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TRANE

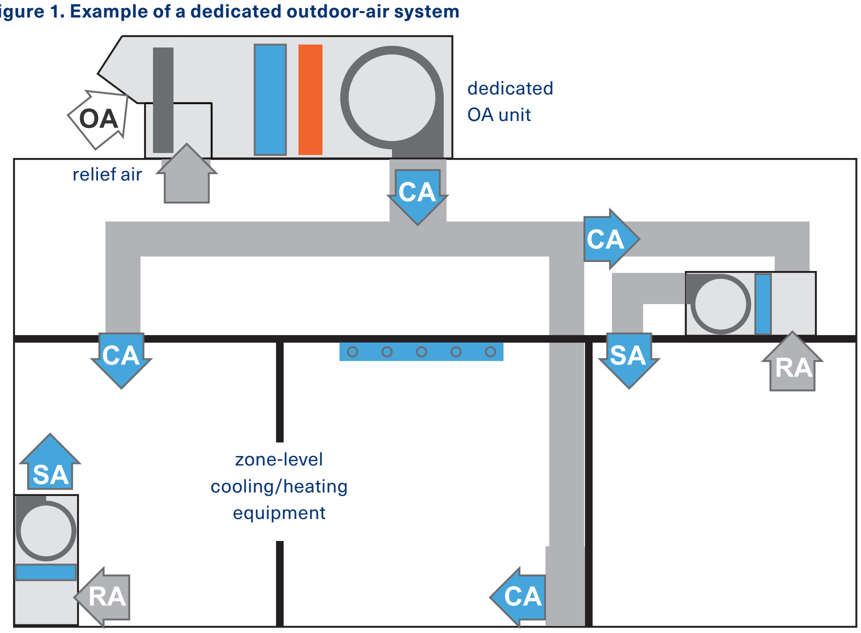
AHRI 920: Rating Standard for DX Dedicated Outdoor Air Units

Originally published in 2016, this EN has been updated to reflect changes implemented in the 2020 version of AHRI Standard 920.

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.

In June 2013, ANSI/AHRI Standard 920, *Performance Rating of DX Dedicated Outdoor Air System Units*, was first published by AHRI. The latest revision was published in 2020. This standard applies to factory-assembled, direct-expansion (DX) products designed to dehumidify 100 percent outdoor air to a low dew point. They are equipped with either an air-cooled or water-cooled condenser (including air-, water-, or ground-source heat pumps).

Figure 1. Example of a dedicated outdoor-air system



With this industry rating standard in place, the ASHRAE® Standard 90.1 committee added minimum efficiency requirements for DX dedicated OA units, beginning with the 2016 version of that standard.

Because Standard 920 is still relatively new, there is often 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, highlight some of the changes implemented in the 2020 version of this standard, and help specifying engineers cite this as the appropriate rating standard for DX dedicated OA units.

Minimum equipment efficiencies required by ASHRAE Standard 90.1

Prior to the 2016 version, Standard 90.1 did not include minimum efficiency requirements for DX dedicated outdoor-air units. In order for the Standard 90.1 committee to include a certain class of equipment in the minimum equipment efficiency tables in Section 6.4.1.1 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 6.4.1.1] and Tables 6.8.1-1 through 6.8.1-20 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 90.1-2019 User's Manual*, p. 120

[2] *Standard 90.1-2019 User's Manual*, p. 123

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 (ISMRE2, lb/kWh). ISMRE2 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 (ISCOP2). ISCOP2 is a weighted calculation of heating efficiencies at full-load and part-load conditions).

The **first difference** between these two rating standards is that Standard 340/360 rates cooling efficiency (EER) by dividing the total cooling capacity (Btu/hr) of the equipment by the power input (W), whereas Standard 920 rates dehumidification 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, ensuring that it is capable of dehumidifying 100-percent outdoor air to a leaving-air dew point no higher than 55°F.

The **second difference** is in how the two standards determine an integrated (or weighted) efficiency rating: IEER by Standard 340/360 and ISMRE2 (or $ISMRE2_{70}$) 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

$$ISMRE2 = (0.14 \times A) + (0.34 \times B) + (0.39 \times C) + (0.13 \times D)$$

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 ISMRE2 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.

Standard 920 also requires the equipment to operate at four different dry-bulb temperatures entering the air-cooled condenser: 95°F, 80°F, 70°F, and 63°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).

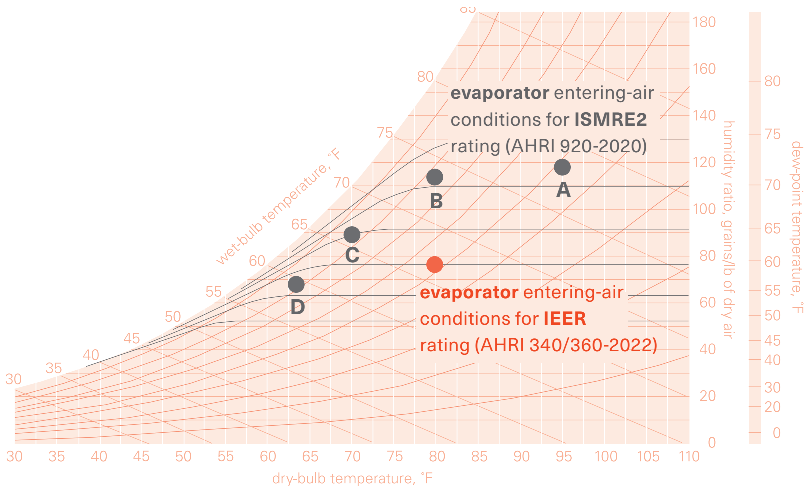
In addition, because Standard 920 is intended to rate the dehumidification capacity and efficiency of a dedicated OA unit, the evaporator must dehumidify the air to a target leaving-air dew point no higher than 55°F at test condition A. The leaving-air dew point at operating conditions B, C, and D must then be controlled to be within +/- 0.3°F of this target.

This emphasizes a **third difference** between the standards. Standard 340/360 does not require controlling to a specific leaving-air condition. In contrast, Standard 920 requires dehumidification capacity control specifically designed to achieve the target leaving-air dew point at all four rated operating conditions. If the unit is unable to dehumidify within the required tolerance at any part-load operating condition, a weighted averaging process is used to determine the MRE.

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 (AHRI 340/360-2022)	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
ISMRE2 rating conditions (AHRI 920-2020)	ISMRE2 = (0.14 × A) + (0.34 × B) + (0.39 × C) + (0.13 × D)			
evaporator entering-air conditions	95°F DBT 78°F WBT	80°F DBT 73°F WBT	70°F DBT 66°F WBT	63°F DBT 59°F WBT
condenser entering-air conditions	95°F DBT	80°F DBT	70°F DBT	63°F DBT

Figure 2. Evaporator entering-air conditions for standard ratings



And the **final difference** is that Standard 920 also incorporates the impact of hot gas reheat (HGRH) on equipment efficiency.

The term MRE depicts unit efficiency when dehumidifying outdoor air to the target leaving-air dew point, with no requirement to reheat this dehumidified air. But the leaving-air dry-bulb temperature can be no warmer than 75°F.

The term MRE_{70} is used to depict unit efficiency when dehumidifying outdoor air to the target leaving-air dew point, and then reheating it to at least 70°F dry bulb (but no warmer than 75°F). If the equipment's HGRH system is unable to achieve this minimum leaving-air dry-bulb temperature—which is most likely to occur at cooler ambient temperatures, like rating condition D, for example—supplemental reheat energy must be accounted for when calculating MRE_{70}.

Then $ISMRE2_{70}$ uses the same equation and weightings as ISMRE2 to depict dehumidification-plus-reheat efficiency at full-load and part-load conditions.

If a DX dedicated OA unit is equipped with reheat, MRE_{70} and $ISMRE2_{70}$ provide a more accurate comparison of overall unit performance, since these metrics account for the performance of the reheat component(s).

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

- They require more compressor capacity (and power) per CFM due to the higher sensible and latent loads required to cool and dehumidify 100-percent outdoor air (versus a mixture of outdoor and recirculated air) to a low dew point. Dehumidifying from AHRI 920 rating condition A to a leaving-air dew point of no higher than 55°F equates to about 150 cfm/ton or lower. In comparison, units rated to AHRI 340/360 are more often in the range of 400 cfm/ton.

- They require more fan power per CFM due to the need for deeper/denser evaporator coils and possibly hot gas reheat coils.

- They may require additional power to effectively control dehumidification capacity.

Therefore, DX dedicated OA units should be specified using the updated rating standard (AHRI 920-2020), which was developed specifically to reflect these differences.

Cold versus neutral air?

In some cases, the dehumidified outdoor air might be reheated to a dry-bulb temperature of approximately 70°F. 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 the following 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 90.1-2022, Section 6.5.2.6

Minimum Efficiency Requirements Revised in ASHRAE Standard 90.1

After AHRI Standard 920 was initially published, the ASHRAE Standard 90.1 committee added minimum efficiency requirements for DX dedicated OA units to that standard for the first time as an addendum to its 2013 version:

> *"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]

Then, addendum CV to ASHRAE 90.1-2022, which was approved by the ASHRAE Board of Directors on 28 February 2023, revised these minimum efficiencies for this class of equipment, so they are now based on the ISMRE2 and ISCOP2, as defined by AHRI Standard 920-2022 (Table 2 and Table 3).

The 2025 version of Standard 90.1 will include these revised 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)		3.8 ISMRE2	AHRI Standard 920-2020
Air-source heat pump (dehumidification mode)		3.8 ISMRE2	
Water-cooled (dehumidification mode)	cooling tower condenser water	4.7 ISMRE2	
	chilled water	3.8 ISMRE2	
Water-source heat pump (dehumidification mode)	ground-source (closed loop)	4.6 ISMRE2	
	groundwater-source (open loop)	4.6 ISMRE2	
	water-source	3.8 ISMRE2	
Air-source heat pump (heating mode)		2.05 ISCOP2	
Water-source heat pump (heating mode)	ground-source (closed loop)	2.13 ISCOP2	
	groundwater-source (open loop)	2.13 ISCOP2	
	water-source	2.13 ISCOP2	

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)		5.0 ISMRE2	AHRI Standard 920-2020
Air-source heat pump (dehumidification mode)		5.0 ISMRE2	
Water-cooled (dehumidification mode)	cooling tower condenser water	5.1 ISMRE2	
	chilled water	4.6 ISMRE2	
Water-source heat pump (dehumidification mode)	ground-source (closed loop)	5.0 ISMRE2	
	groundwater-source (open loop)	5.0 ISMRE2	
	water-source	4.6 ISMRE2	
Air-source heat pump (heating mode)		3.2 ISCOP2	
Water-source heat pump (heating mode)	ground-source (closed loop)	3.5 ISCOP2	
	groundwater-source (open loop)	3.5 ISCOP2	
	water-source	4.04 ISCOP2	

Calculating Moisture Removal Capacity (MRC)

The example in Figure 3 depicts a dedicated OA unit that dehumidifies 4000 cfm of outdoor air from standard rating condition C, 70°F dry bulb and 66°F wet bulb (which equates to a humidity ratio of 89.7 $gr_{water}/lb_{dry\ air}$) 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 × Vot × (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

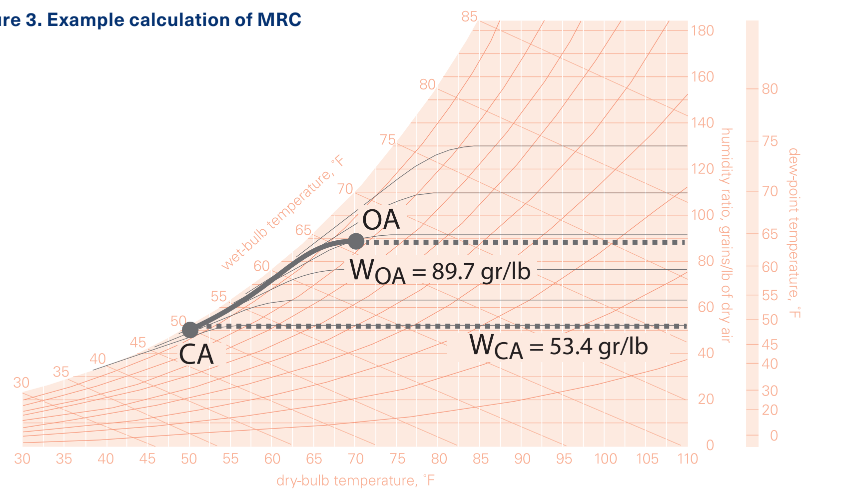
W_{CA} = humidity ratio of the leaving conditioned (dehumidified) air, gr/lb

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 MRC of the dedicated OA unit in this example is 93.3 lb/hr (or about 11 gallons/hr):

MRC = 4.5 × 4000 cfm × (89.7 - 53.4 gr/lb) / (7000 gr/lb) = 93.3 lb/hr

Figure 3. Example calculation of MRC



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

Further, Standard 90.1 (see excerpt below) 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]

At the time of this publication, 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 ASHRAE Standard 90.1.

[5] ASHRAE Standard 90.1-2022, Section 6.4.1.4

How This Impacts Specifying Engineers

Use MRC and ISMRE2 or ISMRE2$_{70}$ (tested in accordance with AHRI 920-2020) when specifying the required dehumidification performance of a DX dedicated OA unit; and not IEER based on AHRI 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 and MRE for a specific application, be sure to also specify the associated airflow, entering-air conditions, and desired leaving-air conditions.

If the DX dedicated OA unit is equipped with reheat, MRE$_{70}$ and ISMRE2$_{70}$ should be specified. This allows a more accurate comparison of overall unit performance, since these metrics account for the performance of the reheat component(s). And if the unit's ISMRE2$_{70}$ rating complies with the minimum efficiency requirement (see Table 2 and Table 3), then it's ISMRE2 rating will also comply.

Help educate code officials that older versions of ASHRAE Standard 90.1 did not prescribe minimum efficiency requirements for DX dedicated OA units, and inform them about the revisions to these values being implemented in the 2025 version of Standard 90.1.

Prior to the 2016 version of Standard 90.1, there was no industry standard to uniformly rate the efficiency of DX dedicated OA units, so older versions of Standard 90.1 did not prescribe a minimum equipment efficiency for this class of equipment. As explained in this EN, the minimum efficiency requirements in Standard 90.1 have now been revised to coincide with the 2020 version of AHRI Standard 920.

Also, the U.S. Department of Energy (DOE) has published federal regulations that govern the efficiency of DX dedicated OA units. They align with addendum CV to Standard 90.1-2022 (Table 2 and Table 3), and are scheduled to go into effect on 7 May 2025.

When should AHRI 920 metrics be used versus AHRI 340/360 metrics?

When applying a DX unit where its primary function is dehumidification, requiring a low cfm/ton and control to a low leaving-air dew point, this most closely matches the test requirements of AHRI 920, regardless of the percent outdoor air.

When applying a DX unit where its primary function is space cooling, this most closely matches the test requirements of AHRI 340/360.

For applications in between, its up to the specifying engineer's discretion as to which rating standard allows for the best comparison of unit performance, given the equipment's intended use.

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.

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