Specifying DX Dedicated Outside Air Units

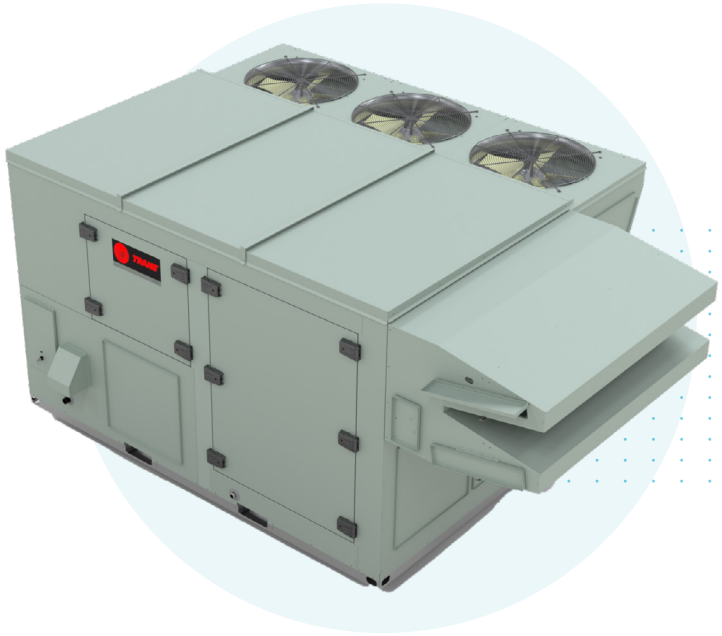
White Paper

Executive Summary

Dedicated Outdoor Air Systems (DOAS) in modern HVAC configurations function to dehumidify 100-percent outdoor air to a dew point drier than the space before delivering this conditioned air (CA) to occupied spaces. This dew point is lower than the space to offset the internal latent load. DOAS units can operate either independently or in conjunction with local HVAC equipment, which is responsible for maintaining the desired space temperature through additional cooling or heating. The proper specification of DX DOAS equipment is essential for optimizing system efficiency, ensuring occupant comfort, and maintaining indoor air quality (IAQ). Specifying the correct DOAS equipment ensures that the system operates efficiently, preventing issues such as mold growth, humidity problems, and overall occupant discomfort.

Problem Statement

There has been ongoing confusion in the industry regarding the proper specification of DOAS equipment and efficiency. Historically, engineers have relied on AHRI Standard 340/360 for rating DOAS equipment. However, a relatively new standard, AHRI 920-2020, was specifically developed for DOAS applications. Despite this, there remains significant confusion around the different efficiency ratings between these standards, leading to potential misapplication and inefficiencies in system performance, particularly in part load dehumidification performance. Clarifying the appropriate use of these standards is crucial for accurate specification and optimal operation of the overall HVAC system including DOAS equipment.



Solution

To address the confusion surrounding the proper specification of DOAS equipment and efficiency, it is essential to understand the distinct functions and rating standards of DOAS compared to traditional rooftop units. The AHRI 920 standard is specifically designed for DOAS equipment, whose primary function is to remove moisture from the air, unlike typical rooftop equipment rated under AHRI 340/360, which focuses on cooling efficiency. Under AHRI 920, the full load rating for DOAS is Moisture Removal Efficiency (MRE), which measures dehumidification efficiency, rather than the Energy Efficiency Ratio (EER) used for cooling efficiency in traditional rooftop units.

A more comprehensive efficiency measure for DOAS is the Integrated Seasonal Moisture Removal Efficiency (ISMRE2), which evaluates how the unit operates throughout the year under various dynamic dehumidification conditions, with a requirement to maintain a supply air dew point at or below 55°F. In contrast, traditional rooftop equipment is rated using the Integrated Energy Efficiency Ratio (IEER), which assesses cooling efficiency across an operating envelope with static test conditions of 80°F dry bulb and 67°F wet bulb. The dynamic dehumidification capacity conditions for AHRI 920-2020 necessitate capacity modulation through modulating compressors and/or staging to handle varying humidity loads effectively.

Furthermore, since DOAS equipment is specifically designed to manage latent humidity loads, the AHRI 920 standard uniquely incorporates the impact of Hot Gas Reheat (HGRH) on overall efficiency.

By adhering to the AHRI 920 standard for DOAS equipment, engineers can ensure accurate specification, optimal performance, and efficient operation tailored to the unique dehumidification needs of their applications.

Example 1 For Part Load Performance, IEER is Scheduled Instead of ISMRE2

Issue:

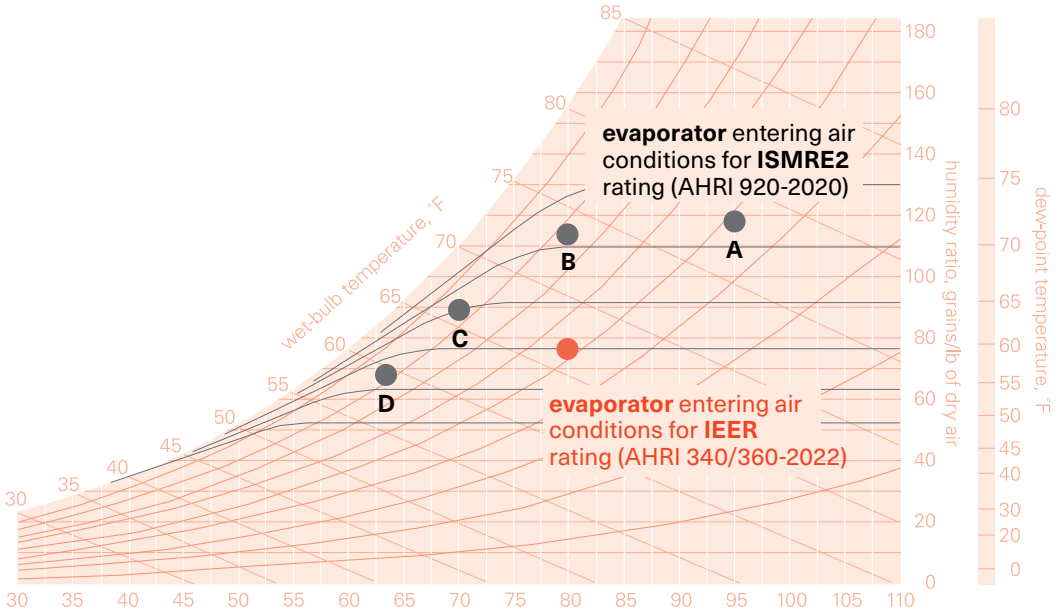
IEER is based on 340/360 and is rated on different condenser capacities but the same evaporator coil conditions 80°F/67°F. Which depicts a how a unit would operate with a mixed air condition. This is because Standard 340/360 is intended to rate the cooling capacity and efficiency of an air-conditioner, it does not address dehumidification. During testing there is no requirement that the evaporator achieve and maintain 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 and packaged DX DOAS units

	condition A	condition B	condition C	condition D
IEER rating conditions (AHRI 340/360-2022)	IEER = (0.020 x A) + (0.617 × B) + (0.238 × C) + (0.125 × D)			
evaporator entering-air conditions	80°F DBT	80°F DBT	80°F DBT	80°F DBT
condenser entering-air conditions	67°F DBT	67°F DBT	67°F DBT	67°F DBT
ISMRE2 rating conditions (AHRI 920-2020)	ISMRE2 = (0.14 x A) + (0.34 x B) + (0.39 x C) + (0.13 x D)			
evaporator entering-air conditions	95°F DBT 78°F DBT	80°F DBT 73°F DBT	70°F DBT 66°F DBT	63°F DBT 59°F DBT
condenser entering-air conditions	95°F DBT	80°F DBT	70°F DBT	63°F DBT

Solution:

ISMRE2: Standard 920 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. Also, 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 as outdoor air conditions change throughout the year.



Standard 920 is intended to rate the dehumidification capacity and efficiency of a dedicated outdoor air 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.

Solution ++

Trane Horizon DOAS is able to provide additional performance and efficiency data at non-standard part load conditions. By providing specific application data, you are ensured peace of mind your DOAS is specifically designed to maintain the required supply-air dew point, and reheat, at all outdoor air conditions in your climate zone.

Example 2 — Not Adjusting the Terminal Equipment Schedule When Designing a DOAS System

Issue:

Terminal equipment and DOAS equipment are independently designed without considering OA conditioning. Incorporating DOAS equipment into your design without integrating it into the terminal performance schedule can lead to several issues:

Comfort Control Challenges:
Terminal equipment sized to handle the total space load and added latent load from OA can limit turndown and part-load conditioning capabilities, negatively impacting space comfort.

Energy Code Compliance:
It may become more difficult to comply with energy codes.

Increased Costs:
The design may become more expensive due to oversized terminal equipment and potential additional costs for managing condensate in the space.

Condensate issues typically arise in systems that fail to decouple the space sensible and latent loads. These issues are exacerbated by the use of Dedicated Outdoor Air Systems (DOAS) units that are unable to maintain the necessary supply-air dewpoint and reheat across all outdoor air conditions. Consequently, these condensate problems are attributable to elevated relative humidity levels within the space.

Solution:

Evaluate the impact of the DOAS equipment on your terminal schedule to meet performance.

Example: Elementary School Classroom

750 ft²
floor area

26 people
(1 teacher + 25 students)

Zone	space dry-bulb temperature	space relative humidity	$Qspace_{sensible}$	$Qspace_{latent}$	outdoor airflow V_{OZ}
Classroom 101	73°F	50%	20,300 Btu/h	4,030 Btu/h	350 cfm

Designing with a conventional rooftop which can only achieve 55°F dewpoint

Example Classroom

Design Space Sensible Cooling Load

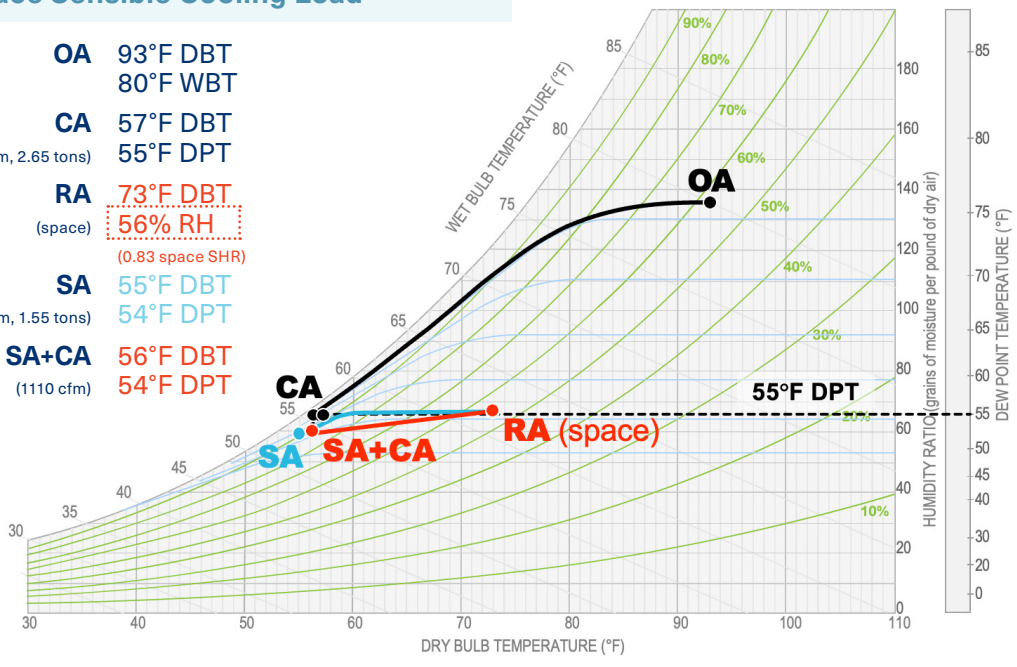
OA 93°F DBT, 80°F WBT

CA (DOAS: 350 cfm, 2.65 tons) 57°F DBT, 55°F DPT

RA (space) 73°F DBT, 56% RH (0.83 space SHR)

SA (terminal: 760 cfm, 1.55 tons) 55°F DBT, 54°F DPT

SA+CA (1110 cfm) 56°F DBT, 54°F DPT



57°F DBT
55°F DPT

Designing with a DOAS rated piece of equipment like Horizon with 45°F dewpoint

Example Classroom

Design Space Sensible Cooling Load

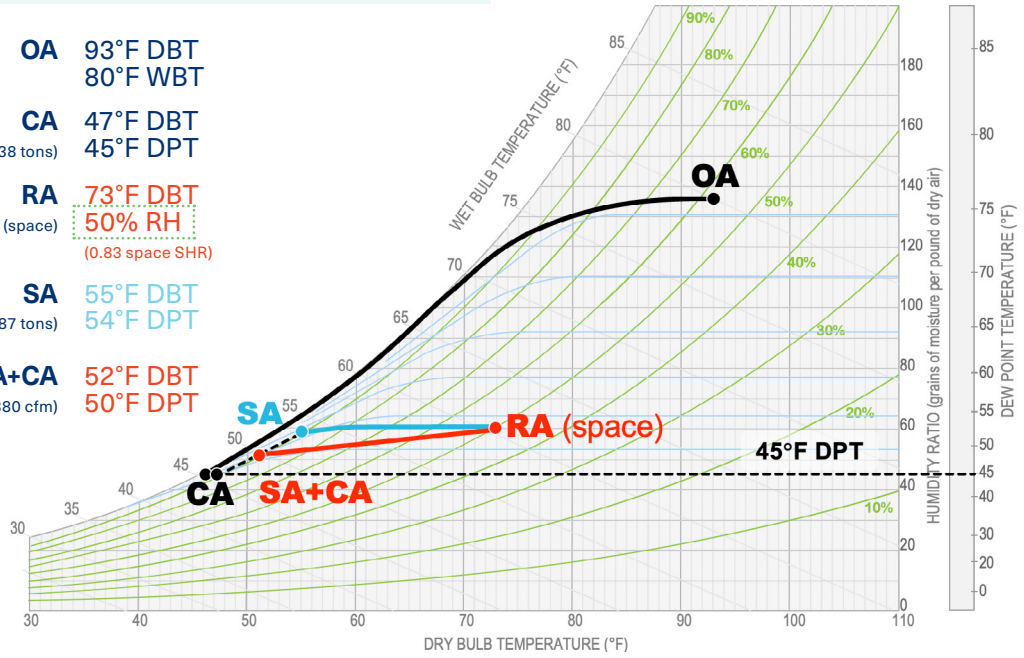
OA 93°F DBT
80°F WBT

CA 47°F DBT
(DOAS: 350 cfm, 3.38 tons) 45°F DPT

RA 73°F DBT
(space) 50% RH
(0.83 space SHR)

SA 55°F DBT
(terminal: 530 cfm, 0.87 tons) 54°F DPT

SA+CA 52°F DBT
(880 cfm) 50°F DPT



47°F DBT
45°F DPT

Significant load reduction, both sensible and latent, can be achieved for terminal equipment by designing around a DOAS with a lower dewpoint. This approach not only provides an opportunity to right size terminal equipment, thereby saving project costs, but also addresses IAQ concerns related to moisture in the terminal equipment within the space. In this classroom example, Demand Control Ventilation (DCV) should be deployed to avoid over-cooling the space during unoccupied or part-load operation, thereby preventing the need for reheat. Alternatively, the Dedicated Outdoor Air System (DOAS) can deliver room-neutral air with a low dew point and space-neutral dry-bulb temperature instead of using DCV. Sizing a DOAS unit specifically designed to maintain the supply-air dew point to offset the space's latent load, and reheating it back to a space-neutral dry-bulb temperature, allows the terminal unit to be sized to offset the sensible space load.

Conventional Rooftop Delivering 57°F DBT, 55°F DPT

tag	entering -air DBT	entering-air DPT	airflow	sensible capacity	latent capactiy	total capacity
FCU-101	73°F	56°F	760 cfm	15,010 Btu/h	3580 Btu/h	18,590 Btu/h(1.55 tons)
DOAS-1	93°F	75.6°F	350 cfm	14,380 Btu/h	17,370 Btu/h	31,750 Btu/h(2.65 tons)

DOAS Delivering 47°F DBT, 45°F DPT — **44% capacity reduction**

tag	entering -air DBT	entering-air DPT	airflow	sensible capacity	latent capactiy	total capacity
FCU-101	73°F	53°F	530 cfm	10,470 Btu/h	0 Btu/h	10,470 Btu/h (0.87 tons)
DOAS-1	93°F	75.6°F	350 cfm	18,130 Btu/h	22,400 Btu/h	40,530 Btu/h (3.38tons)

Consider that terminal equipment is typically sized based on design (full load) conditions. The benefit of incorporating a low dewpoint DOAS, in conjunction with terminal equipment, is enhanced part-load humidity and comfort performance throughout the year. This ensures a more efficient and comfortable environment, regardless of varying load conditions.

Example 3 | Specifying DX-DOAS Equipment That Does Not Comply with AHRI 920-2020 Standard

Issue:

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

To comply with ASHRAE 90.1 minimum efficiency rating, equipment efficiency information supplied by manufacturers shall be verified by one of the following:

(a) Equipment covered under EPACT shall comply with U.S. Department of Energy certification requirements.

(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.

Solution:

U.S. Department of Energy (DOE) has published federal regulations that govern the efficiency of DX DOAS. They align with addendum CV to Standard 90.1-2022 and went into effect on May 7, 2025. Horizon™ will be included AHRI 920-2020 certification program which will allow designers to comply with efficiency verification under part (b) above. For DOAS equipment that is not covered under the certification program (AHRI 920-2020), their efficiency ratings shall be verified by an independent laboratory – per part (c). This includes typical rooftop equipment that has been modified to claim DOAS operation.

Minimum Efficiency Standards for Direct Expansion-Dedicated Outdoor Air Systems

Table 17 to § 431.97(g)

Subcategory	Supplementary heating type	Efficiency level
Direct expansion-dedicated outdoor air systems	(AC)—Air-cooled without ventilation energy recovery systems	ISMRE2 = 3.8
	(AC w/VERS)—Air-cooled with ventilation energy recovery systems	ISMRE2 = 5.0
	(ASHP)—Air-source heat pumps without ventilation energy recovery systems	ISMRE2 = 3.8 ISCOP2 = 2.05
	(ASHP w/VERS)—Air-source heat pumps with ventilation energy recovery systems	ISMRE2 = 5.0 ISCOP2 = 3.20
	(WC)—Water-cooled without ventilation energy recovery systems	ISMRE2 = 4.7
	(WC w/VERS)—Water-cooled with ventilation energy recovery systems	ISMRE2 = 5.1
	(WSHP)—Water-source heat pumps without ventilation energy recovery systems	ISMRE2 = 3.8 ISCOP2 = 2.13
	(WSHP w/VERS)—Water-source heat pumps with ventilation energy recovery systems	ISMRE2 = 4.6 ISCOP2 = 2.64

For more information, join us at trane.com/doas

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