FEDERAL UTILITY PARTNERSHIP WORKING GROUP SEMINAR

November 2-3, 2016
Bellevue, WA

DOE FEMP "Call For Innovation" Award Winner 2016

High Efficiency Dehumidification System (HEDS)

New Technology Update: 30%+ Savings from HVAC Optimization

Hosted by:

FEMP Federal Energy Management Program

PSE PUGET SOUND ENERGY

Discussion Topics

- This presentation will discuss several different methods that are currently utilized for Relative Humidity (RH) control in DoD facilities and some of their comparative strengths and weaknesses.
- The main focus of the discussion will be on the "High Efficiency Dehumidification System" or "HEDS" that is in the process of undergoing testing thru the ESTCP process.
- HEDS Recently won the inaugural DOE FEMP nationwide "Call for Innovation" competition, and has been showing 30%+ BTU savings for the cooling/dehumidification /reheat RH control process at the two ESTCP test sites.
- The appendices contain FAQ's for HEDS.

Why was HEDS originally created?

- **To solve massive energy waste and mold growth problems for our Military!**
- The HEDS inventor, Scot M. Duncan, P.E., is an Energy Efficiency and Relative Humidity control “Subject Matter Expert” for the U.S. Army Corps of Engineers (USACE). The High Efficiency Dehumidification System or “HEDS” was developed because we got sick of seeing mold growth in the living spaces of the military facilities that we were evaluating for energy efficiency upgrades.
- ***Current HVAC designs actually promote mold growth at many facilities!***

Why was HEDS Created (Cont'd)

- **In many places, our fighting men and women are literally living and working in mold-infested facilities, this is so WRONG!**

  These Patriots are willing to fight for our freedom, and potentially give up their lives for us, they should not be living and working in moldy rooms. The facilities maintenance people do their best to kill the mold, but it grows back very quickly due to the design and control of the Heating, Ventilation and Air Conditioning (HVAC) systems. Currently, it is a losing battle.
- A USACE engineer asked us to solve the mold growth problem in a manner that was lifecycle cost effective, energy efficient, and easy to maintain. HEDS is the result, and the ESTCP field tests being conducted for the DoD are showing that we can reduce the total cooling and heating energy required for relative humidity control by greater than 50% at the two test sites.
- The current methods of performing Relative Humidity (RH) control in Commercial, Industrial and Institutional (CII) facilities wastes billions of kWh and BTU's each year. Poor RH control wastes hundreds of $millions each year due to lost products, lost productivity, mold growth, facility reconstruction, abatement and remediation, negative health impacts and excessive sick days.

ASHRAE 90.1 Almost Mandates HEDS!

Standard 90.1-2013 addresses dehumidification in Section 6.4.3.6, which states the following:

Humidity control shall prevent the use of fossil fuel or electricity…to reduce RH below 60% in the coldest zone served by the dehumidification system.

Section 6.5.2.3 further prohibits this strategy of cooling with reheat by stating:

Where humidity controls are provided, such controls shall prevent reheating, mixing of hot and cold airstreams, or other means of simultaneous heating and cooling of the same airstream.

Included in Section 6.3.2 of Standard 90.1-2010 is the following:

i. The system controls shall not permit reheat or any other form of simultaneous heating and cooling for humidity control.

ASHRAE 90.1 is a huge deal for Dehumidification /Reheat systems

- ASHRAE 90.1 will not allow current cooling/reheat systems to be replaced with the same system that is being taken out!
- Something different must be done!
- HEDS can be the solution you are looking for!

Very Important! How to use HEDS financial benefits to help your clients get more done:

Example: Combine 3, 5 or 7 year payback HEDS projects with 20 year paybacks to get larger projects with 15 year paybacks.

	HEDS	Other	total
Cost	$ 1,000,000	$ 16,000,000	$ 17,000,000
Savings	$ 333,333	$ 800,000	$ 1,133,333
Simple payback	3	20	15.0
	HEDS	Other	total
Cost	$ 1,000,000	$ 8,000,000	$ 9,000,000
Savings	$ 200,000	$ 400,000	$ 600,000
Simple payback	5	20	15.0
	HEDS	Other	total
Cost	$ 1,000,000	$ 4,600,000	$ 5,600,000
Savings	$ 143,000	$ 230,000	$ 373,000
Simple payback	7	20	15.0

How to benefit your clients

- Current projects in CA are showing 2 year payback periods, but CA has very high electric rates and a pretty decent Energy Efficiency Incentive Program.
- The average rate on the CA projects is $0.13 per kWh and $8.00/MMBTU and the incentives are about $0.15/kWh saved.

Sample Project Matrix

<table>
<tr><th>Project Name</th><th>Project Type</th><th>Project Simple Payback/ ROI %</th><th>Annual Electrical kWh savings for Dehumidification/ Reheat Process</th><th>Annual Therms savings for Dehumidification/ Reheat Process</th><th>Approximate % total BTUH Savings for Dehumidification/ Reheat Process</th></tr>
<tr><td>UC Irvine Medical Center</td><td>Operating and Post-Op Rooms</td><td>Over $100,000 per year.
Over 50% ROI.</td><td>GT 40%</td><td>100%</td><td>GT 60%</td></tr>
<tr><td colspan="6">Equivalent to VA Medical Centers and all hospitals around the globe that need RH- controlled spaces.</td></tr>
<tr><td>XXXXX (Well known Manufacturer)</td><td>Semiconductor Manufacturing/clean rooms</td><td>Over 50% ROI</td><td>GT 40%</td><td>GT 40%</td><td>GT 45%</td></tr>
<tr><td colspan="6">Equivalent to any lab or manufacturing/R&D facility that uses high % of OSA and needs RH control.</td></tr>
<tr><td>Fort Bragg, NC</td><td>DFAC Kitchen</td><td>ESTCP Test Site</td><td>40% to 60%</td><td>100%</td><td>55% to 65%+</td></tr>
<tr><td colspan="6">Equivalent to DFAC's and commissaries around the globe. From a comfort perspective, kitchens are one of the nastiest places to work on a base. At this site, the kitchen is now more comfortable than the serving and dining areas because of HEDS.</td></tr>
</table>

Sample Project Matrix (cont'd)

Project Name	*Project Type*	*Project Simple Payback/ ROI %*	*Annual Electrical kWh savings for Dehumidification/ Reheat Process*	*Annual Therms savings for Dehumidification/ Reheat Process*	*Approximate % total BTUH Savings for Dehumidification/ Reheat Process*
Tinker AFB, OK	Office area	ESTCP Test Site	35% to 60%	100%	50% to 75%+
Equivalent to any and all office spaces in high RH areas. HEDS eliminated "musty" smell and keeps the area comfortable, even when the chiller is delivering 55°F to 60°F chilled water supply temperatures due to pre-existing equipment failures.					
Tinker AFB, OK Corrosion Control Facilities	Aircraft and Paint Hangars 700,000 CFM of 30% OSA (Proposed new Construction)	Estimated lower first cost than base case. GT 100% ROI	30% to 60%+	100%	Typical 50% to 80%+
A White Paper developed by R.O.I. for the proposed new 700,000 CFM CCF's is showing the ability to keep the space at 72°F +/-2°F and 50% RH +/- 5% with substantially lower energy input than using the status quo design strategy.					
Fort Schafter, HI (Estimated Costs and Savings)	147 room Barracks	Estimated at 2.5 years without utility incentives.	**Over $300,000 per year for a single 147 room Barracks**	N/A Electric strip heat is the reheat source.	GT 45%

Oddball Project that can save 10’s of $millions

- Fort Benning is in the process of mothballing 50 to 60 barracks.
- If they do not run the HVAC in these empty buildings to keep them dried out, they will become completely mold infested in a few weeks in the summer.
- When they are needed again, they will have to be completely abated, then rebuilt, at a cost of several million $ each.
- We have developed a HEDS unit specifically for this duty, that actually reclaims 100% of the electrical, chiller, pump, thermal and fan energy (even the latent heat is 100% reclaimed) to provide very low RH air into each of the rooms.
- We call it the 100% Energy Recovery HEDS, or “100% ERHEDS” for short.
- Yes, it is an unfortunate acronym, but it is memorable!

HEDS for Naval Vessels

- We are just starting to work with the Navy to see if HEDS might be appropriate for their ships.
- We do not know if it will make sense yet, but it is a very cool idea brought to us from the folks in Bethesda, they are very out of the box thinkers.
- If a ship has a home port in your service territory, can it fall under a UESC?

Comparative Baselines at DoD and Nationally

Industry "State of the Art" is 100 Years Old

Baseline in most DoD buildings/installations for the demonstrated technology comes in several variations.

1. The simplest and by far the most widespread comparative baseline system consists of an AHU with a chilled water or DX refrigerant sourced cooling coil that cools the air down to between 52F and 55F to remove moisture from the air via condensation, then utilizes a heating coil, either sourced by hot water or an electric reheat coil to raise the supply air temperature to lower the Relative Humidity of the air entering the spaces, drying the spaces out.

    a. Due to the high cooling, heating and electrical energy consumption of these designs and the fact that many installations shut their heating systems off during the summer, the reheat portion of the dehumidification process is typically shut down.

    b. This allows 100% water saturated, 100% Relative Humidity, very cold supply air to enter the occupied spaces. When this cold, water saturated air comes in contact with solids in a space, condensation can occur.

    c. Wherever there is condensation, there is the high likelihood of unwanted biological growth occurring, which will later require substantial expense to remediate.

Comparative Baselines at DoD and Nationally (cont.)

2. Other comparative dehumidification systems consist of variations of high pressure AHU's equipped with some form of desiccant wheel that absorbs moisture from the supply air without requiring cooling to dry the air out via condensation of moisture.

   The relatively new desiccant wheel based Dedicated Outdoor Air System (DOAS) system usually requires a substantial amount of ductwork, over and above that required for a HEDS unit, as the exhaust air, plus a substantial amount of added heat, are used to dry out the chemicals in the desiccant wheel so that the process can begin anew.

   The relative downsides of these desiccant wheel based systems may include a very high construction cost, higher operational costs, higher energy use, specialized and higher maintenance requirements that are typically not available in facility maintenance budgets, and maintenance manpower skills that are not typical at the installations.

Simplicity Advances the State of the Art

- The HEDS design was born out of the global need for a simple to operate, simple to maintain, simple to understand, energy efficient, cost effective, sustainable way to reduce biological growth and promote occupant health, comfort and productivity.
- At energy efficiency projects for a multitude of installations in a variety of climates, we found mold present in a widespread manner. The facility maintenance and operations staffs were all aware of the situation, they were all concerned about the mold growth and they were doing what they could to kill the worst case growths, but when the HVAC system is working against them continually, they were never able to win the battle, let alone win the war, against biological growth.
- The usual culprits were poorly designed HVAC systems that were never designed for relative humidity control, the lack of heat to perform reheat duties to lower the RH of the supply air, and failed DOAS units due to complexity and lack of maintenance funds and skill sets.
- **Faced with the status quo of rampant mold growth in many facilities, the challenge was to develop a dehumidification system that did not need new, added energy for reheat and that could be maintained by an operator with the skill sets to maintain a normal chilled water based AHU.**

Attribution

- Many figures and substantial information for the older dehumidification technologies are excerpted from or based on several articles written by***: Donald P. Gatley, P.E. President, Gatley and Associates, for HPAC Engineering Magazine in 2000.***
- For more details on the older technologies, Mr. Gatleys' articles are available on-line.

Run Around Coil System Piping

Can hurt CHW system TD, no temperature control, much longer AHU, Higher air pressure drop, more fan energy, condensate re-evaporation when blown off CC,

not scalable to FCU sizes

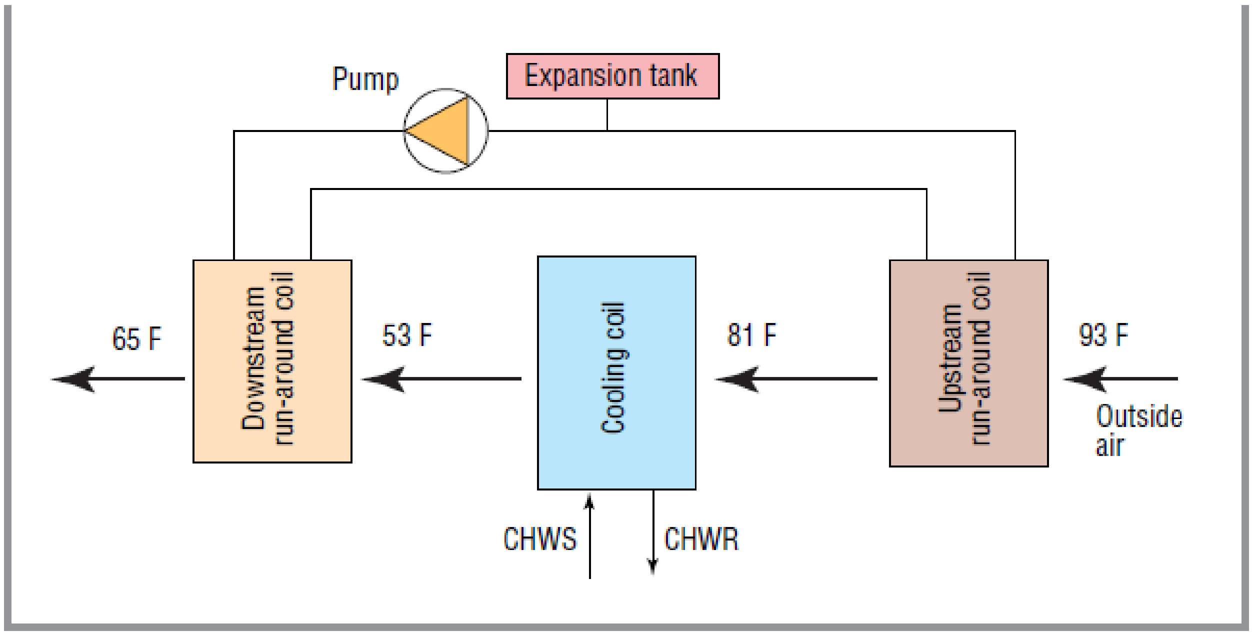


FIGURE 3. Run-around-coil piping.

Run Around Coil

Can hurt CHW system TD, no temperature control, much longer or taller AHU, Higher air pressure drop, more fan energy, condensate re-evaporation when blown off CC,

not scalable to FCU sizes

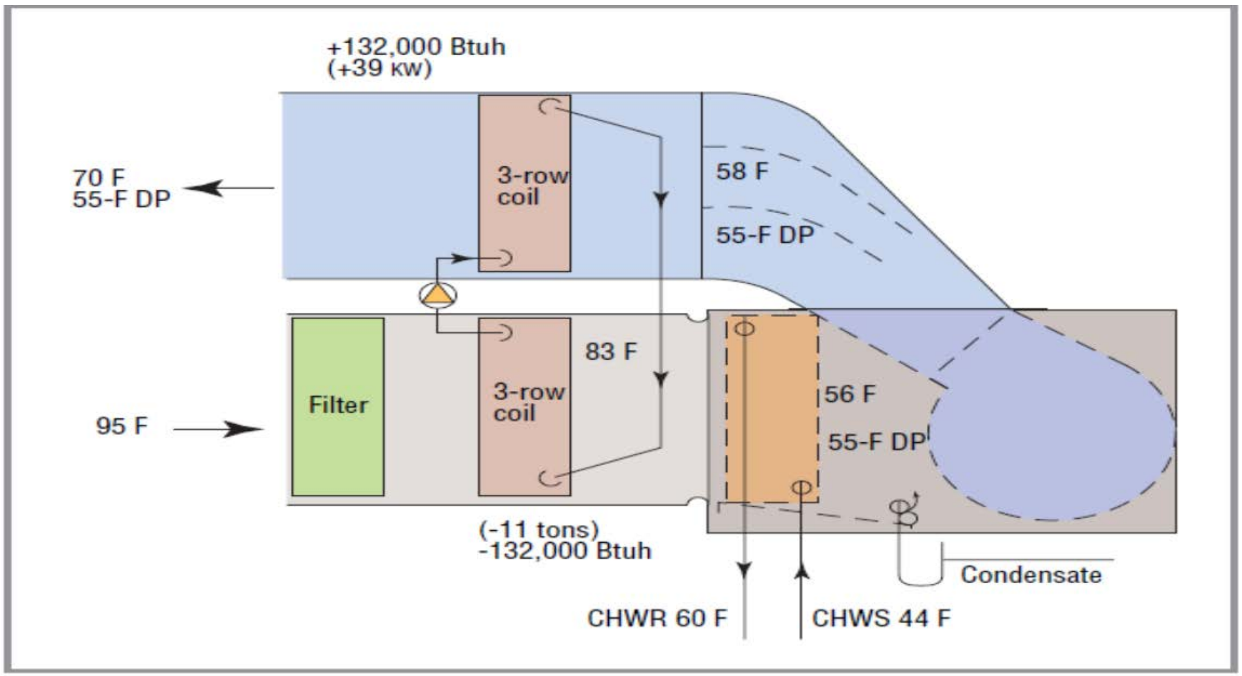


FIGURE 4. Run-around coil.

Heat Pipe Coils

Can hurt CHW system TD, no temperature control, much longer or taller AHU, Higher air pressure drop, more fan energy, condensate re-evaporation when blown off CC,

not scalable to FCU sizes

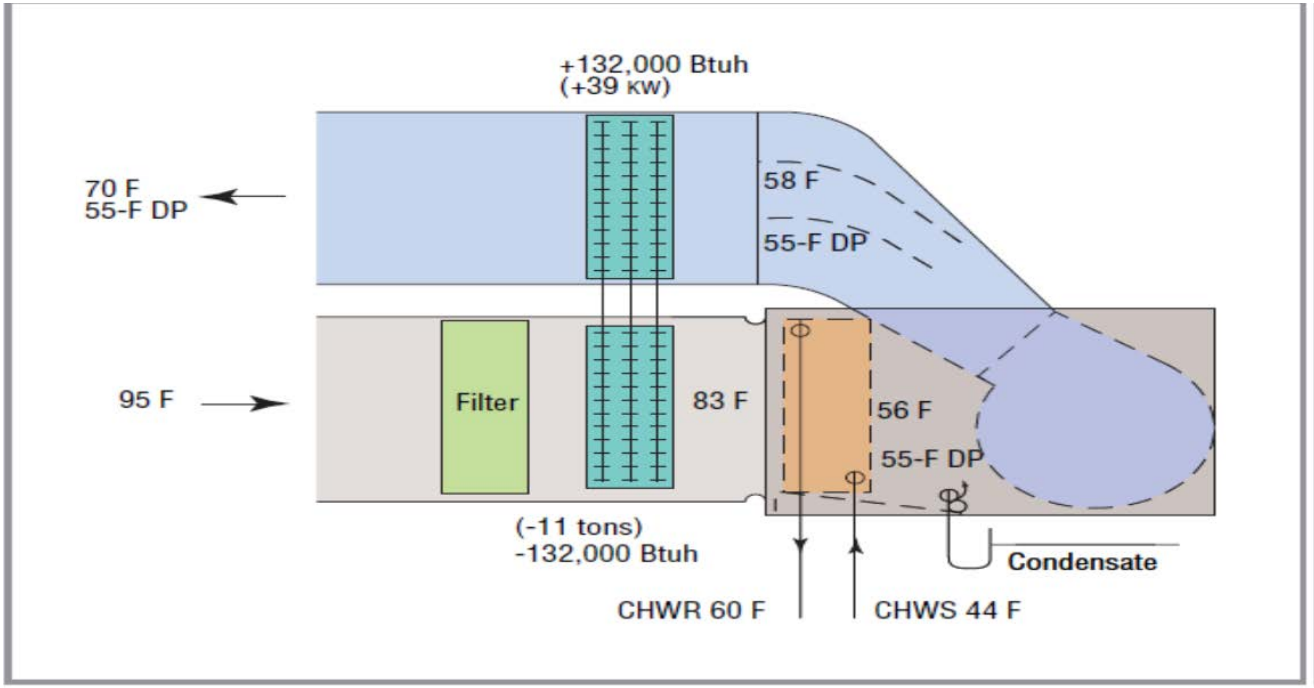


FIGURE 5. Heat-pipe coil.

Air to Air HX

Can hurt CHW system TD, no temperature control, lots more ductwork, longer or taller AHU, maintenance issues, Higher air pressure drop, more fan energy, condensate re-evaporation when blown off CC,

not scalable to FCU sizes

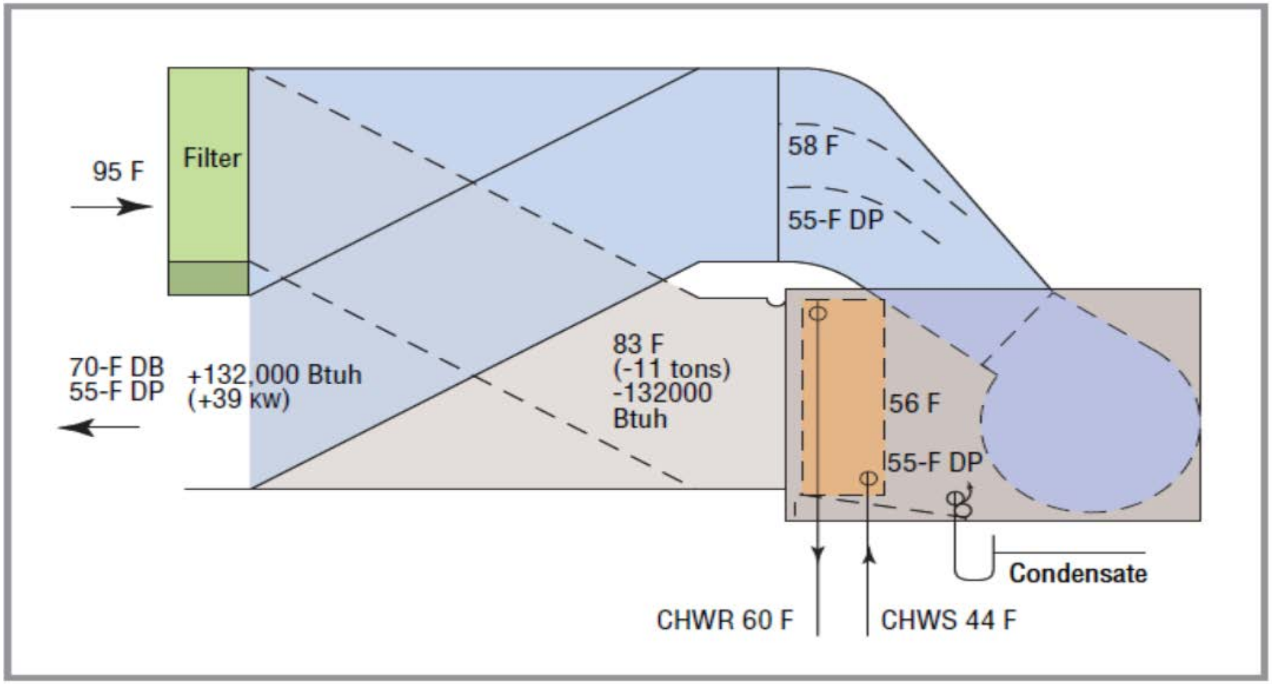


FIGURE 6. Air-to-air heat exchanger.

Rotary Wheel HX

Can hurt CHW system TD, no temperature control, much larger AHU, Higher air pressure drop, more fan energy, added regeneration heat energy with some desiccant designs, condensate re-evaporation when blown off CC,

not scalable to FCU sizes

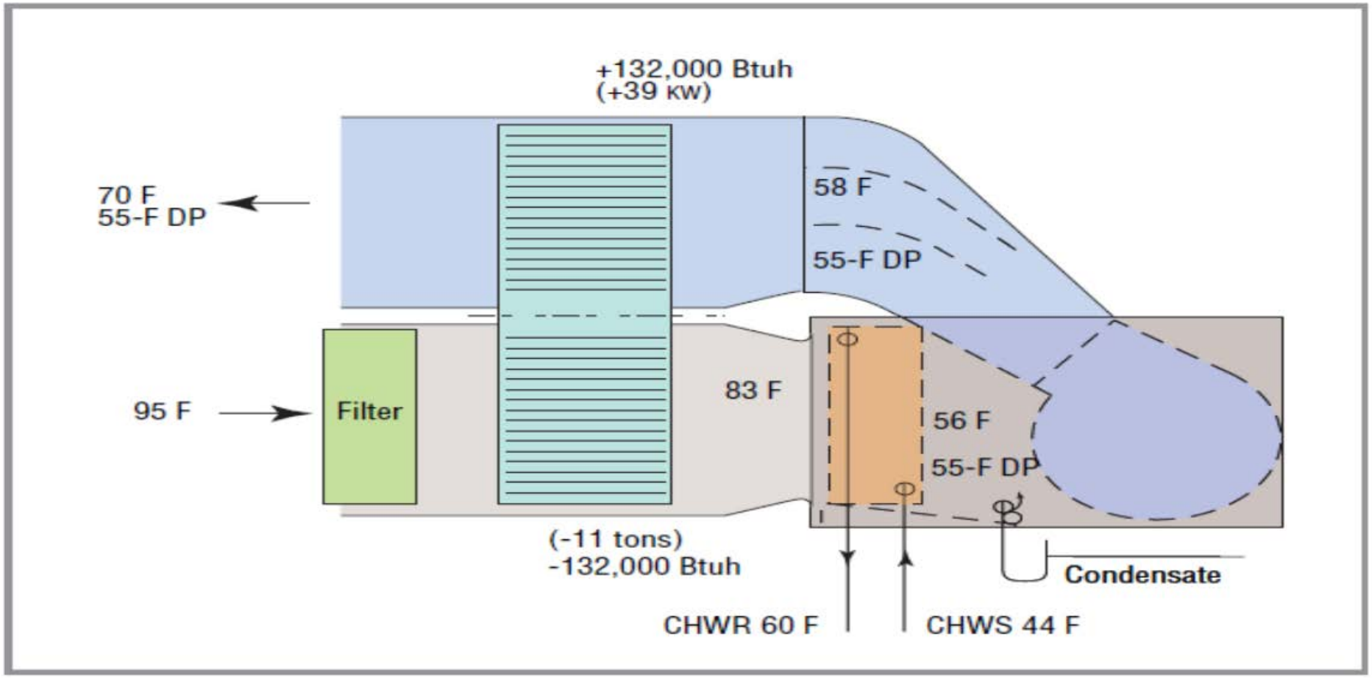
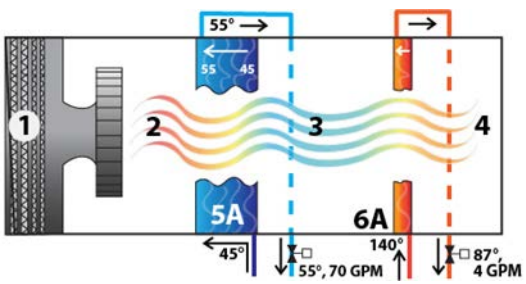


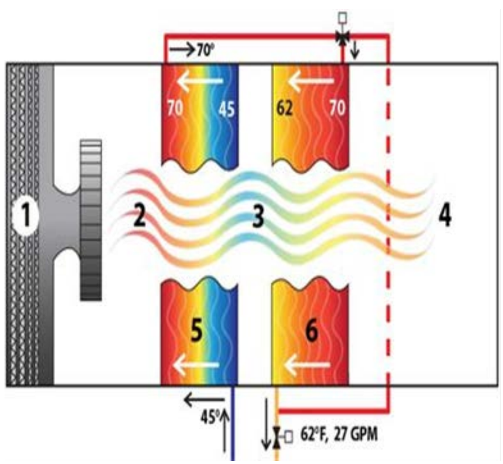
FIGURE 7. Rotary-wheel heat exchanger.

HEDS Comparison to "Normal" Dehumidification/ Reheat AHU



Traditional AHU Designed for Dehumidification Duty. Small cooling and reheat coils, high CHW flow rates, low CHW temperature differential and high AHU air pressure drops. 45°F CHW enters the cooling coil (5A) at 70 GPM and leaves the cooling coil at 55°F. A new source of 140°F water enters the reheat coil (6A) at 4 GPM and leaves the reheat coil at 87°F. The unit requires **479,319 BTU's per hour** to cool, dehumidify and reheat 10,000 CFM of air at the design conditions in this example

Data Points 1 thru 4: [1] 10,000 CFM airflow [2] 78°F dry bulb temp, 65°F wet bulb temp [3] 55°F dry bulb, 55°F dewpoint, essentially 100% relative humidity [4] 65.3°F dry bulb, 55°F dewpoint, 55% RH



High Efficiency Dehumidification System (HEDS) AHU (53% Peak Day BTUH Savings) Very large cooling and cooling recovery coils, low CHW flow rates, high CHW temperature differential and low AHU air pressure drops. 45°F CHW enters the cooling coil (5) at 27 GPM and leaves the cooling coil at 70°F. This 70°F water then enters the CRC coil (6) at 27 GPM and leaves the CRC coil at 62°F while heating the air to 65°F. The HEDS unit requires **226,187 BTU's per hour** to cool, dehumidify and reheat 10,000 CFM of air at the same conditions**, a BTUH savings of 53% and a CHW flow reduction of 62% in this example.**

Blue=Cold Temperatures, Yellow to Red = Warm to Hot Temperatures.

Excerpts from FEMP Competition follow

- **What is HEDS?**

- The technology is so simple that it will change the way that dehumidification and reheat are performed, while driving energy, maintenance and construction costs lower.

- It is so simple that the Patent office took us thru 4 years of reviews prior to issuing a Patent, they could not believe that no one had thought of this before.

- The HEDS unit is essentially a standard AHU, equipped with a very large face area and depth cooling coil designed to deliver very warm chilled water (CHW) return temperatures, and a "Cooling Recovery Coil" (CRC) designed to reclaim the wasted low quality heat that was generated in the cooling process.

- Very high CHW return temperatures can be obtained from large cooling coils as evidenced by over 200 cooling coil systems that have been designed to deliver over 70°F chilled water return temperatures on hot summer days while serving sensitive occupants.

- By adding a high surface area Cooling Recovery Coil to provide reheat duties using waste heat to raise the supply air temperature for RH control in lieu of using boilers or electric heaters for the reheat energy source, the HEDS unit is born. The CRC accomplishes 3 things – it reheats the air, creating non-saturated conditions to reduce the potential for biological growth and also reduces the loads on the chiller and boiler plants by the amount of energy that is used to reheat the air.

FEMP Info, (cont'd)

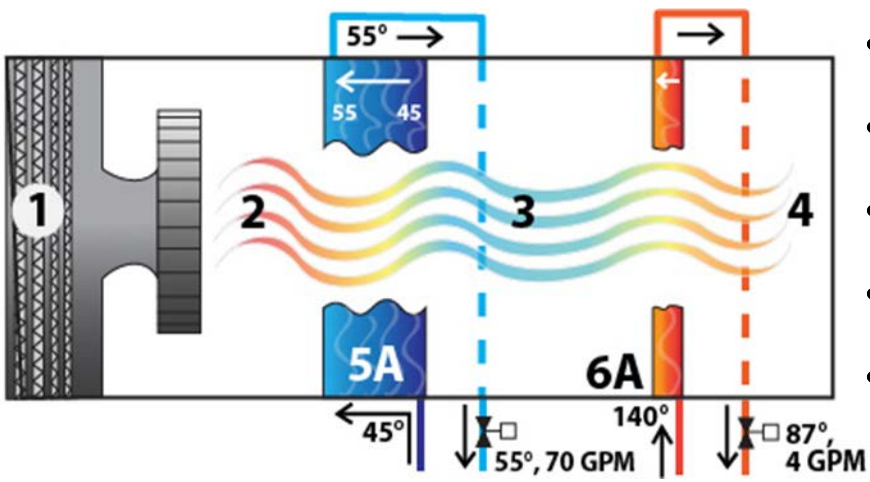
- Where else can you get a 15% to 50% Return On Investment (ROI) on retrofit projects, while improving the lives of our Federal workers and fighting men and women at the same time?

- The ROI can actually be in excess of 100%.
- (Potentially lower first cost than the alternatives)
- If you must comply with ASHRAE 90.1, HEDS may be the least cost alternative, in addition to being the most energy efficient option.

- On new construction or large rehab projects, or where facility expansions have exceeded the capacity of the chilled water plant and/or CHW distribution system, the first cost for a HEDS-based retrofit project may be lower than the base case retrofit or expansion project, so the ROI can actually be in excess of 100%.

Technology Snapshot – Typical Base Case

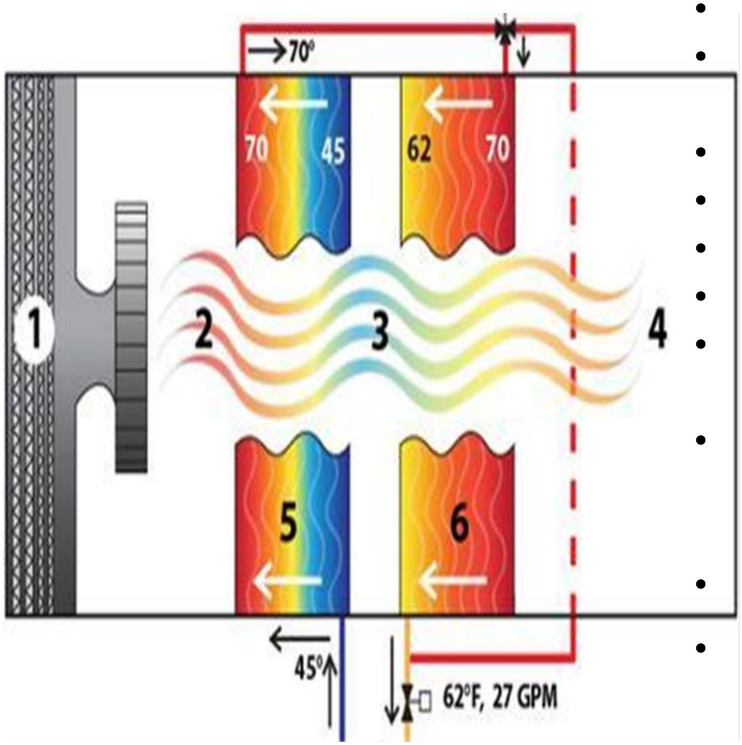
Conventional AHU - Requires new energy for reheat and greater chiller energy use



- Small cooling & reheat coils
- High CHW flow rates
- Low CHW temperature differential
- High AHU air pressure drops
- Propensity to suffer “Low Delta T Syndrome”

Technology Snapshot – HEDS Unit

HEDS AHU - Recovers at least 20% of cooling energy and eliminates 100% of reheat energy for RH control on peak load days



- Very large face area & depth cooling & cooling recovery coils
- Low CHW flow rates/high CHW TD
- High CHW temperature differential
- Low AHU air pressure drops due to large face area and low face velocity
- Delivers cool, dry air in an energy efficient manner
- Reduces Infrastructure, Operation and Maintenance Costs
- Eliminate “Low Delta T syndrome”
- Reduces pumping and chiller energy use
- Allows chillers to be piped in series to further improve chiller capacity and energy efficiency
- Reduces water consumption where evaporative cooling towers are used due to lower cooling plant loads and improved system efficiency
- Increased cooling capacity at lower CHW flows
- Increases CHW system infrastructure delivery capacity via approximately 2x the CHW system TD, saves infrastructure $$$.
- Works for ASHRAE 90.1 Compliance

72°F Space Temps at lower energy use than 78°F

- **Everyone HATES the 68°F/78°F temperature mandates, and there is a reason:**
  Comfort, productivity, physical well-being, attitudes and morale all drop when you have to work in a hot and muggy 78°F indoor environment. Mold grows when too much moisture is in the air and it is too warm.
- HEDS can deliver a cool and dry 72°F indoor environment at lower energy and lifecycle costs than the typically installed HVAC system can deliver hot and muggy 78°F indoor temperatures!
- **Non-HEDS** **78°F - Hot, muggy, and wastes energy**
- **HEDS** **72°F - Cool, dry and saves energy**

Preliminary DoD ESTCP Test Results: Fort Bragg NC, and Tinker AFB, OK

- The first set of trend data below for the Tinker AFB HEDS test site shows what the cooling and dehumidification cooling load would have been without the HEDS design and control system in place, in the top, red line. The line directly below that, in green, shows the actual cooling load that was imposed on the chiller plant, when the HEDS control system was enabled, all in real time.

Tinker AFB HEDS ESTCP

- The area between those curves is the amount of load that was taken off of the chiller plant. When converted to BTUH, it is also the amount of new reheat energy that was avoided by using the HEDS technology.

Tinker AFB HEDS % savings

- The trend graph directly below shows the cooling BTUH savings % based on the information above.
- What is not shown here is that the natural gas energy that would have been required for relative humidity control has been eliminated – it is reduced by 100%.
- Full summer data has not been completely analyzed, but it looks like the floor of the BTUH savings may be around 25% to 30%.

Fort Bragg HEDS % Savings

- The trend graph for Fort Bragg, below, is showing 40% to greater than 60% cooling BTUH savings. As with the Tinker AFB test site, the natural gas energy that would have been required for relative humidity control has been eliminated – it is reduced by 100%, for a total BTUH savings of 55% to 75% or more.

- Full summer data has not been completely analyzed, but it looks like the floor of the BTUH savings may be around 25% to 30%.

Double Energy Reductions + Water Savings too!

- Eliminating the reheat load required for RH control reduces the total load on the chiller plant, piping system and cooling towers – for every 1,000,000 BTU's added for reheat, 900,000 BTU's are added to the cooling load, in a typical recirculated-air system with a 10% OSA fraction. HEDS eliminates this added cooling load, allowing the cooling capacity to be used elsewhere, or saved.

- Many chiller plants and many power generation stations cool their equipment by evaporating water. With HEDS reducing RH-control related cooling energy in excess of 30% and reheat energy by 100% in most cases, both site energy consumption and the need for source energy production are reduced.

- Both of these events reduce the amount of water and chemicals consumed for the respective processes.

Fossil Fuel Reductions

- HEDS falls perfectly into the mandates to reduce fossil fuel use, as we eliminate 100% of the reheat energy required for RH control in the summer. The typical reheat method is by using a hot water reheat coil. The coil is sourced by boiler systems, typically fed by oil or natural gas fuels. Boiler system efficiencies in the summer, when loads are much lower, are very poor, so saving 1 MMBTU at the reheat coil may be the equivalent of saving 2 MMBTU at the inlet to the boilers.

UESC/ESPC – Deep Dive Projects

- HEDS can provide such a significant energy savings, and capital cost reduction on facility expansions, that it will allow more comprehensive UESC/ESPC projects to be undertaken.

- **HEDS is not an "incremental" savings – it is a savings that can drive other projects.**
- For the projects that we have looked at to date, in southern California, with actual construction bids provided by contractors and energy and cost savings calculated by 3rd parties, we are seeing 40% to 50% ROI's – 2 year to 2.5 year simple paybacks.
- If you combine HEDS with other needed facility upgrades that may not have stellar ROI's, such as chiller and cooling tower replacement projects, which are capital intensive, you can deliver a more comprehensive solution.
- In many parts of the Country, the utility rates will be lower, so the ROI's may fall to the 15% to 20% range for likely projects, this is still high enough savings to create a more comprehensive project.
- In tropical climates, or areas around the globe with very high utility costs, ROI's may exceed 50%, and ROI's for facility expansions or new construction can exceed 100% - HEDS can have a lower first cost than the alternatives.

UESC/ESPC – Deep Dive Projects

(Cont'd)

- **Where it works:**

- HEDS works pretty much anywhere there is a need for Relative Humidity control for at least a few months out of the year, the cooling loads are served by a chiller plant, and there is some room to install larger coils in existing AHU's. In the case of an AHU replacement project there needs to be room for a slightly larger AHU.

- In some locations that are equipped with large DX cooling systems, it may be cost effective to replace the DX system with a chilled water based system and use HEDS.

- **It is the only cost effective RH control solution for the tens of thousands of buildings on Bases and at Forts that were built using "2-pipe" water distribution systems – with a 2-pipe water distribution system, AHU's only get cooling in the summer and they only get heating in the winter – they cannot get heat for the re-heat part of the dehumidification/reheat process, so by nature, mold growth and the problems that go with mold, occur.**

- The design of HEDS uses recovered heat energy from the cooling loads as the reheat source, so there is no need for a new, added source of reheat energy for the RH control process.

Ease of retrofit to existing facilities;

- The two retrofit projects that have been installed to date thru the ESTCP testing process were relatively easy to install.
  - The HEDS unit at Tinker was able to be installed on the roof, using the same support columns as the unit that was removed.
  - The HEDS unit at Fort Bragg was able to be installed in the same indoor mechanical room as the unit that was removed. A slightly longer pad had to be installed for the HEDS unit.
- The two projects that have been bid but not installed are also easy to install:
  - The UCI Medical Center OR project HEDS unit fits in exactly the same footprint as the unit being removed.
  - The Semi-conductor clean room HEDS project does not require any additional space. The piping has to be modified in a 15' by 20' physical area, and the controls on 28 MAU's need to be upgraded to HEDS controls.
- The projects that we have looked at for the Tinker AFB 350,000 CFM OSA Corrosion Control Facilities (paint hangars) can have the HEDS technology applied in the same footprint that the present AHU's are built to fit.
- As noted elsewhere if the mechanical space is too tight and an alternate equipment location cannot be found, the HEDS unit may not be a good fit.

Energy savings potential

- For retrofit projects, we are seeing combined heating and cooling energy savings related to the dehumidification / reheat process of greater than 30%. Depending upon the utility rates and a bunch of other variables, this can equate to 15% to 50% ROI's.

- For new construction projects that incorporate the entire HEDS design philosophy, we expect to see capital cost reductions, as well as combined heating and cooling savings related to the dehumidification process at greater than 65%.
  - On many projects this will equate to an ROI exceeding 100%.

Lifecycle cost savings/HEDS Maintenance

- If you are able to include the avoided costs of mold abatement and facility reconstruction, HEDS would be the most cost effective HVAC option there is, especially in retrofit applications.

  Even without this real world benefit, the energy cost savings, and potential capital cost savings for larger projects can provide an excellent lifecycle cost, based on the projects that we have evaluated so far.

  The maintenance aspect of the HEDS unit is the same as a normal AHU. There are no desiccant wheels, motors, belts, face and bypass dampers and actuators, or all the other things that complicate the lives of the already overworked facilities maintenance staffs to go wrong.

Safety in installation and for building inhabitants

- This is where HEDS shines above all others. People living and working in properly ventilated and air conditioned facilities are healthier, more productive, happier and take fewer sick days than people in buildings that are not properly designed or operated.

  Anyone that has ever lived or worked in an environment that "smells musty" or feels damp and clammy, or has experienced mold growth in their home or work environment knows firsthand how bad and expensive the problem can become, very quickly. People get sick from and die from allergies to mold.

  It is a widely known but hidden fact that many facilities do not have properly designed HVAC systems, and that in order to lower the indoor temperatures in the summer, the amount of fresh air being brought into the building is dramatically reduced. In many cases, there is near zero fresh air going into the building for much of the summer. Reducing fresh air intake lowers the loads on the chiller plant, but it can create so many other problems that it is ridiculous.
- **I have seen this done at hospital operating rooms as well as less critical facilities. HEDS eliminates this problem.**

Manufacturability

- The HEDS units are essentially normal AHU's with larger heat transfer surface areas, and a novel set of control strategies, built into the unit controls. The controls can interface directly with LONworks, BACnet, Modbus, and approximately 100 other native DDC systems.

  The two HEDS units that are in field testing came right off the standard production line in the USA at a global integrated HVAC manufacturer, not out of their custom AHU shop. They are easy to build.

Added Benefits for You "Techies"

- Chiller plants using design and control strategies developed for HEDS implementations can require approximately 50% less energy than typically designed chiller plant systems, in addition to the 30%+ load reductions provided by HEDS.
- HEDS eliminates "Low Delta T Syndrome" by providing 14°F to 20°F+ chilled water Delta T's.
  - HEDS can reduce chilled water pipe, pump & VFD sizes, while also reducing energy, manpower and maintenance costs.
- High CHW system temperature differentials allow chillers to be piped in series, improving upstream chiller capacity and efficiency by 20% to 25%, with no negative effects on the downstream chiller capacity or efficiency.
- Piping infrastructure upgrade capital costs can be reduced or avoided completely.
- Cooling Loads that were not served properly due to CHW pipe size restrictions can now be served when using HEDS

Added Benefits for You "Techies" (Cont'd)

- Chiller Plant failures do not have the same effect on HEDS designs.
- HEDS can reduce chiller plant sizes, and lower the overall first cost on new construction projects.
- Reduces the square footage required by the chiller plant, reducing first cost.
- Reduces electrical infrastructure costs due to lower connected loads.
- Energy Efficiency Incentives are available from many utilities to further reduce first costs.
- AHU fan energy savings may be substantial due to lower AHU fan air pressure drops.
- The use of HEDS designed systems allows the use of recovered cooling energy for RH control, allowing the boilers to be shut down all summer, saving utility, manpower and maintenance costs.

Added Benefits for You “Techies” (Cont’d)

- Reduced reliance on fossil fuels/elimination of fossil fuel use during the summer for reheat energy for relative humidity control.
- Allows a greater percentage of the HVAC system energy to be provided by renewable energy.
- Reduced water and chemical use in the chiller plant cooling tower and power plant cooling tower systems, due to smaller systems and loads.
- Reduced total cooling loads and annual ton-hours due to reduced reheat energy on recirculated air systems.
- Ability to bring the facilities into temperature and RH compliance faster, means a reduced equipment run time, reducing lifecycle costs.
- HEDS is the most Lifecycle cost effective method to perform relative humidity control for bases/ facilities that have central plants with two-pipe chilled water and hot water distribution systems.

Technology/Methodology Description

HEDS is a "Cooling Recovery System" designed to reduce space Relative Humidity (RH) and improve occupant safety, comfort and productivity.

- Recovers 20% or more of the heat obtained during the cooling and dehumidification process to maintain RH control.
- Eliminates the need for new reheat energy on peak load days.
- Cuts the peak day need for new cooling and reheat energy by approximately 50%, while simultaneously reducing water usage in the cooling process.

Exceptionally large face area and depth of cooling coil dry the air out resulting in a relatively high chilled water temperature leaving the coil (above 70°F on peak load days).

- The 70°F water leaving the cooling coil can be used in a "Cooling Recovery Coil" to raise the temperature of the 48°F to 55°F air leaving the cooling coil to between 62°F and 68°F.
- Lowers the RH of the air entering the space, reducing the potential for condensation to occur and thus reducing the potential for biological growth.
- Also reduces the load on the chiller plant by exactly the amount of reheat energy added to the air for RH control.

HEDS Advances the State of the Art

At its core, the HEDS unit is just an AHU with really big heat exchangers for the cooling coil and cooling recovery coil that allows the very low quality heat captured in the cooling coil of an AHU to be used as the reheat energy source for space RH control.

This demonstration will verify whether or not HEDS can:

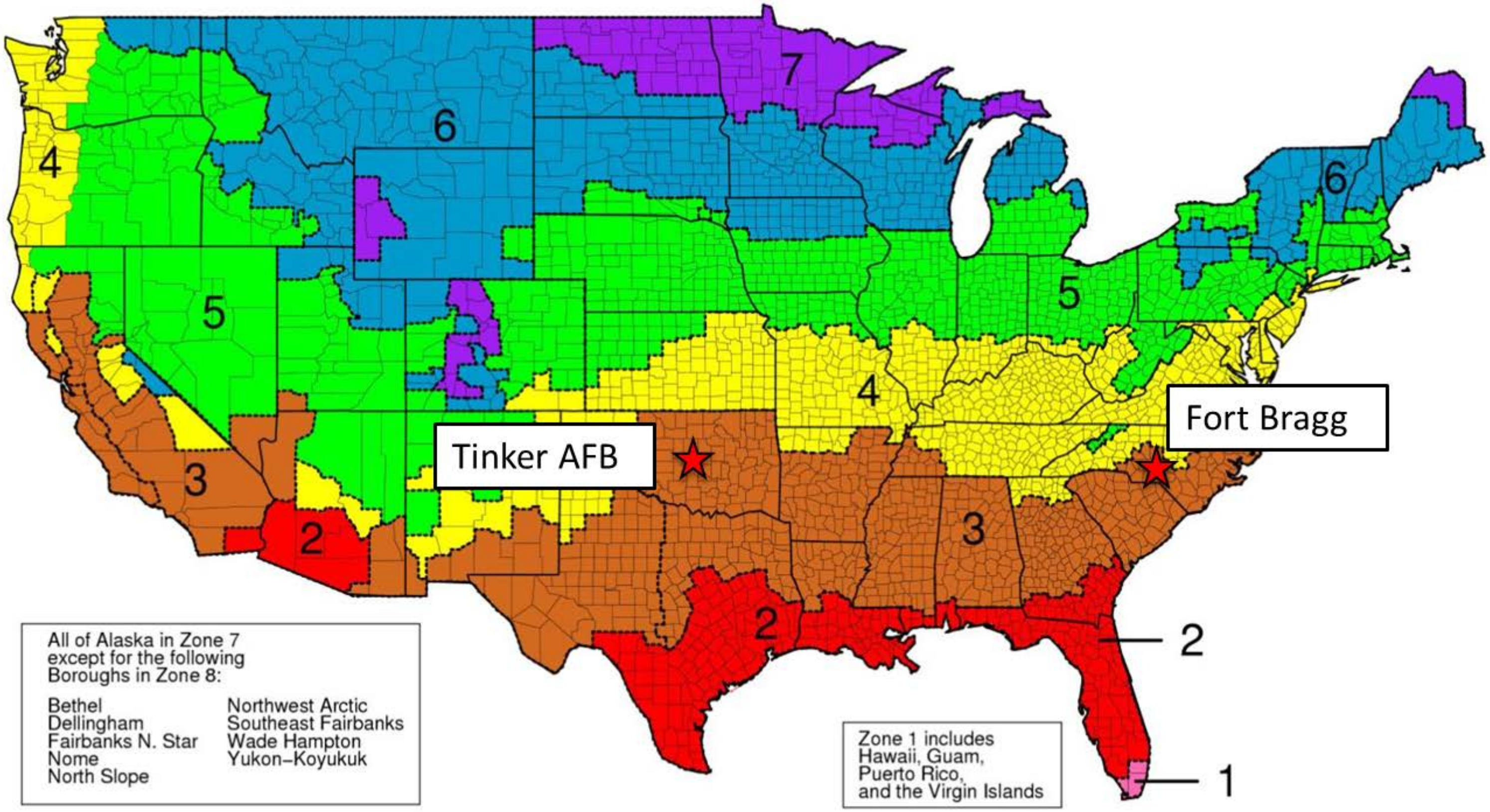
- satisfy all of the criteria for advancing the state of the art in a leapfrog from the current state of the art
- be simple to operate – the standalone controls work without connections to the site DDC system in case of site DDC system failure
- be simple to maintain – it is a normal AHU with big, low air pressure drop coils
- be energy efficient – it has the potential to reduce cooing and heating energy use associated with dehumidification/reheat by over 50% on peak load days
- be cost effective – depending upon the facility, HEDS system could reduce construction costs required to properly meet the loads and perform dehumidification/reheat duties by millions of $
- be a sustainable, financially viable way to reduce biological growth and promote occupant health, comfort and productivity

Technology Lifecycle Cost Savings

The ESTCP process will help us determine the real world lifecycle savings potential of the HEDS AHU design.

1. Benefits of the HEDS design include
   a. Very simple design process,
   b. Simple installation process
   c. Simple operation and maintenance requirements
2. Reduced First and Lifecycle Cost Potential
   a. Ability to greatly extend the life of capacity constrained chilled water generation plants and chilled water distribution systems.
   b. Potential to save millions of $$$ in reduced infrastructure costs for facilities that are adding loads to the cooling loop.
3. Renewable/HEDS Benefits
   a. The energy efficiency benefits of a HEDS based system will allow renewable energy technologies to either be downsized, or be used to serve a greater overall percentage of an installations energy consumption.

Demonstration Sites



Existing Conditions: Tinker AHU

- Air Handling Unit shows water carry off from the cooling coils – solids build up on the fan shroud.

- Water in the airstream due to 100% saturated air conditions and cooling coil high air velocities.

Tinker AFB Existing AHU on Rooftop

HEDS AHU will fit on the same structural support system as the existing AHU

Ft Bragg DFAC Existing AHU In Mechanical Room

HEDS AHU will fit in the existing mechanical space – an equipment pad extension was required

Expected Performance Improvements

Original Peak Day Computer Simulation Comparative Analysis (10,000 CFM unit)

Normal vs. HEDS

Coil APD	0.94” vs. LT 0.40”
CHW System Flow	70.3 GPM vs. 26.8 GPM
Load to Chiller Plant	28 Tons vs. 18 Tons
Nat Gas to Boilers	112,000 BTUH vs. Zero BTUH

Total Cooling + Reheat Energy Savings = 52.8%

Supporting Technical Data

As shown in the illustration and data points 1 through 4, the entering and leaving air conditions are identical between the two units. As shown in the table below, the HEDS design delivers the same results while using 52.8% less BTUH and 62% lower CHW flow for the design conditions shown.

Example System Summary Data taken from the "PACE" cooling and heating coil rating program.	5 HEDS Cooling Coil Performance	5A Normal Cooling Coil Performance	6 Cooling Recovery Coil Performance	6A Normal Reheat Coil Performance
Air Pressure Drop (in. W.C.)	0.17	0.89 (523%)	0.05	0.08 (160%)
Water Pressure Drop (ft.wtr)	8.9	7.0 (79%)	5.1	4.0 (78.4%)
Chilled Wtr Flow Rate (GPM)	26.8	70.3 (262%)		
Cooling Coil Face Velocity/ Rows (approx, site specific)	150 - 200 FPM/ 8 rows	550 FPM +/- 6 rows		
Entering Chilled Wtr Temp (°F)	45°F	45°F		
Coil Leaving Chilled Water Temperature (°F)	70°F or higher	55°F		
Cooling Required to Obtain 55°F Air Temp (BTUH)	338,690 28.22 tons	338,690 28.22 tons		
Heating Hot Water Flow Rate (GPM) (flow rate to CRC)			26.8	4.2 (15.7%)
Heating Coil Face Velocity/ Rows (approx, site specific)			150 - 200 FPM/ 6 rows	550 FPM +/- 1 row
Entering Heating Wtr Temp (°F)			70°F or higher	140°F or higher
Coil Leaving Heating Water Temperature (°F)			61.9°F	87°F
Heating Required to Obtain 65.3°F Air Temp (BTUH)			-112,503 -9.38 tons	112,503
Natural Gas BTUH at 80% Boiler System Efficiency			N/A	140,629

SUMMARY	HEDS with Cooling Recovery Coil	Normal AHU with Reheat Coil & Boiler Plant	Net BTUH Savings
Cooling Load at Coil (BTUH)	338,690	338,690	Load is Identical
Cooling Recovery Coil (BTUH)	-112,503	0	below
Net Cooling Load on Plant	226,187	338,690	-112,503/32.8%
Reheat Energy at 80% Boiler Efficiency	0	140,629	140,629/100%
Total Cooling + Heating BTUH	226,187	479,319	52.8%
Total net BTU per hour savings at these design conditions = 52.8%			

Technology Implementation/Available Products

What should DoD consider when implementing the technology?

1. Although the HEDS testing has not been completed yet, when designing an HVAC system for comfort conditioning, RH control or process loads (such as paint hangars), adequate physical space needs to be allocated for the HEDS units.

2. In very tight mechanical spaces, the HEDS unit will not be able to be located in that space, as they are physically larger than a "normal" AHU. HEDS units will typically be smaller than a desiccant wheel based system that delivers the same conditions.

What products are on the market or will emerge soon?

1. There are no products currently on the market that offer the benefits of the HEDS design.

2. It is possible to build HEDS AHU's immediately, or to retrofit existing facilities that desire RH control for process, comfort or biological control with the HEDS design strategies.

3. We are hoping that the upcoming demonstration at Tinker AFB will demonstrate that the HEDS design can be a viable retrofit option to massively cut energy use for their 100% outside air paint hangars, which are the largest single energy users on the base. You can imagine the electrical and thermal demand of cooling and reheating 300,000 CFM of outside air in Oklahoma in the summer for one paint hangar.

Tinker AFB HEDS Unit Performance Specifications

ROOF TOP UNIT SUPPLY FAN SCHEDULE

				SUPPLY FAN							ELECTRICAL			FILTER		UNIT	
SYMBOL	MANUFACTURER AND MODEL	LOCATION	SERVICE	TYPE	TSP (in. WC)	ACFM	FAN WHEEL DIAMETER	DRIVE TYPE	MOTOR RPM	BLADE TYPE	HORSEPOWER (HP)	NEMA NOMINAL FULL LOAD EFFICIENCY (%)	VOLTS / PHASE / FLA 60 Hz.	EFFICIENCY (MERV RATING)	FACE VELOCITY (FPM)	OPERATING WEIGHT (LBS)	REMARKS
RTU 4	TRANE PERFORMANCE CLIMATE CHANGER	BLDG. 3 ROOF	FIRST FLOOR	PLUG	3.6"	10,000	25"	BELT	1,780	AF	10	93%	460V/3ϕ/–	14	182	13,500	VARIABLE FREQUENCY DRIVE CONTROL – –

PRE–HEAT, COOLING, COOLING RECOVERY AND RE–HEAT COILS

	SYMBOL	COIL DUTY	LOCATION	SERVICE	ROWS / FPI	MAXIMUM FACE VELOCITY (FPM)	EADB (°F.)	EAWB (°F.)	EWT (°F.)	LADB (°F.)	LAWB (°F.)	LWT (°F.)	AIR PRESSURE DROP (in. wc)	GPM	WATER PRESSURE DROP (Ft. WATER) @ 30% E.G.	CONTROL VALVE Cv	COIL SQUARE FEET	TUBE O.D.	TUBE WALL THICKNESS	FIN THICKNESS	TOTAL MBTU	SENSIBLE MBTU	COIL ACFM	REMARKS
	RTU–4 PREHEAT	PRE–HEAT COIL	BLDG. 3 ROOF	HEATING	4/8	210	40°F.	N/A	140°F.	107°F.	N/A	80°F.	0.07	24	1.7	–	49	1/2"	0.016"	0.008"	727	727	10,000	MAXIMUM HEIGHT BETWEEN "THROUGH THE COIL" DRAIN PANS FOR THE COOLING COILS IS 30".
CONDITION #1	RTU–4 COOLING	COOLING COIL	BLDG. 3 ROOF	COOLING	10/12	210	85°F.	69.5°F	45°F.	50.3°F.	50.2°F.	68.3°F.	0.28	50	6.9	–	48.3	5/8"	0.020"	0.008"	584	383	10,000	
CONDITION #1	RTU–4 CLG. RECVRY	COOLING RECOVERY COIL	BLDG. 3 ROOF	HEATING	6/10	210	50.3°F.	50.2°F.	68.3°F.	66.6°F.	58°F.	61.3°F.	0.11	50	8.4	–	49.1	1/2"	0.016"	0.008"	175.8	175.8	10,000	
CONDITION #2	RTU–4 COOLING	COOLING COIL	BLDG. 3 ROOF	COOLING	10/12	210	85°F.	69.5°F	45°F.	47.6°F.	47.5°F.	62.2°F.	0.29	76	14.3	–	48.3	5/8"	0.020"	0.008"	656	413	10,000	
CONDITION #2	RTU–4 CLG. RECVRY	COOLING RECOVERY COIL	BLDG. 3 ROOF	HEATING	6/10	210	47.6°F.	47.5°F.	62.2°F.	60.8°F.	54°F.	56.5°F.	0.11	76	8.6	–	49.1	1/2"	0.016"	0.008"	143	143	10,000	
	RTU–4 REHEAT	EXISTING RE–HEAT	BLDG. 3 ROOF	HEATING	← EXISTING REHEAT COIL IN EXISTING SUPPLY AIR DUCTWORK. →																			

NOTE: CONDITION #1 AND CONDITION #2 HAVE DIFFERENT FLOW RATES AND TEMPERATURE VALUES.

Fort Bragg HEDS Unit Performance Specifications

AIR HANDLING UNIT SUPPLY FAN SCHEDULE

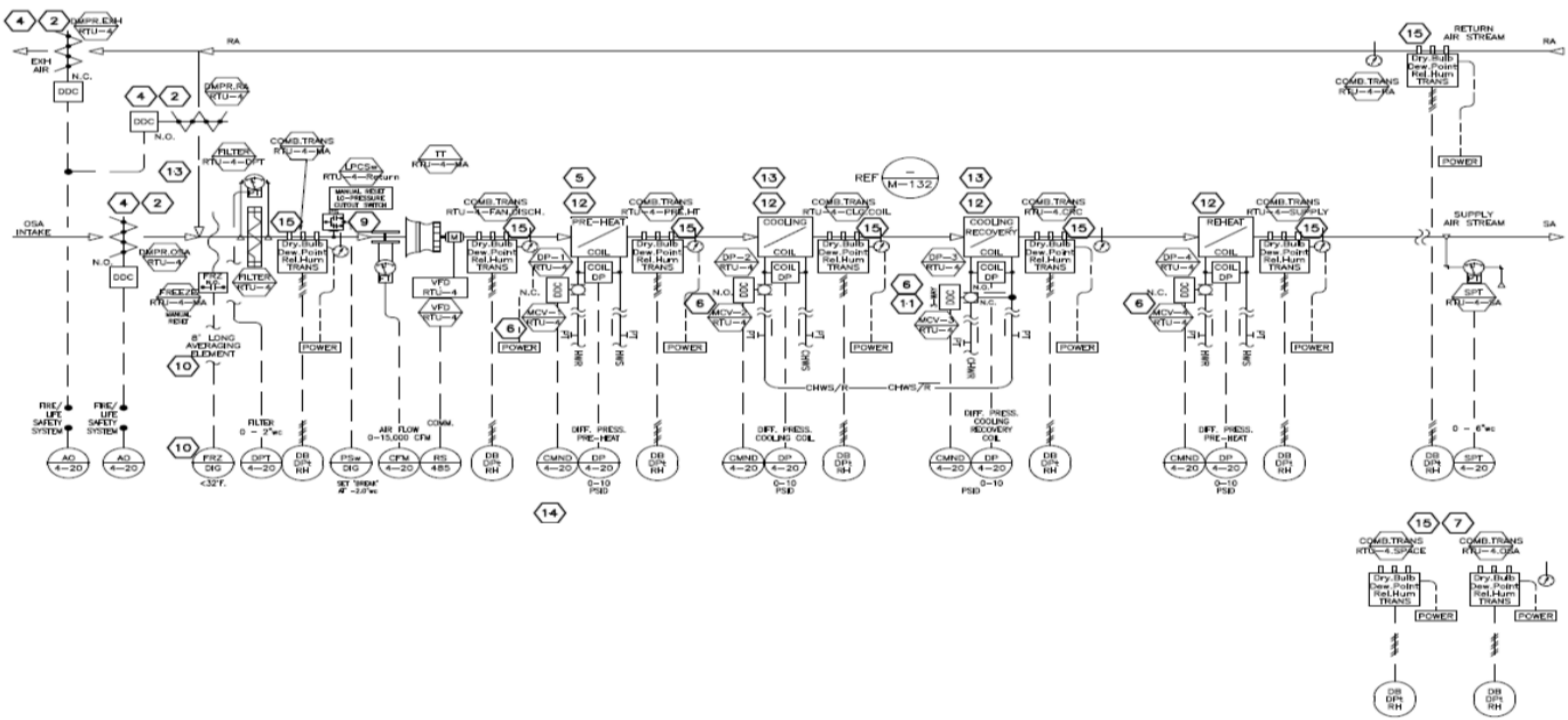
				SUPPLY FAN							ELECTRICAL			FILTER		UNIT	
SYMBOL	MANUFACTURER AND MODEL	LOCATION	SERVICE	TYPE	TSP (In. WC)	ACFM	FAN WHEEL DIAMETER	DRIVE TYPE	MOTOR RPM	BLADE TYPE	HORSEPOWER (HP)	NEMA NOMINAL FULL LOAD EFFICIENCY (%)	VOLTS / PHASE / FLA 60 Hz.	EFFICIENCY (MERV RATING)	FACE VELOCITY (FPM)	OPERATING WEIGHT (LBS)	REMARKS
AHU 1	TRANE PERFORMANCE CLIMATE CHANGER	BLDG. MECH. ROOM	KITCHEN	PLUG	3.7"	10,000	25"	BELT	1,780	AF	15	93%	208V/3ø/–	14	182	11,000	VARIABLE FREQUENCY DRIVE CONTROL – –

PRE-HEAT, COOLING, COOLING RECOVERY AND RE-HEAT COILS

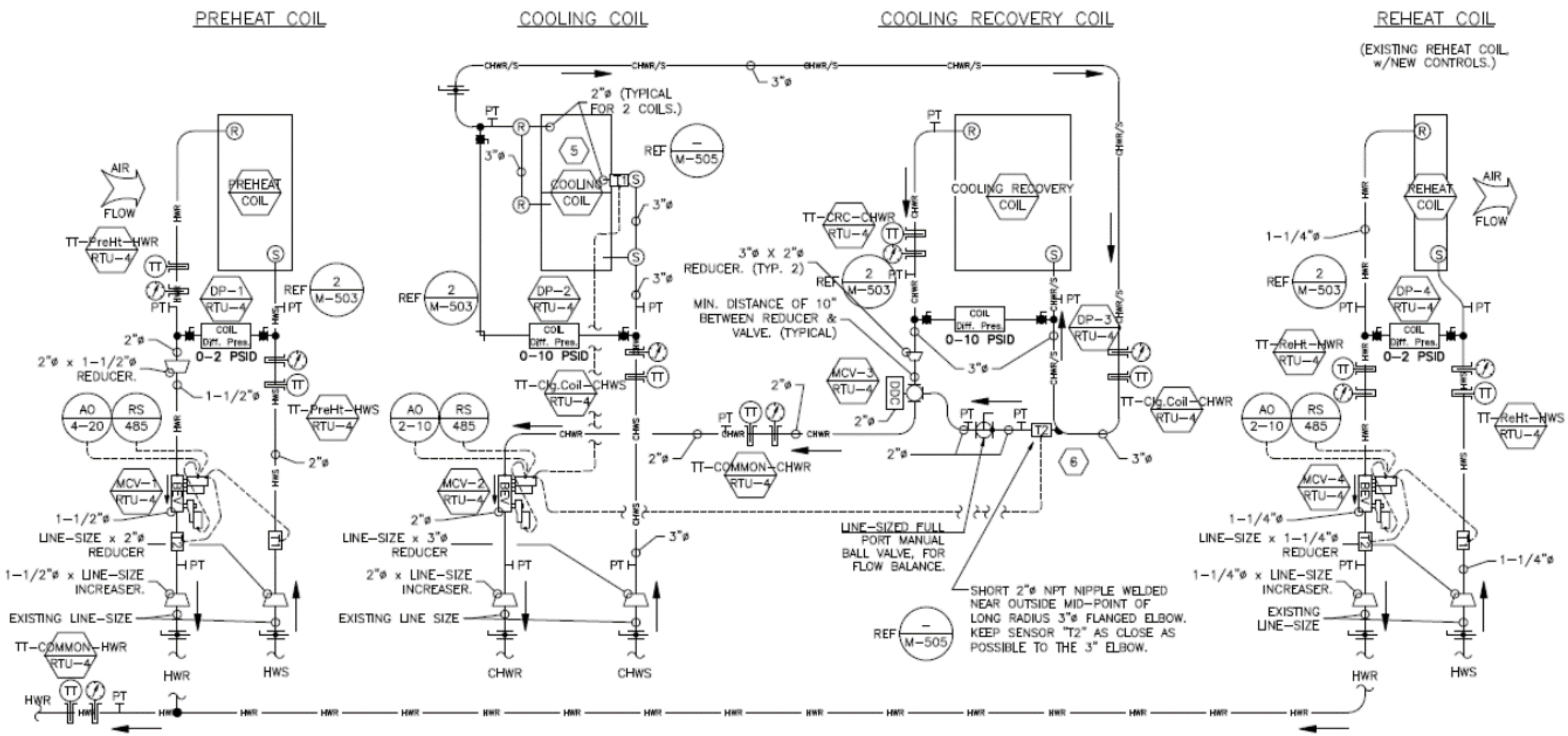
	SYMBOL	COIL DUTY	LOCATION	SERVICE	ROWS / FPI	MAXIMUM FACE VELOCITY (FPM)	EADB (°F.)	EAWB (°F.)	EWT (°F.)	LADB (°F.)	LAWB (°F.)	LWT (°F.)	AIR PRESSURE DROP (In. wc)	GPM	WATER PRESSURE DROP (Ft. WATER) NO GLYCOL	CONTROL VALVE Cv	COIL SQUARE FEET	TUBE O.D.	TUBE WALL THICKNESS	FIN THICKNESS	TOTAL MBTU	SENSIBLE MBTU	COIL ACFM	REMARKS
	AHU-1 PREHEAT	PRE-HEAT COIL	1	HEATING	4/8	210	40°F.	N/A	140°F.	107°F.	N/A	80°F.	0.07	24	1.7	–	49	1/2"	0.016"	0.008"	727	727	10,000	MAXIMUM HEIGHT BETWEEN "THROUGH THE COIL" DRAIN PANS FOR THE COOLING COILS IS 30".
CONDITION #1	AHU-1 COOLING	COOLING COIL	1	COOLING	10/12	210	87°F.	72°F	45°F.	51.9°F.	51.8°F.	70.8°F.	0.29	50	6.9	–	48.3	5/8"	0.020"	0.008"	647	389	10,000	
CONDITION #1	AHU-1 CLG. RECVRY	COOLING RECOVERY COIL	1	RE-HEATING	6/10	210	51.9°F.	51.8°F.	70.8°F.	69.0°F.	59°F.	63.4°F.	0.11	50	8.4	–	49.1	1/2"	0.016"	0.008"	185	185	10,000	
CONDITION #2	AHU-1 COOLING	COOLING COIL	1	COOLING	10/12	210	87	72°F	45°F.	48.1°F.	48.0°F.	64.4°F.	0.30	76	14.2	–	48.3	5/8"	0.020"	0.008"	738	430	10,000	
CONDITION #2	AHU-1 CLG. RECVRY	COOLING RECOVERY COIL	1	RE-HEATING	6/10	210	48.1°F.	48.0°F.	64.4°F.	63.3°F.	54.5°F.	60.1°F.	0.11	76	17.4	–	49.1	1/2"	0.016"	0.008"	164	164	10,000	

NOTE: CONDITION #1 AND CONDITION #2 HAVE DIFFERENT FLOW RATES AND TEMPERATURE VALUES.

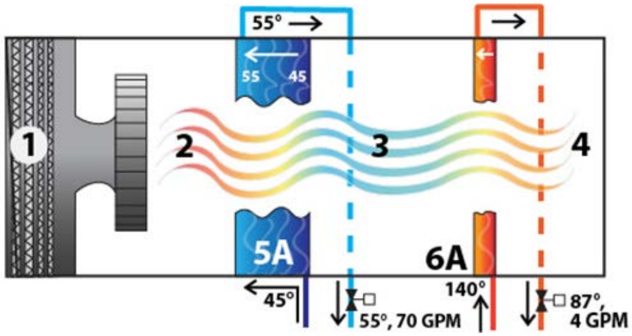
HEDS Test Airside Instrumentation



HEDS Test Waterside Instrumentation

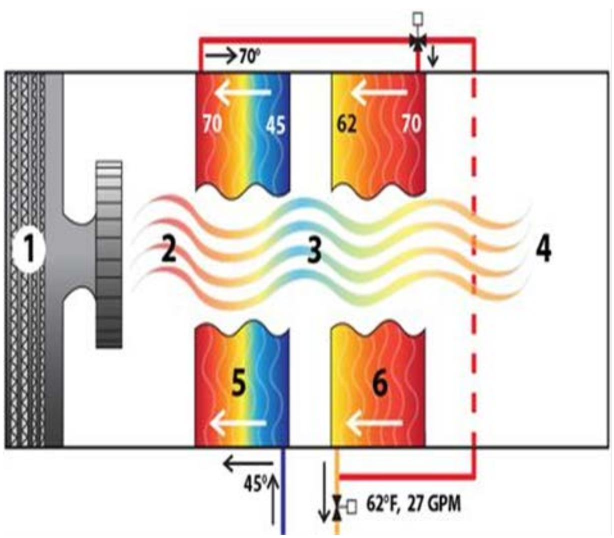


Section 1.5 Appendices, Supporting Technical Data & FAQs Cont.



Traditional AHU Designed for Dehumidification Duty. Small cooling and reheat coils, high CHW flow rates, low CHW temperature differential and high AHU air pressure drops. 45°F CHW enters the cooling coil (5A) at 70 GPM and leaves the cooling coil at 55°F. A new source of 140°F water enters the reheat coil (6A) at 4 GPM and leaves the reheat coil at 87°F. The unit requires **479,319 BTU's per hour** to cool, dehumidify and reheat 10,000 CFM of air at the design conditions in this example

Data Points 1 thru 4: [1] 10,000 CFM airflow [2] 78°F dry bulb temp, 65°F wet bulb temp [3] 55°F dry bulb, 55°F dewpoint, essentially 100% relative humidity [4] 65.3°F dry bulb, 55°F dewpoint, 55% RH



High Efficiency Dehumidification System (HEDS) AHU (53% Peak Day BTUH Savings) Very large cooling and cooling recovery coils, low CHW flow rates, high CHW temperature differential and low AHU air pressure drops. 45°F CHW enters the cooling coil (5) at 27 GPM and leaves the cooling coil at 70°F. This 70°F water then enters the CRC coil (6) at 27 GPM and leaves the CRC coil at 62°F while heating the air to 65°F. The HEDS unit requires **226,187 BTU's per hour** to cool, dehumidify and reheat 10,000 CFM of air at the same conditions**, a BTUH savings of 53% and a CHW flow reduction of 62% in this example.**

Blue=Cold Temperatures, Yellow to Red = Warm to Hot Temperatures.

Frequently Asked Questions

FAQs

Scot M. Duncan, P.E. started designing "Large Temperature Differential" (LTD) cooling systems in 1985, with initial systems designed to deliver 76°F chilled water return temps when the coils were provided with 39°F chilled water from a chilled water Thermal Energy Storage (TES) system. The LTD design reduced the TES tank size by 65% due to the very large CHW temperature differential. Most LTD coils provide 70°F to 74°F CHW return temps on design days, so there is enough low quality heat available for reclaim to be used as a reheat source for Relative Humidity control. 25 years of experience with large cooling coils delivering high CHW return temperatures contributed to the design of the HEDS.

Q: Is HEDS acceptable to be used in a retrofit, or only new installs?

A: The biggest target market is the retrofit market, where the most problems exist and the most obvious benefits are to be had.

In a retrofit application, we are hoping that HEDS will solve the high RH/ mold/ mildew problems that exist, substantially cut energy and water waste, solve the "Low Delta T" problem, solve heating and cooling capacity problems, solve undersized infrastructure problems, reduce manpower and maintenance costs, and lower the overall lifecycle costs for DoD facilities.

If HEDS is designed into new construction or facility expansion projects, we are hoping that lower overall installation costs will occur, as well as lower overall lifecycle costs.

NOTE: the answers are based on studies and evaluations, the ESTCP project is needed to prove the performance and potential limitations in the real world.

FAQ’s, Cont.

Q: Will HEDS really provide chiller plant downsizing? A: Yes, based on the evaluations completed so far. To reduce the possibility of condensation forming, the COE would like to deliver approximately 65°F dry bulb temperature air at 55°F dewpoint conditions, which results in a supply air RH of around 55%. On a sample barracks project of approximately 150 rooms, the cooling load to dehumidify the air to 55°F dewpoint, starting at 78°F dry bulb and 65°F wet bulb calculates out to approx. 147 tons. To raise the supply air temperature from 55°F to 65°F to obtain 55% RH air conditions, heat totaling 486,000 BTUH must be added. With a “normal” dehumidification/reheat design, 486,000 BTUH of heating hot water, or 142 kW of electric strip heaters would be required to warm up the air. With the HEDS unit, the “Cooling Recovery Coil” uses the chilled water that leaves the cooling coil at approximately 70°F as the source of heating water that is used to raise the air temp to 65°F. Simultaneously with the rise in air temperature, there is a corresponding drop in the chilled water return temperature in the CRC, equal to the same 486,000 BTUH that was transferred into the supply air. 486,000 BTUH equates to approximately 41 tons, so the net load on the chiller plant equates to approximately 147 tons cooling load, minus the 41 tons of cooling energy that was recovered in the reheat process, for a net chiller plant load of 106 tons. This should allow the chiller plant associated with a HEDS design to be reduced in capacity by approximately 25% to 30% while still meeting peak load days.

FAQ’s, Cont.

Q: Can HEDS reduce Infrastructure Costs? A: Yes, based on the evaluations completed so far. A benefit of HEDS is that the chilled water flow rate required to meet peak day cooling/dehumidification needs will be reduced by approximately 50% to 60% by a combination of reduced cooling plant loads and increased chilled water system temperature differentials provided by the very large cooling coils.

On sites that may be stretching the limits of their piping infrastructure, the ability to meet the same cooling loads with a 50% to 60% reduction in the flow rate can mean that the avoided costs from not having to replace the piping infrastructure can cover the most or all of the costs of HEDS retrofit projects. While not a HEDS project, one of our team members has been working with the University of Southern California since 1992, and has helped raise their CHW system temperature differential from 8°F to 9°F during peak summer months in 1992, up to 25°F to 27°F today. This has allowed USC to avoid replacing their underground piping, as the installed piping can now move 300% more BTU’s per gallon due to the higher chilled water temperature differential. This is a savings of over $15,000,000 for the campus.

FAQ's, Cont.

Q: Can HEDS improve efficiencies of added facilities? A: Yes. When new facilities are being added, or facilities are being rehabilitated or expanded, the HEDS design can be incorporated to reduce lifecycle costs. If a chiller plant has reached the maximum capacity that it can deliver, the piping infrastructure may also be maxed out as described above. If the plant and piping system capacity is maxed out, there are two remedies – 1) add more chiller, cooling tower, pumping and piping capacity, and potentially an addition to the chiller plant building to house the new equipment, which can all add up to tens of millions of dollars just to add one more building, or 2) make better use of the installed equipment and piping by decreasing the cooling loads on the plant and increasing

FAQ's, Cont.

Q: Can HEDS help to solve the "Low Delta T Syndrome"?

A: Yes. One of the key drivers for the Low Delta T Syndrome is undersized cooling coils. By nature of the HEDS design, the heat transfer surface area of the cooling coils is more than 300% greater than a typical 6 row, 10 fins per inch coil at the normal 550 feet per minute face velocity.

Q: Can HEDS handle added loads without additional equipment and reduce expensive upgrades?

A: Yes. As described above, if HEDS is incorporated, it will free up additional capacity in the cooling plants and the chilled water distribution piping systems.

Q: Does HEDS require a 2-pipe system, or will it also work with a 4-pipe system?

A: HEDS works with both system types. One of the beauties of the HEDS design is that it can provide cooled and dehumidified air with a 2-pipe system, without requiring electric reheat or complex and hard to maintain desiccant wheel based equipment. With a 2-pipe system in the winter, the hot water return (HWR) temperature approaches the coil entering air temperature, since there is so much heat transfer surface area available and the air is moving at such a low velocity thru the coils. This means that with a 180°F hot water supply (HWS) temperature, you will end up with a 100°F to 120°F temperature differential, delivering substantial efficiency gains to the HW system. With a 4-pipe system, the Cooling Recovery Coil (CRC) can either be piped to operate as a heating coil in the winter (via a Belimo 6-way valve or the equivalent), or a heating coil can be utilized in the unit. If the CRC is used as a heating coil, the chemical treatment systems for the HW and CHW should be checked for compatibility

FAQ’s, Cont.

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FAQ's, Cont.

Q: How will the HEDS design work with an existing boiler during the heating season?

A: If the HEDS system is used in a 2-pipe system, the hot water system temperature differential will be larger than with a typical coil selection, allowing a few different things to occur – substantial pump energy savings due to the larger HW system temperature differential that occurs due to the much larger coils, potential infrastructure savings when facilities are added – the existing piping infrastructure can carry at least 25% more BTU's per gallon of water delivered. With a 4 pipe system, either a typical heating coil can be installed, or, if the hot water and chilled water systems have compatible chemical treatment systems, the CRC or cooling coils can be used as heating coils with a switchover valve system, similar to the Belimo 6-way valves. When it is time for boiler upgrade or augmentation, condensing type boilers that can deliver efficiencies in the high 90% range can be used, since it would be possible to serve the heating loads with 100°F to 120°F hot water supply temperatures vs. needing 180°F to 200°F required by typical designs.

FAQ's, Cont.

Q: Is a separate heating coil also needed downstream of this arrangement?

A: In a 2-pipe system, the cooling coil or CRC can be used as the heating coil, so a downstream heating coil is not required for heating. The Tinker HEDS unit is using the existing reheat coil as needed, the Ft. Bragg HEDS unit does not have a reheat coil – mimicking the installed unit.

In a four pipe system, if the CRC or cooling coils are not used in a switchover design to act as heating coils in the winter, there will be the need for either an upstream or downstream heating coil to provide heat to the facility. We will be monitoring the data to determine if a downstream heating coil is needed when it is cool and muggy outside and the internal cooling loads are low, but still exist.

FAQ's, Cont.

Q: Since the return temperature for the chilled water is increasing above a standard ten degree delta t, does this mean that the chiller also needs to be evaluated to see if it can handle this large spread of water temperatures without causing issues?

A: Typically not. We have been using 30°F to 36°F CHW system TD's since the mid 1980's in new and retrofit projects using chillers designed for 10°F to 15°F TD's with the two basic mechanical designs out there – primary/secondary, (Pri/Sec) and primary-only variable flow, (POVF), sometimes called "Variable Primary Flow" or "VPF".

Both of these designs automatically accommodate for higher than "normal" chilled water distribution system temperature splits by recirculating some of the cold supply water back into the chiller return line when site TD's greatly exceed chiller design TD - this lowers the effective TD that the chillers see. With a Pri/Sec system, as the secondary CHW loop flow drops off due to the higher system TD, the primary loop flow remains the same, which recirculates more chilled water from the supply into the return line, creating the desired TD thru the chiller. As an example, if there was a 500 ton load that was operating at a 20 degree TD, (use 45°F/65°F as example) and the chiller was originally designed for a 10 degree TD, the secondary CHW flow would be 600 GPM. The design primary CHW flow would be 1,200 GPM – consisting of 600 GPM of recirculated 45 degree supply water, and 600 GPM of 65 degree return water for a blended temperature of 55 degrees at 1200 GPM into the chiller. (Answer continued on next page)

FAQ's, Cont.

A continuation of previous answer.:

Similarly, a POVF/VPF system will reduce flow thru the chiller as the site TD increases and the site flow is reduced. At some point in time, the minimum CHW flow limit thru the chiller evaporator is reached, and the minimum CHW evaporator flow bypass valve will start to open, sending some of the cold supply water back to blend with the CHWR and the return water temperature entering the chiller will be reduced.

To dramatically improve chiller plant efficiency, chiller plants with high potential TD's can be slightly modified to allow a "series or parallel" piping arrangement with the addition of a few valves and some control logic. These valves allow the chillers to run in parallel when the TD's are normal, and in series when the TD's get to about 15°F to 18°F. This allows the upstream chiller to operate at an increased efficiency of at least 25% due to lower lift required on the upstream chiller.

An example of these design strategies is a low temperature CHW TES based system we designed for a Pacific Gas and Electric facility, the SRVCC. The peak day CHW loop TD ever recorded was 45°F, consisting of 32°F CHWS temperature and 77°F CHWR temperature. The chillers were designed for a 15°F split each, using POVF and the series-parallel design, we create chilled water at 32°F at less than 0.60 kW/ton for the entire chiller plant electrical consumption, including chillers, CHW pumps, CDW pumps TES pumps and CT fans.

Typical, existing, old chillers can usually operate with CHW flow rates of less than 50% of design flow, if the flows are varied at less than 10% every couple of minutes. Cutting the flow in half results in a TD of double the design TD.

Policies and Standards

The following are recommendations to DoD policies and standards to improve adoption of the technology:

1. Mandate proper designs for high RH localities

    1. Mandate that all spaces that are air-conditioned in areas with the potential for high relative humidity be designed with HVAC systems that are specifically designed to control the relative humidity in the space. “Areas with the potential for high relative humidity” will need to be better defined.

2. Mandate no new energy be used for the reheat portion of RH Control, and no new energy for regeneration of desiccant based systems.

    1. Mandate that 100% of the reheat energy used to control relative humidity on peak load days be taken from the return side of the chilled water loop, that a net cooling load reduction at the chiller plant equal to the reheat energy required for relative humidity control be experienced, and that no new reheat–related energy, over and above that required by the chiller plant be used in the control of relative humidity of the spaces. Mandate that only recovered energy can be used to regenerate Desiccant systems.

3. Mandate that the AHU maintenance required be no greater than for a “normal” AHU. (Need to define “Normal”.)
4. Mandate that the maximum face velocity for the pre-filter bank, the preheat coil, the cooling coil, the cooling recovery coil, the run-around coils, the reheat coil(s), and the after filter bank be no greater than 250 feet per minute.
5. Mandate that the maximum, total, combined air pressure drop of all the heat transfer coils and desiccant wheels be no greater than 0.65” WC at the maximum design air flow rate and the maximum air pressure drop operating conditions.
6. There can be a lot more, when it is time for this, we will focus on it.

Psych Chart for "Normal" Dehumidification/Reheat AHU

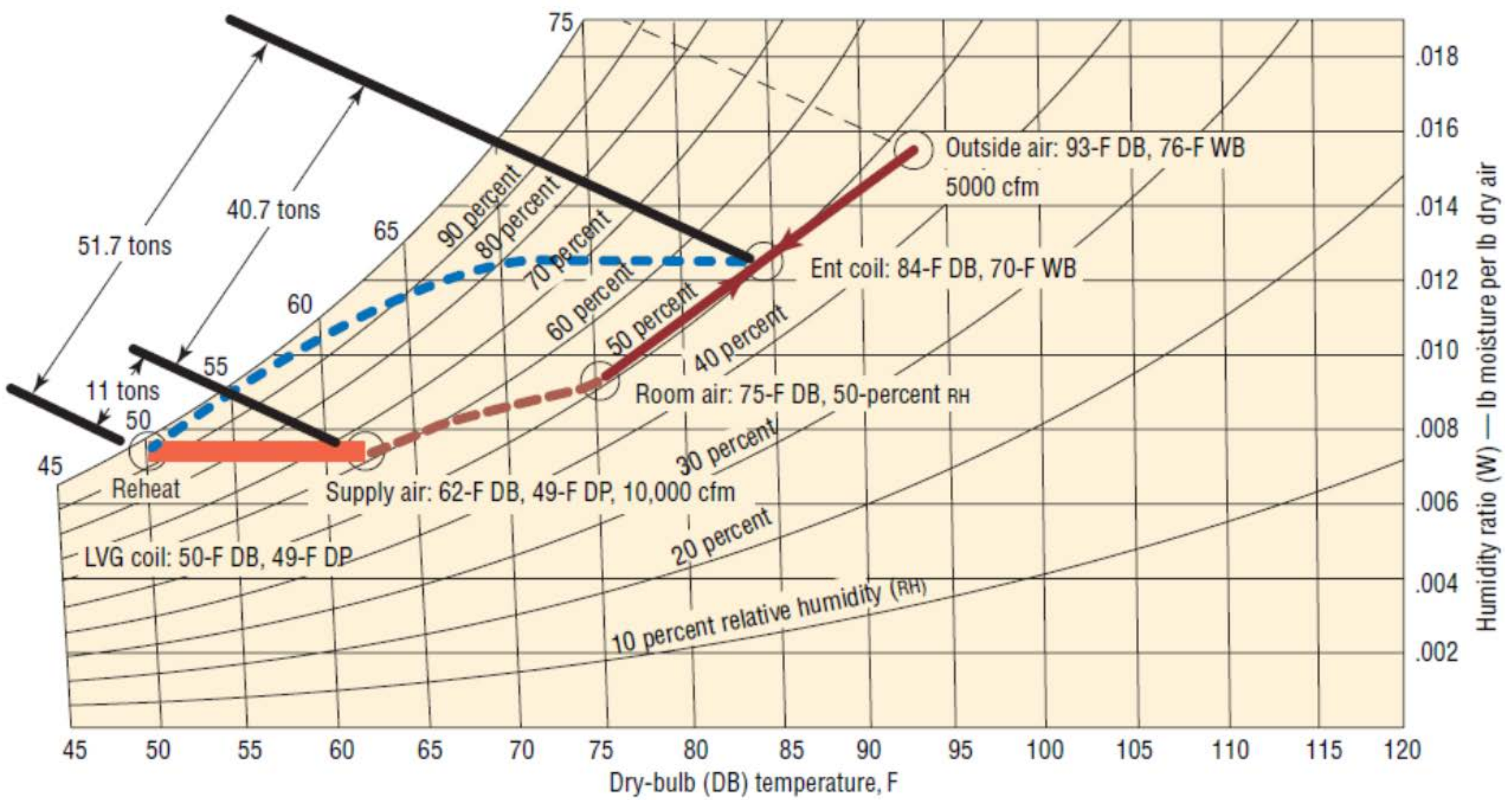

FIGURE 1. Psychrometric chart of a reheat system.

Psych Chart for an Energy Recovery System

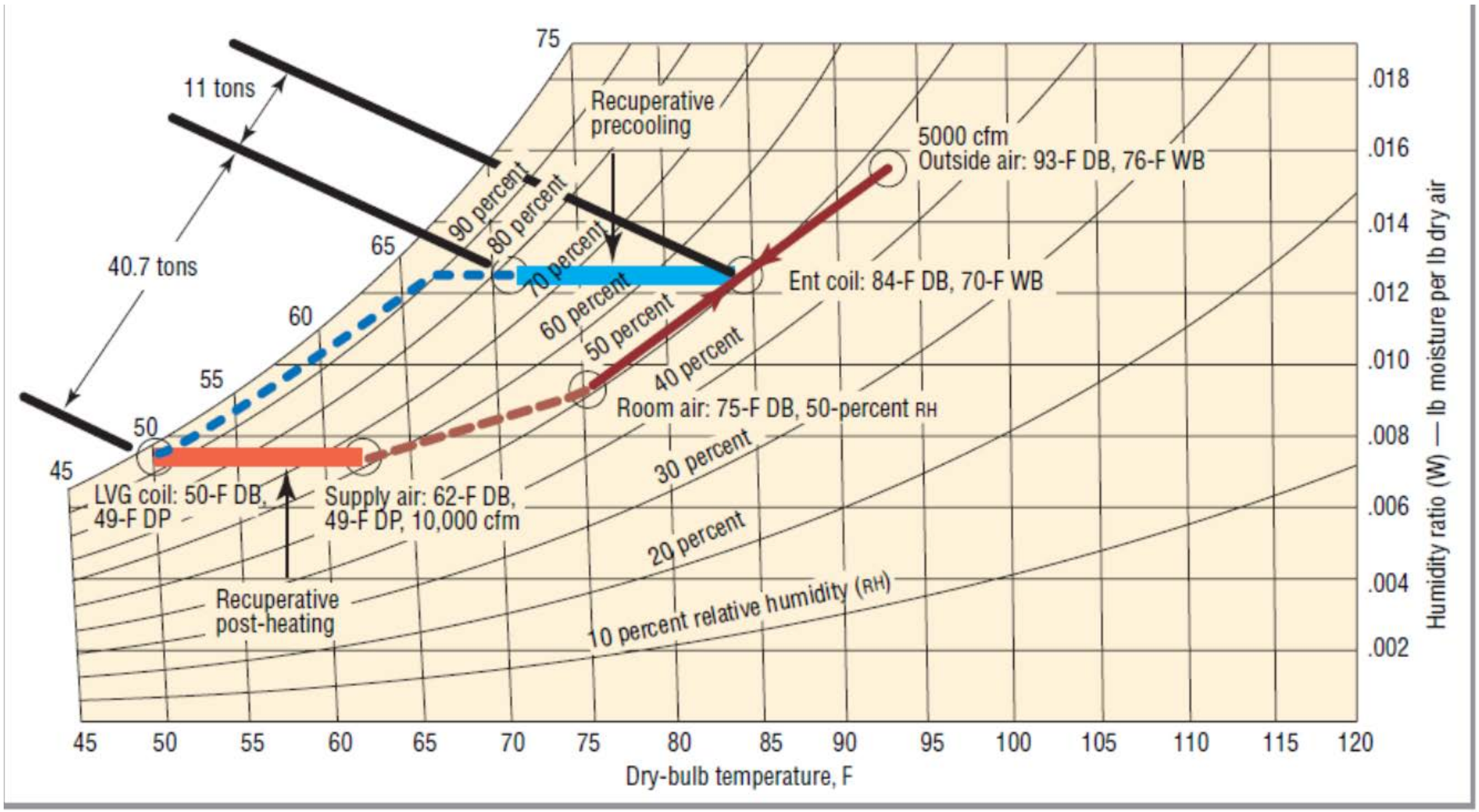

FIGURE 2. Psychrometric chart of a recuperative reheat system.

Questions?

Scot M. Duncan, P.E.

Inventor/Developer of the High Efficiency Dehumidification System (HEDS)

Retrofit Originality Inc.

(949) 370-8582

sduncan@roi-engineering.com

www.roi-engineering.com

FEMP Federal Energy Management Program

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