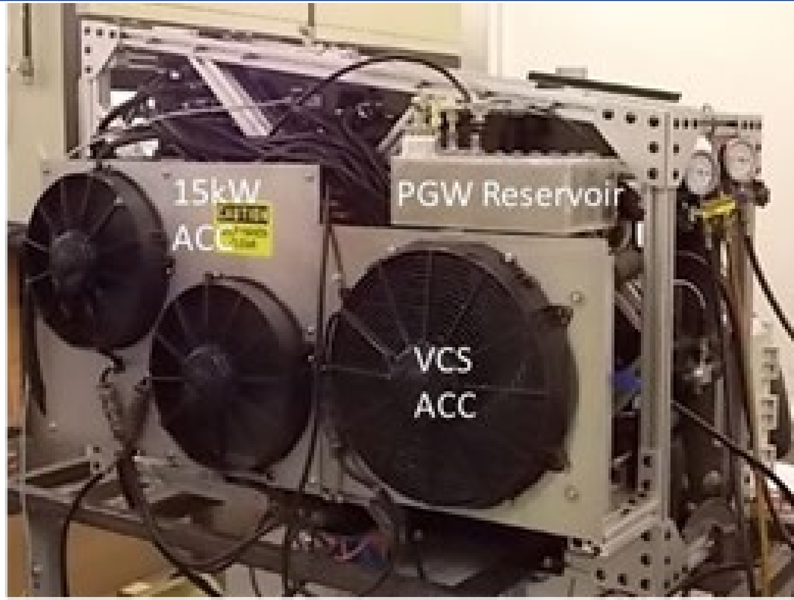


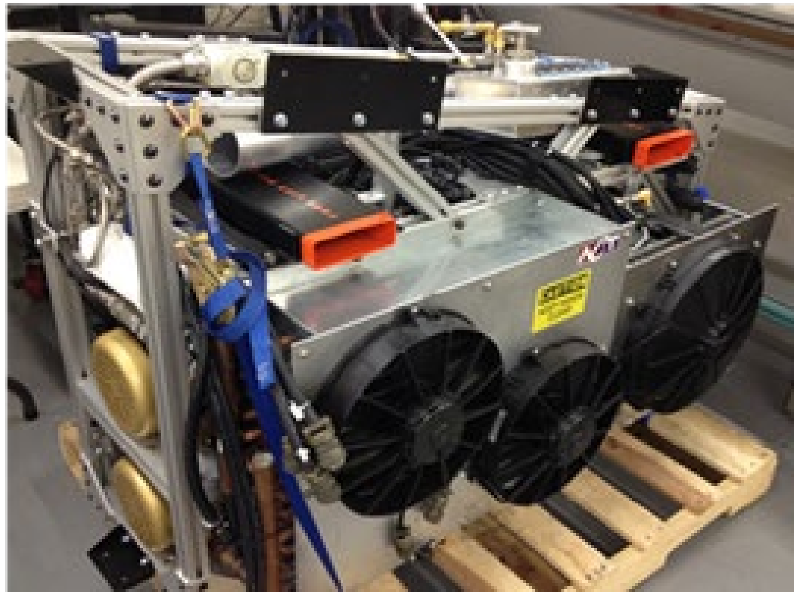
CASE STUDY- DEW SYSTEM

Technologies used:

- Chiller
- PCM



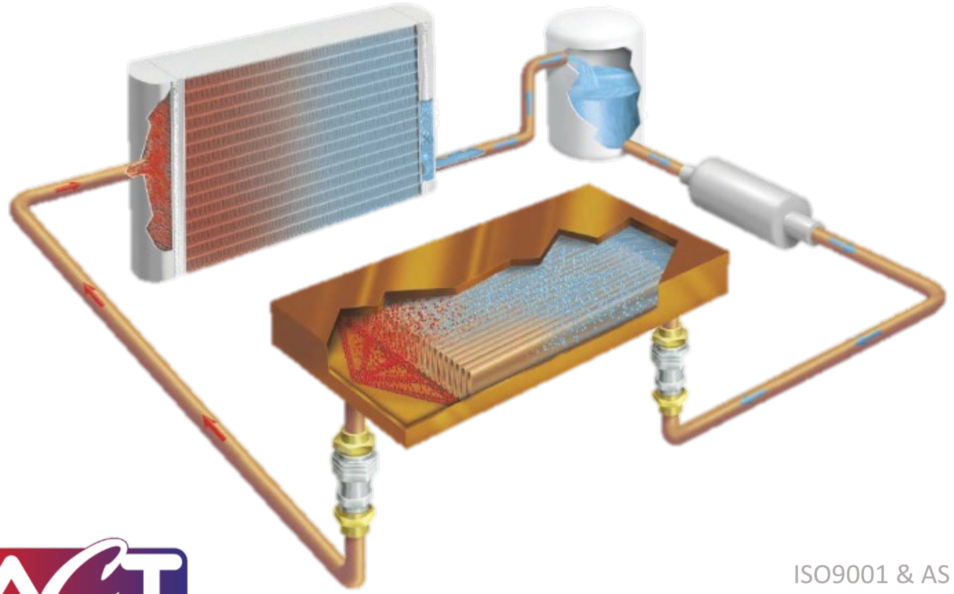




PUMPED TWO-PHASE COOLING

What is P2P Cooling?

- Above ambient liquid cooling system where the working fluid is allowed to boil and condense as it flows around the loop
  - Can be paired with chiller and liquid/liquid heat exchanger to provide cooling to below ambient conditions

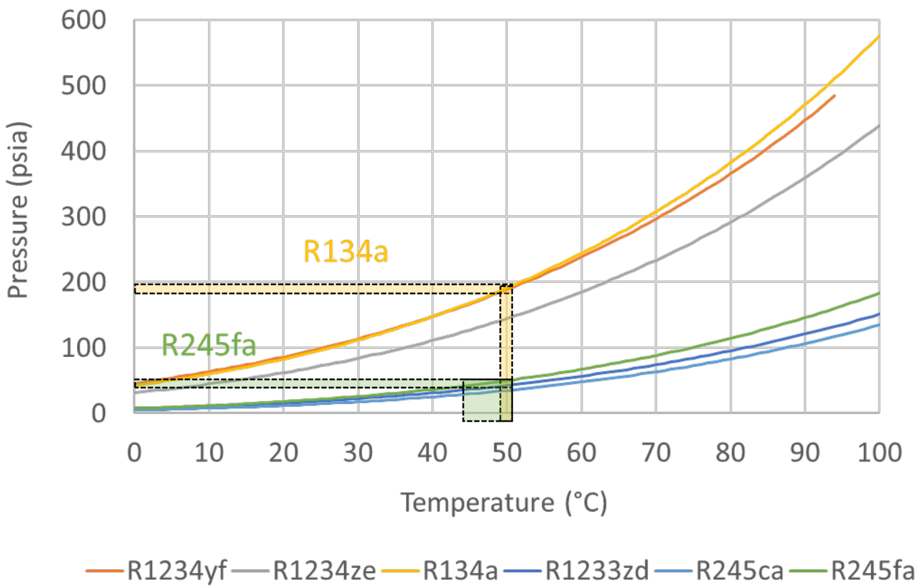


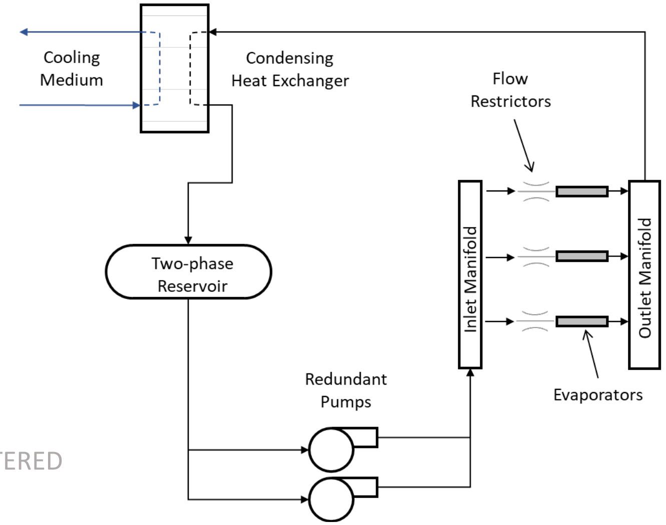
Benefits of P2P Cooling:

- Utilizes the latent heat of the working fluid as opposed to sensible heat in Glycol Coolers
- Working fluid operates between sub-cooled liquid and saturated liquid thermodynamic states
  - Typically the vapor quality is maintained below 80%
- Constant temperature heat absorption
  - Fluid ΔT around the loop is often less than 10°C (mostly a result of pressure drops)
  - Cold plate surface (evaporator) ΔT is often less than 5°C

P2P DESIGN CONSIDERATIONS

- Requires P2P specific evaporators for cooling components
  - Conduction-based evaporators (i.e. cold plates) and air-to-refrigerant evaporators (i.e HX coils) are possible within the same system
- Passive or active flow balancing is required for parallel evaporators
- Working fluid selection has impact of efficiency of the system
  - Regulatory implications of using some high GWP refrigerants
- Pumps must be suitable for low viscosity fluid transport and have minimal NPSH





P2P APPLICATIONS

- Air-cooled and Liquid cooled condensers are possible depending on the application
- Since P2P utilizes the same refrigerants as vapor compression hybrid systems are possible
  - Improved energy efficiency by using above ambient cooling when the ambient is suitable and refrigeration when ambient are at their highest

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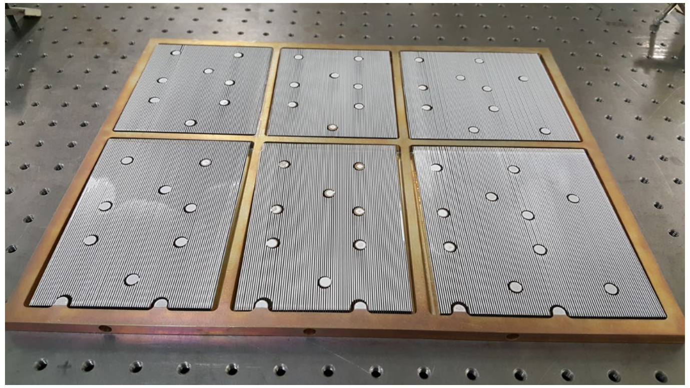
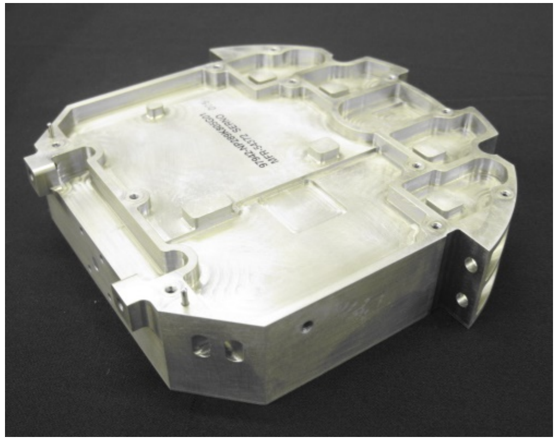
PHASE CHANGE MATERIALS

- Can be used to supplement air and liquid systems as well as electronics packages with transient heat loads

- In air systems, PCM can be used to damp out local intermittent loads while the system air handler provides constant supply air

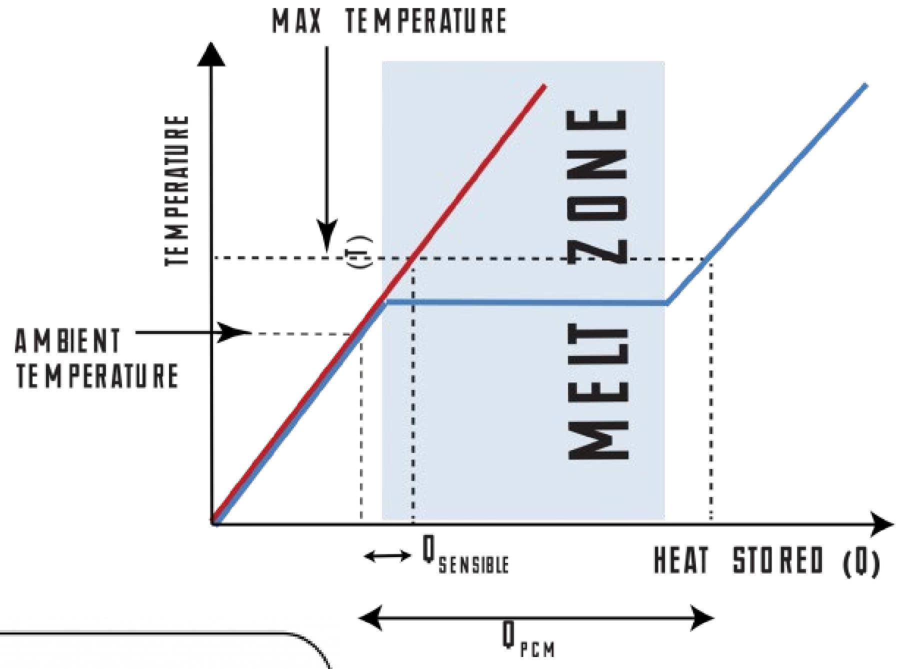
- In glycol systems, PCM can be used to reduce the size and weight of glycol storage to address intermittent system loads.
  - Highly effective for high energy laser and DEW applications

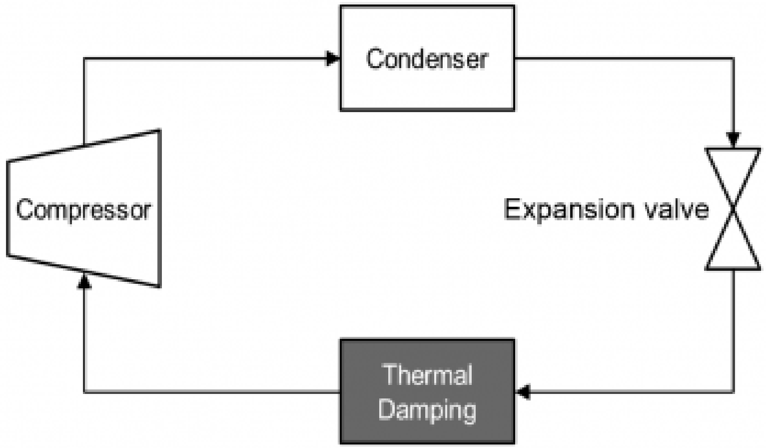


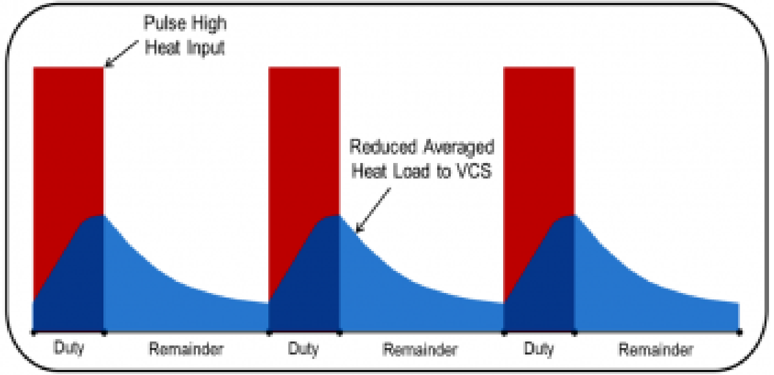


PCM DESIGN CONSIDERATIONS

- Material selection dependent on required temperature control range and SWaP considerations
- PCM HX can be implemented directly with a VCS to absorb peak transient loads reduce compressor capacity requirements
- Heat transfer path into PCM is critical to optimize material utilization and minimize temperature gradients
- PCM materials are available in a wide range of melt temperatures from -60°C to +400°C

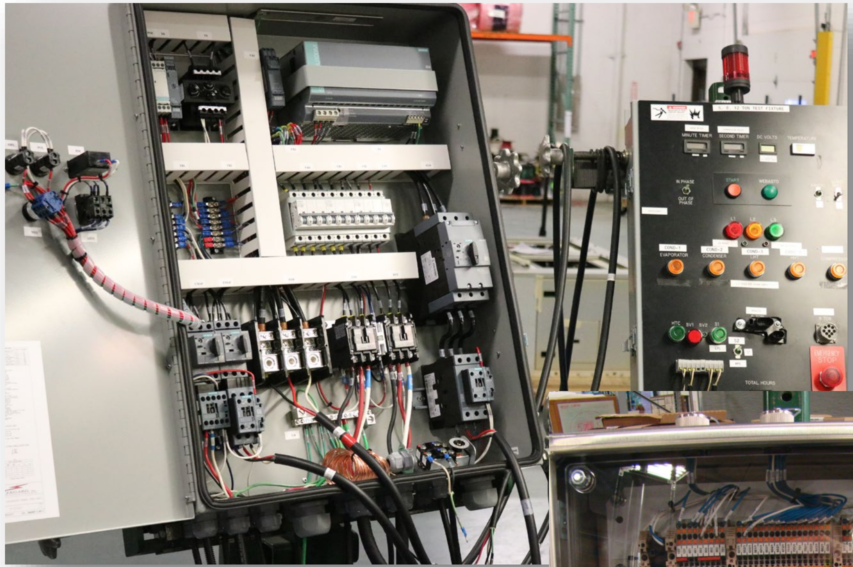


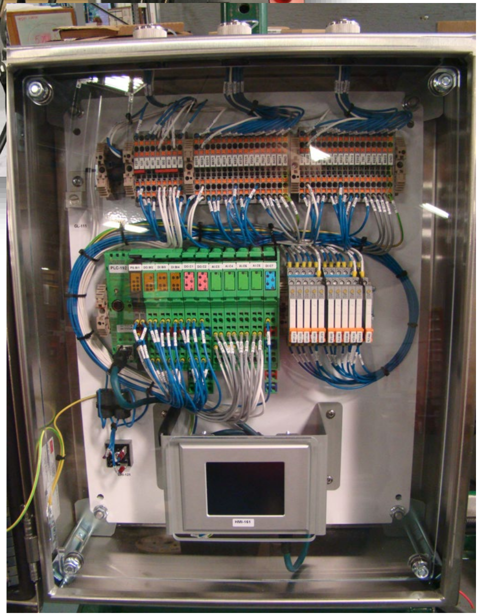




SYSTEM CONTROLS CONSIDERATIONS

- What temperature is being controlled?
  - Return air/glycol (occupied spaces)
  - Supply air/glycol (electronics and managed airflow)
  - Critical location in the system
  - Humidity?
- Power draw, Inrush events
- Fan/Pump speed modulation
- Electromechanical Controls, Digital Temperature Controllers, PLC (Programmable Logic Controllers)
- Local control interface
  - ON/OFF, Analog Blue-Red dials, Mode selection, Touchscreen
- Remote connectivity
  - Ethernet based communications (Modbus, SNMP, TCP/IC, Etc.)
  - Discrete digital/analog signals

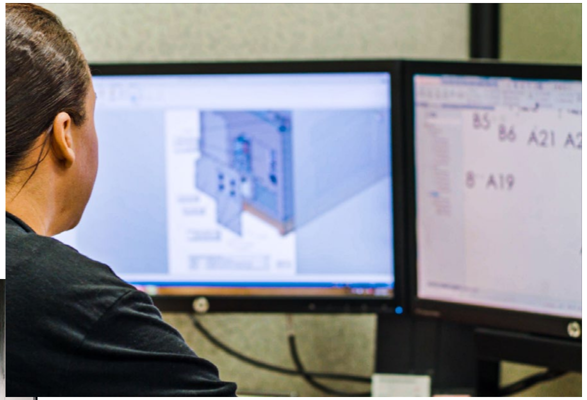




ACT CAPABILITIES

Being involved in your project early allows us to create a better system

- System Requirements Definition
- Preliminary Design Phase
- Critical Design Phase
  - Mechanical packaging for Environment Requirements
  - EMI mitigation
  - Reliability analysis
- Procurement
- Manufacturing
- Testing
  - Thermal performance in-house testing
  - Environmental testing as national labs
- System Support
  - Operations and Maintenance Manual
  - Spare Parts / Replacement Procedures
  - Component Obsolescence
  - Training
  - Service and Support
  - Repair and Reset



QUESTION & ANSWER SEGMENT

- Enter your questions into the question panel to the right of your screen

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