PART 1: INTRODUCTION

1.1 PURPOSE

A. System Description

1. This section pertains to the material and installation requirements for air-to-air energy recovery equipment that is intended for use as a standalone piece of equipment, or as part of a packaged air handling unit, either indoors or outdoors.
2. This section includes four styles of air-to-air energy recovery equipment and notes the appropriate use application for each. The four styles of air-to-air energy recovery equipment are:
   a) Rotary energy recovery wheels
   b) Fixed plate heat exchangers
   c) Air-to-air heat pipe exchangers
   d) Run-around coil exchangers

PART 2: GENERAL DESIGN REQUIREMENTS

2.1 GENERAL

A. Design

1. In general, factory-assembled dedicated air-to-air energy recover units or energy recovery units installed within modular, semicustom, or custom air handling units shall comply with the provisions of standard 23 75 00 Air Handling Equipment.
2. Tempered air leaving an air-to-air heat exchanger shall not be introduced directly into a space. The tempered air shall be post-conditioned through secondary equipment to achieve the required thermal performance requirements for occupied and unoccupied periods.
3. Where frost control is required, the engineer of record shall ensure that the system is designed with the appropriate supplemental systems to maintain room thermal temperature requirements.
4. Frost control strategies shall not include the interruption of mechanical ventilation during occupied hours.
5. For winter conditions, terminal-level equipment shall be designed to maintain a minimum space temperature of 68°F, during occupied and unoccupied periods.
6. For summer conditions, terminal-level equipment shall be designed to maintain a maximum space temperature of 75°F db, during occupied and unoccupied periods.
7. For summer conditions, terminal-level equipment shall be designed to maintain a maximum space relative humidity of 60 percent, during occupied and unoccupied periods.
8. Energy recovery ventilators shall not be selected based on the operation of equal supply and opposing exhaust air streams. The engineer of record shall account for other exhaust sources and

operate the building at a positive pressure.

9. Air-to-air energy recovery equipment shall be capable of operating at temperatures ranging from -20°F to 120°F.
10. Where possible, locate all air-to-air energy recovery equipment within the conditioned envelope of the building, or within a conditioned penthouse. Where this is not possible, air-to-air energy recovery equipment shall be installed within rooftop mounted air handling equipment that complies with standard 23 75 00 Air Handling Equipment.
11. Utilize air-to-air energy recovery systems to maximize energy recovery from non-hazardous exhaust sources within a building, including but not limited to general building exhaust, toilet exhaust, general storage room exhaust, mechanical/electrical room exhaust, etc.
12. Provide a minimum of MERV-8 filters on the building exhaust side of the exchanger and a minimum of MERV-13 filters on the incoming outdoor air side of the exchanger unless MERV-13 filters are provided further upstream within an air handling unit. Provide mechanical and digital building management system (BMS) filter gauges at each filter rack.
13. Provide minimum of 24-inch-wide access sections on the upstream and downstream side of the air-to-air energy recovery exchanger.
14. Provide sufficient space for the largest single piece of the energy recovery core, wheel, coils, or sections of wheel to be pulled and replaced.
15. Select the appropriate air-to-air energy recovery technology based on the use of the building and the class of air being exhausted. Select the air-to-air energy recovery technology with the highest total effectiveness possible given the building type and application.
16. Rotary energy recovery wheels allow minimal leakage across the wheel from the exhaust side to the supply side, so this type of exchanger shall not be used where any leakage, even in small amounts, is not acceptable.

    a) Rotary energy recovery wheels shall be designed with the maximum total effectiveness that is practical for both sensible and latent heat transfer. Air handling units shall be designed and configured to maximize the wheel area exposed to supply and exhaust air streams. Keep velocities through the wheel low to minimize a pressure drop through the wheel on the supply and exhaust sides.
    b) In some cases, sensible-only wheels may be utilized for reheating a cooling coil downstream. The same design guidelines relative to sensible effectiveness and air velocity in line (A.1.) applies for sensible-only wheels as well.
    c) Rotary energy recovery wheels shall be designed and selected within air handling units to limit carryover leakage from the exhaust to the supply side by 2% or less. Rotary energy wheels shall be selected with an adjustable purge section.
17. Fixed plate heat exchangers do not allow leakage from the exhaust side to supply side. However, the supply and exhaust tunnels must be adjacent to each other, and generally part of the same packaged unit. This type of exchanger should be used where no leakage is acceptable from the

exhaust to supply, excluding laboratory applications.

a) Fixed plate heat exchangers shall be designed with the maximum total effectiveness that is practical for sensible and latent heat transfer. Air handling units shall be designed and configured to maximize the heat exchanger plate area that is exposed to the supply and exhaust air streams. Keep velocities through the exchanger low to minimize a pressure drop through the exchanger on the supply and exhaust sides.

b) In some cases, sensible-only exchangers may be utilized where latent transfer is not desired. The same design guidelines relative to sensible effectiveness and air velocity in line (A.1.) applies for sensible-only fixed plate exchangers as well.

18. Heat pipe exchangers do not allow leakage from the exhaust side to supply side. However, the supply and exhaust tunnels must be adjacent to each other, or at least in close proximity to each other, and generally part of the same packaged unit. Confirm the distance and elevation limitations between heat recovery coil pairs with the heat pipe exchanger manufacturer. Heat pipe exchanges are only capable of sensible heat transfer and should only be considered for applications where a latent heat transfer is not required or desired. These types of exchangers may be used for any application where zero leakage from the exhaust to supply is required, including laboratory applications. Heat pipe exchangers shall only be passive type.

19. Run-around coil exchangers are typically used where there is a separate supply air handling unit and exhaust air handling unit and when zero cross contamination is acceptable from the exhaust side to the supply side. Run-around coil exchangers are only capable of sensible heat transfer and should only be considered for applications where latent heat transfer is not required or desired. These types of exchangers may be used for any application where zero leakage from the exhaust to supply is required, including laboratory applications.

20. Provide temperature and humidity sensors at all four airstreams entering/leaving the exchanger, including incoming outdoor air, leaving exhaust air, building exhaust air, and building outdoor supply air.

PART 3: MINIMUM PRODUCT REQUIREMENTS

A. All equipment and components shall be new, and the manufacturer's current model.

B. All parts and components shall be readily available in the United States of America.

C. Rotary energy recovery wheels

1. The rotary energy recovery wheel supplier shall have a minimum of five (5) years of experience designing and installing rotary energy recovery wheels, specifically energy recovery applications.

2. Wheels will be constructed from corrugated aluminum, specifically treated to create a porous surface and coated with a 3A molecular sieve desiccant, conforming to NFPA 90A. Wheels shall be mounted on permanently lubricated bearings and be removable. Wheels constructed solely of paper media are not acceptable. Silica gel, oxidized aluminum, and other non-molecular

desiccants are not acceptable.

3. For total enthalpy wheels, a selection of wheel desiccant and controls sequences shall be selected to prevent “dirty sock” syndrome.
4. NovelAire wheels shall be reviewed with Yale Engineering prior to specifying.
5. Wheel effectiveness will be rated in accordance with the current versions of ASHRAE Standard 84 and AHRI 1060 (I-P).
6. Flame spread index (FSI) should be 25 or less, when tested in accordance with ASTM E84-21a or UL 723.
7. Smoke developed index (SDI) should be 50 or less, when tested in accordance with ASTM E84-21a or UL 723.
8. Rotor wheels should be reinforced with spokes, welded at the hub and perimeter to prevent any uneven runout during normal operations.
9. Air seals and internal partitions shall separate the supply and exhaust air streams so that the exhaust air does not contaminate the supply air. The exhaust and supply sides shall have full face seals spanning the entire perimeter of both air streams. Wheels shall incorporate an adjustable purge section.
10. Pressure differential is adjustable by means of a lockable quadrant operator.
11. Tensioned drive with a full perimeter link-style belt with shock absorber.
12. Airflow gauges provide the digital building management system (BMS) and local differential pressure gauges with measurements and a display of the pressure drop across the wheel in both air streams.
13. Frost control of the wheel shall be provided by the central BMS controls. Upon sensing frost on the exhaust discharge side of the wheel, the unit shall enter into defrost mode. In defrost mode, the wheel shall be modulated to maintain a constant exhaust discharge air temperature, as recommended by the manufacturer, or as calculated by the unit based on the air conditions. Five (5) minutes after frost is no longer sensed, the wheel shall be returned to a normal operating speed. Account for the degradation in wheel performance, due to frost control, in the design of the heating capacity of the unit.
14. Bacteria and mold resistance will be mitigated by a membrane which will not promote the growth of mold or bacteria. The membrane must have successfully passed AATCC 30 with no growth of *Aspergillus niger* observed after 14 days.

D. Fixed plate heat exchangers

1. The fixed plate heat exchanger supplier shall have a minimum of five (5) years of experience designing and installing fixed plate heat exchangers specifically energy recovery applications.
2. The core can be constructed of alternate layers of corrugated open mesh aluminum material and polymeric desiccant impregnated media observes 3A or smaller pore size. The enthalpy plate energy exchanger shall transfer sensible and latent energy between outgoing and incoming air

streams in a crossflow arrangement. Hydroscopic polymer shall exchange water by a direct vapor transfer and use molecular transport without the need of condensation.

3. Framing the core shall be assembled into a self-supporting structure made of aluminum corner extrusions and 16-gauge aluminum end plates.
4. Capabilities will operate at temperatures between -20°F and 120°F. Withstand more than a 10% increase of pressure drop, pressure differentials of at least 5-inch water gauge. Withstand pressure differential of 10-inch water gauge without permanent deformation.
5. The enthalpy plate exchanger shall bear the AHRI 1060-certified product seal. Sensible, latent, and total effectiveness along with pressure drop, EATR, and OACF ratings shall be clearly documented with the performance tests conducted in accordance with ASHRAE Standard 84-91 and per the official Air-Conditioning, Heating, and Refrigeration Institute (AHRI) laboratory.
6. Fire resistance should follow the UL 1995 guide to "Electrical Heating and Cooling Equipment," where the enthalpy plate exchanger shall be a UL-recognized component and bear the UL certification trademark (tested under UL 723 with success by the UL laboratory). Exchangers only tested in accordance with UL 723 shall be unacceptable.
7. See section "C.14."
8. Longevity tests (frosting/defrosting cycles) for the exchanger must have successfully passed 1,920 frosting/defrosting cycles with less than 10% change of its performance.
9. Frost control shall be accomplished by a face and bypass damper, where temperatures fall below freezing. Account for the degradation in wheel performance due to frost control in the design of the heating capacity of the unit.

E. Air-to-air heat pipe exchangers

1. Heat pipe circuits comprise multiple tubes connected in series, end-to-end to form a closed, continuous loop. Both vapor and liquid will travel in the same direction around the circuit in a single convectional path, making wicking and capillary action unnecessary for continuous heat transfer. Single tube circuits where gas and liquid travel in the same tube in opposite directions are not acceptable.
2. Heat pipe modules shall be located inside the equipment cabinet. The interconnecting piping between the heat pipe modules shall be located within the assembled access/coil/access sections if possible. If not, the piping shall be external, but enclosed within a removable and insulated enclosure. When possible, all interconnecting piping shall be located at the end of the cooling coil opposite from the coil header and piping connections.
3. Heat pipes shall be completely manufactured and fully assembled at the manufacturer's facility. The conversion of third-party coils is not acceptable.
4. The heat pipe supplier shall have a minimum of five (5) years of experience designing and installing heat pipes, specifically for dehumidification and heat recovery applications.
5. The tubes shall be made of half-inch (1/2"), outside diameter copper specifically designed for heat pipe application and permanently expanded onto the fin collar to form a firm, rigid, and

complete pressure contact at all operating conditions. Aluminum tubes will not be allowed, and copper tubes shall be no larger than five-eights-inch (5/8"), outside diameter.

6. The tubes' fin surface shall be continuous plate-type aluminum fins specifically designed to produce maximum heat transfer efficiency for heat pipe applications. Airside pressure loss shall be as given on the schedule, or otherwise specified. Fin density and the number of rows of tubes shall be as scheduled.
7. Heat transfer fluid shall be classified as safety group "A1" in the current version of ASHRAE 34.
8. Heat pipe capacities entering and leaving dry and wet bulb temperatures in addition to face velocity shall be as scheduled.
9. The heat pipes shall be installed as shown on the submittal drawings.
10. Frames, mounting structure, and drain pan extensions (if required) shall be minimum 20-gauge galvanized steel.
11. Heat pipe interconnecting piping and circuitry shall be specified by the manufacturer's design. Each circuit shall be individually processed, charged, hermetically sealed, and tested.
12. Scheduled effectiveness or heat recovery shall be met at a minimum, and a total pressure drop shall not be exceeded. The resulting recovery efficiency ratio (RER) shall be met at a minimum.
13. Heat pipes shall not be field installed, except in a retrofit application. All retrofit applications shall be reviewed by Yale Engineering and need to be installed at the air handler manufacturer's facility, or the heat pipe manufacturer's facility.

F. Run-around coil exchangers

1. Refer to section 23 82 16 Air Coils for construction requirements of hydronic coils.

G. Controls

1. Manufacturer packaged control of air-to-air energy recovery equipment shall not be allowed unless reviewed with Yale Engineering.
2. The central BMS system shall control all aspects of the air-to-air energy recovery equipment, including the following as applicable to each equipment type.
   a) Frost control
   b) Wheel speed
   c) Bypass
   d) Damper control
   e) Filter status
   f) Temperature and humidity at each of the four airstreams

Date	Description of Change	Pages / Sections Modified	ID
11/2023	New standard for air-to-air energy recovery equipment	N/A	Office of Facilities, Engineering and Operations