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Engineers Newsletter

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AHRI 920

Rating Standard for DX Dedicated Outdoor-Air Units

Dedicated outdoor-air units are typically used to dehumidify 100-percent outdoor air to a low dew point, and then deliver this conditioned air (CA) to each occupied space, either directly or in conjunction with local HVAC equipment serving those same spaces (Figure 1). This local (zone-level) HVAC equipment is then used to provide cooling or heating to maintain space temperature.

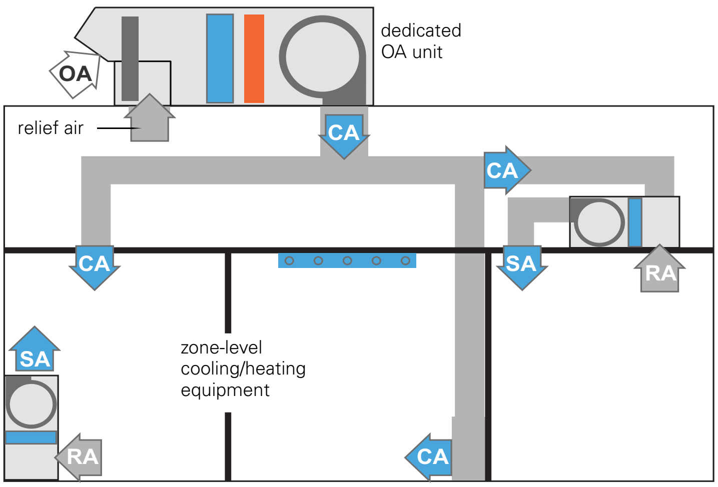
Until recently, an industry rating standard for direct-expansion (DX) dedicated outdoor-air units didn't exist. And without a rating standard to cite, ASHRAE Standard 90.1 has not prescribed a minimum efficiency requirement for this class of equipment (see sidebar).

In June 2013 ANSI/AHRI Standard 920, *Performance Rating of DX Dedicated Outdoor Air System Units*, was approved by ANSI and published by AHRI. This standard applies to DX "products which dehumidify 100-percent outdoor air to a low dew point," and are equipped with either an air-cooled or water-cooled condenser (including air-, water-, or ground-source heat pumps).

With this industry rating standard in place, the ASHRAE Standard 90.1 committee proposed and published an addendum to prescribe minimum efficiency requirements for DX dedicated OA units (more on this later).

However, because this rating standard is relatively new, there is still confusion in the industry when specifying the efficiency of this class of equipment. The purpose of this EN is to introduce the reader to AHRI Standard 920 and help specifying engineers cite this as the appropriate rating standard for DX dedicated OA units.

Figure 1. Example of a dedicated outdoor-air system



Minimum equipment efficiencies required by ASHRAE Standard 90.1. In order for the Standard 90.1 committee to include a certain class of equipment in the minimum equipment efficiency tables in Section 6.4.1 of the standard, there must be an industry standard that defines how to uniformly rate the efficiency of that class of equipment.

"Equipment efficiency levels defined in this section [Section 6.4.1] and Tables 6.8.1-1 through 6.8.1-13 are based on industry rating standards, such as those of the Air-Conditioning, Heating, and Refrigeration Institute (AHRI)."[1]

The User's Manual that accompanies Standard 90.1 clarifies that HVAC equipment that is not included in the minimum equipment efficiency tables can still be used; it's just that Standard 90.1 does not prescribe a minimum efficiency requirement for that class of equipment.

"Although Sections 6.4.1.1 and 6.4.1.2 include many types of HVACR equipment, not every type of HVACR equipment that might be used in a project is covered. This section [Section 6.4.1.3] clarifies that the use of HVACR equipment not covered by these sections does not prohibit compliance with the Standard. Equipment not covered by these sections is not regulated by this standard, but may be regulated by other standards, codes, or federal regulations."[2]

[1] Standard 90.1-2013 User's Manual, page 6-14

[2] Standard 90.1-2013 User's Manual, page 6-18

AHRI Standard 920 or Standard 340/360?

Historically, some engineers have specified that DX dedicated OA units should be rated in accordance with AHRI Standard 340/360. Is this appropriate? How does this standard compare with AHRI Standard 920?

AHRI Standard 340/360, *Performance Rating of Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment*, is used to rate the performance of DX air-conditioning equipment. This rated performance includes the total cooling capacity (Btu/hr), full-load Energy Efficiency Ratio (EER, Btu/W-hr), and an Integrated Energy Efficiency Ratio (IEER, Btu/W-hr). IEER is a weighted calculation of *cooling* efficiencies at full-load and part-load conditions. This standard also rates heating capacity and efficiency (Coefficient of Performance, or COP).

AHRI Standard 920, *Performance Rating of DX Dedicated Outdoor Air System Units*, is used to rate the performance of DX equipment that is used to dehumidify 100-percent outdoor air to a low dew point. This rated performance includes the Moisture Removal Capacity (MRC, lb/hr), full-load Moisture Removal Efficiency (MRE, lb/kWh), and an Integrated Seasonal Moisture Removal Efficiency (ISMRE, lb/kWh). ISMRE is a weighted calculation of *dehumidification* efficiencies at full-load and part-load conditions. The standard also rates heating capacity, efficiency (COP), and Integrated Seasonal Coefficient of Performance (ISCOP, which is a weighted calculation of heating efficiencies at full-load and part-load conditions).

The **first obvious difference** between these two rating standards is that Standard 340/360 rates efficiency (EER) by dividing the total *cooling* capacity (Btu/hr) of the equipment by the power input (W), whereas Standard 920 rates efficiency (MRE) by dividing the *dehumidification* capacity (lbs of water removed/hr) of the equipment by the power input (kW).

This highlights the difference in scope between these two standards. Standard 920 was specifically developed to rate the performance of DX equipment that is used to dehumidify 100-percent outdoor air to a low dew point.

The **second difference** is in how the two standards determine an *integrated* (or weighted) efficiency rating: IEER by Standard 340/360 and ISMRE by Standard 920. While both standards use four operating conditions to perform a weighted calculation of full-load and part-load efficiencies, the operating conditions and method of testing differ greatly.

$$IEER = (0.020 \times A) + (0.617 \times B) + (0.238 \times C) + (0.125 \times D)$$

where,

A = EER at 100% capacity and standard rating conditions

B = EER at 75% capacity and reduced condenser temperature

C = EER at 50% capacity and reduced condenser temperature

D = EER at 25% capacity and reduced condenser temperature

$$ISMRE = (0.12 \times A) + (0.28 \times B) + (0.36 \times C) + (0.24 \times D)$$

where,

A = MRE at standard rating condition A

B = MRE at standard rating condition B

C = MRE at standard rating condition C

D = MRE at standard rating condition D

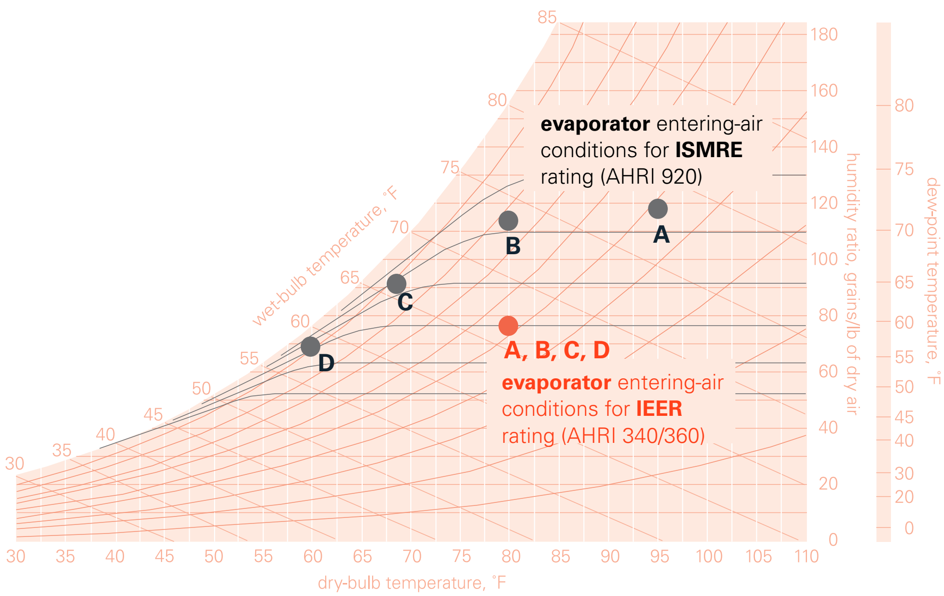
Table 1 compares the rating conditions used to determine both IEER and ISMRE for equipment with an air-cooled condenser. Notice that Standard 340/360 requires the equipment to operate at four different dry-bulb temperatures entering the air-cooled condenser: 95°F, 81.5°F, 68°F, and 65°F. This is intended to depict the equipment operating during different times of the year. However, the air entering the evaporator coil remains the same (80°F DBT, 67°F WBT) for all four conditions, which essentially depicts how a unit would operate with a constant return-air condition and no outdoor air.

This is because Standard 340/360 is intended to rate the cooling capacity and efficiency of an air-conditioner, it doesn't address dehumidification. During testing there is no requirement that the evaporator achieve a dew point temperature low enough to ensure dehumidification.

Table 1. Comparison of standard rating test conditions for packaged DX units with air-cooled condensers

	condition A	condition B	condition C	condition D
IEER rating conditions (per AHRI 340/360)	IEER = (0.020 × A) + (0.617 × B) + (0.238 × C) + (0.125 × D)			
evaporator entering-air conditions	80°F DBT 67°F WBT	80°F DBT 67°F WBT	80°F DBT 67°F WBT	80°F DBT 67°F WBT
condenser entering-air conditions	95°F DBT	81.5°F DBT	68°F DBT	65°F DBT
ISMRE rating conditions (per AHRI 920)	ISMRE = (0.12 × A) + (0.28 × B) + (0.36 × C) + (0.24 × D)			
evaporator entering-air conditions	95°F DBT 78°F WBT	80°F DBT 73°F WBT	68°F DBT 66°F WBT	60°F DBT 58°F WBT
condenser entering-air conditions	95°F DBT	80°F DBT	68°F DBT	60°F DBT

Figure 2. Evaporator entering-air conditions for standard ratings



Standard 920 also requires the equipment to operate at four different dry-bulb temperatures entering the air-cooled condenser: 95°F, 80°F, 68°F, and 60°F. But the air entering the evaporator coil matches the outdoor-air conditions, so it is different at each of these four conditions. This depicts how a 100-percent outdoor-air unit would operate during different times of the year (see Figure 2).

In addition, because Standard 920 is intended to rate the dehumidification capacity and efficiency of a dedicated OA unit, the evaporator must dehumidify the air to a leaving-air dew point no higher than 55°F at each of the four test conditions.

This emphasizes a **third difference** between the standards. Whereas Standard 340/360 is a static test, Standard 920 is a dynamic test that requires dehumidification capacity modulation via compressor staging, variable-speed or variable-capacity compressors, or other methods of capacity modulation.

And finally, Standard 920 also incorporates the impact of hot gas reheat (HGRH) on equipment efficiency, since the dry-bulb temperature of the air leaving the unit must be no lower than 70°F at each of the four test conditions (see sidebar). If the equipment's HGRH system is unable to achieve this minimum leaving-air temperature—which is likely to occur at rating condition D, for example—supplemental reheat energy must be accounted for when determining Moisture Removal Efficiency (MRE).

DX dedicated OA units are more energy intense than conventional air conditioners for several reasons:

- More compressor capacity (and power) per CFM due to the higher sensible load of cooling 100-percent outdoor air (versus a mixture of outdoor and recirculated air)
- More compressor capacity (and power) per CFM due to the higher latent load of dehumidifying 100-percent outdoor air to no higher than a 55°F dew point
- More fan power per CFM due to the need for deeper/denser evaporator coils and hot gas reheat coils
- Possible added power demand due to the need for compressor capacity modulation

Therefore, DX dedicated OA units should be specified using the rating standard (AHRI 920) developed specifically to reflect these differences.

Cold versus neutral air? As explained, AHRI Standard 920 requires the dehumidified outdoor air to be reheated to a dry-bulb temperature of at least 70°F for the purpose of rating this class of equipment. However, reheating to a "neutral" air temperature is not necessarily the most efficient way to operate the overall system.

When a chilled-water or DX cooling coil is used for dehumidification, a byproduct of that process is that the dry-bulb temperature of the air leaving the coil is colder than the occupied space. If the dehumidified outdoor air is reheated to a "neutral" dry-bulb temperature, most (or all) of the sensible cooling performed by the dedicated OA unit is wasted.

The Standard 90.1 committee recognizes this inefficiency and added a new requirement to the 2016 version that prevents reheating this air to any warmer than 60°F during the cooling season:

"Units that provide ventilation air to multiple zones and operate in conjunction with zone heating and cooling systems shall not use heating or heat recovery to warm supply air above 60°F when representative building loads or outdoor air temperature indicate the majority of zones require cooling."[3]

For more discussion of cold versus neutral air in a dedicated OA system, refer to the Trane application guide, *Dedicated Outdoor Air Systems* (SYS-APG001-EN).

[3] ASHRAE Standard 90.1-2016, Section 6.5.2.6

New Efficiency Requirements Added to ASHRAE Standard 90.1

After AHRI Standard 920 was published, the ASHRAE Standard 90.1 committee drafted addendum CD to include minimum efficiency requirements for DX dedicated OA units.

> *"Dedicated outdoor air systems (DOAS) ... are now used in many buildings covered by ASHRAE 90.1. However, the current ASHRAE 90.1 standard has no minimum energy efficiency requirements for this equipment. Through AHRI, manufacturers of DOAS developed Standard 920 to establish common rating conditions for these products. This proposal establishes for the first time a product class for DOAS."* [4]

This addendum included minimum efficiencies for this class of equipment, which are based on the Integrated Seasonal Moisture Removal Efficiency (ISMRE) and Integrated Seasonal Coefficient of Performance (ISCOP) defined by AHRI Standard 920 (Table 2 and Table 3).

Addendum CD to ASHRAE 90.1-2013 went through two public reviews before being approved by the ASHRAE Board of Directors on September 6, 2016. The 2016 version of Standard 90.1 will include these tables of minimum efficiency requirements in Section 6.4.1.

Table 2. Minimum efficiency requirements for electrically-operated DX-DOAS units *without* energy recovery

Equipment Type	Subcategory	Minimum efficiency	Test procedure
Air-cooled (dehumidification mode)		4.0 ISMRE	AHRI Standard 920-2015
Air-source heat pump (dehumidification mode)		4.0 ISMRE	
Water-cooled (dehumidification mode)	cooling tower condenser water	4.9 ISMRE	
	chilled water	6.0 ISMRE	
Water-source heat pump (dehumidification mode)	ground-source, closed loop	4.8 ISMRE	
	groundwater-source	5.0 ISMRE	
	water-source	4.0 ISMRE	
Air-source heat pump (heating mode)		2.7 ISCOP	
Water-source heat pump (heating mode)	ground-source, closed loop	2.0 ISCOP	
	groundwater-source	3.2 ISCOP	
	water-source	3.5 ISCOP	

Table 3. Minimum efficiency requirements for electrically-operated DX-DOAS units *with* energy recovery

Equipment Type	Subcategory	Minimum efficiency	Test procedure
Air-cooled (dehumidification mode)		5.2 ISMRE	AHRI Standard 920-2015
Air-source heat pump (dehumidification mode)		5.2 ISMRE	
Water-cooled (dehumidification mode)	cooling tower condenser water	5.3 ISMRE	
	chilled water	6.6 ISMRE	
Water-source heat pump (dehumidification mode)	ground-source, closed loop	5.2 ISMRE	
	groundwater-source	5.8 ISMRE	
	water-source	4.8 ISMRE	
Air-source heat pump (heating mode)		3.3 ISCOP	
Water-source heat pump (heating mode)	ground-source, closed loop	3.8 ISCOP	
	groundwater-source	4.0 ISCOP	
	water-source	4.8 ISCOP	

Calculating Moisture Removal Capacity (MRC). The example in Figure 3 depicts a dedicated OA unit that dehumidifies 4000 cfm of outdoor air from 84°F dry bulb and 76°F dew point (which equates to a humidity ratio of 135.9 $gr_{water}/lb_{dry\ air}$) to a leaving-air dew point of 50°F (which equates to 53.4 $gr_{water}/lb_{dry\ air}$).

Moisture Removal Capacity (MRC) = $4.5 \times V_{ot} \times (W_{OA} - W_{CA}) / (7000\ gr/lb)$

where,

MRC = Moisture Removal Capacity, lb/hr

V_{ot} = design outdoor airflow, cfm

W_{OA} = humidity ratio of the entering outdoor air, gr/lb

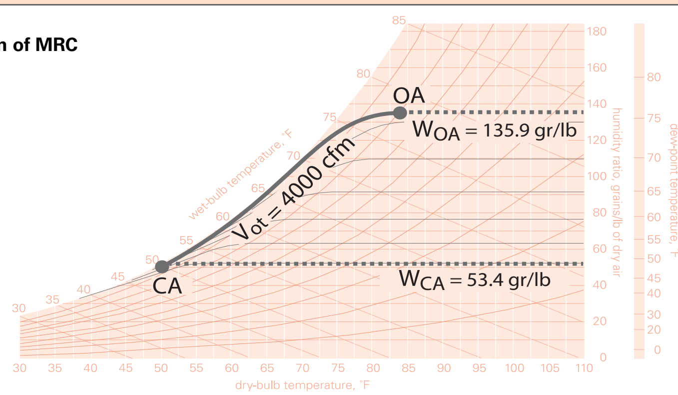
W_{CA} = humidity ratio of the leaving conditioned (dehumidified) air, gr/lb

Note: In this equation, 4.5 is not a constant, but is derived from multiplying the density of air at "standard" conditions (69°F dry air at sea level has a density of 0.075 lb/ft^3) by the conversion of 60 minutes/hr. Air at other conditions and elevations will cause this factor to change.

The required MRC of the dedicated OA unit in this example is 212 lb/hr (or about 25 gallons/hr):

MRC = $4.5 \times 4000\ cfm \times (135.9 - 53.4\ gr/lb) / (7000\ gr/lb) = 212\ lb/hr$

Figure 3.
Example calculation of MRC



[4] Excerpt from the "Foreword" to addendum CD to ASHRAE Standard 90.1-2013

Further, Section 6.4.1.4 of Standard 90.1 requires verification of equipment efficiency information provided by the manufacturer. If a certification program exists for the product class, then the selected product must be either listed in the directory of certified products (www.ahridirectory.org) or its efficiency rating(s) must be verified by an independent laboratory test report (per options B and C, listed below). However, if no certification program exists for the product class, then the efficiency rating data furnished by the manufacturer is considered sufficient for demonstrating compliance (per option D, listed below).

"Equipment efficiency information supplied by manufacturers shall be verified by one of the following:

(a) …

(b) If a certification program exists for a covered product, and it includes provisions for verification and challenge of equipment efficiency ratings, then the product shall be listed in the certification program.

(c) If a certification program exists for a covered product, and it includes provisions for verification and challenge of equipment efficiency ratings, but the product is not listed in the existing certification program, the ratings shall be verified by an independent laboratory test report.

(d) If no certification program exists for a covered product, the equipment efficiency ratings shall be supported by data furnished by the manufacturer." [5]

AHRI is in the process of starting a certification program for DX dedicated OA units, to accompany AHRI Standard 920. Until that is in place, however, efficiency rating data furnished by the manufacturer is sufficient for demonstrating compliance with Standard 90.1.

[5] ASHRAE Standard 90.1-2016, Section 6.4.1.4

How This Impacts Specifying Engineers

Use MRC and ISMRE (tested in accordance with AHRI Standard 920) when specifying the required dehumidification performance of a DX dedicated OA unit; and not IEER based on AHRI Standard 340/360.

As explained in this EN, DX dedicated OA units are constructed differently, tested differently, and operated differently than conventional DX air conditioners. Therefore, they should be specified using AHRI Standard 920, which was developed to reflect these differences. When specifying the required MRC for a specific application, be sure to also specify the associated airflow and entering-air conditions (see sidebar).

Help educate code officials that the current version of ASHRAE Standard 90.1 does not prescribe minimum efficiency requirements for DX dedicated OA units by informing them about the new tables being added to the 2016 version of the standard.

Since there was no industry standard to uniformly rate the efficiency of this class of equipment, previous and current versions of Standard 90.1 did not prescribe a minimum equipment efficiency for DX dedicated OA units. This will change with the publication of ASHRAE 90.1-2016 when minimum efficiency requirements, tested in accordance with AHRI Standard 920, are added to the standard for the first time.

Until the corresponding certification program is in place, efficiency rating data furnished by the manufacturer is sufficient for demonstrating compliance with Standard 90.1. However, once the certification program is in place, the product must be listed in AHRI's directory of certified products (www.ahridirectory.org) or the ratings must be verified by an independent laboratory test report.

By John Murphy, applications engineer, Trane. You can find this and previous issues of the Engineers Newsletter at www.trane.com/EN. To comment, send e-mail to ENL@trane.com.

References

- ANSI/ASHRAE/IES, Standard 90.1-2016, *Energy Standard for Buildings Except Low-Rise Residential Buildings* (I-P Edition), Atlanta: ASHRAE, 2016.
- ANSI/ASHRAE/IES, Standard 90.1-2013, *Energy Standard for Buildings Except Low-Rise Residential Buildings* (I-P Edition), Atlanta: ASHRAE, 2013.
- ANSI/AHRI Standard 920-2015, *Performance Rating of DX Dedicated Outdoor Air System Units*. Air-Conditioning, Heating and Refrigeration Institute. 2015.
- AHRI Standard 340/360-2015, *Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment*, Air-Conditioning, Heating and Refrigeration Institute, 2015.

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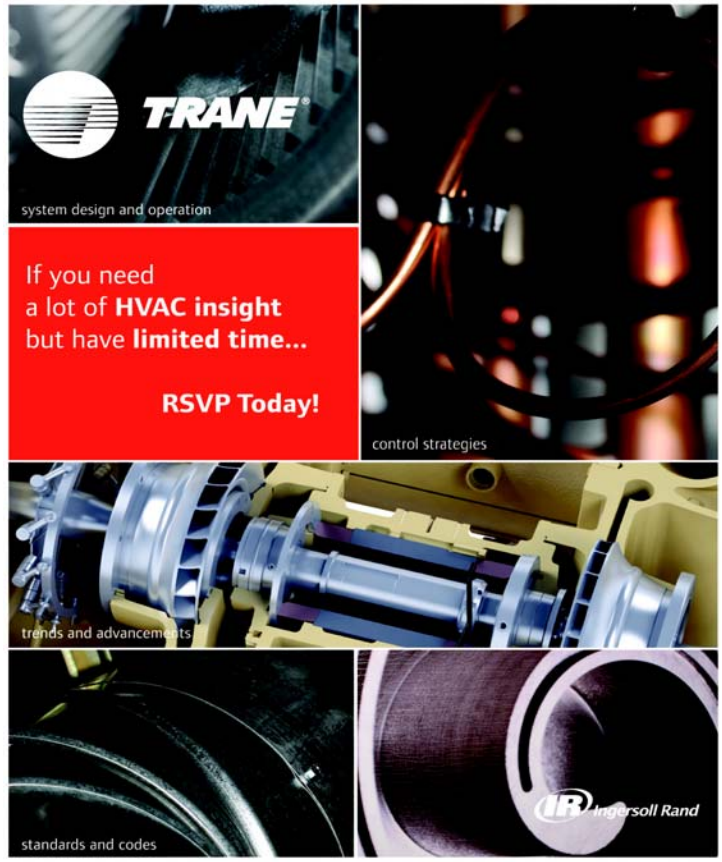

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