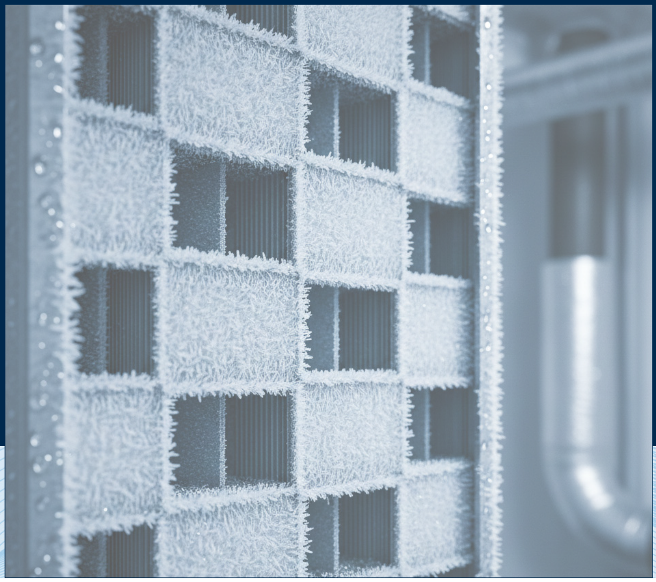
OXYGEN8

BEHIND THE BUILD

ERV & HRV FROST DETAILS

HOW TO AVOID AND REMOVE FROST



Frost Formation on ERV and HRV Heat Exchangers

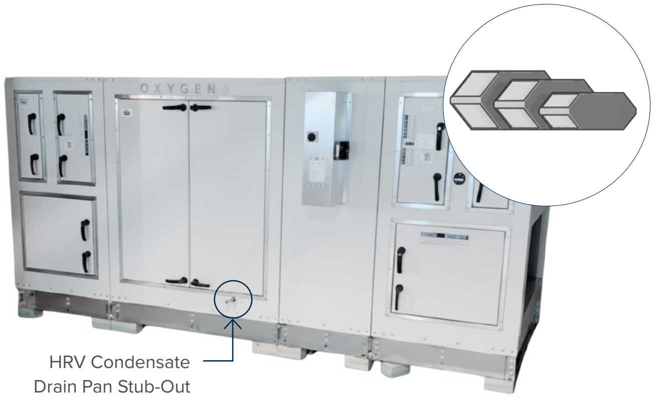
ERV and HRV heat exchangers can form frost when the exhaust air reaches saturation under winter conditions, but each type behaves differently. ERVs transfer moisture to the incoming outdoor air, lowering the relative humidity of the exhaust air as it cools, whereas HRVs do not transfer moisture, so exhaust air retains higher humidity as it moves through the heat exchanger. When exhaust air reaches 100% relative humidity, or saturation, it becomes foggy, depositing water droplets on the heat exchanger surface. If the incoming outdoor air on the other side of the heat exchanger material (polymer membrane for ERVs or aluminum plates for HRVs) is below freezing, these droplets will freeze and form frost.
Because of these differences in moisture transfer, HRVs typically develop frost at much higher outdoor air temperatures than ERVs. **Depending on design conditions, high efficiency HRVs often frost between 20–30 °F, while ERVs commonly frost between -10 °F and +10 °F.**

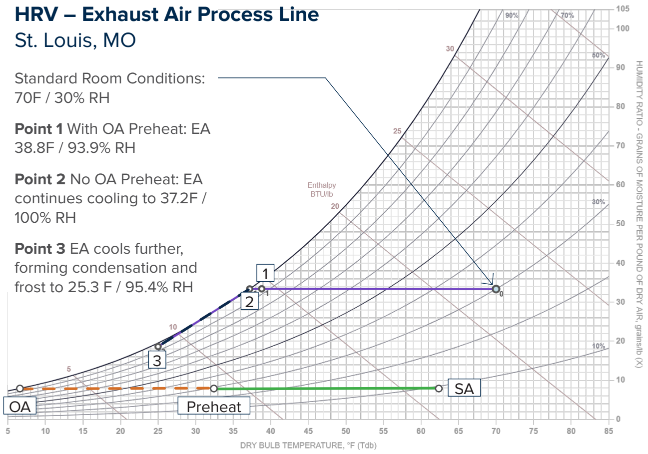
Return air (RA) relative humidity is a critical factor in determining frost formation. Oxygen8's Configur8 software calculates the frost temperature for each unit automatically, but it defaults to 30% RA humidity regardless of the winter design outdoor air temperature. In some applications, such as locker or shower rooms, RA humidity may be 30% or higher at winter design conditions. However, in typical commercial spaces, RA humidity is often much lower, ranging from 10–25%, particularly in cold climates where outdoor air has a low dewpoint and building exfiltration is high. Entering accurate RA humidity values into the software is important to avoid overspecifying preheaters. For example, if the outdoor air is 0 °F, it is probably unlikely that the space RA is actually 30%.

HRV (Sensible Only) Heat Exchangers

HRV heat exchangers transfer temperature only, using aluminum plates. As exhaust air cools, the EA process line moves horizontally left across the psychometric chart toward saturation. In cold climates without a preheater, the exhaust air will become saturated and frost will form on the heat exchanger. While high-performance HRV units typically frost when the outdoor air temperature is slightly below 32 °, lower-performance units may frost at colder temperatures but transfer less sensible heat the rest of the year.

HRV units always require a drain pan and condensate piping because even when frost formation is prevented with a preheater, condensation can still occur at OA temps above freezing. This means that frost prevention strategies must also account for water drainage and space ventilation.





Example 1: HRV Heat Exchanger; 6.6F OA needs to be preheated up to 31.6F to avoid frost.

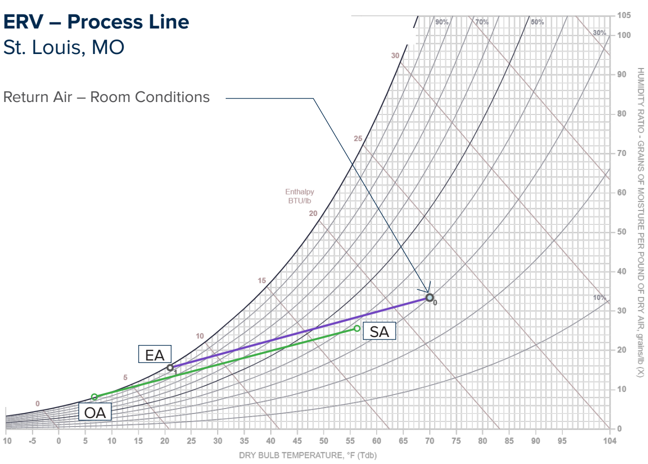
ERV & HRV FROST DETAILS

HOW TO AVOID AND REMOVE FROST

ERV (Sensible & Latent Heat Exchanger)

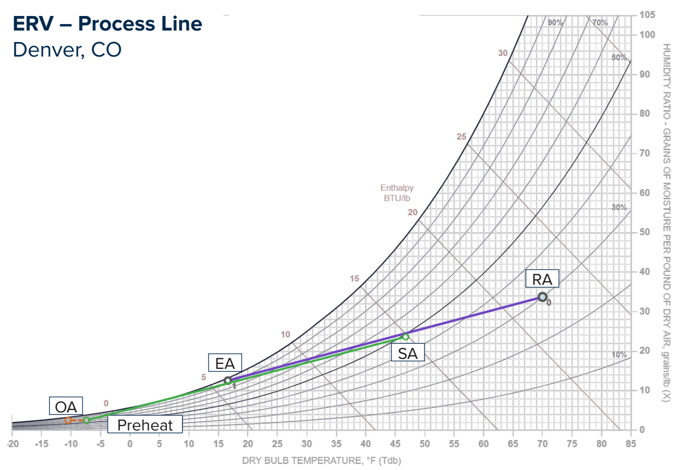
ERV heat exchangers transfer both temperature and moisture, which causes the exhaust air (EA) process line to move diagonally left and downward on the psychometric chart. If the EA process line reaches the saturation curve, condensation will occur, and if the outdoor air (OA) on the opposite side of the membrane is below freezing, frost will form.

ERV – Process Line
St. Louis, MO



Example 2: ERV in St. Louis, MO. EA process line stops before reaching the saturation curve.

ERV – Process Line
Denver, CO



Example 3: ERV in Minneapolis, MN with 30% RH room air. OA preheater is required to keep the EA process line from reaching the saturation curve. The preheater heats the OA from -11.2F up to -7.2F to avoid frost.

Heat Exchanger		
Design Condtions	**Outdoor Air**	**Return Air**
SCFM:	5000	5000
Summer DB (F) / WB (F) / RH (%):	95.5 / 76.8 / 43.6	75 / 63 / 51.2
Winter DB (F) / WB (F) / RH (%):	6.6 / 6.5 / 97.6	70 / 52.8 / 30
Performance Leaving Air	**Supply Air**	**Exhaust Air**
Summer SCFM:	5000	5000
Winter SCFM:	5000	5000
Summer DB (F) / WB (F) / RH (%):	79.5 / 67.2 / 53.3	91 / 73.3 / 43.8
Winter DB (F) / WB (F) / RH (%):	55.6 / 44 / 38.1	21 / 20.8 / 96.5

Heat Exchanger		
Design Condtions	**Outdoor Air**	**Return Air**
SCFM:	5000	5000
Summer DB (F) / WB (F) / RH (%):	90.9 / 72.9 / 43	75 / 63 / 51.2
Winter DB (F) / WB (F) / RH (%):	preheat -11.2F to -7.2 / -7.7 / 76	70 / 52.8 / 30
Performance Leaving Air	**Supply Air**	**Exhaust Air**
Summer SCFM:	5000	5000
Winter SCFM:	5000	5000
Summer DB (F) / WB (F) / RH (%):	79.7 / 66.1 / 49.6	86.2 / 70 / 45.2
Winter DB (F) / WB (F) / RH (%):	46.5 / 39 / 50.5	16.3 / 16 / 95.3

Using preheat in cold climates prevents the exhaust air from cooling to saturation. By slightly increasing the incoming outdoor air temperature, the exhaust air temperature remains high enough that its process line stops short of the saturation curve. When this condition is maintained, frost is prevented entirely rather than removed after formation.

The following conditions increase the likelihood that the exhaust air process line will reach the saturation curve and may require either a preheater or a defrost strategy:

- **Higher Return Air Moisture**
  Raises the RA starting point on the psych chart and causes saturation at warmer temperatures
- **Lower Outdoor Air Temperatures**
  Further cools the exhaust air, increasing frost potential
- **Air low Imbalance (More OA than EA)**
  Makes the exhaust air colder than with balanced airflow operation
- **Lower Latent Effectiveness Heat Exchanger**
  Produces flatter EA process line that will reach saturation sooner

ERV & HRV FROST DETAILS

HOW TO AVOID AND REMOVE FROST

ERV – Process Line with Preheat
Denver, CO | 50% RH

Balanced Airflow: 5,000 CFM EA & SA

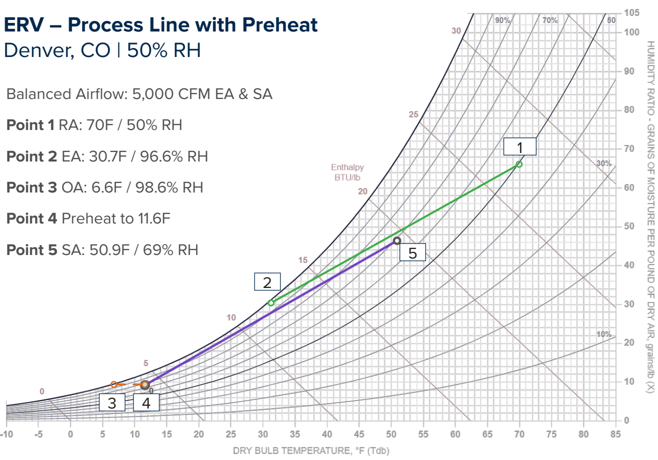
Point 1 RA: 70F / 50% RH

Point 2 EA: 30.7F / 96.6% RH

Point 3 OA: 6.6F / 98.6% RH

Point 4 Preheat to 11.6F

Point 5 SA: 50.9F / 69% RH

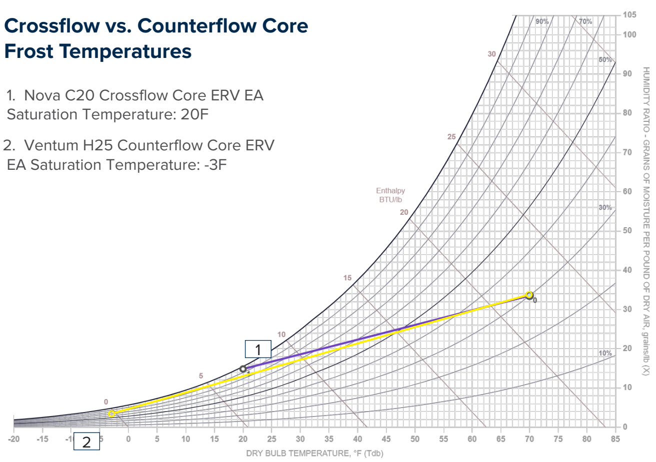


Example 4: ERV frost temperature with 50% RH IA is 11.6F with 5,000 CFM balanced airflow. Unbalancing the airflow to 5,000 CFM OA and 3,500 CFM EA would make the frost temperature 14.6F and the supply air temperature would drop to 45.9F from 50.9F.

Counterflow heat exchangers with high latent recovery effectiveness transfer more moisture to the incoming outdoor air than typical crossflow heat exchangers. Greater moisture transfer results in a steeper EA process line, helping keep the exhaust condition away from saturation. Because of this higher latent transfer capability, counterflow cores can achieve frost temperatures that are 10–20°F lower than comparable crossflow designs.

Crossflow vs. Counterflow Core Frost Temperatures

1. Nova C20 Crossflow Core ERV EA Saturation Temperature: 20F
2. Ventum H25 Counterflow Core ERV EA Saturation Temperature: -3F



Example 5: Substantially lower EA saturation temperature with high efficiency counterflow cores

If winter operational conditions indicate saturated EA and frost formation are possible, there are a couple of ways to prevent the frost or remove it once it has formed:

- **Frost Prevention**
  OA preheat heats the incoming OA to the calculated temperature that will result in the EA avoiding the saturation curve
- **Frost Removal**
  Exhaust fan only operates to melt the frost based on differential pressure across the heat exchanger
- **Frost Removal**
  Exhaust fan only operates to melt the frost based on the EA temperature setpoint

When a controls-based defrost strategy is used, the OA fan is shut off while the exhaust fan continues operating to melt accumulated frost. During defrost periods, no ventilation air is supplied to the space, and the building pressure becomes negative. Negative pressure can create operational challenges such as difficulty opening doors and unintended airflow between building zones.

Additionally, systems using defrost require a condensate drain pan and drainage piping beneath the heat exchanger to manage meltwater. In contrast, when frost is prevented through preheat using an ERV, no drain pan is required because frost does not form and condensation is not a concern.

As shown in the table on the following page, indoor relative humidity assumptions at winter design conditions are critical when evaluating frost potential. If outdoor temperatures are between 0°F and -20°F, indoor RH in many commercial buildings is unlikely to remain at 30%. Tools such as Oxygen8's Configur8 Selection Software may default to 30% indoor RH, but leaving that value unchanged can incorrectly indicate the need for preheat. Accurate indoor humidity inputs are essential for proper frost prediction and optimal equipment selection.

High-performance ERVs with increased heat exchanger surface area and elevated latent effectiveness further reduce frost risk. For example, a Ventum+ V60 operating at 5,000 CFM with 30% indoor RH has a frost temperature of approximately -7°F, and with 20% indoor RH the frost temperature drops to -21°F. This illustrates the combined impact of humidity levels and high-efficiency counterflow cores in dramatically lowering frost formation potential.

ERV & HRV FROST DETAILS
HOW TO AVOID AND REMOVE FROST

ERV Frost Temperature Summary | Winter Design Conditions

OA (DB/WB)	-10 / -10.1			
Indoor Temperature / RH	70F / 30%			
Airflow (CFM: OA/EA)	2000 / 2000			
		Winter Effectiveness %		20% Indoor RH
	Frost Temperature (F)	Sensible	Latent	Frost Temperature (F)
Nova C20	3	65.1	44.7	-11
Ventum H25	-3	66.7	59.2	-18
Ventum+ H25	-4	68.5	63.1	-18

OA (DB/WB)	-10 / 10.1			
Indoor Temperature / RH	70F / 30%			
Airflow (CFM: OA/EA)	5000 / 5000			
		Winter Effectiveness %		20% Indoor RH
	Frost Temperature (F)	Sensible	Latent	Frost Temperature (F)
Nova C48	3	65.0	44.5	-11
Ventum+ V60	-7	69.6	69.6	-21

Ultimately, frost formation depends on how the exhaust air moves toward saturation under real winter operating conditions. The absence of moisture transfer in HRVs results in higher frost temperatures compared to ERVs, and high efficiency counterflow core ERVs have lower frost temps than units with crossflow cores. Unbalanced airflow will impact the frost temperature and making accurate return air humidity assumptions is essential in cold climates. By carefully considering winter design inputs and psychometric behavior, engineers can select the appropriate frost strategy while avoiding unnecessary energy use and equipment.

LET'S TALK ABOUT YOUR NEXT PROJECT!
CONTACT US AT APPLICATIONS@OXYGEN8.CA