



Air-Conditioning, Heating,  
and Refrigeration Institute

# Advanced Rooftop Unit Concept AHRI Initial Feedback

*Karim Amrane, Ph.D.  
Air-Conditioning, Heating, and Refrigeration Institute*

CEE Industry's Partners Meeting – 29 September 2009  
New Orleans

# Introduction

- HVAC industry is facing unprecedented regulatory challenges
  - New federal energy efficiency standards – 1/1/2010
  - Phase-out of HCFCs – 1/1/2010
  - Climate change - Phase-down of HFCs
  - Building energy codes
    - ASHRAE 189, IGCC, LEED, IECC, ASHRAE 90.1, Title 24
    - Waxman legislation HR 2454
  - Building labeling program
  - Energy Star, CEE specifications, advanced rooftop unit concept

# Introduction

- Initial feedback
  - Some of the proposed requirements are too prescriptive
    - Specification should be based on an overall performance requirement and not a specific design solution
  - Not clear how the rating system will be developed and how the features will be weighted
    - Energy savings, cost effectiveness (need to quantify savings/cost effectiveness for each feature separately)
  - Specification should result in affordable ARTU

# Category 1 - Economizers

Category 1 - Economizers		
1-1	Factory supplied economizer	The issue has more to do with the quality of the design than it does with where the installation occurs. With a quality design, it doesn't matter whether the unit is factory- or field-installed. "Factory approved" is what should matter.
1-2	- Direct drive modulating actuator - Gear driven interconnections - Permanently lubricated bushings or bearings on outside air and return air dampers.	Direct drive can improve reliability. Permanently lubricated bushings or bearings are not always needed. Other methods will provide very acceptable reliability for its useful life. Any specification should not be based on a design solution but rather on an overall performance requirement
1-3	Economizer control type is differential dry-bulb, differential enthalpy or dewpoint/dry-bulb temperature control.	Economizer changeover methods have been available as options in ASHRAE 90.1 for many years. Differential enthalpy is typically better but there are some exceptions.
1-4	Economizer controller is capable of operating if appropriate under demand controlled ventilation (DCV) control.	This is already a requirement in ASHRAE 90.1 for densely occupied spaces
1-5	Compressor is locked out when the outside air is at a temperature low enough to satisfy the cooling load (OAT is less than SAT would be at same load conditions).	Adding user setpoints is not always the best solution as users don't necessarily understand the ramification of the settings. A good controller will not bring the compressor on when the economizer can satisfy the load. A new setpoint to lockout the compressor will add complexity and could result in more energy consumption due to improper settings.

# Category 1 - Economizers

1-6	The outside air damper modulates toward closed if the discharge air temperature falls below a low limit (40 to 45°F, field adjustable), until a safe DAT is obtained.	This is a redondant setting as the economizer controller already incorporates a mixed air sensor on the unit discharge to modulate the economoizer dampers and cycle between economizer operational modes.
1-7	Economizer controller has a deadband between economizer enable / disable operations of no greater than 2°F in a dry-bulb temperature application and 2 Btu/lb in an enthalpy application.	This feature is reasonable with digital systems. However, it is not reasonable to go tighter than the suggested deadbands due to both sensor accuracy and losses that might occur if too many on/off cycles were created by a small deadband.
1-8	Economizer systems (sensors, dampers, actuators and controller) are factory warranted for parts and labor by the manufacturer for at least 2 years.	Warranty is not the real issue. However, the lack of trained,qualified technicians and proper commissioning and maintenance is at the center of the issue and should be addressed.
1-9	Outside air and return air dampers have maximum leakage rates meeting the requirements of ASHRAE 90.1-2004.	The ASHRAE 90.1 leakage requirements apply to outside dampers only. While studies have shown some energy savings in certain applications, there are situations such as in building with nigh setback and interminant fan operation where the savings are margi

# Categories 2 – 4 Fans, Unit Efficiency, Refrigeration Cycle Economizers

<b>Category 2 - Fans</b>		
2-1	Supply fan motor power is limited as addressed in ASHRAE 90.1, when tested according to current AHRI rating standards.	The issue is poor duct design and not the AHRI rating conditions. Changing the AHRI standard 340/360 rating conditions will not improve duct design and will not save energy. We need to correct the issue at the source (i.e., the ducts) and not attempt to provide a bad solution to a wide spread problem.
<b>Category 3 - Unit Efficiency</b>		
3-1	Unit complies with ENERGY STAR.	The Energy Star program for light commercial HVAC is currently under revision. EPA will likely suspend the program for sometime in 2010 (at least 6 months) until the specification is revised. However, there are other standards such as ASHRAE advanced guide, ASHRAE 189, IGCC that have or will have energy efficiency requirements for unitary large equipment.
<b>Category 4 - Refrigeration Cycle</b>		
4-1	Unit uses a high efficiency hydrofluorocarbon (HFC) refrigerant with no ozone depletion potential, such as R410a.	Refrigerant use is regulated by the U.S. EPA. Ozone depleting chemicals will be phased out on January 1, 2010.
4-2a	The condenser fan motor is an ECM type motor.	Higher efficiency fans are clearly desirable. It is part of the total system design, and should be evaluated as such. Care must be taken to recognize that ECM motors might not be the best, let alone the only, way to reduce energy consumption. In addition, the power of the fan is accounted for in the EER and IEER requirements, so a separate requirement for the fan is redundant.
4-2b	The condenser fan motor is a PSC type motor.	This requirement is not clear. However, the fan power in part of the EER and IEER calculation

# Categories 5 – 6 Fan Control & Refrigerant Control

Category 5 - Fan Control		
5-1	Default operating modes are continuous supply fan operation during occupied hours and intermittent operation during unoccupied hours.	Addendum n to ASHRAE 90.1-2007 requires supply fans controlled by two-speed motors or variable speed drives for units greater than 10 tons or having fan motors greater than 5 Hp.
5-2	During unoccupied hours, supply fan operates for a short period after compressor turns off.	For commercial buildings, the fans operate continuously due to ventilation requirements. This proposed requirement could result in increased latent load in the space due to re-evaporation of the water.
Category 6 - Refrigeration Control		
6-1	Unit uses an adjustable expansion control device such as a thermostatic expansion valve (TXV) or an electronic expansion valve (EXV).	There can be other ways to accomplish the needed task. Designs should not be limited in the methods that are acceptable. The full system design is what matters, not the specific parts that it is made of. This should not be a requirement. This is too prescriptive.

# Category 7 – Thermostats

Category 7 - Thermostats		
7-1	Supplied thermostats are appropriate for commercial buildings and meet the following requirements:	
	<b>ASHRAE 90.1</b>	
	Separate heating and cooling setpoints ("dual" setpoints) and capable of a deadband of at least 5 degrees between the heating and cooling setpoints	
	The thermostat prevents:	
	– Reheating of previously cooled air (except in humidity control applications)	For VAV systems some reheat is required.
	– Recooling of previously heated air	These requirements are already in ASHRAE 90.1
	– Mixing or simultaneously supplying air that has been previously mechanically heated and air that has been previously cooled, either by mechanical cooling or by economizer systems.	These requirements are already in ASHRAE 90.1
	<b>Other</b>	
	<i>Default temperature and schedule programming.</i>	
	Solid state electronic	
Capable of continuous fan op. during occ. hours		
Capable of programming time-of-day sch. and multiple day types.	Already covered in ASHRAE 90.1	
Capable of temporary occupied override (no hold button)	Already covered in ASHRAE 90.1	
Capable of two-stage cooling.		
7-2	The thermostat or unit controller incorporates "integrated economizer" control.	An "integrated economizer" is necessary to maximize both economy and comfort, especially if there is a conflict between the two. ASHRAE 90.1 is developing requirements which will be included in the 2010 standard.
7-3a	Capable of programming ind. holiday schedules	This is a desirable feature. But what are its full costs? Not just the price of the control necessary to do this, but the commitment to update the holidays each year. The market should decide what method(s) it is willing to pay for and use.
7-3b	Thermostat or controller is capable of interfacing with an occupancy sensor and of switching the unit to intermediate temperature settings when no occupants are present during normally occupied hours.	As desirable as this is, a system to do this reliably under all conditions must be at a price that allows reasonable payback. Inexpensive sensors do not work under all conditions. Computer-operated systems should be capable of doing this today, but at w

# Category 8 - Sensors

## Category 8 - Sensors

8-1	Outdoor air and return air sensors have the following accuracy.	<p>This is a desirable requirement. However, the accuracies will add cost that must be justified by the improved consistency of the unit. In addition, proper sensor location is more important than the sensitivity of the sensor.</p> <p>Other than temperature, the A/D conversion should have negligible effect on the accuracy.</p> <p>For temperature, the A/D can be quite significant. It depends on the type of sensor used as well as the A/D method used. For example, a common thermistor fed into an 8-bit A/D will have a result with a resolution of 0.7°F at the center of its range, but considerably worse away from the center. The point is that specifying a temperature sensor accuracy of 1°F is a good idea. But without further clarification, it might not produce the improvement that is hoped for.</p>
	– Temperature sensors are accurate to $\pm 1^\circ\text{F}$ .	
	– Enthalpy and humidity sensors are accurate to $\pm 5\%$ .	
	– CO2 sensors are accurate to $\pm 100$ ppm (0-2000ppm range).	
8-2	Enthalpy sensors have solid state electronic humidity sensing elements.	Is humidity to be part of some other requirement? If not, this seems an unnecessary requirement as long as the enthalpy measurement meets the desired accuracy.
8-3	Connectors prevent reversed polarity connections at the sensor/controller and actuator/controller connections, or, sensors that are not polarity sensitive are used.	These principles would be part of a list of "best practices". But the only part that effects efficiency is the question of whether the devices are hooked up and operating. An indication of missing or failed devices is highly desirable.
8-4	For DCV control, the controller manufacturer supplies a compatible CO <sub>2</sub> sensor with terminals that can easily be connected.	Most field-installed devices, such as CO <sub>2</sub> sensors, are installed to screw connectors. Many customers want to be able to use the sensors they have already standardized on. Limiting the CO <sub>2</sub> sensors that can be used will be perceived as user-unfriendly by many.

# Category 9 – Installation & Checkout Capability

Category 9 - Installation and Checkout Capability		
9-1	Units with multiple compressors have labels on the suction, discharge, and liquid lines indicating the appropriate circuit.	This is irrelevant to the efficiency of the unit. A decent service technician will not have a problem with this, and he is the only one who will see it.
9-2	A high-pressure refrigerant port is located on the liquid line and a low-pressure port is located on the suction line.	This is desirable, but should it be required? There are alternate methods that can be just as effective.
9-3	If the compressor is located within the condenser fan plenum, pressure ports and adequate refrigerant piping to measure temperature are accessible from outside the plenum.	This should not be required.
9-4	Controls to adjust the minimum outside air position are accessible with air plenum panels in place.	If an "integrated economizer" control is used as referenced in section 7-2, that should meet the purposes described.

# Category 10 – Advanced Monitoring

Category 10 - Advanced Monitoring		
10-1	<p>The following sensors are permanently installed and the controller is capable of displaying each sensor reading:</p> <ul style="list-style-type: none"> <li>• Refrigerant suction pressure</li> <li>• Refrigerant suction temperature</li> <li>• Liquid line pressure</li> <li>• Liquid line temperature</li> <li>• Outside air temperature</li> <li>• Outside air relative humidity</li> <li>• Return air temperature</li> <li>• Return air relative humidity</li> <li>• Supply air temperature</li> <li>• Supply air relative humidity.</li> </ul>	<p>Requiring all these sensors should not be desirable. For example, pressure sensors might not provide a value that justifies the price. They can be accurate or inexpensive. Not both. Most of the information desired from the pressure sensors can be obtained by other less costly means.</p> <p>Outside, Return, and Supply sensors are desired to determine the best operation of almost any system. But the humidity sensors might not matter for certain applications.</p> <p>For any sensor in the system, it is desirable to be able to monitor it, display it if a display is available, and indicate any failure that can be recognized.</p>
10-2	<p>The controller provides system status by indicating the following conditions:</p> <ul style="list-style-type: none"> <li>• Compressor enabled</li> <li>• Economizer enabled</li> <li>• Free cooling available</li> <li>• Mixed air low limit cycle active</li> <li>• Heating enabled.</li> </ul>	<p>This would certainly be valuable to the service technician. Which means this could be provided through a display/tool he carries with him.</p>
10-3	<p>The unit controller has the capability to manually initiate each operating mode so that the operation of compressors, economizers, fans, and heating system can be independently tested and verified.</p>	<p>This appears to be a Checkout feature, not a Monitoring feature. This might be more cost effective if it is through a display/tool that the technician carries with him. It must be something that is priced reasonably, programmed so a new technician can learn its use quickly and easily.</p>

# Category 11 – Advanced Diagnostics

Category 11 - Advanced Diagnostics		
11-1	Unit controller has an analog to digital resolution no less than 8 bits.	The 0.4°F resolution assumes an input that is 0 at 0°F, and full scale at 102°F. That is an unlikely situation. The input is more likely to be a thermistor or nickel sensor. Without significant signal conditioning, the thermistor will have a resolution of 0.7°F at mid-scale, and the nickel sensor will be worse. The point is that the resolution must be specified over a range, and not specified by the A/D capability.
11-2	Controller is able to detect faulty and failed sensors (short or open circuit). Upon detecting a faulty sensor, the controller will send a fault signal to the thermostat and/or energy management system. The thermostat and/or energy management system will be capable of receiving and displaying the signal.	The concept has been around a long time. Application at either end (thermostat or unit controller) has been spotty. Part of the problem is that it gives no indication of what the problem is. As long as it indicated a system failure, immediate response was clearly required. But with more sophisticated controls, when do you turn on the fault indicator? For system failure only? Or for any bad sensor? The failure might only mean you're running 2% less efficient. The need might be real, but the urgency of getting a technician visit is not. Indicating a difference is highly desirable.
11-3	Controller can sense a non-operating or improperly operating economizer and send a fault signal upon detection.	The listed failures could all exist just because the economizer isn't using the "best operation" possible. That must be corrected first. Then temperature monitoring can be used to recognize the faults of the system, and cause the "trouble" light to turn on.

# Category 11 – Advanced Diagnostics

11-4	Unit has the diagnostic capability to detect when the temperature differential across the evaporator coil is less than a predetermined minimum or greater than a predetermined maximum (i.e. target temperature drop as determined by Carrier Slide Rule or equivalent calculator).	This diagnostic can also be strongly effected by humidity. Using 4 coil temperature sensors as well as the air sensors, diagnostics are possible. Otherwise the diagnostic can only work under specific conditions in order to provide reliable data.
11-5	Unit has the diagnostic capability to monitor refrigerant charge level, and detect when the refrigerant charge is outside preset limits.	Similar to 11-4.
11-6	<p>Unit controller is able to diagnose and send fault signals for the following faults:</p> <p><b>Severe faults:</b></p> <ul style="list-style-type: none"> <li>- Failed compressor</li> <li>- Failed evaporator fan motor</li> <li>- Failed evaporator fan belt</li> <li>- Failed condenser fan motor</li> </ul> <p><b>Degradation faults:</b></p> <ul style="list-style-type: none"> <li>- Dirty air filter</li> <li>- Dirty condenser coil</li> <li>- Dirty evaporator coil</li> <li>- Failed relief damper</li> <li>- Air in refrigeration loop</li> <li>- Restriction in refrigeration loop</li> </ul>	<p>Recognizing the need for a service technician visit is a good idea. It is highly desirable to identify the source of the fault, but just as important to identify the severity of the fault. The consumer must not be led to feel the need is urgent, when in reality a later scheduled visit is sufficient (and cheaper). The "cry wolf" syndrome must be avoided.</p> <p>The more accurate and complete the information given to the consumer, who can pass it on to the technician when calling for service, the more desirable and better used this feature will become.</p>

## Summary & Next Steps

- Eliminate prescriptive design requirements
- Define overall performance requirement
  - Leave design to manufacturers
- Measures should be cost-effective
- Recommend creation of a Joint AHRI-CEE committee to refine requirements