ENGINEERING & FACILITY DESIGN STANDARD

Cold Storage Facility Technical Specifications

Standard Reference Specification for Multi-Chamber Chiller, Freezer, and Controlled-Atmosphere Warehousing

Document Ref.	[CS-SPEC-001]	**Facility Classification**	Multi-Temperature Cold Warehouse
Project / Site	[Facility Name / Location]	**Applicable Standards**	ASHRAE, IIAR, ISO 22000, IEC 60364

1. General Scope & Design Criteria

This specification defines the baseline civil, thermal insulation, mechanical refrigeration, electrical, and safety requirements for a commercial cold storage facility. All systems shall be engineered for continuous 24/7 operation under peak ambient conditions while maintaining strict thermal stability, vapor tightness, and energy efficiency across distinct temperature zones.

Zone Classification	Design Temperature	Relative Humidity	Typical Stored Commodities
Ante-Room / Staging	+8 °C to +12 °C	65% – 75% RH	Receiving, sorting, pallet wrapping, dispatch buffer
Fresh Chiller Zone	0 °C to +4 °C	85% – 95% RH	Fresh produce, dairy products, chilled beverages, floriculture
Controlled Atmosphere	−1 °C to +2 °C	90% – 95% RH	Apples, pears, kiwifruit (O_2: 1–3%, CO_2: 1–5%)
Frozen Storage Zone	−18 °C to −25 °C	80% – 90% RH	Frozen meats, seafood, poultry, frozen processed foods
Blast Freezer Tunnel	−35 °C to −40 °C	Uncontrolled	Rapid core freezing of fresh meat, fish, and bakery products

2. Civil Works & Floor Insulation System

The structural envelope must prevent ground moisture migration and frost heave beneath sub-zero chambers. Sub-floor heating systems are mandatory for all chambers operating below 0 °C.

- **Sub-Base & Vapor Barrier:** Compacted engineered fill topped with a minimum 150 mm reinforced concrete blinding slab, sealed with two layers of overlapping 300-micron high-density polyethylene (HDPE) vapor barrier membrane with heat-welded seams.
- **Underfloor Frost-Heave Protection:** Closed-loop glycol heating pipes (16 mm PEX-a tubing at 300 mm centers) or thermostatically controlled electric heating cables embedded in the sub-slab, maintaining sub-soil interface temperatures at +4 °C ± 1 °C.
- **Floor Thermal Insulation:** High-density Extruded Polystyrene (XPS) or rigid Polyisocyanurate (PIR) boards with compressive strength ≥ 350 kPa, laid in two staggered layers (total thickness 120 mm for chillers; 160–200 mm for freezers) separated by a slip-sheet membrane.
- **Wearing Slab:** Minimum 180 mm steel-fiber reinforced concrete wearing slab (M35 grade) with laser-screeded flatness tolerance (FM2 special), armored construction joints, and food-grade polyurethane screed topping.

3. Insulated Envelope & Cold Room Doors

Walls and ceilings shall be constructed using factory-manufactured, cam-lock or tongue-and-groove rigid Polyisocyanurate (PIR) sandwich panels achieving a continuous thermal envelope without thermal bridges.

Envelope Parameter	Chiller Zone (0 °C to +4 °C)	Freezer Zone (−18 °C to −25 °C)
Core Material & Density	B1/B2 Fire-rated PIR foam, 40 ± 2 kg/m^3	B1/B2 Fire-rated PIR foam, 40 ± 2 kg/m^3
Thermal Conductivity (λ)	≤ 0.022 W/(m·K) at 10 °C mean temp	≤ 0.022 W/(m·K) at 10 °C mean temp
Panel Thickness	100 mm (Wall) / 120 mm (Ceiling)	150 mm to 200 mm (Wall & Ceiling)
Facings & Coating	0.50 mm galvanized steel, food-safe polyester	0.50 mm galvanized steel, food-safe polyester
Cold Storage Doors	80 mm insulated sliding door, EPDM gaskets	120–150 mm sliding door + perimeter heater

- **Vapor & Air Tightness:** All internal and external panel joints shall be sealed with non-hardening food-grade butyl sealant. Ceiling panels exceeding 6 m span shall be suspended from overhead structural steel trusses via thermally broken stainless-steel hanger rods.
- **Infiltration Control:** Motorized high-speed roll-up doors (opening speed ≥ 1.5 m/s) or dual-louvered air curtains shall be installed at high-traffic freezer thresholds alongside heated bi-directional pressure relief valves (PRVs) sized for rapid barometric equalization.
- **Dock Levelers & Shelters:** Loading bays shall feature inflatable dock shelters with vertical hydraulic dock levelers and insulated sectional overhead doors closing directly onto the pit to eliminate ambient air ingress during trailer loading.

4. Mechanical Refrigeration System

The refrigeration plant shall utilize environmentally compliant refrigerants with low Global Warming Potential (GWP) and zero Ozone Depletion Potential (ODP), configured with N+1 compressor redundancy for critical storage zones.

Subsystem / Component	Technical Specification & Performance Standard
Refrigerant Selection	R-717 (Ammonia) in pumped overfeed/DX configuration for large facilities (> 500 kW), or transcritical R-744 (CO_2) / low-GWP A2L blends (R-454C / R-455A) for commercial installations.
Compressors	Semi-hermetic reciprocating or industrial screw compressors equipped with Variable Frequency Drives (VFDs) for capacity modulation (25%–100%), oil separators, crankcase heaters, and suction accumulators.
Condensers	Evaporative condensers (stainless steel basin/coils) or high-efficiency air-cooled microchannel condensers with EC axial fans, low-noise blades, and floating head-pressure control.
Evaporator Unit Coolers	Dual-discharge or cubic ceiling-mounted evaporators with internal grooved copper or stainless-steel tubes, hydrophilic aluminum fins (7 mm–10 mm fin spacing for freezers), and EC fans.
Defrost Mechanism	Hot-gas defrost or electric cartridge heater defrost (coil and drain pan) initiated on demand via differential air-pressure sensors or adaptive time-temperature algorithms.
Piping & Insulation	Seamless carbon steel (ASTM A106 Gr. B) for Ammonia or Type LACR copper for HFC/HFO/CO_2, insulated with closed-cell elastomeric foam or PIR pipe sections with aluminum cladding.

5. Electrical, Lighting & Automation Controls

All electrical installations inside cold chambers shall be rated for low-temperature, high-moisture environments (minimum IP65 ingress protection) with dedicated emergency power backup.

- **Power Distribution & Backup:** Main LV switchgear complying with IEC 60364, supported by an automatic-transfer-switch (ATS) standby diesel generator sized to carry 100% of refrigeration, lighting, door heaters, and control loads.
- **Cold-Rated LED Lighting:** Vapor-tight IP66 LED luminaires rated down to −40 °C, delivering a minimum illuminance of 200 lux in storage aisles and 300 lux in staging/inspection areas, controlled via microwave occupancy sensors.
- **SCADA & PLC Monitoring:** Centralized PLC control panel with HMI touchscreen and cloud-enabled SCADA logging. Continuous recording of chamber temperatures (±0.2 °C accuracy calibrated PT100 sensors), relative humidity, defrost cycles, and compressor status at 5-minute intervals for HACCP/GDP audit compliance.

6. Safety, Fire Protection & Compliance

Life-safety and hazard-mitigation systems shall be integrated into the building management system with audible and visual annunciation both locally and at the central security desk.

- **Entrapment Prevention:** All cold room doors must feature internal glow-in-the-dark mechanical push-release overrides operable even when locked externally, paired with illuminated "Man-in-Room" push-button alarm stations mounted 1.2 m above finished floor level inside every chamber.
- **Refrigerant Leak Detection:** Continuous infrared or electrochemical gas detectors interlocked with emergency exhaust ventilation (minimum 15 air changes/hour in plant rooms), automated solenoid isolation valves, and strobe/horn alarms.
- **Fire Detection & Suppression:** Aspirating Smoke Detection (ASD) systems with heated sampling pipes for sub-zero chambers, complemented by dry-pipe or pre-action automatic sprinkler networks engineered to prevent pipe freezing.

> **Commissioning & Acceptance Testing:** Prior to handover, the facility shall undergo a mandatory 72-hour continuous pull-down and thermal stability test verifying design temperatures, defrost recovery times, door-heater operation, vapor-seal integrity, and automated alarm fail-safes.